Summary Report of the Fourteenth Session of the Terrestrial Observation Panel for Climate (TOPC) of the Global Climate Observing System and the Global Terrestrial Observing System

WMO, Geneva, Switzerland, 1-2 March 2012

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1. Welcome and Introduction

The Terrestrial Observation Panel for Climate (TOPC) was set up 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. TOPC is jointly sponsored by the Global Climate Observing System (GCOS), the Global Terrestrial Observing System (GTOS) of the United Nations Food and Agricultural Organization (FAO) and the World Climate Research Programme (WCRP).

The fourteenth session of the TOPC was held on 1 and 2 March 2012 at WMO Headquarters in Geneva, Switzerland. This report summarizes key discussions and outcomes rather than being a full record of the meeting.

1.1 Opening Remarks

The Chairman of the TOPC, Prof. Han Dolman, opened the meeting and in particular welcomed the two new panel members, Prof. Wolfgang Wagner and Dr Michael Zemp, who already attended last year's session in their respective capacities as experts on soil moisture and glaciers. In exchange, Prof Jay Famiglietti rotated off the panel recently.

Dr Wenjian Zhang, Director of the WMO Observing and Information Systems Department, warmly welcomed panel members and invited experts to the session on behalf of WMO. He explained that WMO is currently focussing on the establishment of the Global Framework for Climate Services (GFCS), which is the reason for holding an extraordinary session of the WMO Congress from 29 October to 1 November 2012. Dr Zhang highlighted the important contribution of GCOS to the 'observation and monitoring' segment, one of the five 'fundamental pillars' of the envisaged GFCS, and hence the TOPC, will be providing to this effort. He also stressed the need of strengthening the terrestrial observing systems as the terrestrial component is far less developed compared to the atmospheric component.

1.2 Approval of Agenda

The panel adopted the agenda on the basis that it could be adjusted during the session if necessary. The final meeting agenda is given in Annex I and the list of participants is included in Annex II.

2. Update on programme activities

2.1 Update on GCOS

Dr Carolin Richter, Director of the GCOS Secretariat, presented the recent work undertaken within the programme and outlined upcoming GCOS-related meetings and activities. She also informed the panel that the GCOS programme is supposed to undergo a review by its sponsoring organisations during the upcoming year.

Recent core activities to provide advocacy for sustained climate observation included involvement in the envisaged GFCS, for which an Implementation Plan (IP) is currently being drafted. The GCOS Secretariat contributed significantly to its observations and monitoring part. The role of GCOS in underpinning the structure of the proposed GFCS is shown in Figure 1 below. To this end, Dr Harrison noted that GCOS should be more active in making a statement how useful the GCOS data is for society, in particular for adaptation.

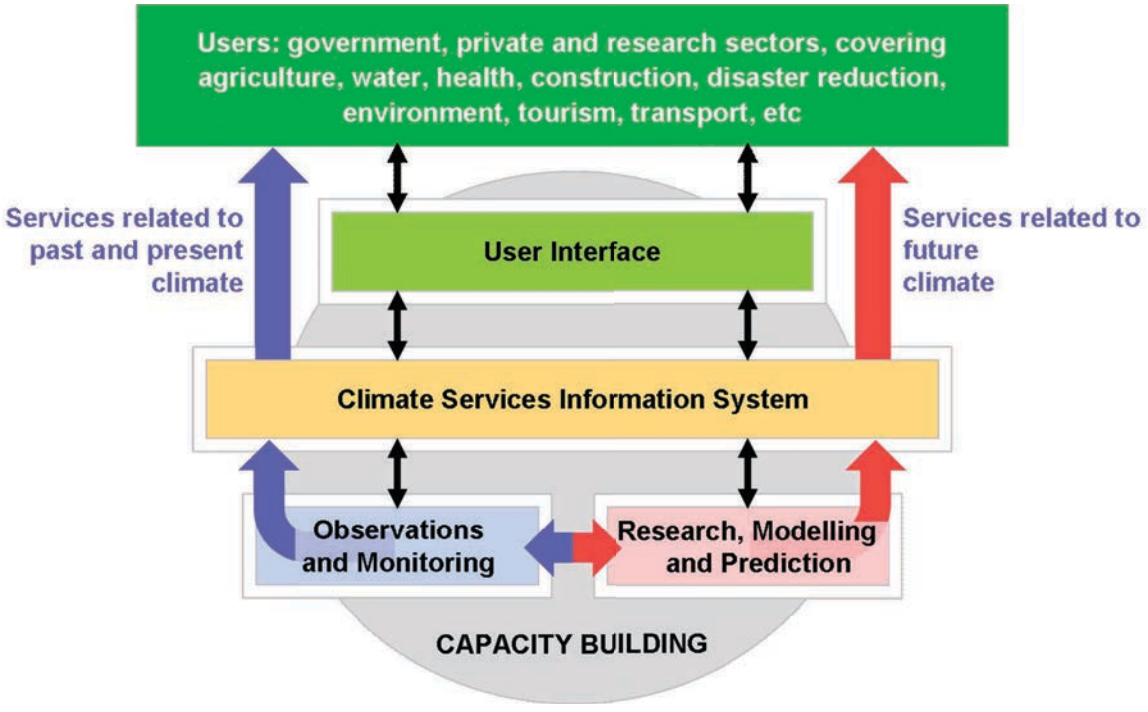

Figure 1: Structure of the proposed GFCS

Further, central functions of GCOS are to identify gaps in the existing observing systems and to review its status of implementation. Dr Richter outlined the upcoming steps in the GCOS cycle of periodic assessments on the status of observing systems and on progress against the GCOS IP. Next steps are the preparation of a new adequacy report by early 2015, to be followed by a new IP to be published in 2016, which will need to take into account the increased focus on adaptation. Thus, a review of data needs for adaptation and service provision will

have to be conducted within the next two years. In addition, supplementary details of the *in-situ* observing component could be published in a similar fashion as the so-called 'satellite supplement'. The meeting discussed this subject and agreed on the usefulness of such an '*in-situ* supplement', however, producing an *in-situ* document of the same quality as the satellite supplement would be a big task and will require input from many different groups. Given the resources available and because one would not want to ask the same experts twice for input, the *in-situ* observing component might be covered in more detail in the next IP version instead of producing a separate document. Prof. Dolman proposed that TOPC, in consultation with the other panels, could make a suggestion to the GCOS Steering Committee on how to cover the *in-situ* component.

Action 1: Come up with a first proposal on how to bring an *in-situ* supplement forward; recommend to GCOS SC that the next IP will have a proper coverage of the *in-situ* component instead of producing a separate document. (TOPC Chairman together with AOPC & OOPC Chairs)

GCOS is also monitoring the performance of networks and is working on improvements in the frame of the GCOS Cooperation Mechanism (GCM). The GCOS Implementation Manager is maintaining a 'shopping list' of projects for potential donors and he is looking in particular for projects in the terrestrial domain, which he could suggest to the donor's board.

With regard to support GCOS implementation at the regional scale[1], the GCOS Secretariat organised a regional workshop for South America from 13 to 15 March in Guayaquil, Ecuador. This workshop follows an assessment of the outdated GCOS Regional Action Plan with the aim to revise it. Prof. Steffen, chair of the WCRP Climate and Cryosphere Project (CliC) Scientific Steering Group, stressed that CliC is very active in South America and the opportunity could be used to better link activities.

Closer interaction would also be desirable with the Intergovernmental Panel on Climate Change (IPCC). GCOS has the status of an observer organization to the IPCC and would like to strengthen the link with Working Groups I and II, e.g. by inviting IPCC experts to a future workshop on data needs for adaptation.

Finally, on 29 June, a Birthday Symposium and dinner sponsored by courtesy of the Swiss Government will be held at WMO Headquarters in Geneva to celebrate the 20th anniversary of the GCOS programme.

2.2 WCRP update

Since WCRP became co-sponsor of TOPC two years ago, it co-sponsors all three scientific advisory panels of GCOS. TOPC noted that information at FAO web pages does not reference WCRP. The panel urged these to be updated to reflect the current sponsorships in consistency with the GCOS web pages.

[1] Note that in WMO terminology regions mean continents.

Dr Michel Rixen from the WCRP Joint Planning Staff presented the mission and objectives of WCRP, stressing the importance of research for practical application, to be of direct relevance, benefit and value to society. WCRP aims to support climate-related decision making and adaptation planning by coordinating research required to improve climate predictions and understanding the human influence on climate.

Core projects of WCRP are:

- CliC, for the cryosphere,
- the Climate Variability and Predictability (CLIVAR) project, that has particular focus on the role of ocean-atmosphere interactions in climate,
- the Global Energy and Water Cycle Experiment (GEWEX), studying the role of the land surface, and
- the project on Stratospheric Processes And their Role in Climate (SPARC).

To meet the information needs of society, the WCRP programme focuses on key the deliverables in the areas of:

- Decadal Variability, Predictability and Prediction,
- Sea-Level Variability and Change,
- Climate Extremes,
- Atmospheric Chemistry and Dynamics,
- Centennial Climate Change Projections,
- Seasonal Climate Prediction, and
- Regional Climate WCRP core projects.

Very relevant for GCOS are also the activities in support of integrating themes:

- climate-quality datasets and analyses,
- a new Generation of Climate/Earth System Models, and
- developing capacity regionally, and globally, by educating the next generation of climate experts.

Besides this, WCRP is calling for the integrated study of the Earth' System as part of the Earth System Science Partnership (ESSP) together with DIVERSITAS, the International Geosphere-Biosphere Programme (IGBP), and the International Human Dimensions Programme on Global Environmental Change (IHDP). The ESSP is being revised within the International Council for Science (ICSU) 'Visioning Process'. From the perspective of the climate science community, this process seems leaning towards the human dimension, and therefore WCRP has been mainly an observer so far. Meeting participants criticized the language used in ICSU scoping documents, in particular the 'Future Earth Initiative', which will be presented at the 'Planet Under Pressure Conference' (26-29 March 2012 in London), as it seemed to need more in-depth discussion within the community.

Action 2: Submit feedback on the ICSU Future Earth Initiative. (GCOS & WCRP Secretariats)

Michael Zemp further noted that in the frame of the ICSU visioning process a new ICSU World Data System (WDS) has been created and international data centres such as the WGMS had to re-apply and were re-evaluated. This might provide an opportunity for GCOS to liaise with ICSU in order to strengthen data centres that host datasets of Essential Climate Variables (ECVs).

Action 3: GCOS to liaise with ICSU in the view to identify additional data centres for ECVs. (GCOS & ICSU Secretariats)

A large event with about 1900 participants was the WCRP Open Science Conference, held in Denver, USA, in October 2011. Main outcome of the conference was a strong demand for 'actionable science', for science being useful for end users, including the private sector. The conference provided an opportunity to identify most urgent scientific issues and research challenges, as well as to ascertain how WCRP can best facilitate research and develop partnerships. The WCRP Joint Scientific Committee met for an extraordinary session back to back with the Open Science Conference and decided to change the WCRP structure by creating a Modelling Advisory Council, a Data Advisory Council and a Working Group on Regional Climate. The nomination process for these new bodies was just closed.

The WCRP Data Advisory Council (WDAC) is supposed to act as a single entry point for all WCRP data, information, and observation activities with its sister programmes and will replace the WCRP Observation and Assimilation Panel (WOAP), a joint activity of WCRP and GCOS. GCOS will be presented in the WDAC by its panel chairs. WDAC will work with the WCRP Modelling Advisory Council (WMAC) to promote effective use of observations with models and to address issues related to the coordinated development of data assimilation, reanalysis, observing system sampling experiments, fluxes and paleo-climatic data and their assessments (metrics, etc.). A WCRP modelling panel has been deactivated already some years ago, whereas the Working Group on Regional Climate is entirely new.

New developments emerged also from the cooperation between WCRP and WMO's World Weather Research Programme (WWRP) leading to activities on sub-seasonal prediction as continuation of the Observing System Research and Predictability Experiment (THORPEX), as well as a polar weather prediction research project. Recent WOAP activities, namely the Frascati workshop on Evaluation of ECV datasets and the action plan for WCRP research activities on surface fluxes were presented in meeting documents 2.4 and 6.3b, respectively, and were covered under separate agenda items.

Dr Rixen also presented the 'grand science challenges' for the global water cycle as identified by GEWEX.
The main scientific questions related to water are:

- How can we better understand and predict **precipitation** variability and changes?
- How do changes in the **land surface and hydrology** influence past and future changes in water availability and security?

- How does a warming world affect **climate extremes**, and especially **droughts, floods** and heat waves, and how do **land area processes**, in particular, contribute?

The main scientific question related to precipitation – also with the view on related climate services - is: **How can we better understand and predict precipitation variability and changes?** Understanding and prediction of precipitation variability will be improved by:

- exploitation of improved datasets of precipitation and related variables (e.g. soil moisture, water storage and sea surface salinity),
- satellite missions and *in-situ* observations,
- evaluation and analysis to document mean, variability, patterns, extremes and probability density functions,
- confront models to improve the understanding of atmospheric and land-surface processes,
- improve simulations of precipitation and prediction of the hydrological cycle,
- new techniques of data assimilation.

The main scientific question related to global water resources is: **How do changes in the land surface and hydrology influence past and future changes in water availability and security?** To answer this, one needs to:

- Understand terrestrial water storage changes to **close the water budget over land (catchments, hydrogeology and ground-water recharge)**,
- Use **realistic land-surface** complexity with anthropogenic effects (e.g. water management, land-use change and urbanization),
- Study impacts on temperature, water quality, nutrients, **ecosystem response**, and
- **Permafrost thawing** and changes in mountain glaciers.

Dr Rixen pointed out that in particular to close the water budget over land is still very difficult to achieve. He presented the example of record precipitation over Australia in the last year, which led to increased water storage on land, whereas the sea-level has been sinking by about 6 mm in this period. The sea-level at the Australian cost is rising back now and land storage is an important factor in the process; this has often been neglected and is not yet understood very well. Dr Grabs expressed his view that the hydrological component within GEWEX needs to be strengthened.

2.3 WOAP Frascati Workshop

Prof. Dolman briefed participants on the WOAP Workshop on Evaluation of Satellite-Related Global Climate Datasets that was held 18-20 April 2011 at the European Space Agency (ESA) in Frascati, Italy. Prof Dolman has been a member of the scientific organizing committee which was led by the WOPC chairman, Prof. Mike Manton.

GCOS and WCRP aim 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. In 2010, GCOS and WCRP called in a joint letter for a systematic international approach to foster transparency, traceability, and sound scientific judgment in the generation of climate-data records. In order to move this process forward, WOAP convened that workshop to promote the inter-comparison and evaluation of satellite and *in-situ* datasets suitable for climate studies with the goal to develop an inventory. Such an inventory should eventually cover datasets for all ECVs, including indices of the maturity and uncertainties of each product. It would serve identification of best practices in evaluating and inter-comparing global climate datasets, especially where there are more than one dataset for a given parameter. The admission of new datasets into the inventory is expected to be managed by the GCOS Panels. The establishment and maintenance of such an inventory at a portal, such as the Global Observing Systems Information Centre (GOSIC), hosted by NOAA's National Climatic Data Centre (NCDC), would provide a consistent and accessible source of information on global climate datasets. The GCOS Steering Committee has agreed that GOSIC would be a good place to host the inventory, under the condition that NCDC is able to ensure that a robust process can be established and maintained.

The workshop started the assessment of a number of key satellite-related global climate datasets against the GCOS guidelines as detailed in the meeting report[2]. Workshop participants were experts in the generation of specific ECV products and representatives of the modelling, analysis, and diagnostic communities. Prof. Wagner, who has been one of these panel members, reported from his experience how the workshop recommendations were received by the satellite communities of the NASA Soil Moisture Active & Passive Mission (SMAP) and the ESA Soil Moisture and Ocean Salinity Mission (SMOS). The recommendations seemed too early for these important players as they are still in the very early stage of producing (more or less stable) products and funding is an issue for many of the producer teams. However, it helped to identify the lack in terms of documentation and compliances to standards. It was also positive was also to see space agencies reply that they did or planned to take on quite a lot of what was suggested, already. The panel uniformly expressed the view that active follow-up and more engagement, in particular from the satellite agencies, was needed. To this end, GCOS and WCRP Secretariats should re-launch a call to data centres and transport this message to satellite coordination bodies like the Committee on Earth Observation Satellites (CEOS). The obvious link could be the current effort to establish an architecture for climate monitoring from space. Jean-Louis Fellous explained the problem that the GCOS Climate Monitoring Principles have not been reflected in space agencies' planning documents and it would be very costly and difficult for them to change their internal rules and procedures.

Action 4: Foster follow-up from the WOAP Frascati Workshop and more active engagement, in particular from the satellite agencies; re-launch a call to data centres. (GCOS & WCRP Secretariats)

[2] The report of the WOAP Workshop on Evaluation of Satellite-Related Global Climate Datasets is available under: http://www.wmo.int/pages/prog/gcos/Publications/gcos-153.pdf

2.4 Relations TOPC-GCOS, WCRP and GTOS

TOPC has originally been a joint panel between GTOS and GCOS; WCRP became a co-sponsor in 2009.

The meeting discussed the past and current contributions of GTOS, noting with strong concern that GTOS Secretariat support continuously diminished in recent years to the extent that no more working level contact seems available.

GTOS has published a series of standard documents for terrestrial ECVs in 2008/2009 in order to gather existing standards and best practices. TOPC experts were actively involved in this community effort coordinated by the GTOS Secretariat, which has been a very valuable contribution to the UN Framework Convention on Climate Change (UNFCCC) Subsidiary Body for Scientific and Technological Advice (SBSTA). These existing standard documents, as well as the GTOS homepage, need to be updated urgently, taking into account the fast progress prevailing in the development of terrestrial observations, including the updated list of ECVs following the in 2010 updated GCOS Implementation Plan. Michael Zemp, head of the World Glacier Monitoring Service (WGMS), stressed that data centres such as the WGMS had invested a lot in the community effort producing these documents, which also suits the credibility of GTOS. He urged the GTOS Secretariat to activate and up-date its website which serves as the document depository, or to have the ECV documents moved to the maintained GCOS sites.

Although GTOS developed a new strategic plan in 2009, there is no sign of its immediate implementation. Due to the lack of support for the GTOS Secretariat at FAO in Rome, TOPC meetings were hosted by the GCOS Secretariat at WMO in Geneva for the past two years. Meeting participants widely agreed that the current situation was not satisfactory and in particular in the light of the emerging UN-wide GFCS initiative, sustained support of GTOS must be guaranteed. The panel would like to bring to the attention of FAO`s executive management the importance of GTOS as an active and useful partner for the global observing systems for climate. The director of the GCOS Secretariat reminded the panel that according to the current GCOS Memorandum of Understanding, the climate component of GTOS falls under the authority of the GCOS Director, which allows her to reach out to partner agencies and to manage the TOPC within her responsibilities.

Antonio Bombelli, who represented the GTOS Secretariat in this meeting, explained that GTOS experienced a peak of funding in the 90's, but had to suffer a sharp drop of income later. He proposed that the GTOS Secretariat will write a brief concept note outlining possible scenarios on GTOS's future which should enable the sponsors to discuss and to make a decision before summer 2012.

The question was raised to what extent GTOS and FAO were involved in GFCS planning. The FAO-liaison officer pointed out that her function was to make the connection between FAO and planning activities for the GFCS. Unlike other FAO departments, the GTOS Secretariat has not yet been included in the FAO engagement for GFCS. She encouraged the panel and GTOS Secretariat to consider how FAO could integrate GTOS in the GFCS effort. The panel stressed that the

observation programme is (or should be) essential for every of the agencies engaged in GFCS activities.

On the question: "What would happen if there was no more GTOS?", the risk was stated that the process started with UNFCCC on standardization of terrestrial ECVs might loose ownership. The meeting agreed that without FAO partnership the global observing system community would loose a great part of its terrestrial component, which, without a sufficiently large transition period to move to an other organization or agency, could not be re-established easily.

The Director of the GCOS Secretariat added that the upcoming review of the GCOS programme might also provide an opportunity for proposing a solution, but that the findings of this review would only be published in more than a year's time.

Action 5: TOPC Chairman to get into direct contact with the Director of the Natural Resources Management and Environment Department (Alexander Müller) expressing the concern about the lack of institutional support for GTOS Secretariat before the meeting of WMO and FAO Secretary Generals on 22nd of March 2012. (TOPC Chairman, GCOS Secretariat, FAO Liaison Office)

GTNs-overview

3. Cryospheric issues

3.1 Update from the WMO-EC Expert Panel on Polar Observations, Research and Services; Global Cryosphere Watch and its relationship towards TOPC

Dr Barry Goodison from the WMO Observations and Information Systems Department reported on the WMO Executive Council Expert Panel on Polar Observations, Research and Services (EC-PORS), and more specifically on the progress in one of its key tasks, the establishment of a Global Cryosphere Watch (GCW).

PORS is a service driven approach with focus on the polar regions, including the 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. Its key tasks are to foster Antarctic coordination, to implement the GCW, to facilitate implementation of a Global Integrated Polar Prediction System (GIPPS), as well as to build an associated user interface. Its services and research initiatives would contribute to the development by WMO of proposed Polar Regional Climate Centres.

To facilitate monitoring and understanding of the global impact of changes in polar regions, PORS seeks integration of operational and research observing networks. The recent 16th WMO Congress in September 2011 adopted the EC-PORS

recommendation to integrate all WMO Antarctic networks (surface and upper-air stations, including all GCOS Surface Network (GSN) and GCOS Upper-air Network (GUAN) and Global Atmospheric Watch (GAW) stations) into an Antarctic Observing Network (AntON). AntON will request all stations to produce monthly CLIMAT messages for collection and dissemination via the WMO Information System (WIS).

The GCW is being set-up with the aim to provide authoritative, understandable, useable data, information, and analyses for past, current and future state of cryosphere. It will encompass requirements, integration, standardization, access, and coordination, building upon and serving as an international mechanism for implementing the recommendations of the Integrated Global Observing Strategy (IGOS) - Cryosphere Theme (CryOS). The proposed GCW structure is shown in Figure 2. The first GCW Implementation Workshop was held from 21-25 November 2011 in Geneva. Activities are organised on two broad themes a, observations and b, products and services, to become accessible via a web portal, which will be provided by the Norwegian Meteorological Service. Focus areas for the observations theme will be:

- Supersites, reference stations, contributing networks, inventories;
- Standards; and
- Element specific initiatives and partnerships (e.g. Intercomparisons).

The products and services will focus on:

- Element specific products and services, user support;
- Operational and research;
- Trends, indicators, terminology, reanalyses...

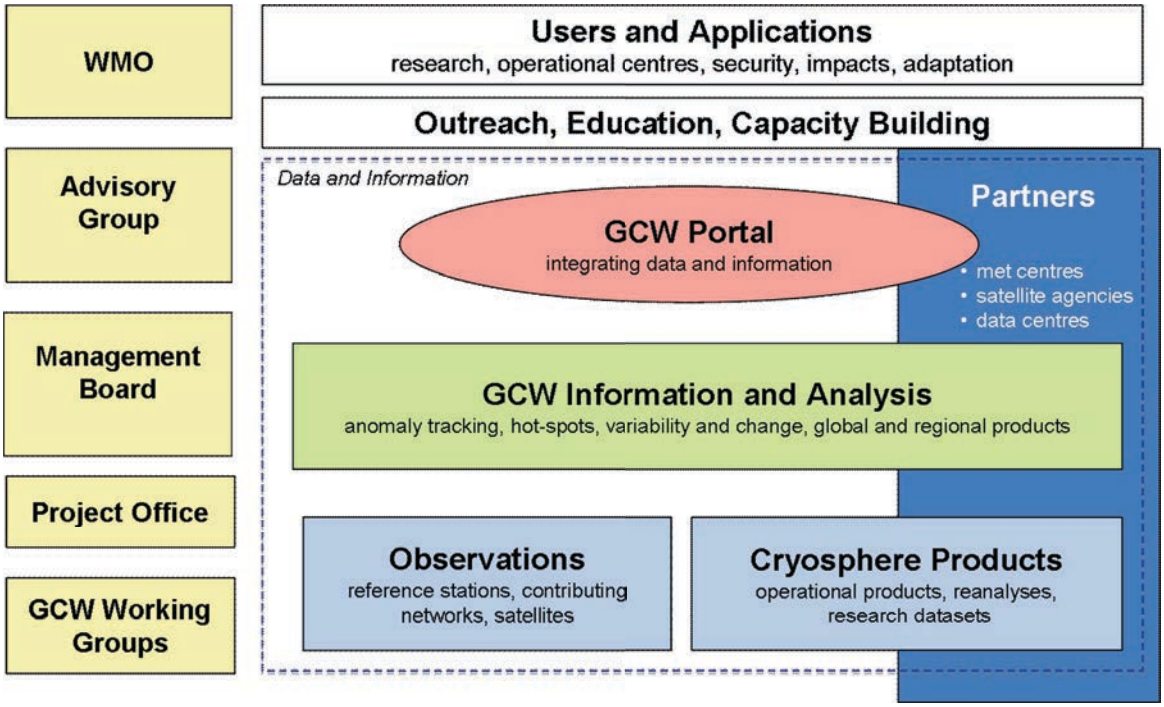

Figure 2: Proposed GCW framework.

In 2011, a measurement campaign, called the Solid Precipitation Inter-Comparison Experiment (SPICE), was initiated under the auspices of the WMO Commission for Instruments and Methods of Observation (CIMO) and has been suggested as a demonstration project for GCW. The mission of SPICE is to develop a reference using automatic gauges and to provide guidance on the performance of modern automated sensors, for measuring:

I. total precipitation amount measurement in cold climates for all seasons, especially when the precipitation is solid,
I. snowfall measurement, and
II. snow depth measurement,

with the goal to understand and document the differences between automatic and manual measurements of solid precipitation of equally sheltered gauges, including their siting and configuration.

An initial survey of weather, water, and climate products and services was undertaken to assess requirements for additional or emerging services from the user's perspective. This initial survey identified a relatively small number of existing climate products and services for the polar regions. It concluded that Regional Polar Climate Centres and Polar Climate Outlook Forums could fill this gap. A services 'white paper' summarizing the finding of this and other surveys, e.g. focussing on sea ice, is supposed to provide a services basis for the GIPPS.

Finally, Dr Goodison presented the following set of issues relevant for TOPC:

- The GCOS Steering Committee agreed that the most effective linkage was directly with the terrestrial networks. – This has worked effectively for GCW and the panel particularly welcomed that the Global Terrestrial Network for Permafrost (GTN-P) is now moving towards becoming a full network.
- There are potential links between ecological supersites proposed by TOPC and GCW supersites.
- The development of standards, guidelines, and best practices for cryospheric observations is a central task for GCW.
- TOPC contribution to GIPPS would be highly welcomed, especially for the carbon cycle. –Agreeing to this in general, the panel noted that there were no TOPC activities specifically on the carbon cycle.
- It is proposed to link the IGOS-P report (CryOS) with the WMO Rolling Review of Requirements (RRR) process and update/refine these requirements over time.

3.2 Ice Sheets / Global Terrestrial Network for Permafrost (GTN-P)

Prof. Konrad Steffen reported on research concerning ice sheets and permafrost in his capacity as co-chair of the WCRP CliC project, whose mission is to determine the stability of the global cryosphere. CliC aims to assess and quantify the impacts that climatic variability and change have on components of the cryosphere, and to assess as well the feedback of these impacts on the climate system. Furthermore, a positive development is that the CliC office is staffed again after two years.

CliC is divided into four theme areas:

- **Ice Masses and Sea Level (IMSL)**
  - *contribution of glaciers, ice caps and ice sheets to sea level rise*
  - *how will ice shelves respond to changes in ocean and atmosphere*
- **The Marine Cryosphere and Climate (MarC)**
  - *impacts and feedbacks of a reduction in sea ice cover*
  - *nature of hemispheric differences between the two polar regions*
- **Terrestrial Cryosphere and Hydroclimatology of Cold Regions (TCHM)**
  - *role of terrestrial processes in water, energy, carbon cycles of cold regions*
  - *interactions and feedbacks between terrestrial and other elements of cryosphere/climate*
- **Global Predictions and the Cryosphere (GPC)**
  - *impacts of changes on ocean and atmosphere circulation*
  - *likelihood of abrupt climate changes*

Current CliC priorities are:

- **Polar Climate Predictability** (as part of a WCRP SPARC and CliC initiative)
  - explanation of causes and prediction of the sea-ice changes
  - ice-sheet dynamics and the role of the major ice sheets in sea-level rise
  - regional Arctic climate modelling and improved parameterisation of cryospheric processes
- **Cryospheric inputs to the Arctic and Southern Ocean freshwater budgets**
- **The role of carbon and permafrost in the climate**
- **Sea-ice: observations, modelling and data products, endorsements of a community sea-ice concentration and ice extent product**
- **Changes in mountain cryosphere and water resources, via regional activities** (Asia – CliC, South America)

Prof. Steffen reported on the WCRP-Intergovernmental Oceanographic Commission (IOC) sea level group. As 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, IOC member states have asked for "Periodical Policy Briefs on sea level be established and regularly updated". The sea-level group is supposed to integrate across all WCRP activities and to collaborate with other Programmes and relevant parties.

The evolution of global mean sea levels since 1870 results partly from the melting of glaciers and ice sheets, whereas the thermal expansion of the oceans contributes typically to about 30 %-40 % of the rise. Compared to the 2007 IPCC report, the estimated cryospheric increase 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. Despite this new insight was gained through GRACE, the GRACE-II mission is expected to be launched not before 2016. The observed changes on the western slope of the Greenland ice sheet are only partly caused by warmer air temperatures, which increased by 4 °C in global annual mean over the last two decades, but also by warmer water that predominantly melts floating parts of ice. Changes in ocean circulation and ocean temperatures

will produce changes in basal melting; the magnitude of these changes is currently not modelled or predicted.

Most interesting for risk assessment and adaptation purposes are, however, estimates of local sea-level rise. In case of Antarctica, most of the ice is ocean-grounded, therefore western Antarctica and the Antarctic Peninsula are melting very fast, in contrast to this, the amount of ice in eastern Antarctica is slightly increasing. From the 30 year record of Greenland ice sheets, the area of melting increased by 2 % per year. In conclusion, the acceleration in ice-sheet loss for Greenland and Antarctic ice sheets over the last 18 years was found to be three times larger than for mountain glaciers and ice caps. Scientists are beginning to understand quantitatively the observed sea-level rise in terms of an ice sheet mass balance, even terrestrial storage terms are not yet included.

In the following discussion, the point was made that in order to move an ECV successfully forward, it needs ownership. Critical is to have an active science team and/or even to have a designated data centre in place. The WGMS has been approached for hosting ice-sheet information, but unfortunately does neither have the capacities nor the expertise to take on this task. NASA holds the largest amount of data at the moment.

3.3 Global Terrestrial Network for Glaciers (GTN-G) / World Glacier Monitoring Service

Dr Michael Zemp, Director of the WGMS presented the state of knowledge in glacier research, as well as specific challenges and needs from data centres perspective and his ideas on how TOPC could support the internationally coordinated glacier monitoring.

GTN-G is largely based on the scientific monitoring community, and is jointly run by three operational bodies: the World Glacier Monitoring Service (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'[3] to allow exploration of data products from all three operational services (WGMS, GLIMS, and NSIDC), including a metadata browser, is being developed. Progress in setting up a World Glacier Inventory (WGI) database[4] has been made with the inventory holding 2/3 of the estimated total information by now and its documentation being updated in 2012. The WGI contains information on 130,000 glaciers that cover over 470,000 km^2. However, glacier area is not the driver for glacier thickness. Efforts are made to compile standardized data on glacier thickness measurements.

On global average, glaciers are loosing 1 m of thickness per year. These findings are based on geodetic observations. Glacier front variations based on *in-situ* observations and reconstructions are undertaken to extend glacier information back to the 'Little Ice Age' and beyond with the aim of establishing a robust glacier mass

[3] GTN-G website:www.gtn-g.org
[4] World Glacier Inventory: http://nsidc.org/data/glacier_inventory/index.html

balance. A workshop on measurement and uncertainty assessment of glacier mass balance will be held 9–11 July 2012 in Tarfala, Sweden. This should also provide ground for discussions for the next update of the GCOS IP. Current sections on glaciers include area and area change, but what the glacier community really would like to have is information on volume or mass.

Common terminology, best practices, and guidelines for glacier monitoring are summarized in the GTOS ECV Report No. 61[5]. Most recently, the 'Glossary of Glacier Mass Balance and Related Terms', prepared by the Working Group on Mass-balance Terminology and Methods of the International Association of Cryospheric Sciences (IACS), was published in 2011.

Dr Zemp presented findings of a recent evaluation undertaken by the Swiss GCOS Office on the availability of ECV data through international data centres as shown in figure 3. In particular for the terrestrial ECVs groundwater and soil moisture full GTNs need to be established. The critical step is of course to enable the transition from research to long-term operations, as it requires sustained funding.

ECV (Selection)	International Data Center	Status[1]
River Discharge	GRDC	Well-established
Glaciers	WGMS, NSIDC	Well-established
Permafrost	NSIDC	Well-established
Land Cover	FAO Global Land Cover Network	Well-established
Fire Disturbance	GFMC, FIRMS	Well-established
Snow cover	NSIDC, NCDC	Limited use, insufficient international data exchange
Lakes	HYDROLARE	Under construction
Groundwater	-	GTN-GW to be established by 2014
Soil Moisture	-	GTN-SM to be established by 2014

Figure 3: Evaluation on the availability of ECV data through international data centres; Source: Swiss GCOS Office.

Michael Zemp suggested TOPC could help to improve the visibility and funding situation for monitoring activities, as well as support enforcement of correct data citation. Participants agreed with his view that it has not yet been fully resolved

[5] The GTOS Report No. 61 on Glaciers and Ice Caps is available under: http://www.fao.org/gtos/doc/ECVs/T06/T06.pdf

how to advise users on the proper use of fundamental data records, including their citation. Noting that within a scientific environment, there is limited acknowledgement for monitoring as such, Michael Zemp reported from the WGMS's approach to strengthen the existing scientific collaboration networks, by:

- encouraging monitoring sessions at scientific conferences, e.g. the annual meetings of the American Geophysical Union or the European (AGU) and European Geophysical Union (EGU);
- encouraging the production of citable data reports, e.g. the fluctuations of glaciers series and the glacier mass balance bulletin;
- encouraging journals to provide publication categories dedicated to observational datasets, e.g. the 'Data Science Journal' of the ICSU Committee on Data for Science and Technology (CODATA);
- encouraging dedicated chapters in IPCC Assessment Report on observations and related uncertainties;
- enforcing strict citation rules for datasets, e.g. using the Digital Object Identifier (DOI) System.

The meeting agreed that this approach was very useful and could serve as the role model. Michael Zemp proposed TOPC to take the following actions:

- link every ECV with an internationally established data centre;
- strengthen the national support for long-term monitoring (e.g. GCOS Switzerland achieved highest political recognition for the value of long–term observation series and in parallel involved the UNFCCC process);
- postulate budget for monitoring in every scientific proposal (through ICSU to National Science Foundations);
- develop clear citation rules for datasets together with GT-Net data centre; and
- enforce strict use of these citation rules (through ICSU, NSFs, journals).

This was widely supported by the panel.

Action 6: Bring to the attention of GCOS SC that data centres are suffering from the amount of reporting obligations to different organizations and their programmes (GEO, GMES, EU Framework Projects, etc.); express the need for standardized reporting, e.g. though one centralized body. (TOPC Chairman, GCOS Secretariat)

4. Hydrological Issues

4.1 Global Terrestrial Network for Lakes (GTN-H/Lakes)

Prof. Valery Vuglinskiy briefed meeting participants on activities of the International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE)[6], operated by the Russian State Hydrological Institute (SHI) since 2009. Its main tasks are:

- development and regular update of the international database; including support in data rescue if requested;

[6] HYDROLARE website: http://www.hydrolare.ru/

- periodic preparation of information products on the world's hydrological regime of lakes and reservoirs;
- development of computer technologies to support these activities.

HYDROLARE started from a prototype database of metadata and historical *in-situ* data of lakes, reservoirs and gauging sites in Russia and other former USSR countries. Available long-time series typically encompass:

- Extreme level (highest and lowest level per year and regime phase; start and end date of the event; number of cases);
- ten-day-averaged water temperature;
- ice phenomena (dates and durations of ice regime phases);
- ice thickness, every ten-days.
- water-surface temperature of the area, ten-days and monthly averaged;
- monthly and yearly surface influx (into the reservoir).

Outside of former USSR countries, data have been received from China, Sweden, Switzerland and Slovenia so far; in addition, submissions from Ice Land and the USA are expected. Unfortunately, many countries have not submitted their data in spite of repeated requests. Data arriving in a variety of formats and languages cause problems for data identification, processing and uploading. Encoding of water bodies and gauges is also aggravated if data providers do not indicate WMO sub-regions in the datasets.

In February 2012, Jean-Francois Crétaux from the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) of the French space agency (Centre National Centre National d'Etudes Spaciales, CNES) visited SHI. Purpose of the cooperation between LEGOS and HYDROLARE is to combine HYDROLARE *in-situ* data for selected lakes from the 'priority list of lakes and reservoirs for sustained monitoring'[7] with LEGOS satellite observations. Water level *in-situ* data for five large lakes in Russia was handled for comparison with satellite data to achieve estimates for water level products. The possibility to cross-link between HYDROLARE and HYDROWEB sites is foreseen. In exchange of Jean-Francois Crétaux' visit, the visit of a scientist from SHI in Toulouse is planned.

4.2 HYDROLARE - LEGOS cooperation

Jean-Francois Crétaux, who joined the meeting from remote, further presented activities within the HYDROWEB[8] project as a contribution to HYDROLARE.

A formal agreement on the LEGOS – HYDROLARE cooperation has been signed between CNES/CNRS and SMI in July 2011, and cooperation is also foreseen with the 'Central Asia Regional Water Information Base Project'[9] to reference a regional database for Central Asia on both, HYDROLARE and HYDROWEB. Preparation for an

[7] The GTN-L priority list of lakes is available under: http://www.wmo.int/pages/prog/gcos/documents/List%20of%20GTNLakes%202010.pdf
[8] HYDROWEB database: http://www.legos.obs-mip.fr/en/equipes/gohs/resultats/i_hydroweb
[9] Web portal of the Central Asia Regional Water Information Base Project: http://www.cawater-info.net/index_e.htm

international conference on lakes and reservoirs, to be held in Toulouse in 2013, has started.

The HYDROWEB page is being developed further to provide information on water level (from altimetry), surface (from imagery) and volume (from a combination of altimetry and imagery), eventually comprising water level variations from radar for 163 lakes,. HYDROWEB, which currently gives access to surface and volume information of 29 lakes, shall be expanded to 50 to 100 lakes within 2012. Furthermore, information on lake-ice duration for boreal lakes will be added. A prototype portal is under construction to link LEGOS and HYDROLARE, as each lake's web page shall be accessible from both data centres. Automatisation of data processing for near-real-time updating has been partially achieved so far, and harmonisation of data policies is foreseen. This harmonised data policy will not set up restrictions for scientific use, but should outline the conditions, including track of usage. Two articles have already been published in 2012, compared to 11 in 2011, and a report on the comparison of HYDROLARE data and radar altimetry is in progress to be presented at the upcoming ESA conference '20 years of altimetry' in Venice in September 2012.

Jean-Francois Crétaux described this engagement as very useful to get support from CNES for shaping their existing data base towards the requirements on climate observations stated by GCOS and towards user requirements. Due to the engagement in the CNES/NASA mission on Continental Water Monitoring from Space (SWOT), he is confidential that funding will be secured for the next 10 years. If launched as planned in 2019, SWOT is supposed to allow monitoring the level and surface variations of lakes bigger than 250x250 m^2 worldwide with a precision of 10 cm and a return period of 22 days. In addition, cooperation with a private company having expertise in radar altimetry will start for the generation of improved waveform re-tracking for lakes and reservoirs. The panel thanked Jean-Francois Crétaux for this presentation and encouraged LEGOS and HYDROLARE to maintain and increase their cooperation for better visibility of both organizations.

Action 7: Maintain and increase cooperation of LEGOS/HYDROLARE for better visibility of both organizations. (LEGOS & HYDROLARE)

4.3 Global Terrestrial Network Hydrologie (GTN-H)

Dr Wolfgang Grabs from the WMO Climate and Water Department informed meeting participants on ongoing water programme activities of relevance to TOPC.

Most important to mention is the World Hydrological Cycle Observing System (WHYCOS)[10] that contributes to improved forecasting and water management capabilities of participating countries as shown in figure 4. Coupling of climate information with hydrological information is supposed to lead into climate-related services under the future GFCS. In analogy to climatological normals, hydrological normals shall be developed, as well as hydrological forecasting products in response

[10] WHYCOS hompage: http://www.whycos.org

to seasonal climate outlooks. WMO promotes the sharing of hydrological data and aims to advance standardization of metadata catalogues in hydrology to improve access to hydrological data and information. Data sharing from, e.g., trans-boundary basins, is often prohibited by national security concerns, but also because the data is inconsistent, not compatible or of bad quality. The planning and implementation of regional and basin-wide projects under WHYCOS will be continued. Projects for the 2012 - 2015 timeframe include:

- Developing a proposal to seek upgrades to the hydrometric network and to promote the development of integrated data products;
- Undertaking technical activities related to the calibration and rating curves for select rivers and storage volume changes for large lakes and reservoirs primarily through the Global Runoff Data Centre (GRDC);
- Advancing the use of 'Water ML2'[11] in the exchange of hydrometric data;
- Development of a country-by-country inventory of stream flow measurement, including its status and data transfer issues;
- Developing a proto-type database of surface water storage that will complement observations of water levels from satellites;

GTN-H was established in 2001 as a joint project of the GCOS, GTOS, and the WMO Climate and Water Department to support a range of climate and water resource objectives, while building on existing networks and data centres, and producing value-added products through enhanced communications and shared development. The GTN-H website[12], which is currently hosted by the University of New Hampshire, USA, is supposed to move to, and to be maintained by, the German Hydrological Service in the near future.

Dr Grabs also reported from the Global Hydrological Network (formerly known as Hydrological Applications and Run-Off Network, HARON) proposal to integrate, in a phased approach, dedicated river gauging networks of existing hydrological stations into a global runoff observation network, and to make the data available using standardized formats. Despite the network has been identified, no funding could be secured, yet. Further details on the Global Terrestrial Network for River Discharge (GTN-R) were covered under the following agenda item 4.4.

[11] 'Water ML2' is a derivate of Extensible Markup Language (XML)
[12] GTN-H website: http://gtn-h.net

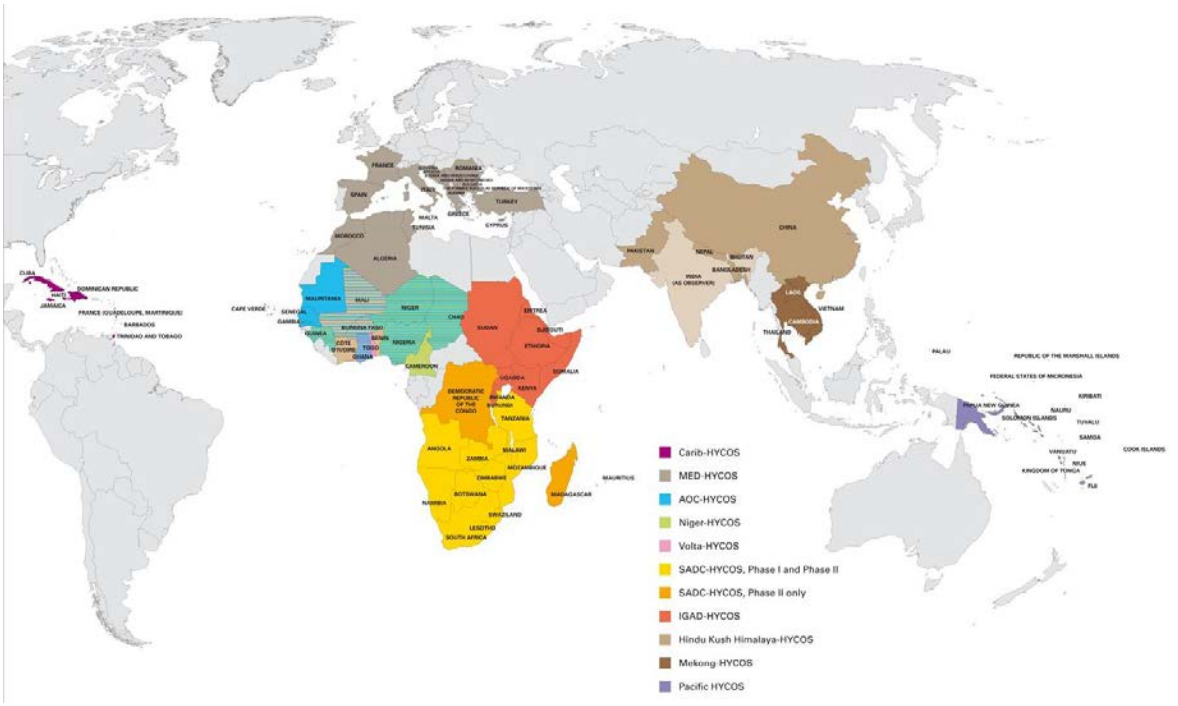

Figure 4: Components of WHYCOS.

4.4 Global Terrestrial Network for River Discharge (GTN-R) and Climate Sensitive Stations (Pristine Basins)

Ulrich Looser from the GRDC reported on the status of the GTN-R and on climate sensitive stations, so-called pristine basins.

The availability of discharge data at GRCD, as shown in figure 5, peaked in the 70ies, however, historic data series are typically published with a delay of about ten years. Besides this, the database now holds about nearly equal amounts of daily and monthly data, whereas in former times it was predominantly monthly data. The next step would be to enable about 400 stations to report data up to the present in an institutionalized way and directly to the GRDC. Unfortunately, due to resource constraints, still no operational system for data collection is available for GTN-R.

Nevertheless, GRDC will participate in the seventh EU framework programme (FP 7) project, 'GEOWOW'[13], to support standardisation of hydrological data transfer.

[13] Homepage of the FP 7project GEOWOW: http://www.geowow.eu/

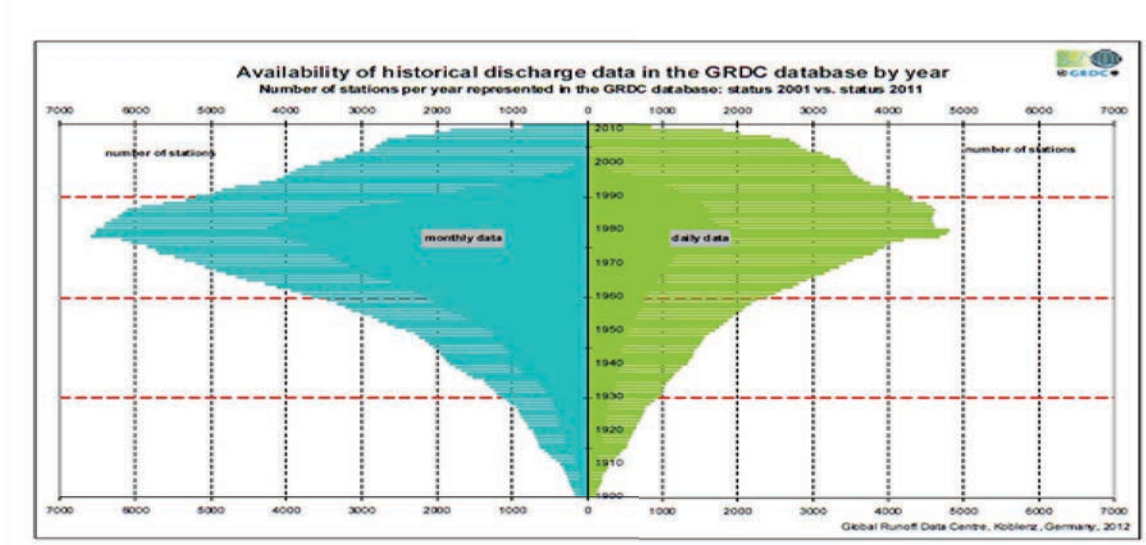

Figure 5: Availability of historical discharge data at GRCD.

GTN-R support letters accompanied by information packages have been sent to 67 WMO member countries in June 2011 to encourage GTN-R participation. Currently, the status on contacts with the 82 GTN-R countries is as following:

- 50 countries (61%) did not respond to the 2005 and 2011 requests;
- 19 countries (23%) responded either after 2005 or 2011 with various levels of progress on station selection and data provision, but have no yet reached the level for regular data exchange;
- 13 countries (16%) are delivering data or are expected to deliver 'without major hurdles', these are: Australia, Brazil, Canada, Finland, Germany, Iceland, The Netherlands, New Zealand, Norway, Romania, South Africa, Sweden, United States of America.

Following Ulrich Looser's presentation, in which he stressed the lack of resources for GRDC and for hydrological observations in general, leading to the decline of hydrological networks, the TOPC chairman asked whether GRDC could provide a list of key stations (or at least a selection of stations where contact exists) in the need of update, and to suggest renovation projects for these stations to the GCM donors' board.

Action 8: Provide a small list of hydrological stations that could be supported from the GCM. (GRDC)

With respect to climate sensitive stations, Ulrich Looser reported that GRDC data acquisition activities now encompass the request for identification of climate sensitive stations according to the WMO selection criteria, including the provision of

station metadata and discharge data. Stations from pristine basins are gradually included in the GRDC database starting from countries with a large number of identified sensitive stations, e.g. Canada and United States. Currently, GRDC is negotiating with Indonesia, New Zealand, Austria, Slovenia, Germany, Switzerland, Italy and France. Identification of stations for which no data have been provided to GRDC and acquisition efforts of missing station metadata and discharge data are continuing.

4.5 Soil Moisture ECV

Prof. Wolfgang Wagner from the Vienna University of Technology reported on the progress regarding the soil moisture ECV, based on contributions from the International Soil-Moisture Network (ISMN), the Water Cycle Multi-mission Observation Strategy (WACMOS) and project teams of the ESA Climate Change Initiative (CCI).

There has been significant progress in setting up the global *in-situ* soil-moisture database in 2011, namely, the number of contributing networks increased to 29 networks with a total over 800 stations, data covering the period from 1952 to present. Several networks are providing data in near-real-time and automated quality management has been implemented. The quality-control procedures show that operational networks often produce data of lower quality than the research networks, even they follow best practices. On the other hand, the way the database evolves can help to agree on uniform best practices among the scientific community, where even peer-reviewed methods are not necessarily accepted by parts of the community. Participants stressed the need to agree on protocols and guidance on best practices first - before defining standards. Joanne Nightingale from the CEOS Working Group on Calibration and Validation (WGCV) noted that endorsement from space agencies, e.g. though a CEOS validation protocol, can be a major step, because full consensus on standards might never be reached. Barry Goodison mentioned that even WMO produces only 'guidance' and the need was identified to update the soil moisture sections in WMO standing literature, in particular the CIMO guide.

Action 9: GCOS Secretariat and WMO/OBS to liaise with TOPC, Wolfgang Wagner in particular, to update the soil moisture part in CIMO standing literature. (GCOS Secretariat, WMO/OBS, Wolfgang Wagner)

The more than 350 registered users of the *in-situ* soil-moisture database predominately work for research organizations or in higher education with the largest numbers of users coming from the USA and China.

Quality assessment studies comparing *in-situ* data of different sensor types versus the 'Global Land Data Assimilation System' model revealed that apparent poor performance often results from poor time correlation. Performance assessment across the depths for different sensor types showed that the correlation with deeper soil is usually better, because the deeper column better represents the area. It is a

general problem to estimate the representativeness of an *in-situ* station with respect to its surrounding area, e.g. for comparison with satellite observations.

A CCI project on soil moisture to develop an ECV production system just started in January 2012 and validation of WACMOS with *in-situ* measurements is carried out. Global soil moisture maps for 1988-2010 using linear regression (including uncertainties) of yearly averages show that, even in the 30-year records, trends are strongly influenced by individual extreme events. The El Niño / Southern Oscillation (ENSO) phases also have large impact, whereas the climate change signal is much smaller. On the question what time resolution would be desirable, Wolfgang Wagner, recommended daily products, which are already used by first Numerical Weather Prediction (NWP) centres, leading to improved predictability.

Concerning validation activities and the development of standards, Prof. Wagner stated the three major pending tasks:

- Global soil moisture assessment study (following the WOAP Frascati Workshop in 2011),
- White paper on soil moisture standards (recommended by TOPC-XIII),
- Validation protocol for the CEOS Working Group on Land Product Validation (LPV).

Though none of these activities has been pursued in an internationally coordinated manner, so far, much progress has been made by several project teams. The product validation plan established in the frame of the CCI soil moisture project might form the basis for a CEOS validation protocol, and round robin exercises for ASCAT and AMSR-E Level-2 retrievals might serve for global inter-sensor assessment. Prof. Wagner noted the many different opinions on what validation means and how it should be performed, given the prevalent lack of time and funding. He further stressed the need for a community building effort to get a soil moisture assessment study started, which is not just a technical challenge. The prime challenge for his group is to find a way for continuing the ISMN as the current ESA contract runs out by end of 2012.

The panel recognized the very encouraging progress achieved in setting up a soil moisture database and the important steps undertaken within the CCI project.

5. Carbon and Land Cover Issues

5.1 Fire Disturbance

Dr Kevin Tansey from the University of Leicester presented a brief document reviewing progress against the GCOS IP actions on fire disturbance. As TOPC fire expert, he is coordinating activities studying burned area, active fire detection, and radiative power. Information about radiative power allows estimating equivalent fuel loadings and the amount of gases produced. However, the ESA CCI projects focus solely on burned area. Recognising that the GCOS IP actions and GTOS standards document are weighted towards burned area and that these measurements are currently more mature, meeting participants stressed the need

to keep a balanced view on developments in active fire and burned area, taking into account the burned area products, but without a bias towards certain products. Over the previous year Dr Tansey has coordinated the update of the Satellite Supplement with particular effort been given to sections on active fire and radiative power.

He reported that strong progress has been made against product development and validation using data from European and US satellites. The ESA CCI project has pioneered the development of documents on user requirements and product specification that are in line with GCOS requirements. An operational near-real-time burned-area product, called geoland2, is in final stages of completion. Validation activities are progressing through NASA and ESA funded projects with some coordination of these activities, e.g. the CEOS Working Group on Climate requested 'activity and update templates' for the fire disturbance actions, which are being coordinated through NOAA. Nevertheless, more work on the active fire and fire radiative power (FRP) channels was needed, both on the documentation expected by GCOS, and in the coordination of data products. Kevin Tansey recommended that closer communication with the Sentinel mission groups could be established. He affirmed that the CEOS Working Groups on Calibration/Validation and Land Product Validation (LPV), as well as the GTOS Panel on Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD), are being updated at regular intervals to give them a better understanding of the GCOS documentation (including the requirements for accuracy, etc.), the development of the ECVs, and the work of TOPC in general. The last GOFC-GOLD Fire IT meeting (Stresa, Italy, 18-19 October 2011) recommended updating of the GTOS document on fire disturbance, taking into account discussion on the following points:

- the status of FRP developments,
- how future ESA Sentinel and geostationary missions will contribute to this effort, and
- the understanding of the status of ground fire detection and monitoring.

Kevin Tansey will lead this effort for completion by end of 2012.

Developments on the GCOS IP action T34, 'Establish validation protocols working through CEOS LPV and other partners', are reported on the LPV website[14]. Validation is a critical element of the ESA CCI fire ECV project and the CCI programme has developed a number of approaches towards validation of the global products, which are being discussed within the community. Funding has also been secured from NASA to continue development of validation protocols and datasets. The Moderate Resolution Imaging Spectrometer (MODIS) team are also creating validating datasets.

The idea of a centralized facility for all fire data seems to be a long way off despite various interoperability efforts are underway in the various agencies, and the products are still in development. The community has developed a land measurement portal[15] which includes fire and that is being managed by NASA at this time. A different approach might be to push for one single portal, where all fire

[14] http://lpvs.gsfc.nasa.gov/
[15] http://landportal.gsfc.nasa.gov/

products would be listed with active links to data, including validation data with the published accuracy assessment and an informed description for the user community as to which data are appropriate for which broad kind of analysis. Once operational agencies with operational fire products will be in place and move out of the research domain, and then perhaps, the centralization issue should be revisited.

The European Centre for Medium-range Weather Forecast (ECMWF) is interested in near-real-time observations for direct forecasting of air quality and for process parameterization in climate models.

5.2 Biomass

Prof. Shaun Quegan from the University of Sheffield's Centre for Terrestrial Carbon Dynamics delivered a presentation on current capabilities for observing forest above-ground biomass.

The 'Global Forest Resources Assessments' from FAO provide the main source of information on global forest carbon stocks. These reports are issued every five years, based on national reporting statistics. This implies certain shortcomings, in particular, the underlying data is not complete (not every country is reporting) or standardized, nor deal the assessments with representativeness or uncertainty. Hence, they can not provide reliable insight on the spatial distribution of biomass. As the relative error of emissions add up the errors of its products, even for the best characterized system (Brazil), the uncertainty in emissions from humid tropics ends up in the order of 80 % to 95 %. Since the UN policy framework for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) encourages developing countries to contribute to mitigation actions in the forest sector, involving a great amount of money in carbon trading, emission rates need to be known correctly. An important approach, in particular for the tropics, is measuring biomass from space. However, there is no space-borne sensor specifically designed to measure biomass. Observations from the 'ICESat' satellite allow estimating carbon fluxes in the tropics within an uncertainty range of about 50 %. Other analyses, comparing values for deforestation rate and mean biomass from literature, satellite and *in-situ* observations, showed a similar large range of possible results. Summarizing the current status of measuring biomass from space, Prof. Quegan noted that no current space-borne sensors can measure biomass or forest height. A dedicated biomass mission would be crucial for:

- Quantifying land use change (emissions and uptake),
- Scientific support for international treaties,
- Landscape scale carbon dynamics and prediction,
- Initialising and testing the land element of European Satellite Missions, and
- Forest ecosystem services & biodiversity.

The status of satellite instruments sorted by their measurement technique is as following:

- **Lidar**

  ICESat-1 failed in 2009. ICESat-2 is scheduled for 2016; it will be optimised for ice-sheets, cloud and aerosol applications.

- **L-band radar**
  ALOS-PALSAR acquired systematic a five-year archive of forest data before its failure in April 2011. PALSAR-2 is planned for launch in 2013 and intended to have a systematic acquisition strategy for forests, but with strong focus on disaster monitoring. The current JAXA data policy implies commercial handling of the data. The first launch for two Argentinean Microwaves Observation Satellites (SAOCOM), is foreseen in 2013, though without a systematic forest observation strategy.

In future, the use of a **P-band satellite radar concept** could allow to measure at longest possible wavelength and to compare this with the vegetation height obtained from an interferometer at the same time. After the required frequency permission for the use of p-band has been given, the decision on the suggested BIOMASS mission will be made in late 2012 or early 2013.

Besides this, an important technique is flying Lidars with 1 m to 5 m resolutions on airplanes. This is improving inventories at national scale and helps overcoming the problem that information on private property is often not available. Those flights also offer a great opportunity of cross-use, e.g. for glacier monitoring, but the scientific community needs to be informed.

The panel noted satisfaction on the progress with regard to biomass and suggested GOFC-GOLD could be involved more in forest activities.

6. Reference Observation and Validation

6.1 Report from GCOS Space Rapporteur

Dr Richter introduced Dr Jean-Louis Fellous, who has accepted the new function of a GCOS space rapporteur only recently and for the first time attended a TOPC meeting. The role of the space rapporteur is to foster communication between satellite coordination groups and the GCOS science panels.

The supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)", documented in the so-called 'satellite supplement', have been up-dated and the new version has been released in December 2011[16]. The document has been publicly reviewed and comments have been taken into account after consultation with the respective GCOS expert community. The GCOS Secretariat also kept a record on how the individual comments were treated, which can be made available upon request.

The 'satellite supplement' provides additional technical detail to the actions and needs identified in the 2010 updated GCOS Implementation Plan related to satellite-based observations for climate for each of the ECVs. In particular, it

[16] The updated "Satellite Supplement" (GCOS-154) is available under: http://www.wmo.int/pages/prog/gcos/Publications/gcos-154.pdf

details the specific satellite data records that should be sustained in accordance with the GCOS Climate Monitoring Principles, as well as other important supplemental satellite observations that are needed on occasion or at regular intervals. The Satellite Supplement details GCOS requirements for Fundamental Climate Data Records (FCDRs) and derived products in terms of:

- Accuracy,
- Stability,
- temporal/spatial resolution,
- calibration and validation needs and opportunities,
- relevant international working groups,
- for atmosphere, ocean, land and cross-cutting actions.

An overview of terrestrial products is given in Figure 6 below. Dr Fellous further announced that an official response from CEOS to the 2010 updated GCOS Implementation Plan is expected at the end of the year.

ECV	Global Products	FCDR required
Lakes	Lake levels, areas	VIS/NIR, radar
Snow Cover	Snow areal extent, SWE	VIS/NIR/IR, passive MW
Glaciers and Ice Caps	2D vector outlines, DEM	VIS/NIR/IR, InSAR, stereo
Ice Sheets	Elevation changes	Altimetry, SAR, gravity
Albedo	BRDF	Multispectral radiances
Land Cover	Moderate/High res. maps	VIS/NIR, radar
FAPAR	Maps	VIS/NIR
LAI	Maps	VIS/NIR
Biomass (Forest)	Regional, above ground	Radar, lidar
Fire Disturbance	Maps, burnt areas/active	VIS/NIR/SWIR/IR
Soil Moisture	Maps	Active & passive MW
(*Land surface Temperature*)	*Temperature records*	*IR from GEO, MW from LEO*

Figure 6: Overview of satellite data products for terrestrial ECVs.

Dr Fellous then continued to present ESA-relevant activities on behalf of Olivier Arino. He reported on consistent global land datasets for digital global vegetation models. Consistency refers to self-consistency with respect to time, inter-satellite consistency and inter-variable consistency. For example, historic fire data (covering 1995 to present) is being reprocessed for the so-called 'World Fire Atlas'[17], using the newly produced ATSR Top of Atmosphere products as part of ESA's Data User Element (DUE). Projects of the ESA CCI comprise among others land cover, snow

[17] The ATSR World Fire Atlas is accessible under: http://due.esrin.esa.int/wfa/.

and albedo. Jean-Louis Fellous explained that their evaluation strategy and methods are based on cross-validation techniques using remote sensing products and ECMWF Re-Analysis (ERA) interim data, as well as ground measurements. Ground data is essential to validate satellite products and derive higher level information. The two permafrost monitoring programmes of the Global Terrestrial Network for Permafrost (GTN-P), for example, provide an extensive ground-truth database for the entire circum-Arctic Region. A CCI sub-project also deals with biodiversity variables and a first workshop on defining 'Essential Biodiversity Variables' (EBVs) was hosted by ESA's European Space Research Institute (ESRIN) in February 2012. EBVs are supposed to cover the marine, freshwater and terrestrial domains, as well as genes, species, ecosystems and ecosystem services. EBVs address both the state of biodiversity and associated pressures and responses to derive indicators for the 2020 biodiversity targets of the UN Convention on Biodiversity (CBD). A new Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) will be launched later this year. The TOPC Chairmen mentioned, despite GCOS will not be directly involved in defining EBVs, it was encouraging to see that the biodiversity community was trying to learn from, and to follow, the GCOS approach and GTOS would like to take account of this through a new configuration of the Terrestrial Carbon Observations (TCO) panel. Antonio Bombelli affirmed that, in principle, this was foreseen in the GTOS strategy.
Finally, Jean-Louis Fellous reported on work in progress within CCI projects for the newly acknowledged terrestrial ECVs soil moisture and ice sheets that were added in 2011.

6.2 CEOS Cal/Val activities

Dr Joanne Nightingale, chair of the CEOS WGCV sub-group on Land Product Validation (LPV), had been invited to the panel session to present the Cal/Val activities of the CEOS LPV Focus Groups. Their goal 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 so they are relevant to users. This approach to find a community-wide accepted way how to do validation emerged from the from land validation of MODIS products, mainly land cover, fire and land index. Therefore, the groups are ECV-focused. Nevertheless, international representation is pursued. The group chairs aim to engage community members by organizing at least one topical workshop within their leadership term. The role of the LPV groups is to guide the development and publication of 'best practice' in from of land product validation protocols and to lead product inter-comparisons, as well as to formulate product error definitions for Land Long Term Data Record (LTDRs) of ECV's for the climate modelling community. They strive to increase 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 / information exchange.

The CEOS LPV groups are advising new satellite missions and projects on land product validation planning, e.g. through the NASA Decadal Survey (HyspIRI,

SMAP) and the ESA CCI. They are actively involved in preparing the CEOS' response to the 2010 updated GCOS IP as 12 out of the 138 actions in this Plan relate directly to land validation (data quality, inter-comparison, collection of in-situ data).
Furthermore the groups are providing input to an ECV inventory that is being set up by the CEOS WG on Climate. LPV groups are involved in several data-quality initiatives to define quality- information standards in terms of metadata and quality-assessment flags for eventually all remote-sensing products. Joanne Nightingale pointed out that an assessment of 'fitness for purpose' and ways of defining this within the product metadata needs to be conducted on a product-by-product basis.

First draft validation protocols exist for Leaf Area Index (LAI), land cover area change (via GOFC-GOLD), and burned area (via GOFC-Fire); for albedo members for the writing team have just been identified. The LAI validation protocol, for example, provides 104 detailed recommendations for best practice. These should be followed by CEOS agencies, LAI product producers, the scientific research community, and LAI product validation investigators. At the beginning of each LPV document its purpose is explained. The panel stressed that, in order to serve its purpose, the GTOS website needs to refer to these validation protocols.

Action 10: Make sure that the GTOS website adequately refers to CEOS Cal/Val activities. (GTOS Secretariat)

Joanne Nightingale also presented the OnLineInteractive Validation Exercise (OLIVE). This web-interface tool for independent validation of biophysical land products (LAI, fAPAR and Albedo) shall become operational later in 2012. It provides *in-situ* data and high resolution reference maps for validation and hopefully can attract submission of further validation datasets.

Finally, she explained how the Surface Radiation Focus Group plans to evaluate the representativeness of tower sites for comparing geo-statistical measures and high resolution imagery over various seasons. About 100 existing sites from the US National Ecological Observatory Network (NEON), the Baseline Surface Radiation Network (BSRN) and the Flux and Energy Exchange Network (Fluxnet) could be characterized (with and without leaf cover). However, the establishment of more instrumented sites would be required. The panel fully agreed the LPV groups' view that a global terrestrial reference network of multi-instrumented monitoring sites, with a sustained funding perspective, was essential. Such a terrestrial reference network could address scaling issues, and would greatly enhance the spatial and temporal understanding of satellite resources for Earth-system monitoring. Meeting participants mentioned that, as NASA already provides funding for validation activities associated with every satellite launch, the message about the practical use and high potential for improving forecasting skills of such a terrestrial reference network needs to go out to space agencies and data producers. The panel decided that more continuous interaction between CEOS LPV and TOPC, e.g. through an ex-officio member, was in the interest of GCOS and WCRP.

Action 11: Ensure continuous interaction between CEOS LPV and TOPC by inviting a CEOS LPV representative as ex-officio member. (GCOS & WCRP Secretariats)

6.3 Reference Network for Ecosystem Sites / Update on land fluxes

In conjunction with the previous topic, the discussion on setting up a reference network for ecosystem in combination with land-flux measurements was carried on. Following the discussions from the previous TOPC, session a concept note for establishing a reference network for ecosystem sites had been submitted to the scientific advisory committee of ESA's Climate Change Initiative (CCI) for request of support in the CAL/VAL programme. As a result of this, Prof. Riccardo Valentini, the GTOS Chairman, has been invited to present a final consolidated proposal at the next ESA scientific advisory committee (ESAC) meeting on May14 – 16 2012. Input from the panel members, as well as from the CEOS LPV community on the ECAC proposal (document 6.3) would be highly valuable.

Action 12: Provide feedback on the ESAC proposal for a surface site reference network. (TOPC & GTOS members & chairmen)

7. Review of Action Items from last year

Due to time constrains, this topic was not discussed in detail. The status of individual actions is described in the associated meeting document 7.1.

8. Items of Discussion

8.1 Discussion on TEMS database

The GTOS website serves as the entrance point for guiding and advisory documents, as well as for the database of Terrestrial Ecosystem Monitoring Sites (TEMS), which is not available for technical reasons since summer 2011. Site visitors are being redirected without any explanation to the Global Observing System Information Centre (GOSIC)[18] portal, what caused user complains. GCOS Secretariat as well as the US National Climatic Data Centre (NCDC) received several requests from users and station operators demanding access to TEMS. The panel urged GTOS to maintain its website and to re-launch the TEMS database.

8.2 Discussion on standards and guidelines for terrestrial

Dr Antonio Bombelli outlined the International Standardisation Organization (ISO) mechanism for standardisation of terrestrial ECVs envisaged by GTOS. He emphasised the flexibility of this process, in general and at this stage, as nothing has been submitted to ISO, yet. Currently, FAO is working with ISO with the main focus on land cover classification.

[18] Global Observing System Information Centre portal: http://gosic.org/

The uniform view of the panel was that GTOS is focusing on ISO standardization, a process which has changed significantly from what was planned earlier with regard to ECV standardization, and this might be the cause that the scientific community lost a lot of its interest in the activity. The following discussion reiterated the panel's concerns from the previous year that the attempt to establish an ISO standard-setting process was too far reaching and best practices needed to be established first. Otherwise, the standardisation process for terrestrial ECVs started with the UNFCCC might loose the necessary involvement of the scientific expert community, and therefore its ownership. This apprehension was shared by the GCOS Steering Committee, which at its last session in October 2011, expressed its concern "at the amount of work and expense required to establish standards for the terrestrial ECVs through a formal International Organization for Standardization (ISO) process and at the risk that emphasis on standardisation would divert effort from other tasks."

It was mentioned that WMO has been accredited as a standard setting organization, too, and even in the position to submit standards for the proposed ISO 'fast-track route'. Dr Isabelle Ruedi from the WMO Observations and Information Systems Department explained that no WMO document passed the ISO road, up to now. She described it as a balance of interest, because once going through the ISO process, one would have to work with all other players interested and might not be able to control where the standard would go. If no consensus, no agreement on a meaningful standard in the ISO process was reached, the situation for WMO, whose standards work very well in practice, could become very difficult. Dr Isabelle Ruedi again offered collaboration on standards for observations covered by WMO guides.

Meeting participants noted that the ISO mechanism was mostly tailored for industrial applications, not for operating in a scientific environment. If the GTOS standard documents did not reach large important user groups, e.g. in the frame of GEO, the creation of an ISO label would not make a difference. ISO standards might be good for data products, but would add a whole level of bureaucracy that potentially kills existing useful initiatives. On the other hand, Prof. Quegan, suggested for carbon trading a standard on the level of ISO would be truly needed.

Antonio Bombelli suggested an 'International Workshop Agreement' with ISO, which could start at a technical level and then lead into standardization. The meeting felt even this was too far reaching. In particular for the terrestrial variables, one was still very far away from the agreement on standards mature enough for ISO. The example of soil moisture was given, where no single documentation exists, even million dollar instruments are send to orbit.

In summary, despite fully acknowledging the need for standards, the panel raised serious concerns about the usefulness and appropriateness of the proposed ISO framework. TOPC members urged the GTOS Secretariat to circulate the ECV-standardization proposal for comments before its submission to SBSTA. The meeting recommended GTOS Secretariat to write this submission with the help of the GCOS Secretariat and input from WCRP. The SBSTA document should state a temporally hold off for the submission of ISO standards, as after extensive

consultation by GTOS and its partners, the ISO process is considered as a too ambitious road to perceive. It was rather seen useful to emphasize the need of maintaining the highest level of data quality and error estimates, as well as to guaranty data availability.

Action 13: Circulate ECV-standardization proposal before its submission to SBSTA. (GTOS & GCOS Secretariats with input from TOPC)

8.3 WMO-BIPM collaboration - report from recent WMO-BIPM Joint Liaison Group Workshop

Following the ISO standards discussion, Dr Carolin Richter briefly reported on the cooperation between WMO and the Bureau de Poids et Mesures (BIPM), which might offer an alternative approach for ECV standardization. The BIPM General Conference in October 2011 recognized the need for climate change studies to be traceable to SI units[19] and a WMO-BIPM joint liaison group workshop was held in February 2012 in Geneva.

BIPM standardization is provided through a peer-reviewed system. It evaluates how a given measurement method of an observable compares to SI. This is under the authority of National Metrology Institutes (NMIs), whereas ISO provides written standards on practices and processes that govern given tasks, including those at the downstream of measurements. Outcome of the meeting was that BIPM will start with some pilot ECVs, e.g., CO_2. BIPM will need a list of ECVs to know the current status of traceability chain for each of the ECVs. Current requirements based on the RRR are independent of measurement techniques. WMO will provide BIPM a list of observation technologies used for ECVs including information on the traceability chain, and identify where gaps exist between what is deliverable and the requirements. A second WMO-BIPM conference is planned for 2016.

The panel thanked Dr Richter for these explanations and decided to come back to this topic at future meetings.

8.4 RRR Database Requirements

The new WMO database for observational data requirements went on-line in summer 2011[20]. This database is the official WMO repository of requirements for observation of variables from space. It builds the foundation for the so-called Rolling Requirements Review (RRR) process, overseen by the Expert Team on Evolution of the Global Observing Systems (ET EGOS) of WMO's Commission for Basic Systems (CBS). The RRR database gives information on physical variables (not derived products), in terms of five criteria: horizontal resolution, vertical

[19] Resolution 2 of the BIPM General Conference, "On the importance of international collaboration so as to place measurements to monitor climate change on an SI traceable basis": http://www.bipm.org/en/CGPM/db/24/2/

[20] WMO database for observational data requirements : http://www.wmo.int/pages/prog/sat/Databases.html

resolution, observing cycle, timeliness and accuracy. For each of these criteria the table indicates three values:

- The 'threshold' is the minimum requirement to be met to ensure that the data is useful.
- The 'goal' are an ideal requirement above which further improvements are not necessary.
- The 'breakthrough' is an intermediate level between 'threshold' and 'goal' which, if achieved, would result in a significant improvement for the targeted application. The breakthrough level may be considered as an optimum, from a cost-benefit point of view, when planning or designing observing systems.

Participants stressed they preferred the approach followed in the GCOS Satellite Supplement that only describes the 'goal' value.

The panel members are invited to review definitions and values for observational requirements in their respective area of expertise and to provide feedback on the entries in the "RRR Database". An extract of the database entries for terrestrial variables was made available prior to the meeting in document 8.4.

Action 14: Provide feedback on the CEOS/WMO RRR database entries to GCOS Secretariat, who will pass on these corrections to the satellite programme. (TOPC members, WCRP data and modeling councils)

8.5 How to get more peer-reviewed papers on ECVs

The meeting briefly discussed how to stimulate peer-reviewed papers on ECV standards in order to more formally establish ECVs. Michel Verstraete identified 'Environmental Science and Policy' as a suitable journal for what could be developed as citable papers from the GTOS documents. He was asked to circulate a proposal among TOPC panel members how to publish ECV papers.

Action 15: Develop a proposal how to publish ECV papers and circulate it among TOPC panel members. (Michel Verstraete)

9. UNFCCC/ SBSTA related activities

The meeting decided this topic had been sufficiently discussed under item 8.2 before.

10. Upcoming Meeting

A list of upcoming meetings is maintained on the GCOS website under 'calendar'. Further discussions of this agenda item had to be dropped due to time constrains. It was decided to hold the upcoming TOPC-XV meeting on 7 and 8 March 2013 at WMO Headquarters in Geneva.

Annex I: Meeting Agenda

Item	Doc. No.	Presenter(s) (time slots include discussion)
Thursday 1 March		
9.00 – 10.30		
1. Opening of the Meeting		
1.1 Welcome and introductions		Zhang, Dolman
1.2 Adoption of Agenda	1.1	Dolman
1.3 Conduct of the Meeting		GCOS Secretariat
2. Update on programme activities		
2.1 GCOS Update	2.1	Richter
2.2 WCRP Update (new data council replacing WOAP; GEWEX activities)	2.2	WCRP Secretariat
2.3 WOAP Frascati Workshop	2.3	Dolman
2.4 Relations TOPC-GCOS, WCRP and GTOS		all
10.30 – 11.00 Coffee Break		
11.00 – 12.30		
GTNs-overview		
3. Cryospheric issues		
3.1 Update from the WMO-EC Expert Panel on Polar Observations, Research and Services; Global Cryosphere Watch and its relationship towards TOPC	3.1	Goodison
3.2 Ice Sheets / GTN-P	3.2	Steffen
3.3 GTN-G / WGMS	3.3	Zemp
12.30 – 14.00 Lunch		
14.00 – 15.30		
4. Hydrological issues		
4.1 GTN-H/lakes	4.1	Vuglinskiy

4.2 Hydrolare/Legos cooperation	4.2	Crétaux (from remote)
4.3 GTN-H	4.3	Grabs
4.4 GTN-R	4.4	Looser
4.5 Soil Moisture ECV	4.5	Wagner
15.30 – 16.00 Coffee Break		
16.00 – 18.30		
5. Carbon and Land Cover issues		
5.1 Fire Disturbance	5.1	Tansey
5.2 Biomass	5.2	Quegan
18.30 End of Day 1		
20.00 Group Dinner		
Friday 2 March		
9.00 – 10.30		
6. Reference Observations and Validation		
6.1 Report from GCOS Space Rapporteur	6.1	Fellous
6.2 CEOS Cal/Val activities	6.2	Nightingale
6.3 Reference Network for Ecosystem Sites / Update on land fluxes	6.3	Dolman
7 Review of Action Items from last year	**7.1**	**Dolman / all**
8. Items of discussion		
8.1 Discussion on TEMS database	8.1	all
8.2 Discussion on standards and guidelines for terrestrial ECVs	8.2	Bombelli / all
8.3 WMO-BIPM collaboration - report from recent WMO-BIPM Joint Liaison Group Workshop	8.3	Richter
10.30 – 11.00 Coffee Break		
11.00 – 12.30		
8.4 RRR database requirements	8.4	all

8.5 How to get more peer-reviewed papers on ECVs & ECV standards	8.4	Riccardo Valentini, Han Dolman & Shaun Queg
12.30 – 14.00 LUNCH		
14.00 – 16.00		
9. UNFCCC/ SBSTA related activities?	**9.1**	**GCOS Sec / GTOS Sec**
10. Upcoming meetings		all
Wrap-Up		
11 Closure		
11.1 AOB, Next session		
11.2 Adjourn		

Annex II: Meeting Participants

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Annex III: List of Actions

List of Actions		
No.	**Subject**	**Responsible**
1	Come up with a first proposal on how to bring an in-situ supplement forward; recommend to GCOS SC that the next IP will have a proper coverage of the in-situ component instead of producing a separate document.	TOPC Chairman together with AOPC & OOPC Chairs
2	Submit feedback on the ICSU Future Earth Initiative.	GCOS & WCRP Secretariats
3	GCOS to liaise with ICSU in the view to identify additional data centres for ECVs.	GCOS & ICSU Secretariats
4	Foster follow-up from the WOAP Frascati Workshop and more active engagement, in particular from the satellite agencies; re-launch a call to data centres.	GCOS & WCRP Secretariats
5	TOPC Chairman to get into direct contact with the Director of the Natural Resources Management and Environment Department (Alexander Müller) expressing the concern about the lack of institutional support for GTOS Secretariat before the meeting of WMO and FAO Secretary Generals on 22nd of March.	TOPC Chairman, GCOS Secretariat, FAO Liaison Office
6	Bring to the attention of GCOS SC that data centres are suffering from the amount of reporting obligations to different organizations and their programmes (GEO, GMES, EU Framework Projects, etc.); express the need for standardized reporting, e.g. though one centralized body.	TOPC Chairman, GCOS Secretariat
7	Maintain and increase cooperation of LEGOS/HYDROLARE for better visibility of both organizations.	LEGOS & HYDROLARE
8	Provide a small list of hydrological stations that could be supported from the GCM.	GRDC

List of Actions		
No.	**Subject**	**Responsible**
9	GCOS Secretariat and WMO/OBS to liaise with TOPC, Wolfgang Wagner in particular, to update the soil moisture part in CIMO standing literature.	GCOS Secretariat, WMO/OBS, Wolfgang Wagner
10	Make sure that the GTOS website adequately refers to CEOS Cal/Val activities.	GTOS Secretariat
11	Ensure continuous interaction between CEOS LPV and TOPC by inviting a CEOS LPV representative as ex-officio member.	GCOS & WCRP Secretariats
12	Provide feedback on the ESAC proposal for a surface site reference network.	TOPC & GTOS members & chairmen
13	Circulate ECV-standardization proposal (before submission to SBSTA)	GTOS & GCOS Secretariats with input from TOPC
14	Provide feedback on the CEOS/WMO RRR database entries to GCOS Secretariat, who will pass on these corrections to the satellite programme.	TOPC members, WCRP data and modeling councils
15	Develop a proposal how to publish ECV papers and circulate it among TOPC panel members.	Michel Verstraete

Annex V: TOPC Work Plan (2007 – 2011)

- To identify key ECV's that play a role in feedbacks (amplification and impacts) within the climate system (snow, glaciers, lake level) and reassess whether current approaches to their measurement is adequate.
- Increased attention on coordination and long term maintenance of *in-situ* networks to establish both independent bottom up datasets of ECV's and datasets required for calibration and validation of Earth Observation data.
- Investigate how a number of current research networks (e.g. Fluxnet, LTER's) can be effectively adopted (or endorsed) by GCOS/GTOS terrestrial networks.
- Promote the development of data integration and assimilation techniques for the terrestrial domain.
- Ensure that the five current Global Terrestrial Networks (hydrology, glaciers, permafrost, rivers, lakes) are fully implemented.
- Through GCOS and GTOS maintain strong links with SBSTA and UNFCCC and relevant international research programmes (e.g. WCRP, IGBP) in defining key requirements for observations of the terrestrial ECV's.
- Contribute to the 2009 GCOS progress report to the UNFCCC.
- Link with international opportunities to promote the need for continued observations such as the International Polar Year 2007-2008 (www.ipy.org), the International Year of Planet Earth 2007 - 2009 (www.esfs.org) and subsequent initiatives.
- Maintain engagement of CEOS to ensure delivery of required satellite observations as stated in the GCOS 107 report.
- Maintain engagement with efforts to establish international (continental) terrestrial observation networks.
- Liaise with GTOS wherever appropriate, e.g. in the establishment of guidelines and standards for the observation of terrestrial ECVs.
- Liaise with GCOS and GTOS science Panels on issues of common interest.

Annex VI: TOPC Terms of Reference (Status 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.

Members of the panel participate in several working groups assigned particular tasks. These are:

- AOPC/TOPC Working Group on Land-Surface/Atmosphere Issues (WG-LSA)
- Working groups foreseen in the new GTOS Implementation Plan, cross cutting different panels and dealing with, for example, vulnerable areas (coastal, mountains, wetlands) and land degradation.

Annex VII: TOPC Panel Members (Status March 2012)

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Acronyms

AGU	American Geophysical Union
BIPM	Bureau de Poids et Mesures
BSRN	Baseline Surface Radiation Network (WMO)
CBS	Commission for Basic Systems (WMO)
CBD	Convention on Biological Diversity
CEOS	Committee on Earth Observation Satellites
CCI	Climate Change Initiative (ESA)
CIMO	Commission for Instruments and Methods of Observation (WMO)
CliC	Climate and Cryosphere Programme (WCRP)
CLIVAR	Climate Variability and Predictability (WCRP)
CNES	Centre National Centre National d'Etudes Spaciales (France)
CNRS	Centre National de la Recherche Scientifique
CODATA	Committee on Data for Science and Technology (ICSU)
DIVERSITAS	International Programme of Biodiversity Science of the he Earth System Science Partnership
DUE	Data User Element (ESA)
EBVs	Essential Biodiversity Variables
ECMWF	European Centre for Medium-Range Weather Forecast
EC-PORS	Executive Council Expert Panel on Polar Observations, Research and Services (WMO)
ECVs	Essential Climate Variables
EGU	European Geophysical Union
ESRIN	European Space Research Institute (ESA)
ESSP	Earth System Science Partnership
ETN-R	European Terrestrial Network for River Discharge
FAO	Food and Agriculture Organization of the United Nations
FLUXNET	Flux and Energy Exchange Network
FAPAR	Fraction of Absorbed Photosynthetic Active Radiation
FRP	Fire Radiative Power
GAW	Global Atmosphere Watch (WMO)
GCM	GCOS Cooperation Mechanism
GCOS	Global Climate Observing System
GCW	Global Cryosphere Watch
GEO	Group on Earth Observations
GEOBON	GEO Biodiversity Observation Network
GFCS	Global Framework for Climate Services
GEWEX	Global Energy and Water Cycle Experiment (WCRP)
GIPPS	Global Integrated Polar Prediction System
GLIMS	Global Land Ice Measurements from Space initiative
GMES	Global Monitoring for Environment and Security Initiative

GOSIC	Global Observing Systems Information Centre (NCDC)
GOFC-GOLD	GTOS Panel on Global Observation of Forest and Land Cover Dynamics
GRACE	Gravity Recovery and Climate Experiment (NASA)
GRDC	Global Runoff Data Centre
GSN	GCOS Surface Network
GUAN	GCOS Upper-air Network
GTNs	Global Terrestrial Networks
GTN-G	Global Terrestrial Network for Glaciers
GTN-GW	Global Terrestrial Network for Groundwater
GTN-H	Global Terrestrial Network for Hydrology
GTN-P	Global Terrestrial Network for Permafrost
GTN-R	Global Terrestrial Network for River Discharge
GTN-SM	Global Terrestrial Network for Soil Moisture
GTOS	Global Terrestrial Observing System
HYCOS	Hydrological Cycle Observing System (WMO)
HYDROLARE	International Data Centre on the Hydrology of Lakes and Reservoirs
IACS	International Association for Cryospheric Sciences
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IHDP	International Human Dimensions Programme on Global Environmental Change
IGBP	International Geosphere-Biosphere Programme
IGOS	Integrated Global Observing Strategy
IP	Implementation Plan
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
ISMWG	International Soil Moisture Working Group
ISO	International Organization for Standardization
LAI	Leaf Area Index
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LTDRs	Land Long Term Data Record
LPV	Land Product Validation (CEOS)
MODIS	Moderate Resolution Imaging Spectrometer
NCDC	National Climatic Data Centre (NOAA)
NSIDC	National Snow and Ice Data Center (NSIDC)
NEON	National Ecological Observatory Network (USA)
NWP	Numerical Weather Prediction
OOPC	Ocean Observation Panel for Climate (GCOS/WCRP)
REDD	UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries

SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC)
SC	Steering Committee
SHI	State Hydrological Institute (Russia)
SMAP	Soil Moisture Active & Passive Mission (NASA),
SMOS	Soil Moisture and Ocean Salinity Mission (ESA)
SPARC	Stratospheric Processes And their Role in Climate (SPARC)
SPICE	Solid Precipitation Inter-Comparison Experiment (CIMO)
SWOT	Continental Water Monitoring from Space (CNES/NASA)
TCO	GTOS Panel on Terrestrial Carbon Observations
THORPEX	Observing System Research and Predictability Experiment
TOPC	Terrestrial Observation Panel for Climate
UNEP	UN Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WACMOS	Water Cycle Multi-mission Observation Strategy
WCRP	World Climate Research Programme
WDAC	WCRP Data Advisory Council
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)
WIS	WMO Information System
WMAC	WCRP Modelling Advisory Council
WOAP	WCRP/GCOS Observation and Assimilation Panel
WWRP	World Weather Research Programme (WMO)