

**GENERAL SUMMARY OF THE SESSION OF THE  
INTERCOMMISSION TASK TEAM ON REGIONAL  
CLIMATE CENTRES**

**(Geneva, Switzerland, 30 April – 3 May 2001)**

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**General Summary of the session of the  
Intercommission Task team on Regional Climate Centres  
Geneva, Switzerland, 30 April to 3 May 2001**

**1. Opening of the Session of the Intercommission Task Team on Regional Climate Centres**

1.1 The Meeting of the Intercommission Task Team on Regional Climate Centres was opened by the Chairman at 1100 on 30 April 2001. In attendance were Task Team members: Mr. S. Mildner, Chairman of the Intercommission Task Team and representing CBS; Mrs. A. Simard representing CBS; Mr. M. Nicholls representing CCI; Dr. H. Kondo representing CCI; Dr. B. Kirtman representing CAS; Dr. J. Salinger representing CAgM; Prof. L. Ogallo representing the President of RA I. In attendance from the Secretariat were Dr. M. Harrison, Chief, CLIPS Project Office; Mr. M. Mlaki, Chief, DPS Division, WWW; Dr. M. Coughlan, DC/CAP; Mr. D. Schiessl, D/WWWB; Mr. B. Westermeyer, GCOS.

1.2 The Meeting was opened formally by the Deputy Secretary General of WMO, Dr M. Jarraud. In his opening comments the Deputy Secretary General noted that the Intercommission Task Team on Regional Climate Centres had been set up by EC-LII to develop proposals for delivery to EC-LIII that would define the definition, roles, designation and development of Regional Climate Centres within the infrastructure for delivering climate services to end users. Recognising that the delivery of services proceeds through a series of stages beginning with the capture of the basic data needed and ending with the application of information, and acknowledging that each stage requires specific expertise and competencies, the Deputy Secretary General suggested that Regional Climate Centres might overcome the need to develop full competencies in all countries. He charged the Intercommission Task Team with developing the detail necessary to begin implementation of Regional Climate Centres.

1.3 The Deputy Secretary General indicated that an important issue to be resolved was the relationship between the Regional Climate Centres and the NMHSs. Noting that Cg-XIII had confirmed that the authority concerning climate issues in each country should remain with the NMHS, the Deputy Secretary General nevertheless acknowledged that detailed relationships between the NMHSs and the Regional Climate Centres might differ between regions. Several models of possible structures within which Regional Climate Centres and NMHSs might sit exist. These models include the possibility of direct service delivery where appropriate and acceptable and the Deputy Secretary General recommended that the experience with the RSMCs be used in this regard. The evolving end-to-end infrastructure for delivery of climate services includes organisations other than NMHSs with both numerical and empirical forecast capabilities. Organisations outside the WMO system are also engaged in the processing of climate information and it is necessary to keep links with these organisations open.

1.4 In closing the Deputy Secretary General wished the Intercommission Task Team every success in their deliberations and stated that he was looking forward to receiving their recommendations.

1.5 The Chairman noted that the issue of Regional Climate Centres (RCCs) had been prominent at both Cg-XIII and EC-LII, and that additionally both CBS and CCI had discussed it. In terms of expectations for the Meeting, the Chairman noted that the Intercommission Task Team on Regional Climate Centres (ICTT) was not expected to define a final network of RCCs but to advise on how such a network might be achieved.

It was agreed that input was necessary from a number of WMO Programmes on how the system should work and what the requirements for it should be.

## **2. Adoption of the Agenda**

2.1 The ICTT agreed on the working arrangements for the meeting. The agenda was approved with the addition that consideration should be given to the application of Seasonal to Interannual (SI) Forecast products to meet the needs of end users.

## **3. Introduction, Meeting Objectives and Expected Outcomes**

3.1 The ICTT noted Resolution 8 (Cg-XIII) and Resolution 2 (EC-LII), the latter including the Terms of Reference. The immediate requirement is to prepare and agree on the content of the presentation to EC-LIII by the President of CCI on the outcomes from the ICTT.

3.2 The ICTT noted the chronology of developments leading to the formation of the Team and that certain structures relevant to the work of the ICTT, specifically within the CBS OPAG on the DPFS, have already been formed. The OPAG on the DPFS has mainly focussed on global SI Forecasts and within that context has considered infrastructure for SI Forecasts, data, standards, verification and dissemination issues. It was agreed that a joint approach across several Commissions is necessary to handle most aspects of the infrastructure. A Working Group on Applications for SI Forecasts exists within CAgM and CCI is considering further groups.

3.3 Cg-XIII and EC-LII have agreed that the best approach to enhancing regional capabilities is to improve the efficiency of existing structures to handle the development of climate services, with additional functions being added to these structures as necessary.

3.4 The ICTT was pleased to note that there is a high level of consistency amongst recommendations from various prior meetings concerning the roles of the proposed RCCs and that a need for such Centres had been recognised in several parts of the World.

3.5 Previous work on verification of SI Forecasts has been done across three Commissions – CAS, CCI and CBS, and the ICTT agreed that this work was significant but that further work on the development of verification and estimation of value is required. Work within the CLIVAR Programme Working Group on Seasonal to Interannual Predictions (WGSIP) towards standardisation of verification was also noted, and the ICTT recommended further work and communication between activities in this important area.

3.6 The ICTT recognised that Cg-XIII had agreed that the role of the NMHSs should be fundamental in the delivery of services within their own countries. However the ICTT noted that climate activities are undertaken by organisations other than the NMHS in some countries. It was also agreed that the establishment of new Centres is within the prerogative of Members. In terms of establishing RCCs, it was noted that the functions of RCCs may extend beyond those of NMHSs and involve other organisations, thus perhaps adding to the complexity of gaining intergovernmental agreement on the establishment of the Centres. The ICTT noted the standard WMO method of establishing new RSMCs. It was agreed that there may be differing bases on which to determine the geographical coverage of RCCs in various parts of the world, existing examples including establishment under economic groupings and within specific climatic zones.

#### **4. Review of Outcomes from the Initial Planning Meeting on the Co-ordination of Infrastructure Needs for Seasonal to Interannual Climate Prediction, Geneva, 28-30 April 1999**

4.1 The ICTT noted the Report of the Initial Planning Meeting on the Coordination of Infrastructure Needs for Seasonal to Interannual Climate Prediction. Follow-up activity was anticipated at the CBS OPAG on the DPFS Meeting (Expert Team on Infrastructure for Long-Range Forecasting) scheduled for November 2001. CCI and CAgM are represented on the Team.

4.2 One outcome related to the Initial Planning Meeting on the Coordination of Infrastructure Needs for Seasonal to Interannual Climate Prediction was the creation of the experimental system for exchange of forecast verifications between producing centres.

4.3 The ICTT expressed concern over the state of atmospheric climate observations globally, and in particular the decline in the number of in-situ land based observations, but agreed that the state of ocean observations, critical to SI Forecasts, has improved substantially over recent years. Nevertheless there is a continued need for further improvement in ocean observations.

#### **5. Review of other Meetings concerned with, and Reports on, Regional Climate Centres**

5.1 The ICTT reviewed the Final Report to CBS by the consultant H. Allard as revised and endorsed by the GDPS Implementation Coordination Team on Data Processing and Forecasting System meeting held in Pretoria, South Africa, during November 1999. The ICTT noted that, while incorporating organisations not currently linked to the WWW system, the consultant's Report assumed that these organisations would commit to stable links to the system. The harmonisation of products in different formats from the various producers was not resolved within the Report.

5.2 The ICTT felt that the three level approach proposed in the Final Report to CBS by the consultant H. Allard – with RSMCs acting to produce global forecast products at level 1, a structure to produce consensus products based on the level 1 outputs at level 2, and the NMHSs at level 3 – is useful, but agreed that the level 2 structure needs further consideration. It was noted that this included the incorporation of all organisations concerned with SI Forecasts, whether directly linked to WMO or not, within the infrastructure provided they had demonstrated capabilities. In these terms 'demonstrated' is interpreted as providing reliable products of satisfactory quality.

5.3 From the CCI/CLIPS perspective issues of training, verification of products, climate monitoring, observations and archiving, supporting research activities, and user group liaison, all fit into a level 2 approach, and this suggests that a more substantive approach to the second level is required. The ICTT noted that the Report to CCI by the consultant P. Ryder had taken a flexible approach to the level 2 requirements, and had indicated that individual regions may have specific and different requirements.

5.4 In discussing differences in regional approaches the ICTT noted that existing examples include both centralised and distributed functionalities, the latter being met by a network of existing centres (a virtual centre) each contributing within their resources.

5.5 The ICTT agreed the need to include all available expertise in the development of the infrastructure and that different approaches to the infrastructure, including that of virtual centres, needs to be tested. It was recommended that testing be made with a small number of products. It was recognised that Regions may have specific needs for products and that these need to be determined in consultation with Regional Presidents and Associations. The ICTT agreed that Regional Associations would be approached for their positions. In summary, in developing the infrastructure, flexibility and experimentation, the inclusion of a variety of organisations, and enhanced cooperation between WMO Programmes are all required. The ICTT noted that these conclusions were consistent with those from the CCI AWG Meeting held in Reading, United Kingdom, during April 2000.

5.6 In discussing the designation of RCCs, the ICTT agreed that a process similar to that for RSMCs is necessary (as defined in the Manual on the Global Data Processing System (1992 edition, Suppl. No. 4 (VIII.1997))). Reliability of service is a criterion. There is a need to build on existing structures as far as possible and to avoid duplication. Priorities recognised for RCCs include the interpretation of received information and predictions, training, data management (including CLICOM), climate analysis and monitoring, and maintaining a related research agenda. It was agreed that there may be difficulties in demonstrating capabilities as the requirements may differ from those of weather forecast centres.

## **6. Review of current status of climate information and prediction services**

6.1 The ICTT commended the Survey of the Present Status of Climate Forecasting, presented by Y. Kimura to the President for CCI. It was recommended that future surveys subdivide the dynamical prediction methods used. The ICTT also commented on the verification processes revealed by the survey, expressing concern that not all centres produce verification statistics. A distinction needs to be made between verification applied to dynamic and statistical model output and to derived products. The ICTT suggested that a question concerning willingness to verify past performance be added to the next survey.

6.2 The ICTT noted the Secretariat report on the Status of SI Forecasts. The ICTT noted that the expanding use of Regional Climate Models (RCMs) for downscaling of General Circulation Model (GCM) outputs was causing concern in the research community because of the potential for misapplication. While significant advances have been made, and evidence for skill exists, many scientific questions remain, not least concerning the relative performances of RCMs and statistical downscaling methodologies. However it is not clear on what basis the qualities of both method types should be judged. The position of the CLIVAR WGSIP regarding RCMs was reported to the ICTT. The ICTT also noted that the quality of the driving models may affect the RCMs and agreed that RCMs can play an important role in capacity building.

6.3 The ICTT noted and supported the activities towards the development of a standardised verification system for SI Forecasts. Liaison between the CBS and CLIPS groups working on verification was recommended and it was agreed that the conclusions drawn by these groups should be available for presentation to CBS-Ext. 2002.

6.4 Papers from the Global Review of Regional Climate Outlook Forums, organised by CLIPS in Pretoria, South Africa, during October 2000, were considered and it was agreed that these present a statement on the state-of-the-art in providing climate services through Regional Climate Outlook Forums (RCOFs). Delegates at the Global Review had recognised the need for the development of a research agenda and, in that

context, the ICTT proposed that this might include modelling impacts of different climate regimes (such as hydrology impacts for a given prediction), the development of downscaling methodology from global models, research on regional consensus methodologies (including the treatment of both dynamical and empirical inputs), handling of forecast discontinuities across regions, coping with changing forecasts in time, verification of hindcasts, and local data processing (including satellite data). Given that a research agenda may include differing regional priorities it was agreed that the RCCs might undertake the necessary research in part. The research agendas already outlined by the various CLIVAR Working Groups as well as by CLIPS activities were noted and further development of links between CAS, CLIVAR, CCI and CAgM encouraged, as were links with any other relevant research groups. Resources necessary to keep abreast of research developments and/or to undertake appropriate activities will thus be required in RCCs. Demonstration that a proposed centre has a research agenda may be part of the designation procedure.

6.5 Recognising that much of the research agenda has evolved from the RCOFs in their current form, the ICTT considered whether these Forums might become established functions. It was agreed that the evidence was insufficient to support this suggestion as, although Forums represent an important opportunity for capacity building and network development, they may be too expensive to sustain in the long term and alternate approaches, such as virtual Forums, are available. Consideration needs to be given to maintaining good links between climatologists and users once Forums cease in their current form, and the ICTT noted that activities of this type were already in place in certain regions. Nevertheless the ICTT agreed that Forums should continue in the current form for the immediate future in regions where they are desired and funded. It was recommended that RCCs should play a lead role in the management of RCOFs

## **7. Review of user requirements**

7.1 In introducing the Draft Statement of User Requirements for SI Forecast Products and Training prepared by M. Nicholls on behalf of CCI, the ICTT was informed that this did not deal with inputs to either the global dynamical and empirical forecast systems nor with the numerous and variable end user requirements; the Statement is focussed on requirements for data and products in the central part of the delivery chain covered by RCCs and NMHSs. It was recognised that these requirements represent one input into the determination of the necessary infrastructure. Further feedback, using planned meetings as far as possible, is required to develop the Statement. In developing the Statement, consideration had been given to the regularity with which specific requirements had been proposed in prior meetings. No consideration has been given at this stage to the feasibility of production nor to the ability of individual producers to satisfy the requirements. Key requirements include monthly rather than seasonal forecast averages, and the need for information on confidence levels, verification and reliability of forecasts. The support structure, including training of service providers and dealing with end users, is incorporated into the Statement.

7.2 A rolling review of the User Requirements is necessary, with mechanisms allowing feedback to infrastructure development. The ICTT strongly endorsed the Draft Statement of User Requirements for SI Forecast Products and Training and requested that the revised Statement be attached as part of the Meeting Summary and Report to EC-LIII for presentation by the President of CCI (Annex 1). The ICTT proposed that the User Requirement should be further progressed by a Team of Experts from one or two major providers of basic numerical and statistical products, two or three NMHSs/established regional centres who are major service providers, and one

individual from each of the four Commissions already involved. The task would be to set up and maintain a rolling review procedure in which (based on contact with end users) the requirements are updated, compared with capabilities, and the providers are advised on priorities for improvements and continued development. The review procedure would be similar to that already adopted by CBS with regard to observational and other needs. The Expert Team would report directly to the President of the Commission for Climatology. The Team would also address issues such as quality specifications and controls, calibration of basic outputs, and requirements for climatological data sets.

7.3 The ICTT noted that the generation of SI Forecast products for end users will involve the handling and interpretation of a substantial quantity of state-of-the-art and experimental outputs from global centres in a consistent way. The ICTT noted the likely benefits of a regional entity to achieve this.

7.4 The ICTT noted additional statements prepared by Working Groups of RAs II and VI, further papers from the Global Review of Regional Climate Outlook Forums, the Report from the CLIPS Working Group, and a summary document of possible functions of RCCs prepared by M. Nicholls. Given all inputs the ICTT considered whether RCCs were required. The ICTT noted that gradients exist within all RAs in terms of climate regimes and in terms of the resources and capabilities of NMHSs to handle climate-related issues. The overarching requirement of the NMHSs is in the provision of services and in this regard it may be necessary to develop RCCs to provide the essential support to NMHSs. The ICTT noted, nevertheless, that the perceived necessity for RCCs varies between Regions, but that where RCCs are considered necessary that regional coordination in the supply of services to end users will be required. Both physical and virtual centres might be considered within each Region.

7.5 The ICTT considered the situation in each WMO Region. It was noted that there may be gradients across some Regions in the needs for and the structure of RCCs. It was agreed that EC-LIII will require a list of possible functions of RCCs but with the rider that Centres do not necessarily need to provide all functions; such a list endorsed by the ICTT is provided at Annex 2. It was agreed that virtual centres cannot provide the same level of functionality as physical centres but that other activities, such as training workshops, can fulfil some of the deficiencies. The ICTT noted that there are management issues regarding virtual centres that will need to be resolved within the Regions concerned.

7.6 In terms of funding for RCCs, the ICTT recognised that several options for seed funding exist and arrangements for joint funding of specific activities (e.g. workshops, user forums, training events, etc.) may be sought. Funding of the normal operations of an RCC, however, will be part of the overall commitment of the responsible NMHS concerned stated in the designation process.

## **8. Considerations of the justifications for Regional Climate Centres, of their roles, and of the facilities required**

8.1 In reviewing the information presented, the ICTT concluded that there is a need for RCCs, that this need varies between and across Regions, and that further development will require close coordination with RAs. The ICTT also recognised that there are important organisations with critical skills and resources not directly linked to the WMO WWW structure and that these should be entrained into a common infrastructure as far as possible. The ICTT expressed concerns over the possibility of duplication and conflicts emerging from the substantive numbers of players with

prediction capabilities. Nevertheless the first priority is to establish a WMO structure providing essential services to Members. Development of RCCs should take advantage of existing structures, in particular the WWW structure, as far as possible. Further consideration needs to be given to the use and impacts of new communications technologies on RCC structures and activities.

8.2 The ICTT agreed that RCCs should play an important function in buffering information produced by global prediction centres for onward provision to the NMHSs. The ICTT stressed that a key role of RCCs should be in expressing the quality of products and recommended that any exchange of forecast products should always be accompanied by verification information. At the same time the RCCs should be able to provide guidance in terms of state-of-the-art material that is also considered as experimental by many producing centres.

8.3 The ICTT agreed that future development activities should be focused around the Expert Teams already created or in the process of being created by the concerned Commissions. This process will be facilitated by the OPAG structure.

## **9. Considerations of the potential status of Regional Climate Centres within the GDPS structure and of their designation, including examination of capabilities of existing WMCs and RSMCs**

9.1 The ICTT noted the designation procedure for RSMCs as prescribed in the Manual on the Global Data Processing System (WMO No.-485) and agreed that this appears to have the inherent flexibility necessary for designation of RCCs. It was recognised that the designation process covers the identification of new centres and the broadening of activities of existing centres. Given the specific and partially unique requirements of RCCs the ICTT recommended that the designation process be undertaken in consultation with an agreed list of possible functions of such Centres; a collated list of functions derived from all user requirements is at Annex 2 for further consideration by the Programme bodies concerned.

9.2 The ICTT highlighted those aspects of RCCs that are distinct from current activities within the GDPS and noted that several Commissions will need to be involved in the designation process. Distinct activities may include, depending of Regional requirements, development and implementation of a research agenda, downscaling activities related to the customised requirement of specific end user groups, applications training, assimilation of feedback from users and involvement in information dissemination. Member's requirements may be handled through OPAGs dealing with the PWS and CCI and CAgM Programmes.

9.3 The ICTT recommended that the designation procedure should follow established CBS practise but may be revised in the light of experience gained. Demonstration of capabilities falls into the remits of both the CBS and the CCI. Proposed Centres should be introduced at the first CBS or CCI constituent body meeting following receipt of the proposal and that both Commissions be represented at that meeting. Both Commissions should have equal rights to take the initiative in recommending to the Executive Council the designation of RCCs. The designation process would follow the procedure indicated in the Manual on the Global Data Processing System (1992 edition, Suppl. No. 4 (VIII.1997)).

### **9a. Centres committed to global SI Forecasting**

9.4 The ICTT recommended a phased approach to the securing of input products from global prediction centres, then the involvement of other organisations, followed by

creation of centres with specialised roles. The ICTT recognised that there may be a practical need to have a limited number of formal commitments with global forecast producers. However it was agreed that inclusion of a larger number of forecast producers was desirable from the dynamic prediction perspective, for example in order to facilitate development of a multi-model ensemble. Use of several models, including empirical models, also permitted examination of more forecast scenarios. In the early experimental stage a limited number of producers, including some not directly linked to the WWW, would be included. Commitments to continue holding responsibilities will be sought after the initial experimental stage. However, in order to provide flexibility, incorporation of contributing producers alongside committed producers was recommended.

9.5 The ICTT noted the latest reports available concerning current facilities and capabilities of existing RSMCs and proposed that the following initial list of centres capable of providing global outputs be approached to obtain their commitment to providing outputs on an operational basis as outlined in the designation procedure for RSMCs:

- Bureau of Meteorology, Melbourne, Australia;
- Centro do Previsão de Tempo e Estudos Climáticos, Cachoeira Paulista, Brazil;
- Meteorological Service of Canada, Montreal, Canada;
- Météo-France, Toulouse, France;
- Japan Meteorological Agency, Tokyo, Japan;
- South African Weather Bureau, Pretoria, South Africa;
- Met Office, Bracknell, United Kingdom;
- Climate Prediction Center, Washington, United States of America;
- European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom;
- International Research Institute for Climate Prediction, New York, United States of America.

9.6 Current services are based on a variety of data sources, methodologies and forcing models. There is a requirement to catalogue what is already available and what needs to be developed by comparison with the requirements list in Annex 1. The ICTT noted the role of the CBS Expert Team on the Infrastructure for Long-range Forecasting in this regard. The ICTT acknowledged that there is a need to distinguish between model output and post processing and that some countries may prefer to control their own post processing. The ICTT also recognised that producing centres may need to provide specific products in certain circumstances.

## **10. Considerations of issues relating to existing organisations and centres not designated as a WMC or a RSMC, including those not directly linked into the WMO system, but that might become, or might collaborate with, RCCs**

10.1 The ICTT noted that other centres and organisations not already discussed are working in the climate area. The ICTT recognised that there are an impressive number of centres with global capabilities and suggested that all products should be available in principle to WMO Members.

10.2 The ICTT noted that discussions so far had had limited reflection of statistical products and recommended that these be included in the list of requirements alongside dynamical products. Centres with empirical capabilities need to be included also in the list of producing centres.

10.3 The ICTT considered the paper submitted by M. Voice concerning developments in information systems technologies likely to affect the delivery of services. It was recognised that CBS was actively following these developments and was considering them on behalf of all WMO Programmes. These developments would have inevitable impacts on the WMO structure, especially that of WWW. The ICTT agreed that these developments need to be followed carefully.

**11. Recommendations concerning the identification, designation, roles, resources, infrastructural links, training, and collaborations required to develop a network of RCCs**

11.1 The ICTT agreed that most discussion in this context had occurred under earlier items.

11.2 The ICTT noted that there is a need for collaboration and coordination of activities between centres, both within and across Regions.

**12. Recommendations on mechanisms and options for future cross-programme co-operation between CCI, CBS and CAgM**

12.1 The ICTT agreed that much interaction might take place through OPAGs and their Expert Teams; CBS OPAGs already exist, CAgM OPAGs are in the process of formation and CCI OPAGs will be considered at CCI-LIII. The proposed designation procedure will require co-operation.

12.2 The ICTT recommended that closer coordination is needed on the applications side between CLIPS, CHy and CAgM.

12.3 Future activities recommended by the ICTT include interactions on production activities and with users. It was recognised that the development of an SI Forecasts infrastructure may be facilitated by identification of a project manager.

12.4 In considering future activities of the ICTT, the ICTT recommended, pending concurrence by EC-LIII, that this might include:

- (a) contact with production centres to seek their commitments for regular provision of global SI Forecasts to RCCs and NMHSs;
- (b) establishment of mechanisms for cooperation between production centres and other participating institutes;
- (c) establishment of interaction mechanisms between producing and Regional Climate Centres and NMHSs;
- (d) developing cooperation between Programme groups;
- (e) arranging workshops, including implementation/coordination meetings;
- (f) monitoring capacity building.

12.5 The ICTT strongly recommended that its proposals, once approved by EC-LIII, be advised throughout the WMO system to ensure open contact with all Members. An article in the WMO Bulletin is one mechanism by which this will be achieved.

### **13. Considerations concerning preparation of the meeting report and presentation to EC-LIII**

13.1 The ICTT noted that the President of CCI will make the presentation of the Report to EC-LII and requested the Secretariat to prepare a summary for the President's consideration.

13.2 Considering the continuing activity necessary in the development of RCCs and the level of coordination required in those activities, the ICTT recommended that its activities be extended in order to provide the high-level guidance needed. The ICTT recommended that EC-LIII, through the President of CCI, keep in force Res. 2 (EC-LII) suitably modified.

### **14. Closure**

14.1 In his closing remarks the Chairman of the Intercommission Task Team on Regional Climate Centres commended the Team on its activities and on the outcomes of the Meeting. He commented that through the discussions considerable clarification on the case for and the activities of the RCCs had been obtained and he thanked everyone for their contributions.

14.2 The Chairman closed the Meeting at 1345 on 3 May 2001.

## REQUIREMENTS FOR SEASONAL TO INTERANNUAL OPERATIONAL PREDICTION AND FORECAST PRODUCTS

### 1. Introduction

The Initial Planning Meeting (IPM), on the Co-ordination of Infrastructure Needs for Seasonal to Interannual (SI) Climate Prediction (April 1999), proposed that the WCP should undertake the preparation of a comprehensive statement of requirements for operational SI prediction and forecast products. It noted that much of the planning for infrastructure will depend on this requirement statement, and that input from Regional Centres, NMHSs as well as end users of climate services will be necessary. The Planning meeting further considered that the statement should include an analysis of training requirements and that sources of training documents should be identified. The need for a detailed user requirement for SI predictions was endorsed by Resolution 2 of the WMO Executive Council (EC-LII).

This paper meets many of the objectives of the IPM proposal although a wider range of inputs for the assessment would have been beneficial and continued work will be necessary. **Whilst the intent of the paper is to aid the planning of infrastructure**, it must be noted that the User Requirement must be subject to further changes as both service providers and end-users become more familiar with the products, their application and value.

**The focus in the paper is on the inputs needed by those who provide a service, comprising customer-oriented products, to the end-users.** These service providers may be NMHSs or private weather companies or institutions, Regional Centres serving the needs of a group of NMHSs, or a loose-knit regional organisation with responsibilities distributed amongst several members, or even a section of a global forecasting centre which may have customers in the public or private domain for products derived from its basic output. **It is the requirements of these providers that define this particular User Requirement.** No consideration is given to conditions that may attach to the provision of available products to points in the distribution chain.

The requirements should be seen as targets. **In several cases, it is not yet feasible to meet the stated needs.** It is acknowledge that in some regions during some seasons these requirements may not be achievable with sufficient skill. Producers need to identify which of these requirements are likely to be achievable and (if possible) with what quality on about a 5-year time frame. Likely shortcomings of quality need to be discussed with service providers so that they can review their priorities; this comparison is only likely to be possible on a general basis until requirements for quality can be properly quantified (see Section 2). In no way should the requirements be seen as rigid, rather they should be subject to a rolling review along the lines already established within WMO for dealing with observing needs and capabilities.

The input requirements of global centres of excellence in modelling of the climate system and NWP-based SI forecasting, and in statistical/empirical forecasting, are not considered here. These centres require inputs of observational data and products in order to function, and such requirements are considered and documented separately by the CBS Expert Team on Observational Requirements and Redesign of the Global Observing System. The Team has recently issued a Statement of Guidance relating to observations for NWP based SI forecasting, including those needed for

coupled atmosphere-ocean models. However, observational needs **are** included in this paper if they relate to activities that will be carried out on a regional or national basis in many parts of the world. Such activities will include climate monitoring within a forecast period, SI forecast verification, locally developed statistics-based forecasting and downscaling.

Neither are the requirements of end users, for tailored products, considered here. The user end of the infrastructure, comprises the end-users themselves (i.e. a user external to the meteorological community) and sometimes an "intermediary" who is an adviser to the end-user on applications and impacts. Such intermediaries can be part of an NMHS but are often from Universities, other government or private agencies or international organisations. The range of tailored products the end-users and intermediaries require is very extensive, related to some 20 or so discrete applications (agriculture, water management, disaster preparedness, insurance, disease management etc), geographical region, season, forecasting skill etc. It is not yet possible to produce an overall listing, nor necessary as explained later.

The paper is also intended to focus the attention of producers (of the basic statistical and numerical products) on the needs of service providers, and to lead to opportunities for the latter to examine more detailed output and thus facilitate capacity building.

## **2. Methodology**

A methodology for determining the global user requirements was described in a consultancy report by Dr P Ryder, obtainable through the Secretariat of WCP Department. This report includes a "zeroth" order assessment as a basis for further focussed, purpose designed and directed research on the requirement. The proposed research involved either the establishment of regional workshops to explore the requirements related to a range of sectors of application, or of national points of contact determined by PRs who would be asked to provide detailed inputs to a questionnaire with updates on a three year cycle.

However, due to limitations on time and funding, the global assessment has been developed further by taking advantage of other meetings related to SI forecasting. In particular the Regional Climate Outlook Forum held in Pretoria, South Africa from 16 - 20 October 2000 was devoted to issues of global and regional infrastructure in support of SI forecasting and applications. The meeting was attended by representatives of NMHSs in Africa, South and Central America, the Caribbean, South East Asia, and the Pacific Islands, by the Presidents of the WMO Regional Associations in Europe and South America, by representatives of established regional centres such as ACMAD, the DMCs, AGRHYMET, and CATHALAC, by international providers such as NCEP, IRI, and ECMWF, by various national and international user agencies and by applications scientists (university and field-based) from most continents. Valuable input was generated relevant to the statement of requirements.

Account has also been taken of inputs from a range of institutional and commercial users at a workshop held on June 13-14, 2000 at the ECMWF on its SI outputs, and of an individual submission from Dr R Basher at the IRI.

It is at present very difficult for the users to state anything constructive with regard to the product quality that they wish producers to achieve. This is because the applications-related decision-making models, for which probability forecasts are but one input, range widely in complexity and utility around the world, and the sensitivity of decisions to errors in weather inputs has been assessed only on a limited and mostly

theoretical case-study basis. Certainly users are not in a position to quantify the range of accuracy from which the forecast becomes useful to a limit beyond which further improvement will have little or no incremental benefit, a concept which is much more appropriate to deterministic forecasts.

However those who provide output tailored for end-users do need information on, or information that will enable them to derive some measure of the technical reliability and quality of the inputs they receive.

### 3. Product Requirements

Requirements are segmented according to whether they relate to forecast or data products, with further sub-divisions regarding variables, statistical nature of products, lead times etc. Requirements that have attracted a significant consensus are shown **in bold** (noting the need for wider review). Of course several of the requirements are new or newly stated. The skill associated with some products or product characteristics needs too be proven, an activity which should involve the user. As stated earlier, some requirements are not achievable at all at present.

#### 3a. Forecast Products

Temporal resolution **Monthly averages/accumulations/incidences** are preferred to seasonal values.

Spatial resolution For the tropics and sub-tropics 2° x 2° target for squares/grid points, but 10° x 10° acceptable. Or catchment, river basins or other regions of comparable area.

Spatial coverage Area of interest of user, but generally sub-regions of a continent.

Lead time. **0 - 6 months for products to be issued to end user, implies longer (0 - 7 months) for model and statistical inputs to regional or national centres.** Some requirements to 15 months. **3 months minimum** for warnings to end user of high amplitude and abnormal events, such as increase in tropical storm frequency or change in phase of ENSO.

Issue frequency. **Monthly** much preferred to three-monthly.

Output types Grid point values, grid box area values or geographical contouring of probabilities **to remove discontinuities at boundaries.** Gridded fields for applications model initialisation

#### Forecast Content

- **For (land) surface temperature and total precipitation, calibrated ensemble outputs (from the single and multi-models) showing the full spectrum of distribution** in terms of probabilities of exceeding the full range of climatologically feasible values, expressed in absolute values or anomalies. ("Calibrated" implies the correction based on past performance of individual members for systematic errors e.g. in anomaly predictions). Alternatively or additionally, tercile or **decile** probability forecasts. These targets are implied also for outputs of the statistical/empirical models.
- As above for sunshine, solar radiation, cloudiness, temperature range and rainfall range.

- **Calibrated ensemble predictions of sea surface temperature in the Niño areas, tropical Atlantic, specified sectors of North Atlantic and Indian Oceans.**
- **Ensemble related predictions of surface pressure field indices including the SOI (e.g. Tahiti-Darwin pressure difference) and the NAO (Iceland -Azores difference).**
- Ensemble related predictions of the equatorial zonal wind average at heights of 30 and 50 hPa, as an indicator of the QBO.
- **For events such as tropical cyclones, wet (including heavy rain) and dry spells, hot and cold (including frost) spells, indications of whether the frequencies and severity will be above normal.**
- **Ensemble output related heating/cooling and growing degree-days using regionally supplied thresholds.**
- **Ensemble output related onset/duration of rainy and monsoon seasons.**
- Non-ensemble outputs of all the above variables/events where models are not operated in ensemble mode.
- Information **downscaled to higher spatial and/or temporal resolution** as far as achievable using statistical and/or dynamical methods once these have been validated.
- **General purpose consensus products relating to the variables listed above, based on model inputs, statistical/empirical inputs from physically based local, regional and international methods, downscaling schemes and recent climate and weather experience. Monthly updates especially in rainy season. Other characteristics (e.g. resolutions, lead times, output types including the statistical characteristics) as described earlier.**
- Some users require short range to monthly forecasts together with the seasonal output, and all in the same probability format.
- **Tailored forecasts for different applications areas as determined regionally and nationally. The requirement for more detailed statistical inputs from various models, as described earlier, should allow for the likelihood of exceeding various applications related thresholds to be determined. (As stated in the introduction, tailored forecasts for the end-users are not the primary focus of this paper. However continuing dialogues with end-users are bound to result in changes to the input needs of their suppliers.**

#### Confidence level

- **An indication (text statement) of the confidence in each forecast for example based on model ensemble characteristics, uncertainties in initial conditions, model uncertainties, and degree of consensus.**
- **An alert, to accompany forecasts, of significant changes in models or practices used to generate the forecasts.** Examples are changes to analysis schemes for surface wind stress and sea surface temperature changes in assimilation techniques and model resolution.
- Regions where probabilities are close to climatology level reflect either a lack of predictability demonstrated for the region, or no clear forcing on the climate for the particular forecast period, even though predictability on the average has been demonstrated for the region. It may be useful to distinguish between the two in map format.

#### Verification and reliability

- **With each statistical and NWP model output (single forecast and ensembles), and each consensus forecast, a time series of verification data describing the model and consensus performance. Such data to include outputs from the**

**WMO Standardised Verification Scheme for Long Range Forecasts including ROC catering for flexible event definitions.**

- **Reliability data for 2° x 2° boxes, or other natural geographical regions, in the tropics/sub tropics to demonstrate success in predicting exceedence of predefined thresholds, in the form of hit rates and skill scores.**
- **Verification to discriminate between seasons and lead times, and phase of major events such as ENSO.**
- Verification based skill masks to be applied to forecasts for areas where there is little skill, to be developed using criteria agreed with users.

Documentation

- **Text descriptions of statistical and numerical models including scope and limitations.**
- **Text descriptions of run processes.**
- **Text description of consensus procedures.**
- **Notifications of intention to upgrade or change models and procedures.**

*3b. Observational data and Products.*

As stated earlier, the observational requirements proposed here are related to regional and national forecasting and verification activities.

- **Real time synoptic data from the Regional Basic Synoptic Network.**
- **Sufficient national synoptic and climatological data to permit the development and updating of methods of downscaling.**
- **Monthly data and other statistics based on daily rainfall and temperature data (such as decile rankings) to be supplied from a subset of national stations to approved regional verification and monitoring centres. At least monthly data required within one week of end of month. Subset to give adequate representation of geographical regions (plateaux, flood plains etc)**
- **Grid box (2-degree square) averages of observational station percentile rankings for monthly rainfall and mean temperature within region, available within a month.**
- Regional soil moisture deficits and flood cover on a weekly basis, to be available within a week.
- Regional drought, fire and pollution indices on a weekly basis, to be available within a week.
- Global mappings of monthly pressure, rainfall and cloud cover anomalies, and anomaly maps of Northern Hemisphere snow cover, on a monthly basis.
- **Sea surface temperature measurements, but preferably weekly and monthly anomaly maps for the global oceans averaged over 2 1/2 degree squares.**
- Analyses of sea level, surface wind stress and global sections of temperature and salinity to 400m depth on a monthly basis.
- **SO and NAO indices, four week running means updated weekly and available within a few days.**
- **Archival data, including metadata, sufficient to determine the monthly climatology of the nation and region.**
- **Climate Atlases, station climate normals and other statistics relating to historical percentiles, extremes, return periods etc.**
- Historical data series for the SOI and Niño area SSTs.

#### **4. Requirements for Training**

The following list mostly originates from discussions at the Pretoria meeting. All points relate to the training of forecasters and other providers of information to the end users. Many items on the following lists are already included in the CLIPS Training Workshops and the CLIPS Curriculum.

##### *4a. Modelling and statistics*

- The basics of the NWP based models, including coupled ocean-atmosphere models. Ensemble forecasts. The statistical interpretation and presentation of model outputs. Scope, limitations and opportunities.
- The physical foundations for statistical correlations. Probability distributions. Existing statistical techniques including regression methods and discriminant analysis. Creating empirical models. Software packages for isolating and visualising statistical relationships between predictors and predictands and modelling. Scope and limitations.
- Downscaling techniques.
- Development of a consensus forecast.
- Verification techniques and activities. Hit rates. Skill scores. Developing measures of quality for local and sectoral use.
- Observational requirements for forecasts and verifications. Climate data banks and management. Access to predictand data holdings.
- Identifying research requirements in support of local and regional applications.

##### *4b. Dealing with end users.*

- Tools, techniques and pilot projects to assess the economic value of consensus predictions.
- General information on the economic value of climate information and services.
- The sectoral impacts of climate, and applications of climate forecasts. Identifying decisions that may benefit from the application of climate forecasts. Identifying sectorally related probability thresholds and critical weather events. Understanding the nature and scope of the users' decision making processes to react to probabilistic input, and assisting users to develop these processes. The need for close working relationship with users and intermediaries to determine their information, presentation and delivery requirements.
- The wider impacts of the release of advice, e.g. on water management in catchment areas, on futures buying and on national investment.
- Training the users on the strengths and limitations of products, understanding measures of quality, and future developments in service and quality. Assisting users to set up their own verification schemes and assessments of added value, and reporting back to the provider.
- Media interaction and Public Relations.

#### **5. Other comments**

There will be several determinants to an infrastructure to support the generation, distribution and application of seasonal forecasts. The analysis of product, verification and training requirements given above is an aid towards identifying some hubs in the structure and broad areas of responsibility. Some, but not all regions of the globe, have regional centres already established which undertake some of the tasks listed.

The information presented above will also facilitate a more precise specification of the functionality of Regional Specialised Meteorological Centres (RSMCs) with activity specialisation relating to climate, if that is required.

## LIST OF REGIONAL CLIMATE CENTRE FUNCTIONS

The requirements of NMHSs for RCC functions will vary from Region to Region, and may comprise only a subset of the following list. The required activities may be undertaken within a single centre or distributed amongst NMHSs.

### *Operational Activities:*

- Interpretation and assessment of relevant output products from global prediction centres;
- Generation of tailored products to meet NMHS needs including seasonal outlooks etc.;
- Product verification, including the necessary exchange of basic data;
- Product distribution.

### *Coordination Functions:*

- Strengthen collaboration between NMHS on related observing, communication and computing networks including data collection and exchange;
- Development of systems to facilitate harmonisation and assistance in the use of SI Forecast products;
- Assist in coordination with end users, including the organisation of workshops and other forums on users' needs;
- Assist NMHSs in the development of a media and public awareness strategy relating to SI Forecasts;
- To represent the needs of associated NMHSs.

### *Data Services:*

- Rescue of climate data sets;
- Provision of climate data base and archiving services;
- Assist in the development and maintenance of software modules for standard applications;
- Advising on data quality management.

### *Training and Capacity building:*

- Training of NMHS staff in SI Forecasting methods and characteristics to assist NMHSs to strengthen their services;

- Assist in the training of end-users on the application and impact of SI Forecast products;
- Assist in the introduction of appropriate decision models for end-users, especially as related to probability forecasts;
- Assist in technical capacity building on NMHS level.

*Research and Development:*

- Develop a climate Research and Development agenda and coordinate it with other RCCs in the Region;
- To arrange for studies of climate variability, predictability and impact in the Region;
- To develop consensus practices to handle conflicting information for the Region;
- Develop validation procedures relating to SI Forecast products in coordination with other centres;
- Develop and validate regional models, methods of downscaling and interpretation of global output products;
- Undertake application research, and assist in the specification and development of sector specific products;
- Arrange for studies of the economic value of climate information.

## ACRONYM LIST

ACMAD	African Centre for Meteorological Applications for Development (Niamey, Niger)
AGRHYMET	Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (Niamey, Niger)
AWG	Advisory Working Group
CAGM	Commission for Agricultural Meteorology
CAS	Commission for Atmospheric Sciences
CATHALAC	Centro del Agua del Trópico Húmedo para América Latina y el Caribe (Panama City, Panama)
CBS	Commission for Basic Systems
CCI	Commission for Climatology
Cg	Congress
CHy	Commission for Hydrology
CLICOM	Climate Computing Project (project of WCDMP)
CLIPS	Climate Information and Prediction Services (project of WCASP)
CLIVAR	Climate Variability and Predictability (sub-Programme of WCRP)
DC/CAP	Director Co-ordinating Climate Activities Programmes
DMC	Drought Monitoring Centre (Nairobi, Kenya and Harare, Zimbabwe)
DPFS	Data Processing and Forecasting Systems
DPS	Data Processing System
D/WWWB	Director WWW, Basic Systems Department
EC	Executive Council
ECMWF	European Centre for Medium-Range Weather Forecasts (Reading, UK)
ENSO	El Niño/Southern Oscillation
GCM	Global Circulation Model
GCOS	Global Climate Observing System
ICTT	Intercommission Task Team on Regional Climate Centres
IPM	Initial Planning Meeting
IRI	International Research Center for Climate Prediction (New York, USA)
NAO	North Atlantic Oscillation
NCEP	National Centers for Environmental Prediction (Washington, USA)
NMHS	National Meteorological and Hydrological Service
NWP	Numerical Weather Prediction
OPAG	Open Programme Area Group
PWS	Public Weather Services (part of WWW)
QBO	Quasi-Biennial Oscillation
RA	Regional Association
RCC	Regional Climate Centre
RCM	Regional Climate Model
RCOF	Regional Climate Outlook Forum
ROC	Relative Operating Characteristics
RSMC	Regional Specialised Meteorological Centre
SI	Seasonal to Interannual
SO	Southern Oscillation
SOI	South Oscillation Index
SST	Sea Surface Temperatures
WCASP	World Climate Applications and Services Programme (sub-Programme of WCP)
WCDMP	World Climate Data and Monitoring Programme (sub-Programme of WCP)
WCP	World Climate Programme

WCRP	World Climate Research Programme
WGSIP	Working Group on Seasonal to Interannual Prediction (CLIVAR)
WMC	World Meteorological Centre
WMO	World Meteorological Organization
WWW	World Weather Watch