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GCOS • WCRP

TOPC Terrestrial Observation Panel for Climate

19th Session of the GCOS /WCRP Terrestrial Observation Panel for Climate

(TOPC-19)

TU Wien, Vienna, Austria

5-7 April 2017

GCOS-209

WCRP-14/2017

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Note this report does not describe all the presentations but summarises the discussions and actions agreed. Presentations are made available at:

http://www.wmo.int/pages/prog/gcos/index.php?name=TOPC-XVIII

A summary of all the actions from the TOPC meeting and the joint session are included in Appendix 2

This report also includes tables of ECV requirements (Appendix 3). From the new Implementation Plan (GCOS-200).

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19th Session of the GCOS /WCRP Terrestrial Observation Panel for Climate

Vienna, Austria, 5-7 April 2016

NOTE: This report refers to presentations which are available on the web at http://www.wmo.int/pages/prog/gcos/TOPC-19.htm. The contents of the presentations are not included here, this is a report of the main points and agreements and decisions made at the meeting.

This report also includes tables of ECV requirements. These will be reviewed and updated in the new Implementation Plan until it is published, the report *The Global Observing System for Climate: Implementation Needs* (GCOS-200) be the definitive source of this information.

1. Welcome & Round Table

Wolfgang Wagner, Chair of the GCOS /WCRP Terrestrial Observation Panel for Climate (TOPC) welcomed the participants to the 19th TOPC meeting at the Department of Geodesy and Geoinformation (GEO) at the Technical University Vienna (TU Wien). He introduced the agenda, explaining that the larger thematic blocks in the agenda would be handled flexibly and an additional topic, the GCOS climate indicators, will be discussed. The agenda was accepted by the participants.

2. Introduction from GCOS SC Chair

Stephen Briggs, Chairman of the GCOS Steering Committee, welcomed the participants as well and thanked Wolfgang Wagner for hosting the meeting. He introduced GCOS in general for the new panel members and underlined the importance of the new GCOS Implementation Plan (*The Global Observing System for Climate: Implementation Needs*, GCOS-200), which describes also the work plan of the TOPC for the next years.

3. Aim of meeting

Presentation	
Wolfgang Wagner (TOPC Chair)	Aim of meeting

Wolfgang Wagner introduced himself as the new TOPC Chair following the departure of Konrad Steffen. TOPC-19 is the start of a new phase after the publication of the GCOS status report and implementation plan. There is a new political environment and budgetary limitations for GCOS and WCRP.

Following the decisions of the GCOS steering committee, the panel membership will be 3 years plus the possibility of one extension of 3 years. Exceptions are possible in special circumstances. There was an open call for members and this produced a good response. TOPC and GCOS would like to thank Ulrich Looser and Valery Vuglinsky for their membership and contributions since 2007 and hope we can collaborate with them in the future. There will be more new panel members next year.

This meeting will have to consider its work plan which will include

- A status report or similar in 4 years and update of IP in 5 years;
- Reviewing the performance of ECV observations and progress on actions in the implementation plan;
- Consideration of Adaptation Needs -> what does it mean for panel/observations;
- The proposal for Evaporation/Latent Heat Flux.

During the discussion it was stressed that the new work cycle of the TOPC after the release of the GCOS implementation plan will be challenging particularly because adaptation and mitigation will become increasingly important for GCOS. This also implies a shift in the expertise of the panel. Related parameters such as carbon flux measurements or human water use will be very relevant for global, regional and local policies. The important role of GCOS in IPCC was underlined.

4. Introduction of participants

- Darren Ghent see presentation. He is part of the National Centre for Earth Observation (NCEO) in the UK and leads the International Land Surface Temperature and Emissivity Working Group (ILSTE) which is monitoring the status of the Actions in GCOS-200. He introduced the state of Land Surface Temperature (LST) observations. This is relevant for the proposed GCOS Surface Reference Network (GSRN). The community are beginning to address the Actions in GCOS-200;
- Lijuan Ma see presentation. On behalf of the Global Cryosphere Watch (GCW) Lijuan Ma introduced the organization of GCW and her role. As it was the first time attending TOPC meeting, she introduced her background and relevant work in China: developing snow cover and sea ice monitoring products for more accurate climate prediction. Other terrestrial variables monitored in the National Climate Center and reported in their annual report were introduced briefly;
- Matthew McCabe see presentation. Irrigation is often neglected in modelling: for climate this has an effect at local to regional level while the on global scale the influence of irrigation is marginal. TOPC should still address this as it is important for adaptation, especially agriculture. As GTOS is absent there is no one looking at this;
- Nigel Tapper see presentation. Nigel is an Australia-based climate scientist with key interests in surface/biosphere - atmosphere interactions. He has a current focus on climate change adaptation, with particular emphasis on adaptation of global cities and populations to heat;
- Ulrich Looser see presentation. The sharing of hydrological data and information still poses major challenges to the GRDC. This is reflected in the difficulties with many national services to determine and confirm GTN-R stations. The decline of monitoring networks is often cited as a reason for lacking data, however, in many cases it is due to the inability to share data for a variety of different reasons. Modernising monitoring infrastructure is often neglected by national services. While private companies in the hydro-power and river navigation sectors monitor for their own needs: the data are rarely shared. In the navigation sector water level is more useful than discharge and so rating curves are not established. The GRDC only deals with quality assured data. Although real-time water level data are often posted on official websites, the increasing lack of experienced staff in hydrological services is causing delays in the quality control of these hydrological data;
- Valery Vuglinsky see presentation;

- Kevin Tansey see presentation;
- Hirouyoki Enomoto introduced himself. He is working at the National Institute of Polar Research, Japan;
- Nadine Gobron introduced herself. She works on radiative transfer modelling and improving the validation of data sets, including new protocols for in-situ measurements;
- Pierre-Philippe Mathieu is an oceanographer, working for the European Space Agency. His current research focuses on a new generation of data, which includes data generated by digital technologies like apps but also the use of artificial intelligence in the extraction and interpretation of data and tailoring the products to the needs of user.

5. GCOS Implementation Plan

Presentation	
Simon Eggleston (GCOS Secretariat)	GCOS work plan and GCOS implementation plan tasks for TOPC

The new GCOS implementation plan signals a shift in focus from supporting climate science to also supporting adaptation planning. Long-term targets for the 3 climate cycles carbon, water and energy have been agreed that will, if achieved, improve our understanding and monitoring of the climate processes. The science panels will need to focus on ensuring that the performance of the monitoring of ECVs is performed, monitoring progress on the action in the implementation plan and starting the process to review and refine the ECV product requirements. The panel agreed that supporting the requirements review process was important and should be supported by the panel.

Action	Who	When
1) Panel members shall actively support and encourage their community for contributions during the GCOS open call for comments and views on the ECV Product requirements as presented in the 2016 GCOS implementation plan.	All TOPC panel members	Second half of 2017

6. Copernicus Climate Change Service (C3)

Presentation	
Dick Dee (Deputy head Copernicus)	Copernicus Climate Change Service

The panel agreed that the Copernicus Climate Service is a very positive opportunity for GCOS, though cooperation mechanisms have to be clarified. In addition, the panel agreed to invite a quality control expert from Copernicus to the next TOPC panel meeting.

Action	Who	When
2) Ask Copernicus Climate Change Service if further input from TOPC is necessary at the current stage.	Secretariat	After approval of TOPC-19 meeting report
3) Invite Copernicus expert on quality control of the products to the next panel meeting to present their work on ECV product quality control to support TOPC actions on monitoring the quality of ECV observations.	Secretariat	When planning TOPC-20 meeting

7. Tasks from TOPC-18

Presentation

Simon Eggleston (GCOS Secretariat) Overview on tasks

Most of the task from TOPC-18 have been completed. The outstanding actions are dealt with in the agenda of this meeting (see Table 1).

Table 1. Actions from TOPC-18

Action	Who	When	Outcome
1) Encourage the use of air-borne observations with space and in situ observations to fill gaps. (Land Validation Product)	TOPC	ongoing	Ongoing
2) Look for areas of cooperation between TOPC and WIGOS	GCOS Sec	Next TOPC meeting	Working with WIGOS to include ECV requirements into OSCAR. WIGOS can contribute to GCOS by monitoring network performance for some ECVs (hydrology and cryosphere)
3) Improve description and specification of uncertainty	TOPC	new IP	Done
4) Discuss possible attendance of TOPC at GCW Steering Committee	GCOS Sec & TOPC Chair & GCW	June 2016 (WMO EC)	Done – GCW representative at this meeting

Action	Who	When	Outcome
5) Letter about continued support for ISMN	GCOS Sec	ASAP	Done
6) Proposal to change "Land Cover" to "Land Cover & Use" was rejected but text in new Implementation Plan to discuss derivation of land use for land cover.	GOFC_GOLD & TOPC	IP	Done
7) Send letter of concern about continued funding GTN-P signed by TOPC Chair	GCOS Sec TOPC Chair	ASAP	Done
8) LST was agreed and actions and requirements should be included in the new Implementation Plan	TOPC CEOS/ CGMS WG Climate	IP	Done
9) Adopt the proposed description of the Fire disturbance ECV in future and in the new Implementation Plan	TOPC	IP	Done
10) ECV: Water Use. Agree to refocus on all uses. Support pilot projects	TOPC	IP	Done
11) ECV: Anthropogenic GHG Emissions, ask working group to produce justification and specification before next SC for potential inclusion in new Implementation Plan	Shaun/ Sassan/ Simon/ Stephen	Now - Sept 2016	Included in new IP
12) Technical workshop on consistency between ECVs (e.g. Fire and Albedo)	GCOS Sec	2017	agenda 7.3
13) ECV: Heat Fluxes. ask working group led by Han to produce justification and specification before next TOPC meeting for consideration at next TOPC meeting	Han …	Next TOPC meeting	Done – Han to report – agenda 7.1
14) It was agreed to include Lake Surface Temperature, ice extent and lake colour as part of the Lakes ECV in the new Implementation Plan.		IP	Done
15) Specification of all Terrestrial ECV, based on existing material (e.g. unpublished technical supplement to 2004 plan, GTOS brochures) to be published.	GCOS sec & TOPC	2017/8	This meeting to consider this action - agenda 9?
16) Experts to report to TOPC before meeting on status of ECV observations. Experts to be allocated		Next TOPC	Topic a main point on this meeting's

Action	Who	When	Outcome
to each ECV.		meeting	agenda – agenda 9
17) Need to agree on a rotation cycle for TOPC membership and balanced composition	GCOS Sec & SC	Oct 2016 (SC)	SC agreed normally 3-year term, possibly followed by a second 3-year term. Some flexibility for longer terms
18) Include action on use of DOI in new Implementation Plan	GCOS Sec	NOW	Done
19) Find out about use of DOI on GCOS Reports	GCOS Sec	June 2016	Done
20) Discuss joint meeting of TOPC and OOPC at GOOS SC June 1st	GCOS SC Chair	June 1st	SC agreed and TOPC will discuss proposal at this meeting – coastal zones – agenda 7.2

7.1 Terrestrial Heat Fluxes

Presentation

Han Dolman (Task Force on Latent and Sensible Heat from Land) Evaporation

Han Dolman proposed *Evaporation from Land* as an ECV. TOPC-19 considered the paper *Proposal for evaporation/latent heat flux as ECV* submitted by Han Dolman, Diego Miralles, Carlos Jimenez & Matthew McCabe. TOPC noted that accurate knowledge of evaporation is important for closing the water, energy and carbon cycles. It is used to, inter alia:

a. diagnose the influence of the land surface on air temperature;
b. constrain estimates of convection and cloud formation in the troposphere;
c. understand the relevance of water vapour, lapse rate and cloud feedbacks;
d. unravel the two-way interaction between vegetation and climate;
e. monitor drought and heatwave occurrence and their impacts;
f. benchmark climate model representation of these processes.

TOPC noted that, while there are analogous ECV products for the oceans, the land is more heterogeneous than the oceans.

Table 2. Oceanic Latent and Sensible Heat fluxes from the GCOS implementation plan (GCSOS-200)

ECV	Products	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)
Ocean surface heat flux	Latent heat flux	Hourly to monthly	1–25 km	10–15 Wm^2	1–2 Wm^2
	Sensible heat flux				
	Radiative heat flux				

TOPC agreed that *Evaporation from Land* should be a new ECV.

TOPC agreed the following requirements for *Evaporation from land* and its component ECV products:

Table 3. ECV Product requirements for proposed new ECV: Evaporation from land

ECV	Products	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)
Evaporation from land	Latent heat flux	sub-daily, latency of less than 1 month	threshold 25km goal 1km	<10%	Better than 1%
	Sensible heat flux				

During the discussion, addressing the question if the products related to evaporation are mature enough for proposing it as an ECV, it became evident that evaporation can be measured with acceptable uncertainty. It was decided to propose evaporation with the products sensitive and latent heat flux and their measurement requirements to the GCOS steering committee.

Action	Who	When
4) Convey proposal of new ECV on evaporation from land including the products and requirements to the GCOS steering committee for approval.	Secretariat	For GCOS steering committee meeting in September 2017

7.2 Coastal Waters

Presentation

Simon Eggleston (GCOS Secretariat) Cooperation with OOPC

The coastal zone is important to the climate system and is covered by separate ECVs from both the terrestrial and oceanic domains. It is an important carbon pool with land categories such as mangroves, salt marshes and sea grass included in *Above Ground Biomass* and *Land Use.* Significant flows of water (through groundwater) and carbon (through river discharge) are currently unmonitored.

The panel agreed that while the coastal zone is a very important domain at the interface of ocean, (e.g. as spawning zone for fish and hence for food production, river discharge of nutrients and soil carbon into oceans) more information on needs and options between the panels is needed to strengthen the collaboration. It was noted, that the Land-Ocean Interactions in the Coastal Zone (LOICZ) project covered the coastal zones in the past and has changed its name to Future Earth Coasts.

Action	Who	When
5) Consider having a teleconference between relevant TOPC members and the biogeochemistry panel of the OOPC.	Secretariat, Wolfgang Wagner	June 2017
6) Ask OOPC for data needs from terrestrial communities in order to take future steps.	Secretariat	Immediately
7) Identify and invite coastal expert from OOPC for next TOPC meeting in order to clarify options for collaboration.	Secretariat	When planning TOPC-20 meeting.

7.3 Cross-validation of ECV products

Presentation

Nadine Gobron Cross-validation

Cross validation of ECVs includes first benchmarking of the same ECV from different sources taking into account uncertainties over various spatial and temporal resolution. The respective retrieval algorithms require validation against definition and assumptions. Physical, temporal and spatial consistencies between changes of different ECVs need to be assessed across various sources.

The panel agreed that physical consistency is not only an issue for the presented LAI but also for other ECVs such as albedo and surface temperature. It was decided that a report based on Nadine Gobron's work should be written as basis for further discussion and in order to tackle this issue in the next cycle of the Implementation Plan.

Action	Who	When
8) Prepare report for next TOPC meeting on physical consistency of ECVs, including a proposal on a way forward.	Nadine Gobron	For TOPC-20 meeting in 2018

8. Earth Observation Data Centre for Water Resources Monitoring

The host organized a trip to the newly established Earth Observation Data Centre for Water Resources Monitoring, where experts introduced the participants to the new high performance computing cluster. The panel expressed the gratitude about the very interesting excursion and the kind welcome at the centre.

9. How to review the performance of ECV observations

9.1 Science Perspective from an ECV producer

Presentation	
Wolfgang Wagner	ECV production

The panel agreed that in order to monitor the use of ECV datasets, a traceable monitoring system is necessary. A standard method like counting citations using DOI is not feasible for all ECV datasets, since some like discharge data from the GRDC, where the organisation is only the custodian of the data and the rights stay with the producing National Hydrological Service. To solve this problem other data monitoring options should be explored.

Action	Who	When
9) Review available tools for monitoring the use of datasets.	Wolfgang Wagner	For TOPC-20 meeting in 2018
10) Develop proposals on how to ensure that data citations should be traceable to original versions and software.	TOPC chair and GCOS secretariat	By TOPC-20 in 2018
11) The panel members should check for their domain if all data sets come with DOI and if citations are traceable.	TOPC panel members	By TOPC-20 in 2018

9.2 Role of Global Cryosphere Watch & possible cooperation with GCOS

Presentation	
Rodica Nitu (via internet)	GCW

The Global Cryosphere Watch is a mechanism established by the World Meteorological Organization to enable the availability and exchange of demonstrated quality cryosphere data and products from the polar and high mountain regions of the globe. Currently under development, GCW is expected to be fully functional by 2020. Recommended best practices for measurements and observations, and data and metadata consistency and exchange will be made available widely to ensure the expected

level of quality and availability. GCW is aiming at working with a broad range of stakeholders, including research organizations, and international projects. One activity of relevance for GCOS is historical data rescue.

GCW has developed recommendations on the minimum observing program for the stations in its network, taking into account the recommendations of the GCOS IP.

Rodica Nitu highlighted the current state of the observation system and the collaboration between GCW and other groups such as GTN-P and on the detailed work plan of GCW. The panel expressed its appreciation for the ambitious agenda of GCW. The improvement of observations from the cryosphere will help to close gaps in the current observation systems and the panel ensured support for GCW where necessary and possible.

9.3 ECV monitoring

Presentation	
Michael Zemp	Approaches in the cryosphere

The presentation discussed the advantages of having a steward institution or consortium for each ECV and, possibly, formalizing the relationship with GCOS (e.g. MoU)). It was also proposed that TOPC should ask for annually updated indicator graphs for each ECV which could be used as a basis for a set of GCOS Climate Change Indicators (see sections 11 and 12.3). It will also be important to introduce regular checks on data access by all the GCOS science panels.

It was agreed that TOPC should identify steward institutions for each ECV, who would also annually report on the ECV e.g. with an indicator graph. This would tackle some of the fundamental questions of GCOS on observational performance. The process was discussed later in the agenda (see 12.4).

9.4 The Role of GTN-H in coordinating observations

Presentation	
Wolfgang Grabs	GTN-H

As a “Network of Networks” for global and regional climate and water applications, GTN-H links existing terrestrial observation networks for integrated observations of the global water cycle. One of its goals is to facilitate access to water-related ECVs including through standardized approaches. GTN-H covers all water-relevant ECVs with the exception of evapotranspiration. GTN-H successfully promotes the generation of data products through its federated data centres. However, there is currently an insufficient capability to facilitate the production of multi-database products mainly as a result of resource issues both for the data centres and for support for the coordination of GTN-H.

A critical requirement for water-related ECVs is the definition of global core networks for essential in-situ observations and including linkages with satellite-based observations. This would go a long way to focus data acquisition from Members for the global data centres. Likewise, through the involvement of a wider GCOS community, the actual use of the data provided through the federated global data centres of GTN-H needs to be documented in a transparent manner.

It was agreed that the broader community, and including existing observation networks, should be involved in the process to determine ECV product requirements as also proposed by the GCOS secretariat.

9.5 WMO on hydrological coordination

Presentation	
Tommaso Abrate (via internet)	WMO coordination

Hydrological and hydrometric activities, especially but not limitedly in developing countries suffer from two types of weakness: a) infrastructural, due to ageing network and instrumentation, discontinuation of station with long historical series, insufficient QA/QC and data management practices and b) institutional, due to the limited visibility of NHSs, lack of awareness by decision makers of the importance of hydrological information which results in insufficient funding and staffing of the services themselves.

WMO has established in 2016 the HydroHub, (Global Hydrometry Support Facility) federating existing and new WMO's activities and programmes which addresses all the elements of the value chain from data observation and collection, management, archiving and rescue, distribution and sharing, as well as development of relevant innovative technologies. Particular emphasis in now placed on the development of a Quality Management Framework, including standards and recommended practices, and the further development of the WMO Hydrological Observing System from the present portal to the online (meta)data of National Hydrological Services (NHS) to a coordinated service allowing storage of hydrologic observational data, publication via web services on the internet, federation with hydrologic observations published by NHSs, and search across the various data holdings in the network.

10. How to Review Progress of GCOS implementation plan actions

Presentation	
Simon Eggleston	GCOS implementation plan actions

An important role for all the science panels including TOPC is to monitor and review progress in all the actions in the implementation plan. These actions are contained in the relevant chapter (Terrestrial Observations for TOPC) but also in general actions for all the panels covering a range of topics such as adaptation, climate indicators, ensuring the performance of ECV observations is monitored and reported and data stewardship, open access and discoverability.

The ECV anthropogenic water use was discussed and the fact that it does not only represent the climate was raised. The panel agreed, however, that anthropogenic water use is especially relevant for adaptation planning. ECVs are not just physical parameters but also cover drivers of climate change and socio-economic factors. Climate change cannot be considered without including the human dimension.

10.1 Cryosphere

Presentation	
Hiroyuki Enomoto	Cryosphere

Actions T19-T34 in the implementation plan relate to the cryosphere and a mechanism is needed to ensure that progress is monitored. Monitoring the cryosphere requires a combination of in situ and satellite observations and, while funding remains an issue, improvements in satellite observations

are anticipated in the near future. The full implementation of the Global Cryosphere Watch (GCW) in 2020 and developments in WIGOS should also help maintain quality assured in situ observations.

10.2 Hydrosphere

Presentation	
Ulrich Looser	Hydrosphere

Actions T6 to T17 of the 2016 GCOS implementation plan are covering the ECVs Lakes, River Discharge, Groundwater and Soil Moisture. To a large extent the in situ monitoring of these ECVs is done by National Services with many of them reluctant to share data with data centres and the research community. TOPC and GCOS can promote the supply of data from National Services to the scientific community and to the international data centres with the assistance of commissions and bodies such as the WMO CHy. Awareness for proper funding of the data centres can be raised by TOPC and GCOS to ensure continued operations. Remote sensing capabilities are constantly improving to complement in situ monitoring of the hydrosphere EVCs and the development of new techniques and tools must be carefully monitored by GCOS and TOPC.

Improved data acquisition from in situ networks and from remote sensing platforms will result in useful ECV datasets for product development supporting management decisions and actions. Regular reporting to TOPC needs to be done on ECV network and database development, as well as on the development of tools and products derived from either purely remote sensing or an integration of remotely sensed and in situ data.

10.3 Biosphere

Presentation	
Kevin Tansey	Biosphere

The panel considered the monitoring of ECV requirements and the proposal to use a wiki or a dedicated website was raised. To allow the community access but to keep spam to a minimum, access should be limited. This was further discussed in the breakout sessions and in 12.4.

10.4 Breakout group discussions (Hydrology, Cryosphere and remaining ECVs) on how to monitor actions in the GCOS implementation plan

10.4.1 Biosphere

Participants of group discussion: Darren Ghent, Nadine Gobron, Kevin Tansey, Valentin Aich

Presentation	
Group biosphere	Discussion results

It was noted that the group is missing an expert on Soil Carbon.

The group agreed that before TOPC-20 it will:

1. Confirm that the requirements are fit for purpose if not modified in the past review for ECVs for the current IP;
2. Write a narrative around the requirements and evaluate other domain areas. Ensure requirements are well defined;
3. Prepare a short phase 1 report that scopes out the cross-cutting adaptation action that describes a pathway to evolve ECV products to meet needs, key stakeholders, funding and way forward to develop case studies in domain areas.

After presenting the results of the group session, it was decided to continuously work on the biosphere tasks until the next GCOS implementation plan is established. Therefore, a working group will be established under the lead of Nigel Tapper. In order to facilitate the requirements discussion, an online platform will be established.

Action	Who	When
12) Nigel Tapper to lead the group that will continue to further develop a way to include adaptation requirements.	Nigel Tapper	Interim report for TOPC-20 meeting in 2018
13) Establish online platform for interactive discussions on ECV requirements for community.	Wolfgang Wagner	Have demonstration running by end 2017

10.4.2 Cryosphere

Participants of group discussion: Michael Zemp, Hiroyuki Enomoto and Lijuan Ma.

Presentation	
Group cyrosphere	Discussion results (link to presentation)

Responsibilities were assigned as follows:

- Snow: Tom Painter, Jet Propulsion Laboratory;
- Ice Sheets: Hiroyuki Enomoto, National Institute of Polar Research;
- Permafrost: Hugues Lantuit, Alfred Wegener Institute;
- Glaciers: Michael Zemp, University of Zurich;
- Lake and river are partly covered by ECV lake;
- Sea ice covered by OOPC;
- Seasonal frozen ground not covered.

It was agreed that currently the Cryosphere is covered by panel members. However, there might be a need to invite experts for cryosphere-ocean and cryosphere-atmosphere interaction. GCW is open for input from and collaboration with TOPC/GCOS and this link should be pursued.

Main actions for TOPC-20 meeting:

- Add explanation for all requirements in GCOS 2016 IP (Panel members make draft for 2018 meeting);
- Assign responsibility for all action items in GCOS 2016 IP (Panel members make draft for 2018 meeting; responsibility: in panel & outside);
- Find steward consortia for each ECV (Map existing, find consortium where missing (starting points for finding stewards: ESA CCI, Copernicus, NASA project, ICSU/WDS, …));
- Get one indicator graph for each ECV as a basis for GCOS indicator selection (Ask stewards to suggest a regularly updated key graph; set up a GCOS dashboard);
- Make (annual or quarterly?) checks for data access (Break-out group at next panel meeting);
- How to communicate between panel meetings?
- How to (better) reach out to the research communities?

The group assigned responsibilities for actions in the GCOS implementation plan related to Cryosphere (a number of groups/organisations still need to be identified):

- Michael Zemp
  - Maintain and extend the in situ mass balance network (T19) => WGMS => capacity building& twinning
  - Multi-decadal glacier inventories (T23) => GLIMS/RGI
  - Observations of glacier velocities (T27) => NSIDC/space agencies
  - Allocate additional resources to extend the geodetic dataset (T24) => C3S
  - Global glacier inventory (T22); => GLIMS/RGI
  - Glacier observing sites (T26) => WGMS
  - Extend the glacier-front variation dataset both in space and in time (T25) => WGMS
- Hiroyuki Enomoto
  - Snow-cover and snowfall observing sites (T28);)(and Tom Painter ?)=> GCW,
  - Ice-sheet model improvement (T31) => ?
- Hugues Lantuit
  - Mapping of seasonal soil freeze/thaw (T34) => ?
  - Standards and practices for permafrost (T33) => ?
- Tom Painter
  - Integrated analyses of snow (T29) Tom painter => ?
  - Ice-sheet measurements (T30) => ?
- Tbd, GCOS
  - Improve the funding situation for international glacier data centres (T20) => ?
  - Encourage and enforce research projects to make their ECV-relevant observations available through the dedicated international data centres (T21) GCOS => National Science Foundations
  - Continuity of laser, altimetry and gravity satellite missions (T32) possibly GCOS/EC-PHORS => space agencies

Action	Who	When
14) Assign responsibility for all cryospheric action items in GCOS 2016 implementation plan. Identify steward consortia for each ECV.	Michael Zemp, Hiroyuki Enomoto, Tom Painter Hugues Lantuit	TOPC-20 meeting in 2018
15) Ensure communications between cryosphere experts on TOPC to coordinate their activities	Michael Zemp, Hiroyuki Enomoto, Tom Painter Hugues Lantuit Simon Eggleston	June 2017
16) Tom Painter, Hugues Lantuit and Sassan Sacchi shall be contacted by the secretariat on their future involvement in the TOPC.	Simon Eggleston	May 2017

10.4.3 Hydrosphere and Human use of natural resources

Participants of group discussion: Ulrich Looser, Valery Vuglinsky, Wolfgang Grabs, Wolfgang Wagner, Matthew McCabe, Simon Eggleston.

Presentation	
Group hydrosphere	Discussion results

Table 4 Data Centres Identified

ECV	Corresponding data centre
Lakes and Reservoirs	HYDROLARE
Groundwater	IGRAC
Soil Moisture	TU Wien
River discharge	GRDC

Table 5. Identified individuals for reporting

ECV	GCOS implementation plan Task	Person
Soil Moisture	15, 16,17,18	Wolfgang Wagner
Lakes and Reservoirs	8,9,10	Valery Vuglinskiy
Satellite Lake and Reservoirs (and rivers with SWOT)	8,10	Jean-Francois Cretaux (CNES/LEGOS)

ECV	GCOS implementation plan Task	Person
River discharge	11,12	Ulrich Looser
Groundwater	13,14	Nienke Ansem
Satellite, Groundwater	14	?
Evaporation (Terrestrial & remote)	No task in current IP	Matthew McCabe
Anthropogenic water use	65,66	Wolfgang Grabs to find somebody at FAO and/or WHO
Anthropogenic GHG fluxes	67 – 71	Simon Eggleston to find suitable persons

Action	Who	When
17) Draft requirements table for soil moisture as example for all other terrestrial ECVs	Wolfgang Wagner	June 2017
18) Provide short text that explains or justifies ECV requirements for each ECV	All panel members,	TOPC-20 meeting in 2018
19) The secretariat will establish process for contributions to GCOS (e.g. IP) can be cited similar to the process of contributing authors in the IPCC reports.	Simon Eggleston	July 2017, for decision be steering committee, October 2017

11. Climate indicators

Presentation	
Stephen Briggs	Summary of discussion

TOPC agreed that deforestation should not be an indicator as its relationship to climate change is too complicated. Other potential indicators related to phenology were also discussed (see Table 6) but, while they are very useful at a local and regional level, given the regional differences in phenology they were unlikely to provide an easily understood indicator. TOPC agreed that an indicator related to phenology would be a good addition but could not identify such an indicator at this meeting. TOPC also noted that glacier mass balance, based on the world glacier monitoring service (wgms) reference glaciers[1] would also be a good indicator, but this overlaps with the ice and snow coverage.

TOPC did agree with the remaining list of indicators.

[1] http://wgms.ch/latest-glacier-mass-balance-data/

11.1 Cryosphere – Global Cryosphere Watch (GCW).

To be concise and clear only a few, representative, climate indicators are needed. GCW suggested picking up one, at most two, climate indictors from each terrestrial group. Snow cover extent would be the first one to be recommended because it makes much more sense to public than others such as permafrost active layer thickness. In addition, it's relatively easy to compile the climate indicator from the GCW minimum observation requirements. Otherwise TOPC may need to raise observing requirements with GCW according to decided indicators.

GCW discussed if one indicator is enough for cryosphere; e.g. sea ice extent and area of land covered by snow and ice. Other possibilities are glacier mass balance, sea ice extent, snow cover. The meeting agreed that Arctic and Antarctic ice should be reported separately as this would avoid cherry-picking and be more transparent. The responses of sea ice in the Arctic and Antarctic are different and have differing seasonality.

GCW noted there are other potential indicators such as:

- ice sheet volume;
- permafrost active layer thickness;
- glacier mass balance;
- freshwater lake freeze-up/break-up dates (at least selected lakes).

Table 6. Proposed biosphere indicators

	DEFORESTATION	BREATH OF THE EARTH
Topic	Land use/ vegetation	Land use/ vegetation
Headline Indicator	Deforestation (area per year)	Biosphere and Climate Indicator - the Breath of the Earth, Greening of the Earth
Baseline	Average of previous 10 years or average of previous decade (i.e. 2000-2010)	
Subsidiary Indicators	Broken down by region/major ecosystems and for main change types (i.e. fire), maybe a IPCC Tier 1 carbon emissions estimation	Indicator could, at a minimum be produced with an annual update (if integrated across growing season) , but seasonal/monthly anomalies could also be produced. Links can also be made to amplitude of atmospheric CO2 i.e. the breath (esp. terrestrial), following early and more recent works. E.g. http://www.nature.com/nature/journal/v382/n6587/abs/382146a0.html and http://science.sciencemag.org/content/early/2016/01/20/science.aac4971.

	DEFORESTATION	BREATH OF THE EARTH
Notes	As GCOS TOPC member, GOFC-GOLD is willing to coordinate the establishment of this indicator. Important to note that this indicator could be interlinked with SGD indicator 15.1.1: Forest area as a proportion of total land area.	The media have picked-up and well-covered recent scientific studies on these topics e.g. see http://www.bbc.com/news/science-environment-36130346, if there is interest Copernicus (e.g. C3S) and/or JRC could host dedicated workshop. This could include relevant UN agencies and programmes (WMO, GCOS, GOFC-GOLD, GOOS, GEO) other international partners (NOAA, NASA etc.) and members of the scientific community. Ideally the indicator should represent a quantity that can be derived equivalently over land and ocean. Ideally this could be NPP/GPP, but this probably still has too many additional uncertainties, so a suggestion would be for a photosynthetic absorption coefficient, with could be directly determined from the available ECVs and integrated for land and ocean over the growing season or annually. This would inform the general public on the interactions and feedbacks between the biosphere and the rest of the climate system link to agriculture, land and ocean resource management, biodiversity and as a consequence the SDGs life below water, life on land. Link also to other UN conventions UNCCD, CBD. Also linked to IPCC WGII.
Availability	Derived from satellite data time series using Landsat/Sentinel regular monitoring. So far only University of Maryland/Global Forest Watch (GFW) is providing annual updates in tree cover loss on a regular basis but that will be a starting point. Integration of data from FAO-FRA will have to be considered. Expectation is that this headline indicator will stimulate monitoring programs (i.e. from ESA/EU) to improve their efforts/services to improve reporting on this indicator over time.	Based on cross domain datasets for land and ocean, for land the primary data source from ECVs is FAPAR and LAI and for oceans is the Ocean Colour ECV with ECV products for Water Leaving Radiance and Chlorophyll. For all these there are long-term commitments for the required input data (which is the same for land and ocean) covered by the mid-resolution multispectral imagers typical of Sentinel-3/VIIRS type present in confirmed roadmaps for the next 20+ year a as well as in WIGOS Vision for 2040. The indicator would be produced integrated over the globe, but regional and domain specific assessments could also be considered. These could include, across land and ocean, latitudinal zones, (high-lat, temperate, tropics), for hotspot areas i.e. notable sinks regions in ocean and land and/or for specific land class groupings and ocean biomes. The ECV products used are all based on satellite data input and there could be produced very rapidly following the end of a given time period. The indicator should have a “common scale” across land and ocean, it could be routinely presented with “biosphere animations” i.e. spinning globe of land-ocean greenness (from ECVs), hotspot updates i.e. sink areas and for terrestrial domain integration with land cover data.

Table 7. Historic Indicators following discussions by GCOS science panels (references in endnotes)

Topic	Headline Indicator	Baseline	Subsidiary Indicators	Notes	Availability
Temperature and Energy	Global surface temperature	Pre-industrial temperatures	Top-of-the-atmosphere energy balance	The near surface temperature is important for political process, is a target of the Paris agreement, and is well understood by public. Need a more understandable name for top-of-the-atmosphere energy balance	NOAA, NASA, UK Met Office
	Ocean Warming: 0-2000m ocean warming (how to express tbd)	data from 1970 onwards	0-700m ocean warming – has the advantage of a much longer time series.	Is "Ocean Warming" the best phrase to use? What units to express it in? (suggestions include: Wm-2 relative to Earth's surface area (what does this mean SE???); and ocean warming in °C and include conversion to equivalent atmospheric warming?)	Reconstructed gridded products from various institutes (e.g.CSIRO, NOAA) and Argo-based products are available - http://www.argo.ucsd.edu/Gridded_fields.html
Atmospheric composition	Atmospheric CO2 (ppm)	Pre-industrial	Methane, N20, hydrogenated greenhouse gases	While mole concentrations are measured this not widely understood: talk about concentrations for wide understanding	GAW
Oceans	Sea Level Rise	1870	Ocean Acidification,	Reconstructed from a combination of tide gauges and satellite altimetry	CSIRO & others
Cryosphere	Arctic and Antarctic Sea Ice Extent separately	1980	Arctic and Antarctic sea ice extent	The hemispheres must be reported separately, differences in behaviour & timing could misrepresent the change. Often the annual changes in the two hemispheres offset each other to some degree. Reports in terms of minimum, maximum or rate of change could be more relevant when reporting to the public.	Regularly reported by a number of agencies (e.g. National Snow and Ice Data Center, JAXA-National Institute for Polar Research, etc
	Area of land covered by snow and ice, for the N and S Hemispheres,	1980 (selected for consistency with the sea ice)	Snow and ice anomaly trackers	Snow Anomaly trackers: Near real-time tracking of NH SWE from GlobSnow (FMI) and the CMC daily snow depth analysis (ECCC)	reported by several agencies (e.g. National Snow and Ice Data Center; ECCC; not available for SH
Extremes	Heatwaves			Heatwave magnitude index[a]	WMO CCI
	Extreme Rainfall			As 95% percentile of rainy days >1mm[b]	
	Drought			GPCC Drought Index[c] (based on SPI and SPEI)	

Notes

a) Heat wave magnitude index: -Russo, S.; Dosio, A.; Graversen, R. G.; Sillmann, J.; Carrao, H.; Dunbar, M. B.; Singleton, A.; Montagna, P.; Barbola, P.; Vogt, J. V. (2014) Magnitude of extreme heat waves in present climate and their projection in a warming world. J. Geophys. Res. Atmos. 2014, 119, 12,500-12,512.
or alternatively see
Coumou D. and Robinson A.(2013) Historic and future increase in the global land area affected by monthly heat extremes, 2013 Environmental Research Letters, Volume 8, Number 3

b) Karl, T.; Nicholls, N.; Ghazi, A. (1999) Clivar/GCOS/WMO workshop on indices and indicators for climate extremes workshop summary. Weather Clim. Extrem. 1999.
and
Albert Klein-Tank; Francis W. Zwiers; Xuebin Zhang (2009) Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation. Clim. Data Monit. 2009, 72.
And see:
http://www.eea.europa.eu/data-and-maps/indicators/precipitation-extremes-in-europe-3/assessment/#indicator-definition

c) M. Ziese, U. Schneider, A. Meyer-Christoffer, K. Schamm, J. Vido, P. Finger, P. Bissolli, S. Pietzsch, and A. Becker (2014) The GPCC Drought Index – a new, combined and gridded global drought index, Earth Syst. Sci. Data, 6, 285–295, 2014 www.earth-syst-sci-data.net/6/285/2014/ doi:10.5194/essd-6-285-2014

12. Any other business (AOB)

12.1 Progress on coordination of in-situ terrestrial observations with ICSU and GEO

Presentation	
Simon Eggleston	Progress

That coordination of terrestrial observations would have both economic and scientific benefits including increased efficiency and cost savings; wider use of standards and guidelines leading to improved accuracy; and greater interoperability and use of the data collected. It is important that the GCOS secretariat keeps the panel informed of developments, especially ensuring their involvement in a proposed workshop with a broad participation.

12.2 Global Surface Reference Network

Presentation	
Simon Eggleston	Progress

AOPC has prepared a proposal for a GCOS Surface reference network based on the GRUAN but focusing on surface measurements, both atmospheric and terrestrial. Initial ideas are to have a number of sites measuring precipitation and temperature together with one or two sites simultaneously measuring a wide suite of atmospheric and terrestrial ECVs. AOPC has setup a task force to further develop these ideas and would like the involvement of TOCP in this work.

Action	Who	When
20) Put Nigel Tapper in contact with Peter Thorne about the GCOS Surface Reference Network	Valentin Aich	After meeting.

12.3 ECVs and TOPC web presence

It was proposed that TOPC, as part of the proposed web presence, present several ECVs or indicators, on a trial web site. Several members who were in a position to do so, agreed to monitor and deliver an indicator for an ECV per year as shown in Table 8.

Table 8. Proposed ECV or indicators for initial TOPC web site

Name	Indicator or ECV
Wolfgang Wagner	Soil moisture as deviation from long term mean
Darren Ghent	Temperature (as anomaly), possibly as comparison to screen temperature
Nadine Gobron	FAPAR based on anomaly
Michael Zemp	Glacier mass balance
Kevin Tansey	Hazard, fire disturbance, transport plumes, land cover change
Nigel Tapper	Heat extremes, Potentially something additional relevant for adaptation
Valery Vuglinsky	Lake level for 60 largest lakes

It was agreed that the next step would be to draft a website (see action 13.) and organize a videoconference afterwards to clarify details and further tasks.

Action	Who	When
21) Prepare videoconference for panel when website draft is done.	Secretariat	When

12.4 Goals for next TOPC meeting

The panel collected goals and expectations for the next TOPC meeting:

- Progress in adaptation;
- Intercomparison between in-situ and satellites;
- No presentations on what people are doing but about what TOPC wants and can achieve;
- Actions of TOPC should be publically traceable via website, similar to the idea of the GCOS implementation plan actions as decided under action 13;
- Having arguments for numbers in requirements of table A in IMPLEMENTATION PLAN.

Action	Who	When
22) Prepare list with email addresses of all panel members and distribute amongst panel members.	Secretariat	After meeting.
23) The secretariat asks the panel members to supply important messages form their presentations	Secretariat	After meeting.

12.5 Next TOPC meeting

The panel agreed to have the next TOPC meeting from 20 to 22 March 2018 probably in Geneva.

13. Closure

The meeting closed with thanks to Ulrich Looser and Valery Vuglinsky, who are both retiring from the panel, for their efforts for GCOS and TOPC over the past years.

TOPC also expressed its thanks to the Technical University of Vienna for hosting and supporting the meeting.

Appendix 1 Agenda

TOPC-19 - Day One – 5 April			
	09:00	WELCOME COFFEE	
1	09:30	Welcome & Round Table	Wolfgang Wagner
2		Introduction from GCOS SC Chair	Stephen Briggs
3		Aim of Meeting The meeting aims to plan the future activities of TOPC. There will be a brainstorming session on how TOPC should work in future to continue to monitor the observations of ECVs, their requirements and new and up-coming observational needs. The meeting will also consider ECV specifications and documentations, terrestrial latent and sensible heat fluxes, coastal areas and cross-validation of ECVs.	Wolfgang Wagner
4	10:00	Introduction of participants 5-8 min for each presentation	All
	12:30	LUNCH	
5	13:30	GCOS Implementation Plan 2016 Implementation Plan - general overview;	Simon Eggleston
6	13:50	Copernicus Climate Services Dick Dee (ECMWF and C3S) Followed by a discussion	Dick Dee (internet)
7		Tasks from TOPC 18	
7.1		Terrestrial Heat Fluxes ACTION: Decide status of terrestrial latent and sensible heat fluxes and way forward	Han Dolman
8	15:05	Earth Observation Data Centre for Water Resources Monitoring Presentation of Earth Observation Data Centre for Water Resources Monitoring	Christian Briese

	18:00	Finish	
		Welcome Drinks	
TOPC-19 - Day Two – 6 April			
7	09:00	Tasks from TOPC 18 (continued)	
7.2		Review of actions arising from TOPC XVII	Simon Eggleston
7.3		Coastal Waters Report on discussions at OOPC on coastal zones and linkages with TOPC. ACTION: Agree coastal working group and workshop	Simon Eggleston
7.4		Cross-validation of ECV products ACTION: Consider further actions including need working group and meeting,	Nadine Gobron
9		How to Review the performance of ECV observations?	
9.1		Science Perspective from an ECV producer	Wolfgang Wagner
9.2		Implementation Plan General and ECV specific requirements for TOPC.	Simon Eggleston
9.3	10:10	Role of Global Cryosphere Watch & possible cooperation with GCOS	Rodica Nitu (internet)
9.4		Presentation on existing approaches in the cryosphere	Michael ZEMP
9.5		The Role of GTN-H in coordinating observations	Wolfgang Grabs
9.6	11:25	WMO on hydrological coordination	Tommaso Abrate (internet)
9.7		Progress on coordination of in situ observations with ICSU and GEO	Simon Eggleston

9.8		Breakout Groups (Possibly: Hydrology, Cryosphere and Biosphere)	Discussion
	12:35	LUNCH	
10	13:35	How to Review Progress of GCOS IMPLEMENTAITON PLAN Actions? Introduction to actions in new Implementation Plan	Simon Eggleston
10.1		Cryosphere	Hiroyuki ENOMOTO
10.2		Hydrosphere	Ulrich LOOSER
10.3		Biosphere	Kevin Tansey
10.4		Human use of resources	Simon Eggleston
10.5	14:35	Breakout group discussions (possibly Hydrology, Cryosphere and remaining ECVs) considering how to monitor the actions in the Implementation Plan: 1) Decide if their group is appropriate or could be divided 2) Decide how will the actions in GCOS IMPLEMENTAITON PLAN be monitored and reported? 3) is data access and stewardship is adequate. 4) are there any issues for the broader TOPC panel to consider Agree responsibilities and actions needed. Identify people or organisations responsible for each ECV.	Breakout group discussions
	17:30	Finish	
	18:30	Conference Dinner	
TOPC-19 - Day Three – 7 April			
11	09:00	Reports from Breakout groups	
12	10:50	Presentation of draft Work Plan, Discussion and approval Prepared based on yesterday's discussions ACTION: Agree outline of work plan for TOPC, actions and responsibilities	
13		AOB	
	12:30	Finish	

Appendix 2 Actions

Action	Who	When
1) Panel members shall actively support and encourage their community for contributions during the GCOS open call for comments and views on the ECV Product requirements as presented in the 2016 GCOS implementation plan.	All TOPC panel members	Second half of 2017
2) Ask Copernicus Climate Change Service if input from TOPC is necessary at the current stage.	Secretariat	After approval of TOPC-19 meeting report.
3) Invite Copernicus expert on quality control of the products to the next panel meeting to present their work on ECV product quality control to support TOPC actions on monitoring the quality of ECV observation.	Secretariat	When planning TOPC-20 meeting.
4) Convey proposal of new ECV on evaporation from land including the products and requirements to the GCOS steering committee for approval.	Secretariat	For GCOS steering committee meeting in September 2017
5) Consider having a teleconference between relevant TOPC members and the biogeochemistry panel of the OOPC.	Secretariat, Wolfgang Wagner	2017
6) Ask OOPC for data needs from terrestrial communities in order to take future steps.	Secretariat	Immediately
7) Identify and invite coastal expert from OOPC for next TOPC meeting in order to clarify options for collaboration.	Secretariat	When planning TOPC-20 meeting.
8) Prepare report for next TOPC meeting on physical consistency of ECVs, including a proposal on a way forward.	Nadine Gobron	For TOPC-20 meeting in 2018
9) Review available tools for monitoring the use of datasets.	Wolfgang Wagner	For TOPC-20 meeting in 2018
10) Develop proposals on how to ensure that data citations should be traceable to original versions and software.	TOPC chair and GCOS secretariat	By TOPC-20 in 2018
11) The panel members should check for their domain if all data sets come with DOI and if citations are traceable.	TOPC panel members	By TOPC-20 in 2018

12) Nigel Tapper to lead the group that will continue to further develop a way to include adaptation requirements.	Nigel Tapper	Interim report for TOPC-20 meeting in 2018
13) Establish online platform for interactive discussions on ECV requirements for community.	Wolfgang Wagner	Have demonstration running by end 2017
14) Assign responsibility for all cryospheric action items in GCOS 2016 implementation plan. Identify steward consortia for each ECV.	Michael Zemp, Hiroyuki Enomoto, Tom Painter Hugues Lantuit	TOPC-20 meeting in 2018
15) Ensure communications between cryosphere experts on TOPC to coordinate their activities	Michael Zemp, Hiroyuki Enomoto, Tom Painter Hugues Lantuit Simon Eggleston	June 2017
16) Tom Painter, Hugues Lantuit and Sassan Sacchi shall be contacted by the secretariat on their future involvement in the TOPC.	Simon Eggleston	May 2017
17) Draft requirements table fpr soil moisture as an example for all other terrestrial ECVs	Wolfgang Wagner	June 2017
18) Provide short text that explains or justifies ECV requirements for each ECV	TOPC Panel Members	
19) The secretariat will establish process for contributions to GCOS (e.g. IP) can be cited similar to the process of contributing authors in the IPCC reports.	Simon Eggleston	July 2017, for decision be steering committee, October 2017
20) Put Nigel Tapper in contact with Peter Thorne about the GCOS Surface Reference Network	Valentin Aich	After meeting.
21) Prepare videoconference for panel when website draft is done.	Secretariat	When
22) Prepare list with email addresses of all panel members and distribute amongst panel members.	Secretariat	After meeting.
23) The secretariat asks the panel members to supply important messages form their presentations	Secretariat	After meeting.

Appendix 3 ECV Product Requirements from the 2016 GCOS implementation plan (GCOS-200)

This Annex presents requirements for the ECV products for all ECVs in this Implementation Plan. As these requirements are for products, they are independent of the observational method, whether mainly satellite or in situ. GCOS recognizes that these requirements have not been always well described, especially for in situ-based observations and observations needed for adaptation, and there are actions in this Implementation Plan to refine the list before the end of 2017 and then to maintain it as needs and observational capacities change.

These requirements follow on from, and update, previous product requirements provided for satellite-based ECV products in the GCOS satellite supplements to the Implementation Plans for 2004 and 2010.[2] The requirements contained in these supplements have been of considerable importance for satellite data providers. They have proved extremely effective in accelerating implementation initiatives by these communities both through concerted efforts, globally, for coordination (i.e. the CEOS-CGMS Working Group on Climate,[3] as well as in the definition and implementation of dedicated programmes at the level of individual space agencies (e.g. ESA's CCI programme[4]).

Whilst the value of these supplements is clear, the delay introduced by their preparation and the corresponding response from space agencies, resulted in some inefficiencies: space agencies were only able to provide a combined response to the Implementation Plan and Satellite Supplement shortly before the GCOS review, the Status Report, was written, leaving little time for implementation.

This Implementation Plan therefore includes the core component of the previous supplements (i.e. the ECV product requirements themselves) and extends them to cover all ECVs. This will allow a better review of whether or not the observing systems are achieving their goals and will align the reviews with the overall GCOS review cycle and reporting to the UNFCCC. Merging the ECV product requirements with the Implementation Plan itself has additional advantages such as a more direct and traceable link between the Implementation Plan actions and the product requirements (i.e. where an action is proposed to improve the accuracy of a product).

By no means is this intended to undermine the importance of data providers (e.g. WMO, GOOS and

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[2] GCOS, 2011: Systematic Observation Requirements for Satellite-based Products for Climate: 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)". GCOS-154, WMO, Geneva, December 2011.

GCOS, 2006: Systematic Observation Requirements for Satellite-based Products for Climate: Supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC". GCOS-107, WMO, Geneva, September 2006.

[3] http://ceos.org/ourwork/workinggroups/climate/

[4] http://cci.esa.int

the space agencies) in supporting the implementation of GCOS. On the contrary, it should be seen as for a key step towards improved and consistent reporting to SBSTA.

This addition of requirements for in situ-based ECV products is more complicated, due to the greater fragmentation of the communities with the relevant knowledge. In this Annex, an attempt is made to provide a first coherent and exhaustive representation of ECV product requirements but further consultations with the user communities are needed to ensure that these values better represent their needs and not just observational system capabilities. Action G10 is included in the Implementation Plan to further consolidate and refine these requirements over the course of the next Implementation Plan cycle.

The ECV products requirements in this Annex should be considered target requirements, i.e. requirements that data providers should aim to achieve over the next 10 years. Annex B provides an explanation of some of the terms used in this annex.

NOTES:

(a) The required measurement uncertainties are presented as 95% confidence intervals (approximately two standard deviations);[5]
(b) Stability is quoted per decade, unless otherwise indicated;
(c) Resolution is horizontal resolution where one value is quoted.

[5] WMO, 2012: *Guide to Meteorological Instruments and Methods of Observation.* WMO-No. 8, 2008 edition updated in 2010 (Section 1.6.4.3), WMO, Geneva

Table 9. Terrestrial ECV product requirements

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
River discharge	River discharge	Daily	Per river	10 % (relative)		ISO/TC 113: WMO (2010) WMO (2008(a)) WMO (2009)		WHYCOS
	Water Level	Daily	100 m	10 cm	1 cm/yr			WHYCOS
	Flow velocity	Few times per year for station calibration	Per river	10 % (relative)				WHYCOS
	Cross-section	Few times per year for station calibration	Per river	10 % (relative)				WHYCOS
Groundwater	Groundwater volume change	Monthly	100 km	10 cm	TBD	ISO/TC 147 ISO 5667-18:2001 part 18		WHYCOS
	Groundwater level	Weekly	Per well	1 cm				WHYCOS
	Groundwater recharge	Weekly	Per well	10 % (relative)				WHYCOS
	Groundwater discharge	Weekly	Per well	10 % (relative)				WHYCOS

[6] Responsible for analysing ECV products according to actions G11, G12 and G13. Key to abbreviations is given at the end of this annex. The GCOS Science panels will review and update this allocation as needed.

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
	Wellhead level	Weekly	Per well	1 cm				WHYCOS
	Water quality	Weekly	Per well	TBD				TBD
Lakes	Lake water level	Daily	100 m	3 cm for large lakes, 10 cm for the remainder	1 cm/decade	WMO (2006, 2008(a))	WGClimate	HYDROLARE
	Water extent	Daily	20 m	10 % (relative) 5% (for 70 largest lakes)	5%/decade		WGClimate	HYDROLARE
	Lake surface-water temperature	Weekly	300 m	1 K	0.1 K/decade		WGClimate	HYDROLARE
	Lake-ice thickness	Monthly	100m	1–2 cm			WGClimate	HYDROLARE
	Lake-ice cover	Daily	300 m	10 %	1 % /decade		WGClimate	HYDROLARE
	Lake colour (Lake water-leaving reflectance)	Weekly	300 m	30 %	1 %/decade		WGClimate	
Soil moisture	Surface soil moisture	Daily	1–25 km	0.04 m^3/m^3	0.01 m^3/m^3/year	WMO (2008(b))	WGClimate	ISMN
	Freeze/thaw	Daily	1–25 km	90 %	TBD		WGClimate	ISMN

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
	Surface inundation	Daily	1–25 km	90 %	TBD			ISMN
	Root-zone soil moisture	Daily	1–25 km	0.04 m^3/m^3	0.01 m^3/m^3/year			ISMN
Snow	Area covered by snow	Daily	1 km (100 m in complex terrain)	5% (maximum error of omission and commission in snow area); location accuracy better than 1/3 IFOV with target IFOV 100 m in areas of complex terrain, 1 km elsewhere	4% (maximum error of omission and commission in snow area); location accuracy better than 1/3 IFOV with target IFOV 100 m in areas of complex terrain, 1 km elsewhere	WMO (2008(c)), IGOS (2007), IACS/UNESCO(2009)		WIGOS, GCW
	Snow depth	Daily	1 km (100 m in	10 mm	10 mm			WIGOS,

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
			complex terrain)					GCW
	Snow-water equivalent	Daily	1 km	10mm	10 mm			WIGOS, GCW
Glaciers	Glacier area	Annual (at end of ablation season)	Horizontal 15–30 m	5%		IGOS (2009), Paul et al. (2009), Zemp et al. (2013)	WGClimate	GCW
	Glacier elevation change	Decadal	Horizontal 30 m–100 m x vertical 1 m	2 m/decade	1 m/decade		WGClimate	GCW
	Glacier mass change	Seasonal to annual (the latter at end of ablation period)	Vertical: 0.01 m or 10 kg/m^2 (at point location)	Better than 200 kg/m^2/year (glacier-wide)			WGClimate	GCW
Ice sheets and ice shelves	Surface elevation Change	30 days	Horizontal 100 m	0.1m/year	0.1m/year		WGClimate	GCW
	Ice velocity	30 days	Horizontal 100 m	0.1m/year	0.1m/year		WGClimate	GCW
	Ice mass change	30 days	Horizontal 50 km	10 km^3/year			WGClimate	GCW

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
					10 km^3/year			
	Grounding line location and thickness	Yearly	Horizontal 100 m Vertical 10 m	1 m	10 m		WGClimate	GCW
Permafrost	Thermal state of permafrost	Daily to weekly	Sufficient sites to characterize each bio-climate zone	0.1 K				GCW
	Active layer thickness			2 cm				GCW
Fraction of FAPAR	Maps of FAPAR for modelling	Daily	200/500 m	Max (10%; 0.05)	Max (3%; 0.02)		WGClimate	
	Maps of FAPAR for adaptation		50m	Max (10%; 0.05)	Max (3%; 0.02)		WGClimate	
Leaf area index	Maps of LAI for modelling	Daily	250 m	Max (15%)	Max (10%; 0.25)		WGClimate	
	Maps of LAI for adaptation		50 m				WGClimate	
Albedo	Maps of DHR albedo for adaptation	Daily	50 m	Max (5%; 0.0025)	Max (1%; 0.001)		WGClimate	BSRN
	Maps of BHR albedo for adaptation		50 m	Max (5%; 0.0025)	Max (1%; 0.001)		WGClimate	BSRN

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
	Maps of DHR albedo for modelling	Daily	200/500 m	Max (5%; 0.0025)	Max (1%; 0.001)		WGClimate	
	Maps of BHR albedo for modelling		200/500 m	Max (5%; 0.0025)	Max (1%; 0.001)		WGClimate	
Land-surface temperature	Maps of land-surface temperature	3 hour	1 km	1 K	<0.1 K/decade		WGClimate	
Above-ground biomass	Maps of AGB	Annual	500 m-1 km (based on satellite observations of 100–200 m)	< 20% error for biomass values > 50 t/ha, and 10 t/ha for biomass values ≤ 50 t/ha	10%	No agreed standards but see: GOFC-GOLD (2015b) GFOI (2013)	WGClimate	
Land cover	Maps of land cover	Annual	250 m	15% (maximum error of omission and commission in mapping individual classes), location accuracy better than 1/3 IFOV with target IFOV 250 m	15% (maximum error of omission and commission in mapping individual classes), location accuracy better than	No agreed standards but see GLCN (2014) and GOFC-GOLD (2015(a))	WGClimate	GOFC-GOLD

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
					1/3 IFOV with target IFOV 250 m			
	Maps of high-resolution land cover	5 year	10–30 m	5% (maximum error of omission and commission in mapping individual classes), location accuracy better than 1/3 IFOV with target IFOV 10–30 m	5% (maximum error of omission and commission in mapping individual classes), location accuracy better than 1/3 IFOV with target IFOV 10–30 m		WGClimate	GOFC-GOLD
	Maps of key IPCC land use, related changes and land-management types	1–10 years (including historical data)	10–1 000 m (depending on time period)	20% (maximum error of omission and commission in mapping individual classes), location	20% (maximum error of omission and	IPCC (2006)		GOFC-GOLD

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
				accuracy better than 1/3 IFOV with target IFOV	commission in mapping individual classes), location accuracy better than 1/3 IFOV with target IFOV			
Soil carbon	% carbon in soil	5–10 years	20 km					TBD
	Mineral soil bulk density to 30 cm and 1 m	5–10 years	20 km					TBD
	Peatlands total depth of profile, area and location	5–10 years	2 m vertical 20 m horizontal	10%				TBD
Fire	Burnt Areas	24 hours	30 m	15% (error of omission and commission), compared to 30-m		None	WGClimate	

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
				observations				
	Active fire maps	6 hours at all latitudes from polar-orbiting and 1 hour from geostationary	0.25-1 km (polar); 1–3 km (geo)	5% error of commission 10% error of omission Based on per-fire comparisons for fires above target threshold of 5 MW/km² equivalent integrated FRP per pixel (i.e. for a 0.5 km² pixel the target threshold would be 2.5 MW, for a 9 km² pixel it would be 45 MW).		None	WGClimate	
	Fire radiative power	6 hours at all latitudes from polar-orbiting and 1 hour from	0.25-1 km (polar) 1–3 km (geo)	10% integrated over pixel. Based on target detection threshold of 5 MW/km² equivalent integrated FRP per pixel (i.e. for			WGClimate	

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
		geostationary		a 0.5 km² pixel the target threshold would be 2.5 MW, for a 9 km² pixel it would be 45 MW).and with the same detection accuracy as the Active Fire Maps.				
Anthropogenic greenhouse-gas fluxes	Emissions from fossil fuel use, industry, agriculture and waste sectors	Annual	By country and sector	Globally 5% Nationally 10%		IPCC (2006) IPCC (2013)		TBD[7]
	Emissions/ removals by IPCC land categories	Annual	By country/region	Globally 15% Nationally 20%				
	Estimated fluxes by inversions of observed atmospheric	Annual	1 000–10 000 km	10%		Maps for modelling and adaptation	WGClimate	

[7] While GAW has responsibilities for the composition measurements, there is no single body considering the overall flux estimates though this has been done to some extent by the GCP.

Terrestrial ECV product requirements								
ECV	**Products**	**Frequency**	**Resolution**	**Required measurement uncertainty**	**Stability (per decade unless otherwise specified)**	**Standards/ References**	**Entity (see Part II, section 2.2)[6]**	
							Satellite	**In Situ**
	composition - continental							
	Estimated fluxes by inversions of observed atmospheric composition - national	Annual	100–1 000 km	30%			WGClimate	
	High-resolution CO_2 column concentrations to monitor point sources	4 hourly	1 km	1ppm			WGClimate	
Latent and sensible heat fluxes	TOPC is considering the practicality of this being an ECV and, if so, what the requirements might be.							

Stakeholders:

AQUASTAT	FAO database and data collection system on water use
BSRN	Baseline Surface Radiation Network
GAW	WMO Global Atmosphere Watch
GCP	Global Carbon Project
GCW	WMO Global Cryosphere Watch
GOFC-GOLD	Global Observation for Forest Cover and Land Dynamics
GOOS	Global Ocean Observing System Sponsored by WMO, UNESCO-IOC, UNEP and ICSU
GTN-G	Global Terrestrial Network - Glaciers
GTN-H	Global Terrestrial Network - Hydrology
GTN-P	Global terrestrial Network - Permafrost
HYDROLARE	International Data Centre on Hydrology of Lakes and Reservoirs
JCOMM	WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology
WGClimate	Joint CEOS/CGMS working group on climate
WHYCOS	WMO World Hydrological Cycle Observing System (a WMO programme)
WIGOS	WMO Integrated Global Observing System

Box 10: Terrestrial standards: references.

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WMO (2008c) Guide to meteorological instruments and methods of observation, WMO-No. 8, (Updated in 2010 and 2012).

Appendix 4 List of Participants

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5-7 April 2017
Vienna, Austria

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