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GLOBAL CLIMATE OBSERVING SYSTEM

WMO IOC UNEP ICSU International Council for Science

Summary Report of the Sixteenth Session of the GCOS/GTOS/WCRP Terrestrial Observation Panel for Climate (TOPC-XVI)

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TOPC Terrestrial Observation Panel for Climate

Executive Summary

The Terrestrial Observation Panel for Climate (TOPC) held its Sixteenth Session in the offices of the Joint Research Center (JRC) of the European Commission (EC) in Ispra, Italy, from 10th to 11th March 2014. The TOPC is co-sponsored by the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS), and the World Climate Research Programme (WCRP).

The goals of the Session were: (1) To seek guidance on drivers and priorities from TOPC sponsors and network partners, (2) to initiate the revision of the TOPC Terms of Reference and the panels' vision for the future, (3) to identify initial steps in the next GCOS assessment cycle, and (4) to discuss a potential stronger engagement of TOPC with the AOPC (Atmospheric Observation Panel for Climate) and OOPC (Ocean Observations Panel for Climate).

In the opening remarks, Professor Konrad Steffen and Dr Carolin Richter outlined the history of terrestrial observations and the past efforts of TOPC, and stressed the need for an improved observation in the terrestrial system, which is especially important in light of the Global Framework for Climate Services (GFCS). Subsequent presentations and discussions addressed the current status of observations for each terrestrial Essential Climate Variable (ECV), and the needs of the Global Terrestrial Networks (GTNs), including their related data management. Discussions placed substantial emphasis on the issue of assessing the status of ECV observation, and reporting on the progress of implementing the GCOS in the domains of hydrosphere, cryosphere and land. During their deliberations, the TOPC Chair highlighted the following issues that require the future attention of the terrestrial observation community in the upcoming years:

- Review the implementation status of the actions from the last GCOS Implementation Plan, assess the progress and current status of the observing, and identify data analysis gaps.
- Develop and evaluate the design of terrestrial observing systems, considering developments in applications and technologies through workshops and evaluation exercises (e.g. Observations for Climate Change Mitigation, potential joint workshops for different data centers that collect observations for one specific terrestrial ECV, etc.).
- Identify and address gaps in the sustained observing system, and address cross-cutting issues with AOPC and OOPC, such as land surface temperatures, ice shelves, coastal inundation and freshwater fluxes.

At the conclusion of TOPC-XVI, Professor Konrad Steffen discussed the agreed-on actions from the meeting, and outlined the next steps for the panel. It was agreed that the panel members would revise the current draft of the TOPC Terms of Reference, and edit the first draft of a reporting template for terrestrial ECVs. Both documents would then be circulated to participants for a final critical review and comment prior to being discussed at the GCOS Steering Committee Meeting in October 2014. The final version of documents, the meetings' presentations and supporting documents will be published on the GCOS/TOPC website.

To aid the development of the tasks identified, it was decided that TOPC will fill out the revised reporting template for each terrestrial ECV to be used for the next GCOS assessment and progress report, which will be published in late 2015. Critically, it was recommended that each terrestrial ECV has a designated lead and focal point from TOPC who will be in charge of providing the needed information.

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The GCOS/GTOS/WCRP Terrestrial Observation Panel for Climate (TOPC) was established to develop a balanced and integrated system of in situ and satellite observations of the terrestrial ecosystem. The Panel focuses on the identification of terrestrial observation requirements, assisting the establishment of observing networks for climate, providing guidance on observation standards and norms, facilitating access to climate data and information and its assimilation, and promoting climate studies and assessments.

The 16th Session of the TOPC was held on 10 and 11 March 2014 at the JRC in Ispra, Italy. This report summarizes key discussions and outcomes rather than being a full record of the meeting.

1 Opening of the Meeting

The Chairman of the TOPC, Professor Konrad Steffen, opened the meeting on the 10 March 2014 at the Joint Research Center (JRC) of the European Commission in Ispra, Italy. Furthermore, Dr Alan Belward, official representative for the JRC, GCOS Steering Committee Member, and former Chairman of the TOPC, welcomed participants (see Annex II), and shared some information on the TOPC history, displaying the importance of the work of TOPC and how activities regarding terrestrial climate observations have been evolving in the past years.

The experts were furthermore welcomed by Dr Carolin Richter, Director of the GCOS Secretariat. She thanked Professor Steffen for his work and great leadership for TOPC within the past year, and introduced reminded participants that this year's discussions will support the process of reporting on the progress of implementing the GCOS. The Chair then reviewed the proposed agenda, inviting changes and comments from the invited community. The panel adopted the agenda with the understanding it could be adjusted during the Session if necessary. The final meeting agenda can be found in Annex I.

2 Update on Programme Activities

2.1 GCOS Update

Dr Carolin Richter presented the recent work undertaken within the programme and outlined upcoming GCOS-related meetings and activities. She gave a short overview about the scope and framework of GCOS, and pointed to the newly published autobiography from the first GCOS Steering Committee Chairman Sir John Houghton 'In the eye of the storm', which includes a short history of GCOS. She announced that Dr Stephen Briggs (ESA), has been appointed by the sponsoring organizations to be the new GCOS Steering Committee (SC) Chairman, taking over the Chairmanship from Professor Adrian Simmons, who had stepped down after concluding his duty-cycle as Chair of four years.

She further informed participants on the upcoming 19th Session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC) to be held from 9 to 11 April 2014, with a preceding AOPC/AGG Network Meeting from 7-8 April 2014.

Professor Adrian Simmons will also step down as AOPC Chair[1] at the end of the meeting. The next AOPC panel meeting in 2015 will be arranged back-to-back with the next TOPC Session[2], including an overlapping day where experts from both panels can discuss cross-cutting links and issues. The 17th Session of the GCOS/GOOS/WCRP Ocean Observations for Panel (OOPC) will take place from 22-24 July 2014 in Barcelona, Spain. The next meeting of the WCRP Data Advisory Council (WDAC) will meet from 6 to 7 May 2014 in Galway, Ireland, where experts from GCOS will be present. Dr Richter in particular noted the review of the GCOS Programme by its sponsoring organisations. Chaired by former Permanent Representative (PR) of Germany and special WMO advisor for the WMO Integrated Global Observing System (WIGOS), Mr Wolfgang Kusch, the review board has assessed the Programme's mandate and objectives, and the added value it provides to the sponsors and the Earth Observation (EO) community. The final review report will be published in April 2014.

Recurring Programme activities include continuous support to the UN Framework Convention on Climate Change (UNFCCC) in the areas of research and systematic observation, adaptation to climate change, reporting of actions with regard to the global climate observing system, and the development of observation networks. A GCOS statement was presented to the Subsidiary Body for Scientific and Technological Advice (SBSTA) at the 19th Conference of Parties (COP19) in Warsaw, Poland, in December 2013. GCOS representatives will be present at the 40th Session of SBSTA (from 4 to 15 June 2014 in Bonn, Germany). The Federal Ministry of Transport and Digital Infrastructure (BMVI) in Bonn, Germany, will host the 9th Session of the GCOS Cooperation Mechanism (GCM) Board on the 3rd of June 2014, taking advantage of delegations present to attend the SBSTA sessions. In addition, GCOS will represent the global climate observing community at both COP20 and COP21 in Lima, Peru, and Paris, France, respectively. Furthermore, Dr Richter mentioned that one of the central functions of GCOS is to identify gaps in the existing observing systems and to review its status of implementation. The GCOS Programme has started the process for a 2015 report on the progress and status of climate observations, to be followed by a new GCOS Implementation Plan (IP) to be published in 2016. The IP will identify continuing and new requirements, including an updated statement of the rationale for the list of ECVs, taking into account the need for observations of climate services.

Actions:

Dr Richter additionally informed participants on the current situation of the Global Terrestrial Observing System (GTOS) at the Food and Agriculture Organization (FAO), which is still unresolved, and the status of the Secretariat is in a continued undefined state. There is a strong need for WMO and FAO to discuss about potential future opportunities for the GTOS Secretariat, as FAO is undergoing a restructuring with new strategic objectives that are currently being developed.

[1] Dr Kenneth Holmlund (EUMETSAT) and Dr Albert Klein-Tank (KNMI) have accepted to chair and vice-chair the AOPC after the upcoming AOPC panel session.
[2] TOPC-XVII will be held from 16-20 March 2015 at the WSL in Zurich, Switzerland.

A2.1 GCOS to provide WMO management with a brief to assist in the discussion with representatives of FAO about the potential future of GTOS.

2.1.1 AOPC Update

Dr Michel Verstraete, who is not only a panel member of TOPC but also AOPC, presented the AOPC Update on behalf of current AOPC Chair Professor Adrian Simmons, who unfortunately was not able to attend the meeting himself. Professor Simmons and Dr Verstraete, in collaboration with Mr Stephan Bojinski, Dr Thomas C. Peterson, Dr Carolin Richter, and Dr Michael Zemp, have submitted an overview manuscript describing the scope, purpose and role of Essential Climate Variables (ECVs), which is called "The concept of Essential Climate Variables in support of climate research, applications and policy" [3] and has been accepted for publication in the Bulletin of the American Meteorological Society (BAMS). The paper addresses issues that are of wide interest to all GCOS panels and associated networks.

AOPC will held it's next session (AOPC-XIX) from 9 to 11 April 2014 in Ispra, Italy. The focus of this years' panel will be on the review of the progress, status and requirements for atmospheric observations and atmospheric data products ECV-by-ECV, to be able to prepare for the next GCOS status report on progress and assessment of adequacy and the next GCOS Implementation Plan. He furthermore mentioned that the session will be preceded by a two-day workshop on network issues to cover GSN/GUAN/GRUAN (GCOS Surface Network/GCOS Upper-Air Network/GCOS Reference Upper-Air Network) and GAW (WMO Global Atmosphere Watch) networks.

There is a strong need to discuss cross-cutting issues between AOPC and TOPC more intensively, which is why GCOS has already planned to host the next AOPC and TOPC meeting back-to-back in 2015. It was further noted that AOPC welcomes TOPC's views on its future interaction with the atmospheric panel, especially in regard to what TOPC's requirements are for observations within the atmospheric domain. Dr Verstraete furthermore stressed the concern that it has to be kept in mind that atmospheric composition networks heavily rely on model inversions to estimate surface fluxes, which also affect the terrestrial observation community. Additionally, AOPC is strongly interested in issues relating to atmospheric reanalysis, as this is linked to land surface analyses that may have a higher spatial resolution.

2.1.2 OOPC Update

Dr John Wilkin, member of the OOPC and expert for observations in coastal areas, presented the update on OOPC and its latest session. He updated participants on the current status of the Global Ocean Observing System (GOOS), as well as the GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), and presented the Panel's revised new Terms of Reference and the work plan 2013-2018. The work plan is set on assessing requirements for scales and accuracy of observations, and areas of focus are air sea flux estimates, a Deep Ocean Observing System (DOOS), the Tropical Pacific Observing System (TPOS), boundary currents and inter-basin flows, and observations in the polar seas and coastal areas. Dr Wilkin presented a technical template for reporting on Ocean ECVs and the nomination of potential Essential Ocean

[3] Bojinski, S., Verstraete, M., Peterson, T.C., Richter, C., Simmons, A., and Zemp, M. (2014): The concept of Essential Climate Variables in support of climate research, applications and policy. Bulletin of the American Meteorological Society 2014, e-View; http://journals.ametsoc.org/doi/abs/10.1175/BAMS-D-13-00047.1.

Variables (EOVs), which will help to evaluate the current status of monitoring, and gather information on the monitoring progress.

In January 2014, OOPC co-hosted a technical workshop on the evaluation of the Tropical Pacific Observing System (TPOS) for climate research and forecasting. Main motivation for the workshop was the deterioration of the TAO/TRITON Mooring Array, and the need to ensure a sustained observation of Ocean ECVs. Main outcome of the meeting was the recommendation to create a TPOS Project to achieve the major change from a loosely coordinated set of ocean observing activities in the tropical Pacific area to a systematic and sustained TPOS by 2020. The TPOS 2020 Project will advance the degree to which the tropical Pacific (physical and biogeochemical) and its climate impacts are predictable, and determine how inter-annual and multi-decadal variability and human activities impact the relation between marine biogeochemistry and biology to carbon budgets, food security and biodiversity.

Key cross-cutting issues between OOPC and TOPC include the connection of observations in coastal regions, especially in regard to freshwater fluxes and coastal precipitation, as well as ocean and ice shelf interactions, regional sea level rise/variability and coastal inundation, and observations in wetland and estuary areas. Additionally, OOPC and GOOS would like to stronger integrate coastal observing systems within the Global Coastal Network of Regional Observatories, which is also of interest for TOPC.

Actions:

Participants acknowledged the need for a more detailed discussion about cross-cutting issues that are associated with both terrestrial and ocean observations. These issues include the following:

A2.1.2-I OOPC to foster a follow-up discussion on the importance of ice shelves at the next OOPC-XVII, and where it fits in both within the frameworks for TOPC and/or OOPC.

A2.1.2-II OOPC to identify the current monitoring status of the variable biogeochemical fluxes, as well as to foster contact with potential data centers. Report back to TOPC.

2.2 GCOS Cooperation Mechanism (GCM)

Mr Tim Oakley gave a presentation on his role as the GCOS Implementation Manager, the work of the GCOS Cooperation Mechanism (GCM) and items of relevance to TOPC. He emphasized that whilst most of the activities and benefit of the GCM had traditionally been focused on atmospheric observing systems, there were no reasons (subject to funding) why this work could not be extended to both the terrestrial and ocean observations. Following the 15th TOPC meeting in 2013, a proposal in support of the Global Terrestrial Network for River discharge (GTN-R) to improve the availability of measurements from the African region, was taken forward by Ulrich Looser (Global Runoff Data Center - GRDC).

This has identified a potential to support the river gauge measurements in Tanzania, a number of which were not operational. However it was clear from the request sent by the country representative, that there was no direct link to the GCOS requirements (i.e. availability of baseline measurements from Tanzania at the data-center). Guidance was requested from TOPC and the representative of the GRDC on the scope of the Tanzania proposal and a process of approval.

Actions:

TOPC members agreed that the Implementation Manager should work with the GRDC representative to identify support activities in Tanzania that will benefit the GCOS community in terms of data access and availability. Subject to funding this project would be initiated, under the management of the GCOS Cooperation Mechanism, on a step by step basis, both to develop the process and to ensure the benefit to the GRDC.

A2.2 Guidance from GRDC on the GCOS Cooperation Mechanism River gauge project in Tanzania. Plus agreement from TOPC to continue with this proposal.

2.3 WCRP Update

The World Climate Research Programme (WCRP) is an official co-sponsor of all three expert panels of GCOS, and hence also of TOPC. Professor Konrad Steffen presented an update on current activities of WCRP on behalf of Dr Michel Rixen from the WCRP Joint Planning Staff, who unfortunately was not able to attend the meeting.

He updated panel members and invited experts on recent and upcoming activities of the Programme, and stressed the importance of climate research for practical application, benefit and value to society. WCRP's future directions will need to ensure that it delivers into the GFCS and ICSU's Future Earth Initiative, and also the need to be more agile and flexible in responding to requirements and drivers.

WCRP has identified six grand challenges (each hosted by one of WCRP's core projects) – regional climate information, regional sea-level rise, cryosphere in a changing climate, changes in water availability, science underpinning the prediction and attribution of extreme events, and clouds, circulation and climate sensitivity. Those challenges have been identified following the WCRP Open Science Conference in 2011, which commissioned whitepapers that were published on the WCRP website and in the book 'Climate Science for Serving Society'[4]. Dr Steffen also presented the recently revised structure of WCRP, including a new WCRP Working Group on Regional Climate, which will be the main connection between WCRP, the GFCS, and ICSU's Future Earth activities.

Professor Steffen also briefed panel members on the upcoming Third Session of the WCRP Data Advisory Council (WDAC), which will be held in Galway, Ireland, from 6 to 7 May 2014. As a reminder, the WDAC has succeeded the former joint GCOS/WCRP Observations and Assimilation Panel (WOAP). GCOS is represented in the WDAC ex-officio by its Panel chairs. TOPC members were interested to hear that there will be a special session on (sea and land) fluxes. Additionally, WCRP announced the date for the Climate Symposium, which will be held in cooperation with EUMETSAT from 13 to 17 October 2014 in Darmstadt, Germany. The main goal of the symposium is to provide a forum to discuss the current state of climate science and climate observations in order to evaluate recent achievements, ascertain critical objectives to be achieved with satellite-based climate information, and identify gaps in the current space-based component of the climate observing system. A major topic that will be discussed is the proposed Architecture for sustained Climate Monitoring from Space that has been developed under the auspices of the Committee on Earth Observation Satellites (CEOS), the Coordination Group of Meteorological Satellites (CGMS), and WMO.

[4] Asrar, G. and Hurrel, J.W. (2013): Climate Science for Serving Society – Research, Modeling and Prediction Priorities; Springer publishing house.

Suggested future actions for TOPC and WCRP in regard to the new GCOS Implementation Plan should include the exploration of ways to bring terrestrial ECV data sets into the Earth System Grid Federation (ESGF) archive (i.e., in regard to obs4MIPs and ana4MIPs). At the end of his presentation, Professor Steffen underlined the importance of international cooperation, as well a stronger support for education, training and development of the next generation of climate experts and networks.

Actions:

The GCOS Steering Committee has stressed that the three GCOS expert panels need to work stronger in-line with each other, as there are important cross-cutting issues in the observation of the global climate that need to be addressed.

A2.3 GCOS to discuss potential funding opportunities with WCRP, which include future workshop (related to terrestrial climate observations), and a potential joint meeting of representatives from all GCOS/WCRP co-sponsored expert panels.

3 Evaluation of the Cryospheric Essential Climate Variables

3.1 WMO Global Cryosphere Watch

Dr Barry Goodison, Vice-Chair of the Global Cryosphere Watch (GCW)[5] Steering Group, presented an update on recent activities of GCW. Its mission is to provide authoritative, clear, and useable data, information, and analyses on the past, current and future state of the Cryosphere, and will include observations, monitoring, assessments, product developments, predictions, and research to do so.

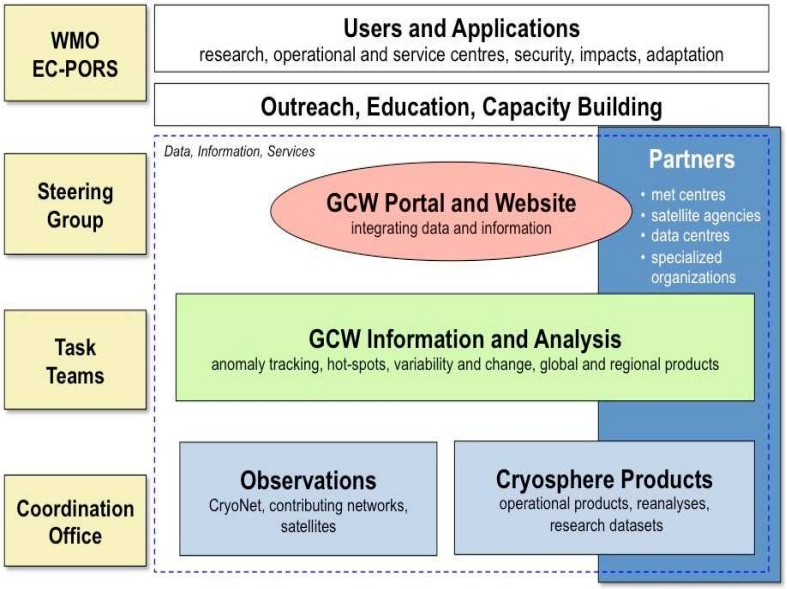

Figure 3.1 – The updated GCW conceptual framework.

The GCW Implementation Plan and its structure (Steering Group, ToR, Partnership criteria, etc.) have been approved by the WMO Executive Council, and the WMO Expert Panel on Polar Observations, Research and Services (EC-PORS). PORS is focusing on polar and high-altitude alpine regions, including the Himalayan and Tibetan Plateau, the

[5] The Global Cryosphere Watch (GCW) website: http://globalcryospherewatch.org/.

so-called ‘Third Pole’, with one of its roles being to facilitate integration and coordination between legacy initiatives of the International Polar Year (IPY) and WMO observing systems and programmes. PORS integrates all WMO Antarctic stations (surface and upper-air stations, including all GSN, GUAN, and GAW stations) into an Antarctic Observing Network (AntON), which requests all stations to produce monthly CLIMAT messages for collection and dissemination via the WMO Information System (WIS). GCW consists of six task teams, including the CryoNet team, and teams for requirements and capabilities, infrastructure and practices, products (Snow watch, and terminology), for the portal, and for outreach.

CryoNet, which is led by the Austrian Meteorological Service, is the core network of the GCW surface measurement sites, and is currently being under development. It will be comprised of sites with varying capabilities, build on existing cryosphere observing programmes, and promote the addition of standardized cryospheric observations to existing facilities in order to create more robust environmental observations. Dr Goodison reported on current CryoNet activities, site types (baseline, reference, and integrated sites), and introduced TOPC participants to the minimum set of requirements for the sites:

- The site location is chosen such that, for the variables measured, it is spatially/temporally representative for measuring one or several components of the cryosphere.
- CryoNet sites have to be active, and perform sustained observations according to CryoNet agreed practices.
- Technical personnel are trained in the operation of the equipment at the site.
- For reference and integrated sites, there is intent by the responsible agencies to long-term observations of at least one of the CryoNet variables.
- The relevant CryoNet observations are of documented quality. The measurements are made and quality-controlled according to CryoNet agreed practices.
- Associated standard meteorological in situ observations, when necessary for the accurate determination and interpretation of the GCW variables, are made with documented quality.
- The data and metadata, including changes in instrumentation, traceability, and observation procedures, are submitted to a data center, which is interoperable with the GCW portal in a timely manner. Metadata are also provided to the WMO Operational Information Resource (WIR), and maintained regularly.
- The station characteristics and observations programmes are kept up-to-date in the GCW station information database.
- A station logbook for observations and activities that may affect observations is maintained and used in the data validation process.
- User needs have been considered in the observation design process.

He updated participants on the current status of existing guidelines and best practices, presented a compiled database of requirements that is existing in the Rolling Review of Requirements/OSCAR database. Additionally, Dr Goodison reported about the first GCW *‘Snow Watch’ W*orkshop, which was held in Toronto, Canada, in January 2013. The main

purpose of the workshop was to determine the current status of snow data, products and information, as well as to identify any critical issues that need to be addressed in the future.

During follow-up discussion, participants wanted to know if GCW is working actively in cooperation with the GEO Cold Regions Initiative, which focuses on the coordination of observation activities over the poles (North Pole, South Pole, and the third Pole of the Tibetan Plateau and mountain cold regions). The GCW portal should be linked to the GEO data portal to promote the activities of GCW.

Actions:

The GCW Implementation Plan (Status March 2014) and the background document for TOPC participants can be found on the meeting website[6].

A3.1 Identify the activities of the GCW that are of particular importance to TOPC, and where GCW could contribute to TOPC efforts, e.g. data quality, data standards.

3.2 ECV Snow cover

Dr Richard Armstrong from the National Snow and Ice Data Center (NSIDC) gave a status and progress update on observations of the global snow cover. He briefed TOPC members on why snow cover is recognized as a fundamental indicator of climate variability and change, as it is highly sensitive to changes in temperature and precipitation regimes, and affects other ECVs such as albedo, soil moisture, the state of permafrost, growth conditions for vegetation, etc. It is also required for snow melt runoff forecasts and flood predictions. He presented the fact that approximately 1/6 of the world's population relies on snow melt runoff for water supply, whereas 75-80 % of water in the western US results from snow melt. He explained to participants the main user requirements, and combined those findings with the ones that are already included in the main GCOS reports and documents (2011 Satellite supplement, etc.).

He presented the main climate data records and data sets, and therefore showed some best practice examples of how well snow cover monitoring has been evolved within the past decades. Ongoing and future activities of the community include various efforts to develop new satellite data products to extend the length of records, increase spatial resolution, and the frequency of observation.

He presented the work of the NASA (international) Snow Working Group for Remote Sensing (iSWGR), whose mission it is to engage the US and international science communities in building a vision for future snow remote sensing efforts, including but not limited to, future NASA missions, to promote international collaboration, and engage in capacity-building within the US and international snow remote sensing communities. The work of this group of experts should also encourage more snow and snow remote sensing research.

3.3 ECV Ice sheets

Professor Konrad Steffen reported on the current status of research on ice sheets, and changes in sea level. Sea-level rise is one of the major impacts of anthropogenic climate change, and it is the most obvious impact in the oceans, which directly affects society. Professor Steffen stated that since the last glacial maximum, the sea level

[6] Official website for the 16th Session of the GCOS/GTOS/WCRP Terrestrial Observation Panel for Climate (TOPC-XVI): http://www.wmo.int/pages/prog/gcos/index.php?name=TOPC-XVI.

rose more than 120 metres, and gave an update on what has been said in the 2014 IPCC AR5. The evolution of global mean sea levels since 1870 result partly from the melting of glaciers and ice sheets, whereas the thermal expansion of the oceans contribute typically to about 30-40 % of the rise. Compared to the 2007 Intergovernmental Panel on Climate Change (IPCC) report, the estimated cryospheric contribution rose from 1.28 mm/yr (averaged over 7-8 years) to now 2.2 mm/yr, according to observations from NASA's Gravity Recovery and Climate Experiment (GRACE) instrument.

To underline that climate warming does not only cause changes in ice-sheet regions, Professor Steffen introduced Panel members to the example of Greenland. Observed changes on the western slope of the Greenland ice sheet are only partly caused by warmer air temperatures, which have increased by 4°C on an annual mean over the last two decades, but also by warmer ocean water that predominantly melts floating parts of ice. Changes in ocean circulation and ocean temperatures will produce changes in basal melting, resulting in changes in the overall Greenland ice-sheet mass balance. Due to limited monitoring, the magnitude of these changes can currently not be well modelled or predicted. He also used the example of the evolution of the Antarctic Ice Sheet, and showed that the mass loss from Antarctica is responsible for 5.5 mm global sea level increase since 1992. Both ice sheets combined contributed to 1.2 mm to global sea level increase every year during the 2007-2011 time periods.

Actions:

The participants of the meeting expressed their concern that there is currently no main focal point and/or data center for ice sheet information, but the data is scattered among different centers.

A3.3 GCOS to facilitate a workshop/meeting that will bring together all the main data centers that provide information/data on the ECV Ice sheets.

3.4 ECV Glaciers and ice caps

Dr Michael Zemp, Director of the World Glacier Monitoring Service (WGMS), reported on opportunities and challenges of a research-based monitoring system for ECVs, and gave a status update on the Global Terrestrial Network for Glaciers (GTN-G). GTN-G is largely based on the scientific monitoring community, and is jointly run by three operational bodies: the WGMS, the U.S. National Snow and Ice Data Center (NSIDC), and the Global Land Ice Measurements from Space (GLIMS) initiative. A 'One-stop data-portal' allows the exploration of data products from all three operational services (WGMS, GLIMS, and NSIDC), including a metadata browser. Today, four major challenges in climate-glacier research and observations have been identified:

- climate-glacier processes;
- glacier distribution;
- glacier change rates; and
- uncertainty assessment.

He briefly introduced the GTN-G SC and the structure of the GTN-G network, and mentioned that the GTN-G Advisory Board is now under the lead of the International Association for Cryospheric Sciences (IACS). One of the main goals of GTN-G is to

combine in situ and remote sensing data, but it was expressed that there is currently only little funding available. The data is freely available online[7] and published in periodical reports. In addition, users can send data requests to the WGMS mailbox. Furthermore, glacier inventories are available at the NSIDC website. Dr Zemp stressed that even after 50 years of glacier observations there is still no complete inventory due to monitoring challenges, which include that fully automated algorithms are challenged by snow, perennial snow, and debris cover, as well as the problem that it is difficult in some regions to get minimal snow and cloud free images at the end of an ablation season. He also gave an update on the current status of several different fluctuation observations, including GRACE, ICESat, TanDEM-X, etc.

Concluding his presentation, Dr Zemp presented his conclusions for the GTN-G, which has been doing great work at maintaining a consistent long-term storage of existing databases and an active compilation of glacier change data from in situ networks. He stressed the lack of funding resources for a better inclusion of remote sensing data.

He furthermore expressed his concern that concepts like the GFCS can only be successful if the monitoring of each ECV is run by assigned operational data centers that have long-term funding for active data compilation, storage, and data dissemination.

After the presentation, participants briefly discussed the results and products from the ESA Climate Change Initiative (CCI), and how they could included within the WGMS database.

3.5 ECV Permafrost

Dr Jeanette Noetzli, member of the Executive Committee of the Global Terrestrial Network for Permafrost (GTN-P) and working for the Swiss Permafrost Monitoring Network (PERMOS), presented an update on GTN-P, its strategy and the current implementation status. GTN-P, established in 1999 by the International Permafrost Association (IPA), contributes greatly to the overall work of GCOS, as the network consists of over 800 boreholes for permafrost thermal monitoring, and about 100 active layer monitoring sites to date that contribute to the Circumpolar Active Layer Monitoring Programme (CALM), as more than 25 countries are now involved in observation and monitoring.

In early 2013, GTN-P introduced its strategy and implementation plan for 2012-2016, which aims to provide systematic and long-term documentation of the distribution, status, variability and trends of permafrost in a global network of in situ measurements. Observational elements are the Thermal State of Permafrost (TPA), which measures permafrost temperatures in boreholes of different depths, and the Active Layer Thickness (ALT), where the depth of seasonal thaw is determined in grids with probing/frost tubes or in boreholes with already recorded temperatures. The GTN-P observation strategy has identified the following challenges:

- to merge the two networks TSP and CALM as well as other operational and scientific monitoring activities into one global permafrost monitoring network;
- to assess the observation elements, and select a list of reporting parameters and key observation sites;
- to extend observation elements (i.e., ice content changes, creep velocities, etc.);

[7] The WGMS website: http://www.wgms.ch/access.html

- to extend the network and include sparse regions;
- to assess the needs for policy makers, the scientific community, and modelers (as there seems to be a strong demand for high spatial and temporal resolution data); and
- to integrate new methods for field observations as well as remote sensing (i.e., ESA DUE Permafrost).

Dr Noetzli introduced TOPC members to the GTN-P Database management system that was develop within the framework of the EU-funded FP-7 project 'PAGE21 – Changing Permafrost in the Arctic and its Global Effects in the 21st Century'[8]. The system is currently being evolved from an earlier metadata collection to a web-based monitoring services hosted by the Arctic Portal.

GTN-P presents annually updated and peer-reviewed information on recent permafrost observations in form of an Arctic Report Card, and has also published annual updates in BAMS: one for permafrost in the Arctic, and one for the current status on permafrost on a global scale. Additionally, biannual reports on permafrost temperatures and the active layer at selected reference sites are planned.

In the following-up discussion, Dr Noetzli stressed about the fact that there are currently scarce opportunities for financial support of GTN-H. A secretariat is urgently needed, but funds need to be found outside of GTN-P.

4 Evaluation of the Hydrological Essential Climate Variables

4.1 ECV Soil moisture

Professor Wolfgang Wagner from the Vienna University of Technology updated participants on the progress made regarding monitoring the ECV soil moisture, and highlighted the soil moisture contributions to the updated WMO/CIMO Guide to meteorological instruments and methods for observation, the GOSIC website, the BAMS State of the Climate 2013, and in the book 'Remote sensing of energy fluxes and soil moisture content'[9].

He reported on the Satellite Soil Moisture Validation and Application workshop, which was held at ESA-ESRIN in Frascati, Italy, from 1-3 July 2013. The workshop was organized by ESA in cooperation with EUMETSAT, WMO, GEWEX, CEOS and GCOS. The objective of the workshop was to discuss and reconcile recent methodological advances in the validation and application of global satellite soil moisture data. It brought together producers and users of satellite soil moisture data, and provided a platform to discuss data quality, error characterization, validation approaches, data assimilation, and the broadening range of applications. Three working groups developed recommendations for both in situ validation networks and best practices for validation, which can be found on the workshops' website[10].

Professor Wagner furthermore introduced participants to specific validation tools – an online ASCAT Validation Tool and Pytesmo, a python toolbox for validation. The soil moisture community is becoming more and more commanding, and therefore, new standards and validation techniques need to be made available.

[8] PAGE21 website: http://www.page21.eu/.
[9] Petropoulos, G.P. (editor) et al. (2013): Remote Sensing of Energy Fluxes and Soil Moisture Content. CRC Press, United States.
[10] Satellite Soil Moisture Validation and Application workshop: http://www.soil-moisture-workshop-2013.com/.

There has been significant progress in maintaining and updating the ISMN[11], which currently consists of 42 networks, comprising about 1590 stations, and covers a time period from 1952 until the present. Migration of data has been started from the in-house written software IDL to Python for fully automated processing of data that is acquired by scatterometers (METOP ASCAT, ERS SCAT) and synthetic aperture radars (Sentinel-1, ENVISAT ASAR). New networks/stations have been added to the database, and most data sets are now automatically updated in near-real time.

Professor Wagner expressed his concern for the future of ISMN, as funding from ESA's Soil Moisture and Ocean Salinity (SMOS) will stop at the end of 2015, and there is a strong need to find new funding opportunities from early 2016 onwards either of the private sector or on a governmental/state level or both.

4.2 ECV Ground water

Ms Nienke Ansems introduced TOPC members to the work of the International Groundwater Resources Assessment Center (IGRAC), which works under the auspices of UNESCO and the WMO, and facilitates and promotes sharing groundwater information and data, and associated knowledge. Main scope of activities focuses on a global groundwater monitoring network, transboundary aquifer assessments, and groundwater governance and legislation. She explained to participants, why ground water is such an important resource and key variable, and introduced the main monitoring parameters regarding ground water quantity (ground water recharge and discharge, ground water storage changes), and ground water quality (saline ground water).

IGRAC has established the Global Groundwater Monitoring Network (GGMN), which is a web-based network of networks containing measurements and aggregated estimations to periodically produce online maps displaying ground water changes in time on a regional scale. The GGMN portal[12] displays data as point measurements, time series, proxy information (such as precipitation), and in aggregated mode. Currently, data of 34 countries have provided data to the portal, which includes a time span of up to almost 100 years.

With the help of regional workshops, bringing together regional experts to review the state of ground water monitoring in specific regions, IGRAC tries to stronger involve additional networks, and strengthen international cooperation while collaborating on joint projects. This years' workshop will take place in China and India. Other ongoing GGMN activities include the release of new GIS software, and an application to analyse time series of ground water data.

Representatives of IGRAC kindly agreed to act as a focal point for the ECV ground water in the next GCOS assessment and reporting cycle.

4.3 ECV Lakes

Professor Valery Vuglinsky from the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) updated the TOPC members on activities of the International Data Center on Hydrology of Lakes and Reservoirs (HYDROLARE)[13], operated by the Russian State Hydrological Institute (SHI) since 2009. HYDROLARE,

[11] International Soil Moisture Network (ISMN) website: http://ismn.geo.tuwien.ac.at/.
[12] The GGMN/IGRAC data portal: http://ggmn.e-id.nl/ggmn/GGMN.html.
[13] HYDROLARE website: http://www.hydrolare.ru/.

working within the WMO framework, has implemented major activities regarding the acquisition of data and information on lakes and reservoirs on a global scale. In the last intersession period, the main directions of HYDROLARE activities were the following: (1) collection of data for the database, its formation and maintenance; (2) website management (further development of the technology for monitoring the lake database content on the HYDROLARE website); (3) development of a cooperation with the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) at the Center National d'Etudes Spatiales (CNES); (4) review and correction of the GTN-L priority list of lakes for monitoring climate change under the GCOS programme; and (5) preparation of the annual newsletter and other publications.

Professor Vuglinsky announced that an agreement has been reached with the executives of the International Lake Environment Committee (ILEC) about the organization of an international Workshop on 'Hydrological Monitoring of Lakes and Reservoirs' in 2014 under the umbrella of the 15th World Lake Conference, which will be held from 1-5 September 2014 in Perugia, Italy. The workshop is aimed at the exchange of international experience in hydrological monitoring of large lakes and reservoirs. Data of hydrological monitoring of large lakes and reservoirs provide a basis for studies of their hydrological regime, water balance and water exchange, maintaining the environmental balance and ensuring the most efficient use of large lakes and reservoirs by different economic sectors. Hydrological monitoring data are not available for many large lakes of the world. Monitoring datasets available in different countries are incomplete and isolated, having different content of observed elements and measurement techniques, while the results of observations are very often not easily comparable. The proposed special session is expected to address the most challenging problems of obtaining, collection and dissemination of hydrological monitoring data of the world's largest lakes. Outcomes of this workshop will directly contribute to the next GCOS assessment of the adequacy for the current global observing system for climate, and will help to further identify implementation actions that will be needed for the new GCOS Implementation Plan. The proposed themes for discussion are:

- Observations of hydrological characteristics of the world's largest lakes and reservoirs, their content and measurement techniques.
- Collection and processing of observation data on large lakes and reservoirs. Long-term data archiving and database maintenance.
- Development of international cooperation in the field of hydrological monitoring of large lakes and reservoirs.
- Improvement and development of international monitoring data exchange.

Additionally, HYDROALRE (in cooperation with LEGOS/CNES) has updated its three priority lists for lakes (natural, regulated, and transboundary) on a global scale for monitoring main characteristics of the water and ice regime.

In addition to Professor Vuglinsky's presentation about HYDROLARE, Dr Jean-François Crétaux from the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales/Center National d'Etudes Spatiales (LEGOS/CNES) reported on the current cooperation with HYDROLARE that has been extended. HYDROLARE/Hydroweb have developed a lake database to monitor near real-time water-level and storage variations from remote-sensing data, which provides level variations from radar altimetry for 163

lakes and reservoirs, freely available on the website[14], and surface-volume variations of about 50 lakes, which are calculated through a combination of various satellite images (from MODIS, ASAR, Landsat, etc). Within the last year, LEGOS/CNES and HYDROLARE have further implemented steps to allow direct access from HYDROLARE to the Hydroweb website to obtain satellite lake level data and vice versa. Dr Crétaux also discussed the possibility to update and enlarge the HYDROLARE database by the inclusion of satellite observation data available in Hydroweb. As a result of this discussion, HYDROLARE developed a new technical complex, which now includes an integrated database of in situ and remote sensing data that is directly accessible from the website.

Actions:

Professor Vuglinsky updated TOPC participants on the planned activities of HYDROLARE and LEGOS/CNES for the upcoming year, and asked to include the following items as official TOPC actions:

A4.3-I To update and enlarge the HYDROLARE database by inclusion of satellite observation data in Hydroweb.

A4.3-II To develop a new technical complex for integrating in situ and remote sensing data in the HYDROLARE database.

4.4 ECV River discharge

Mr Ulrich Looser from the GRDC reported on the importance of monitoring river discharge, and gave an update on the current status of the GTN-R. The ECV river discharge has a strong role in driving the climate system, as the freshwater inflow to worlds' oceans may influence oceanic circulation patterns at an interannual to decadal time scale. It serves as an indicator for climatic change and variability as it reflects changes in precipitation and evapotranspiration.

GTN-R is actively working in close cooperation with the Global Terrestrial Network for Hydrology, and delivers data for long-term freshwater fluxes into the world's oceans, long-term mean river discharges, and global composite runoff fields. Initially, GRDC has identified 380 near real-time river discharge stations that need verification from the National Hydrological Services (NHSs). GTN-R serves and supports the GCOS baseline river-discharge network, and has built a basis for future versions of the GRDC product 'Long-term mean annual Freshwater Surface Water Fluxes into the Worlds Oceans' as well as for a cooperation with the UN GEMS/Water Programme Office (which has been moved to the German Federal Ministry of Hydrology) of the UNEP Division of Early Warning and Assessment (UNEP/DEWA) Division for biogeochemical flux computations, and has contributed to the map layer for river discharge within the Worldwide Hydrogeological Mapping and Assessment Programme (WHYMAP) project that is mainly sponsored by UNESCO and the Federal Institute for Geosciences and Natural Resources (BGR) in Germany.

GTN-R now focuses on getting access to near real-time river-discharge data for selected stations around the world to capture the majority of the freshwater flux into the oceans. This will be beneficial for GTN-R for the baseline river-discharge network supported by the GCOS IP, climate and hydrological modelling, research and data assessment, GTN-H, GRDC – GEMS/Water products on chemical loads, the GRDC Freshwater Surface

[14] See full list at LEGOS website: http://www.legos.obs-mip.fr/fr/soa/hydrologie/hydroweb/Objets.html.

Water Flux product, and GEOSS (through the GEOWOW FP7 project). The current status as of March 2014 of the network includes 235 stations that contribute to the GEOSS data-CORE.

GTN-R also works in collaboration with the GCOS Cooperation Mechanism (GCM) on two projects in Moldova and Tanzania. Although discussions with Moldova have been stagnating since late 2013, Tanzania has expressed interest to participate in the GCM, and a river gauge project is currently being prepared. For further information, please see item 2.2.

4.5 Update on GTN-H

The GCOS Secretariat presented a short update on the current status of the coordination for the Global Terrestrial Network for Hydrology (GTN-H) on behalf of Dr Wolfgang Grabs, who could not attend the meeting.

The GTN-H was established in 2001 as a baseline network in support of UNFCCC, and is a joint project of GCOS, the Climate and Water Department of WMO (WMO/CLW), and GTOS. It also represents the observational arm of the Integrated Water Cycle Observations Theme of GEO (IGWCO). GTN-H was developed as a global hydrological network of networks to fulfill the need for improved global hydrological data, information and joint data products for assessing environmental changes, identifying significant trends and developing response strategies by building on existing networks and global data centers that hold key data on hydrological ECV and other important variables.

Due to the unresolved situation of the GTN-H Coordination at the Federal Institute of Hydrology (BfG) in Koblenz, Germany, GTN-H has been put into an undefined state. The 6th Session of the GTN-H Coordination Panel took place in June 2013 at the BfG in Koblenz, Germany, and was supposed to set the strategy and operative goals for the coming few years. Since then, certain coordination responsibilities have not been properly implemented, and there is an urgent need to resolve the GTN-H coordination issue with the BfG at the earliest.

In the past, GTN-H has been working in close collaboration with major hydrology networks and global databases that have been established by international organizations: the GRDC, the Global Precipitation Climatology Center (GPCC), the Global Environment Monitoring Center on Water Quality (GEMS/Water), and IGRAC. It has been noted that GTN-H needs to redefine the current partnership between its network partners, as well as define its potential role within both the GFCS and the WMO Integrated Global Observing System (WIGOS).

In the discussion following the presentation, Professor Wagner expressed his concern for the lack of recognition for the work that some of the networks are doing voluntarily additional to their every day work. Therefore, GTN-H needs to think about potential options to show recognition to those involved.

Actions:

A4.5-I GCOS/TOPC to formulate a letter addressed to the BfG, stating the concern about the current status of the GTN-H coordination.

A4.5-II GCOS to discuss with GTNs about a potential Memorandum of Understanding (or something similar) to recognize the networks as official GTN partners and data contributors.

A4.5-III GTN-H needs to clarify the current status of its network partners. TOPC recommends an information meeting for current and potential new partners of GTN-H by the end of 2014.

4.6 Climate observations in coastal areas

Dr Robert Christian, who has years of experience working with the Coastal GTOS, was invited as an expert to update participants on the current status of climate observations in coastal areas, and what has been done within the past years. Detailed background material can be found on the TOPC-XVI website[15].

Coastal GTOS has been implemented in a first phase, but there is a continued need for information on global and regional climate key variable changes in coastal areas. This issue was identified by the GCOS SC as a cross-cutting item that needs further discussion with representatives from both TOPC and OOPC. The collection of in situ and remote sensing data must be improved, and associated data management and model production pursued. In the past, GTOS had developed a coastal module in collaboration with GOOS, GCOS, GEOSS, and the Integrated Global Observing System (IGOS). The IGOS Coastal Theme report provides an important supplementary foundation to the Coastal GTOS plan in developing coast-related ECVs. Dr Christian briefed participants on the primary goal of the Coastal GTOS programme, which has been to detect, assess and predict global and large-scale regional change associated with land-based, wetland and freshwater ecosystems along the coast. Dr Robert explained that the most important terrestrial ECVs needed for the initial Coastal GTOS projects are river discharge, water use, groundwater, glaciers and ice caps, land cover, and soil carbon. He furthermore presented the main parameters needed for coastal climate observations, as well as their current status of monitoring.

Proposed initial products of Coastal GTOS included the following:

- understanding the distribution and the rate of change of population, urbanization, and land use in the coastal environment;
- evaluating informatics accessibility through the study of vulnerability of ecosystem services in deltaic systems with respect to climate change and impact of dams;
- assessing and promoting integrated management of conservation and cultural sites in the coastal zone;
- enhancing the GTOS metadata capabilities for coastal data needs through further development of the GTOS Terrestrial Environmental Monitoring Sites (TEMS) database; and
- assessing the distribution of and promoting the establishment of sites appropriate for analyses of delivery systems.

Priority coastal issues and discussions should focus observations that depict the current status on coastal vulnerability, biological diversity, ecosystem health and resultant services, carbon sequestration in coastal wetlands, and the intensity of human activities in coastal areas. Dr Christian mentioned that coastal vulnerability has been given more attention of late then indicated by the Coastal GTOS plan. This is an area where TOPC could contribute in the future beyond the plan.

[15] GCOS TOPC-XVI website: http://www.wmo.int/pages/prog/gcos/index.php?name=TOPC-XVI.

TOPC and OOPC, in collaboration with GCOS and GOOS, need to decide whether the initially made strategic plans are still valid. Further discussion is needed to decide the future integration of global climate observations in coastal areas, especially now that the current state of the GTOS programme is unknown. Current and potential future coastal observation activities may be addressed best by the GEO Coastal Community of Practice, if GTOS cannot be resurrected.

5 Evaluation of the Biological/Ecological Essential Climate Variables

5.1 ECV Land cover

Professor Martin Herold from the University of Wageningen, which hosts the Global Observations on Forest Cover and Land Dynamics (GOFC-GOLD) project office, gave an update on observing land cover as an ECV. GOFC-GOLD's overall objective is to improve the quality and availability of observations of forests and land cover at regional and global scales, and to produce useful, timely and validated information products from the data for a wide variety of users.

He reported on the development of the in situ reference network for land cover, presented the current list of global/regional land cover reference datasets, and once again stressed that there is a strong need for reference data, as land-cover data is often constructed for a certain purpose and therefore not available on a long-term basis. Further information on the land cover reference datasets is available from the GOFC-GOLD data portal[16].

He furthermore presented the current land cover products that are available at a moderate resolution, and reported on the notable progress that has been made in ESA's CCI project on land cover, which includes four major land cover products. A download is expected to be offered within this year.

Professor Herold also announced the joint GCOS/GOFC-GOLD Workshop on Observations for Climate Change Mitigation to the TOPC community, which will be held at WMO headquarters in Geneva, Switzerland, from 5-7 May 2014. The goals of the workshop are to identify observational requirements for mitigation, to review the ECVs and associated guidelines to determine their adequacy for mitigation, and to develop a plan to address these gaps and deficiencies identified. The workshop results will directly feed into the preparation for the next GCOS Progress Review and the new GCOS Implementation Plan, to be developed in the 2015-2016 timeframe. The workshop will bring together approximately 25 participants of sectors in which mitigation to climate variability and climate change is, or is likely to become, an important concern. These also include the communities of agriculture, forestry, and land use. More information about the workshop, and associated background documents, can be found on the GCOS website[17].

5.2 ECV Fire disturbance

Dr Kevin Tansey from the University of Leicester reviewed the progress made in regard to the ECV fire disturbance, and gave an update on fire disturbance activities in 2013. Main focus of the community are the need to define user requirements in the ECV context, to expand the data records to the past while maintaining operations, to assess if

[16] GOFC-GOLD Reference Data Portal: http://www.gofcgold.wur.nl/sites/gofcgold_refdataportal.php.
[17] Joint GCOS/GOFC-GOLD Workshop on Observations for Climate Change Mitigation: http://www.wmo.int/pages/prog/gcos/index.php?name=ObservationsforMitigation.

the data products available are meeting the ECV requirements (including validation techniques), and to improve the spatial resolution of data in the future.

He presented the paper 'Ten years of global burned area products from spaceborne remote sensing – A review'[18], which discusses current and past user needs from the community, and asked for input from TOPC whether or not those identified user requirements are needed within the context of GCOS. Additionally, he filled participants in on the latest product development (e.g., ESA CCI, VIIRS active fires, Fire Radiative Power (FRP) in MAC-II, and GFED-4), improvements in the validation process, and presented the advances from the step-changes in spatial resolution.

Dr Tansey reminded participants that although there are a lot of improvements, more work on active fire and FRP channels is needed in the future, both on future documentation expected by GCOS, as well as with regard to the co-ordination of data products. A stronger liaison/communications channel with the Sentinel mission groups could be established. Currently, the CEOS Working Group on Calibration and Validation – Land Product Validation (WGCV-LPV) and GOFC-GOLD are supported with fire information and data, and the experts are working on a validation protocol for CEOS. Additionally, the detection of low-intensity fires needs to be improved, and therefore as many satellites as possible should be used to increase the data quality.

During the follow-up discussion, Dr Tansey informed participants that a majority of data sets is available online. Although different networks are feeding information into the portal, the data included is mainly derived from the same operational systems. He also announced that the GOFC-GOLD Fire implementation team will meet for a workshop at the University of Maryland, United States, from 29-31 July 2014.

Future potential activities in regard to fire disturbance monitoring should stronger focus on representing the fire community in IPCC-class models, improving validation techniques, improving spatial resolution, supporting the process of operational archive processing, and increasing efforts in regard to trend analysis.

5.3 ECV Above ground biomass

Professor Shaun Quegan, representing the Center for Terrestrial Carbon Dynamics (NCEO), held a presentation on current capabilities for observing forest above-ground biomass, and updated participants on what has been done in regard to monitoring of forest biomass in the past. For additional information on the knowledge status until 2010, please see the 2010 UN Global Forest Resources Assessment[19] (FRA). Professor Quegan also expressed his concerns regarding the assessment, as it does not include any spatial distribution of biomass, displays inconsistent and incomplete data, and has no error reporting. Global biomass monitoring seems to vary strongly in quality, which is further concerning as validated biomass data is needed as a reference for international treaties and carbon trading, and strongly supports the work of the UN programme for Reducing Emissions from Deforestation and Degradation (UN-REDD+). The Global Forest Observations Initiative (GFOI) is supporting countries to prepare them for REDD+ (which most probable won't be able to operate within the next few years) and organize forest inventories on a national level.

[18] Mouillot, F., et al. (2014): Ten years of global burned area products from spaceborne remote sensing – A review: Analysis of user needs and recommendations for future developments. International Journal of Applied Earth Observation and Geoinformation, Vol. 26, pp. 64-79.
[19] The FAO Global Forest Resources Assessment: http://www.fao.org/forestry/fra/fra2010/en/.

It has to be kept in mind that those inventories mostly seem to use only low resolution data that is not validated. Additionally, spaceborne data is not available, as no sensors have been designed to measure biomass from space just yet. This is expected to change with the launch of satellite Sentinel-1, whose mission will ensure the continuity of radar data at large. The satellite has been selected to become ESA's 7th Earth Explorer mission to observe forest biomass for a better understanding of the carbon cycle, and to provide an easier and more accurate way to monitor biomass regularly.

Professor Quegan also mentioned that the biomass community is well connected and supportive in regard to in situ (i.e., RAINFOR, AFRITRON) and remote sensing monitoring, and various projects are currently being implemented to establish an operationally fit observing system. He moreover presented the current status for several different of those monitoring technologies, and their current status.

Missing terrestrial ECVs

Dr Carolin Richter gave participants a short update on the current status of those four terrestrial ECVs where a focal point is missing within the GCOS community, which includes FAPAR, LAI, albedo, and water use. She expressed that there is a pressing need to find experts for each of those key variables, as they will be crucial for the next GCOS assessment cycle.

She furthermore introduced participants to the European Framework 7 project on Quality Assurance for multi-decadal ECVs (QA4ECV), which is led by scientists from the Royal Netherlands Meteorological Institute (KNMI), and a complementary project to the ESA CCI. LAI, FAPAR, and spectral albedo are ECVs that were chosen to explain and define the surface vegetation status. Furthermore, TOPC members uttered their wish to include experts from the Institute for Environment and Sustainability of host JRC. Dr Nadine Gobron, who is involved in the KNMI project and was present at the TOPC meeting, expressed her interest, but also mentioned that the current workload might not make a stronger participation within TOPC possible.

The ECV water use is currently not taken care of, and there are currently no validated data sets or data products available. The GCOS Steering Committee will need to discuss the future inclusion of water use as an official GCOS ECV.

6 Space-based Observations and Validation, and Data access

6.1 Report from the GCOS Space Rapporteur

Dr Robert Husband from EUMETSAT has taken over the role of GCOS Space Rapporteur for the upcoming two years from Dr Jean-Louis Fellous in the beginning of this year. He updated TOPC participants on the First Meeting of the Joint CEOS/CGMS Working Group on Climate, which coordinates and encourages collaborative activities between the world's major space agencies in the area of climate monitoring. The mandate of the Working Group, chaired by Mr John Bates (NOAA), is to facilitate the implementation and exploitation of ECV time series through coordination of the existing activities that are undertaken by CEOS/CGMS member agencies.

The overarching goal of the CEOS-CGMS Working Group on Climate will be to improve the systematic availability of Climate Data Records through the coordinated implementation, and further development of the architecture for climate monitoring from space. Current main focus is set on the provision of a comprehensive and accessible

view as to which climate data records are currently available, the good practice use of currently available data by delivering additional climate data records, and the optimization of the planning of future satellite missions and constellations to expand existing and planned climate data records, in terms of both coverage and record length.

Dr Husband furthermore reported that the WG Climate is strongly interested in engaging with GCOS, and the climate monitoring architecture (see Figure 6.1) could act as a potential mechanism for addressing application-dependent requirements. The WG Climate focuses on the first two pillars – sensing, and climate record creation.

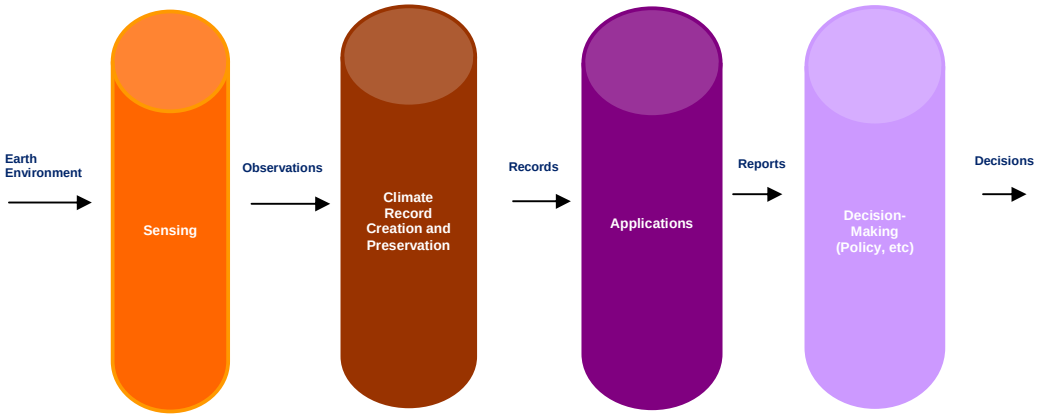

Figure 6.1 – Sequence of case studies (using the climate monitoring architecture), discussed in relation to GFCS and the GCOS Scoping Report, as a link between decision-making and observations.

Additionally, the WG Climate is focusing on the evolution of the CEOS/CGMS/WMO ECV Inventory, which was originally intended to provide a repository for information on climate data products from only space-based observations. There are current discussions to include in situ networks, and a questionnaire to associated networks and international organizations (that directly contribute to an ECV product) has been prepared for circulation. More information on the ECV Inventory can be found in paragraph 6.4 of this report.

Dr Husband also briefed participants on the current status of the CEOS Carbon Task Force, as the WG Climate has volunteered to take over as coordinator of the actions arising out of that task force. After extensive debate is was decided to recommend that the Carbon Task Force should continue without this activity, as the WG Climate should focus on its core objectives.

6.2 CEOS Cal/Val activities

Professor Wolfgang Wagner presented an update on current CEOS Cal/Val activities on behalf of Dr Gabriela Schaepman-Strub, Chair of the CEOS Working Group on Calibration and Validation (WGCV) sub-group on Land Product Validation (LPV). The goal of the CEOS LPV activities is to foster and coordinate quantitative validation of higher level global land products derived from remotely sensed data, in a traceable way, and to relay results to whether products are relevant to users.

Professor Wagner updated participants on the current focus area co-leads of the LPV group, which currently focuses on validation in nine different focus areas, which include snow cover and ice, surface radiation, land cover, Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), Leaf Area Index (LAI), fire,

land surface temperature, soil moisture and land surface phenology. A teleconference with those co-leads is organized every two months. He furthermore briefed TOPC on the working concept of the LPV, whose approach it is to find a community-wide accepted way how to do validation emerged from the land validation of MODIS products, mainly land cover, fire and land index. The LPV group met in January 2014 to discuss the concept of good practice documents that will represent the latest status for validation methods for each variable. Those documents might be published in different formats: validation plans, peer-reviewed papers, or peer-reviewed good practice protocols. The documents will then be available on the official LPV website[20]. Additionally, LPV plan to identify reference data sets for validation that will help increase quality control of existing in situ data sets, and evaluate new potential validation data sources that display a continuity perspective.

Professor Wagner briefed participants about the existing CEOS Online Validation Exercise (Olive)[21], which provides a web service that was designed to quantify the performances of earth observation land products like LAI, and FAPAR to use transparent and traceable methods following standards defined by the CEOS LPV sub-group, to provide open access of results to the whole scientific community, and to capitalize on the several initiatives undertaken within this scientific community. Furthermore, next to increasing the quality and efficiency of global satellite product validation by developing and promoting international standards and protocols for field sampling, scaling techniques, accuracy reporting, and data and information exchange, LPV provides feedback to international structures, in particular GEOSS, for requirements on product accuracy and quality assurance, terrestrial ECV measurement standards, as well as definitions for future missions.

Future activities could include a potential extension of LPV that would add additional focus areas/variables. During the discussion that followed the presentation, Professor Wagner underlined the importance that not only remote sensing data is being validated, but that the WG is also starting to validate in situ data.

6.3 Update on GOSIC

Ms Christina de Groot-Lief from the US National Climatic Data Center (NCDC), and manager of the Global Observing Systems Information Center (GOSIC), updated Panel members on the status of the GOSIC website[22], and provided some new insight into the current activities of the information center. The goal of GOSIC is to provide users with the data they are looking for and the tools to search for these data in a variety of ways from a single text, to searching by keyword, programme, observation, variable, data center, etc. The GCOS ECV data access matrix on the GOSIC portal includes all 50 ECVs, and links to in situ and satellite data sets, and new products are constantly being added. Metadata exists for each ECV, whereas the metadata records are held in the NASA Global Change Master Directory (GCMD) and can be requested through a GOSIC portal to the GCMD[23].

Ms de Groot-Lief briefed participants on the role of GOSIC within the project of the CEOS ECV Inventory Database[24], which includes results from an initial CEOS satellite questionnaire from World Data Centers. The CEOS Data Inventory is further discussed in

[20] Official website of the CEOS LPV: http://lpvs.gsfc.nasa.gov/.
[21] OLIVE website: http://calvalportal.ceos.org/cvp/web/guest/olive.
[22] Official GOSIC website: http://gosic.org/.
[23] The Global Change Master Directory Portal for GOSIC: http://gcmd.nasa.gov/KeywordSearch/Home.do?Portal=gosic&MetadataType=0.
[24] The CEOS ECV Data Inventory website: http://ecv-inventory.com/ecv2/.

paragraph 6.4 of this report. Ms de Groot-Lief further stressed that although information from the currently stalled website of the Global Terrestrial Observing System (GTOS) have partly been restored on the GOSIC website, there is a need to further discuss how the data can be saved if the GTOS website will be discarded some time in the foreseeable future.

TOPC participants were interested to know about the GOSIC user statistics. Ms de Groot-Lief explained that the user information is being monitored with the help of Google Statistics, which also allows distinguishing user statistics by ECV.

Actions:

Following the discussion on a few items from the 15th Session of TOPC in 2013, participants agreed to include the following actions as ongoing, as most of the ECV information had not been updated by meeting participants.

A6.3-I TOPC members to check the GTOS website[25] (which has not been updated since 2011), and see if there are any additional information that should be moved (and saved) to the GOSIC website.

A6.3-II ***FROM TOPC-XV:*** Provide feedback to the GOSIC ECV data access matrix – relevant ECV panel experts need to check and update the individual ECV definition/text, suggest more links to data sets if appropriate.

A6.3-III GCOS to discuss the potential purchase of a GCOS doi, which could be provided to data sets/products from GCOS network partners.

6.4 CEOS/CGMS/WMO ECV inventory

Dr Robert Husband presented the joint CEOS, CGMS, and WMO ECV Inventory in more detail, as he updated participants on the current status, and the inventory's overview and background. The latest strategy report can be found on the TOPC-XVI website as a background document.

Main goals of the ECV inventory are the following:

- To describe the current and planned monitoring capability of an ECV basis (that will allow a more systematic space agency response).
- To enable the definition of an optimum 'macroscale' space system configuration and its components, due to the combined perspective of the logical and physical views.
- To identify gaps and shortfalls at ECV/data product level.
- To formulate a coordinated action plan to address such gaps and shortfalls.
- To trigger medium-term activities that are needed to sustain the long-term implementation of the architecture.

It additionally represents the full scope of the GCOS requirements baseline, and acts as a repository for representing the current ECV-relevant data-holdings of agencies in a manner that exposes their degree of compliance with the relevant GCOS requirements, and act as a repository for representing the planned ECV-relevant data-holdings of agencies. Therefore, the inventory's structure contains of two different components: the current component (sections: general, dataset usage, dataset stewardship, dataset

[25] Official website of the Global Terrestrial Observing System (Status Sept 2011): http://www.fao.org/gtos/.

properties, etc.), and the future planning component, which has a similar section structure as the current component but is reduced in scope.

Participants were interested to know whether or not there is access provided to the datasets that have been used to validate the data, but Dr Husband stressed that currently there are no in situ data sets that qualify for long-term validation assessments for ECV products.

Actions:

Following the detailed discussion about the potential inclusion of in situ data sets within the ECV Inventory that was originally planned to only focus on space-based data monitoring,

A6.4-I Foster a follow-up on the discussion regarding whether or not the CEOS/CGMS WG Climate should facilitate an inclusion of in situ network data in the ECV inventory at the next GCOS SC Meeting in September/October 2014.

A6.4-II TOPC to recommend a "test/pilot phase" in which the CEOS/CGMS Working Group Climate will facilitate the inclusion of in situ network data in the ECV inventory.

7 Review of action items

The Panel reviewed the status of actions from the last TOPC Session (TOPC-XV), as outlined in the associated meeting document 7.1. It was noted that almost all actions from 2013 were completed; a few became ongoing activities or were superseded by new action items as given in Annex III. The Chairman and the Panel members decided to maintain an ongoing status for two out of the 16 actions from TOPC-XV in 2013, which include action items 2.3.1 and 9.2.1. The latter refers to support from TOPC panel members regarding an update on the GOSIC website, which is further discussed in paragraph 6.3.

Additionally, panel members discussed the possibility of a conference call in 5-6 months, which will include participation of a few TOPC core panel members and those experts that are directly linked to the actions that need to be discussed.

Actions:

During the TOPC Meeting in 2012, the then Chairman Professor Dolman briefed participants on the GCOS-WCRP Workshop on Evaluation of Satellite-related Global Climate Data sets, which was held from 18-20 April 2011 at ESA in Frascati, Italy. The workshop aimed to ensure that climate-data records and derived products are quality-assessed by the international scientific community to ensure their wide recognition and acceptance by users. Information exchange and discussion are still going on and therefore, the action item from TOPC-XV was maintained on this years' list:

A7-I Foster a follow-up from the GCOS-WCRP Frascati Workshop and more active engagement, in particular from the satellite agencies, and re-launch a call to data centers.

A7-II GCOS to facilitate a TOPC conference call with TOPC panel members to discuss open actions, and the current status of issues raised at TOPC-XVI. Provide agenda.

8 Items of Discussion

8.1 TOPC Terms of Reference

At the last GCOS Steering Committee Meeting in October 2013 it was decided that in light of the new GCOS Implementation Plan, panel members should revise the Terms of Reference (ToR) for each panel, and a draft version of those new and updated ToR should be provided at the next GCOS SC in 2014. The current version of the ToR can be found in Annex IV of this report.

During the debate it was noted that the new ToR draft should not be formulated by all participants of the meeting, but only a small group of experts that have been involved in GCOS activities for a long time. The ToR should be formulated a bit more detailed, and include mentioning of ECVs, its link to the GCOS Cooperation Mechanism, and clarify the federation of activities on an international level.

8.2 TOPC Work Plan 2015-2018

The TOPC Chair, Professor Steffen, introduced the GCOS Steering Committee's vision to draft a new work plan for the Terrestrial Observation Panel for Climate, which should set out potential priorities for the panel within the next five years. TOPC's main roles will include regular reporting to its main sponsors GCOS (with TOPC focusing on the terrestrial component), and WCRP (TOPC to provide support and advice on observations for climate research), as well as to deliver scientific advice to the GCOS Cooperation Mechanism (GCM), and strengthen its links to both the AOPC and OOPC. The item discussion placed substantial emphasis on the issue of addressing a number of cross-cutting topics in the domains of atmosphere-land and land-ocean observation.

The future focus of TOPC will be set on assessing and reviewing existing components of the terrestrial observation system, and to deliver recommendations on requirements. Key timeframes/deadlines that TOPC will need to consider include the next GCOS assessment and reporting cycle (Status Report, to be published in 2015, and the new GCOS Implementation Plan, to be published in 2016).

Additionally, TOPC participants would like to see a clear definition on what is needed for climate observations in the future, especially in regard to adaptation and mitigation efforts to climate variability and climate change. Therefore, expertise for those issues is needed. Furthermore, GCOS needs to communicate its requirements, and explain on how to best implement an observing system for climate in the future.

Actions:

Following the discussion on how to better involve WCRP and the climate modeling community in future GCOS activities, TOPC members expressed their desire to contact WCRP Representatives, and think about a potential meeting of a terrestrial observation sub-group that would include both representatives from WCRP and TOPC.

A8.2 TOPC Chairman to contact the Chairs of the different WCRP programmes to ask for representatives from the climate modeling community at the next TOPC Sessions to strengthen the link with WCRP and climate modelers.

8.3 How to report on terrestrial ECVs

The Director of the GCOS Secretariat, Dr Carolin Richter, presented the timeframe for

the current GCOS assessment and reporting cycle, and updated participants on how GCOS is planning on reporting on the status and progress of terrestrial ECVs. The concept is further explained in the report for the GCOS Scoping Meeting for the Assessment of the Adequacy of the Global Observing System for Climate[26] that took place in Geneva, Switzerland, in December 2013. The reporting template is available on the GCOS website[27]. Meeting participants agreed on a list of focal points for each terrestrial ECV. This list will remain internal and is only to be circulated among experts directly involved in TOPC and/or GCOS.

Moreover, she introduced the road map for 2014 to 2016 for GCOS, which will focus on the GCOS Status Report, to be published in 2015, as well as the next GCOS Implementation Plan, to be published in 2016.

Actions:

TOPC ECV focal points agreed to support GCOS in their next assessment and reporting cycle, and providing information on the current reporting status of each terrestrial ECV.

A8.3-I	GCOS to build-up a framework for terrestrial ECVs that identifies a main assigned operational data center (and a scientific focal point) for each ECV.
A8.3-II	TOPC members to give feedback/edits on the reporting template for terrestrial ECVs that was provided by the GCOS Secretariat within the next 4 weeks.
A8.3-III	TOPC members in their area of expertise to fill out the ECV reporting template once the updated version has been provided by the Secretariat.
A8.3-IV	GCOS to provide a more detailed timeline for the next assessment cycle.

9 Wrap-Up

During the wrap-up Session of the meeting, TOPC members agreed on the new action list for the upcoming year, which can be found in Appendix III.

10 Closure

The Panel agreed provisionally to hold its next Session as a back-to-back meeting with the next Session of the WCRP/GCOS Atmospheric Observation Panel for Climate (AOPC). The joint meeting will take place from ***16 to 20 March 2015***.

The TOPC Chairman, Professor Steffen, invited the TOPC to hold its next TOPC Meeting at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Zurich, Switzerland.

[26] Report of the Scoping Meeting (GCOS-178): http://www.wmo.int/pages/prog/gcos/Publications/gcos_178.pdf.

[27] Reporting template for terrestrial ECVs: http://www.wmo.int/pages/prog/gcos/TOPCXVI/ECV_tables_terrestrial_plus_extras_and_cross-cutting_actions.pdf.

Annex I

MEETING AGENDA of TOPC-XVI
10-11 March 2014

Item	Doc. No.	Presenter(s) (including discussion)	Supporting documents/ additional information
Monday, 10th March 2014			
9.00 – 10.45			
1. Opening of the Meeting (15')			
1.1 Welcome and introductions	1.1	Richter/Steffen	
1.2 Adoption of Agenda	1.2	Steffen	
1.3 Conduct of the Meeting	1.3	Belward	
2. Update on programme activities (60')			
2.1 GCOS Update	2.1	Richter (30')	*- Review outcomes, progress report, what is needed from terrestrial observation community for the next GCOS Implementation Plan.*
2.1.1 AOPC Update	2.1.1	Verstraete (15')	*- Update on AOPC, including idea of cross-cutting AOPC/TOPC projects.*
2.1.2 OOPC Update	2.1.2	Wilkin (15')	*- Update on OOPC, including idea of cross-cutting AOPC/TOPC projects.*
2.2 GCOS Cooperation Mechanism (GCM)	2.2	Oakley (15')	*- Update on GCM; Potential input from/benefit for TOPC.*
2.3 WCRP Update (WDAC, CliC, GEWEX)	2.3	Steffen (15')	*- Expectations from WCRP – how TOPC will fit into the overall WCRP structure and its core projects; WCRP input for new GCOS IP.*
10.45 – 11.00 Coffee Break			

11.00 – 12.40			
DISCUSSION – ECV-BASED EVALUATION OF THE OVERALL TERRESTRIAL MONITORING SYSTEM			
3. Cryospheric ECVs (100')			
3.1 WMO Global Cryosphere Watch	3.1	Goodison (20')	
3.2 ECV Snow Cover	3.2	Armstrong (20')	
3.3 ECV Ice Sheets	3.3	Steffen (20')	
3.4 ECV Glaciers & Ice Caps	3.4	Zemp (20')	*GTN-G/WGMS*
3.5 ECV Permafrost	3.5	Noetzli (20')	*GTN-P*
12.45 – 13.45 Lunch			
13.45 – 15.15			
4. Hydrological ECVs (90')			
4.1 ECV Soil moisture	4.1	Wagner (20')	
4.2 ECV Ground water	4.2	Ansems (20')	
4.3 ECV Lakes	4.3	Vuglinsky/Crétaux (20')	*GTN-L*
4.4 ECV River discharge	4.4	Looser (20')	*GTN-R*
4.5 Update on GTN-H	4.5	Holterhof (10')	
15.15 – 15.45			
Coastal observations (30')			
4./5. Climate observations in coastal areas	4./5.	Christian (30') with input from Wilkin	*Moving into the coastline – climate observations in coastal areas as a cross-cutting issue for hydrological/land-based ECV monitoring.*
15.45 – 16.00 Coffee Break			

16.00 – 17.00			
5. Biological/Ecological ECVs (60')			
5.1 ECV Land cover	5.1	Herold (20')	
5.2 ECV Fire disturbance	5.2	Tansey (20')	
5.3 ECV Above ground biomass	5.3	Quegan (20')	
17.00 – 18.30 Missing ECVs and Wrap Up discussion (90')			
Evaluation of missing terrestrial ECVs	-	Richter (30')	
18.30 End of Day 1			
19.45 Group Dinner			
Tuesday, 11th March 2014			
9.00 – 10.45			
6. Space-based Observations and Validation, Data access (60')			
6.1 Report from GCOS Space Rapporteur, including CEOS Climate activities / ESA Climate Change Initiative	6.1	Husband (20')	
6.2 CEOS Cal/Val activities	6.2	Wagner (20')	
6.3 Update on GOSIC	6.3	Lief (20')	
6.4 CEOS ECV Inventory	6.4	Husband (15')	
7. Review of Action Items	7.1	Steffen/GCOS Secretariat (30')	*Review of last years' actions and a brief summary of possible new actions.*
10.45 – 11.00 Coffee Break			

11.00 – 12.30			
8. Items of discussion			
8.1 TOPC Terms of Reference	8.1	Steffen/all (30')	*Revision of TOPC ToRs, including a discussion on defining the future TOPC role and its key connections.*
8.2 TOPC Work Plan 2015-2018	8.2	Steffen/all (60')	*Key TOPC activities to progress within the next 3 years; discussion on timeline, ECV requirements, etc.*
12.30 – 13.30 LUNCH			
13.30 – 15.15 (105')			
8.3 How to report on terrestrial ECVs	8.3	Richter/all (60')	*Discussion of the Scoping Report, etc.*
8.4 How to connect ECVs with the help of common integrators	8.4	Steffen/all (30')	
8.5 Introduction to UNEP-Live	8.5	Holterhof (15')	
15.15 – 15.30 Coffee Break			
15.30 – 17.00			
9. Wrap-Up (110')			
10. Closure (10')			
10.1 AOB, Next session			
10.2 Adjourn			

Annex II

TOPC-XVI PARTICIPANT LIST

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Annex III

LIST OF ACTIONS

Action Number	Subject	Responsible
A2.1	GCOS to provide WMO management with a brief to assist in the discussion with representatives of FAO about the potential future of GTOS.	GCOS Secretariat, GCOS SC Chairman, TOPC Chairman, WMO Management
A2.1.2-I	OOPC to foster a follow-up discussion on the importance of ice shelves at the next OOPC-XVII Session, and where it fits in both within the frameworks of TOPC and/or OOPC.	TOPC and OOPC Members
A2.1.2-II	OOPC to identify the current monitoring status of the variable biogeochemical fluxes, as well as to foster contact with potential data centers. Report back to TOPC.	TOPC and OOPC Members
A2.2	Guidance from GRDC on the GCOS Cooperation Mechanism river gauge project in Tanzania. Plus agreement from TOPC to continue with this proposal.	GCOS Implementation Manager, GRDC Representative
A2.3	GCOS to discuss potential funding opportunities with WCRP, which include future workshops (related to terrestrial climate observations) and a potential joint meeting of representatives from all GCOS/WCRP-sponsored panels.	GCOS and WCRP Secretariats
A3.1	Identify the activities of the GCW that are of particular importance to TOPC, and where GCW could contribute to TOPC efforts, e.g. data quality, data standards, etc.	TOPC Members, GCOS Secretariat, WMO/GCW Representative
A3.3	GCOS to facilitate a workshop/meeting that will bring together all the main data centers that provide information/data on the ECV Ice Sheets, as the data is currently scattered among different centers.	GCOS Secretariat, TOPC Representative for the ECV Ice Sheets
A4.3-I	To update and enlarge the HYDROLARE database by inclusion of satellite observation data in Hydroweb.	HYDROLARE, LEGOS/CNES
A4.3-II	To develop a new technical complex for integrating in situ and remote sensing data in the HYDROLARE database.	HYDROLARE, LEGOS/CNES
A4.5-I	GCOS/TOPC to formulate a letter addressed to the BfG,	GCOS Secretariat, TOPC Chairman

	stating the concern about the current status of the GTN-H coordination (cc: WMO/CLW).	
A4.5-II	GCOS to discuss with GTNs about a potential Memorandum of Understanding (or something similar) to recognize the networks as official GTN partners and data contributors.	GCOS Secretariat, TOPC Chairman, GTN/Network Representatives
A4.5-III	GTN-H needs to clarify the current status of its partner networks. TOPC recommends an information meeting for current and potential new partners of GTN-H by the end 2014.	GTN-H Coordinator, GTN-H Partner Networks, GCOS Secretariat
A6.3-I	TOPC Members to check the GTOS website (which has not been updated since 2011), and see if there are any information that should be moved (and saved) to the GOSIC website.	TOPC Members, GOSIC Representative
A6.3-II	Provide feedback to the GOSIC ECV data access matrix – relevant ECV panel experts need to check and update the individual ECV definition/text, suggest more links to data sets if appropriate.	TOPC Members in there area of expertise, GOSIC Representative
A6.3-III	GCOS to discuss the potential purchase of a GCOS doi, which could be provided to data sets/products from GCOS network partners.	GCOS Secretariat
A6.4-I	Foster a follow-up on the discussion regarding whether or not the CEOS/CGMS WG Climate should facilitate an inclusion of in situ network data in the ECV inventory at the next GCOS SC Meeting.	TOPC Chairman, GCOS SC Chairman, GCOS Space Rapporteur, CGMS Representative
A6.4-II	TOPC to recommend a “test/pilot phase” in which the CEOS/CGMS WG Climate will facilitate the inclusion of in situ network data in the ECV inventory.	TOPC Chairman, GCOS SC Chairman, GCOS Space Rapporteur, CGMS Representative
A7-I	Foster a follow-up from the WOAP Frascati Workshop and more active engagement, in particular from the satellite agencies, and re-launch a call to data centers.	GCOS and WCRP Secretariats
A7-II	GCOS to facilitate a TOPC conference call with TOPC Members to discuss open actions, current status of issues raised at TOPC-XVI. Provide agenda.	GCOS Secretariat, TOPC Chairman, TOPC Members

A8.2	TOPC Chairman to contact the Chairs of the different WCRP programmes to ask for representatives from the climate modelling community at the next TOPC Sessions to strengthen the link with WCRP and the climate modelling community.	TOPC Chairman
A8.3-I	GCOS to build-up a framework for terrestrial ECVs that identifies a main assigned operational data center (and a scientific focal point) for each ECV.	GCOS Secretariat, TOPC Members in their area of expertise
A8.3-II	TOPC Members to give feedback/edits on the reporting template for terrestrial ECVs that was provided by the GCOS Secretariat within the next four weeks.	TOPC Members
A8.3-III	TOPC Members in their area of expertise to fill out the ECV reporting template once the updated version has been provided by the Secretariat.	TOPC Members
A8.3-IV	GCOS to provide a more detailed timeline for the next assessment cycle.	GCOS Secretariat

Annex IV

Terms of Reference for the TOPC
- Status March 2014 -

Terms of Reference (October 2010)

1. Recognizing the need for specific and technical input concerning terrestrial observations for climate purposes, the sponsoring organizations of GTOS and the GCOS have jointly established TOPC with the following terms of reference:

    - To define the requirements for long-term monitoring of terrestrial properties for climate and climate change;
    - To liaise with relevant research and operational communities to identify measurable terrestrial (biosphere, cryosphere, and hydrosphere) properties and attributes which

2. control the physical, biological and chemical processes affecting climate,
3. are themselves affected by climate change, are indicators of climate change and provide information on impacts of climate change;
4. To assess and monitor the adequacy of terrestrial observing networks (*in situ*, satellite-based), promote their integration and promote the development of their capacity to measure terrestrial properties and exchange climate data and information;
5. To identify gaps in present systems and design, promote and periodically revise plans for a long-term systematic observing system that fills these gaps, makes the data available and so better serves the needs of the research and operational communities;
6. To coordinate activities with other global observing system panels and task groups to ensure consistency of requirements with the overall programmes;
7. Publish and update GCOS/GTOS studies and planning documents;
8. To liaise with the other GCOS panels, WCRP steering groups and other relevant entities, such as WMO Commissions and CEOS, on terrestrial climate observing system issues., and also to other GTOS panels, where relevant.
9. Carry out agreed assignments from the GCOS and GTOS Steering Committees;
10. Report regularly to the GCOS Steering Committee and GTOS Steering Committee on issues related to the terrestrial component of GCOS.

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Annex V

LIST OF ACRONYMS

AntON	Antarctic Observing Network
AGU	American Geophysical Union
AON	Antarctic Observing Network
AOPC	Atmospheric Observation Panel for Climate
ATCM	Antarctic Treaty Consultative Meeting
BAMS	Bulletin of the American Meteorological Society
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Germany)
CCI	Climate Change Initiative (ESA)
CALM	Circumpolar Active Layer Monitoring Programme
CATCOS	Capacity Building and Twinning for Climate Observing Systems
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CIMO	Commission for Instruments and Methods of Observation (WMO)
CliC	Climate and Cryosphere Programme (WCRP)
CLIVAR	Climate Variability and Predictability (WCRP)
CNES	Center National d'Etudes Spatiales (France)
CoML	Census of Marine Life
COMNAP	Council of Managers of National Antarctic Programmes
COP	Conference of Parties
COSPAR	Committee of Space Research (CNES)
DEWA	Division of Early Warning and Assessment (UNEP)
DOI	Digital Object Identifier
EC	European Commission
ECMWF	European Center for Medium-Range Weather Forecast
EC-PORS	Executive Council Expert Panel on Polar Observations, Research and Services (WMO)
ECVs	Essential Climate Variables
EO	Earth Observation
EOV	Essential Ocean Variable
ESA	European Space Association
ETN-R	European Terrestrial Network for River Discharge
FAGS	Federation of Astronomical and Geophysical data-analysis Services
FAO	Food and Agriculture Organization of the United Nations
FAPAR	Fraction of Absorbed Photosynthetic Active Radiation
FARO	Forum of Arctic Research Operators
FLUXNET	Flux and Energy Exchange Network
FOO	Framework for Ocean Observation
FRP	Fire Radiative Power
GAW	Global Atmosphere Watch (WMO)
GCI	GEOSS Common Infrastructure
GCM	GCOS Cooperation Mechanism
GCMD	Global Change Master Directory (NASA)
GCOS	Global Climate Observing System
GCW	Global Cryosphere Watch
GEF	Global Environment Fund
GEMS	United Nations Global Environment Monitoring System
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water Cycle Experiment (WCRP)
GFCS	Global Framework for Climate Services
GFOI	Global Forest Observation Initiative

GIPPS	Global Integrated Polar Prediction System
GLIMS	Global Land Ice Measurements from Space initiative
GOSIC	Global Observing Systems Information Center (NCDC)
GOFC-GOLD	GTOS Panel on Global Observation of Forest and Land Cover Dynamics
GOOS	Global Ocean Observation System
GRDC	Global Runoff Data Center
GSN	GCOS Surface Network
GTNs	Global Terrestrial Networks
GTN-G	Global Terrestrial Network for Glaciers
GTN-H	Global Terrestrial Network for Hydrology
GTN-L	Global Terrestrial Network for Lakes
GTN-P	Global Terrestrial Network for Permafrost
GTN-R	Global Terrestrial Network for River Discharge
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper-air Network
HYDROLARE	International Data Center on the Hydrology of Lakes and Reservoirs
IACS	International Association for Cryospheric Sciences
ICSU	International Council for Science
IHP/HWRP	International Hydrology Programme/Hydrology and Water Resources Programme
IGOS	Integrated Global Observing Strategy
IGRAC	International Groundwater Resources Assessment Center
IGWCO	Integrated Global Water Cycle Observations Theme
ILEC	International Lake Environment Committee
IP	Implementation Plan
IPA	International Permafrost Association
IPCC	Intergovernmental Panel on Climate Change
IPI	International Polar Initiative
IPY	International Polar Year
IOC	Intergovernmental Oceanographic Commission of UNESCO
ISMN	International Soil Moisture Network
ISMWG	International Soil Moisture Working Group
ISPRS	International Society for Photogrammetry and Remote-Sensing
IUGG	International Union of Geodesy and Geophysics
JDIMP	Joint Data and Information Management Panel
JRC	Joint Research Center
LAI	Leaf Area Index
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LPV	Land Product Validation (CEOS)
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center (NOAA)
NGO	Non-Governmental Organization
NHS	National Hydrological Service
NSF	National Science Foundation
NOAA	National Oceanic and Atmospheric Organization
NSIDC	National Snow and Ice Data Center (NSIDC)
OBS	Observing and Information Systems (WMO)
OCG	Open Geospatial Consortium
OOPC	Ocean Observation Panel for Climate (GCOS/WCRP)
PR	Permanent Representative
PSFG	Permanent Service on Fluctuations of Glaciers
PSTG	Polar Space Task Group
REDD	UN Collaborative Programme on Reducing Emissions from

	Deforestation and Forest Degradation in Developing Countries
RRR	Rolling Review of Requirements
SBA	Societal Benefit Area
SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC)
SC	Steering Committee
SCAR	Scientific Committee for Antarctic Research
SCOR	Scientific Committee for Oceanic Research
SDC	Swiss Agency for Development and Cooperation
SHI	State Hydrological Institute (Russia)
SMOS	Soil Moisture and Ocean Salinity (ESA)
SOG	Statements of Guidance
SPARC	Stratospheric Processes and their Role in Climate
TOPC	Terrestrial Observation Panel for Climate
TSP	Thermal State of Permafrost
TTS/WGI	Temporal Technical Secretary/World Glacier Inventory
USGS	United States Geological Survey
UN	United Nations Organization
UNEP	UN Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US DOE	United States Department of Energy
VOS	Voluntary Observing Ship
WACMOS	Water Cycle Multi-mission Observation Strategy
WCRP	World Climate Research Programme
WCS	Web Coverage Service
WDAC	WCRP Data Advisory Council
WDC	World Data Center (ICSU)
WDCM	World Data Center for Meteorology
WDS	World Data System (ICSU)
WGCV	Working Group on Calibration and Validation (CEOS)
WGMS	World Glacier Monitoring Service
WGI	World Glacier Inventory (NSIDC)
WHYCOS	World Hydrological Cycle Observing System (WMO)
WHYMAP	Worldwide Hydrogeological Mapping and Assessment Programme
WIGOS	WMO Integrated Global Observing System
WIS	WMO Information System
WMAC	WCRP Modeling Advisory Council
WMO	World Meteorological Organization
WOAP	WCRP/GCOS Observation and Assimilation Panel
WSL	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (Switzerland)

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