Work plan and Guidelines for updating the GCOS 2015 Status Report and 2016 Implementation Plan

11 July 2019, V7

1. Introduction

This document describes the process GCOS secretariat will follow from 2019 to 2022 in updating the GCOS Status Report[1] and Implementation Plan[2] to be delivered to the UNFCCC by 2022, in time for its Global Stocktake in 2023.

GCOS has three expert panels that will provide the input to the updated reports and coordinate with their wider communities: the Atmospheric Observation Panel for Climate (AOPC), the Ocean Observations Physics and Climate Panel (OOPC) and the Terrestrial Observation Panel for Climate (TOPC). GCOS expert panels are also responsible for maintaining definitions of Essential Climate Variables (ECVs) which are required to systematically observe Earth`s changing climate.

This document covers the timeline for this work and provides definitions and explanations of the ECV Product requirements that will be provided. This document reiterates information given to the GCOS expert panels, most recently at the Joint Panel Meeting on Marrakesh[3] together with a more detailed wok plan developed with the GCOS Steering Committee Chair.

The agreed timeline is given in chapter 3. Chapter 4 discusses the ECV Product requirements and guidelines on supplying the required information is given in chapter 5.

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[1] Status of the Global Observing System for Climate, October 2015, GCOS-195.
[2] The Global Observing System for Climate: Implementation Needs, 2016, GCOS-200
[3] To be published.

2. Background

The WMO-IOC-UN Environment-ISC Global Climate Observing System (GCOS) is an internationally coordinated system of global, regional and national observing systems, designed to meet the needs for climate observations. Climate observations are fundamental to detect, model and assess climate change, support adaptation to climate change, monitor the effectiveness of policies for mitigating climate change, develop climate information services, promote sustainable national economic development and meet other requirements of the UNFCCC and other convention and agreements.

GCOS has been recognized by the United Nations Framework Convention on Climate Change (UNFCCC) since 1997 as the programme that leads the improvement of systematic observations to meet the needs of the Convention (e.g. Decisions 8/CP.3, 14/CP.4, 9/CP.15,19/CP.22). (See also unfccc.int/3581).

GCOS prepares regular reports on the status of the global climate observing system[4] followed by implementation plans[5] that address issues and gaps, and new developments and user needs. These reports are submitted to the UNFCCC Subsidiary Body on Scientific and Technological Advice (SBSTA), see FCCC/SBSTA/2015/L.18 *Research and Systematic Observation* and Decision 19/CP.22 *Implementation of the global observing system for climate*. These reports have been updated regularly and these new updated reports will be the fourth Status Report (SR4) and the fourth Implementation Plan (IP4).

A major GCOS objective is to present a revised implementation plan to UNFCCC in time for the Conference of Parties (COP) in November 2022, to allow it to be available for the UNFCCC's Global Stocktake in 2023 and align with the Intergovernmental Panel on Climate Change (IPCC) assessment cycle. This implies that an updated Status Report should be available a year earlier, before October 2021.

The Memorandum of Understanding governing GCOS[6] states that "*Specifically the GCOS will ensure the data needs are met for climate system[7] monitoring, for assessing the impacts of climate variability and change and applications to national economic development, as well as research leading to improved understanding, modelling and prediction of the climate system*;".

[4] The latest status report was the Status of the Global Observing System for Climate, October 2015, GCOS-195.

[5] The most recent implementation plan is The Global Observing System for Climate: Implementation Needs, 2016, GCOS-200

[6] Memorandum of Understanding between the World Meteorological Organization, the Intergovernmental Oceanographic Commission of the United Nations, Educational, Scientific and Cultural Organization, the United Nations Environment Programme and the International Council for Science. 1998

[7] According to WMO's Commission on Climatology, the climate system consists of five major components: the atmosphere, the hydrosphere, the cryosphere, land surface and the biosphere. The climate system is continually changing due to the interactions between the components as well as external factors such as volcanic eruptions or solar variations and human-induced factors such as changes to the atmosphere and changes in land use.

3. Workplan

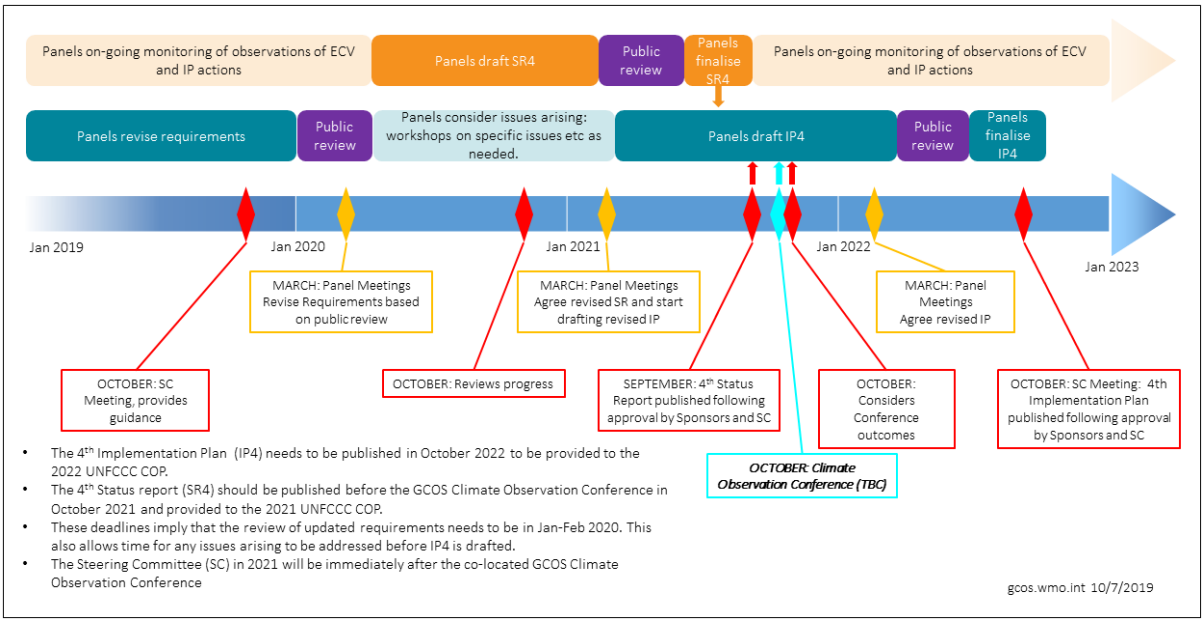

Figure 1 GCOS Workplan, 2019-2022 addressing the update of the Status Report (SR) and Implementation Plan (IP)

In developing this workplan, a number of considerations were addressed:

- The need for transparency and community involvement in the process;
- Allowing enough time for any issues to be resolved on individual ECVs;
- Ensuring that the status report and implementation plan are updated consecutively not simultaneously;
- Deadlines of October 2021 for SR4 and October 2022 for IP4

An important concept of the GCOS programme are the Essential Climate Variables (ECV). Each ECV may comprise of one or more parameter, called ECV Products, and for each of these GCOS provides requirements in terms of definitions, resolution and uncertainty.

At mid 2018 the panels have already been tasked with considering the ECV requirements, assessing if they are still fit-for-purpose and proposing refinements in consultation with their respective communities. An on-going task of the GCOS panels is to review how well ECVs are monitored and to review the status of actions in the most recent implementation plan. Panels have ECV Stewards and IP action rapporteurs for these purposes.

The timeline we have agreed with the Steering Committee Chair, and approved at the 30th IOC Assembly in July 2019, is shown in Figure 1 with more detail on some activities in Table 1.

Table 1 Proposed GCOS Timeline for revising the SR and IP

<table>
<tr><th colspan="2"></th><th>4th Status Report (SR4)</th><th>4th Implementation Plan (IP4)</th></tr>
<tr><td>2019</td><td>Now-Dec</td><td rowspan="2">Continue monitoring IP actions and ECV observations – the on-going tasks of the panels. The information collected here should allow easy compilation into the Status Report.</td><td>Review and revise ECV requirements. Include at least threshold and goal values led by ECV Stewards who should include views of the respective communities. The Secretariat will monitor progress.</td></tr>
<tr><td rowspan="3">2020</td><td>Jan - Feb</td><td>Public Review of initial proposed ECV requirements. While this should be open to all, all the relevant communities specifically invited.</td></tr>
<tr><td>Mar</td><td rowspan="3">Draft revised Status Report. This will be based on contributions from the ECV Stewards and IP Action Rapporteurs, compiled and coordinated by the GCOS Secretariat.</td><td>Panel Meetings. Consider responses to ECV requirements, identify areas for further work</td></tr>
<tr><td>Apr-Dec</td><td>Activities focused on ECVs where additional consideration is needed. Some of these areas can be anticipated (GHG for example) but others will be identified through the public review. There may workshops or Task Teams on specific areas</td></tr>
<tr><td rowspan="5">2021</td><td>Jan - Feb</td><td rowspan="4">Draft revised IP4, this will be led by the GCOS Panels and incorporated the revised ECV requirements that have been developed since 2019. Contributions and inputs will come from the SR4, Climate Observation Conference, and interested scientific communities.</td></tr>
<tr><td>Mar-Apr</td><td>Public Review of SR4 draft. While this should be open to all, all the relevant communities specifically invited.</td></tr>
<tr><td>May-Aug</td><td>The GCOS Panels and Secretariat will finalise SR4 by addressing all the comments and the final document should be approved by the GCOS Sponsors</td></tr>
<tr><td>Sep</td><td>Publish SR4 in time for the UNFCCC COP 8-19 November 2021</td></tr>
<tr><td>Oct-Dec</td><td rowspan="4"></td></tr>
<tr><td rowspan="4">2022</td><td>Jan -Mar</td><td rowspan="3">Public Review of IP4 draft. While this should be open to all, all the relevant communities specifically invited.</td></tr>
<tr><td>Mar-Apr</td></tr>
<tr><td>May-Sep</td><td>The GCOS Panels and Secretariat will finalise IP4 by addressing all the comments and the final document should be approved by the GCOS Sponsors</td></tr>
<tr><td>Oct</td><td>Publish revised IP4 in time for the UNFCCC COP 7-18 November 2022</td></tr>
</table>

KEY:	Document drafting	Public Reviews

4. ECV Product Requirements

4.1. User Requirements

There is a wide range of users of climate data. GCOS is intended to meet the needs of[8]:

1. Climate System Monitoring, climate change detection and monitoring the impacts of and the response to climate change, especially in the terrestrial ecosystems and mean sea-level;
2. Data for application to national economic development;
3. Research towards improved understanding, modelling and prediction of the climate system.

Initially GCOS concentrated on scientific users aiming to "*meet the comprehensive scientific requirements for monitoring the climate, and provide the observational basis for detecting climate change, for predicating climate variations and change on a variety of time and space scales, and for observing the impacts of climate change*" (GCOS-10, WMO-TD 666, 1995[9]). Recognising the increasing importance of systematic observations to climate policy development, the GCOS 2010 Implementation Plan[10] includes assisting the Parties in meeting their responsibilities under Articles 4 and 5 of the UNFCCC. This was reinforced by the 2016 Implementation Plan[11], endorsed by WMO and UNFCCC where systemic observations also have an explicit role in the UNFCCC's Paris Agreement[12] linked to adaptation and public information.

In this document the term "***users"*** covers all those users who use climate data for these purposes.

GCOS is a global system and therefore does not address all local monitoring needs. The scope of GCOS's contribution to monitoring of, and for, adaptation is being considered separately by a GCOS Task Team. The task team comes to the conclusion that GCOS can inform adaptation through ECV indicators and potentially directly monitor adaptation through some ECVs. However, the related adaptation needs will not be part of this update. Only general information for each ECV on whether the related ECV products are relevant for adaptation will be provided. For the observation of extremes the same approach is used. GCOS also does not aim to meet all the needs of early warning systems and similar applications.

Users, especially in the policy sphere, often do not use observations directly but instead need to use information derived from observations such as statistical analyses, outputs of reanalysis and climate models. Services using such information depend on accurate and timely long-term observational data. GCOS's role is to improve, support and ensure the availability of global climate observations and to ensure all users have access to climate observations, data records and information required to address their climate-related concerns.

An ECV is a physical, chemical or biological variable or group of linked variables that critically contributes to the characterization of Earth's climate and human response (see Box 1). Thus, many ECVs comprise a number of measurable parameters called *ECV Products*. In some cases, the ECV Products are used directly, in other cases they are used as input into reanalysis or climate models. GCOS provides instrument-agnostic requirements in terms of definitions, resolution and uncertainty for the ECV Products.

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[8] Memorandum of Understanding between the World Meteorological Organization, the Intergovernmental Oceanographic Commission of the United Nations, Educational, Scientific and Cultural Organization, the United Nations Environment Programme and the International Council for Science. 1998

[9] Summary of the GCOS Plan, Version 1.0, GCOS-10, WMO-TD 666, 1995

[10] Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update), August 2010 GCOS-138 (WMO-TD/No. 1523).

[11] The Global Observing System for Climate: Implementation Needs GCOS-200 (GOOS-214), pub WMO, Geneva 2016)

[12] UNFCCC Decision 1/CP.21, Paris Agreement: http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf, "strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making" (Article 7.7c: Adaptation)

4.2. New elements in this update for the 2022 Implementation Plan

In general, this update is not intended to make large-scale changes to the ECV Product requirements from the 2016 Implementation Plan. However, in a few areas, there may be new information and science that should be considered. The GCOS Implementation Plan presents four targets for closing the Earth System cycles and budgets based on observations. These targets will eventually be met by achieving the individual ECV requirements. Consistency of requirements across ocean, atmosphere and land needs to be ensured. In addition, there are some significant change in the presentation of the ECV Product requirements discussed below.

4.2.1. Threshold and Goal Values

For this update the GCOS Steering Committee has decided that the numerical requirements for each ECV Product should be defined by two values, i.e., "Threshold" and "Goal" following the approach of WMO's Observing Systems and Capability Analysis and Review Tool (OSCAR, WMO, 2011) requirements. Breakthrough values are optional intermediate values

- The ***Goal*** is an ideal requirement above which further improvements are not necessary. This is likely to evolve as applications and technologies progress.
- The ***Threshold*** is minimum requirement: the value that has to be met to ensure that data are useful.
- Optionally, one or more, **Breakthrough** values can be defined. These are intermediate between "threshold" and "goal" that enables additional uses within climate monitoring. The additional uses need to be explained.

4.2.2. Explanatory Text

It is important that each number is, in future, traceable and that the choice of numbers for these requirements is documented. An additional field is provided where the source of the data should be documented, and a justification for the specific choices made provided. References can be made to other documents, papers and reports. If specific breakthrough values were chosen, this information may also indicate their areas of usefulness.

It is also important that clear, unambiguous, definitions for each ECV Product are provided and that a clear, concise and complete definition is also given.

4.2.3. Timeliness

Timeliness, often called latency, is the delay between the observation and the data being available. This is particularly important in uses which are time-critical such as where the data is used to support annual reporting of the state of the climate. This only applies to current observations: there is value in rescued data as well. Reconstructing past climates and extending trends into the past can be critical for understanding the climate. These historic uses are not covered by this requirement.

4.3. Components of an ECV Product Requirement

The ECV Product requirement will consist of (more detailed guidance is given in chapter 5 as part of the guidelines for updating the requirements):

- **Name of ECV and ECV Product**,
    - ***Name***: A clear, recognised, unambiguous name.
    - ***Definition***: A precise, complete definition of the product.
    - ***Measurement units***: in SI units, customary units can be given in addition
- **Resolution**

- ***Horizontal and vertical resolution*** needed by users.
- ***Temporal resolution*** of the ECV Product needed by users
- ***Timeliness***: this is the delay between the observation and the data being available

- **Uncertainty**
  - ***Required Measurement uncertainty***[13] GCOS follows the terminology of the International Vocabulary of Metrology (VIM, De Bièvre, 2012; International Bureau of Weights and Measures (BIPM), 2017) and the Guide to the Expression of Uncertainty in Measurement (GUM, International Bureau of Weights and Measures (BIPM), 2012). Uncertainty should be expressed in units of 2 standard deviations. Note that uncertainty replaces the deprecated terms of accuracy and precision which, erroneously, implicitly pre-suppose that the true state of the measurand is known / knowable.
  - ***Stability for users*** is the permitted systematic non-adjustable drift in the observations that allows useful climate monitoring applications.

- **Background Information**
  - ***References and Standards***.
  - ***Derivation***. Additional information to explain the choice of requirement. Each number has to be explained to make the choice of requirement understandable and traceable. May include links to other documents.

[13] A parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand [VIM:1993, definition 3.9]

BOX 1 ESSENTIAL CLIMATE VARIABLES (ECV)

The concept of Essential Climate Variables (ECV) emerged in the context of the needs of the UNFCCC in the Second Adequacy Report[14].

Data needs are organized around the concept of Essential Climate Variables (ECVs).

An Essential Climate Variable (ECV) is a physical, chemical or biological variable or group of linked variables that critically contributes to the characterization of Earth's climate and human response. ECV datasets provide the empirical evidence needed to understand and predict the evolution of the climate, to guide mitigation and adaptation measures, to assess risks and enable attribution of climatic events to underlying causes, and to underpin climate services. The ECVs must not be understood as a select group of stand-alone variables; they are part of a wider concept (Figure *2*).

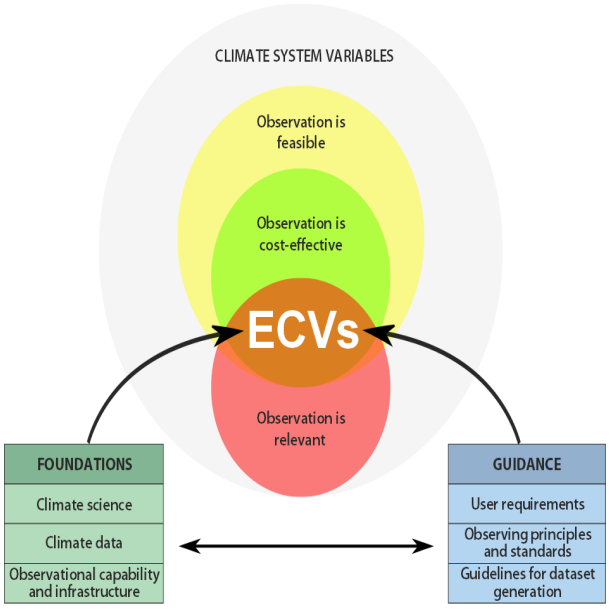

Figure 2 - Schematic of the ECV concept (Source: Bojinski, et al, BAMS, 2014).

ECVs are identified according to the following criteria:

(1) **Relevance:** The variable is critical for characterizing the climate system and its changes;

(2) **Feasibility:** Observing or deriving the variable on a global scale is technically feasible, using proven, scientifically understood methods;

(3) **Cost-effectiveness:** Generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

Knowing existing climate-relevant observing capabilities, climate datasets, and the level of scientific understanding of the climate system are the foundations (lower left box) necessary for selecting the ECVs from a pool of climate system variables. In addition, guidance is needed to make practical use of the ECVs (lower right box): user requirements capture the data quality needs of science, services and policy; climate-specific principles guide the operation of observing systems and infrastructure; guidelines facilitate the transparent generation of ECV data records. The latter address the availability of metadata, provisions for data curation and distribution, and the need for quality assessment and peer review.

SOURCE: The Global Observing System for Climate: Implementation Needs, GCOS-200, 2016. Based on Bojinski, et al, (BAMS, 2014). DOI:10.1175/BAMS-D-13-00047.1

[14] Second report on the adequacy of the global observing systems for climate in support of the UNFCCC. GCOS-82, 85 pp. [Available online at WMO Library here.]

5. Guidelines for reviewing the GCOS ECV Product Requirements

The guidelines in this chapter provide experts with relevant, practical information for updating the ECV Product requirements for the GCOS Implementation Plan in 2022. Definitions for all requirements, and an example, are provided to assure consistency across all ECVs. The most significant improvements, compared to the 2016 Implementation Plan, are the mandatory provision of threshold and goal values (see below) and provision background information on the source and choice of each value which to ensure full transparency.

5.1. ECV Products and their requirements

ECVs are physical, chemical or biological variables that critically contribute to the characterization of Earth's climate (Bojinski et al., 2014). ECVs are concepts and each ECV may be characterized by one or a group of ECV Products. For example, the ECV "lakes" is a concept and in order to characterize it, several ECV Products such as lake water level and lake colour are required to monitor the relevant climate aspects.

ECV Product requirements are "user requirements" for climate information. Therefore, they are instrument-agnostic: the requirements do not imply that any specific equipment should be used. Indeed, in some cases, the sum total of the observational capacities including different technologies, platforms and networks may be integrated to satisfy the criteria, which cannot be met by a single technology.

The application for the requirements is climate monitoring, which includes:

1. Climate System Monitoring, climate change detection and monitoring the impacts of and the response to climate change, especially in the terrestrial ecosystems and mean sea-level;
2. Data for application to national economic development;
3. Research towards improved understanding, modelling and prediction of the climate system.

GCOS's contribution to monitoring of, and for, climate adaptation is being considered separately by a GCOS Task Team and so adaptation needs, including early warning systems and similar applications shall not be considered in the review.

5.2. Reviewing ECV Product Requirements

In consultation with their communities and the GCOS science panels, ECV Stewards should complete the information needed for each ECV Product as specified in Table 2. This table includes both numeric and text information – both are essential.

In addition, the ECV Stewards should answer the following questions which were agreed at the GCOS Joint Panels Meeting in March 2019, where it was decided to explore further if the ECVs are fit for monitoring extremes and to support adaptation. Therefore, for each ECV Product, the following questions should be answered, only a "yes" or "no" is needed:

1. Is the ECV Product directly relevant for adaptation?
   1.1. If yes, is the proposed set of requirements sufficient?
2. Can the ECV Product be used to monitor climate extremes or aspects of extremes?
   2.1. If yes, is the proposed set of requirements sufficient?

Table 2 Information needed to define ECV Product Requirements. x = mandatory data, y = if needed for vertical resolutions, o = optional. All the text fields are mandatory.

Item needed		Definition				
Definitions	ECV	Name of ECV which needs to be clear and unambiguous. For example, "Atmospheric Temperature" instead of "Temperature". If the ECV name is ambiguous discuss with the panel chair(s) and secretariat and propose minimal changes.				
	ECV Product	The names of ECV Products need to be clear and unambiguous. Check that the ECV Product name is unambiguous and is defined precisely and completely. If the ECV name is ambiguous propose a revised name.				
	ECV Product Definition	A clear definition of the ECV Product that enables all readers to understand exactly what needs to be measured. The measurement units must be given (3).				
		Threshold (1)	Breakthrough (1)	Goal (1)	Metric (2)	Units (3)
Resolution	Spatial Resolution: Horizontal (4)	x	o	x	x	x
	Spatial Resolution: Vertical (4)	y	o	y	x	x
	Temporal resolution (5)	x	o	x	x	x
	Timeliness (6)	x	o	x	x	x
Uncertainty	Required measurement uncertainty (7)	x	o	x	x	x
	Stability for users (8)	x	o	x	x	x
Background Information	References and Standards	Any recognized standards and methodological references for the ECV Product should be provided here.				
	Derivation	Additional information to explain the choice of requirement. Each number has to be explained to make the choice of requirement understandable and traceable. May include links to other documents.				

Notes:

1) In line with WMO's Observing Systems and Capability Analysis and Review Tool (OSCAR, WMO, 2011) requirements and in order to allow flexibility for the design of observing networks, the requirements for each of these criteria, are provided by a minimum (threshold) and ideal (goal)values. Breakthrough values are optional intermediate values.

   Threshold: The minimum requirement: the value that has to be met to ensure that data are useful.

   Goal: The ideal requirement above which further improvements are not necessary. This is likely to evolve as applications and technologies progress.

   Breakthrough: One or more values that enable additional uses within climate monitoring. The additional uses need to be described in the "derivation" section.

2) The metric field can be used to more precisely define the parameters, and how they relate to the spatial and temporal resolutions. For example, is the requirement for a value at a point in time, an average over the specified period or an average of shorter periods (e.g. 10-minute values)? Does the

requirement refer to a measurement at a spatial point or is it an average over an area, e.g. a pixel value? This may overlap with the definition given above. The usefulness of defining the uncertainty and stability metrics has been debated by the GCOS panels: while different ways of expressing uncertainty are used in some areas it has been argued that these are measurement technique specific and it should be possible to define uncertainty of products delivered to users in a uniform way. For the first stage of updating the requirements it is proposed that metric remains, and the usefulness of this item is reviewed again by the panels after the public review.

3) SI units must be used. Customary units can be given **in addition** if this increases ease of use.

4) The spatial resolution has two parts a horizontal and a vertical component which refer to the user needs. The vertical component is not applicable for all ECV Products. Increasing the resolution from the threshold to the goal values leads to more detailed information and may allow additional uses to be possible. If possible, the level at which these additional uses occur should be marked by breakthrough values. Some ECV Products may need additional text explanation how the resolution is defined, for example river discharge should be measured on rivers greater than x at the closest possible point to the mouth. Note that the resolution may vary by region, height or depth, to ensure adequate global coverage (e.g. where the parameter has little variation in some areas): in these cases, the different resolutions with ranges of applicability should be given.

5) Temporal resolution is that needed by users. Increasing the temporal resolution leads to more detailed information and may allow additional uses to be possible. The level at which these additional uses occur should be marked by breakthrough values. Note that this may vary by region, depth or height, to ensure adequate global coverage (e.g. where the parameter has little variation in some regions): in these cases, the different resolutions with ranges of applicability should be given.

6) Timeliness is the delay between the observation and the data being available, for example to support annual reporting of the state of the climate. This only applies to currently observations: there is value in rescued data as well, but this is not covered by this requirement.

7) Uncertainty, in line with the International Vocabulary of Metrology (VIM, De Bièvre, 2012; International Bureau of Weights and Measures (BIPM), 2017) and the Guide to the Expression of Uncertainty in Measurement (GUM, International Bureau of Weights and Measures (BIPM), 2012), the required measurement uncertainty includes all quantifiable uncertainties. The uncertainty is considered the range within which the true state of the measurand will plausibly reside. Uncertainty should be expressed in units of two standard deviations. Note that uncertainty replaces the deprecated terms of accuracy and precision which, erroneously, implicitly pre-suppose that the true state of the measurand is known / knowable.

8) Stability is defined as the maximum permissible cumulative effect of systematic changes of the measurement system to allow long-term climate records compiled from assorted measurement systems. If not stated differently, it is defined as maximum permissible percentage change per decade. In order to set the stability requirement, an approach frequently used is to use a percentage of the expected trends, chosen so that the expected trend is clearly detectable.

5.3. References

Bojinski, S., Verstraete, M., Peterson, T.C., Richter, C., Simmons, A., Zemp, M., 2014. The Concept of Essential Climate Variables in Support of Climate Research, Applications, and Policy. Bull. Am. Meteorol. Soc. 95, 1431–1443. https://doi.org/10.1175/BAMS-D-13-00047.1

De Bièvre, P., 2012. The 2012 International Vocabulary of Metrology: "VIM." Accredit. Qual. Assur. 17, 231–232. https://doi.org/10.1007/s00769-012-0885-3

International Bureau of Weights and Measures (BIPM), 2017. VIM definitions with informative annotations [WWW Document]. URL https://jcgm.bipm.org/vim/en/index.html (accessed 7.3.19).

International Bureau of Weights and Measures (BIPM), 2012. Guide to the Expression of Uncertainty in Measurement (GUM) [WWW Document]. URL https://www.bipm.org/en/publications/guides/gum.html (accessed 7.3.19).

WMO, 2011. WMO Observing Systems Capability Analysis and Review Tool (OSCAR) [WWW Document]. URL https://www.wmo-sat.info/oscar/ (accessed 7.3.19).

5.4. Example

ECV: Upper-air Wind Speed and Direction

The ECV upper-air wind and direction has 10 products, wind vector (horizontal) in the Boundary Layer, in the free troposphere, in the UTLS, in the middle and upper stratosphere and in the mesosphere; and vertical velocity in the Boundary Layer, in the free troposphere, in the UTLS, in the middle and upper stratosphere and in the mesosphere.

The following example shows the requirements for the ECV Product wind vector (horizontal) in the Boundary Layer.

ECV Product: Wind vector (horizontal) in the Boundary Layer

Definition: 3D field of the horizontal vector component (2D) of the 3D wind vector (m/s) in the Boundary Layer

Measurement unit: m/s

	unit	threshold	breakthrough	goal	Metric (optional)	Background information
Horizontal resolution	km	500	100	10		(1)
Vertical resolution	m	500	100	10/1		(2)
Temporal resolution	min	720	60	10/1		(3)
Timeliness	hr	48	18	6		(4)
Uncertainty	m/s	5	3	1		(5)
Stability	m/s	0.5	0.3	0.1		(6)

Background information:

These values are inferred mainly from the viewpoint of reanalysis and its near-real-time continuation as users of this ECV. Some additional considerations are also made, for which explanations are given in the tables. Additional goal requirements for the lower most part of the boundary layer (values in parentheses) are for better sampling of micrometeorological phenomena and accurate calculation of fluxes.

(1) Horizontal resolution

Threshold (T) minimum resolution needed to resolve synoptic-scale waves, Breakthrough (B) a typical horizontal error correlation length in first guess fields, Goal (G) roughly corresponds to the current global NWP model resolution, which would be used for next generation reanalyses

(2) Vertical resolution

(T) minimum resolution considering the layer depth, (B) roughly corresponds to the assimilating model resolution (Fujiwara et al. 2017), (G) This high resolution allows different users the option to subsample or process the data in ways that suit their applications (Ingleby et al. 2016).

This value is still under discussion – For the lowest portion of the Boundary Layer (up to 100m above the ground) , where winds need to ascertain and monitor fluxes, a vertical resolution of 1m for the goal is suggested. For the rest of the Boundary Layer the goal can be set at 10m.

(3) Temporal resolution

(T) minimum resolution needed to resolve synoptic-scale waves, (B) a typical time interval of analysis, (G) a typical 4D-Var timeslot length, a sub-division into which observations are grouped for processing (ECMWF 2018).

Given the large diurnal cycle in the Boundary Layer, higher temporal sampling is required in the first 100m of the Boundary Layer. A value of 10min roughly corresponds to the model time step.

(4) Timeliness

(T) a typical master decoding cut-off time, beyond which observations are not automatically decoded and incorporated into the operational observation archive, (B) a typical cut-off time for the Climate Data Assimilation System (a near-real time continuation of reanalysis), (T) a typical cut-off time of the operational NWP cycle analysis (JMA 2019), which might also be used for climate monitoring

(5) Uncertainty

These values are inferred based on the standard deviations of 6-hourly analysis with respect to the monthly climatology (Figs. 1, 2). (T) corresponds to regions of high variability, (B) of medium variability and (G) of low variability.

The metric used to measure uncertainty would be the RMS departures of observed values from first guess field values, in accordance with the practical verification schemes applied by the GUAN Monitoring Centre for upper-air observations (Fig. 3).

(6) Stability

These values are inferred based on the RMS trends of monthly analysis for the 1981-2010 period (Fig. 1). (T) corresponds to regions of large trend, (B) of medium trend and (G) of small trend.

The metric used to measure uncertainty would be the mean departures of observed values from first guess field values (Fig. 3).

References

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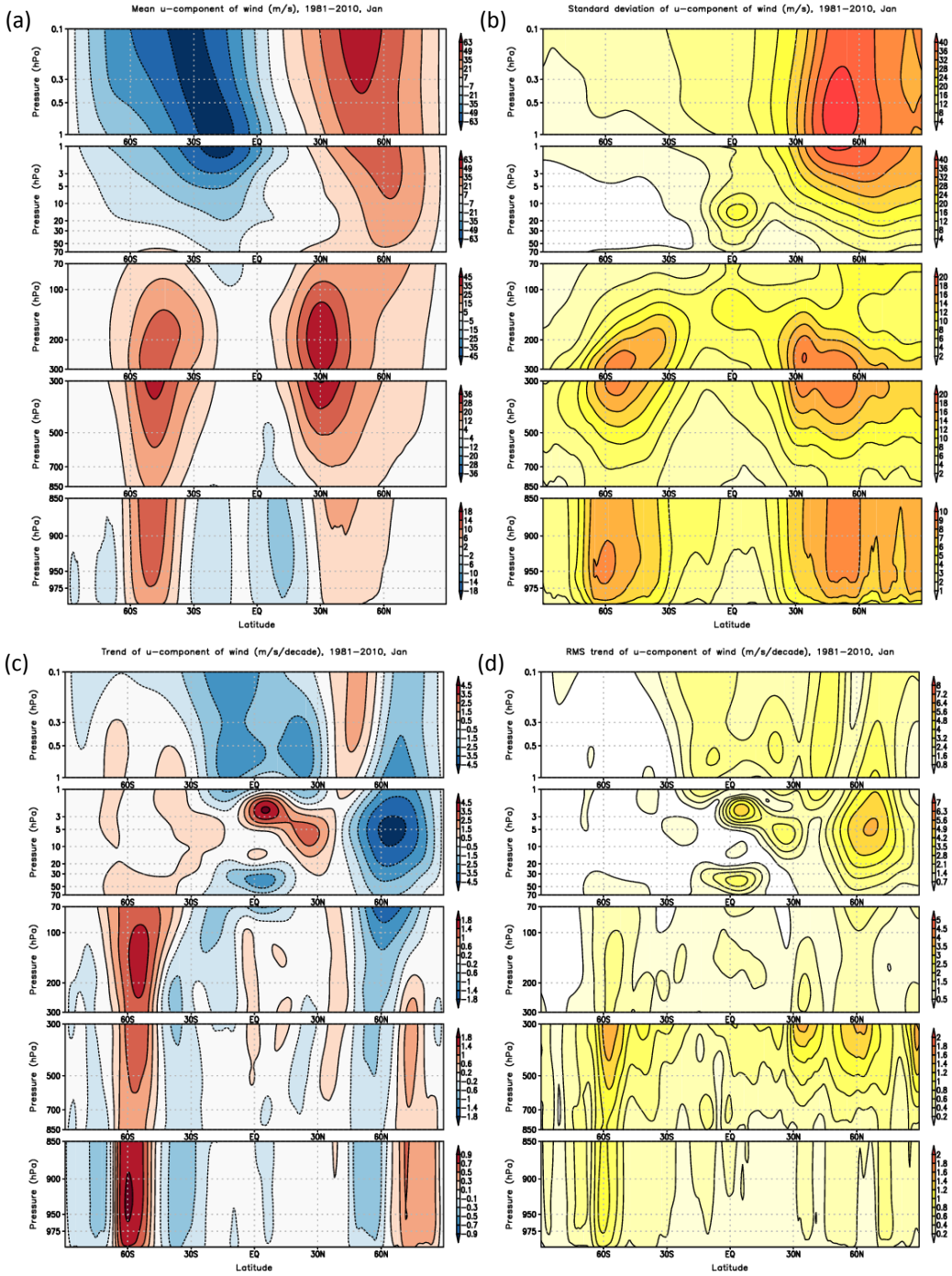

Fig. 1 U-component of wind from JRA-55 for January

(a) zonal means averaged over the 1981-2010 period, (b) standard deviations of 6-hourly analysis with respect to the monthly climatology, (c) zonal mean trends of monthly analysis for the 1981-2010 period and (d) RMS trends.

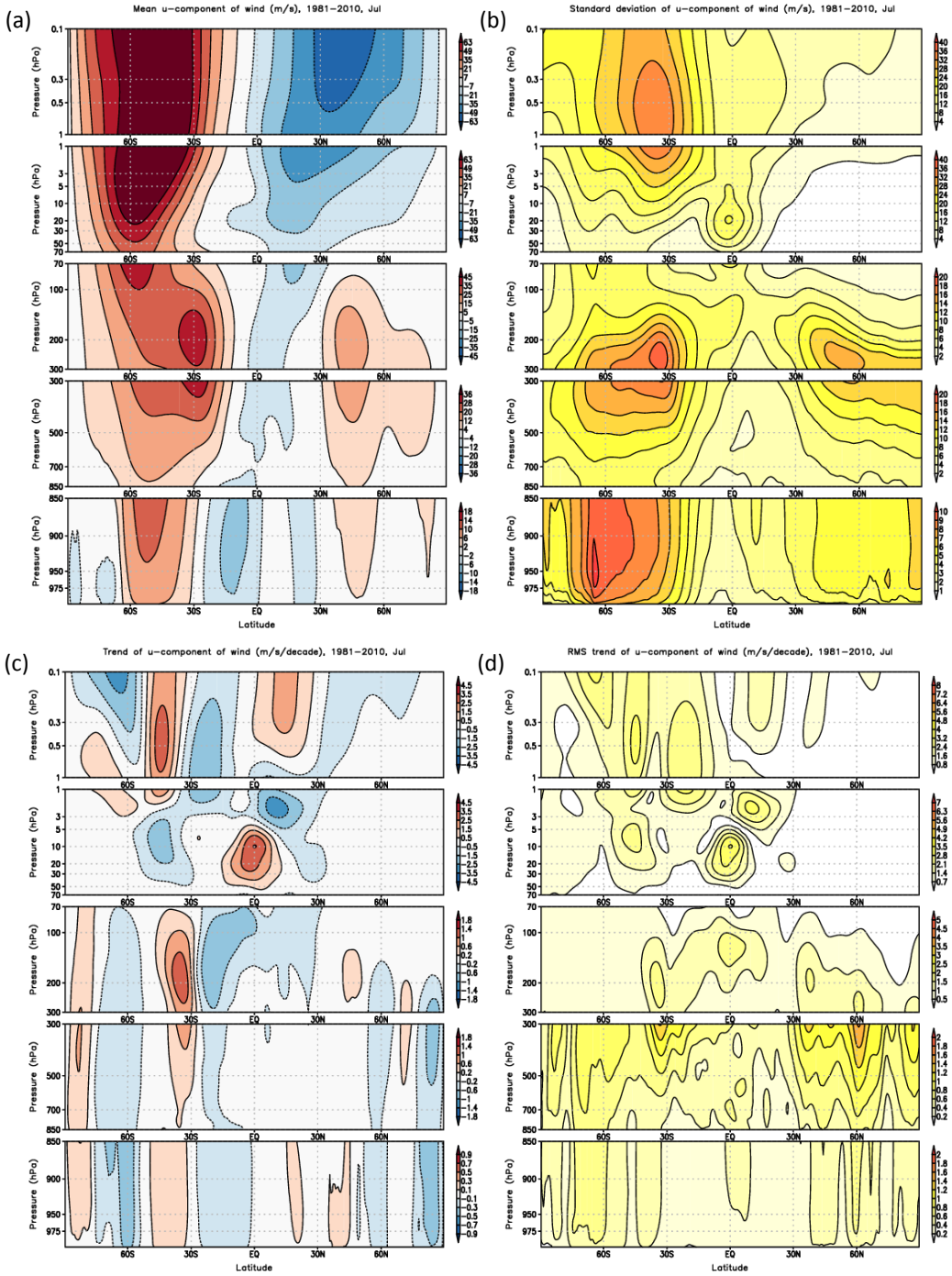

Fig. 2. As Fig. 1, but for July.

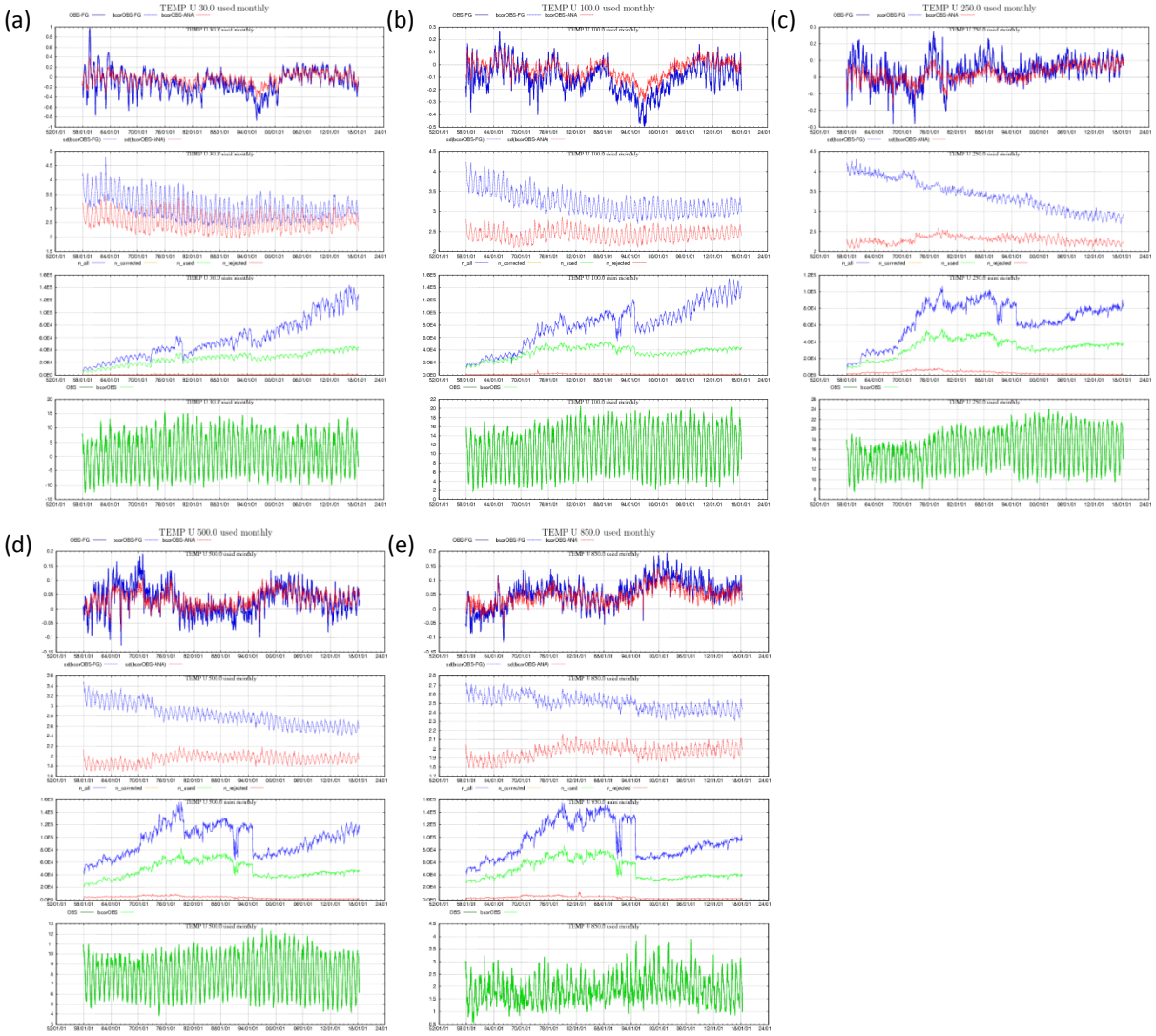

Fig. 3. (Top) global mean and (2nd) standard deviation of departure, (3rd) the number and (bottom) global mean observed values of radiosonde u-component of winds used in JRA-55 for (a) 30 hPa, (b) 100 hPa, (c) 250 hPa, (d) 500 hPa and (e) 850 hPa.