PROGRESS/ACTIVITY REPORTS PRESENTED AT THE COMMISSION FOR ATMOSPHERIC SCIENCES (FIFTEENTH SESSION) (Incheon, Republic of Korea)

(unedited)

World Meteorological Organization **CAS-XV/INF. 1**

COMMISSION FOR ATMOSPHERIC SCIENCES Date: 5.VI.2009

FIFTEENTH SESSION Original language: English
Incheon, Republic of Korea
18 to 25 November 2009

MATERIAL ARRANGEMENTS FOR THE SESSION

Accommodation

1. At the kind invitation of the Government of the Republic of Korea, the fifteenth session of the Commission for Atmospheric Sciences (CAS-XV) will be held in Incheon, Republic of Korea, from 18 to 25 November 2009. The opening ceremony will take place at 10:00 a.m. on Wednesday, 18 November, at the Hyatt Regency Hotel, Incheon. The session will be preceded by a two-day Technical Conference, which will be held in the same hotel from 16 to 17 November 2009.

2. The main conference room will be equipped for simultaneous interpretation. Additional meeting rooms without interpretation facilities will also be available.

3. A Conference Information and Documentation Desk will be established close to the meeting rooms and will be responsible for the registration of participants, provision of general information, and distribution of documents.

Registration of participants

4. Registration for CAS-XV will take place at the Conference Information and Registration Desk at the Hyatt Regency Hotel from Wednesday, 18 November 2009, from 8.00 a.m. to 10.00 a.m. and will continue throughout the session. Participants will receive identification cards at the time of registration.

Credentials

5. Pursuant to Regulation 20 of the General Regulations, prior to a session of a constituent body other than the Executive Council, each Member should, if possible, communicate to the Secretary-General the names of the persons composing its delegation to that body, indicating which of these shall be regarded as its principal delegate. Besides this communication, a letter giving these particulars and otherwise conforming with the provisions of the WMO Convention and of the WMO General Regulations and signed by, or on behalf of, an appropriate governmental authority of the Member shall be sent to the Secretary-General or handed to his representative at the session and shall be regarded as appropriate credentials for the participation of the individuals named therein in all activities of the constituent body.

List of participants

6. A provisional list of participants will be distributed shortly after the beginning of the session. This list will be revised as soon as all participants have registered, and a new list will be distributed, if necessary.

Submission of documents

7. Delegations wishing to submit documents before the session are invited to send them to the WMO Secretariat, as soon as possible but not later than sixty days before the opening of the session, according to the provisions of Regulation 189(b) of the WMO General Regulations to allow time for translation and reproduction. According to Regulation 188 of the WMO General Regulations, session documents should be distributed as soon as possible and preferably not later than forty-five days before the opening of the session. Any document presented by a delegation should be submitted in the name of the Member of the Organization and not by an individual person. If the documents include bulky appendices and/or material such as drawings, photographs, tables, etc., it will speed up reproduction if a sufficient number of copies are provided by the Member concerned.

Working languages

8. Simultaneous interpretation in Arabic, Chinese, English, French, Russian and Spanish will be provided at plenary meetings. In this connection, it is to be noted that only one team of interpreters will be available.

Numbering of documents

9. All documents, working papers and PINKs will receive a common, consistent numbering in the top right-hand corner of the front page, and on the header of all subsequent pages; this numbering will allow delegates to easily track a document through its various stages.

Categories and languages of documents

10. Following the practice of previous sessions of the Commission, the documents for CAS-XV will be issued in Arabic, Chinese, English, French, Russian and Spanish except for those mentioned under (d) below:

(a) Main supporting papers to the agenda items, which will be listed as CAS-XV/Doc...;

(b) Working papers emanating from the plenary meetings. These will be listed as CAS-XV/WP.... They will contain changes from previous versions of texts in "track changes" format;

(c) Reports submitted to plenary by the chairmen or by the president of the session. These will be listed as CAS-XV/PINK…;

(d) Information papers containing items of general information which may be of use to delegates attending the session. These will be listed as CAS-XV/INF. … and will be issued in English and French only;

(e) Text and resolutions contained in documents and working papers may be approved by plenary at any time, provided no substantive changes are made. In this case, the text will be given the category of APP_Doc. or APP_WP, as appropriate, and their first page will be green.

Distribution of documents

11. Following the example set by EC-LX, the principal means of distribution of all documents (DOCs, WPs and PINKs) pre-session will be electronic. Documents issued before the session are made available in electronic format on the ftp server

(url:ftp://ftp.wmo.int/Documents/SESSIONS/CAS-XV), and WMO Members and members of the Commission are notified accordingly by mail. In order to avoid wastage of paper and thereby reduce the carbon footprint, a hard copy of the documents will only be mailed to participants on request.

12. Electronic versions of all documents produced in-session will be posted on the WMO ftp server as soon as they are available. Delegates are encouraged to use electronic versions in preference to hard copy versions. However, during the session, hard copies of documents will be available in limited numbers. Each delegation will receive one copy only of each Working Paper and PINK in the language requested. Additional copies may be requested from the Conference Information and Registration Desk. However, because of limited stocks, some delays may be expected.

Provisional Abridged Report

13. The Provisional Abridged Report comprises the set of texts, resolutions and annexes approved by the plenary meeting. Each delegation will receive a folder to enable them to assemble the provisional report. An electronic version of the approved documents (i.e. APP_Docs., APP_WPs or PINKs as explained in paragraph 10 above) showing plenary amendments in English only will be posted on the above ftp server as soon as possible after the session.

Entry requirements

14. In general, foreign visitors wishing to enter the Republic of Korea are required to hold passports valid for a minimum of 6 months and entry visas, except nationals of those countries with which Korea has signed a visa exemption agreement. If uncertain as to the necessity of an entry visa to Korea, please contact your local Korean Embassy or consulate as soon as possible.

For more information, please visit the following websites:

http://www.mofat.go.kr/english/visa/apply/index.jsp
http://www.learn4good.com/travel/south_korean_visas_requirements.htm
http://www.hikorea.go.kr/pt/index.html (Information > Immigration Guide > VISA)

If an invitation letter is necessary for your visa application, please directly contact the Local Organizing Committee at the following address:

Local Organizing Committee for CAS-XV
Korea Meteorological Administration (KMA)
45 Gisangcheong-gil, Dongjak-gu
Seoul 156-720
Republic of Korea

Tel.: +82 2 836 2385
Fax: +82 2 836 2386
E-mail: jcnam@kma.go.kr, ksw@kma.go.kr, or juebo@kma.go.kr

Currency

15. The local currency is the Korean Won (KRW). There are currency exchange offices at Incheon International Airport and Gimpo International Airport, as well as all banks (business hours are 10 a.m. to 4:30 p.m.). The hotels where you will be staying also accept major credit cards.

Currencies such as the US Dollar and Euro are easy to exchange into the local currency. The exchange rates for the major currencies against KRW as of April 2009 are as follows:

1 USD ≈ 1350 KRW
1 EUR ≈ 1750 KRW
1 CHF ≈ 1200 KRW

Health requirements/Medical Services

16. Up-to-date information on International Travel and Health is provided by the World Health Organization (WHO) at http://www.who.int/ith/countries/listk/en/ (Countries), and alternatively at http://www.who.int/countries/kor/en/

17. Medical services are of high standard, with most international prescription drugs readily available at retail pharmacies. It is suggested that you purchase personal medical insurance for the duration of your stay in Korea.

Electricity and Mobile Phone Connection

18. City and town power systems are generally 220 volts and 60 Hz. Plugs have two cylindrical pins (CEE 7/16, Schuko (CEE 7/4) type plugs). Adaptors or transformers may be required for foreign-made appliances.

19. Given that the host country has adopted the CDMA system for mobile communications, mobile telephones with GSM configuration will not function unless your operator has signed a roaming agreement with the Republic of Korea that enables you to use your own SIM card and hence keep your own mobile number on a handset from a local renter. For further detail, please visit the website of the largest Korean mobile carrier, SK Telekom, at http://www.skroaming.com/en/index.html, or contact your local service operator.

Hotel reservation

20. Participants are responsible for their own hotel reservations. The Korea Meteorological Administration (KMA) has reserved accommodation at Hyatt Regency Incheon, the conference venue, at extremely preferential rates, as well as lower-budget accommodation at the Best Western Premier Incheon Airport Hotel and Hotel Zeumes nearby.

21. It is strongly recommended that participants place their hotel reservations through the Local Organizing Committee using the attached Hotel Reservation Form (see Appendix A) **before 15 October 2009**. We may honor reservations made past the above date, provided that there are rooms available; please note also that rates may differ for reservations placed after the deadline.

22. Where applicable, the Hotel Reservation Form should also be used to reserve accommodation for those attending the preceding Technical Conference (16-17 November 2009).

- **Hyatt Regency Incheon** (5-star) http://english.hyattregencyincheon.com/

  Located at a 500 meters distance from Incheon International Airport, Hyatt Regency Incheon is a 3-5 minute complimentary shuttle ride away from Incheon International Airport. The shuttle runs every 15 minutes.

  This hotel is the venue for CAS-XV, as well as the Technical Conference on “Environmental Prediction in the Next Decade”, to be held from 16 to17 November 2009.

Room rate per night including breakfast package (tax exemption for foreign nationals)

Standard single room	145,000 KRW
Standard double/twin room	165,000 KRW

Buffet luncheons at a very reasonable rate are expected to be made available by the hotel.

- **Best Western Premier Incheon Airport Hotel** (4-star) http://www.airporthotel.co.kr/en/

  The Best Western Premier Incheon Airport Hotel is located at a mere 700 meters distance (a 5-minute shuttle ride) from Incheon International Airport. The hotel offers complimentary shuttle service at 20 minute intervals between the hotel and the airport, and is 5 minutes (on foot) away from Hyatt Regency Incheon.

  Room rate per night including continental breakfast (tax exemption for foreign nationals)

Standard single room	120,000 KRW
Standard double/twin room	138,000 KRW

- **Hotel Zeumes** (3-star) http://www.hotelzeumes.co.kr/en/

  The hotel is located in a new town in the vicinity of Incheon International Airport, approximately 11 km away. Complimentary pick-up services are available around the clock for the 8 minute ride between the airport and the hotel. Shuttle bus services will also be provided free of charge for participants from/to the conference venue at designated times in the morning and evening.

  Room rate per night including continental breakfast (tax exemption for foreign nationals)

Standard single room	100,000 KRW
Standard double/twin room	110,000 KRW

Local climate

23. Climate data for the period of the session in Incheon and Seoul are listed below:

	INCHEON	SEOUL
Mean temperature:	5.6°C	5.2°C
Mean maximum temperature:	9.7°C	9.6°C
Mean minimum temperature:	2.0°C	1.3°C
Mean precipitation:	15 mm	17 mm
Mean humidity:	65 %	65 %

Internet Facilities

24. Wireless internet connection will be available in the main conference room, as well as an internet booth with wired Ethernet. Internet connectivity will also be available at all three hotels.

Information and Contact Details of Local Organizer

25. For further local information, please contact the Local Organizing Committee using the information below:

Local Organizing Committee for WMO CAS-XV
Attn.: Dr. Jae-Cheol Nam or Mr. Se-Won Kim
International Cooperation Division
Korea Meteorological Administration
45 Gisangcheong-gil, Dongjak-gu
156-720 Seoul
Republic of Korea

Tel.: +82-2-836-2385
Fax: +82-2-836-2386
E-mail: jcnam@kma.go.kr, ksw@kma.go.kr, or juebo@kma.go.kr

Appendices: 2

Hotel Reservation Form

WMO CAS-XV
(Incheon, Republic of Korea, 18-25 November 2009)

and/or

Technical Conference
(Incheon, Republic of Korea, 16-17 November 2009)

Please complete and return this form, along with your payment, to:

Local Organizing Committee
Korea Meteorological Administration
45 Gisancheong-gil • Dongjak-gu • Seoul 156-720 • Republic of Korea
Tel.: +82 2 836 2385 • Fax: +82 2 836 2386 • E-mail: pb_int@kma.go.kr

Section 1: Identification: Delegate

Title (Dr/Prof/Mr/Ms/Mrs/Miss/Other): **Name & Surname:**

Representing Country/Organization:

Position:

Postal address:

Postcode: **Country:**

Phone (Work): (   ) **Phone (Home):(   )**

Fax: **Mobile:**

E-mail:

Section 2: Conference Attendance

Please indicate which conference you will be attending:

- ❑ Technical Conference 16-17 November 2009
- ❑ WMO CAS-XV 18-25 November 2009

Section 3: Accommodation

Please reserve the following accommodation for me: (Price includes breakfast)

Hotel choice (Please check box)		Rate per room per night		Room type (Please circle)	Check-in date	Check-out date
		Single	Double/Twin			
Hyatt Regency Incheon		KRW 145,000	KRW 165,000	Single/Double/Twin		
Best Western Premier Incheon Airport Hotel		KRW 120,000	KRW 138,000	Single/Double/Twin		
Hotel Zeumes		KRW 100,000	KRW 110,000	Single/Double/Twin		

Section 4: Dietary Requirements / Special Requests

Please indicate any specific dietary requirements or requests:

- ❑ Kosher (Beth Din)
- ❑ Halaal
- ❑ Vegetarian
- ❑ Hearing impaired
- ❑ Visually impaired
- ❑ Physical disability (Please specify)___________________________

Section 5: Credit Card information

Please fill in the requested information as guarantee for your hotel reservation:

Credit Card Details

Cardholder's name ____________________ ☐ Visa ☐ Mastercard ☐ Amex ☐ Diners

Card number: ☐☐☐☐-☐☐☐☐-☐☐☐☐-☐☐☐☐ Expiry date (mm/yy): /

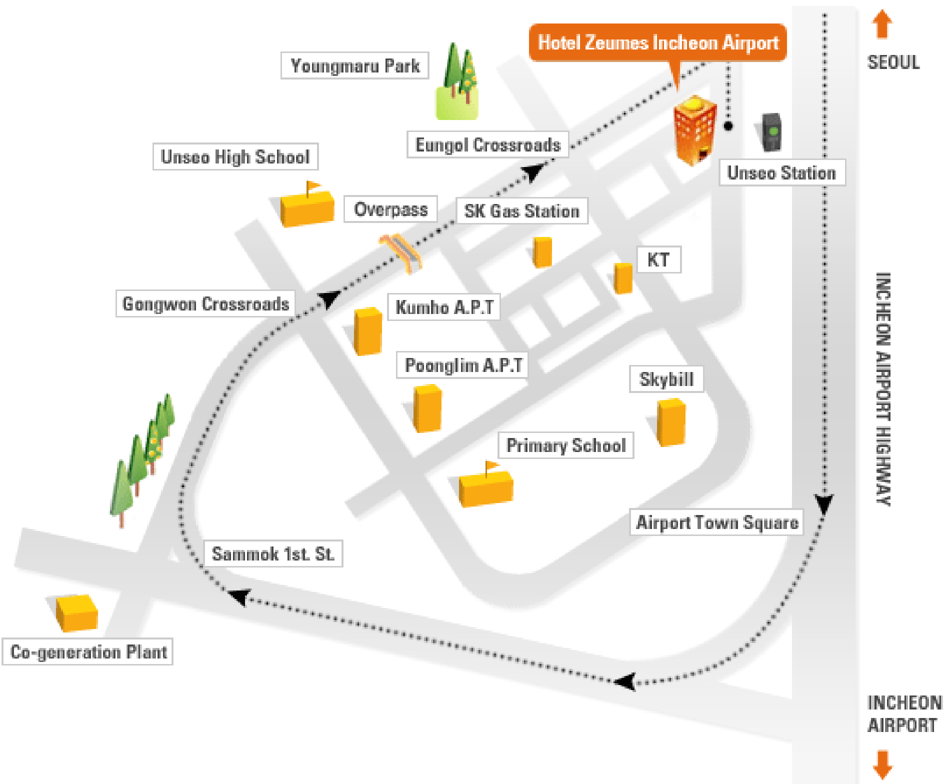
Signature ____________________________________

____

Location of Hotels

- "Hyatt Regency Incheon" and "Best Western Incheon Airport Hotel"

- "Hotel Zeumes Incheon Airport"



Bird's-eye view

A: Hotel Hyatt Regency Incheon
B: Best Western Premier Incheon Airport Hotel
C: Hotel Zeumes Incheon Airport

World Meteorological Organization

COMMISSION FOR ATMOSPHERIC SCIENCES

FIFTEENTH SESSION
Incheon, Republic of Korea
18 to 25 November 2009

CAS-XV/INF. 2.2, REV. 1

Date: 23.X.2009

Original language: English

TENTATIVE WORK PLAN

1. The tentative work plan, as given in the Appendix, has been prepared by the Secretariat in consultation with the president and vice-president of the Commission.

2. The work plan shows the meetings (General Plenary, Plenary A and Plenary B) and the agenda items proposed to be taken up each day, based on the assumption that the Commission decides that the technical work of the session be carried out in Plenary, as suggested in the explanatory memorandum relating to the provisional agenda (CAS-XV/Doc. 2.2, REV.1).

3. The Coordination Committee, which the Commission may wish to set up in accordance with General Regulation 28, would have the task of reviewing the work plan as the session proceeds with its work.

Appendix: 1

TENTATIVE WORK PLAN FOR THE FIFTEENTH SESSION OF CAS
Incheon, Seoul, Republic of Korea, 18-25 November 2009

	Wednesday		Thursday		Friday		Saturday		Sunday		Monday		Tuesday		Wednesday	
	18 Nov		19 Nov		20 Nov		21 Nov		22 Nov		23 Nov		24 Nov		25 Nov	
	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm	am	pm
GENERAL PLENARY	*** 1 2 11	4			7		10	8	NO SESSION	NO SESSION	8	9 8	9	WP PK	WP	PK 12 13
PLENARY A	3	3				5.3					WP		WP	WP	WP	
PLENARY B			5.1	5.2			6				6		WP	WP	WP	

Explanatory notes:
Figures indicate the document numbers or agenda items
WP: Consideration of working papers
PK: Consideration by General Plenary of "PINK" reports

Working hours:

*** 18 Nov (Wed) Registration	08:00-10:00	
Session starts	10:00-13:00	15:00-18:00
19-23 & 25 November	09:00-12:00	14:00-17:00
24 November	08:00-11:00	13:00-16:00

For ease of reference, the main items of the provisional agenda are the following:

1. OPENING OF THE SESSION
2. ORGANIZATION OF THE SESSION
3. PROGRESS AND FUTURE DIRECTION OF THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME
4. DECISIONS OF CONGRESS AND THE EXECUTIVE COUNCIL OF RELEVANCE TO THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME (AREP)
5. RECOMMENDATIONS ON AREP ACTIVITIES
6. RECOMMENDATIONS ON COLLABORATIVE RESEARCH AND ACTIVITIES AT THE RESEARCH-OPERATIONS INTERFACE
7. RECOMMENDATIONS ON COLLABORATIVE ACTIVITIES AT THE WEATHER-CLIMATE INTERFACE
8. FUTURE PROGRAMME OF WORK OF THE COMMISSION
9. WMO LONG-TERM PLANNING RELEVANT TO THE COMMISSON
10. ELECTION OF OFFICERS
11. THE COMMISSION AND GENDER
12. DATE AND PLACE OF THE SIXTEENTH SESSION
13. CLOSURE OF THE SESSION

World Meteorological Organization	**CAS-XV/INF. 2.1**
COMMISSION FOR ATMOSPHERIC SCIENCES	Date: 2.IX.2009
FIFTEENTH SESSION Incheon, Republic of Korea 18 to 25 November 2009	Original language: English

PROVISIONAL LIST OF DOCUMENTS

Item No.	Title	Documents
1	OPENING OF THE SESSION	
2	ORGANIZATION OF THE SESSION	
2.1	Consideration of the report on credentials	
2.2	Adoption of the agenda	2.2, REV. 1
2.3	Establishment of committees	
2.4	Organizational questions	
	Material arrangements for the session	INF. 1
	Provisional List of Documents	INF. 2.1
	Tentative Work Plan	INF. 2.2
3	PROGRESS AND FUTURE DIRECTION OF THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME	3
3.1	Report by the president of the Commission	INF. 3.1
3.2	Report by the Chair of OPAG-EPAC	INF. 3.2
3.3	Report by the Chair of OPAG-WWRP	INF. 3.3
3.4	Report by the Chair of the ICSC THORPEX	INF. 3.4
4.	DECISIONS OF CONGRESS AND THE EXECUTIVE COUNCIL OF RELEVANCE TO THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME (AREP)	4; INF. 4
5.	RECOMMENDATIONS ON AREP ACTIVITIES	
5.1	WWRP Activities	5.1; INF. 5.1
5.2	WWRP-THORPEX Activities	5.2; INF 5.2
5.3	EPAC/GAW Activities	5.3; INF 5.3
6	RECOMMENDATIONS ON COLLABORATIVE RESEARCH AND ACTIVITIES AT THE RESEARCH-OPERATIONS INTERFACE	6; INF 6
7	RECOMMENDATIONS ON COLLABORATIVE ACTIVITIES AT THE WEATHER - CLIMATE INTERFACE	7; INF 7
8	FUTURE PROGRAMME OF WORK OF THE COMMISSION	8; INF 8
9	WMO LONG-TERM PLANNING RELEVANT TO THE COMMISSON	9; INF 9
10	ELECTION OF OFFICERS	10
11	DATE AND PLACE OF THE SIXTEENTH SESSION	
12	CLOSURE OF THE SESSION	

World Meteorological Organization **CAS-XV/INF. 3**

COMMISSION FOR ATMOSPHERIC SCIENCES

FIFTEENTH SESSION
Incheon, Republic of Korea
18 to 25 November 2009

Submitted by:	Secretary-General
Date:	5.XI.2009
Original language:	English
Agenda item:	3

PROGRESS AND FUTURE DIRECTION OF ATMOSPHERIC RESEARCH AND ENVIRONMENT ACTIVITIES

SUMMARY

Reference: CAS-XV/Doc. 3

CONTENT OF DOCUMENT:

Appendix:

- Report on accomplishments and high level vision of future research related to weather, climate, water and the environment

REFERENCES:

1. *Abridged Final Reports with Resolutions of the Fifty-seventh* (WMO-No. 988) *and Sixtieth* (WMO-No. 1032) *Sessions of the WMO Executive Council*
2. *Abridged Final Report with Resolutions of the Fourteenth Session of the Commission for Atmospheric Sciences* (WMO-No. 1002)
3. *WMO Global Atmosphere Watch (GAW) Strategic Plan 2008-2015, and GAW Report No. 172* (WMO/TD-No. 1384) (see http://www.wmo.int/gaw)
4. *Strategic Plan for the Implementation of WMO's World Weather Research Programme (WWRP): 2009-2017* (WMO/TD-No. 1505) (see http://www.wmo.int/wwrp)
5. WMO/IUGG book on "Aerosol Pollution Impact on Precipitation: A Scientific Review" published by Springer Science, 2009 (386pp, ISBN: 978-1-4020-8689-2)
6. ESA (ESA SP-1282) - GAW No. 159 (WMO/TD-No. 1235)

REPORT ON ACCOMPLISHMENTS AND HIGH LEVEL VISION OF FUTURE RESEARCH RELATED TO WEATHER, CLIMATE, WATER AND THE ENVIRONMENT

1. Report of the president of CAS

In January 2006, a few weeks before CAS-XIV, the president submitted a vision document to CAS Members on what would be his three focal areas in the event that he would be elected as president of CAS at the Cape Town February 2006 meeting. They were related to weather research, atmospheric chemistry research and a unified approach to weather climate and earth system prediction. What follows is a highlight of activities and results that illustrate his belief that this vision, and more, was achieved in the last four years through the collective action of the CAS Management Group, the OPAGs, numerous experts from the Members of WMO and the WMO Secretariat.

1.1 Weather Research

1.1.1 In 2006, the first focal area was to rebuild the World Weather Research Programme (WWRP), and put it on a track that in future would transform it into a strong, internationally recognized scientific programme. It had to ensure its relevance, through productive technology transfer activities in support of NMHS's operations and services and through increased use of research (RDP's) and forecast demonstration projects (FDP's). CAS has made substantial progress with the completion of the first Strategic Plan of implementation of WWRP (WMO/TD-No. 1505) renewal of the Chair and membership of the JSC-WWRP, the restructuring of WWRP working groups, and a number of important FDP's, RDP's and cross-cutting activities between CAS programmes and between Commissions, which will be reported on later. However, WWRP is not there yet. CAS still has to refine the JSC-WWRP membership, streamline WWRP activities, and re-examine how WWRP interacts with the THORPEX programme.

1.1.2 In 2006, the president had indicated that the new WWRP should slowly expand the scope of its scientific activities to migrate from delivering strictly weather-only products to delivering to NMHSs and Members a broader spectrum of environmental prediction products. In doing so, it would have to establish a dialogue between the traditional meteorological community and end users of their research or products, and include a strong socio-economic research component. Again, the president believes CAS has made significant progress in that direction through a number of research initiatives and collaborations, such as the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS; agenda item 6.3), the Mesoscale Alpine D-Phase programme (agenda item 5.1.2) and others reported on at CAS-XV. However, the president is still not satisfied by CAS progress in the area of Societal and Economic Research and Applications (SERA; agenda item 5.1.4) linked with the FDP's and RDP's. The recent decision to co-sponsor this initiative with the Integrated Research on Disaster Risk (IRDR) programme of ICSU is promising.

1.1.3 The president also had noted the transition from the purely deterministic forecasts to ensemble or probabilistic forecasts, and that the WWRP THORPEX-TIGGE project would remain a top priority of CAS in CAS-XV as evidence of this success abounds (agenda items 5.2 and 7.2)

1.1.4 Finally, the president had indicated the necessity to increase collaborations between the WWRP, THORPEX and the World Climate Research Programme (WCRP), the slowly evolving trend towards Earth system simulation models, and the ensuing need to expand collaboration outside of the usual realm of WMO Members, particularly with other international institutions more closely linked with the academic scientific community, all of this for the ultimate benefit of the WMO Members. Again, CAS can report that it has made good progress in this direction. Indeed at CAS-XV there is a session (agenda item 7) devoted to this issue. Progress has been made in YOTC, seasonal prediction and verification research. CAS has also approached the International Council of Science (ICSU) on a number of issues, and will hold further discussions on possible cosponsorships, made even more relevant in the recent context of its initiative to develop a 10 year vision on Earth system modelling research which will involve many other institutions, including WMO. The complexity of the science issues one needs to tackle in order to make progress in climate and earth system modelling, and in some cases, weather modelling, necessitates these partnerships.

1.2 Atmospheric Chemistry Research

1.2.1 In 2006 the second focal area that was identified had to do with atmospheric chemistry research, in view of the fact that many NMHS's have operational air quality mandates, or contribute significant input to those institutions in their country which have this responsibility and that atmospheric chemistry plays a key role in issues such as climate change, human health and food production. The IGACO strategy (WMO/TD-No. 1235) was finalized at the time of CAS-XIV, and provided a scientifically sound way forward on many of the issues surrounding atmospheric chemistry issues. The president welcomed the significant steps taken by the JSC-EPAC and the WMO Secretariat through the WMO-GAW community in integrating IGACO concepts and recommendations into the third GAW Strategic Plan for 2008-2015 (WMO/TD-No. 1384). At the time, he considered the assessment of IGACO on the feasibility of real time atmospheric chemical data delivery as unduly pessimistic. Today, some global NWP centres routinely provide pre-operational atmospheric chemical constituents analyses using data assimilation of space-based remote sensing as well as whatever surface and air observations they can obtain in real time and soon some will be running real-time fully coupled chemical-weather prediction systems. More recently, as will be presented later in this meeting, it has become clear that chemistry impacts weather even on time scales as small as 1-2 days and that, at least in some part of the globe, to ignore these effects adds considerably to model uncertainty. Many of these effects are caused by aerosols, through their direct impact on radiation and the much more uncertain indirect effect on precipitation and cloud formation. The Commission activities have added to our understanding of this through the successful completion of the WMO/IUGG International Aerosol Precipitation Science Assessment that was called for by Cg-XIV, approved by Cg-XV and published as a peer reviewed book in 2009 (Aerosol Pollution Impact on Precipitation: A Scientific Review). Another aspect which has become much clearer recently is the high rate of morbidity that can be related to fine particulate matter (diameter less than 2.5 microns). One estimate puts it as high as 2 million persons per year, which is an order of magnitude more important than that resulting from all meteorological extreme events added together in the year 2008 for example. Air pollution is a (slow) killer directly influenced by meteorology; yet, it does not appear in the list of WMO or NMHS's prioritized lists of high impact events. The Commission has begun to reflect on this and come up with suggestions on how we may evolve to better involve Members in this problem.

1.2.2 Another emerging aspect which CAS-XV will discuss is the need for accurate observational based carbon tracking systems using data assimilation and inversion modelling, for treaty evaluating the success of carbon mitigation plans to be discussed in Copenhagen in December 2009.

1.2.3 Finally, as is the case for the WWRP and THORPEX, there are increasing potential linkages between the WCRP and the GAW that could and will be explored, given the increasing importance of correctly simulating atmospheric chemistry and its interactions with the physical atmosphere and the underlying surface, be it solid Earth or the oceans.

1.3 Unified Approach to Weather Climate and Earth System Prediction

1.3.1 The third focal area was to develop a unified approach to weather, climate and Earth system prediction for the 21st century, and explore with the WCRP and other programmes the possibility of leveraging serious international funding. The president made this a personal priority and devoted much of his time to it. It is fair to say that the Commission and its partners in this venture were actually quite successful. After two years of long hard work, going to a series of EC WG meetings, and two Executive Councils, an Executive Council Expert Task Team was asked to produced a report which was tabled and formally endorsed by WMO (agenda item 8.1). It formally encouraged its Members to adopt a unified or seamless approach to weather, climate, water and environmental modelling, and eventually couple the core unified systems with a set of sub-models that would meet an expanding set of environmental forecast products (ice, health, water, energy, health to name a few) from very short to seasonal, multi-seasonal and perhaps in a few years decadal time scales. In terms of using these kinds of arguments to stimulate big investments in support of prediction research, the Commission participated and supported most of the World Climate Modelling Summit Recommendations on observational networks, supercomputing and science capacity; the same ideas were expressed at GEO summits, and at the recent WCC-3 meeting. Very recently, ICSU has started a visioning exercise on Earth system modelling that will at some point involve WMO, and through our eventual involvement in committees such as IGFA (International Group of Funding Agencies for global change research), we may perhaps be able to stimulate significant financial support for this kind of research and development

1.4 Other issues

1.4.1 Since CAS-XIV, there have been a number of decisions by both Fifteenth Congress and EC's (LVIII to LXI), as well as events that will have an impact on either the Commission itself, or CAS programmes. One of these has been the reorganization of the management structure of WMO Secretariat into a number of Departments more clearly aligned with the results-based management system that WMO now uses. Thus a Research Department was created, which brought together the three CAS programmes GAW, WWRP and THORPEX with the co-sponsored WCRP programme, under the leadership of two co-directors. One of the intended outcomes of this reorganization is to facilitate interactions between the four programmes, and we will hear more about this later.

1.4.2 At the same time that this change took place, a decision was made by EC to also re-examine the number and TOR's of the WMO Commissions. One of the goals is to see if savings in the operating costs of Commissions cannot be achieved, particularly by looking at options to replace the traditional quadriennial meetings, one Commission at a time. A proposal is to be brought forward for discussion at the next EC in June 2010. I would suggest that CAS-XV participants might wish to express their views on this particular issue.

1.4.3 The decision by WMO Members and the Secretary-General to see their Organization occupy a stronger and more visible presence on climate change science and services, through discussions within the UN with sister organizations such as UNESCO and UNEP, and more recently by organizing the WCC-3, which by a unanimous declaration asked WMO to lead the development and creation of a Global Framework for Climate Services (GFCS) will also definitely have an impact on CAS and its programmes. It is too soon to speculate on the precise aspects, but we already know that this framework will involve observations, science and prediction from seasonal to decadal time scales, as well as closer linkages with users or stakeholders, partly but not exclusively through traditional NMHSs and their national partners. CAS has been, and will be, active in all those aspects.

1.4.4 Recently, EC-LX set up an expert panel on Polar Observations, Research and Services (EC PORS). This Panel met in October 2009 in Ottawa, Canada, to start outlining a draft plan of WMO activities in polar regions, first as a potential legacy to IPY 2007-2009, but also in recognition that the polar areas are rapidly being affected by climate change, and WMO needs to reflect on how it will respond to this in the interest of its Members. Moreover it is well recognized that what happens in those areas has a global impact (one can think of accelerating glacier melt in Greenland and Antarctic, and the subsequent impacts on sea-level rise), and so this is actually of concern to all WMO Members. We will have the opportunity to discuss this further during this meeting.

1.4.5 Finally, I would like to mention the successful conclusion to the sometimes heated debates held at CAS-XIV on weather modification, and more specifically on the completion of an update to the WMO Statement and WMO Guidelines on Weather Modification (agenda item 5.1.5) by a CAS expert group. I would like to report that to my satisfaction the CAS Management Group, the WMO Secretariat and two panels of experts managed successfully an objective review and update of the “WMO Statement on Weather Modification (including an Executive Summary)” and the “WMO Guidelines for the Planning of Weather Modification Activities” thus fulfilling the request of CAS-XIV (paragraph 8.1.2). An objective peer review process was put in place that revisited the drafts submitted to CAS-XIV and made formal and final recommendations to the CAS management group. These recommendations were than endorsed by EC-LX (paragraph 4.2.51, Annex 4), and are available on the WMO Website (http://www.wmo.int/wxmod). I believe that finally the CAS Management Group had managed successfully this objective review and update of the “WMO Statement on Weather Modification (including an Executive Summary)” and the “WMO Guidelines for the Planning of Weather Modification Activities” thus fulfilling the request of CAS-XIV. We further agreed that a periodic rolling review of these documents by the Expert Team on Weather Modification Research as stated in the Strategic Plan of WWRP is desirable, with the request that Members engaged in operational weather modification activities fund this through contributions to the WMO Trust Fund established at the request of Cg-XV.

2. Report of the Chair of OPAG on Environmental Pollution and Atmospheric Chemistry (EPAC)

Overview of GAW

2.1 The **rationale** for the Global Atmosphere Watch (GAW) (http://www.wmo.int/pages/prog/arep/index_en.html) is the need to understand and assist in decreasing the influence of human activity on the global atmosphere. Among the challenges are:

- Stratospheric ozone depletion and the increase of ultraviolet (UV) radiation;
- Changes in weather and climate related to human influence on atmospheric composition, particularly, greenhouse gases, ozone and aerosols;
- Risk reduction of air pollution on human health and issues involving long-range transport and deposition of air pollution.

2.2 Many of these have socio-economic consequences affecting weather, climate, human and ecosystem health, water supply and quality, and agricultural production.

2.3 The **mission** of GAW, taking into account the Integrated Global Atmospheric Chemistry Observations (IGACO) strategy, is to:

- Reduce environmental risks to society and meet the requirements of environmental conventions;
- Strengthen capabilities to predict climate, weather and air quality;
- Contribute to scientific assessments in support of environmental policy.

through

- Maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere;
- Emphasizing quality assurance and quality control;
- Delivering integrated products and services of relevance to users.

2.4 GAW also fulfils a **mandate from WMO Members** by responding to the needs and clearly linking to the plans of national, regional, and international observing projects, programmes, systems and strategies, e.g.

- As a component of the WMO integrated global observing system, contributing to Global Monitoring for Environment and Security (GMES) in support of Global Earth Observation System of Systems (GEOSS);
- In supporting the United Nations Framework Convention on Climate Change (UNFCCC), especially by contributing to the implementation plan for the Global Climate Observing System (GCOS);
- In observing the Vienna Convention on the Protection of the Stratospheric Ozone Layer and follow-up protocols;
- In supporting the Convention on Long-Range Transboundary Air Pollution (CLRTAP);
- In providing a comprehensive set of observations of atmospheric composition in support of the Intergovernmental Panel on Climate Change (IPCC) process.

2.5 A global network is necessary to deal with the transport of atmospheric pollutants, both on regional and global scales. These pollutants are important for air quality questions, health implications, deposition and impact on ecosystems, climate and stratospheric change. Fundamentally, emission controls must be addressed on hemispheric or global levels. GAW provides a framework that can support policy decisions addressing these issues on these scales. GAW activities follow the GAW Strategic Plans, the current activities of the third one, the WMO GAW Strategic Plan: 2008-2015 (GAW Rep 172, http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html), which was published as a joint effort of the GAW community. The report includes the guiding principles for the programme, goals and objectives and the implementation plan for each component of the programme. A system is developed to track the status of the work on the tasks identified in the plan.

GAW Activities

2.6 GAW relies heavily on the support of WMO Members for continuous current and future support of its activities. Table 1 shows the current status of GAW central facilities. On the whole the situation is good but as can be seen, some additional facilities are required. The vital support of the Members is gratefully acknowledged.

Expansion to remote sensing

2.7 GAW is enhancing its connection with satellite and aircraft measurements through implementing the IGACO strategy.

2.8 A new WDC has been established in GAW, the WMO World Data Centre for Remote Sensing of the Atmosphere (WDC-RSAT). The primary principles are to provide free and open access to data and long-term preservation of data and the mission to provide a portal for all satellite data. The data serve a variety of communities, including those interested in the Montreal Protocol, Kyoto Protocol, air quality and the renewable energy communities, and thus RSAT is developing the user interface of the future with the understanding that there are many different users of data with a variety of different requirements. RSAT supports the GAW programme by merging and providing key measurements, particularly ozone and air quality measurements. Through collaborating in MOZAIC and IAGOS-ERI projects, GAW is extending its measurements to those made with aircraft.

2.9 Ground-based remote sensing observations are also expanding (e.g. lidar, sonde and aerosol optical depth measurements) allowing for improved accuracy. Satellite and ground-based monitoring have their individual benefits and limitations and both are needed.

Greenhouse gases (GHG)

2.10 Greenhouse gas measurements are one of the best established parts of the GAW programme. Reliable long-term estimates of sources and sinks appropriate to particular emission management scenarios require very high accuracy and precision observations that are made in

GAW. Scientific activities are aided by the WMO SAG for GHGs and the results are presented in WMO publications. The 5th annual GHG Bulletin will be issued in time for the COP meeting in Copenhagen. The issuance of these bulletins is a service to professionals and public alike, they are well received as is shown by the number of hits on the WMO Website.

2.11 Regarding GHG data, the WDCGG contains data both for greenhouse and reactive gases. The primary role for the WDCGG is interaction with contributors, data quality and analysis, and services to the users. Data are reported from nearly 200 locations, mobile platforms and aircraft worldwide. Data from fixed stations have increased in terms of both data coverage and data volume. For mobile platforms (both ships and aircraft), the data volume have increased significantly year after year, particularly over the last ten years.

Table 1: Overview of the GAW World Central Facilities (as of October 2009). The World Central Facilities have assumed global responsibilities, unless indicated (Am: Americas; E/A: Europe and Africa; A/O: Asia and the South-West Pacific).

Variable	QA/SAC	Central Calibration Laboratory (CCL) Host of Primary Standard	World Calibration Centre (WCC)	Regional Calibration Centre (RCC)	World Data Centre (WDC)
CO_2	JMA (A/O)	ESRL	ESRL Empa (audits)		JMA
CH_4	Empa (Am, E/A) JMA (A/O)	ESRL	Empa (Am, E/A) JMA (A/O)		JMA
N_2O	UBA	ESRL	IMK-IFU		JMA
CFCs, HCFCs, HFCs					JMA
Total Ozone	JMA (A/O)	ESRL[1], Environment Canada[2]	ESRL[1], Environment Canada[2]	BoM[1], ESRL[1], IZO[2] JMA[1], MOHp[1], MGO[3], OCBA[1], SAWS[1], SOO-HK[1]	Environment Canada[5], DLR[6]
Ozone Sondes	FZ-Jülich	FZ-Jülich	FZ-Jülich		Environment Canada
Surface Ozone	Empa	NIST	Empa	OCBA, SOO-HK	JMA
Precipitation Chemistry	ASRC-SUNY	ISWS	ISWS		ISWS
CO	Empa	ESRL	Empa		JMA
VOC	UBA		IMK-IFU		JMA
SO_2					JMA
NO_x					JMA
Aerosol			IfT (Physical Properties)		NILU[5], DLR[6]
Optical Depth		PMOD/WRC[4]	PMOD/WRC		NILU
UV Radiation				ESRL (Am) **PMOD/WRC (Europe)**	Environment Canada
Solar Radiation		PMOD/WRC	PMOD/WRC		MGO

ASRC-SUNY Atmospheric Sciences Research Centre, State University of New York (SUNY), Albany NY, USA (World Data Centre for Precipitation Chemistry, WDCPC)

BoM Bureau of Meteorology, Melbourne, Australia (Regional Dobson Calibration Centre, RDCC for Australia)

BSRN Baseline Surface Radiation Network, Federal Institute of Technology (ETH), Zürich, Switzerland

DLR German Aerospace Centre, Oberpfaffenhofen, Wessling, Germany (Word Data Centre for Remote Sensing of the Atmosphere, WDC-RSAT)

ESRL Global Monitoring Division, Earth System Research Laboratory (ESRL), National Oceanic and

JRC Institute for Environment and Sustainability, Joint Research Centre, Ispra, Italy, (World Data Centre for Aerosols, WDCA)

MGO A.I. Voeikov Main Geophysical Observatory, Russian Federal Service for Hydrometeorology and Environmental, St. Petersburg, Russia (World Radiation Data Centre, WRDC; RCC for Filter Instruments)

MOHp Meteorologisches Observatorium Hohenpeissenberg (Regional Dobson Calibration Centre, RDCC for Europe)

Environment Canada Environment Canada, Toronto, Canada (World Ozone and UV Data Centre, WOUDC)

	Atmospheric Administration (NOAA), Boulder CO, USA
EML	Environmental Measurements Laboratory, Department of Energy (DoE), New York City NY, USA
Empa	Swiss Federal Laboratories for Materials Testing and Research, Dübendorf, Switzerland (QA/SAC Switzerland and WCC-Empa)
FZ-Jülich	Forschungszentrum Jülich, Jülich, Germany
IfT	Institute for Tropospheric Research, Leipzig, Germany
IMK-IFU	Institut für Meteorologie und Klimatologie Atmosphärische Umweltforschung, Forschungszentrum Karlsruhe, Garmisch-Partenkirchen, Germany
ISWS	Illinois State Water Survey, Champaign IL, USA
IZO	Izaña Observatory, Tenerife, Spain (Regional Brewer Calibration Centre, RBCC)
JMA	Japan Meteorological Agency, Tokyo, Japan (World Data Centre for Greenhouse Gases, WDCGG; QA/SAC Japan, Regional Dobson Calibration Centre, RDCC for Asia)
NIST	National Institute for Standards and Technology, Gaithersburg MD, USA
NILU	Norwegian Institute for Air Research
OCBA	Observatorio Central Buenos Aires, Argentina (Regional Dobson Calibration Centre, RDCC for South America)
PMOD/WRC	Physikalisch-Meteorologisches Observatorium Davos/World Radiation Centre, Davos, Switzerland
SAWS	South African Weather Service, Pretoria, South Africa (Regional Dobson Calibration Centre, RDCC for Africa)
SOO-HK	Solar and Ozone Observatory, Hradec Kralove, Czech Republic (RCC)
UBA	German Environmental Protection Agency, Berlin, Germany

[1] Dobson , [2] Brewer , [3] Filter instruments
[4] Precision Filter Radiometers (PFR)
[5] ground-based, [6] satellite-based

Reactive gases

2.12 Reactive gases have been one of the active foci of GAW in the last years. This group is very diverse and includes surface ozone, carbon monoxide (CO) and volative organic compounds (VOCs), NO_x, and NO_y. Data is collected into the WDC GG. The VOC global network is developing strongly as per the recommendations in WMO GAW Report 171. Existing technology allows for measurements of roughly fifteen VOCs with a number of them identified as high priority. The organized audits and regular round robin comparisons are very useful for quality assurance for the community.

2.13 Nitrogen oxide measurements are important for both scientific and policy reasons. Nitrogen oxides can catalyze the production of tropospheric ozone, acid rain and results in acidification that can affect human health. NO_x has a direct influence on the oxidation of the atmosphere, and therefore the self-cleaning behavior of the atmosphere. Data are being provided by 45 sites, with most of them from Europe. There is a need for coordination of nitrogen compound measurements along with quality assurance activities. These were addressed through a specific NO_{xy} workshop arranged in October 2009.

Aerosols

2.14 The goal of the GAW aerosol programme is to improve assessments and predictions through measurements and models. The challenge is to pull together disparate existing networks into one working set of measurements for global assessment and analysis. Multiple parameters are needed, with additional recommended measurements (e.g. chemical properties and vertical distributions) that are helpful. Experience is leading to a better understanding of the different types of measurements, which can guide better recommendations for future measurements. Even though the number of stations taking measurements is increasing, there are many under-sampled regions and many existing networks that have not been entrained into the GAW Global Aerosol Networks.

Stratospheric and column ozone, UV and solar radiation

2.15 The IGACO strategy is being implemented especially well in GAW through ozone and UV activities following the IGACO ozone UV Implementation Plan (GAW Rep 182) and with the assistance of the IGACO office at FMI.

2.16 In 2007 the Dobson, Brewer and ozonesonde networks were acknowledged as baseline networks of the Global Climate Observing System (GCOS).

2.17 The Ozone SAG offers advice and coordinates measurements of stratospheric and column ozone. Roughly 100 Dobson instruments around the world as well as Brewer spectrophotometers provide ozone profile measurements. These have been compared with balloon sondes which show improvement in agreement over time. The World Ozone and UV Data Center (WOUDC) collects and disseminates data as well as promotes validation of satellites and models.

2.18 An important ozone product is the WMO GAW Antarctic Ozone Bulletin that is published each August-November. Effective stratospheric chlorine peaked shortly before 2000. The size of the ozone hole depends primarily on meteorology. The year 2006 had the lowest measured total column ozone value of 114 Dobson Units and 2008 had the longest lasting ozone hole indicating a stable vortex. Results indicate no signs of ozone recovery in Antarctica.

2.19 The goals for the UV programme are to enhance the global coverage of solar UV measurements, increase availability and accessibility of UV data and improve QA/QC of UV data. UV radiation is measured with spectral, broadband and multifilter instruments covering a variety of wavebands and wavelength ranges. The measurements sites are irregularly distributed with the greatest concentration of sites in North America and Western Europe, with very sparse data collection in some other regions, e.g., the Tropics and the Southern Hemisphere. The UV Index is taken as the single common factor that should be obtained from the data at every site. However, time and wavelength resolved data from a site is of much greater value for most applications and should be submitted to the data centre.

2.20 The solar radiation component of GAW has concentrated its efforts on UV radiation. In addition, the GAW programme under CAS has traditionally supported the World Radiation Data Centre (WRDC) in St. Petersburg while other functions of the global radiation network are supported by CIMO and CBS. In response to a request by the WMO EC-LVII (paragraph 3.3.2.6), AREP, acting on behalf of CAS, CBS and CIMO, has addressed the issue of the WRDC at a meeting in June 2006 in St. Petersburg Russia; there has been no significant change in the situation.

Precipitation Chemistry

2.21 The Precipitation SAG is currently in the process of writing the Second Global Atmospheric Deposition Assessment including both measurements and models. Geographic gaps in measurements exist, particularly in southern hemispheric data. Linkages with other programmes include INI (International Nitrogen Initiative), GESAMP, EMEP, HTAP and US-Canada Air Quality Agreement. Current support is insufficient to implement all changes needed for improved measurements, or to establish sites in data sparse regions. Laboratory intercomparisons include twice annual tests; the 39th comparison has just been completed. Data are generally available via the web with data from all six GAW regions, with the bulk of the participating laboratories from Europe, eastern Asia, and North America. Multi-dimensional analyses are used to identify potential problems.

2.22 WMO/GAW collaborates with the Joint Group of Experts on the Scientific Aspects of Marine Environment Pollution (GESAMP) in assessing the atmospheric input of chemicals to the ocean and corresponding impacts on ocean biochemistry and climate through the WMO led GESAMP Working Group on the Atmospheric Input of Chemicals to the Ocean (WG38). The collaboration is in conformity with the agreed WMO EC policy on continuing support of GESAMP to address topics relevant for WMO, such as atmospheric-ocean interactions, including exchange of pollutants, effects on global change and other atmospheric-related processes on the marine environment.

GURME

2.23 GURME assists NMHSs to handle meteorological and related aspects of urban pollution and provides an international platform for cross-cutting air pollution activities with other WMO Programmes, international organizations, environmental agencies and academia. GURME addresses end-to-end aspects of air quality that link observational issues, data assimilation techniques, numerical models, dissemination methods, and capacity building. As interfaces between local and regional and global scales are becoming increasingly important for regional and climate models and forecasting capabilities, and as it is recognized that air quality influences weather, GURME collaboration is expanding beyond the urban scale.

2.24 During this intersessional period activities have focused on pilot projects and air quality modeling and forecasting. The Shanghai GURME project will help address air pollution issues in this megacity and the project results will be implemented in the World EXPO 2010 and beyond. The GURME Training Team developed a basic air quality forecasting (AQF) course with all the materials available on the web. Several AQF courses have been held for Latin America and South Asia. GURME has established strong links to European COST actions, the Task Force on Hemispheric Transport Atmospheric Pollution (TF HTAP) of CLRTAP and is a partner in the European Commission project MEGAPOLI. Other links include regional modelling exercises.

Support to Conventions and international projects

2.25 An important part of GAW is the support to international conventions. The Vienna Convention is supported by the work in ozone. There is a strong collaboration between WMO and the CLRTAP.

2.26 WMO/GAW continues to co-chair the Task Force on Measurements and Modelling (TFMM) and participates in the work of the Task Force on Hemispheric Transport of Air Pollution (TF HTAP) of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) of CLRTAP. The support to the UNFCCC is important through the work in greenhouse gases.

2.27 GAW participates and collaborates in many European Commission projects and in COST actions. These are a very good way to build communities, achieve set goals, promote the work in GAW, bring a global dimension to regional projects and to have GAW participate in the forefront of research activities. Such projects include GEOmon, a project contributing to GEOSS that is integrating a pan-European atmospheric observing system, IAGOS-ERI looking at observations of atmospheric composition, aerosol and cloud particles from a fleet of long-range in-service airline aircrafts, MEGAPOLI on megacities effects on air pollution and climate, and MACC that is building global operational medium range forecast/assimilation capability for atmospheric dynamics and composition. COST Actions of special relevance have been the ones dealing with UV radiation and air quality and urban and mesoscale modelling.

Conclusion

2.28 Air pollutants affect heavily our ecosystems, climate and well being. About 2.3 million people are estimated by WHO to die each year due to the effects of air pollution. Of these, 800,000 are dying as a result of pollutants emitted by energy production, transport and industry. In addition, many more suffer from the health consequences of atmospheric pollutants to their well-being, both in developed and developing countries, especially those related to the respiratory and cardiovascular systems. On the other hand both long-lived greenhouse gases and atmospheric components such as black carbon, tropospheric ozone and sulphate aerosols are coupled to climate change. Addressing either the issue of climate change or air pollution will bring results in both areas. Heat waves cause excess deaths, a large portion of these being due to air pollution. It is estimated that during the heat wave in Europe in the summer of 2003, as much as one third of extra deaths were due to air pollution. In order to be able to deal with these threats to public health, globally coordinated atmospheric chemistry and related physical parameter observations are needed in the long-term to provide accurate information and products to decision makers. WMO has taken the leadership in these actions through GAW. GAW needs the support of Member countries to successfully continue these activities. It is relevant for GAW to retain its nature as a research related programme for the good continuation of the programme.

2.29 Specific details will be discussed under agenda items 5.3 and 6 and a vision paper has been provided in 8.3.

3. Report of the Chair of OPAG for the World Weather Research Programme (WWRP)

3.1 The World Weather Research Programme is an Open Programme Area Group (OPAG) of the CAS. WWRP (http://www.wmo.int/wwrp) is a comprehensive programme dedicated to improving public safety, the quality of life, economic prosperity and environmental quality by serving as an international focal point for:

- Advancing the science of weather-related research with a particular focus on advancing our knowledge of high impact weather, improving the prediction of these events and measuring the prediction improvements;
- Advancing our understanding of how society is impacted by and reacts to high impact weather and forecasts of these events in order to improve the utilization of and response to weather information;
- Contributing to the advancement of the science of broader environmental prediction through partnerships and collaborative multidisciplinary research;
- Promoting and facilitating the transfer of these research advances into the operational practice at NMHSs and among their end-users; and
- Serving as the weather research underpinning for WMO efforts related to weather prediction, user applications, disaster mitigation, and thereby contributing to relevant UN millennium goals.

3.2 The Joint Scientific Committee (JSC) of the WWRP meets annually to provide guidance on the direction of the programme. This report is from the Chair of the WWRP and focuses briefly on highlights since CAS-XIV. One highlight is the implementation of the vision of CAS for a broad programme that covers the critical range of topics, scales and phenomena associated with weather prediction research. The changes proposed by CAS include incorporating the activities of the Tropical Meteorological Research programme into the WWRP and the establishment of research components dealing with Societal and Economic Research and Applications (SERA) and a Mesoscale Weather Forecasting Research to complement efforts in Nowcasting Research and the joint activities with WGNE on Forecasting Verification Research. All these activities are governed by Working Groups whose general terms of reference are included in the Strategic Plan of WWRP. Another change from CAS was the incorporation of the THORPEX programme and its International Project Office into the WWRP and the placing of an Expert Team on Weather Modification within the WWRP. The activities of the new WWRP extend from prediction research on the scales of minutes to seasons for high impact weather events extending from the tropics to the poles as well as activities to understand and improve the interaction between prediction and society, the economy, and ecosystems.

3.3 A major management and scientific effort since the last CAS was the completion of a Strategic Plan for the Implementation of the WMO's World Weather Research Programme (WWRP):2009-2017 for this broad range of activities (a copy is available on the WWRP Website). In addition to a scientific vision and strategy and listing of specific proposed activities for the future, this Strategic Plan also includes descriptions of the past accomplishments of the programme to science, operational prediction and to society. These accomplishments include:

- Forecast demonstration of research techniques for predicting alpine flooding and for convection;
- Major international modeling and field campaigns on mesoscale ensemble prediction, tropical cyclones (genesis, structure and intensity) and convective precipitation in a region of complex terrain;
- The establishment of data archives, such as for monsoon research;
- Fostering long-term research efforts of the international community on topics where progress is required but particularly challenging;
- Through publications in the scientific and WMO TD series that outline progress in research, expert opinions on critical issues and on research to operational transition;
- Training and capacity building in the form of tutorials, workshops, and web-based tools, such as state-of-the-art verification techniques;
- Forming the initial steps on an international effort to advance knowledge and improve how societies utilize weather information particularly for natural disasters;
- Serving as the international community focal point for broad-based research into the atmospheric sciences through these research activities and sponsoring, supporting and arranging workshops, meetings and symposium related to weather research.

3.4 Such activities contributed to advancing the science of prediction, improving forecast systems and when introduced into the forecast environment have been shown to produce a lasting improvement to services.

4. Report of the Chair of International Core Steering Committee of THORPEX

4.1 The THORPEX programme - Scope and research priorities

THORPEX is an international research programme whose scope is global and which aims to accelerate improvements in the accuracy of 1-day to 2-week high-impact weather forecasts. These improvements will lead to substantial benefits for humanity, as we respond to the weather-related challenges of the 21st century. High-impact weather forecasts are defined by their effect on society, the economy and the environment. As such, THORPEX is an element of the WMO World Weather Research Programme and is a major contribution to the WMO Natural Disaster Reduction and Mitigation Programme.

THORPEX priorities are to address:

- Global-to-regional influences on the evolution and predictability of weather systems;
- Global observing-system design and demonstration;
- Targeting and assimilation of observations;
- Societal, economic, and environmental benefits of improved forecasts.

THORPEX is a ten-year programme and following the publication of international plans (http://www.wmo.int/pages/prog/arep/wwrp/new/thorpex_publications.html) the implementation phase began in early 2005.

4.2 Organizational structure

An International Core Steering Committee (ICSC) is responsible for the delivery of THORPEX to leadership of the WWRP and the Commission for Atmospheric Sciences (CAS). Membership of the ICSC is open to all WMO Members under the authority of the CAS. Observers from a number of international organizations participate in meetings of the ICSC. An Executive Committee (EC) (composed of a small number of ICSC members and observers) maintains oversight of the Trust Fund and provides guidance on the conduct of the programme.

The International Programme Office (IPO)

The THORPEX International Programme Office (IPO) at the WMO Secretariat (Geneva) is responsible for planning and implementation of THORPEX. The IPO supports the activities of the ICSC and its main working bodies. The IPO and a number of international meetings are supported through voluntary contributions of the Governments of the WMO Members participating in THORPEX, including donations (from Canada, China, France, Germany, Japan, Korea, Norway and the USA) to the THORPEX Trust Fund established by WMO. In addition, THORPEX benefits in a number of ways from GEO through GEO's support for a number of THORPEX projects.

The Director of THORPEX IPO, and the THORPEX Working Groups and Regional Committees, report to a THORPEX International Core Steering Committee (ICSC). By the time of CASXV, the ICSC will have met three times and reports from these meetings may be found at http://www.wmo.int/pages/prog/arep/wwrp/new/thorpex_publications.html

Working Groups

Two THORPEX Working Groups have been charged by the ICSC to develop and coordinate specific activities for three of the four THORPEX sub-programmes:

- Predictability and Dynamical Processes Working Group (PDP WG) – global-to-regional influences on the evolution and predictability of weather systems;
- Data Assimilation and Observing Systems Working Group (DAOS WG) – global observing system design; targeting and assimilation of observations.

Since CAS-XIV, the WWRP Societal and Economic Research Aspects Working Group has, as one of its tasks, the responsibility for the coordination of the assessment of the societal, economic and environmental benefits of improved forecasts for the THORPEX Programme.

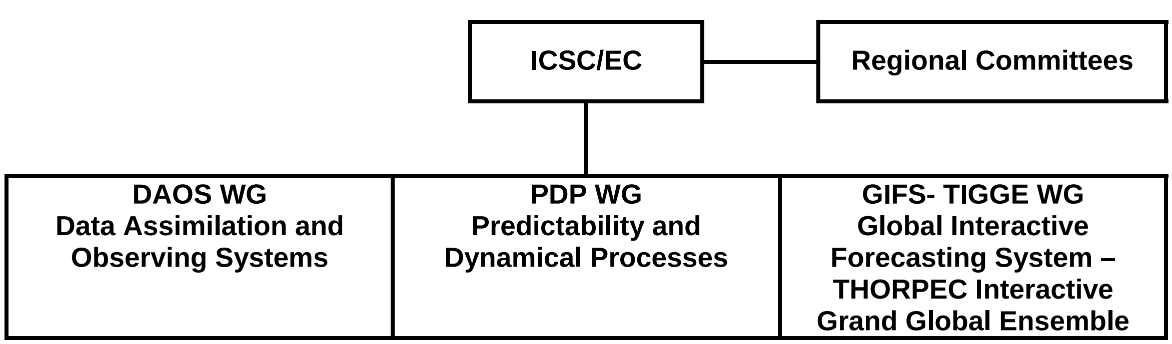
To complement and support the work of these Working Groups, the ICSC established the Global Interactive Forecasting System (GIFS) – THORPEX Interactive Grand Global Ensemble Working Group (GIFS-TIGGE WG). The initial task given to the GIFS-TIGGE WG was to develop and test a global multi-model ensemble prediction system and this is a continuing task.

Regional Committees

Nations and consortia of nations have established THORPEX Regional Committees (RCs) that define regional priorities for participation in THORPEX within the framework of the THORPEX International Science and Implementation Plans.

Organizational structure

Since November 2008, the organizational structure for THORPEX is as illustrated below.



The Trust Fund

The THORPEX Trust fund is used mainly to finance the THORPEX International Programme Office (IPO), to purchase equipment and software and to provide programme support (consultants, workshops, website, publications, meetings, travel, etc.).

The Implementation Plan for THORPEX adopted by the THORPEX ICSC in December 2004 foresaw an annual expenditure of CHF 1,500,000. However, typically, a few WMO Member States contribute the order of CHF 400,000 annually to the Trust Fund. Consequently, IPO support for international activities is significantly lower than planned.

4.3 Project description - content, goals and objectives

In order to implement the THORPEX Science Plan and the THORPEX Implementation Plan, as described above, two sub-programmes have been developed to coordinate research on three of the THORPEX priorities and to foster collaboration with other programmes:

- Predictability and Dynamical Processes;
- Data Assimilation and Observing Systems.

These sub-programmes have been designed to:

- Increase knowledge of global-to-regional influences on the initiation, evolution and predictability of high-impact weather;
- Contribute to the development of advanced data assimilation and ensemble prediction systems;
- Contribute to the design and demonstration of global interactive forecast systems (GIFS) that allow information to flow interactively among forecast users, numerical forecast models, adaptive data-assimilation systems and observations to maximize forecast skill (this includes the THORPEX Interactive Grand Global Ensemble (TIGGE) that develops and evaluates multi-model/multi-analysis ensemble prediction systems);
- Contribute to the development and application of advanced methods that enhance the utility and value of weather forecasts to society, economies and environmental stewardship;
- Carry out THORPEX Observing-System Tests (TOSTs) and THORPEX Regional field Campaigns (TReCs). TOSTs: (i) test and evaluate experimental remote sensing and in-situ observing systems, and when feasible, demonstrate their impact on weather forecasts; and (ii) explore innovative uses (e.g., targeting) of operational observing systems. TReCs are operational forecast demonstrations contributing to the design, testing and evaluation of all components of interactive forecast systems;
- Conduct regional and global campaigns as demonstrations and assessments of new observing technologies and interactive forecast systems. Thereby, THORPEX will provide guidance to the World Weather Watch (WWW) and forecast centres on improvements to forecast systems, and to relevant bodies, such as the WMO Commission for Basic Systems (CBS), concerning optimization of global and regional observing systems;
- Address the influence of inter-annual and sub-seasonal atmospheric and oceanic variability on high-impact forecasts out to two weeks, and therefore aspire to bridge the “middle ground” between medium-range weather forecasting and climate prediction. This provides a link with programmes addressing the improvement of sub-seasonal, seasonal, and global climate change prediction systems;
- Demonstrate all aspects of THORPEX interactive forecast systems, over the globe for a season to one year to assess the utility of improved weather forecasts and user products;

- Coordinate THORPEX research with the World Climate Research Programme (WCRP) and the relevant components of WWRP to address the observational and modelling requirements for the prediction of weather and climate for two weeks and beyond;
- Facilitate the transfer of the results of THORPEX weather prediction research and its operational applications to developing countries through the WMO by means of appropriate training programmes.

4.4 Regional Committees and plans

The THORPEX Regional Committees develop regional activities within the framework of the international plans and their plans are discussed by the EC and reviewed and approved by ICSC. To date Regional Committees have been established for Asia (ARC), Africa (AfRC), Europe (ERC), North America (NARC) and the Southern Hemisphere (SHRC). Ultimately, the responsibility for the implementation of the THORPEX science plan lies with the regional/national institutions and the progress highlighted below is a result of activities in all regional committees.

4.5 Progress - highlights

Since CAS-XIV a number of notable successes have been achieved:

- Three major real-time international observational programmes have been completed (for the Atlantic and Pacific) A-TREC, E-TREC and T-PARC;
- Reports on the effectiveness of data-targeting have been completed;
- International data bases of near-real time global ensemble predictions from ten prediction centres have been established and the results are being provided for research by three archive centres;
- The THORPEX IPY Cluster of projects have made a major contribution to observing and NWP for polar regions;
- A major contribution has been made to AMMA;
- YOTC;
- The THORPEX community has made a contribution to the WWRP Strategic Plan;
- Regional Plans have been developed;
- Two Science Symposia have been held (2006 in Landshut (Germany) and Monterey (USA)).

In addition, the THORPEX community and partners are leading four GEO tasks (for health, climate, ensemble-prediction and high impact weather in Africa) and these projects are now the main elements of the GEO weather prediction activity.

4.5.1 Observational Campaigns

A-TReC

The objective of the Atlantic THORPEX Regional Campaign (A-TREC), the first THORPEX Regional Plan, was to test the hypothesis that short-term forecast errors over Europe and the Eastern seaboard of the USA can be reduced by targeting extra observations over sensitive areas determined each day by the forecast flow patterns using NWP techniques (Mansfield et al., 2004). The field campaign took place in the autumn of 2003. It was the first attempt at real time adaptive control of a full set of operational observing systems (in an international context) in addition to the deployment of research aircraft. The observations available for targeting were 66 European and Canadian radiosonde stations, the EUCOS (European Composite Observing System) ASAP Fleet (13 ships), the EUCOS AMDAR Fleet (550 aircraft) and dropsondes from the NOAA G-IV, the University of North Dakota 'Citation' aircraft, the DLR Falcon and a USA Air Force C130 aircraft, Super rapid scan winds from the GOES satellite.

The European THORPEX Regional Campaign (E-TREC)

The E-TREC took place during five weeks in July 2007 during the MAP D-PHASE Forecast Demonstration Project (for more info see www.pa.op.dlr.de/cops/etrec_docs.html). The project was the first to investigate adaptive measurement strategies for warm season convection and sensitive regions were calculated daily at Météo-France, ECMWF and the Universitat de les Illes Balears (Spain). Special observations were made for seven events, using combinations of the DLR Falcon with wind and water vapour lidars and dropsondes, and additional radiosonde and AMDAR measurements provided by EUCOS.

The THORPEX Pacific Asian Regional Campaign (T-PARC)

The THORPEX Pacific Asian Regional Campaign (T-PARC) is a cross-cutting activity that includes a focus on the research goals of THORPEX and the Tropical Meteorological programmes. The field campaign of T-PARC consisted of two phases – a Summer phase (1 August 2008-8 October 2008) produced data on the evolution of a number of tropical cyclones and the Winter Phase (January–March 2009) provided data to study mid-latitude predictability. T-PARC research is inherently multi-scale and the measurements strategies were motivated by the societal need to improve both shorter range (1-5 day) forecast skill for high impact weather events that affect the Northwest Pacific and East Asian regions and medium range (3-7 days) forecast skill for "downstream" locations such as the Arctic, North America, Europe and North Africa.

Observational activities during the field phases included enhanced use of operational resources (e.g., implementing rapid scan modes for satellite systems and supplemental radiosonde launches), research vessels measuring atmospheric and oceanic properties, research aircraft carrying advanced remote sensing systems that included Doppler radar, wind lidar and water vapour lidar, the deployment of dropsondes from research aircraft and stratospheric balloons called driftsonde and robotic aircraft. The measurements for the Tropical Phase, in particular, relied on collaboration with the associated national efforts in China, Korea and Japan as well as the US's Tropical Cyclone Structure-08 Experiment (TCS-08) that has strong links to the WWRP/Tropical Meteorology Programme.

The two phases of T-PARC have provided valuable data bases which will enable comprehensive studies of the predictability of tropical convection and the various phases of typhoon and storm development and movement in the Pacific Ocean and mid-latitude predictability of weather systems to be carried out.

4.5.2 The IPY-THORPEX project cluster

The First International Polar Year took place in 1882-1883 and established a precedent for international science cooperation. The second took place 50 years later in 1932-1933, and investigated the global implications of the newly discovered "Jet Stream". The third – the International Polar Year (IPY) took place in 2007-2008 and was an international programme of coordinated, interdisciplinary scientific research and observations in the Earth's Polar Regions.

From an enhanced observational network, the sophisticated use of new observations and a better understanding of physical processes in Polar Regions, it is hoped that the International Polar Year 2007-2008 will eventually lead to a similar leap forward in the skill in numerical weather prediction such as was achieved by the FGGE (GWE) year in 1979.

Within the IPY framework, WWRP-THORPEX has developed a set of projects to address key issues that relate to the analysis and forecasting of polar weather, better use of satellite data etc. The IPY-THORPEX project cluster currently includes ten individual IPY projects from nine countries with the following main strategic objectives:

- Explore the use of satellite data and optimized observations to improve high-impact weather forecasts (for Polar THORPEX Regional Campaigns (TReCs) and/or provide additional observations in real-time over the WMO Global Telecommunication System);
- Improve the understanding of physical/dynamical processes in Polar Regions;
- Achieve a better understanding of small-scale weather phenomena;
- Utilize the THORPEX Interactive Grand Global Ensemble (TIGGE) of weather forecasts for polar weather prediction;
- Utilize improved forecasts for the benefit of society, the economy and the environment.

4.5.3 Data impact studies and investigations into the adaptive observation (targeting) approach

Over the last few years the DAOS WG has concentrated on the evaluation of the impact of observations including targeted observations, based on results from field experiments (ATReC, AMMA, IPY), OSEs and OSSEs. In addition, the group has contributed significantly to the preparations for TPARC. The working group's activities have been presented at a number of conferences and a report on the activities of the group has been published in Nonlinear Processes in Geophysics.

The main outcomes from these impact studies may be summarized as follows:

- The value of extra-tropical targeted data has been found to be positive but small on average:
    - Observations taken in sensitive areas have more value than observations deployed randomly;
    - Past experiments do not provide evidence of a major impact obtained from just a few observations (when averaged over a large sample of cases);
    - There are limitations due to the current assimilation methodologies (spatial structure functions which control the use of observations in data assimilation are not yet fully flow-dependent);
    - The methods employed to characterize sensitive areas does not appear to be the major problem;
- Additional observations for tropical cyclones have proven to be useful.

These DAOS WG sponsored studies also suggest that additional benefit may be obtained from:

- Optimization of existing operational resources;
- Regional (vis-à-vis highly localized) and systematic targeting during low predictability flow regimes on a continuous basis (periods of days to weeks);
- Adaptive processing and data selection of satellite data.

4.5.4 Support for research into probabilistic forecasting - TIGGE

Under the guidance of the GIFS-TIGGE WG, an international database/archive of operational, global ensemble forecasts called the THORPEX Interactive Grand Global Ensemble (TIGGE) has been developed to explore the value of combining data from various systems for probabilistic forecasting of severe weather events. Currently, the TIGGE archive is hosted by three archive centres (ECMWF, NCAR and CMA) containing the data from 10 NWP ensemble generating centres: BOM, CMA, CMC, CPTEC, ECMWF, JMA, KMA, Météo-France, NCEP and UK Met Office. The TIGGE archive, which is growing in real-time, provides a research facility to enhance cooperation between Universities and the operational weather prediction centres and is aimed at promoting the concept of probabilistic forecasts and development of new methods of combination and verification of forecasts. The length of the TIGGE archive extends to over 2 years for some members and there are over 500 registered users of the archive. Recently real-time distribution of ensemble track predictions that were based on the TIGGE archive have been distributed in real-time for the T-PARC experiment.

If justified by scientific results (from using the TIGGE archive of ensemble data and other THORPEX research findings) an internationally coordinated system for high impact weather forecasting called the Global Interactive Forecasting System (GIFS) is being considered in collaboration with the WMO Commission for Basic Systems (CBS). Initial development will focus on tropical cyclone and precipitation forecasting as GIFS Prototype Products for two of the highest priority application areas. Probabilistic forecast products will be specifically designed for and tested in a few selected regions where the transfer of new technology can have the greatest benefit, for example for less developed and developing nations, using the experience with the CBS Southern Africa SWFDP.

A TIGGE-LAM Panel has been established to coordinate the regional LAM EPS contribution to TIGGE. The Panel is addressing the interoperability aspects related to the exchange and archiving of LAM EPS products and the provision of Initial and Boundary conditions by the TIGGE Global Systems.

4.5.5 The Year of Tropical Convection (YOTC)

A key element of the THORPEX strategy is the collaboration that has been developed with the World Climate Research Programme (WCRP) to address common requirements for observations and modelling for the prediction of weather and climate for two weeks and beyond.

The realistic representation of tropical convection in global atmospheric models is a long-standing grand challenge for numerical weather prediction and climate projection. To address this challenge, WCRP and WWRP/THORPEX have implemented a Year of coordinated observing, modelling and forecasting of organized tropical convection and its influences on predictability as a contribution to the United Nations Year of Planet Earth to complement the International Polar Year (IPY).

This effort is intended to exploit the vast amounts of existing and emerging observations, the expanding computational resources and the development of new, high-resolution modelling frameworks, with the objective of advancing the characterization, diagnosis, modelling, parameterization and prediction of multi-scale convective/dynamic interactions, including the two-way interaction between tropical and extra-tropical weather/climate. This activity and its ultimate success will be based on the coordination of a wide range of ongoing and planned international programmatic activities (e.g., Outcomes from T-PARC, GEWEX/CEOP/GCSS, THORPEX/TIGGE, EOS, GOOS), strong collaboration among the operational prediction, research laboratory and academic communities, and the construction of a comprehensive data-base consisting of satellite data, in-situ data sets and global/high-resolution forecast and simulation model outputs relevant to tropical convection.

The YOTC began on 1 May 2008. The approach and integrated framework of this effort is intended to leverage the most benefit from recent investments in Earth Science infrastructure as well as entrain a new generation of young scientists into tackling the outstanding problems in the field of weather and climate prediction.

4.6 Long range outlook

In the framework of increasingly powerful high end computing and the expected increasing resolution and sophistication of numerical models the WWRP-THORPEX programme will remain focussed on making significant improvements in the prediction of high impact weather worldwide, extending markedly the range of useful forecasts and encouraging a globally integrated approach through the careful evaluation and scientific assessment of the potential benefits of the introduction of the a GIFS.

A most important issue remains understanding and addressing the societal and economic imperatives for improved forecasts including aspects related to health, agriculture, energy etc., and ensuring that user relevant verification of forecasts is employed throughout. This approach requires strong cross-community collaboration between scientists, social scientists and economists. Other scientific priorities that need to continue to be addressed include:

- Basic issues of predictability and key dynamical processes;
- The required initial conditions and implied observational coverage;
- Strategies for observations targeting in critical situations;
- Tackling the problem issues in data assimilation especially at high resolution;
- Handling of the tropics particularly organized convection, tropical cyclones and extra-tropical transition and interactions;
- Polar weather;
- Seamless prediction of weather and climate from days to weeks and seasons (see agenda item 7).

World Meteorological Organization | **CAS-XV/INF. 4**

COMMISSION FOR ATMOSPHERIC SCIENCES

FIFTEENTH SESSION
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DECISIONS OF CONGRESS AND THE EXECUTIVE COUNCIL OF RELEVANCE TO THE ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME (AREP)

SUMMARY

Reference: **CAS-XV/Doc. 4**

CONTENT OF DOCUMENT:

Appendix:

- Background information on Congress and Executive Council decisions of relevance to the functions, activities and programmes of the Commission for Atmospheric Science

Annexes:

I. Terms of Reference of the Commission of Atmospheric Sciences - Annex to paragraph 3.3.1.2 of the general summary of EC-LVIII
II. Resolution 14 (Cg-XV) - Atmospheric Research and Environment Programme
III. Resolution 3 (EC-LIX) - Executive Council Working Group on the WMO Integrated Global Observing System and the WMO Information System

DECISIONS OF CONGRESS AND THE EXECUTIVE COUNCIL OF RELEVANCE TO THE ATMOSPHERIC AND ENVIRONMENT RESEARCH

1. Decisions related to the Terms of Reference and structure of CAS

1.1 Annex III of the General Regulations of WMO state the “General Terms of Reference of Technical Commissions:

1. Study and review advances in science and technology, keep Members informed and advise Congress, the Executive Council and other constituent bodies on these advances and their implications;
2. Develop, for consideration by the Executive Council and Congress, proposed international standards for methods, procedures, techniques and practices in meteorology and operational hydrology including, in particular, the relevant parts of the Technical Regulations, guides and manuals;
3. Under the general guidance of Congress and the Executive Council, carry out functions - with other bodies as necessary - relating to the planning, implementation and evaluation of the scientific and technical programme activities of the Organization;
4. Provide a forum for the examination and resolution of relevant scientific and technical issues;
5. Promote training by assisting in the organization of seminars and workshops and in the preparation of related material and the development of other suitable mechanisms for the transfer of knowledge and methodology, including the results of research, between Members;
6. Promote international cooperation and maintain, through appropriate channels, close cooperation on scientific and technical matters with other relevant international organizations;
7. Make such recommendations as it may consider necessary.”

1.2 Commissions set their own “specific” terms of reference. In June 2006, EC-LXVIII reviewed the Terms of Reference proposed by CAS-XIV in February 2006 in South Africa and agreed (paragraph 3.3.1.2) “with the Commission that its scope should expand in view of the latest developments of comprehensive Earth System Models for a broad range of forecasting applications including the chemical composition of the atmosphere, new efforts on developing interactive observing systems and ensemble methods being employed to produce probabilistic weather forecasts. The Council decided to recommend the new terms of reference for the Commission as given in {Annex I} to the present report and requested the Secretary-General to submit it to Fifteenth Congress. The Council agreed with CAS that the highest priority in AREP should be the implementation of GAW, THORPEX and the WWRP overall. It also agreed that more emphasis should be given to the connection to climate research activities.”

1.3 Subsequently, Cg-XV (paragraph 3.3.1.3) endorsed the changes in Commission for Atmospheric Sciences documented in the report of the Commission on its fourteenth session, held in Cape Town, South Africa, from 16 to 24 February 2006, and subsequent amendments by the fifty-eighth session of the Executive Council in 2006. It supported the new operating system for CAS with two Open Programme Area Groups (OPAGs). The OPAG for Environmental Pollution and Atmospheric Chemistry supports the Global Atmosphere Watch (GAW) programme and the OPAG for the World Weather Research Programme supports WWRP including THORPEX. Considering these changes in structure of the Commission, Cg-XV adopted Resolution 14 (Cg-XV) – Atmospheric Research and Environment Programme (AREP) (Annex II) that updated the terms of reference so that the programme to be consistent with the new Open Programme Area Structure.

2. Decisions related to the function of CAS

2.1 In June 2008, EC-LX decided to identify seamless weather, climate, water and environmental prediction and services as a major focus in WMO activities. It endorsed the concept of an enhanced climate, weather, water and environmental research initiative within the broader framework of linking research, observations, operational prediction and service delivery, and established to this effect a Research Task Team (EC-RTT) on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework and requested a report to be prepared and submitted for its consideration at EC-LXI in June 2009. The mandate of the (EC-RTT) are included in the final report (WMO/TD-1496) available at http://www.wmo.int/ecrtt. One mandate of EC-RTT was to assess ways to better coordinate the advisory role of prediction research by technical commissions and other bodies supported by WMO. The EC-RTT report (Chapter 4) analyzed the effectiveness, efficiency and crosscutting collaborations of WMO Technical Commissions.

EC-RTT concluded with the General Recommendation 3 that:

The Role of WMO Commissions: Implement a process to review and rationalize the roles and mandates of the Commissions, and to improve their effectiveness in enhancing WMO Member capabilities in research, observations, prediction and services, in particular:

Specific Recommendation 3.1
EC and the Secretariat work closely with the presidents of technical commissions and the Research Department so that any necessary modification to the Commissions' structures and their linkages with the organizational structure is effected to maximize the impact of the proposed paradigm change in prediction research. Simplification and clarity of the roles of the Commissions and the Departments should be the guiding principles of any final decisions.

Specific Recommendation 3.2
Develop a process to harmonize research input, and cross-coordination between different Commissions.

Specific Recommendation 3.3
Set up a mechanism connected with budgetary decision making, whereby cross cutting project proposals developed jointly by at least two Commissions, and one regional association could be reviewed and prioritized by the presidents of technical commissions, for consideration by EC and the Secretariat for eventual implementation.

Specific Recommendation 3.4
Recognizing that WMO is fundamentally a science and technology based organization, establish efficient mechanisms to ensure that optimal science input is provided to WMO decision-making processes and bodies (Cg, EC and Secretariat).

Specific Recommendation 3.5
Reaffirm and support international WMO science and technology leadership in its areas of competence, by nurturing a culture of excellence, relevance and impact, whilst recognizing that the increasing complexity of atmospheric related environmental issues necessitates an increasingly partnership approach.

Based on the analysis by the EC-RTT, EC-LXI (paragraph 8.7) "noted that the EC-RTT was supportive of the need to review the role, structure and cross-coordination of Commissions and organizations in light of the changing needs of Members. It recommended that the EC Working Group on Strategic and Operational Planning continue to emphasize the visibility and role of research in WMO strategic planning and programme implementation."

2.2 Based on the above EC-RTT and other consultations, EC-LXI (paragraphs 8.24-8.26) noted more generally "that there is a strong desire to review the working mechanisms of the Organization and carefully plan for change that would improve the effectiveness and efficiency of the WMO at a time when improved integration between its technical groups is imperative and when the pace of change in the external environment is very high. Any change would have to assist the Organization in being able to respond flexibly and quickly to new challenges as they arise.

For major reform to take place a well thought through proposal, possibly containing around three options for change, including the analysis of advantages and disadvantages, needs to be prepared for the consideration of Congress in 2011. The proposal would have to be developed through wide consultation and have the support of Members beyond those represented in EC.

EC-LXI decided that a task group be formed under the auspices of the Executive Council Working Group on Strategic and Operational Planning which would develop the proposals for change. The proposals should articulate the roles and responsibilities of the WMO's constituent bodies (e.g. CAS) in terms of their concrete contributions to the implementation of the WMO Strategic Plan and to Members' services, and should be in draft form for consideration by EC-LXII prior to submission to Cg-XVI. They requested consultation with Regional Associations and Technical Commissions."

3. WMO Integrated Global Observing System (Of Systems) WIGOS and Related WMO Information System (WIS)

CAS research activities play an important role in supporting WMO coordinated routine observations related to weather, climate, water and environmental prediction and information services. The creation of WIGOS by Cg-XV was followed immediately with an implementation strategy through Resolution 3 of EC-LIX (Annex III) that involved CAS. This resolution "reiterated that Members, regional associations and technical commissions should actively collaborate in testing, developing, and implementing the WIGOS concept, and provide their input to WDIP. The Council requested that the WIGOS implementation strategy clearly indicate that it complements rather than duplicates implementation plans of WIGOS systems, such as GOS, WHYCOS and GAW."

Annexes: 3

Annex I

TERMS OF REFERENCE OF THE COMMISSION FOR ATMOSPHERIC SCIENCES

Annex to paragraph 3.3.1.2 of the general summary of EC-LVIII

The Commission for Atmospheric Sciences is responsible for promoting, coordinating and facilitating activities relating to the atmospheric sciences, including weather research, environmental pollution and atmospheric chemistry research, and associated training and capacity building.

Within the context of this broad role, the specific objectives of the Commission are:

(a) To determine the requirements of WMO Members, including in support of environmental and climate conventions, and facilitate the transfer of knowledge, technologies and advice concerning atmospheric science issues;

(b) To conduct research in atmospheric and related sciences to advance the understanding and predictability of atmospheric processes within the broader Earth system, with emphasis on the following:

- (i) Weather prediction for timescales ranging from very-short to the long range, embracing new developments in environmental prediction, with emphasis on refining the end-to-end forecast process including data assimilation so as to improve the forecasting of high-impact events associated with serious consequences for populations and economies;
- (ii) Atmospheric composition and air pollution, including their interaction with weather, studies of transport, transformation and deposition of air pollutants and related monitoring;
- (iii) Physics and chemistry of clouds, particularly in support of weather prediction, atmospheric chemistry and the prediction of the chemical composition of the atmosphere;
- (iv) Weather modification with emphasis on the underlying physical and chemical processes and the development of rigorous evaluation procedures;
- (v) Tropical meteorology, including studies of processes and phenomena of particular relevance to low latitudes and their influence beyond;
- (vi) Climate, noting the central role of the World Climate Research Programme (WCRP) for improved understanding of climate, the Commission will provide supporting science and contribute expertise, especially in atmospheric, environmental and Earth system modelling, which links the weather interests of the Commission to climate scales;

(c) To maintain and develop the Global Atmosphere Watch (GAW) programme using an integrated approach to global atmospheric chemistry observations and air quality, contributing to scientific assessments in support of international environmental and climate conventions and policies;

(d) In accordance with the WMO Strategic Plan, to coordinate the Commission's activities with relevant WMO bodies and promote cooperation between WMO Members, international scientific organizations, environmental institutions and other scientific groups;

(e) To standardize functions, constants, terminology and bibliographic practices applicable to atmospheric sciences;

(f) To support research on the policy, social and economic impacts of advances in the understanding of atmospheric sciences;

(g) To formulate requirements for observations and for the storage, retrieval and exchange of raw and/ or processed data;

(h) To conduct scientific assessments of technical meteorological procedures, including verification techniques.

Annex II

Resolution 14 (Cg-XV)

ATMOSPHERIC RESEARCH AND ENVIRONMENT PROGRAMME

THE CONGRESS,

Noting:

(1) The *Abridged Final Report with Resolutions and Recommendations of the Fourteenth Session of the Commission for Atmospheric Sciences* (WMO-No. 1002),
(2) Resolution 10 (Cg-XlII) - Atmospheric Research and Environment Programme, and related actions taken by Fourteenth Congress and the Executive Council,
(3) Resolution 12 (Cg-XIV) - THORPEX: A Global Atmospheric Research Programme,
(4) The WMO Strategic Plan,
(5) That the skilful prediction of high-impact weather is one of the greatest scientific and societal challenges of the twenty-first century,
(6) The Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer and its subsequent amendments, the United Nations Framework Convention on Climate Change, the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe and other environment-oriented conventions,

Considering:

(1) The heightened public awareness and concerns for global, regional and local climate, weather and environmental issues in general,
(2) That a major task of National Meteorological and Hydrological Services is weather prediction and, in particular, forecasting events with high societal and economic impacts,
(3) The responsibility of WMO within the United Nations system to provide the authoritative scientific voice on the state and behaviour of the atmosphere, weather and climate of our planet,
(4) The central role played by the atmosphere in environmental issues, which has been foremost among societal concerns during the past years and will continue well into this century, such as the global increase of greenhouse gases and effect of aerosols on weather and climate, stratospheric ozone depletion and related increase in ultraviolet radiation, long-range pollutant transport, air quality and impacts of pollutant deposition,
(5) The increasing demand by numerical weather prediction research and operations for support in adding aerosols, ozone and their gaseous precursors to improve forecasting accuracy as well as enhance products and services,
(6) The increasing need to move towards environmental predictions, using as a core driver the traditional numerical weather prediction systems, coupled with other modelling subsystems, with a consideration of the socio-economic impacts, as distinct from strictly traditional weather-only predictions,
(7) The implementation of the WMO Global Atmosphere Watch (GAW) Programme with the mission of taking into account the Integrated Global Atmospheric Chemistry Observations (IGACO) strategy to: reduce environmental risks to society and meet the requirements of environmental conventions; strengthen capabilities to predict climate, weather and air quality; and contribute to scientific assessments in support of environmental policy; through maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere; emphasizing quality assurance and quality control; and delivering integrated products and services of relevance to user needs,
(8) The focus of the GAW integrated atmospheric chemistry observations is primarily on greenhouse gases, ozone, ultraviolet radiation, aerosols, selected reactive gases and precipitation chemistry with additional support for other IGACO variables,

(9) The potential of the National Meteorological and Hydrological Services to contribute substantially to integrated observations via their extensive monitoring system infrastructures and specific scientific expertise in areas such as numerical modelling with four-dimensional data assimilation techniques and real-time data delivery,

(10) That greenhouse gases, aerosols and ozone are designated Essential Climate Variables in the Global Climate Observing System Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC (GCOS-82, WMO/TD-No. 1143) and that the GAW Global CO2 and CH4 Monitoring Network is a comprehensive network of the Global Climate Observing System,

(11) The international coordination role of WMO in environmental issues that are becoming more extensive and complex not only because of greater activity levels, but also because of the need to encompass a broader range of scientific disciplines (meteorology, atmospheric chemistry, hydrology, oceanography, biosphere sciences and human health) and partner organizations in the resolution of sustainable environmental development issues,

(12) That Thirteenth Congress and the fourteenth session of the Commission for Atmospheric Sciences concurred with the need for the GAW Urban Research Meteorology and Environment activities aimed at improving air quality forecasting, expansion of GAW measurements and strengthening partnerships of National Meteorological and Hydrological Services with key sectors including health,

(13) That despite the substantial increase in the forecast skill achieved by improvements in atmospheric observing technology, data-assimilation methods, new numerical model formulations and the use of ensemble techniques, the ability to forecast high-impact weather events still falls below that required by society,

(14) The decision of the fourteenth session of the Commission for Atmospheric Sciences (CAS) and its Management Group to develop and implement, under the CAS Open Programme Area Group on World Weather Research Programme (WWRP), a strategic plan for a new World Weather Research Programme that integrates WMO Member activities in The Observing System Research and Predictability EXperiment (THORPEX), tropical meteorology, mesoscale weather forecasting, nowcasting, verification and societal and economic benefits with those of partners in global forecast research and Earth observations,

(15) The need of National Meteorological and Hydrological Services for support in practicing sound weather modification research,

Decides:

(1) That the substance of the Atmospheric Research and Environment Programme shall comply with the WMO Strategic Plan adopted under Resolution 27 (Cg-XV), with its major contributions focused on the following expected results:

1. Enhanced capabilities of Members to produce better weather forecasts and warnings;
2. Enhanced capabilities of Members to provide better climate predictions and assessments;
3. Enhanced capabilities of Members to provide better hydrological forecasts and assessments;
4. Integration of WMO observing systems;
5. Enhanced capabilities of Members in multi-hazard early warning and disaster prevention and preparedness;
6. Enhanced capabilities of Members to provide and use weather, climate, water and environmental applications and services;
7. Broader use of weather, climate and water outputs for decision-making and implementation by Members and partner organizations;
8. Enhanced capabilities of National Meteorological and Hydrological Services in developing countries, particularly least developed countries, to fulfil their mandates;

(2) That the Atmospheric Research and Environment Programme should focus on: World Weather Research Programme including THORPEX; the Global Atmosphere Watch including IGACO implementation; and the related transfer of appropriate technology and proven methodologies among Members as indicated in the WMO Strategic Plan;
(3) That education and training aspects be included in all components of the Atmospheric Research and Environment Programme;
(4) That, in the implementation of the Atmospheric Research and Environment Programme, WMO should continue to cooperate, as appropriate, with the United Nations Environment Programme, World Health Organization, United Nations Development Programme and other relevant agencies;

Requests Members:

(1) To give all possible support to the implementation of the Atmospheric Research and Environment Programme, with high priority to the Global Atmosphere Watch and the World Weather Research Programme including THORPEX, for example through contributions to the appropriate trust fund such as the THORPEX trust fund;
(2) To support the central role of the Global Atmosphere Watch in the development of a WMO Integrated Global Observing System;

Requests the president of the Commission for Atmospheric Sciences:

(1) To arrange for the development and implementation of WMO activities in the Global Atmosphere Watch and the World Weather Research Programme including THORPEX using technical strategic plans;
(2) To encourage Members of the Commission to participate in and contribute to THORPEX, and its trust fund, and to facilitate the activities of the International Core Steering Committee for THORPEX;
(3) To coordinate activities in the implementation of the Atmospheric Research and Environment Programme with other relevant WMO Programmes, in particular the World Climate Research Programme and international organizations;
(4) To ensure that the Commission for Atmospheric Sciences continues to assist Members through its Expert Team on Weather Modification in practicing sound weather modification research;
(5) To arrange provision of assistance and advice with respect to the Education and Training Programme;
(6) To stimulate and coordinate socio-economic research and development activities and studies to increase the value of environmental prediction outputs for the benefit of WMO Members;

Requests the Executive Council:

(1) To take, within available budgetary resources, all necessary actions towards the fullest possible implementation of the Atmospheric Research and Environment Programme, in accordance with the WMO Strategic Plan;
(2) To support the work of the Commission for Atmospheric Sciences, and other bodies concerned, in the development of component programmes of the Atmospheric Research and Environment Programme;
(3) To continue its coordinating role regarding the Global Atmosphere Watch and the World Weather Research Programme with other relevant WMO activities through the CAS Open Programme Area Groups on Environmental Pollution and Atmospheric Chemistry and on the World Weather Research Programme;

Requests the Secretary-General:

(1) To take all necessary action, within available budgetary resources, for the implementation of the Programme;

(2) To support the THORPEX international programme office, to assist WMO Members in the international coordination of THORPEX, and to assist Members from developing nations in their utilization of THORPEX-related forecast products;

(3) To devote particular attention to the education and training aspects of the Atmospheric Research and Environment Programme;

(4) To assist Members participating in the Programme, particularly developing Member countries, by facilitating the training and exchange of scientists, and the provision of advice, guidance and services, as required, within available budgetary resources;

(5) To take all necessary actions to develop and maintain collaboration of WMO through the Atmospheric Research and Environment Programme with agencies, groups and institutions such as the Group on Earth Observations, International Council for Science, United Nations Environment Programme and United Nations Development Programme, which can contribute to the further development and implementation of the research-based programmes of the Atmospheric Research and Environment Programme and to seek further financial support from such agencies and other national and international institutions and from Members.

Note: This resolution replaces Resolution 10 (Cg-XIII), which is no longer in force.

Annex III

Resolution 3 (EC-LIX)

EXECUTIVE COUNCIL WORKING GROUP ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM AND THE WMO INFORMATION SYSTEM

THE EXECUTIVE COUNCIL,

Noting Resolution 30 (Cg-XV) – Towards enhanced integration between WMO Observing Systems,

Considering the request expressed in Resolution 30 (Cg-XV) for the Executive Council to:

(1) Establish a mechanism to steer and monitor the activity and to achieve the broadest possible collaboration and cooperation,
(2) Ensure the active participation and representation of the principal bodies concerned and also the participation, as appropriate, of technical experts and representatives of agencies undertaking co-sponsored observing initiatives,
(3) Ensure that this mechanism is closely coordinated with the institutional arrangements for planning and overseeing the WMO Information System,
(4) Submit a comprehensive report on the integration between the WMO observing systems to Sixteenth Congress,

Decides to establish an Executive Council Working Group on the WMO Integrated Global Observing System and the WMO Information System with terms of reference as follows:

(1) Provide advice and guidance in the preparation of an overarching WIGOS Development and Implementation Plan;
(2) Refine the WIS Development and Implementation Plan and ensure coordination between WIGOS and WIS plans to allow for an integrated WMO end-to-end system of systems;
(3) Monitor the development and implementation of WIGOS and WIS through a “rolling review” mechanism;
(4) Monitor the development and implementation of WIGOS/WIS “Pilot Projects”, as suggested by Fifteenth Congress, to test concepts, identify problem areas, and to help in elaborating the Development and Implementation Plan;

Requests:

(1) Regional associations and technical commissions to provide input into an overarching Development and Implementation Plan and to include relevant activities in their strategic plans and work programmes, in particular those activities that require joint actions by regional associations and/or technical commissions for “Pilot Projects”;
(2) The Working Group on WIGOS/WIS to report to subsequent sessions of the Council on the progress in the development and implementation of WIGOS/WIS;

Further requests the Intercommission Coordination Group on WIS (ICG-WIS) to report to the working group to ensure the coordination of the respective WIGOS and WIS Development and Implementation Plan, especially as regards WIS meeting WIGOS data collection, exchange and access requirements;

Authorizes:

(1) The Executive Council Working Group to establish sub-groups and task teams as and when required;

(2) The working group to undertake intersessional activities that require urgent action while keeping the President immediately informed of such actions and in providing specific descriptions of such activities to the next session of the Executive Council;

Decides further:

(1) That a high-level representative from each regional association and technical commission, to be designated by its president, participates in relevant activities of the working group or its sub-groups;
(2) That the WMO/IOC/UNEP/ICSU Steering Committee for the Global Climate Observing System (GCOS), the WMO/ICSU/IOC Joint Scientific Committee for the World Climate Research Programme (WCRP), the WMO/FAO Joint Scientific Committee for the Global Terrestrial Observing System, and WMO/IOC/UNEP/ICSU Steering Committee for the Global Ocean Observing System participate in the working group or its sub-groups;
(3) That the chairperson may seek advice from, or invite experts, in particular from satellite operators, as necessary;

Requests the Secretary-General to provide the necessary assistance and Secretariat support for this working group, within the available budgetary resources.
{end of Resolution 3 (EC-LIX)}

The Chair of the JSC for OPAG for Environmental Pollution Atmospheric Chemistry was designated by CAS as the representative.

Subsequent Executive Councils continued to address WIGOS implementation and particularly clarification to Members of the concept that EC-LXI in June 2009 (paragraph 3.4.44-3.4.46) adopted the updated versions of the WIGOS Concept of Operations (CONOPS) and the WIGOS Development and Implementation Plan (WDIP) as approved by the second session of the EC-WG/WIGOS-WIS, held in Geneva from 6 to 8 May 2009 (see: http://www.wmo.int/pages/prog/www/WIGOS-WIS/reports.html). It reiterated that Members, regional associations and technical commissions should actively collaborate in testing, developing, and implementing the WIGOS concept, and provide their input to WDIP. The Council requested that the WIGOS implementation strategy clearly indicate that it complements rather than duplicates implementation plans of WIGOS systems, such as GOS, WHYCOS and GAW. Furthermore, the strategy should clearly distinguish between GCOS which is a “system of systems for Climate” and WIGOS which is the integration of observing systems needed to meet WMO’s requirements in this area of activity.

World Meteorological Organization **CAS-XV/INF. 5.1**

COMMISSION FOR ATMOSPHERIC SCIENCES

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Incheon, Republic of Korea
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Agenda item: 5.1

RECOMMENDATIONS ON AREP ACTIVITIES - WORLD WEATHER RESEARCH PROGRAMME (WWRP)

SUMMARY

Reference: **CAS-XV/Doc. 5.1**

CONTENT OF DOCUMENT:

Appendix:

- Background information on World Weather Research Programme

BACKGROUND INFORMATION ON WORLD WEATHER RESEARCH PROGRAMME (WWRP)

1. The WWRP is an Open Area Programme Group (OPAG) of CAS, led by the WWRP Joint Scientific Committee (JSC). It is composed of the THORPEX Programme and five working groups. A brief description of the activities of the WWRP goals and activities can be found at http://www.wmo.int/wwrp including the Strategic Plan for the Implementation of the WMO's World Weather Research Programme (WWRP):2009-2017. The WWRP activities discussed in CAS-XV/Doc. 5.1 include the following.

Nowcasting Research

2. Nowcasting is the detection and forecasting of weather over the 0-6 hour time frame. Within the WWRP, nowcasting research is initiated, guided and reported on by the WWRP Working Group on Nowcasting Research (http://www.wmo.int/wwrp/nowcasting). The purpose of this working group is to promote nowcasting (detection and forecasting weather over the 0-6 hour time frame) to advance nowcasting science, and to undertake capacity building and expertise sharing within the WMO framework. The nowcasting research priorities include:

(i) Improving nowcasting predictive skill and characterizing uncertainty;

(ii) Promoting physically based nowcast prediction through high resolution model development and data assimilation;

(iii) Developing improved observational capability in nowcasting;

(iv) Characterizing observational errors and algorithm processing errors and their impact on nowcasting; and

(v) Improving nowcast processes, optimizing the role of humans and developing supporting systems.

3. Key ongoing and recent activities in nowcasting research within the WWRP include:

(i) Beijing 2008 Forecast Demonstration Project (FDP) (see http://www.wmo.int/pages/prog/arep/wwrp/new/documents/Doc3_2_2_1_final_report_Beijing_08_FDP.doc) was conducted successfully during the Beijing 2008 Olympics to demonstrate how operationally tested state-of-the-art nowcast systems can provide an improved (value-added) nowcast service in the Beijing area. Agreed WWRP products were made available to end users for evaluation, the 3rd B08 FDP Workshop during 2009 was a significant event highlighting advances in research undertaken as a result of the FDP;

(ii) Nowcasting was a critical component of the MAP D-PHASE FDP (http://www.map.meteoswiss.ch/map-doc/dphase/dphase_info.htm), which was aimed at evaluating the impacts of new research techniques on operational efforts to predict flooding and heavy rainfall in an alpine setting and will also host symposia summarizing advances in hydrological nowcasting;

(iii) For winter nowcasting research the SNOW 2010 FDP (see http://www.snow-v10.ca/) is proposed in Vancouver with a focus on such issues as nowcasting fog, visibility, and precipitation in various phases in an orographically forced winter maritime regime;

(iv) The working group lends its expertise to radar quality control efforts within GEWEX and organized the 2nd WWRP Symposium on Nowcasting and Very Short Range Weather Forecasting (WSN09) in Canada during 2009;

(v) Topics for planned scientific workshops include the Unified Frameworks for Probabilistic Approaches to Nowcasting and Very Short Range Forecasting, Advancing the Utilization of Satellite Techniques in Nowcasting, and Nowcasting for Hydrological Purposes.

Mesoscale Forecasting Research

4. Within the WWRP, mesoscale weather forecasting research concentrates on the meso-gamma scale using models and observations with spatial scales of ~500m – 3km and time scales extended from 0 - ~48h. The research goals are to strengthen international cooperation in research on mesoscale forecasting, knowledge transfer and capacity building in this field. Within the WWRP research in this area is initiated, guided and reported on by the WWRP Working Group on Mesoscale Weather Forecasting (http://www.wmo.int/wwrp/mesoscale), which fosters research in:

(i) Mesoscale data assimilation: investigations on the strengths and limitations of different data assimilation approaches, and observation impact studies;

(ii) The representation of convection and complex terrain in mesoscale models;

(iii) The role of the surface in mesoscale modeling and assimilation systems, and the ways to represent and consistently assimilate surface characteristics in mesoscale models; and

(iv) Predictability at the mesoscale, and the design and performance evaluation of mesoscale ensemble forecast systems.

5. WWRP activities in the area of mesoscale forecasting research include:

(i) The COPS (Convective and Orographically-induced Precipitation Study) Research Demonstration Project (RDP) in southwest Germany and eastern France was a major field experiment designed to advance knowledge and the prediction of precipitation in low mountain regions. For more information on COPS (see https://www.uni-hohenheim.de/spp-iop/). Research includes a description of convection in mesoscale models, mesoscale data assimilation and observation impact studies;

(ii) The working group participated in the MAP D-PHASE FDP end-to-end forecast and warning chain involving mesoscale atmospheric and hydrological deterministic models and ensembles over the Alps and the Beijing 2008 RDP http://www.wmo.ch/pages/mediacentre/news/documents/beijing_wwrp_2.pdf) through mesoscale forecast deterministic models and ensemble forecast systems. Research is proposed to be conducted during the Vancouver 2010 SNOW FDP to investigate mesoscale ensemble forecasting under steep topography in winter conditions and during the Shanghai 2010 to investigate mesoscale ensemble forecast capabilities within an integrated warning system for high-impact weather;

(iii) The working group is organizing regional IMRE (Integrated Mesoscale Research Environment) activities based on mesoscale data assimilation, convection parameterization, surface and mesoscale ensemble forecasting in association with data sets from past major field campaigns and testbeds;

(iv) The working group will organize a workshop on international surface physiography, data assimilation for nowcasting, has and will contribute to the organization of the WMO Data Assimilation Symposium (2009, 2013) and the Quantitative Precipitation Forecasting Symposium in 2010 or 2011 in China with the Tropical Research Working Group.

Tropical Meteorological Research

6. Within the WWRP, tropical meteorological research focuses on the phenomena of tropical cyclones and monsoons. These research areas are guided by the WWRP Working Group on

Tropical Meteorology Research (http://www.wmo.int/wwrp/tropical) and its two components: the Tropical Cyclone Panel and the Monsoon Panel. Both research areas have the goal of supporting tropical meteorology research among the WMO Members that will lead to improved observation, analysis, forecast, and warning systems for high-impact tropical weather events, and thus contribute to disaster prevention and mitigation. The highest research priorities stem from the most significant health and safety threats where improved science can reduce the impacts:

(i) To advance understanding and capability to forecast tropical cyclone landfall and its impacts which include the areas of tropical cyclone structure, intensity, track and genesis; and

(ii) To advance understanding and capability to predict the heavy monsoon rainfall events and their impacts.

7. Current and future activities in this area will include:

(i) The Tropical Cyclone Programme within the Weather Risk and Disaster Risk Reduction Services (WMO/TCP) and China hosted the second International Workshop on Tropical Cyclone Landfall Processes in October 2009 and the WMO/TCP and the Panel will organize the 7th IWTC in 2010 under the direction of an International Organizing Committee, including preparation of a Workbook by the WGTMR Tropical Cyclone Panel Expert Teams and invitations to forecasters and researchers. The Panel will also be involved in organizing, in conjunction with Météo-France, a workshop for preparation, planning and implementation for Southwest Indian Ocean Cyclone Experiment (SWICE) (http://www.wmo.int/pages/prog/arep/wwrp/new/documents/Doc3_7_4_1_swice_summary.pdf);

(ii) The panel will organize, in cooperation with WGNE, an International Mesoscale Model Intercomparison of Typhoon Sinlaku with the preliminary organization via electronic conferencing and then the final Workshop in 2010 or 2011;

(iii) The Expert Team on Climatic Effects on Tropical Cyclones has issued an updated statement on Tropical Cyclones and Climate Change in 2009 with an article in review for journal publication and will begin ground work on the next statement, while the Expert Team on Seasonal Forecasts of Tropical Cyclone Activity will continue preparation;

(iv) Materials are being prepared for the WMO Website on seasonal forecasts of tropical cyclones;

(v) Co-editors J. Chan and J. Kepert have submitted the updated book, Global Perspectives on Tropical Cyclones, that originated from IWTC-VI and Editor C. Guard will soon submit a website version of the updated Global Guide on Tropical Cyclone Forecasting;

(vi) Monsoon Panel members have collect manuscripts from IWM-IV (the 4th International Workshop on Monsoons) and prepared an updated WMO Technical Document No. 1266 for publication in early 2009. Lecture materials from the International Training Workshop on Monsoons have also been made available by Monsoon Panel in early 2009;

(vii) Editing and production of a hard cover book Global Monsoon Systems: Research and Forecasting will conclude with publication in late 2009 or early 2010;

(viii) The Monsoon Panel Expert Team on Severe Monsoon Weather will, by mid-2009, identify national and regional field experiments/observing projects on heavy monsoon rainfall/high-impact weather and identify potential collaborative research projects;

(ix) Plans are moving forward on the three archive centres proposed by the Monsoon Panel (see JSC report on http://www.wmo.int/wwrp);

(x) The Monsoon Panel will review the overall results of IWM-IV in early 2010 and begin long-range planning for IWM-V in 2012;

(xi) The Monsoon Panel and the Topical Cyclone Panel in conjunction with NCAR, NOAA and host China and the Mesoscale Forecasting Panel will organize, in June 2010, the third International Conference on QPE and QPF with sessions emphasizing monsoon and tropical cyclone rainfall.

Societal and Economic Research and Applications

8. The purpose of the societal and economic research and applications is to advance the science of the application of weather-related information and services. These activities are overseen by the WWRP Working Group on Societal and Economic Research and Applications (SERA) (see http://www.wmo.int/wwrp/societalimpacts) whose membership includes multidisciplinary social, economic or decision scientists, representatives of organizations that engage users in the development, application and use of weather and related information and representatives of users that benefit from this information. The emphasis is on weather conditions that directly influence mortality, morbidity, significant loss of property and critical infrastructure and resources required to support communities. Research priorities of WWRP SERA activities include:

(i) Estimation of the economic (societal) value of weather information;

(ii) Understanding the use of weather information in decision making;

(iii) Communication of weather forecast uncertainty;

(iv) Development of user-relevant verification methods; and

(v) Development of decision support systems and tools.

9. The working group has a new Chair, Brian Mills of Environment Canada and new membership. The first meeting of this working group took place on 13 and 14 October 2009 at the International Centre for Theoretical Physics (ICTP) and ICTP is thanked for hosting this meeting. The first meeting established priorities and endorsed the explored partnership with the multi-sponsor programme on Integrated Research on Disaster Risk (IRDR), which was established by ICSU. The initial proposed projects of the SERA Working Group are listed in Doc. 3.1 with subsequent actions in 2010 focusing on actions to define how to implement these tasks.

Weather Modification Research

10. Members have requested guidance on the scientific foundation for weather modification and this need is met by the WWRP Expert Team on Weather Modification (see http://www.wmo.int/wxmod). This entity within WWRP has long historical roots and this expert team continues to play an important role in providing guidance on the scientific validity of weather modification to WMO Members and also cataloguing weather modification projects among Members. The next statement on weather modification will be produced in 2010 or 2011 following a workshop and meeting of the Expert Team in 2010. The 10th WMO Scientific Conference and Forum on Weather Modification is tentatively planned for 2012 conditional upon Member contributions to the WMO Trust Fund on Weather Modification established at the request of Cg-XV and in-kind contributions.

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World Meteorological Organization	**CAS-XV/INF. 5.2**
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RECOMMENDATIONS ON AREP ACTIVITIES - WWRP-THORPEX ACTIVITIES

SUMMARY

Reference: **CAS-XV/Doc. 5.2**

CONTENT OF DOCUMENT:

Report prepared by the THORPEX International Programme Office (IPO) on THORPEX activities and plans

Appendix:

- WWRp-THORPEX activities and plans

WWRP-THORPEX ACTIVITIES AND PLANS

1. Introduction

The report *(see CAS-XV/INF. 3.4)* by the Chair of the THORPEX International Core Steering Committee (ICSC) has already set out the scope, research priorities and organizational structure of the THORPEX Programme. As explained in CAS-XV/INF. 3.4, two THORPEX Working Groups have been charged by the ICSC to develop and coordinate specific activities for the THORPEX programmes.

- Predictability and Dynamical Processes Working Group (PDP WG) – global-to-regional influences on the evolution and predictability of weather systems;

- Data Assimilation and Observing Systems Working Group (DAOS WG) – global observing system design; targeting and assimilation of observations.

To complement and support the work of these working groups, the ICSC established the Global Interactive Forecasting System (GIFS) – THORPEX Interactive Grand Global Ensemble Working Group (GIFS-TIGGE WG). The initial task given to the GIFS-TIGGE WG was to develop and test a global multi-model ensemble prediction system and this is a continuing task.

Regional Committees

Nations and consortia of nations have established THORPEX Regional Committees (RCs) that define regional priorities for participation in THORPEX within the framework of the THORPEX International Science and Implementation Plans. These THORPEX Regional Committees develop regional activities within the framework of the international plans and their plans are discussed by the EC and reviewed and approved by ICSC. They facilitate provision of funding, logistical and other support, planning, coordination and implementation of THORPEX activities conducted by the region with respect to the THORPEX International Research Implementation Plan. To date Regional Committees have been established for Asia (ARC), Africa (AfRC), Europe (ERC), North America (NARC) and the Southern Hemisphere (SHRC).

2. Activities

2.1 THORPEX Predictability and Dynamical Processes (PDP WG)

The main task of the PDP WG is to identify basic research problems with significant importance for numerical weather prediction and to accelerate the transfer of new techniques from academia to the operational practice. The PDP WG achieves these goals by bringing together the academic dynamical meteorology community and the operational numerical weather prediction centres. It encourages the dynamical meteorology community to carry out dynamical process studies with the specific aim to improve the understanding of the relationship between particular processes and weather forecast accuracy.

In particular, the PDP WG:

- Strives to identify the barriers to improving predictive skill;

- Promotes and encourages research on the dynamics and predictability of high-impact weather events and on research relevant to seamless prediction;

- Contributes to the design of field programmes related to atmospheric dynamics and predictability (in particular T-PARC and T-NAWDEX);

- Promotes the use of data sets compiled by THORPEX (e.g., TIGGE, T-PARC, YOTC);

- Organizes summer schools to contribute to the education of the next generation of dynamical meteorologists;

- Compiles reports on research results that are the most relevant to a better understanding of atmospheric predictability and the improvement of forecast accuracy.

Since the PDP WG has been tasked with identifying barriers to improving predictive skill, which include parameterization and other model errors, strengthening the existing collaboration between PDP WG and the WGNE is crucial and during the joint WGNE and THORPEX ICSC session held on 3 November 2009 further attention will have been given to this collaboration.

The PDP WG has identified a number of tasks with which the group will be involved over the next few years and these include:

- Prepare and publish a comprehensive review of predictability issues;

- Participate in the design, execution and analysis of field experiments including NAWDEX / HYMEX;

- Encourage the dynamical meteorology community (in particular academia) to study the relationship between dynamical processes and forecast accuracy (for example, diagnosis of forecast errors and predictability);

- Encourage further research on the following problems of ensemble prediction:

    - Further development and understanding of multi-model ensemble post-processing techniques, in particular estimates of the relative weights to be given to the various members;
    - Assess the value of an ensemble of high-resolution deterministic forecasts compared with the value of a single- or multi-model ensemble at coarser resolution;
    - Continue investigation on how to best combine high-resolution deterministic control forecasts with lower-resolution ensemble members;

- Sponsor and encourage studies (in conjunction with the African Regional Committee) of model diagnostics, predictability, ensemble forecasting and dynamical processes in Africa; in particular it is recommended that:

    - A catalogue of high-impact African weather events is compiled and the quality of operational predictions for these events is assessed;
    - The utility of Ensemble Prediction Systems for Africa is assessed;
    - Model diagnostic studies of African weather systems are carried out.

2.2 THORPEX Data Assimilation

The Data Assimilation and Observing System Working Group (DAOS WG) was established to ensure that THORPEX contributes to the international efforts to optimize the use of the current WMO Global Observing System (GOS) and to the development of well-founded strategies for the evolution of the GOS to support Numerical Weather Prediction primarily for 1 to 14 day weather forecasting.

To achieve its mission the DAOS WG, in collaboration with the CBS OPAG-IOS:

- Addresses data assimilation issues including the development of improved understanding of the sources and growth of errors in analyses and forecasts;

- Promotes research activities that lead to a better use of observations and the understanding of their value;

- Provides input and guidance for THORPEX regional campaigns for the deployment of observations to achieve scientific objectives.

For the T-PARC the DAOS WG group will:

- Review data impact results for the summer phase;

- Extend the observation impact inter-comparison for the winter phase;

- Support the testing of the impact of enhanced Russian radiosonde network on operational data assimilation systems to determine the value of maintaining the extended network;

- Evaluate the use of alternative satellite data sets that are not available operationally.

In support of future campaigns, such as T-NAWDEX (see below), the group will engage in:

- A review of the results from the NOAA Winter Storm Reconnaissance 2001–2008.

With regard to the additional in-situ data deployed during AMMA the group will:

- Lend support to organizations that are working to keep the additional AMMA in-situ data available;

- Encourage the investigation of the impact of radiosonde and AMDAR data over Africa.

In the context of the THORPEX IPY Cluster Project (see below) International Polar Year, the group will:

- Coordinate the work on satellite data assimilation over the polar regions;

- Investigate the impact of the improved use of satellite data and of in-situ observations.

General studies will be sponsored to:

- Optimize the deployment and usage of existing operational in situ observing systems;

- Support the use of well-calibrated OSSEs to evaluate the impact of new instruments;

- Assess model error using ensembles;

- Investigate fundamental issues such as the use of flow-dependent structure functions, the evaluation of the downscale impact of global scale improvements on the meso-scale and issues on coupled data assimilation and new data sets associated with it.

2.3 Field Campaigns

The field campaigns which are currently receiving the most attention are T-PARC (see CAS-XV/INF. 3.4), T-NAWDEX and HyMeX

T-PARC

Investigators from the research and operational communities within Canada, China, France, Germany, Japan, Korea, Mexico, Russia, and the United States are now leading the evaluation of the T-PARC field data. The general strategies for accomplishing the T-PARC goals span observational, theoretical and modelling disciplines and, of course, long-term research efforts that span years beyond the field phase. The specific research tasks include:

- Providing recommendations on the design of the global observing system through forecast impact studies that utilize operational and experimental data from T-PARC and the collaborative experiments;

- Testing the degree to which skill for short- and medium-range prediction can be improved by future assimilation and modelling strategies including the use of global non-hydrostatic models at very high resolution;

- Further investigating the utility of ensemble models;

- Advancing our understanding of the predictability of high-impact weather events both over East Asia and the western North Pacific region and at “downstream” locations.

T-NAWDEX

The THORPEX-North Atlantic Waveguide and Downstream Impact Experiment (T-NAWDEX) is planned as an integral component of THORPEX with a field phase tentatively scheduled for autumn 2012. The focus of the experimental and theoretical research is the study of processes acting along the North Atlantic wave guide, especially the triggering of wave guide disturbances, their subsequent evolution over the North Atlantic and their eventual downstream impact over Europe.

The overarching scientific goal of T-NAWDEX is the detailed investigation of the diabatic physical processes that are primarily responsible for degradation in 1-7 day forecast skill in global prediction systems and of their representation in numerical weather prediction (NWP) models. Forecast advances will be made by improving the representations of these diabatic processes in various weather systems, including the poleward motion of tropical cyclones, organized tropical convection, warm conveyor belts, and the extra-tropical forcing of convection by high amplitude troughs. A fairly complete version of the T-NAWDEX science plan will become available in mid-2010.

HyMeX

HyMeX (Hydrological cycle in the Mediterranean EXperiment), lead by Météo-France, aims at a better understanding and quantification of the hydrological cycle and related processes in the Mediterranean, with emphasis on high-impact weather events, inter-annual to decadal variability of the Mediterranean coupled system, and associated trends in the context of global change.

The Mediterranean region features a nearly closed sea surrounded by urbanized littorals and mountains from which numerous rivers originate. This results in a lot of interactions and feedback between oceanic, atmospheric, and hydrological processes which are perturbed by anthropogenic activities and play a predominant role in the regional climate and ecosystems. The Mediterranean climate is also influenced by both sub-tropical and mid-latitude climate dynamics and is therefore very sensitive to global climate change. Extreme weather events (heavy precipitation and flash-flooding, strong winds and large swell, droughts, etc) regularly affect the Mediterranean region causing heavy damages and human loss. The ability to predict such dramatic events remains weak because of the contribution of very fine-scale processes and their non-linear interactions with the larger scale processes.

The HyMeX programme seeks to:

- Improve our understanding of the water cycle, with emphasis on extreme events, by monitoring and modeling the Mediterranean atmosphere-land-ocean coupled system, its variability from the event to the seasonal and interannual scales, and its characteristics over one decade (2010-2020) in the context of global change;

- Assess the social and economic vulnerability to extreme events and adaptation capacity.

The multidisciplinary research and the database developed within HyMeX should contribute to:

- Improve observational and modeling systems, especially for coupled systems;
- Better predict extreme events;
- Simulate the long-term water-cycle more accurately;
- Provide guidelines for adaptation measures, especially in the context of global change.

2.4 THORPEX sub-projects

The THORPEX IPO provides support for two international projects, the THORPEX IPY Project Cluster (see CAS-XV/INF. 3.4) and the Year Of Tropical Convection (YOTC, see CAS-XV/INF. 7).

THORPEX IPY Project Cluster

The main strategic objectives of the Project Cluster are:

- Explore the use of satellite data and optimized observations to improve high-impact weather forecasts (for Polar THORPEX Regional Campaigns (TReCs) and/or provide additional observations in real-time over the WMO Global Telecommunication System);
- Improve the understanding of physical/dynamical processes in Polar Regions;
- Achieve a better understanding of small-scale weather phenomena;
- Utilize the THORPEX Interactive Grand Global Ensemble (TIGGE) of weather forecasts for polar weather prediction;
- Utilize improved forecasts for the benefit of society, the economy and the environment.

At its seventh session the THORPEX ICSC "*strongly recommended that WWRP/THORPEX considers the formation of a Polar Research Project to ensure continuity from the THORPEX IPY Cluster and report back to ICSC8 and CAS".*

A CAS-XV vision paper has been written and submitted (main author D. Carlson; co-authors T.E. Nordeng and J.E. Kristjansson) summarizing IPY achievements obtained and outlining proposals for a legacy from IPY.

The conclusions of the vision paper are:

- "We call for an immediate, high-level and sustained focus on polar prediction services, stimulated, led and coordinated by WMO, as the best way to integrate and synthesize the IPY observational efforts and to communicate and maximise the impact of IPY science;"
- "We encourage the Commission for Atmospheric Science of WMO, representing weather, climate, water and environmental prediction research, to find ways to do this. We believe that the WMO Executive Council Panel of Experts on Polar Observations, Research and Services has a mandate to help implement recommendations."

The establishment of a THORPEX NWP IPY follow-on project, complementary to YOTC, represents an appropriate and urgent task for the THORPEX community. Such a polar project would build on the achievements of the IPY cluster and help to coordinate polar predictability research. By the time of CAS-XV, the THORPEX ICSC will have discussed this issue and will have decided on a way forward.

The Year of Tropical Convection (YOTC)

The status of the "*The Year of Tropical Convection" (YOTC) is described in* CAS-XV/INF. 7

2.5 Ensemble Prediction – TIGGE, TIGGE LAM (Limited Area Modelling), GIFS and seasonal prediction

TIGGE-related research

Early research results indicate that multi-model ensemble forecasts are in general better than the forecasts of the best component system. The benefit appears to be clearer for fields such as surface air temperature, but only marginal for dynamical variables such as sea level pressure or geopotential height. Furthermore, the gain is highly variable depending on component systems, parameters, forecast ranges and bias corrections applied. More research is needed to establish the cost/benefits of operational multi-model systems. Research papers based on the TIGGE data set are now starting to be published in peer-reviewed journals. Recently the HEPEX Project (Hydrological Ensemble Prediction Experiment) has proposed establishing linkages to TIGGE to develop applications for hydrological ensemble prediction. Further information on HEPEX can be found at http://hydis8.eng.uci.edu/hepex/. HEPEX seeks to quantify hydrological forecast uncertainty.

A TIGGE-LAM expert panel has been set up to define arrangements for TIGGE-LAM databases, building on the global TIGGE arrangements as much as possible. The priority here is to develop standard formats enhancing the interoperability of the existing systems. Another objective is to facilitate the use of lateral boundary conditions from various global systems by limited–area models.

A Global Interactive Forecasting System

TIGGE is paving the way towards a Global Interactive Forecasting System (GIFS). An urgent development to make GIFS a reality is to accelerate data exchange between the partners and a phased approach has been adopted. A pilot project, based on the real-time exchange of tropical cyclone tracks, was succesfully run during the T-PARC field programme. In order to carry this work forward, it is proposed to establish a GIFS Research and Development Project (GIFS-RDP). The GIFS-RDP will provide a framework for the experimental provision of products to enhance the prediction of high-impact weather. It is planned that GIFS-RDP will initially operate alongside regional subprojects of the CBS Severe Weather Forecast Demonstration Project (SWFDP) This will enhance links between WWRP-THORPEX GIFS and the operational weather forecasting community, and allow products based on TIGGE forecasts and multi-model ensemble to supplement the data available from the SWFDP to operational forecasters. Objective verification and user evaluation of the GIFS products will be a key part of GIFS-RDP. A WMO ad-hoc committee across regional, CBS and CAS efforts is being formed to make recommendations on the implementation of this RDP.

Recently, as follow-on to T-PARC, the Asian Regional THORPEX Committee and collaborators have proposed a project to explore the utility of TIGGE tropical cyclone track ensembles in operational prediction. The tracks were first made available by six centres during T-PARC. The project is tentatively named "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" with the goals to: (i) develop and extract useful information from the TIGGE TC ensemble forecast data; (ii) to deliver the extracted information to Typhoon Committee Members and interested researchers; and (iii) obtain feedback from forecasters/researchers on the delivered information. The project will deliver "ensemble track data" at the beginning and expand other variables, such as precipitation, maximum wind speed, etc. for future consideration. The project is intended to have a strong link with GIFS-RDP and will contribute to the Shanghai EXPO 2010 via CMA/NMC, CMA/SMB and CMA/STI efforts.

Seasonal Prediction

There are growing requirements for operational monthly to seasonal predictions of weather, climate, water and air pollution – see CAS-XV/INF. 7. An effective way to undertake the necessary research to improve predictions at these ranges is to strengthen the collaboration between the programmes of CAS, particularly WWRP and WCRP, with the goal of developing a seamless approach to seasonal weather and climate prediction. As suggested in CAS-XV/INF. 7, such a collaborative effort should be focussed on Ensemble Prediction Systems (EPS), Tropical Convection, Coupled data assimilation and social and economic benefits from monthly to seasonal predictions. With respect to the EPS element, it would be natural to coordinate the research activities of the WCRP CLIVAR Climate-System Historical Forecast Project (CHFP) and the THORPEX Interactive Grand Global Ensemble (TIGGE) on sub-seasonal and seasonal predictions. This will of course require some revision to the THORPEX Working Group structure.

3. Regional Activities and Plans

3.1 African Regional Committee (AfRC)

The overall economic and societal goals of the African Science and Implementation Plans are to provide the research to reduce the adverse effects of meteorological, hydrological and climate-related natural disasters in Africa. Of high importance is to provide more timely and precise advisories and early warnings of high-impact weather and to enable governments, societies and economic sectors to realize the benefits of weather and climate-related information in critical decision-making. Also of importance is the promotion of multidisciplinary collaboration between research, operations and user communities to deliver the benefits of improved earth observations, advanced communications and forecast systems in Africa.

3.2 Asian Regional Committee (ARC)

Asian Regional Plans and activities have included the new Ensemble Prediction System (EPS) introduced by Korea in 2006, the OSE work conducted by Japan concerning tropical cyclones and the ideas for distributing targeting information for tropical cyclones. Important Asian contributions to T-PARC were associated with studies of typhoons, extratropical transition, and downstream propagation.

Within the regional activities THORPEX-China has focussed on establishing the THORPEX-China research plan, making progress with TIGGE at the CMA and EPS developments at CMA. The T-PARC China component sought to enhance international collaboration, to test new techniques for adaptive observations and study the mechanisms and predictability of high-impact weather events that affect China and eastern Asia more generally.

3.3 European Regional Committee (ERC)

The European plan builds upon the overall THORPEX Science Plan and focuses on implementation and prioritisation of the scientific issues that are specific to European interests, and recommendations for actions to be initiated within Europe. The most important links to other organisations and programmes inside and outside THORPEX, and inside and outside Europe, are documented.

The plan reflects the special circumstances of meteorological research in Europe. Most important is the large number of nations, each with its own research funding structure, and its own National

Meteorological Service. These are supplemented by trans-national organizations at the European level, including EUMETNET, EUMETSAT and ECMWF, as well as trans-national research and coordination agencies, such as the European Community Framework Programmes, and the Cooperation in Science and Technology (COST) Programmes.

The diversity of meteorological research in Europe influences the priorities in the plan, notably the significant emphasis on limited-area modelling, data assimilation, multi-model ensembles, and model development.

3.4 North American Regional Committee (NARC)

The NARC engages in and supports a wide range of collaborative activities particularly T-PARC and the IPY. It also has a particular focus on ensemble prediction including TIGGE and the NAEFS. A further strong regional interest is in tropical-extratropical interactions, the improved representation of organized tropical convection in numerical models and the effects on middle latitude weather. Longer term and on-going efforts include capacity building and developing specific projects for societal research.

3.5 Southern Hemisphere Regional Committee (SHRC)

The SHRC has developed Science and Implementation Plans that reflect the key common issues across the Southern Hemisphere. These plans develop a rationale for a Southern Hemisphere regional focus for THORPEX that emphasises a number of important features that are of common interest across the hemisphere. An Implementation Plan was subsequently developed and finalized at a three-day workshop held in Melbourne, Australia, in May 2007. Overall this Plan has been deliberately designed at this stage to be modest. There are, for example, no plans for “big science” or new field programmes. The Plan projects largely draw on focussing and coordinating existing and planned research to contribute to the areas of common interest. Working groups have been set up in areas of SERA, DAOS and PDP.

World Meteorological Organization **CAS-XV/INF. 5.3**

COMMISSION FOR ATMOSPHERIC SCIENCES

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RECOMMENDATIONS ON AREP ACTIVITIES - ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY (EPAC)/GLOBAL ATMOSPHERE WATCH (GAW) ACTIVITIES

SUMMARY

Reference: **CAS-XV/Doc. 5.3**

CONTENT OF DOCUMENT:

Background information on Environmental Pollution and Atmospheric Chemistry (EPAC)/Global Atmosphere Watch (GAW) Activities.

BACKGROUND INFORMATION ON ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY (EPAC)/GLOBAL ATMOSPHERE WATCH (GAW) ACTIVITIES

1. Ozone depletion, Ultraviolet Radiation and the Vienna Convention

Ozone

1.1 In addition to protecting us from harmful solar UV radiation, ozone is also a key variable needed for understanding climate processes and climate change. Column ozone and ozone were designated as Essential Climate Variables (ECVs) in the Second Report on the Adequacy of the Global Climate Observing System (GCOS) in Support of the UNFCCC.

1.2 Column ozone has been measured from the ground with Dobson spectrophotometers since the 1920s and more recently with Brewer spectrophotometers that also measure spectral UV. Ozone profile information can be extracted from Dobson and Brewer Umkehr measurements.

1.3 The Dobson instruments need to be regularly compared with regional standard instruments through side-by-side comparisons. The regional standard instruments are compared in turn with the Dobson world primary instrument. The world primary Dobson instrument has been calibrated by the Langley plot method at the Mauna Loa Observatory at Hawaii at regular intervals since 1972. It is desirable that the Brewer instruments be calibrated every two years.

1.4 Ozonesondes measure profile ozone in the atmosphere up to about 30-35 km above the Earth's surface. For quality assurance the different types of ozonesondes used in the global network need to be regularly intercompared to each other and validated to reference instrumentation. This is of crucial importance to ensure long-term stability and homogeneity of sonde measurements for satellite validation and for the detection of long-term changes of ozone.

1.5 The WDC for ozone and ultraviolet radiation (WOUDC) in Canada started its services with ozone data in 1961 and added UV in the early 1990s. The primary role is data stewardship, data archiving and preliminary QA services. There are 372 ozone stations or platforms and 86 UV stations or platforms with 142 submitting agencies from 76 countries. Data products are available both from the website and on DVDs. Visits to the website and file retrievals have increased over the years, with some levelling in the last five years. The close relationship with data providers is critical to the success of the WOUDC.

1.6 The Network for the Detection of Atmospheric Composition Change (NDACC) is a set of more than 70 high-quality, remote-sensing research stations for observing and understanding the physical and chemical state of the stratosphere and the free troposphere and for assessing the impact of atmospheric composition change on global climate. The NDACC observations comprise, among other, UV spectroradiometric observations, column ozone measurements as well as observations of ozone profiles. The Southern Hemisphere Additional Ozonesondes (SHADOZ) network was established in 1998 to unify the operating and reporting procedures of stations operating in the southern hemisphere tropics and subtropics. SHADOZ coordinates launches, supplies additional sondes in some cases, and provides a central archive location. Currently, fourteen active sites are participating in SHADOZ. The SHADOZ and NDACC networks are contributing to GAW.

1.7 Each year WMO GAW publishes the Antarctic Ozone Bulletins. Effective stratospheric chlorine peaked shortly before 2000. Complete destruction of ozone between 14 and 21 km can be measured in September to October each year. The size of the ozone hole depends primarily on meteorology. The year 2006 had the lowest measured partial column ozone value and the year 2008 had the longest lasting ozone hole indicating a stable vortex. Results indicate no signs of ozone recovery in Antarctica.

1.8 In accordance with the relevant decisions of the Conference of the Parties, the Seventh Meeting of the Ozone Research Managers (ORM) of the Parties to the Vienna Convention for the Protection of the Ozone Layer was held in Geneva in 2008, six months prior to the Eighth Conference of the Parties which was held back-to-back with the Twentieth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer.

1.9 The Seventh ORM reviewed ongoing national and international research and monitoring programmes with a view to ensure the proper coordination of these programmes and to identify gaps that need to be addressed. The Ozone Secretariat together with the World Meteorological Organization (WMO) and in consultation with the Bureau of the Seventh Conference of the Parties to the Vienna Convention proposed to place a stronger emphasis on the future of satellite monitoring of the atmosphere.

1.10 The 21st Quadrennial Ozone Symposium of the International Ozone Commission (IO3C) of the International Association of Meteorology and Atmospheric Sciences (IAMAS) was held in Norway in 2008. This symposium series represents the major meeting place for ozone scientists and several hundred scientists meet to discuss all aspects of ozone depletion.

Ultraviolet radiation

1.11 UV radiation influences both the atmosphere and the biosphere. It is a driver of atmospheric chemistry, and has a range of effects on both aquatic and terrestrial ecosystems. The main interest for UV monitoring came from the negative influences of UV on human health, starting in the 1980s and boosted by concerns about stratospheric ozone depletion and the associated increases in UV.

1.12 GAW Regional Calibration Centres (RCC) for UV exist in NOAA, Boulder, Colorado (USA) and in PMOD/WRC, Davos (Switzerland). The Davos RCC represents the practical application of a calibration system developed originally with European Commission (EC) funding. This is based on a travelling instrument, much as Brewer calibrations revert to a travelling standard, and has proved a popular and effective facility across Europe. While the US and European facilities can be linked through intercomparisons there is not yet a world calibration centre for UV measurements. Expanding UV monitoring, particularly in developing regions, requires greater access to calibration facilities to maintain data quality and the stability of long-term monitoring.

1.13 Currently there is widespread use of the CIE erythema weighting function to represent biological effects. Although this is a compromise between several different versions of an action spectra for erythema it is widely accepted as a common reference. There are nonetheless many other UV effects on humans (e.g., skin cancer, eye diseases, immune suppression, and the positive synthesis of vitamin D) and on plants (e.g., reduced growth, DNA damage) that need to be considered as well. Often the threshold values for these effects are not known. The present knowledge is assessed every four years by the UNEP Effects Assessment Panel.

2. Atmospheric Chemistry and Climate Change

2.1 The reactive gases diverse and include surface ozone (O_3), carbon monoxide (CO), volatile organic compounds (VOCs), oxidised nitrogen compounds (NOx, NOy), and sulphur dioxide (SO_2). All of these compounds play a major role in the chemistry of the atmosphere and, as such, are heavily involved in inter-relations between atmospheric chemistry and climate, either through control of O_3 and the oxidising capacity of the atmosphere, or through the formation of aerosols. With the exception of surface O_3 and CO, the global measurement base is entirely unsatisfactory although the situation with regard to other species is under active review. Due to their importance also as atmospheric pollutants and in the long-range transport of air pollutants, the group of reactive gases is, however, dealt with under item 5.3 “Globalization of Air Pollution”.

Greenhouse gases

2.2 There is a direct connection between the atmospheric concentration of greenhouse gases and climate. Growing emissions of carbon dioxide cause a rise of global average temperature through increase in radiative forcing, its relative contribution to the increase has stood at 87% for the past decade and 90% for the last five years. The decrease in CFC production and consumption due to the Montreal protocol regulation has led to a decrease in the contribution of this group of gases to radiative forcing. On the other hand, the accelerated increase of production and consumption of HFCs and HCFCs as substitutes for CFC uses (by 8% per year in the developed countries and by 20% per year in the developing countries) may lead to a much higher contribution of HFCs to future increases in radiative forcing.

2.3 Regarding the establishment of central calibration laboratories and centers, EMPA has agreed to host and operate the WCC-CO_2 (audits) with a mandate to conduct system and performance audits at Global GAW stations beginning in 2010.

2.4 Intercomparison campaigns have been organized by the Japan Meteorological Agency, as the GAW World Calibration Centre (WCC) for methane in Asia and the South-West Pacific. They initiated intercomparisons of methane reference gases for Asia in 2005-2006 and 2008-2009 and for the South-West Pacific in 2006-2008. NOAA ESRL, CCL for CO_2, CH_4, and N_2O, started the 5th international greenhouse gas comparison experiment (round robin) in April, 2009. Three sets of cylinders, three cylinders in each set covering a range of GHG mole fractions, are circulating in Asia, Africa, and Europe.

2.5 Development/update of measurement guidelines and standard operating procedures (SOPs): CH_4 and N_2O measurement guidelines were updated in 2009 (GAW Report 185); the SAG GHG is working on the CO_2 measurement guidelines; a 'WMO/GAW Glossary of QA/QC-Related Terminology' has been made available at http://gaw.empa.ch/glossary.html.

2.6 Regular independent assessments: WCC-EMPA, established in 1996 and assuming worldwide responsibility for surface ozone, carbon monoxide and methane inter-comparisons at global GAW stations has provided regular system and performance audits at global GAW stations including intercomparison measurements with traveling standards for O_3, CO and CH_4. During 2006-2008 audits were performed at 11 stations which helped to increase data traceability and reliability.

2.7 The WCC-N_2O, established at IMK-IFU (Garmisch-Partenkirchen), has taken over world-wide responsibility for nitrous oxide at global GAW stations. From 2003 till 2008 six system and performance audits were conducted, including intercomparisons of five traveling standards. In a collaborative effort, WCC-EMPA conducts N_2O intercomparisons at Global GAW stations using travelling standards calibrated by WCC-N_2O, thereby increasing the number of stations or the frequency with which they can be assessed.

2.8 The WDCGG receives contributions from 244 stations in 60 countries and the spatial and temporal coverage and volume of the data have been steadily increasing. The WDCGG published the Data Submission and Dissemination Guide (GAW Report No. 174) in June 2007, and a revision in September 2009 as GAW Report No. 188. A technical report was published as GAW Report No. 184 in May 2009 to document the global analysis by the WDCGG.

Aerosols

2.9 Particles in suspension – or aerosols – are critical in determining the absorption or reflection of heat by the Earth's surface, clouds and atmosphere, as well as the formation of these clouds and precipitation. The presence of large amounts of aerosols may also affect the vertical stability of the atmosphere, and when deposited on surface, particles may reduce the albedo of snow, again with impacts on climate.

2.10 GALION will combine the efforts of seven different lidar networks that offer vertical profiles of aerosols at a number of locations around the world. The GAW Report No. 178 describes the plan for the implementation of GALION. As there are only a few GAW stations contributing to aerosol measurements, it should be determined if there is a nearby aerosol station in a national network that would be appropriate to be considered a contributing GAW station, instead of trying to relocate lidar systems to stations already in GAW.

2.11 As per the Precision Filter Radiometer (PFR) observations for aerosol optical depth (AOD), there are in total 30 stations operating around the world. The instruments have been built in Davos and measure four channels with 5 nm bandwidth. The network has been running since 1999 with a total of about 1000 months of data reporting hourly means with a 96% data coverage rate. The data flow within the network results in data going to the World Data Centre for Aerosols, usually as hourly means on an annual basis. Near-real-time data are available at eleven of the fourteen GAW stations, with the remaining three providing data via e-mail on a monthly basis.

2.12 The WCC for aerosol physical properties has assisted developing countries in putting up their programmes and has frequently assisted in GAWTEC training.

2.13 The WDC for Aerosols (WDCA) has been hosted by the Joint Research Centre of the European Commission (JRC) since 1995. The SAG Aerosol discussed at length at their meeting in April 2009 the possibility of moving the World Data Centre for Aerosols (WDCA) from JRC to NILU, Norway and seeked endorsement for this from the OPAG EPAC JSC. The JSC supported this move, provided that appropriate attention be paid to the requirements and to the formulation of the MoU, one concern being retaining the identity of the WDCA.

3. Globalization of air pollution

Precipitation chemistry

3.1 Measurements of precipitation chemistry and wet deposition have been made for many years in various regions of the world with varying degrees of success. In general, those areas in which acid deposition has been a major environmental concern have developed and implemented sophisticated, high quality measurement systems. In other areas, however, the number of sites has been insufficient and the measurement methods and programmes remain inadequate and poorly integrated into the GAW programme. Representatives from major networks from Asia, Europe, and North America are in strong agreement about the major tenets of an acceptable GAW programme and have issued a comprehensive set of guidelines for the GAW programme, published as GAW Report 160 (December 2004). The present challenge continues to concern the need to reduce inconsistencies and improve data quality among established programmes and to stabilize and enhance high quality programmes in present data-sparse regions of the globe.

3.2 Many of the chemical laboratories from DEBITS and from stations associated with other remote regions of the globe continue to participate in the GAW annual laboratory inter-comparison studies. Unfortunately, the performance of many of the laboratories has been inconsistent, and some laboratories simply do not participate. The laboratory intercomparisons will continue in the future under the auspices of QA/SAC Americas. Powerful tools have been established to clearly identify poorly performing laboratories, and protocols have been established to work with such laboratories to improve performance. Twinning activities and expert site visits will be required to ensure measurable progress. To enhance global coverage, a new site near Cordoba, Argentina is being established.

3.3 The WMO precipitation assessment will update the earlier WMO Global Precipitation Chemistry Assessment published in 1995. The writing team of the Assessment consists of scientists from South Africa, Norway, Russia, Australia, Japan, India, Italy, Switzerland, Brazil, the USA and Canada. The objective of the Assessment is to review and synthesize the state of the science on the chemical composition of precipitation and deposition of major ions at a global and regional scale.

3.4 As regards deposition to the oceans, several factors determine whether a part of the ocean will receive atmospheric inputs that could alter biogeochemical processes. Three important factors are the reactivity of the material being deposited, the residence time of the chemical in the atmosphere and atmospheric transport patterns relative to the sources. The collaboration between WMO and GESAMP is in conformity with the agreed WMO EC policy on continuing support of GESAMP to address topics relevant for WMO, such as atmospheric-ocean interactions, including exchange of pollutants, effects on global change and other atmospheric-related processes on the marine environment. WMO has established a trust fund to manage financial contributions of GESAMP partners for the support of this working group.

Reactive gases

3.5 Oxidants are formed through complex atmospheric processes involving precursor compounds (i.e. various oxidized nitrogen (NOy) and volatile organic carbon containing compounds (VOCs)) in the presence of sunlight. The precursor compounds also have adverse effects on health, and there are regulations in place to reduce their emissions. Many of the precursors offer the potential to serve as tracers for source attribution of emissions of pollutants to the atmosphere, and to study the transport patterns and chemical transformation en route. Many of the precursors also contribute to the formation of secondary aerosols, originating from reactive and short-lived species. Such aerosols are important to human health; for ecosystems through deposition; and influence strongly the atmospheric radiation balance, having both positive and negative radiative forcing factors.

3.6 Reactive non-methane hydrocarbon compounds commonly referred to as VOCs play an important role in the chemistry and therefore the oxidizing power of the atmosphere, which in turn affects climate, and air quality. VOCs are emitted by the biosphere and in various forms of air pollution, such as motor vehicle exhaust etc. They are removed from the atmosphere primarily by reaction with the hydroxyl radical with coproduction of CO_2 and H_2O and many intermediate products. They are responsible, together with NOx, for the photochemical formation of O_3 and other photo-oxidant pollutants including secondary organic aerosol. A complex mixture of several hundred VOCs is emitted with half-lives ranging from several months in the case of C_2H_6, to hours for the most reactive ones, such as isoprene or anthropogenic olefins.

3.7 The main importance of VOCs is in the lower troposphere, especially over and downwind of populated areas. However, several compounds have sufficiently long lifetimes to be transported into the background atmosphere where their presence is supplemented by local emissions from the biosphere both over land and over ocean. Only a few compounds, for example formaldehyde, have the potential to be observed by current or proposed satellite instruments. It is therefore important and timely to institute at selected ground-based sites and from aircraft platforms a long-term measurement programme of a subset of VOCs which are relevant to the aims of GAW, and which can be measured simply and accurately with existing technology. Considerable progress has been made recently with the setting up of a VOC network which is being calibrated and audited as required by GAW and first measurements have been submitted to the GAW database.

3.8 The VOC World Calibration Centre, based at IMK-IFU in Garmisch-Partenkirchen (Germany), has recently organized several calibration activities using a standard obtained from the National Physical Laboratory in the UK and the process of auditing stations participating in the network is well underway. This also includes advances in implementing The Central Calibration Laboratory to maintain a traceable VOC calibration scale and to provide calibration standards in cooperation with the National Metrological Institutes from UK, USA, Republic of Korea and the Netherlands.

3.9 For NOxy, a workshop has been held at the Hohenpeissenberg Observatory of the Deutscher Wetterdienst in October 2009 and it is expected that the outcome will be a global network making high quality measurements of the most important species (NO, NO_2, and speciated organic nitrogen) supported by the necessary structures to run a GAW network as outlined in the GAW Strategic Plan (WMO Report No. 172). Peroxy acyl nitrate anhydride (PAN) and PAN-type compounds, nitric acid (HNO_3), monofunctional alkyl nitrates ($RONO_2$), and the sum of reactive gas-phase nitrogen (NOy) would be recommended to be added as capabilities improve.

World Meteorological Organization | **CAS-XV/INF. 6**

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RECOMMENDATIONS ON COLLABORATIVE RESEARCH AND ACTIVITIES AT THE RESEARCH-OPERATIONS INTERFACE

SUMMARY

Reference: **CAS-XV/Doc. 6**

CONTENT OF DOCUMENT:

Appendix:

- Background information on collaborative research and activities at the research-operations interface

BACKGROUND INFORMATION ON COLLABORATIVE RESEARCH AND ACTIVITIES AT THE RESEARCH-OPERATIONS INTERFACE

WIGOS/WIS and Near-Real Time Chemical Data Delivery

1. A number of Antarctic stations deliver chemical data in NRT, but in many cases it is submitted by e-mail and in many different formats. A more rational system is needed where data is submitted to the GTS/WIS in a standardized format. A few Canadian, Czech and Japanese stations submit total ozone data routinely to the GTS. The Norwegian Institute for Air Research (NILU) collects ozonesonde data in NRT from more than 20 ozonesonde stations in Europe and passes these data on to ECMWF from where it is submitted to the GTS. These data are used in the GEMS and MACC projects for model validation. The existing NRT routines for Dobsons, Brewers and ozonesondes should be applied to more stations in the GAW network. AOD data is collected in NRT from a small number of global GAW stations by the World Optical depth Research and Calibration Center (WORCC), and NILU is collecting PM data from a number of European stations.

2. The pilot project IDOA was started on 1 July 2008 with the goal to expand significantly the number of stations submitting ozone and aerosol data to operational users in NRT via GTS/WIS.

3. WIS will be able to meet its objectives only if data discovery and retrieval (DAR) can be improved globally. The ET-WDC PP aims at making metadata on the observations performed in GAW available in a WIS-conformant way. Further, it aims at developing prototype services that will help users to make best use of the data available at dedicated World Data Centres. A project plan with 9 tasks and 11 milestones has been developed by the lead ET-WDC. A progress report has been submitted for the October 2009 SG-WIGOS meeting and can be found at: http://www.wmo.int/pages/prog/www/WIGOS-WIS/meetings/WIGOS-2_Geneva2009/Doc-4-1-1.pdf

Research to Operations in Numerical Weather Prediction

4. The reader is referred to Documents 5.1 WWRP, 5.2 THORPEX and 5.3 EPAC for further information on this section.

5. The JSC-WWRP noted in its strategic plan (Chapter 5.3) that until recently, aerosols, ozone and greenhouse gases were not regarded as “essential weather variables”. As the skill of NWP models has gradually improved over the past two decades due to assimilation of satellite observations, improved model physics and higher resolution, the relative importance of model uncertainties related to chemical variables compared to other sources of uncertainties has grown. In addition, the goal of extending the usefulness of forecasts beyond the classic 3 to 5 days to 14 days or even seasons became seen as increasingly possible. For both reasons, it is becoming clear that aerosols, in particular, through their role in direct radiative forcing, indirect radiative forcing and precipitation formation (WMO/IUGG Review; 2009), need to be included internally in numerical weather prediction models. Much like water components, they are highly variable in time and space in the troposphere (typical residence times of 3 to 14 days) and therefore cannot be represented by climatological distributions. New initiatives are emerging in the research community that are moving toward the incorporation of aerosols, ozone and greenhouse gases into NWP forecast models as active constituents that can be assimilated in near real time or in reanalysis mode. A flagship project in this regard was the Global and regional Earth-system (atmosphere) Monitoring using satellite and in-situ data (GEMS) 2005-2008. GEMS and its successor MACC build on the global weather forecasting system operated by the European Centre for Medium-Range Weather Forecasting (ECMWF). ECMWF and its partners, including the WMO research director serving as advisory board chair in the project, have added a capability for analysing and modelling the distributions of key greenhouse gases, chemically reactive gases and aerosols.

6. The 4th WMO Workshop on The Impact of Various Observing Systems on NWP Forecasts is a series dedicated to reviewing the science and assessing the impact of various observing systems. It advances understanding of the Global Observing System of WIGOS and allows CBS to make recommendations on the future of this system. Further information on the 4th Workshop in this series can be found at:
http://www.wmo.ch/pages/prog/www/OSY/Reports/NWP-4_Geneva2008_index.html

7. The WMO/Forum: Social and Economic Applications and Benefits of Weather, Climate, and Water Services was established as part of the WMO Public Weather Services Programme (PWSP) in 2007 as a successor to the WMO Task Force on Socio-Economic Applications of Meteorological and Hydrological Services. The aim was to expand the scope of the Task Force and to provide WMO with recommendations and guidance for assisting the National Meteorological and Hydrological Services (NMHSs) to more fully assess the socio-economic benefits of weather, climate and water information for a wide range of user communities, and to enhance the provision of such services. The Forum includes a wide membership base and mandate. Further information can be found at: http://www.wmo.ch/pages/prog/amp/pwsp/socioeconomictaskforce.htm

8. Transition of research to operational prediction helped by the participation of CAS programme leaders for WWRP and THORPEX can be found under agenda item 11.4 of CBS-XIV. The session resulted in recommendations for CBS actions regarding operational transition activities related to THORPEX Africa, forecast systems, tropical cyclones (IWTC), nowcasting, FDPs, GIFS-TIGGE, TIGGE-LAM and the relationship of GIFS-TIGGE prototype projects to the CBS-led SWFDPs.

9. EC-LXI (paragraph. 3.1.31) recommended:

(a) Regional, CBS-, and CAS-related entities in the WMO collaborate with the THORPEX GIFS-TIGGE Working Group to plan and execute a GIFS Forecast Demonstration Project (GIFS-FDP) that is designed to benefit Members in the developing world;

(b) To take advantage of existing and planned activities, infrastructure and experience, wherever possible, GIFS-FDP subprojects will be carried out in conjunction with CBS SWFDP, which has an effective mechanism for cascading the benefit of new forecast systems to decision-makers in WMO Members States;

(c) The GIF-FDP should begin with the prediction of tropical cyclone tracks and ensemble-based diagnostics, since EC-LX urged continuation of this real-time programme. The Council encouraged the participation of the relevant TIGGE data providers, TIGGE archive centres, Tropical Cyclone Warning Centres (TCWCs), Regional Specialized Meteorological Centres (RSMCs, including RSMCs with activity specialization in Tropical Cyclones) and WMO Members in executing such GIFS-FDP activities, which will require training and the development of a common set of products;

(d) That a follow on from the GIFS-FDP should focus on improving prediction of heavy rainfall and other problems of high priority, such as contributing to improving food security. The Council requested support from the WWRP SERA Working Group and THORPEX Regional Committees in exploring various societal application areas;

(e) The WMO Secretariat, THORPEX and the TIGGE data providers should work to develop a suitable data policy that will allow the GIFS-FDP to proceed in order to reduce human suffering, mitigate costs and deliver benefits;

(f) For the longer term, CBS and CAS experts should work with the THORPEX community to develop a way forward with the GIFS vision including additional applications with prototype GIFS probabilistic products for high impact precipitation, wind speed, and near surface temperature forecasts that, if successful, could be transitioned into operations to benefit the international community, especially for the developing world.

10. The "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" was proposed to occur in 2010 as an outcome from the recent WWRP JSC and a meeting of the THORPEX GIFS-TIGGE Working Group in September 2009. The goals are to: (i) develop and extract useful information from the TIGGE tropical cyclone ensemble forecast data; (ii) to deliver the extracted information to Typhoon Committee Members and interested researchers; and (iii) to get feedback from forecasters/researchers on the delivered information. The project is proposed to initially deliver "ensemble track data" and then expand other variables (e.g., precipitation, maximum wind speed, etc.).

Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

11. WMO is taking a lead with international partners in coordinating SDS-WAS to develop, refine and provide products to the global community useful in reducing the adverse impacts of sand and dust storms and to assess impacts of the SDS process on society and environment. Dust storms in arid and semi-arid regions play an important role in weather, climate, human health and air quality, transportation air and highway safety and agriculture.

12. In May 2007 upon the recommendation of CAS, the Fourteenth WMO Congress endorsed the launching of SDS-WAS. In June 2008, the sixtieth session of the Executive Council of WMO (EC-LX) welcomed the initiatives towards the development of SDS-WAS to assist Members to gain better access to services related to sand and dust storms prediction and warning advisories through capacity building and improved operational arrangements. EC-60 also welcomed the establishment of the two SDS-WAS Regional Nodes: (a) the Northern Africa - Middle East - Europe Node; and (b) the Asia Node supported by Centres of the Regional Nodes in Spain and China, respectively.

13. In 2008, the SDS-WAS Draft Implementation Plan 2009-2013 was developed and discussed by two regional nodes. Details on SDS-WAS implementation are available in WWRP web page http://www.wmo.int/sdswas/. Research is considered as an essential component of SDS-WAS. The Plan identifies the major challenges for SDS-WAS and proposes an architecture and information exchange that will secure efficient and balanced cooperation between, and participation of, the major components of the SDS-WAS system: research, prediction, observations and service delivery.

14. Because of future operational aspects anticipated in the implementation of SDS-WAS, cooperation of CBS with CAS would ensure that transition of certain SDS-WAS components into operation. In response to EC-LX call for collaboration between CBS and CAS, CBS-XIV (Dubrovnik, 25 March-2 April, 2009) requested appropriate experts in CBS to review the SDS-WAS Draft Implementation Plan (see website above) and to submit comments to CAS-XV. It also delegated final approval of the Plan in 2010 to the CBS Management Group. In October 2010, the OPAG-GDPFS completed its review. Recommendations are posted on the SDS-WAS Website. This is background material for the draft decision (see Doc. 6, paragraph 6.3.6)

15. Spain through a Spanish WMO Trust Fund for capacity building has made major contributions to support of surface aerosol optical depth observations in Africa that will aid in advancing numerical weather prediction models that forecast sand and dust storms. Such surface measurements are particularly valuable for verifying and eventually initializing sand and dust storm models. In addition, Spain intends to support through this trust fund a regional SDS-WAS user consultation and capacity building workshop in WMO Region I, Africa.

Urban-Regional Air Quality GURME

16. WMO Members are broadening their traditional roles so as to respond to air quality and related weather-sensitive public health threats. In order to help enhance the capabilities of NMHSs to handle meteorological and related aspects of urban pollution and to provide an international platform for cross-cutting urban air pollution activities, WMO established the GAW Urban Research Meteorology and Environment (GURME) project. GURME addresses the end-to-end aspects of air quality that link observational issues, data assimilation techniques, numerical models, dissemination methods, and capacity building required especially for developing countries to provide and use air quality services.

17. There have been many expressions of interest for enhancing air quality forecasting activities in the different WMO Regions. As a response, the GURME air quality forecasting (AQF) course was developed by the GURME Training Team. The course is designed to provide the background knowledge needed to design, develop, implement and evaluate a basic air quality-forecasting programme. It contains practical advice, introduces the participants to available tools and methods, and provides reference materials for follow-on activities. The topics covered include: meteorological aspects of air pollution; meteorological products and examples; chemical aspects of air pollution; case studies; air quality forecasting tools; developing a forecast programme; and daily forecast operations. The first course was delivered in July 2006 in Lima, Peru, for the RA III countries and the next for South Asia in 2008. However, due to limited funding, WMO has not been able to respond to the requests from Members for organizing AQF courses in a comprehensive manner. There is a need to hold these workshops in other Regions, especially in Central Asia and Africa in order to assist NMHSs to expand their scope of activities and improve their air quality products.

18. The strong collaboration between GURME and COST Actions has proven very beneficial, specifically with COST Action 728 “Enhancing Meso-Scale Meteorological Modelling Capabilities for Air Pollution and Dispersion Applications” resulting in the preparation of joint publications and holding a joint workshop in 2010 connecting to users of mesoscale models.

Nowcasting Applications and Services

19. The link between CAS and CBS (PWS) is through the JOint Nowcasting Applications & Services (JONAS) Steering Committee. The JONAS activities are focused on improving and accelerating the wide spread operational use of nowcasting systems developed in research settings or NHMSs with such specialties. Thus the Steering Committee is a cross-commission and comprises: a nowcasting expert to be appointed by WWRP as Co-Chair, a PWS/DPM expert to be appointed by PWSP as Co-Chair, a CBS representative in WWRP Nowcasting Working Group, a forecast systems expert, a PWS expert from developing countries, a WMO Secretariat representative and advisors and experts to be invited as required. Their terms of reference and other information can be found in their Strategic Plan at:
http://www.wmo.ch/pages//prog/amp/pwsp/documents/JONAS_Strategic_Plan.pdf

20. Broad WMO involvement will be encouraged in addressing issues associated with the changing forecasting environment in NHMSs, including a growing tendency for forecasting systems to run locally on workstations and local networks, demanding new user requirements, an increased reliance on visualization, and an evolving role of human forecasters in parallel with increasing automation. CBS and CAS-WWRP will cooperate in planning, implementation, and providing input to such a workshop, which should have a strong participation by NMHSs of developing countries, beginning with a small focused meeting in 2010.

Shanghai Multi-Hazard Early Warning System (MHEWS)

21. The Shanghai Multi-Hazard Early Warning System Demonstration Project was initiated in 2007. Shanghai is frequently affected by natural hazards such as typhoons and associated marine

hazards such as storm surge, heavy storms, heavy fog, heat-waves, and also atmospheric pollution episodes. This project provides technical capacity development in nowcasting and forecasting of various hazards to the NMHSs, through a coordinated approach involving all relevant WMO technical programmes with the lead in RES/AER. This approach is being used to demonstrate benefits achieved through leveraging expertise and capacities of WMO Programmes in assisting Members with the development of their early warning systems with a multi-hazard approach. Activities are well on their way for an early detection and warning system for tropical cyclones and marine-associated hazards, on the application of nowcasting to Public Weather Service delivery, on the GURME demonstration project on air pollution and on the development of governance, institutional coordination mechanisms and community preparedness. Different models and their use for the mesoscale ensemble forecasting capabilities are being studied. The component on Heat-Health Warning Systems (HHWS) includes an operational HHWS using a method based on synoptic classification of conditions leading to dangerous heat waves and on epidemiological data from Shanghai. The system will further include operational issuance of various indices familiar to the travelling public and outreach through various communications entities in Shanghai. This Shanghai MHEWS approach is being demonstrated with the goal to scale up to other countries in need of technical capacity development requiring a multi-hazard approach.

22. The project component for governance is underway to strengthen strategic, institutional and operational coordination and cooperation in early warning systems among NMHSs and disaster risk management agencies at national to local levels. The WMO DRR Programme is working with its partners to link know-how, derived from good practices in early warning systems, to national and regional development projects focused on strengthening institutional capacities and cooperation of the NMHSs and disaster risk management agencies. In this context, the WMO DRR Programme has developed a systematic process for identifying and documenting good practices in EWS, with focus on governance, and institutional coordination and cooperation. To date, through a national multi-agency approach, engaging NMHS and their partners in disaster risk reduction, four good practices have been documented including Shanghai MHEWS, Cuba, France and Bangladesh and these have been used to develop a training programme targeted at the directors of NMHS and disaster risk management agencies. This training is carried out in conjunction with development projects in DRR and EWS, in a number of regions in 2009-2010 timeframe. The first training was held in Nanjing, China in June 2009, and a second training of these good practices was held in Pula, Croatia, for 14 countries in Southeast Europe, as part of a project in this region.

23. EC-XVI endorsed the Project Implementation Plan developed for the World EXPO 2010 Nowcast Services Demonstration Project (WENS). It also supported the goals of WENS which are: to demonstrate how nowcasting applications can enhance short-range forecasts of high-impact weather using the opportunity afforded by the World EXPO 2010; and to promote the understanding and enhance the capability of WMO Members in nowcasting services. The project will culminate in the demonstration of the nowcasting services during the Expo in 2010. The major outcomes from WENS will include: publication of WMO Nowcasting services guidelines; and capacity building workshops for WMO Members.

24. The GURME Shanghai project on air pollution, which was started in February 2007, has progressed well, especially for provision of operational ozone forecasting, and is providing real-time display of observational data. Within this project observation stations have been updated and new ones built, data management has been developed, a study on aerosols based on surface measurements and satellites has been made, aerosols have been investigated as related to haze and dust pollution, and urban heat and dry island studies, analysis on distribution of land surface characteristics over Shanghai and a UV radiation study and prediction have been carried out. GURME is assisting the Shanghai Meteorological Bureau to produce their best products, in this context a workshop is planned for 2010 focusing on delivering operational components.

25. The HHWS component relies on effective partnerships between the Shanghai Meteorological Bureau (SMB) and local and regional health, communications and emergency

response authorities (e.g., the Centre for Disease Control, public health authorities, media groups) that have been in place and increasingly developed since the Commission for Climatology demonstration project on HHWS in Shanghai in 2000. During the heat season in 2010, the SMB is prepared to issue specialized warnings and information on heatwaves to its partners, and public warnings for local and visiting populations. Detailed studies of the thermal climatology of Shanghai, along with epidemiological evidence have been used to improve prevention, preparedness, and response activities for heat waves. The project to prepare HHWS for the MHEWS for EXPO 2010 will result in a case study that will enhance the understanding of Members of various HHWSs and requirements for their implementation.

26. Progress has been made with the EWS for Tropical Cyclones and Marine-associated Hazards project component. CMA has been increasing the wave and storm surge observational network in the shallow waters surrounding Shanghai and, through national and international collaborations established under the framework of this project component, it has now access to observational data from networks under the responsibility of other agencies. A direct link with the RSMC-Tokyo was established for an improved EWS. Storm surge and wave models have been implemented. An integrated approach to storm surge, wave and flood forecasting has been built to enable the production and provision of coastal inundation forecasting and warning services, which would be demonstrated during the Expo in 2010. The "North Western Pacific Tropical Cyclone Ensemble Forecast Research Project" will contribute to the Shanghai EXPO 2010 via CMA/NMC, CMA/SMB and CMA/STI efforts. This project will be among the first real-time uses of the GIFS-TIGGE concept.

27. Expert workshops are planned to be held during the EXPO 2010 highlighting issues addressed by the Shanghai MHEWS project components and offering expertise to be used at the WMO CMA Pavilion.

GEO Links to AREP Activities

Development of the GEO Work Plan 2009-2011

28. The annually updated GEO Work Plan provides the agreed framework for implementing the GEOSS 10-Year Implementation Plan (2005-2015). The current version can be downloaded from http://www.earthobservations.org/geoss_imp.shtml. It consists of a set of practical Tasks that are contributed to GEO by various Members and Participating Organizations including the WMO. As GEOSS takes shape over the next several years, connections will be realized between diverse observing, processing, data-assimilation, modeling, and information-dissemination systems. GEO has supported participation of Members in meetings related to SDS-WAS/MERIT, GIFS-TIGGE, THORPEX Science Symposium, and THORPEX Africa. GEO has also worked on behalf of resource mobilization for CAS-led GEO tasks, which will assist efforts in CAS-led to improve forecast capability.

CAS activities within the 2009-11 Work Plan

29. For further information on for the CAS-related tasks and subtasks are found below.

Societal Benefit Area: Health
Task HE-09-02: Monitoring and Prediction Systems for Health, Sub-Task (a): Aerosol Impacts on Health and Environment: Research, Monitoring and Prediction can be found at:
http://earthobservations.org/documents/tasksheets/latest/HE-09-02a.pdf

Societal Benefit Area: Climate
Task CL-09-01: Environmental Information for Decision-Making, Risk Management and Adaptation. Sub-Task (a): Towards Enhanced Climate, Weather, Water and Environmental Prediction is described at:
http://earthobservations.org/documents/tasksheets/latest/CL-09-01a.pdf

Task CL-09-03: Global Carbon Observation and Analysis System including sub-task a) Integrated Global Carbon Observation (IGCO) is described at:
http://www.earthobservations.org/documents/tasksheets/200901/cl-09-03a.pdf

Societal Benefit Area: Weather
Task WE-06-03: TIGGE and the Development of a Global Interactive Forecast System for Weather can be found at:
http://www.earthobservations.org/documents/tasksheets/200903/WE-06-03.pdf
Task is WE-09-01: Capacity Building for High Impact Weather PredictionSub-Task (b): Socio-economic benefits in Africa from Improved Predictions of High Impact Weather is described at:
http://earthobservations.org/documents/tasksheets/latest/WE-09-01b.pdf

Capacity Building

30. The GAW Strategic Plan (GAW Rep 172 available at http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html) includes a chapter on capacity building. Large part of GAW activities are geared towards increasing the capabilities of Members to better address atmospheric chemistry and related physics questions; capacity building is not only training and education. Twinning partnerships of developing GAW measurement programmes with established GAW facilities, laboratories and stations are encouraged to develop the capacity for sustained quality-assured measurements and effective use and publication of data. Guidelines for the different GAW measurement parameters are published and opportunities are seized to conduct on-site audits, calibrations, comparisons and training activities. The GAW Central facilities, such as QA/SACs, WCCs, WDCs, are providing important support for expanding the capabilities of Members.

31. In addition to the GAW Training and Education Centre (GAWTEC) at the Environmental Research Station ‘Umweltforschungsstation Schneefernerhaus’ (UFS), education and training is given by the Solar and Ozone Observatory of CHMI at Hradec Kralove (SOO-HK) in the Czech Republic for Dobson operators either at SOO-HK or at other locations. Switzerland substantially supports the ozone sounding programme and servicing the Dobson instrument in Nairobi (Kenya), the WORCC in Davos organizes calibration sessions and operator training on a regular basis and Empa has conducted training sessions on QA/QC and data analysis for operators of the Global GAW stations Mt. Kenya (Kenya), Bukit Koto Tabang (Indonesia), and Assekrem (Algeria), as well as for operators of the Regional station Shangdian’zi (China). NCAR (USA) has provided training for Mt. Kenya operators specifically for their CO_2 analyzer installed there in 2008.

32. Experts on Carbon Dioxide (CO_2) Measurements in the atmosphere have met regularly for 34 years, with the initial meeting organized by Dave Keeling at La Jolla, California. The major topics of these meetings include promotion of new techniques, issues of standardization and quality assurance and broadening of scope to other climate-relevant trace gases and proxies. The biennial Brewer workshops co-organized by Environment Canada and WMO provide help to operate Brewer instruments, give tutorial sessions on maintenance, quality control and data analysis and can therefore be viewed as contributing to capacity building.

33. Main station twinning activities:

- Switzerland (MeteoSwiss and Empa) twinning with the ozonesonde and Dobson station in Nairobi (Kenya), the high-altitude station Mt. Kenya (Kenya), and the station Bukit Koto Tabang (Indonesia) continuing to help maintain these important equatorial measurement activities and with Assekrem (Algeria);
- Germany (IfT Leipzig) with Danum Valley and BEO Moussala, with the provision of sampling inlets for Beo Moussala and Monte Cimone based on the experience at the Jungfraujoch, all sites are frequently within clouds. The Institute for Meteorology and

Climate Research, (IMK-IFU) has long been a partner of the Global GAW station Cape Point (South Africa);

- The United States (NOAA) has set-up aerosol sampling units in Cape Point and Mt Waliguan, supported the Global GAW station Ushuaia and is a partner of the Regional stations Tiksi (Russia), as well as a number of others;
- Spain has made possible the ozonesonde programme at Ushuaia through support from INTA and AEMET. These two institutions also support measurement programmes at Argentinean GAW stations in Antarctica;
- Australia has twinned with Malaysia on activities at Danum Valley.

34. Numerous intercomparison activities, calibrations and site audits have taken place, for example:

- NOAA ESRL, CCL: for CO_2, CH_4, and N_2O;
- WCC- at Empa: for surface ozone, carbon monoxide and methane inter-comparisons, regular system and performance audits at global GAW stations including inter-comparison measurements with travelling standards for O_3, CO and CH_4. During 2006-2008 audits were performed at 11 stations which helped to increase data traceability and reliability;
- Dobson instruments are compared with standard instruments every 4 years in rotation regionally under the supervision by SAG Ozone with the assistance of NOAA and regional Dobson calibration centres in Argentina, Australia, Germany/Czech Republic, Japan and South Africa;
- The Spanish Meteorological Institute hosts the Regional Brewer Calibration Centre for Europe (RBCC-E), in addition to serving the 50 Brewer spectrophotometers in Europe, the RBCC-E also takes care of stations in North Africa (Casablanca and Cairo). The first GAW regional Brewer intercomparisons for Europe were arranged in 2005, 2007 and 2009;
- UV instrument intercomparisons by the regional calibration centres in Boulder, USA, (NOAA) and in Davos, Switzerland (PMOD-WRC).

35. Discussion on capacity building and training within the WWRP can be found in the WWRP Strategic Plan at http://www.wmo.int/wwrp. The upcoming training workshops and related activities included in this Strategic Plan and recent WWRP and THORPEX planning efforts are:

- Training in 2010 on the use of GIFS-TIGGE ensemble forecasts of tropical cyclone tracks;
- Training in 2011 or beyond to facilitate transfer of THORPEX advances to operational forecast offices by the THORPEX Southern Hemisphere Regional Committee to southern hemisphere support of end user requirements, including involvement in Severe Weather Forecast Demonstration projects and use of TIGGE and GIFS data;
- THORPEX will participate in the development of an AMMA Forecasters Handbook;
- An Asian Nowcasting Training Workshop in 2010 or 2011 will be conducted at the conclusion of the B08 FDP with a focus on Asian region involvement. Activities will attempt to include real-time training on B08 FDP systems;
- An East European Training Workshop 2010 on nowcasting is proposed to be conducted in Romania as part of proposed Testbed activities associated with JONAS;
- Lecture materials from the International Training Workshop on Monsoons have been made available by the Monsoon Panel in 2009 and will be widely distributed in late 2009 and 2010 by the Secretariat;
- Editing and production of a hard cover book Global Monsoon Systems: Research and Forecasting with publication in late 2009 or early 2010;
- The Monsoon Panel will review the overall results of Intl Workshop on Monsoons (IWM) IV in early 2010 and begin long-range planning for IWM-V in 2012 and will likely include another training workshop;
- Periodic international workshops on verification methods, to facilitate the sharing of research results and the development of collaborative relationships among verification researchers will continue to be held and these workshops will include training tutorials on

forecast verification methods and practice. Workshops should take place approximately every two years, with the next one occurring in 2011 or 2012. Verification tutorials will also be held in conjunction with proposed FDPs and relevant RDPs;

- The Joint Working Group on Forecast Verification Research will continue to develop training modules and materials that can be made widely available to anyone with an interest in forecast verification methods and practices and develop written recommendations on verification approaches and methods to be applied for specific research and operational forecast evaluation problems leading to the publishing of each document as a WMO technical report. The first document was on verification of precipitation forecasts, published in 2009 with a document on verification of cloud forecasts planned to be completed and published in 2010;
- The WG SERA will develop the architecture and content for an international *SERA* web resource for social scientists and users (either on the WMO-WWRP site or an external server) interested in understanding and improve the communication of weather information.

36. Information on the projects listed in the document under 6.8.10 can be found in 5.2 WWRP, 5.3 THORPEX, and 6.2 SDS-WAS.

37. The activities of the Joint (WWRP-WGNE) Working Group on Forecast Verification Research can be found at http://www.wmo.int/wwrp/verification with their software tool box and other web-based materials located at:
http://www.cawcr.gov.au/bmrc/wefor/staff/eee/verif/verif_web_page.html

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RECOMMENDATIONS ON COLLABORATIVE ACTIVITIES AT THE WEATHER-CLIMATE INTERFACE

SUMMARY

Reference: **CAS-XV/Doc. 7**

CONTENT OF DOCUMENT:

Background information on Collaborative Activities at the weather-climate interface comprising activity reports and plans from the WGNE, the Year of Tropical Convection (YOTC) project and the Joint Working Group on Verification Research and a proposal for a WWRP/WCRP initiative on Monthly to Seasonal Forecasting.

Appendix:

- Report on collaborative activities at the weather-climate interface

REPORT ON COLLABORATIVE ACTIVITIES AT THE WEATHER-CLIMATE INTERFACE

A key element of the WWRP and the THORPEX strategies is collaboration with the World Climate Research Programme (WCRP) to address common requirements for observations and modelling for the prediction of weather and climate. The following contains activity reports and plans from the WGNE, the Year of Tropical Convection (YOTC) project and the Joint Working Group on Verification Research and a proposal for a WWRP/WCRP initiative on Monthly to Seasonal Forecasting.

1. The Working Group on Numerical Experimentation (WGNE)

1.1 Introduction

The Working Group on Numerical Experimentation (WGNE) is a joint working group of WCRP and CAS. Its main roles are to review the development of atmospheric models and data assimilation systems and, through coordinated numerical experimentation, promote the further development of these systems.

The Terms of Reference of the WGNE are:

(a) Advise the WCRP/JSC and the CAS on progress in atmospheric modelling;

(b) Review the development of atmospheric models for use in weather prediction and climate studies on all scales, including the diagnosis of shortcomings;

(c) Propose numerical experiments aiming to refine numerical techniques and the formulation of atmospheric physics processes, boundary layer processes and land surface processes in models;

(d) Design and promote coordinated experiments for:

  (i) Validating model results against observed atmospheric properties and variations;
  (ii) Exploring the intrinsic and forced variability and predictability of the general circulation of the atmosphere on short to extended ranges;
  (iii) Assessing the intrinsic and forced variability of the atmosphere on climate timescales;

(e) Promote the development of data assimilation methods for application to numerical weather and climate predictions, and for the estimation of derived climatological quantities;

(f) Promote the development of new methods for numerical weather prediction and climate simulation;

(g) Maintain scientific liaison with other WCRP and CAS groups as appropriate;

(h) Promote the timely exchange of information, data and new knowledge on atmospheric modelling through publications, workshops and meetings.

Since atmospheric models and data assimilation systems are also a key component of WWRP's mission, several areas of mutual interest exist between WWRP (including THORPEX) and WGNE that provide opportunities for collaborative research. The Chairs of the WGNE and the THORPEX ICSC participate in ex-officio capacity in each other's sessions as a further means of promoting the collaboration and the WGNE continues to have a specific THORPEX session at its meetings. The WGNE also works in close conjunction with the WCRP Global Energy and Water Cycle

Experiment (GEWEX), in particular the "GEWEX Modelling and Prediction Panel" (GMPP), in the development of atmospheric model parameterizations.

In 2007, the WGNE was tasked by both the WCRP and the CAS to expand its portfolio to meet the increasing needs of WCRP and the programmes of CAS by providing expert advice on, and acting as a catalyst for, the development of numerical experimentation aimed at advancing physical parametrizations in the numerical models used by the weather and climate prediction communities. As a result, the position of a new co-chair of WGNE with specific responsibility for this area was created. In addition, the chairs of the GEWEX parametrization studies groups became members of the WGNE.

Beyond this, the close relationship that exists between WGNE and operational (NWP) centres underpins many of the activities by WGNE and it is the work of these centres that provides the major impetus for the refinement of atmospheric models. As usual, WGNE sessions include reviews of progress at operational centres in all aspects of NWP including data assimilation, numerical methods, physical parameterizations, ensemble predictions, seasonal prediction and verification.

Key activities in data assimilation take place at the operational centres and hence WGNE is well placed to monitor new developments and progress in this crucial and expanding area of science. Furthermore, the WWRP/THORPEX Data Assimilation and Observing Systems Working Group (DAOS WG) represents a major community activity in data assimilation development so that it is clearly an area for strong WWRP/THORPEX-WGNE collaboration. Major science challenges ahead include assimilation at high resolution, globally and regionally, assimilation of new variables including rainfall and cloud (in support of convection-permitting models) and chemical species (in support of air-quality forecasting), and ensemble assimilation techniques in support of global and limited-area Ensemble Prediction Systems. From these trends, it can be concluded that the links between WGNE and the Working Groups on Meso-scale Forecasting Research and Tropical Meteorological Research and the Sand and Dust Storms needs to be strengthened.

1.2 Atmospheric modelling

Numerical models

Each year, the WGNE reviews the new developments, plans and progress made by the main NWP Centres. Over the last four years, the drive to higher resolutions (both in the horizontal and now in the vertical) for both global and regional systems has continued apace and several centres are now employing global models with horizontal resolutions between 20 and 40kms. Furthermore, several centres are now generating operational short-range forecasts with non-hydrostatic models with horizontal resolutions of 1 to 2 km resolution and many centres are using models with these resolutions for research.

There is an increasing the focus on boundary layer and land surface parametrizations and also cloud microphysics. There are substantial challenges emerging as to the choice of algorithms for data assimilation at convective scale resolutions. There is also increasing activity in the application of much higher resolution models for local (for example urban) forecasts.

Systematic errors

Over the last 20 years the WGNE has organized Workshops on Systematic in Numerical Weather Prediction and Climate models - the first held in Toronto (1988) and the second in Melbourne (2000). The latest in the series was held in San Francisco in February, 2007.

Several overarching themes emerged from the San Francisco Workshop. Examination of climate model error structure and error growth in weather prediction mode was demonstrated to be insightful by several groups. As a result of fast processes (e.g., boundary layer, convection, radiation and clouds), climate biases are often manifest within a few days of initialization, which may provide better opportunities for diagnosing the root of common errors. Analogously, the value of running initialized coupled models in forecast mode over seasonal timescales was noted, allowing diagnosis of slower processes, e.g., those associated with ENSO. Accurate simulation of the diurnal cycle was identified as a key deficiency in GCMs.

Models with sufficient horizontal resolution (for example finer than 4km) do somewhat better at simulating the diurnal cycle. Higher resolution is expected to yield improved simulations and better diagnosis of errors at resolutions feasible for century-scale simulations. However, it is clear that better physical understanding is the predominant limiting factor to further reducing systematic errors. Finally, the importance of metrics for climate models was emphasized from a variety of perspectives. Compared with the weather prediction community, efforts to gauge progress (and relative skill) of climate models is lagging, although some progress is now being made.

Parameterization

The representation of physical processes in atmospheric models is a crucial area for weather prediction. The prediction of key weather elements, such as rainfall and near-surface wind and temperature, including their extremes as encountered in severe weather events, relies on the faithful representation of a multitude of physical processes such as clouds and moist convection as well as boundary layer and microphysical processes. As these processes act on scales much smaller than traditional model horizontal grid-lengths, they have to be included in models by means of parameterization. With the continuing increase in computing power, many local and regional forecast systems are now reaching horizontal grid-lengths approaching the scales of deep moist convection, which, combined with the goal of designing seamless prediction system, leads to additional research requirements.

However, there is a misperception that some elements of parameterization schemes, most notably that for deep convection, will soon be obsolete due to the emergence of convection-permitting (that is, cloud-system resolving) global models. It is the firm opinion of the WGNE that the use of such models in global operational numerical weather prediction is at least a decade away. Furthermore, its use in operational seasonal and climate prediction is not likely to occur for an additional decade after that. Consequently, WGNE strongly urges a reinvigoration and increase in activities related to parameterization research particularly for global models. To this end, the WGNE has strengthened its efforts on physical parameterization with the aim of consolidating and better coordinating activities to improve physical processes in atmospheric models. This effort, which has been facilitated by the strengthening of the WGNE mentioned in the introduction, integrates many existing programmes in WMO, such as the GEWEX cloud, land surface, and boundary layer study groups.

A strong interaction of the WGNE physics group's activities with the WWRP efforts is critical for the success of many of WWRP and WGNE's goals such as the development of seamless prediction systems as well as the improved understanding and prediction of the multi-scale organization of tropical convection. The interaction of WGNE and WWRP in this important area will be fostered by integrating WWRP research efforts on physical processes with those in the WGNE group. Early examples for such integration are the joint research under the auspices of the WWRP/THORPEX Year of Tropical Convection (YOTC).

It is recognized that the importance of the representation cloud microphysics is increasing in all areas of modelling especially in convection-permitting models as well as models that include cloud-aerosol interactions. It has been decided to focus research efforts through the recently created GCSS working group on microphysics. The WGNE has encouraged its members and the wider research community to make best use of this effort by participating in existing activities of the group and by suggesting new projects aimed at testing (http://www.wmo.int/wgne) and improving parameterizations for weather and climate prediction. In particular WGNE suggests building on the existing efforts in GCSS and expanding to include the increasing number of operational and research convection-permitting models in the GEWEX model evaluation and development activities. In particular WGNE has also encouraged the modelling groups involved in the WWRP Working Group on Mesoscale Weather Forecasting Research and the limited area modelling component of TIGGE (TIGGELAM) to participate in the GCSS model evaluation efforts.

Three initiatives have been suggested in order to stimulate work in parameterization:

(a) An audit of existing parameterization activities in the broader WMO community and of the problems ascribed to parameterization concerns throughout the application communities including numerical weather prediction and data assimilation, seasonal prediction and climate simulation and projection;

(b) Holding a joint WWRP/THORPEX and WCRP conference on the parameterization for large-scale models;

(c) Preparation of a white paper on parameterization tied to the parameterization conference.

The aAudit is underway and results of the initial phase of the audit are encouraging. Broad community input and support for the conference and the conclusions of the White Paper will be sought by the conference organizers.

1.3 Recommendations on CAS activities

Observation targeting

The WGNE has supported the efforts by the THORPEX Data Assimilation and Observing System Working Group (DAOS WG - see the CASXV item 5.2) to quantify the impacts of the observation targeting carried out in recent THORPEX field experiments and in large-scale Observing System Experiments. Specifically the WGNE supports the conclusions of the DAOS WG that there is little evidence that the current approach for targeted observations in data assimilation leads to improvements in the average forecast skill in the extra-tropics, whilst acknowledging that individual forecasts of isolated and dynamically significant events (for example tropical cyclones) may well improve by using the technique.

Interaction with the THORPEX Predictability and Dynamical Processes Working Group (PDP WG)

Since the PDP WG has been tasked with identifying barriers to improving predictive skill, which include parameterization and other model errors, the WGNE Co-chair with responsibility for parameterization is now a representative on the PDP WG and appropriate reciprocal representation of the PDP group at WGNE meetings has been arranged. During the joint WGNE and THORPEX ICSC session planned for 3 November 2009 attention will be given to strengthening the collaboration with the PDP WG.

HEPEX

WGNE has received a request to support HEPEX and discussion of this request will be clarified at the WGNE and THORPEX ICSC November 2009 session.

Atmospheric composition

It was recognized that the prediction of atmospheric composition and hence pollution is becoming a more and more integrated part of NWP systems and that WGNE through both its connection to operational centres and its new parameterization effort has a strong connection to such efforts. It is however unclear at this stage to what extent WGNE ought to become involved in these efforts. It is suggested to have an in-depth discussion of this issue at the November 2009 WGNE meeting and to invite an expert presentation to guide the discussion.

Forecast verification and model evaluation

The WGNE regularly reviews improvements made in more traditional forecast performance in terms of objective scores such as the 500hPa height fields, MSLP and wind and WGNE members were encouraged to ensure that model developers were kept up-to-date with all these results, especially the less conventional ones.

There are several other WGNE-related projects involving verification of forecasts especially of less standard quantities such as weather parameters and severe weather events.

(a) Multi-centre forecasts of tropical cyclone tracks and intensities;

(b) Precipitation for various regions of the world;

(c) Verification and comparison of MJO forecasts.

Other issues

The WGNE has noted that the TIGGE archives and, to a lesser extent, the YOTC archives are increasing in volume so that they cannot be easily downloaded due to limitations in data transfer capabilities, especially in developing countries and in the university sector. The WGNE has, therefore, urged all data systems groups to consider alternatives to the “download and process at home” paradigm currently in place. One suggestion was to consider coordinating discussions through the existing GOESSP (Global Organization for Earth System Science Portal) effort.

1.4 WGNE Publications

The WGNE Website is hosted by The Canadian Meteorological centre (http://collaboration.cmc.ec.gc.ca/science/wgne/). A key WGNE publication for many years has been the WGNE "blue cover" numerical experimentation report series, which continues to be popular with the modelling community and is prepared on behalf of WGNE by Recherche en Prévision Numérique (RPN), Montreal since its inception. This report is now a web-based at RPN.

2. The Year Of Tropical Convection (YOTC)

The realistic representation of tropical convection in global atmospheric models is a long-standing grand challenge for numerical weather prediction and climate simulation. To address this challenge, WCRP and WWRP-THORPEX have implemented a year (the Year Of Tropical Convection (YOTC)) of coordinated observing, modelling and forecasting of organized tropical convection and its influences on predictability as a contribution to the United Nations Year of Planet Earth to complement the International Polar Year (IPY).

YOTC has been established as an international project coordinated by WWRP-THORPEX and WCRP to address tropical convection and its interaction with the global circulation. YOTC provides the framework and infrastructure for a unique integrated observational-computational resource for research into weather and climate prediction.

The scientific focus is on precipitation systems organized on meso-to-large scales. The emphasis on time scales up to seasonal enables critical issues at the intersection weather and climate (seamless prediction) to be addressed at the process level. Key uncertainties in the prediction of global weather and climate are the main targets – the MJO and convectively coupled waves, intra-seasonal variability of monsoons, easterly waves and tropical cyclones, tropical-extra-tropical interaction, and the diurnal cycle.

The major specific elements of YOTC are:

(a) High-resolution deterministic global prediction model analyses, forecasts and diagnostics;

(b) Satellite, field-experiment and in-situ observations;

(c) Cloud systems in global data sets;

(d) Parameterized, super-parameterized and explicitly modelled convection;

(e) Theoretical studies.

The original "Year" has been extended to cover a two year period, 1 May 2008 to 30 April 2010, to include the T-PARC and TCS08 field experiments and what appears to be a developing El Niño for winter 2009-10 - to date La Niña conditions have prevailed.

2.1 Progress

The Science Plan and an Implementation Plan, which includes summaries of collaborative projects, have been completed through a series workshops and planning meetings supported by WWRP-THORPEX and WCRP. A Project Office, funded jointly by NSF, NOAA and NASA, has been established at NCAR and information and the status of the project can be found on the YOTC Website at www.ucar.edu/yotc.

The YOTC Implementation Plan is deemed to be an evolving document with subsequent updates and revisions completed as required.

Data archives

(a) ECMWF T799 (25 km) analyses, forecasts and diagnostics are on-line and are being added to in real time;

(b) NCEP analyses, forecasts and diagnostics are being made available;

(c) NASA GEOS-5 contributions on-line.

Data analysis, dissemination, visualization

Recently, NASA has provided funding to enable the Goddard Giovanni system to be adapted for YOTC data analysis dissemination and visualization and the YOTC Giovanni system will be available in about one year.

Collaborative projects

A number of collaborative projects involving weather and climate institutions and working groups is being established:

(a) To assess the performance of state-of-the-art weather/climate models by comparing them to the YOTC observation data sources;

(b) To assess a variety of hindcasts for the YOTC period focusing on specific events, field campaign periods (for example T-PARC and TCS08) and phenomena such as the MJO, easterly waves etc.;

(c) To assess the performance of Cloud-system Resolving Models (CRMs);

(d) Based on the results of these assessments, develop and improve parameterizations of cumulus convection in order to improve weather and climate forecast skill.

2.2 Short-term priorities

In additional to developing the scientific programme, the YOTC science community will as a matter of priority:

(a) Identify and secure financial support for the research phase of YOTC from funding agencies worldwide, recognizing the international and collaborative nature of YOTC;

(b) Continue and expand efforts to communicate YOTC to the wider scientific community;

(c) Plan for the first YOTC Research Workshop in October 2010.

3. Monthly to seasonal prediction

Interest, and capabilities, in operational monthly (sub-seasonal) to seasonal predictions is increasing as are the requirements for improved predictions. The scientific problems of weather forecasting and seasonal prediction are similar and it is clear that strengthening the collaboration between the WWRP and the WCRP will enable both the weather forecasting and climate communities to tackle these shared problems more effectively by adopting a seamless approach to the prediction of weather and climate.

Four collaborative research areas have been identified:

(a) Ensemble Prediction Systems (EPSs);

(b) Tropical convection;

(c) Coupled data assimilation;

(d) Social and economic benefits from sub-seasonal to seasonal predictions.

Ensemble prediction

In recent years, both weather and climate modellers have been developing ensemble-based techniques for sub-seasonal to seasonal predictions. There is consensus that an ensemble prediction technique is preferable at that forecast range. Furthermore, there is evidence that ensemble prediction has greater use and value from a Multi-model Ensemble Prediction System (M-EPS) approach. There is evidence that combining forecasts from different systems which employ differing parameterizations, numerical treatments and initial conditions provide more useful Probability Distribution Functions (PDFs) than those obtained from a single EPS.

Thus, coordinating the research activities of the WCRP CLIVAR Climate-System Historical Forecast Project (CHFP) and the THORPEX Interactive Grand Global Ensemble (TIGGE) on sub-seasonal and seasonal predictions is timely: it offers the optimum approach to developing useful predictions at that range. This is also the best forecast range for effective collaborative research to tackle two fundamental scientific issues identified above namely tropical convection and coupled data assimilation.

Tropical Convection

Operational weather forecast systems provide our best representation of synoptic-scale and meso-scale weather events. These short- to medium-range forecast systems are only just beginning to address longer term interactions, for example at the air-sea-ice interface – beyond two weeks the poor representation of these interactions are a significant source of error. It may also well be an impediment for improving forecasts on shorter time scales, particularly for high-impact weather events. These events include extra-tropical and tropical cyclones that, through interaction with the ocean mixed layer, can precondition the atmosphere-ocean interface for subsequent storms.

Climate prediction systems are built for much longer term simulations. They typically include more sophisticated coupled interactions but being run at lower resolution, they fail to adequately resolve meso-scale weather systems, and they are thus missing up-scale interactions that impact the climate.

The limitations of contemporary weather and climate prediction models to represent realistically the life-cycle of equatorial waves and organized convection is usually attributed to inadequacies in parameterizations of moist physical processes. Such basic inadequacies compromise the skill of forecasts on all timescales. It follows that parameterization of organized tropical convection is a critical issue for both the weather and climate communities. Again, a collaborative research effort focussed on the sub-seasonal to seasonal time frame is most appropriate to investigate best approaches.

Coupled data assimilation

As operational forecasts have extended into sub-seasonal prediction, improved coupled data assimilation for the Earth system has become necessary. The seasonal prediction time-frame offers a good opportunity for such tests and for collaborative climate-weather research.

Diagnosis of the performance data assimilation systems can be used to identify the deficiencies in models and since the largest uncertainties in climate and weather models are associated with physical parameterizations, improvement in these schemes may reap great benefits.

Significant new resources will be required to advance research on data assimilation. One mechanism to achieve this is through the various re-analysis projects which are designed to provide a historical record for climate studies. The next generation of re-analysis projects can no longer rely only on operational weather forecast systems: they will require an interdisciplinary research programme on data assimilation methodologies.

Societal and economic benefits

User needs for operational seasonal predictions are an essential element which must be factored into the collaboration. Many users are risk averse, in that they are often more concerned with quantitative estimates of the probability of occurrence of high-impact events then with the most probable future state. A focus on the eventual socio-economic applications will require proper evaluation of the biases and forecast skill of these predictions. The development of societal applications will require that sub-seasonal and seasonal predictions are provided in a form easily accessible to non-atmospheric scientists, user groups and intermediaries who understand both the scientific and socio-economic issues.

It is therefore critical to adopt a seamless approach to the application of sub-seasonal and seasonal predictions, through the active involvement of physical and social science researchers, service providers and users-decision makers.

Priority projects may be selected based on their potential contribution to priority societal objectives or where existing programmes, activities and interdisciplinary collaboration can be leveraged. Examples of such programmes include the Meningitis Environmental Risk Information Technologies (MERIT) project; the Hydrological Ensemble Prediction Experiment (HEPEX), an international project to advance technologies for hydrological forecasting comprised primarily of researchers, forecasters, water managers, and users; the Climate for Development in Africa Programme (ClimDev Africa), a major effort designed to increase the availability of climate information to communities and economic sectors throughout Africa; the World Bank's Disaster Risk Reduction programme, which plans to modernize service providers so that the operational services can take advantage of scientific advances in a timely manner; and the Global Environmental Change and Human Health Initiative, one of four joint projects of the Earth System Science Partnership (ESSP), geared to quantifying and modelling health impacts and vulnerability and evaluating adaptation measures.

4. The Joint Working Group on Forecast Verification Research (JWGFVR)

The Joint Working Group on Forecast Verification Research (JWGFVR) is a joint working group of WCRP and CAS with the following goals:

(a) To plan and implement the verification component of WWRP;

(b) To serve as a focal point for the development and dissemination of new verification methods for WWRP and EPAC, as required;

(c) To facilitate and encourage training and dissemination of information on verification methodologies;

(d) To take into account the needs of users so as to ensure the relevance of the practice of forecast verification;

(e) To facilitate the development and application of improved diagnostic verification methods to assess and enable improvement of the quality of weather forecasts, including forecasts from numerical weather and climate models;

(f) To encourage the sharing of observational data for verification purposes;

(g) To encourage greater awareness in the research community of the importance of verification as a vital part of numerical and field experiments rather than an "afterthought";

(h) To promote collaboration among scientists conducting research on various aspects of forecast verification as well as with model developers and forecast providers;

(i) To collaborate on forecast verification with the Working Group on Numerical Experimentation (WGNE) and WCRP in coordination with CBS.

The JWGFVR meets annually, organizes and implements tutorials and workshops, publishes recommendations on appropriate verification methods and provides support and advice to national and international demonstration projects and other WWRP Working Groups.

4.1 Verification methods

Over the last several years, the JWGFVR has been preparing two documents to provide guidelines for specific types of verification. In October 2008, a document discussing and recommending precipitation verification methods was published as a WMO report (see http://www.wmo.int/pages/prog/arep/wwrp/new/Forecast_Verification.html). This document includes guidelines for verification approaches to be used (for example) in the annual precipitation forecast comparisons that are undertaken by WGNE. The second document on guidelines for verification of cloud forecasts this document is currently in draft form.

As part of its out-reach activities, the JWGFVR maintains a Website on verification methods (http://www.bom.gov.au/bmrc/wefor/staff/eee/verif/verif_web_page.html). This Website contains a wide variety of information on verification methods, as well as links to software tools and references to other sources of verification information and scholarly works. The information on this

Website is widely used in academic settings as a teaching tool for statistics and meteorological courses and provides guidance for operational activities. Members of the JWGFVR also produced four EUMETCAL modules on verification methods (http://satreponline.org/vesa/verif/www/english/courses/msgcrs/index.htm) that provide hands-on instruction in verification methods and approaches. The JWGFVR also supports information exchange through an e-mail discussion group on verification methods.

4.2 Workshops and Tutorials

Since its inception the JWGFVR has organized and implemented workshops and tutorials on verification methods. Most recently, the 4th International Workshop and Tutorial on Verification Methods took place from 4-10 June 2009. Presentations from the workshop and tutorial are available on the workshop Website (http://www.space.fmi.fi/Verification2009/).

The June 2009 tutorial included 26 students from 24 different countries (and all continents). Many of the students were from operational centres. In addition to participating in lectures, the students completed computer exercises and group projects using real forecast and observational data. The results of the projects were presented by the students in a special session at the workshop. The workshop included about 100 participants, with sessions on user-oriented verification, verification tools and systems, coping with observation uncertainty, properties of verification methods, verification of weather warnings, spatial and scale-sensitive methods, seasonal and climate forecast verification, and new ideas in verification.

Overall, the students' reviews indicated that the tutorials are highly successful and meet their needs and expectations. More time for the projects and lectures would be desirable, and some students indicated it would be beneficial to have tutorials located at regional centres, which would allow more students to participate.

The JWGFVR would like to continue periodic workshops on verification. The two-year cycle for these workshops seems to be about right relative to the interest in the workshops and the continuing development of the science of verification. The target period for the next workshop is late 2011 or early 2012. The JWGFVR is also considering the idea of travelling tutorials – essentially implementing periodic tutorials in different regions of the world – to help reach more of the community.

4.3 Demonstration Projects

Beijing Olympics FDP (B08FDP)

The JWGFVR played an important role in the Beijing Olympics FDP (B08FDP) through the development and implementation of the Real-Time Forecast Verification (RTFV) system, which was a combined effort between the Australian Bureau of Meteorology and the Beijing Meteorological Bureau. RTFV successfully provided real-time feedback on the performance of the nowcasting systems that ran during B08, and this feedback was provided to forecasters as well as the system developers. Follow-up analyses (including the application of new diagnostic methods that couldn't be run in real time) are in progress; these analyses are expected to lead to publications describing the verification studies and results.

Other demonstration projects

Members of the JWGFVR have developed an initial verification plan for the SNOW-V10 Research Demonstration Project associated with the Vancouver Olympics, and will be helping to implement the verification analyses for this project during the next few months.

In addition, the JWGFVR is providing guidance on verification for the Shanghai 2010 Expo and a meeting on this topic is planned for October 2009 in Shanghai.

JWGFVR members have collaborated with the CBS, for example, in the preparation of revised recommendations for operational verification; the South Africa Severe Weather Forecast Demonstration Project (SWFDP) and the Nowcasting Research Working Group, and have participated in meetings with THORPEX working groups, including TIGGE, TIGGE-LAM, and the THORPEX Africa and North American regional committees.

4.4 Forecast verification method inter-comparison project (ICP)

Members of the JWGFVR helped to organize and have participated in the ICP, which is an effort to provide useful information on new verification approaches that have been developed in the last few years. The initial focus has been on spatial verification approaches, including object-based methods, scale separation approaches, neighbourhood methods, and field morphing approaches. The methods were all applied to the same datasets, including artificial cases that allow easy interpretation, as well as some high resolution model forecasts from the central US. The results of these studies will be published as a special collection in the journal Weather and Forecasting. At a recent informal workshop for this project (http://www.ral.ucar.edu/projects/icp/index.html), plans were developed to extend the project to new datasets and variables. This project is a significant step toward development of a verification method test-bed, which would be supported by the JWGFVR.

4.5 Future activities

With the emergence of seamless prediction systems as well as the increasing desire to provide societally relevant forecasts, there are many challenges to develop improved methods of forecast verification and to apply them to an ever-increasing set of forecast products. Important areas of research will include developing improved verification methods for high-impact weather forecasts, developing seamless verification methods in support of seamless prediction, as well as developing methods to verify forecasts of parameters of direct relevance to society, such as air quality predictions. Development of societally relevant forecast verification approaches will require close collaboration with the Societal and Economic Research and Applications (SERA) working group. An example area for this collaboration is the development of meaningful approaches for the evaluation of warning forecasts.

In addition to the development and promotion of new techniques, the JWGFVR plans to play a continuing role in the training of weather services and researchers in the use of verification techniques. This effort is of particular importance in developing nations. This role is likely to increase with the increased complexity of the forecasts systems and products. The WGNE has been instrumental in facilitating the development of new verification efforts, such as the verification of operational precipitation forecasts, tropical cyclone track prediction, and the promotion of metrics for climate models. Consequently, close collaboration between WWRP and WGNE in the area of verification is of utmost importance.

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World Meteorological Organization **CAS-XV/INF. 8**

COMMISSION FOR ATMOSPHERIC SCIENCES

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FUTURE PROGRAMME OF WORK OF THE COMMISSION

SUMMARY

Reference: CAS-XV/Doc. 8

CONTENT OF DOCUMENT:

Appendix:

- Background information related to the future programme of work of the Commission.

FUTURE PROGRAMME OF WORK OF THE COMMISSION

The CAS Management Group planned a pre-CAS consultation on five topics related to the future structure and activities of WMO research supporting the Strategic Thrusts and Expected Results of the WMO Strategic Plan. Five “vision papers” were produced by Expert Teams on each of the topics and posted on the website on 15 August 2009 at http://www.wmo.int/cas asking for comments to be e-mailed to cas15vision@wmo.int by 15 October at the latest. This information document summarizes the background information for the decisions suggested in CAS-XV/Doc. 8. For details see the vision papers.

1. Priorities in Strengthening and Promoting Linkages between Climate, Weather, Water and Environmental Prediction Research and Services (agenda item 8.1)

1.1 Background and Rationale

1.1.1 The last three decades have seen impressive successes in weather, climate, water and environmental prediction. Numerical weather prediction has been especially successful in forecasting extreme events, predicting everyday weather for the public and extending the range of predictability. Over the same period, climate modelling has progressed from atmospheric models with a simple representation of the oceans to fully coupled Earth system models complete with biological and chemical processes that are valued in climate assessments. At intermediate timescales, many research and operational centres around the world now produce numerically-based seasonal predictions using observed initial conditions that extend beyond the period of conventional deterministic predictability. In addition, the range of variables in prediction has extended from traditional atmospheric meteorological variables to ocean, air quality, sand and dust and crop production variables, to name a few.

1.1.2 The traditional boundaries between weather forecasting, seasonal forecasting and climate prediction are fast disappearing since progress made in one area can help to accelerate improvements in the other. For example, improvements in the modelling of soil moisture made in climate models can lead to improved forecasting of showers over land in summer, and data assimilation, which has been restricted to the realm of weather prediction, is now becoming a requirement of coupled models used for longer term predictions through seasons to decades. In developing a unified approach to weather, climate, water and environmental prediction, it is useful to view various characteristics of prediction research, operations and service delivery according to the time-scale of a forecast or prediction product (see Figure 1).

1.1.3 There is a mix of research and operational activity for all time scales except decadal (Figure 1A). The weather and climate prediction research community overlap strongly in the monthly to inter-annual prediction range (Figure 1B). There is currently a gap in climate service delivery (Figure 1C). The WMO Global Data-processing Forecasting System (GDPFS) that is supported by the Commission for Basic Systems (CBS) has a well established network delivering seasonal forecasts operationally through major global and regional centres while the WMO and its climate partners are considering a climate prediction services system. An expected outcome of the World Climate Conference-3 (WCC-3; http://www.wmo.int/wcc3/) is the endorsement of the need to develop and implement a Global Framework for Climate (Information and Prediction) Services (GFCS).

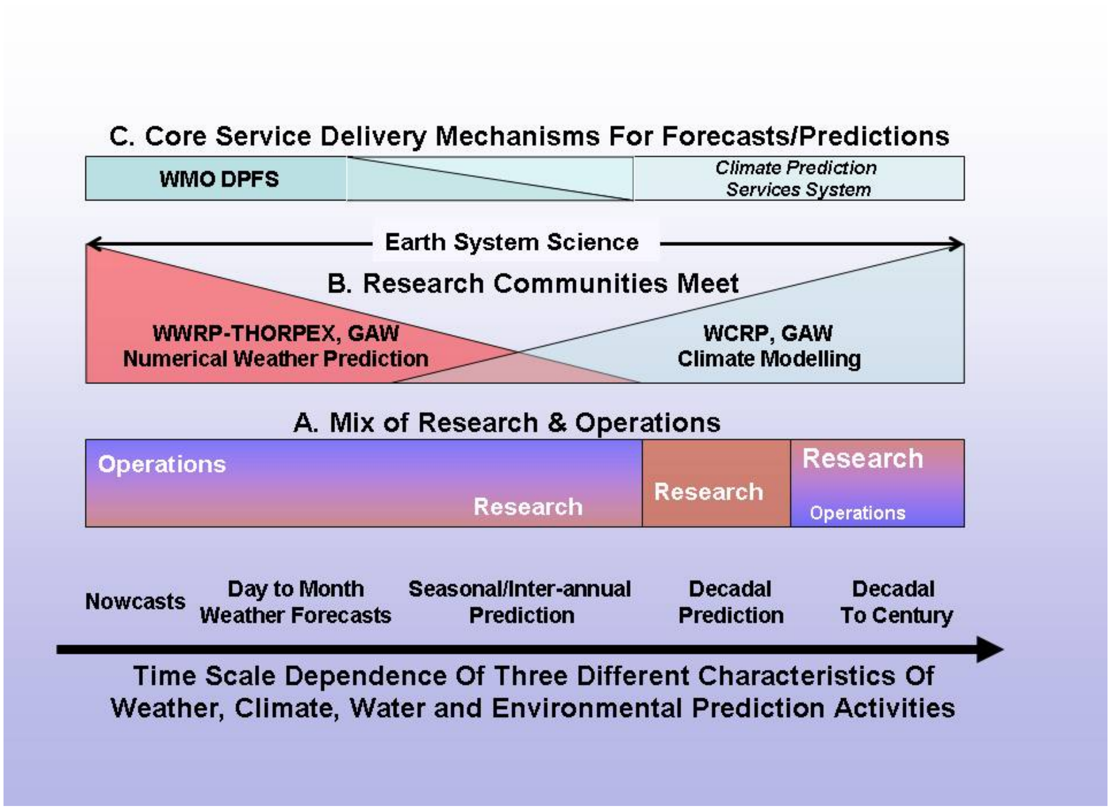

Figure 1. Time scale dependence of various aspects of weather, climate, water and environmental prediction.

1.1.4 As the scope of numerical weather prediction and climate prediction broadens and overlaps, the fact that both involve modelling the same system becomes much more relevant, as many of the processes are common to all time scales. There is much benefit to be gained from a more integrated or "seamless" approach. Unifying modelling across all timescales will lead to efficiencies in model development and improvement by sharing and implementing lessons learnt by the different communities, such as for example, enabling climate models to benefit from what is learnt from data assimilation in NWP models, enabling weather prediction models to learn from the coupling of climate models with the oceans, and sharing validation and benchmarking of key common processes.

1.1.5 The inclusion of atmospheric chemistry will improve not only prediction of air quality, but also weather prediction and predictions of climate change. Predictions of flood events will require better representation of hydrological processes at local, regional, continental and global scales, which are also important for predictions of climate change. In order to adapt to climate change, much improved simulation of regional climate and the modes of climate variability (El Niño Southern Oscillation (ENSO), North Atlantic Oscillation (NAO) etc.) are needed, and much of this is already being tested in seasonal predictions (Appendix B: Shapiro et al.). Users of forecasts and predictions prefer integrated sets of products from as few sources as possible with accuracy estimates (expressed probabilistically) that are simple to understand and to use and in a format they can understand and use.

1.1.6 Collaboration among many scientific disciplines is required spanning disciplines of meteorology, atmospheric chemistry, hydrology, oceanography, marine and terrestrial ecosystems, to name just a few. While atmospheric nowcasting and very short-range weather forecasting are primarily initial value problems, extension to short-, medium-, and extended-range weather forecasting begins to bring in the coupling with Earth system components such as atmosphere/land surface processes (soil moisture feedback, soil dust aerosols) and atmosphere/ocean coupling (heat exchange, seas salt aerosols).

1.1.7 Long-range forecasting through seasonal to inter-annual prediction involves atmosphere-ocean coupling with the initial conditions of the memory inherent in the upper ocean leading to longer-lead time predictive skill. Decadal climate prediction is determined by both initial values and boundary value forcing. On these times scales, deeper oceanic information and changes to radiative forcing from greenhouse gases and aerosols play determinant roles. When considering inter-decadal to centennial climate projections, not only do future concentrations of greenhouse gases, aerosols and ozone need to be taken into account, but also changes in land cover/dynamic vegetation and carbon sequestration governed by marine ecosystems. In addition, regionally specific predictive information will be required across these time scales for environmental prediction such as air quality and water quality.

1.1.8 These and other considerations led the EC-LX ANNEX II (Annex to paragraph 3.2.10.2 of the general summary) in June 2008 to form the Task Team on the Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (EC-RTT). The mandate of the team was to "strengthen and promote the linkages between climate, weather, water and environmental research to enable NMHSs and other related services to provide improved services in the next decade”.

2. The Next Generation of Regional Prediction Systems for Weather, Water and Environmental Applications (agenda item 8.2)

2.1 Background

2.1.1 Weather events account for approximately two thirds of the natural disasters in the form of floods, wind storms, slides (e.g., primarily mud slides and avalanches induced by precipitation), extreme temperatures (e.g., urban heat wave), and wild fires (typically associated with high winds, low humidity and high temperatures). Floods and wind storms (primarily tropical cyclones) are by far the most common type of disasters that impact our planet accounting for over half of the disasters. These events have increased with time. For example, approximately 100 natural disasters per decade occurred between 1900-1940, while that number has risen to almost 2800 events per decade in the 1990s (ICSU 2008). The cost of disasters globally to society have reached nearly 500 billion (US dollars) per decade with the costs of hydrometeorological disasters increasing by a staggering factor of 7 in the time period of 1997 to 2007. Climate change will likely change the probability of some types of high impact weather, like extreme temperature events.

2.1.2 Improved numerical environmental forecasts bring significant health and safety and economic benefits to the public, marine, transportation, agriculture, forests and resource sectors. Weather forecast models are the backbone of environmental prediction systems. In the last decades, they have improved remarkably. A five-day forecast today has more skill than the four-day forecast of a decade earlier. Numerical Weather Prediction (NWP) systems operated by WMO Members are the basis for new specialized environmental prediction tools for decision making. Is the steady linear improvement in the prediction skill of numerical weather prediction sufficient to meet the growing need for atmospheric modelling of the future? The urgency for action has increased as: (i) societies struggle to mitigate the rising economic costs of hydrometeorological disasters and the overall increase in the number of disasters; (ii) demand has grown for air quality, sand and dust and smoke forecasts; (iii) water management becomes even more important as supplies and flooding affects more people; and (iv) Member nations further develop alternative energy sources, which enhance the need for predictions to drive decision support systems for wind, solar and other new energy sources.

2.2 Changing paradigms for regional prediction

2.2.1 Prediction systems are in the midst of several major changes: (i) the first is a movement to increasing complexity as models are moving from predicting solely weather towards a spectrum of environmental prediction services that can include coupled modelling and new forecasting capability for atmospheric constituents, soil-vegetation-ecosystems, cryosphere, and hydrology, oceans and even fresh water systems; (ii) the second is the movement to higher resolution non-hydrostatic models (horizontal scales of order km or less) that begin to directly resolve clouds and deep convection; (iii) the reliance on nowcasting with increasing populations at risk for disasters and the need to expand such systems beyond a reliance on radar data; and (iv) the development and utilization of ensemble prediction systems to indicate uncertainty in a forecast Determining and capturing this uncertainty in the design of the ensemble will require significant research for these new regional coupled environmental modelling systems.

2.2.2 A widespread movement amongst Members towards higher resolution non-hydrostatic modelling on regional domains for weather time-scales is creating new research and operational challenges that will benefit from international coordination, leadership and guidance by the CAS programmes of WWRP, THORPEX and GAW. Such a shift is resulting in challenges of new observing systems and strategies, the development and refinement of high resolution data assimilation techniques, and the evaluation, development, testing and implementing of model physical parameterizations that operate accurately and efficiently on these scales. Such a shift also requires the development of new verification strategies that are aimed to assess the added information content of these new forecast models as well as theoretical studies to determine the level of skill that is possible with such new modelling approaches. More and more Members are using a unified modelling approach for short- and mid-term operational weather forecasting and for climate modelling. Improvements in non-hydrostatic modelling on the regional scale now will benefit global weather and climate prediction systems in the future.

2.2.3 The major scientific challenges to be met to advance regional prediction include:

(a) *Prediction on time scales from minutes to hour*s: Nowcasting fills this forecast niche. Profound changes are needed in nowcasting systems; for example, the development of improved nowcasting techniques based on satellite systems are needed to benefit those nations without advanced radar capabilities. Another change is that the distinction between nowcasting and high resolution data assimilation is becoming blurred as nowcasting systems are becoming blended with high resolution numerical weather prediction models and resolution non-hydrostatic models incorporate so-called "hot starts" where radar, satellite and other observations of precipitation and associated diabatic processes are included in the initial state of the model. Research challenges for both nowcasting (0-6 hours) and limited area modelling (resolution ~ 1-km) for longer time scales are discussed in the WWRP Strategic Plan (agenda item in section 4.2 and 4.3) under activities of mesocale and nowcasting research;

(b) *Shift from hydrostatic to non-hydrostatic modelling:* Limited area models are in the midst of a shifting into the non-hydrostatic domain with grid resolution of ~1 km and global modelling centres are beginning to also plan for this transition. This shift means that cloud systems and many orographic processes are beginning to be resolved directly rather than being parameterized as a subgrid-scale process. Such a shift will require the evaluation, development, testing and implementing of model physical parameterizations that operate accurately and efficiently on these scales. Parameterizations for surface, boundary layer, microphysical and cloud-radiative processes will all be effected. Even investigations into new model formulations and improved numerics will benefit prediction research, particularly in mountainous terrain. Theoretical studies will be needed to determine the level of skill that is possible with such approaches. Such efforts will benefit from greater collaborations between operational centres and the academic research community that has been using and developing such models for many years;

(c) *Coupled numerical prediction:* Coupled Numerical Weather and Environmental Prediction (NWEP) will provide linkage between the land, hydrosphere, cryosphere and atmosphere including the chemical and biological processes relevant to weather. Concentrating on coupled systems means that the feedbacks between these miscellaneous processes will be represented so that prediction of a variety of parameters will be improved. Atmospheric NWP systems are being extended to include atmospheric chemistry and feedbacks to radiative forcing and precipitation, coastal ocean and terrestrial zones, quantitative precipitation and hydrology, urban meteorology and air quality and biogeochemical and ecosystem processes. Initiation, guidance and international coordination in research on the development and utilization of such models would accelerate their development;

(d) *Data assimilation and the explosion in remote sensing capability*: Numerous issues exist in the development of data assimilation systems for these high resolution models. For example, the task of developing rapid, accurate and efficient data assimilation fields to initialize cloud, precipitation and surface variables (e.g., soil moisture, vegetation, etc.) at high resolutions is a major challenge even without exploring the non-meteorological variables. Coupled assimilation such as land-ocean also represents a major investment in research and development. Satellite remote sensing is well suited to many of these tasks but extending the 4-D var approach to fine scales is a computation challenge. Many non-meteorological fields are not yet transferred in real-time, which must be overcome to initialize such models;

(e) *Verification and assessment:* A shift to new coupled, high resolution models also requires the development of new verification strategies that are aimed to assess forecast skill. One major challenge is that the predictability of specific events at a specific time and location, such as the location of a thunderstorm cell, is low. Thus model verification must move from a point based verification strategy to techniques to assess the information content of these models. Object oriented verification is one approach discussed in agenda item 7.3;

(f) *Next generation ensemble systems:* Ensemble models are designed to capture the forecast uncertainty by providing probalistics. For next generation coupled ensembles, the uncertainty in the observation, assimilation and modelling must be understood and incorporated into the design of the system. Regional ensembles must capture both the local uncertainty and the uncertainty in the global model that provides the boundary conditions;

(g) *Information delivery through sophisticated forecast systems*: The effective use of high resolution and seamless regional environmental systems depends not only upon the modeling capability but the ability to provide information that impacts user decision making. Information delivery is ultimately the primary reason for NMS existence and this step of the forecast process is a key stage requiring end-to-end approaches to, and engagement. The density of forecast information means that Members will benefit from well designed Forecast Demonstration Projects to transfer new research capabilities to operations.

2.2.4 The challenge to develop, assess, and implement this next generation of regional models are broad and daunting and match WMO Member needs as a large number of WMO Members employ regional models and the benefits of these new systems will help meet the evolving needs of Members. We propose an enhancement of the WMO leadership role in international research efforts aimed at accelerating the development, quality and use of these new regional modelling capabilities, including coupled models. This WMO role will include the initiation, guidance, and enhancement of research projects to advance these modelling systems and the operational research results in a similar manner as has been done by THORPEX for global prediction. The research projects envisioned under this effort, when taken together, will span from observing strategies and data assimilation to model improvement and the assessment and delivery of high resolution forecast information.

3. The Lead Role of WMO in Global Partnerships for Air Quality/Environmental Forecasting and Tracking Carbon Dioxide and Other Greenhouse Gases (agenda item 8.3)

3.1 Air Pollution in Densely Populated Areas

3.1.1 Air pollution in, around and downwind of megacities affects human health in important ways throughout the world. The forecasting of urban to regional scale air pollution is an important service in order to allow the population to take precautions to reduce risk to health on a daily basis and to identify policy measures to reduce pollutant inputs to the atmosphere so that air quality objectives and standards set to protect society can be met. Air quality and related issues depend strongly on the meteorological conditions that, when better characterized, in numerical weather prediction models improve air quality prediction and management.

3.1.2 Improvement of weather and air quality predictions through the assimilation of chemical data and coupling to radiation and clouds/precipitation holds significant promise. There remain major deficiencies in our observing system for air pollutants to support improved weather forecasts and air quality prediction at multiple scales: (i) expansion of the geographical coverage of air quality measurements; (ii) extending surface-based (in situ and remote sensing) and aircraft measurements above the surface (lowest few km) to provide critical information not well provided by satellite observations; and (iii) adding a near-real-time access to the observations.

3.1.3 The WMO GAW Urban Research Meteorology and Environment (GURME) project enhances the capabilities of Members to provide air quality forecasting. It facilitates easy access to information on measurements, modelling and assimilation techniques, promotes pilot projects to demonstrate how Members can expand their activities into urban environment issues; and works with WHO and environmental agencies to better define meteorological and air quality measurements that support urban forecasting. Near-real time delivery of environmental data is an important component of forecasting urban pollution. Both the near-real-time delivery of urban observations and the forecasting activity should be pursued at the national or local levels. WMO should continue to provide advice and capacity building.

3.2 Transport of Air Pollution Across National and Regional Boundaries

3.2.1 There is growing attention directed at the global reach and impact of air pollution (TFHTAP, 2007). This requires the capability to observe and predict air quality at scales from local to regional to global as addressed in the WMO-GAW programme (see agenda item 5.3). On a regional or continental scale the main air pollution problems are related to elevated surface ozone, particulate matter (determined by chemical composition and physical characteristics), acid deposition, deposition of nutrients (eutrophication) and the deposition of heavy metals and persistent organic pollutants. The economy is globalized with important consequences for the change in abundance of intercontinental transport of air pollution. The emissions of gaseous precursors of particulate matter and oxidants in the atmosphere have grown in the last decades in many parts of the world with high population densities. Aircraft emissions and shipping emissions are growing. Changes in farmland practices and in physical climate give rise to more biomass burning, forest fires and sand and dust storms (see agenda item 6.3). Increasing attention is needed to understand the intercontinental transport of air pollution and its contribution to the pollution levels in various regions (including Europe, the Arctic, marginal seas, etc.).

3.2.2 WMO could assume the lead in linking together technical work on the regional/continental long range transport of air pollution globally to assess the impact of long (and very long) range transport of air pollution through models coupled with observations and quantitative information on impacts to human health and ecosystems of aerosols, ozone and nitrogen.

3.3 Air Pollution, Climate Change and Weather Interact Both Ways

3.3.1 UNFCCC is a convention dedicated to mitigating and adapting to the climate effects of long-lived greenhouse gases. Ozone and particulate matter including aerosol pollution, black carbon and sand and dust are atmospheric constituents that have very short atmospheric residence times compared to greenhouse gases yet the significant direct and indirect radiative forcing of climate. Controls of emission of these short-lived substances (<months in the troposphere) will have an immediate effect on radiative forcing while we must wait much longer for greenhouse gas controls to have a mitigating impact due to the long residence times of carbon dioxide (>100 years) and methane (~10 years) in the atmosphere. In addition radiative forcing by particulate matter and tropospheric ozone is expected to have significant impacts on weather including the frequency and intensity of storms. The extent of the modification and its societal impact is not well known, and needs more research.

3.3.2 To properly account for the coupling of dynamics, physics and chemistry and the cycling of biogeochemical tracers between the soil, the atmosphere and the oceans, chemical transport models need to be integral parts of weather or climate models that in turn are moving toward full Earth System Models (ESMs) as appropriate (report of WMO Executive Council Research Task Team; http://www.wmo.int/ecrtt). WMO should take the lead in the technical analysis of how weather and climate variability or change interact both ways with air pollution on a regional and global basis. This is an issue of immediate concern throughout the world affecting societies to an extent that is not well known but could be significant (air pollution events, storms, floods, droughts, water supply, food supply etc.).

3.4 Tracking Carbon Dioxide (CO_2) and other Greenhouse Gases

3.4.1 Unless mitigation actions are taken, CO_2 emitted into the atmosphere will remain there for a very long time – 100's to 1000's of years, during which it will continue to warm the Earth and acidify the oceans. Other greenhouse gases, with very long atmospheric lifetimes, are increasing in the atmosphere as well, in large part due to human activities. The combined effect of these continued emissions has already led to warming and certain climate change impacts.

3.4.2 A substantial strengthening of efforts to reduce CO_2 emissions will probably happen sooner rather than later. Unlike other large-scale emission reduction efforts (e.g. ozone-depleting compounds, controls on sulphur and nitrogen oxide emissions related to acid rain and human health), these will involve many economic sectors of society and will vary by nation, region, and approach. Large-scale emission reductions in the past have all required on-going verification to ensure that the desired outcomes are achieved. These include measurement of pH in lakes and rain for sulphur emission reduction; atmospheric measurements of ozone and ozone-depleting gases for stratospheric ozone recovery; atmospheric measurements of ozone, other reactive gases and particulate matter for regional air quality policies. The complexity and variability of the carbon cycle, the involvement of other GHGs, the global nature of the problem, and the number and variety of emitters and offset options, however, make independent verification of greenhouse gas management strategies a challenging task, but one that must be done.

3.4.3 The ability of nations to implement policies that effectively limit atmospheric GHG concentrations will depend upon their ability to monitor their progress and determine what is and is not working. While current uncertainties in existing data sources are perhaps acceptable for current policy purposes, they need to be reduced substantially for effective policies on climate mitigation.

3.4.4 Current efforts to monitor and limit GHG emissions are mostly based on land-use observations, self-reported data on energy use, and other economic activities. While such data may be sufficient for today, they are known to have many uncertainties that limit their ability to support implementation of GHG-management related to climate. This presents a challenge to implementing a range of GHG policies that are discussed in many countries, including supporting treaty negotiations, verifying treaty obligations, certifying tradable permits, offsetting GHG emissions, and providing a more accurate inventory of emitters. Added to this is the complexity and variability of the natural carbon cycle and the effects of climate change on natural systems that exchange CO_2 and other GHGs (e.g., N_2O, CH_4). Thus to develop effective GHG management strategies, there is an urgent need for a globally integrated observation and analysis system to track changes in atmospheric GHGs and provide routine estimates (with confidence limits) of net atmosphere-surface exchange on a regional or sub-regional basis.

3.4.5 WMO, through its Global Atmospheric Watch (GAW) programme, has long provided a framework for global greenhouse gas monitoring and integration of those measurements, and it is recognized by UNFCCC and the Global Climate Observing System as the lead international framework (see agenda item 5.3). It includes facilities and observations managed by national partners linked together by GAW. Components of this system include a Central Calibration Laboratory for the World Reference Standard for Greenhouse Gases, the World Data Centre for Greenhouse Gases; WMO sponsored biennial experts' meetings on CO_2, other greenhouse gases, and related tracers; the quadrennial International Carbon Dioxide Scientific Conference and other relevant conferences, workshops, and meetings. GAW also promotes reanalysis to develop informational products; provides training opportunities to help build capacity in contributing to the observational system; and the development strategies for integrating land, ocean, and atmospheric observations to understand the role of the Earth system in greenhouse gas management.

3.5 The Reactive Nitrogen Cycle

3.5.1 Humans continue to transform the global nitrogen cycle on Earth at a record pace, reflecting an increased combustion of fossil fuels, growing demand for nitrogen in agriculture and industry, and pervasive inefficiencies in its use. Much anthropogenic nitrogen is lost to air, water, and land causing a cascade of environmental and human health problems. Simultaneously, food production in some parts of the world is nitrogen-deficient, highlighting inequities in the distribution of nitrogen containing fertilizers. Optimizing the need for a key human resource while minimizing its negative consequences requires an integrated interdisciplinary approach and the development of strategies to decrease nitrogen-containing waste. The technical assessment work on reactive nitrogen takes place in the International Nitrogen Initiative (http://www.iniforum.org/) and through European initiatives on reactive nitrogen in which WMO plays a role through the GAW programme (e.g . COST 729 as well as EU research projects).

3.5.2 Reactive nitrogen influences water bodies, atmospheric oxidative capacity (through the hydroxyl radical, ozone and the nitrate radical) which in turn affects atmospheric residence times of some greenhouse gases such as methane, sources of nitrous oxide (a greenhouse gas and stratospheric ozone impactor) and nitrates in atmospheric particulate matter and precipitation.

3.5.3 The atmospheric component of the biogeochemical cycle of reactive nitrogen including its relation to the sequestration of carbon in ecosystems is not well known. Reactive nitrogen cascades through environmental compartments with approximately 165 Mt-N of reactive nitrogen produced each year, of which about 75% is related in some way to agriculture and 25% to the combustion of fossil fuels and the industrial use of nitrogen.

3.5.4 The cycling of reactive nitrogen between the atmosphere, fresh water systems, terrestrial ecosystems and the oceans influence several issues of high societal relevance. WMO and its Members could take a lead in the global coordination, particularly with respect to its feedback on climate forcing. This has implications locally or regionally on the quality of the water supply and the link between the reactive nitrogen cycle, air pollution and climate change. WMO should actively support the analysis of the reactive nitrogen cycle with the view to advise and build capacity among its Members by advising them on ways to use reactive nitrogen fertilizer in regions where food production is nitrogen deficient while minimizing reactive nitrogen inputs to the atmosphere. This has links to the Commission for Agricultural Meteorology and to other UN organizations.

3.6 The Political Framework of These Challenges

3.6.1 In the past WMO led, or was a major co-sponsor of, a series of scientific assessments that laid the groundwork to establishment of the UN-ECE Convention on Long Range Transboundary Transport (1979) and the Vienna Convention on Protection of the Ozone Layer (1985). Changes in air pollution, climate and the biogeochemical cycles of trace chemicals like carbon and reactive nitrogen give rise to new environmental problems that require internationally coordinated action. The scientific analysis and mitigation strategies for these problems require an interdisciplinary approach both nationally and internationally. WMO and its partners worldwide are well placed to lead a cooperative effort to develop appropriate partnerships.

4. Advancing Weather, Ice and Environmental Predictions in The Polar Regions: An IPY Legacy (agenda item 8.4)

4.1 Introduction

4.1.1 In the justification for nearly every IPY project one can find, prominently, a description of an urgent polar process NOT adequately (if at all) represented in global models. Sea ice drift; aerosol production near polynyas; pulses of deep water formation; photochemical production of oxidants from snow; etc. These polar deficiencies present serious barriers to improved weather, climate and environmental predictions, globally and for polar regions. If most IPY projects identified improved models as a motivation, can we see, or foresee, improvements in predictive skill, for ice, ocean, atmosphere, or carbon cycling, for polar regions or globally? In additional to hoped-for improvements in prediction, what might IPY-induced changes in operational systems or in research contribute to a positive long-term legacy of rapid incorporation of new knowledge into enhanced predictive skill?

4.2 Possible prediction outcomes from IPY-produced knowledge

4.2.1 Most IPY research will not automatically lead to the rapid development of useful predictive skill. To reduce delays between research products and predictive applications, several national research agencies design funding programmes to encourage observationalist-to-modeler interactions; many international research programmes (e.g. WCRP, WWRP, THORPEX) have a similar objective. The transfer of research model developments to operational modelling practice represents another essential and often missing step in developing useful predictive skill. This transfer does occur effectively in advanced numerical weather prediction centers of the WMO system, but many of those centers have ‘blind spots’ when it comes to polar regions. We imagine three user groups, each group including researchers, operators, and decision makers, and then identify the potential for, or obstacles to, rapid development of polar prediction systems and skills.

Marine operations

4.2.2 Largely focussed on transportation and the Arctic, this group could include commercial shipping and resource (e.g. hydrocarbon or fishery) extraction companies, insurance and regulatory bodies, port authorities, tour operators, and national policy- and decision-makers. IPY’s potential impact on this group would occur through improved predictive skills for ice, ocean, and marine weather, embodied in daily, monthly, seasonal and decennial forecasts.

Carbon impact community

4.2.3 This group could include climate modelers, climate negotiators and regulators, national and international assessment groups, and a growing carbon-literate public. IPY's potential impact on this group would occur largely through the development of improved global climate models, expressed through regular seasonal, decennial and centennial predictions and in periodic assessments.

Natural resource managers

4.2.4 This group could represent present and future consumers and managers of polar marine and terrestrial ecosystem resources, health specialists, sociologists and community activists, economists, and local, regional and national governments. IPY's potential impact on this group would occur through development of integrated ocean-atmosphere-ecosystem models with predictive skill for regional and local food abundance and quality; several models have emerged during IPY that show preliminary skill and great potential.

Barriers to polar prediction skill

4.2.5 For each of our imaginary groups, we assign an urgency of need, and a probability of progress. Unfortunately, we score urgency as high but progress as slow or unlikely in every case. Why? A challenging and urgent gap exists between the many observations and studies of polar systems undertaken during IPY and the development of useful predictive skill for integrated geophysical and biological (and Arctic social) systems. This gap has several causes. The natural tendency of science to focus on research publications represents a primary cause. A lack of suitable and capable predictive models for polar systems also contributes to the gap.

4.2.6 Meanwhile, our three user groups need robust predictive skill for key polar questions about ice, carbon and ecosystems; reliance on 'climatologies' or extrapolation of recent trends clearly will not provide sufficient guidance. The follow-up to IPY needs a prediction focus and framework, developed with leadership from and in partnership with organizations like the WMO, but covering the physical, biological and cultural features of polar systems, to quickly and effectively exploit IPY science for the benefit of imagined and real user groups, polar residents, and global citizens.

Several positive steps

4.2.7 Through IPY-stimulated cooperation, operational weather and space agencies as well as national funding programmes have produced some remarkable results. The WWRP-THORPEX cluster of IPY projects has generated new polar cloud, microphysics and surface flux data for improving physical parameterizations, improved high-latitude assimilation techniques for satellite data, advanced the use of ensemble simulations and observational targeting for high latitudes, and demonstrated the positive impact of increased Arctic and Antarctic observations on local and extratropical forecasting. The integrated observations of the Arctic Ocean during IPY, in which the combined international talents of chemical, biological and physical oceanographers has plausibly achieved the stated goal of "being able to measure almost any key environmental variable of interest almost anywhere and at almost any time" represents an extraordinary example of formal and ad hoc international cooperation among funding agencies of at least ten countries.

4.2.8 The IPY Polar View project has established enhanced levels of integration among international sea ice services, making it easier for users to access sea ice information. Space agencies, particularly those operating synthetic aperture radars, have adjusted schedules, modified operational parameters, and offered enhanced free data access as they cooperated in the IPY Global Interagency IPY Polar Year Snapshot (GIIPSY) to produce unprecedented systematic coverage of ice sheets and ocean-ice margins. The European Centre for Medium-range Weather Forecasts (ECMWF) has made daily high resolution model fields available to IPY researchers through a portal at the Norwegian Meteorological Service. Many of these efforts would justify continuation if they could demonstrate a useful predictive impact.

IPY Legacy: A serious polar prediction effort

4.2.9 A WMO-organized network of national prediction centers routinely produce some useful forecasts of daily to weekly polar weather and weekly to seasonal ice conditions. These same groups work with the climate community of WMO to deliver some routine seasonal forecasts on a regional basis. Other groups produce global climate scenarios on multi-decadal to century scales. However, none of these products bring the full potential of IPY research together to addresses the topical needs or range of pertinent times scales envisioned for our polar user groups. We call for an immediate, high-level and sustained focus on polar prediction services, stimulated, led and coordinated by WMO, as the best way to integrate and synthesize the IPY observational efforts and to communicate and maximize the impact of IPY science. We encourage the Commission for Atmospheric Science of WMO, representing weather, climate, water and environmental prediction research, to find ways to do this.

4.2.10 We suggest a prediction focus on snow, ice and air pollution (for weather, climate, sea level and transportation applications), carbon (for emission and ecosystem applications), and ecosystems (for future fisheries, forestry, biodiversity conservation, human and ecosystem health).

4.2.11 Predictions for polar regions will start from weather and climate. Very quickly, however, real prediction skill for snow and ice, carbon, and ecosystems will require assets of and cooperation from meteorology, hydrology, air chemistry, oceanography, glaciology, biology, ecology, physiology, sociology, and economics. While ability to model integrated physical-biological-human systems remains primarily a dream on global scales, polar systems represent a more geographically-manageable situation. Progress on prediction skill for integrated polar systems, while enormously difficult, will represent an important enabling step for other regional or global systems. The strengths of the WMO numerical weather prediction research and operational community at measuring prediction skill will apply here in a broader context. The joint verification research working group of the World Weather Research Programme and the Working Group on Numerical Experimentation of WMO and its co-sposored WCRP programme represents a useful place to start.

4.2.12 The design and development of a polar prediction system represents an appropriate and urgent task for the WMO Executive Council Panel of Experts on Polar Observations, Research and Services. A polar prediction system will draw and coordinate many research and operational elements of WMO and related agencies, of national modelling centers and of other polar science organizations into common purpose; the system will stimulate and support polar research in all it forms. A polar predictions system should represent the central motivating idea of a polar decade.

5. Ocean Prediction Issues Related to Weather and Climate Prediction (agenda item 8.5)

5.1 Introduction

5.1.1 The ocean and atmosphere represent a coupled system across all time and space scales for weather and climate. Much of the focus to date has been devoted to the added-value of coupled systems in critical applications such as severe weather, maritime safety (waves and ice) and increasingly environmental planning and management. An important distinction needs to be made between applications sensitive to the errors of essentially slowly evolving boundary conditions and applications that are sensitive to rapidly evolving boundary conditions. Evidence is growing of where and when coupling is dynamically significant. Enhanced performance of weather prediction systems are expected from coupled data assimilation where the forecast errors of the ocean (land and ice) co-vary with atmospheric forecast errors. Knowledge of the significance and impact of coupled data assimilation corrections to weather will be an active area of research over the next decade.

5.1.2 Present ocean prediction systems are largely constrained by computational cost and the limitations of the observing system leading to sizable errors from system biases and initialization. Over the next decade, the barrier to the use of coupled systems caused by inadequate ocean prediction system performance will diminish leaving coupled ocean-atmosphere systems as the next major improvement to weather prediction.

5.2 Status of our understanding of ocean circulation

5.2.1 Ocean circulation exhibits boundary currents, large-scale gyres and jets, boundary layers, linear and nonlinear waves, and quasi-geostrophic and three dimensional turbulence. Away from the poles, the physics of the ocean is simpler than its atmospheric counterpart because there are no internal state changes. The oceans larger dynamic and thermal inertia leads to longer timescales than the atmosphere and this increases with depth as the influence of weather declines. In contrast, the horizontal scales of ocean geostrophic turbulence have length scales 0 (10-100) km which are an order of magnitude smaller than in the atmosphere. In contrast poleward of 20°, the instantaneous ocean circulation is dominated by mesoscale eddies and not Rossby waves as previously thought.

5.2.2 Mesoscale ocean circulation plays an important role in ocean, atmosphere and climate mean state and variability. Equatorward of 20° are regions dominated by mixed wave-eddy and wave dynamics for which specific modes such as El Niño/Southern Oscillation (ENSO) have been identified as controlling seasonal climate. The dynamics of the Indian Ocean and interaction with the Pacific is an active area of current research. Lower zonal resolution models have limited ability to predict near-surface salinity or accurately reproduce fine scale processes and bathymetric constrained transports such as coastal upwelling. Resolution can also be a limiting factor in the representation of the Equatorial Atlantic. In the tropics, there is evidence that higher vertical resolution is needed for the representation of diurnal and intraseasonal variability of the upper ocean, which is important for weather and climate forecasts.

5.3 Status and future directions of ocean observing systems

5.3.1 The past decade has seen the successful implementation of a global ocean observing system (GOOS) strategy to deliver systematic global information about the physical environment of the oceans. An estimate of the ocean state can now be obtained within years rather than decades permitting tracking over time. A critical future activity for GOOS is to consolidate, optimize and secure implementation as a permanent monitoring system serving not only research, prediction and analysis for climate but also for ocean and weather.

5.3.2 Large gaps remain in observing the mesoscale ocean state in real-time. The present design of Argo buoys (10 day cycling and a target coverage of one float per 3° by 3°) undersample the mid- and high-latitude variability. Argo is Lagrangian and cannot reliably sample features that may be critical to a particular forecast event. Argo is also not designed to observe regions shallower than 2000m including the continental shelves or semi-enclosed seas. It is not realistic to achieve mesoscale coverage from an array of autonomous floats. The future direction will need to be toward adaptive sampling. Argo floats with Iridium 2-way communications together will permit changes in cycling patterns to target sampling of eddies. However the most promising direction are gliders that can navigate their course through controlled ascent/descent cycles.

5.3.3 Over the past decade, satellite remote sensing has been responsible for achieving the first skilful global ocean prediction systems. This effort lags the advances that have been realized in weather prediction from the use of satellite sensing of atmosphere and ocean. Multiple narrow-swath altimetry satellites over the past decade have provided extraordinarily accurate (i.e., error variance equal to 25 cm^2), measurements of sea level anomaly (the ocean analogue to mean sea level atmospheric pressure anomalies) sufficient to initialize mesoscale ocean models. A key disadvantage to the current sampling is the long time that it takes to achieve global coverage (approximately 10 days for Jason and Jason-2) which impacts the quality of near real-time analyses and reduces forecast skill. Both satellite constellations and wide-swath altimeters are expected to be implemented over the next decade and provide greater real-time coverage. The same instrumentation will also greatly reduce the errors in wave initialization and lead to improved boundary conditions for weather prediction systems.

5.3.4 Satellite sea surface temperature (SST) is the most sophisticated network with IR and microwave instrumentation, sun synchronous and geostationary orbits offering accurate and dense coverage. SST strongly co-varies with the ocean temperature over the mixed layer depth, O(50-100)m, and complements altimetry in multi-variate analyses. Maintenance of the current network including the microwave and geostationary platforms is required.

5.3.5 Satellite sea surface salinity (SSS) is a new capability with the launch of Aquarius and SMOS missions. The first generation instruments will achieve modest accuracy that will limit their impact on ocean prediction systems largely to regions with the highest variability such as the tropics. Remote sensing of ice-edge and ice thickness suffered a setback with the loss of Cryosat; however the launch of Cryosat-2 (in addition to climate monitoring) will enable advances in both the science and predictability of sea-ice with potential benefits for weather prediction in high latitudes. SST and SAR remote sensing also contribute to ice edge and concentrations.

5.4 Status and future directions in ocean modeling

5.4.1 We are entering an era where weather and climate simulations with an eddy-permitting/resolving ocean will become common. Community ocean model development has been dominated by two drivers: climate modelling and coastal modelling. Coastal modelling is focused on shelf processes, mixed surface/bottom boundary layers. It is generally high resolution with grid spacing less than 1km, limited area, open boundaries, terrain following vertical coordinates and unstructured grids. Weather applications that could benefit from ocean coupling in the coastal zone include sea breeze, fog forecasting and cyclones that interact with boundary currents. These applications may not require high resolution coastal models to achieve the relevant coupled feedbacks. High resolution global and regional ocean modelling (i.e., grid spacing of 1-10 km) as required by ocean prediction systems will lead climate model development and is currently served by a smaller subset of developers. Several design choices and drivers such as nonhydrostic vs hydrostatic, Boussinesq vs non-Boussinesq, hybrid vertical coordinates, unstructured grids, mixed layer parameterization and sub-mesoscale parameterizations are likely to be distinct between climate and ocean prediction applications over the next decade.

5.5 Status and future directions of ocean prediction

5.5.1 Ocean circulation and ocean state variability are dominated by geostrophic turbulence as is the case for atmospheric circulation. The oceans larger rotational inertia and thermal inertia does lead to longer timescales than the atmosphere. However, the horizontal spatial scale for ocean geostrophic turbulence is an order of magnitude smaller than its atmospheric counterpart. There are several implications for ocean prediction: (a) global eddy resolving models in ocean prediction systems are approaching 1/12° to 1/25° degree resolution (spectral equivalent, T1080 to T2250) to resolve the spectrum although useful skill may be obtained from 1/4° models; (b) 4D variational and Ensemble Kalman Filter methodologies and conventional ensemble forecasting will remain computationally expensive over the medium term; and (c) a higher resolution or targeted observing system than the present GOOS is required to constrain the error growth.

5.5.2 Operational ocean prediction systems producing forecasts of the mesoscale ocean state and circulation have been implemented by agencies and centres in Europe, North America, Asia and Australia. This capability is expected to be developed in Africa and South America over the next five years. Ocean prediction is a maturing field which has successfully demonstrated that the GOOS can sufficiently constrain the mesoscale variability to enhance the skill of weather forecasts but only moderately and inhomogeneously with present systems. Progress could be aided by specific evaluation of ocean prediction products for a comprehensive range of weather forecasting applications to determine the performance targets necessary to achieve consistently positive impacts. Ocean prediction is undergoing rapid development, attracting investment at a national and international level. Performance targets for weather prediction will help drive both the system research and observing system design.

5.6 Prospects for skillful SST prediction from ocean prediction systems

5.6.1 SST is a key variable in coupled weather-ocean prediction. SST forecasts are dependent on the ocean initial thermal and density stratification, advection-diffusion of the ocean dynamics and air-sea fluxes. The vertical stratification in present ocean analyses relies on the projection of surface data with a sparse in situ network for vertical profiles. The analysis error of temperature at the surface is relatively small due to the dense coverage and accurate satellite SST observations. The error grows with depth to a maximum at the base of the mixed layer and then declines with depth due to the reduction in variability. Operational ocean four-day temperature forecasts show skill for the upper ocean. Atmospheric forecast fluxes are currently based on fixed SST's or persisting anomalies from the previous 24 hours observations. SST persistence skill shows a steady decline over the forecast period contributing to a growth in error of sensible and long wave radiation heat fluxes.

5.6.2 Uncertainties in atmospheric initial and boundary conditions and numerical modelling contribute to uncertainties in the modelled ocean state. Errors in the 10m winds lead to errors in the sensible and latent heat fluxes and mixed layer entrainment. Errors in the cloud fraction also impact the penetrative shortwave radiation. Coupling the SST could reduce errors in the sensible and latent heat fluxes which can feed back into the atmospheric boundary layer and ocean mixed layer. The explicit representation of the air-sea interaction in weather forecasting systems improves the forecasts of SST (diurnal variations) and atmospheric deep convection in the tropics. In a first instance, this can be achieved by coupling the atmosphere to an ocean mixed layer model, although ultimately the inclusion of more complete ocean dynamics would be desirable. Improvements in ocean and atmospheric initialization will also be critical to improving SST predictive skill. The air-sea interaction should also be taken into account in the initialization of both the ocean and the atmospheric systems.

5.6.3 The spatial and temporal variability of SST forecasts have been shown to scale with the resolution of the ocean prediction system. This variability is greater than the foundation temperature (the pre-dawn temperature) obtained from equivalent resolution SST analyses. It has not been satisfactorily resolved where the bias lies and is a subject of further research. Nevertheless, the use of ocean forecasts as boundary conditions with or without coupling will introduce additional variability.

5.7 Prospects for skilful inertial coupling from ocean prediction systems

5.7.1 In general, inertial coupling of atmosphere and ocean coupling reduces the net stress permitting higher 10m wind speeds to produce the same momentum transfer into the ocean. This produces the correct intensity in tropical cyclones that matches the more modest reduction in SST cooling. The drag coefficient at high wind speed is a current research topic that suggests the efficiency of momentum transfer is reduced. Including effects of sea spray in boundary layer processes provides additional physical constraints to the relation between momentum, heat and mass fluxes. The forecast skill of ocean currents is low. Improved skill from inertial coupling is obtained from parameterizing or modelling wind-waves. Some of the existing Numerical Weather Prediction systems already include the wave coupling in the estimation of the winds, and will benefit from having ocean currents as input fields, both in the forecasting and in the assimilation phases, this latter being particularly important for the assimilation of scatterometer data. Improvements in atmospheric winds will in turn feedback on the quality of the ocean analysis.

However, there is not yet a consensus strategy shared by the atmospheric and oceanic communities on how to achieve the best representation of the coupled air-wave-ocean inertial coupling.

5.7.2 The observing system for surface motion is limited to a sparse network of drifting buoys with large representative error, feature tracking of SST and ocean color with large analysis errors, and the assimilation of a sparse set of sea level anomalies. Significant advances will follow the introduction of wide-swath and constellation altimetry. Wind stress is directly observed by scatterometry; however, present coverage under observation samples the sub-inertial timescales of the atmosphere. Higher density sea level pressure observations would also improve the quality of winds over the ocean. This could be achieved with barometer instrumentation fitted to Argo floats and gliders and/or enhancing the drifting buoy network.

5.8 Status and future directions of coupled tropical and extra-tropical cyclone prediction

5.8.1 The energy source for a tropical cyclone (TC) is obtained from the ocean and thus knowledge of the heat and moisture fluxes transferred across the air-ocean interface is critical for TC modeling. Similarly many extra-tropical (ET) storms intensify drawing energy from the ocean, such as east coast cyclones that occur off the coasts of North America, Brazil and Australia where there is a boundary current that draws tropical water masses to higher latitudes. Although the dynamics and environment for TC's and ET's have known differences, they share a dependence on time-evolving surface conditions. The exchange coefficients for heat, moisture, and momentum are not fully known for the high wind and wave conditions. Because a key physical process is the wind-wave coupling, which includes sea spray generation from breaking ocean surface waves, a TC/ET models must be coupled with an ocean surface wave model. There are three critical aspects of the air-sea interaction in TCs and ETs:

(a) Dynamical and microphysical processes near and at the sea surface that influence the turbulent exchange of heat and momentum between the ocean and atmosphere;

(b) Vertical and horizontal transport of momentum and heat in the atmospheric and oceanic boundary layers; and

(c) Turbulent entrainment of relatively cold water from the seasonal thermocline into the surface mixed layer, which affects the sea surface temperature and thereby influences storm intensity.

5.8.2 Three-dimensional, coupled atmosphere-ocean research and operational models have been developed to simulate and predict the mutual response of a TC and the ocean (e.g. NOAA/NCEP and Naval Research Laboratory). Recent research in ET prediction has focused on objective analysis of ensemble forecasts from ECWMF and NCEP showing encouraging skill and interesting regional variations. A particularly useful outcome (apart from predictability) is the ability to identify biases in the ensemble and potential flaws in the system. For example storm intensity is found to be over-predicted over the North Atlantic which may point to a bias from fixed SST's due to the shallower mixed layers in mid-latitudes and potential for more rapid cooling than occurs in the tropics.

5.9 Status and future directions of air-sea-ice coupling

5.9.1 Research results have clearly shown that a fully interactive coupling of the atmosphere, ocean and ice models can be beneficial to the accuracy of the forecasts produced by all three. The impact of a two-way coupling between an atmospheric and an ocean-ice model over the Gulf of St. Lawrence (GSL) in eastern Canada is modelled in pre-operational mode at the Canadian Meteorological Centre (CMC). Results for the past two years have demonstrated that the coupled system produces improved forecasts in and around the region during all seasons, proving that atmosphere-ocean-ice interactions are indeed important for short-term weather forecasts in areas in which there is surface ice coverage. Accurate dynamic ice modelling in a coupled model system is essential for “downstream” models such as wind wave and storm surge models, due to the large differences in surface characteristics between ice and water, and hence the surface momentum fluxes.

5.10 Status and future direction of coupled air-wave-sea coupling

5.10.1 The energy transfer from the sea to the air under high wind conditions involves: (i) mixing processes in the boundary layers on both sides of the air-sea interface; (ii) dynamical processes associated with the interaction between the atmospheric boundary layer and the deep convection above it; and (iii) dynamical processes associated with the interaction between the oceanic mixed layer and the deep ocean below it. A fully coupled atmosphere-wave-ocean model system requires a holistic approach to parameterizing those processes that cannot be resolved explicitly at the resolution of the coupled model system, such as: (i) sea state dependence of momentum fluxes; (ii) momentum, energy and enthalpy flux balances across the air-sea interface; (iii) wind-wave-current interaction; and (iv) generation of sea spray and its impact on the air-sea fluxes and the atmospheric boundary layer.

5.10.2 Another fundamental modeling problem is a “no-man’s land" for frictional process representations when a 1-km horizontal resolution model only partially resolves the large eddy circulations that are accomplishing the vertical transports of heat, moisture, and momentum in the atmospheric boundary layer. The key issue is how well the individual model components will perform, especially in the high wind conditions. Because the physical processes are interacting, the proper approach is to construct the complete modeling system and then explore the essential interacting processes. Given the requirement for such a complex, nonlinear modeling system with multiple components that are inter-dependent, questions of predictability naturally arise.

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WMO LONG-TERM PLANNING RELEVANT TO THE COMMISSION

SUMMARY

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CONTENT OF DOCUMENT:

Appendix:

- Background information related to WMO long-term planning relevant to the Commission

FUTURE PROGRAMME OF WORK OF THE COMMISSION

Since Cg-XV, the Executive Council has initiated a review of the structure, functions, and operations of Technical Commissions through a series of consultations with presidents of Technical Commissions and other bodies. The latest discussions are summarized in the Abridged Final Report of EC-LXI, paragraphs 8.17 to 8.26 (enumerated below).

Future Structure of WMO

Background

8.17 The Council referred to the decision taken at its sixtieth session (2008) to work towards creating a flexible and effective working mechanism for studying and developing recommendations for aligning the structure of WMO with the result-based Strategic Plan (Final report of EC-LX, paragraph 7.2.7). It appreciated that the Working Group on WMO Strategic and Operational Planning and the PTC-2009 meeting had considered a number of options on aligning programmes and working mechanisms of constituent bodies to the WMO Strategic Plan.

A proposal for joint meetings of technical commissions

8.18 The Council noted that the PTC-2009 had discussed some of the issues that limit the effectiveness of technical commissions including; the non-alignment of technical commission meetings with the decision making processes of the Organization, at times poor communications between technical commissions and between technical commissions and the regional associations, and the large percentage of the budget of the smaller technical commissions that is spent on their quadrennial Commission meeting which in turn limits the resources available to the volunteers who carry out the implementation work of the Commissions.

8.19 The PTC-2009 considered a proposal that would see the technical commissions meet together at an eight-day, joint technical conference/intergovernmental meeting held every second (even) year. This joint technical commission meeting would have two components: (1) an intergovernmental component of two days where the work of the technical commissions is organized and elections for officers confirmed; and, (2) up to six days of a scientific/technical component where academia, operations and industry could meet and work together, and the management groups of the various technical commissions could meet to coordinate their work.

8.20 Two Commissions would meet in parallel, in an ‘intergovernmental mode’ to discuss their work plans, each with the team of interpreters supporting them, so that for the joint technical commission meeting there would be two teams of interpreters supporting eight Commissions over eight days on a rotation basis. The scientific/technical component of the joint meeting would be composed of parallel sessions focusing on the range of issues faced by the WMO’s technical programmes with NMHS, academic and industry contributions, and, where necessary, Plenary sessions to deal with key cross-cutting or high profile issues. The technical/science component would be held over the eight days of the joint meeting.

8.21 The Council noted that implementation of an arrangement whereby the current eight technical commissions met jointly every two years could be done by decision of the Executive Council as a part of the evolution of the working methods of the technical commissions in much the same way as a number of the technical commissions moved from the working group structure to Open Programme Area Groups (OPAGs) through internal decision.

8.22 The Council, having heard the opinions of presidents of technical commissions, reached a number of preliminary conclusions in its discussion of this particular proposal:

- Members may have great difficulty in releasing enough technical experts to service the needs of all technical commissions at the one time;
- Those attending the joint technical commission meetings would have to be sufficiently expert to make good technical decisions;
- The proposal appeared to offer the opportunity to make more resources available for technical work;
- The technical commissions do need to meet every two years as many experts do not stay in their positions for four years and so continuity is lost in key projects;
- The proposal offered the technical commissions the opportunity to better align their
- development of work programs with the decision making activities of the Organization;
- At least for some technical commissions (JCOMM and CAeM) there was a view that the time available to work in 'intergovernmental' mode would be adequate to complete those parts of their work that led to decision making that would affect Members (for WMO) and member states (in the case of UNESCO-IOC).

A proposal for a broader WMO reform

8.23 The Council noted that the EC Working Group on Strategic and Operational Planning at its March 2009 meeting had considered as a major reform the possibility of a changed number of technical commissions. One option considered was to have a smaller number of technical commissions with one focused on research, another on systems, another on services, and possibly one on capacity building. Such a major reform would need to be considered and agreed by Congress. The Council reached a number of preliminary conclusions in its discussion of this particular proposal:

- A detailed analysis of the strengths, weaknesses, opportunities and threats should be carried out for all the Organizations working mechanisms, not just the technical commissions, before major reform of any single element;
- Major Organizational reform should be holistic in scope;
- Some delegates considered that under the current financial constraints the WMO may have too many technical commissions while others considered that to move away from thematically focused technical commissions to a smaller number of technical commissions focused on particular functions (services, systems or research), if not managed appropriately, would lower the technical effectiveness of the Organization;
- Many Council members considered that capacity building is integral to the work of all technical commissions and that in creating a separate technical commission for capacity building the outcome could well be an overall reduction in the amount of capacity building supported by the other technical commissions and ultimately by the Organization as a whole;
- In any re-structuring care must be given to not disenfranchise small but key technical groups such as those in the instruments, oceanography and hydrology areas of specialty.

8.24 The Council noted that there is a strong desire to review the working mechanisms of the Organization and carefully plan for change that would improve the effectiveness and efficiency of the WMO at a time when improved integration between its technical groups is imperative and when the pace of change in the external environment is very high. Any change would have to assist the Organization in being able to respond flexibly and quickly to new challenges as they arise.

8.25 For major reform to take place a well thought through proposal, possibly containing around three options for change, including the analysis of advantages and disadvantages, needs to be prepared for the consideration of Congress in 2011. The proposal would have to be developed through wide consultation and have the support of Members beyond those represented in EC.

8.26 The Council decided that a small task group be formed under the auspices of the Executive Council Working Group on Strategic and Operational Planning, consulting broadly with the Management Groups of the Regional Associations and Technical Commissions, and working with the Secretariat the task group should develop the proposals for change. The proposals should articulate the roles and responsibilities of the WMO's constituent bodies in terms of their concrete contributions to the implementation of the WMO Strategic Plan and to Members' services, and should be in draft form for consideration by EC-LXII prior to submission to Cg-XVI.