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COMMISSION FOR BASIC SYSTEMS

OPAG ON INTEGRATED OBSERVING SYSTEMS

INTER-PROGRAMME EXPERT TEAM ON THE OBSERVING SYSTEM DESIGN AND EVOLUTION (IPET-OSDE)

WORKSHOP ON OSCAR/REQUIREMENTS

(OSCAR/Requirements Workshop)

Geneva, Switzerland, 3-4 December 2018

FINAL REPORT

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World Meteorological Organization (WMO)

7 bis, avenue de la Paix — Tel.: +41 (0) 22 730 84 03

P.O. Box 2300 — Fax: +41 (0) 22 730 80 40

CH-1211 Geneva 2, Switzerland — E-mail: publications@wmo.int

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CONTENTS

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AGENDA

1. WELCOME AND ROUNDTABLE OF PARTICIPANTS

2. INTRODUCTION ABOUT OSCAR/REQUIREMENTS AND OBJECTIVE OF THE WORKSHOP

3. LISTS OF VARIABLES

3.1 Methodology for the review of variables during workshop

3.2 Review of Atmospheric Composition variables

3.3 Review of Cryosphere Variables

3.4 Review of ECVs which requires workshop's attention

4. LIST OF VERTICAL LAYERS

4.1 Methodology for the review of vertical layers during workshop

4.2 Review of vertical layers

5. ANY OTHER BUSINESS

6. NEXT STEPS & CLOSURE OF THE WORKSHOP

EXECUTIVE SUMMARY

The OSCAR/Requirements Workshop of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the Open Programme Area Group for Integrated Observing Systems (OPAG-IOS) of the Commission for Basic Systems (CBS) was held at the WMO Headquarters in Geneva, Switzerland from 3 to 4 December 2018 and was chaired by the Chair of the IPET-OSDE, Dr Erik Andersson (ECMWF).

The workshop addressed the need to make OSCAR/Requirements database evolve so that all Application Areas can properly record their observational user requirements in the database. In particular, at its 3rd meeting, the IPET-OSDE identified the need to reach consensus with regard to the names and definitions of variables as well as the vertical layers used in OSCAR/Requirements. The Workshop reviewed outcome of actions previously taken in this regard, in particular with regard to Atmospheric Composition variables. It considered cryospheric variables relevant to existing Application Areas (AAs) and to potential new AAs linked to the Global Cryosphere Watch. It also considered variables relevant to climate monitoring and related to GCOS Essential Climate Variables. It agreed on follow up action as reflected in ***Annex II***.

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GENERAL SUMMARY

1. WELCOME AND ROUNDTABLE OF PARTICIPANTS

1.1. Opening of the Meeting

1.1.1. The OSCAR/Requirements Workshop of the Inter Programme Expert Team on Observing System Design and Evolution (IPET-OSDE) of the Open Programme Area Group for Integrated Observing Systems (OPAG-IOS) of the Commission for Basic Systems (CBS) was held at the WMO Headquarters in Geneva, Switzerland from 3 to 4 December 2018 and was chaired by the Chair of the IPET-OSDE, Dr Erik Andersson (ECMWF).

1.1.2. Dr Erik Andersson welcomed the participants and wished for a successful meeting.

1.1.3. The Participants introduced themselves. The list of participants is given in ***Annex I***.

1.2. Adoption of the agenda

1.2.1. The workshop adopted its agenda.

2. INTRODUCTION ABOUT OSCAR/REQUIREMENTS AND OBJECTIVE OF THE WORKSHOP

2.1.1. The workshop recalled that OSCAR/Requirements was introduced for recording technology free observational user requirements of WMO applications areas in a quantitative way. It is regulated in the WIGOS Manual (WMO No. 1160, para 2.2.4 and Appendix 2.3), and GOS Manual (WMO No. 588). Members, both directly and through the participation of their experts in the activities of regional associations and technical commissions, contribute to the RRR process and assist the designated Points of Contact for each application area in performing their roles in the RRR. The Commission for Basic Systems (CBS) in charge of RRR. Decision 16 (CBS-16) also gave IPET-OSDE responsibility with regard to functional requirements with regard to the tools required for the RRR process, including OSCAR/Requirements in particular.

2.1.2. For an Application Area, a Variable, a Vertical Layer and an Horizontal Coverage, requirements are expressed in terms of Vertical Resolution, Horizontal Resolution, Observing Cycle, Timeliness, Uncertainty, and Stability (over 10-year period). For each of these 6 criteria, the requirements are expressed by 3 values:

- **The goal**: Value above which further improvement of the observation would not cause any significant improvement in performance for the application in question
- **The threshold**: Value that has to be met to ensure that data are useful.
- **The Breakthrough**: Intermediate level between "threshold" and "goal" which, if achieved, would result in a significant improvement for the targeted application

2.1.3. Participants were reminded about the contents and structure of OSCAR/Requirements; and particularly discussed:

- The process of going from raw observations to product (such process is clear for applications relying on data assimilation and numerical models, e.g. Global NWP).
- Requirements are expressed in terms of 3D (default) and 2D fields (e.g. total column is integration over the vertical and is therefore a 2D field).
- What we mean by 'variables', that are physical variables and not necessarily

identical to the observables in all cases.

- How do we associate units to variables.
- Our definition of uncertainty.
- Concepts of vertical and horizontal domains, cross cutting themes, and layers, and how they are linked to variables and observational user requirements.
- Status of Parallel ICT-IOS exercise on the Convergence between OSCAR/Requirements, OSCAR/Space, OSCAR/Surface and the WIGOS Metadata Standard.

2.1.4. The goal of the workshop was to progress on the following and agree on the next steps:

(i) Rationalizing Variable names in order to allow ingestion of new observational user requirements in OSCAR/Requirements (e.g. for Atmospheric Composition, Cryospheric variables, Climate Monitoring variables linked to GCOS Essential Climate Variables);

(ii) Integrating variables across all components of OSCAR and the WIGOS Metadata Standard (WMS).

2.1.5. The workshop focused on item (i) above.

3. LISTS OF VARIABLES

3.1. Methodology for the review of variables during workshop

3.1.1. The meeting reviewed status of the discussion related to the review of variables in OSCAR/Requirements. It particularly looked at:

- The scope of the review exercise;
- The WIGOS Metadata Standard (WMS). It was noted that while the WMS is governed under Technical Regulations detailed in WMO No. 1192, the list of observed Variables of the Standard is provided in Code Table 101, which is governed separately from the Standard itself. Code Table 101 is updated through fast track procedure where the ICG-WIGOS Task Team on Metadata (TT-WMD) has authority.
- The methodology from the ICT-IOS Review Group as captured in related spreadsheet;
- Findings and recommendations of the *ad hoc* review group on Atmospheric Composition Variables for which there are observational user requirements.

3.1.2. The workshop also identified the following issues:

- How to introduce different uncertainty requirements for specific variable ranges;
- ICT-IOS has proposed 31 new variables which need to be included in the WMS (***action***).

3.1.3. Before reviewing the list of variables in OSCAR/Requirements, the workshop agreed on methodology for such a review. Methodology is provided in ***Annex VII***.

3.2. Review of Climate Monitoring variables linked to ECVs and requiring the workshop's attention

3.2.1. The workshop reviewed the list of variables proposed for the RRR Application Area "Climate Monitoring".

3.2.2. The workshop noted that AOPC-23 (Darmstadt, Germany, 6-9 March 2018) reviewed the list of Essential Climate Variables of the Atmospheric Domain, introduced the concept of "Revised ECV Product[1]" variables, and compared their names and definitions with those of variables in OSCAR/Requirements, and commented. The workshop further reviewed that list, and provided its comments in the view to progress on making GCOS and OSCAR/Requirements lists of variables more consistent, if not aligned. New column with Workshop comments were provided in new [pink] column in the table of ***Annex IV***. The latest version of this table is provided in the Google Drive[2]. The workshop invited the GCOS Secretariat to further complete the table in ***Annex IV*** by adding corresponding names and definitions of WIGOS Metadata Standard variables in the dark blue columns (***action***).

3.2.3. The workshop noted that "ECV Products" are the geophysical/biological variables needed to describe an ECV. Thus, it is the ECV products that are suitable for OSCAR/Requirements, and not the ECV. It was noted that ECV is a concept, not necessarily referring to specific observed variables. Further improvements to the definitions of ECV products is a work in progress, which will feed into the updates of the GCOS IP.

3.2.4. The workshop also noted that some variables are defined as being observed at a specific height in OSCAR/Requirements. However, height should be specified in the metadata, allowing the definitions of variables to match the variation in the way they are measured in practice. Typically, all surface variables will be treated this way.

3.2.5. Precipitation variables need substantial review, not only for GCOS.

3.2.6. GCOS will have to work further and tune Aerosol variables. The workshop agreed that we will have to focus on the really important variables and rely on the expertise of the Scientific Advisory Group on Aerosols.

3.2.7. The workshop agreed on the following next steps:

- GCW is invited to look at the GCOS requirements from the GCOS IP (with assistance from GCOS Secretariat, Simon Eggleston) (***action***).
- GCOS is invited to feedback and discuss IPET-OSDE Workshop comments with AOPC concerning Variable names and definitions. It was noted that a teleconference of AOPC is planned in January, and will be discussing this issue (***action***).
- Once there is sufficient convergence between GCOS and OSCAR/Requirements variable names, we'll have to translate the current GCOS IP requirements into requirements that can be readily uploaded in OSCAR (***action; Spring 2019***). John Eyre offered to assist in this exercise. The proposal is to upload the figures from the GCOS IP requirements into OSCAR. The requirements will be reviewed and if needed updated for the update of the GCOS IP in 2022. The new figures from the update of the GCOS IP will then be uploaded into OSCAR It was noted that the requirements are now defined as one number (goal or breakthrough ?), and GCOS will have to clarify for what criteria, and perhaps also provide figures for the remaining criteria.
- For Aerosols, it was proposed to use requirements from the GCOS-IP, and variable names according to discussion under agenda item 3.4.
- For Variables of the Terrestrial and Ocean Domains, the workshop invited TOPC and OOPC to conduct similar exercise as AOPC. John Eyre offered to assist reviewing the corresponding variables.

[1] Revised ECV Product can be regarded at true variables corresponding to measurements, and for which observational user requirements can be provided.

[2] https://drive.google.com/open?id=15xBivia4h3lxw3yW2WAF08UsHfsUtsECcRlHjRtS7W8

- Secretariat was invited to look at pending questions from the Atmospheric Composition Variables Spreadsheet, liaise with CAS as needed, and propose resolving them (***action***).

3.3. **Review of Cryosphere Variables**

3.3.1. The Global Cryosphere Watch (GCW) Project Manager, Rodica Nitu, reported on follow up actions of the GCW after IPET-OSDE-3 meeting, with regard to IPET-OSDE guidance on Cryospheric variables. The following was particularly addressed:

- IPET-OSDE-3 report, paragraph 4.1.8: Compliance with WIGOS Metadata Standard and completeness of metadata provided to OSCAR/Surface: a potential barrier to the contribution of observations by external partners. The workshop noted that reaching agreement on terminology is a major challenge within GCW. Two-way communications with partners, such as JCOMM, GCW and the research community is important.
- IPET-OSDE-3 report, paragraph 6.2.4: IPET-OSDE-3 recalled that GCW is not regarded as an Applications Area, and that instead all Application Areas need to reflect the requirements of the Cryosphere in OSCAR/Requirements and their respective Statements of Guidance (see also IPET-OSDE-3 item 7.4.4). GCW is a mechanism to facilitate the access to cryosphere data and information supporting relevant applications.
- IPET-OSDE-3 Action 79 referring to IPET-OSDE-3 report, paragraph 6.2.4: To review one Application Area at a time, and it will take about two months for GCW to complete its review of all SoGs. The goal is for GCW to provide a report for each reviewed SoG, with possible recommendations.
- IPET-OSDE-3 report, paragraph 6.2.5: progress was noted on the international exchange of snow depth data. In 2018 a Snow Water Equivalent (SWE) BUFR template has been published.

3.3.2. The meeting reviewed Cryospheric Variables; in particular those for which observations are required by Application Areas. ***Annex VI*** provides the GCW Spreadsheet of variables and summarizes the reflection of cryosphere observation needs as documented in the Statement of Guidance of Application Areas which have made such references (note that it does not include requirements from the GCOS Implementation Plan). The latest version of the spreadsheet is available from the Google shared space[3]. Based on such review, the workshop agreed on the following:

- The GCW Programme Manager was invited to coordinate action with the Points of contact and GCW Experts to address the issue of further updating the spreadsheet, seeking agreement on the way forward with regard to clarifying cryospheric variable names and definitions, how cryospheric variables are reflected in the Statements of Guidance, as well as how observational user requirements are recorded in the OSCAR/Requirements database (***action***). For example, if requirements and gaps are expressed in the SoGs, the corresponding user requirements should also be documented in OSCAR/Requirements and consistency assured between SoGs and the database. PoCs of AAs may also be requested to adjust terminology about cryosphere variables as needed. It was noted that the IGOS Cryosphere Theme report includes observational user requirements related to specific socio economic areas with priority observations. However, observational user requirements will have to come from the PoCs of the Application Areas. IPET-OSDE Chair will be inviting the PoCs to collaborate with GCW on this issue (***action***).
- It was noted that Hydrology and Water Resources Application Area is working on its SoG, where IPET-OSDE-3 had requested the PoC to focus on operational hydrology.

[3] https://drive.google.com/open?id=1qqNGA_rBIDmtgvSDu307UZluJPvRP8g_O4LGQI9tmi0

Permafrost needs to be better characterized with true geophysical variable, e.g. depth of the active layer.

- The workshop also invited GCOS and GCW to work together on the specifics of Cryospheric variables (***action***), noting that while GCOS IP is regarded as SoG for Climate Monitoring, GCOS still needs to provide and update user requirements in OSCAR/Requirements.
- The Workshop noted that GCW is developing a GCW Pre-Operational Phase Implementation Plan for the next financial period 2020-2023. The Secretariat will organize the discussion in this regard.
- It was noted that the GCW Data Portal can be used as an interface with OSCAR/Surface through Machine to Machine interface.
- GCW Approach is as follows:
    - Firm up the CryoNet minimum observing program: existing observing programs of partners (80% completed);
    - Prepare Guide on the Measurement of Cryosphere Variables (WMO. No-8, 2018) (25% completed);
    - Provide input to the WIGOS Metadata Standard: confirm/ammend/add to WMO No.-1192 (25% completed as some cryosphere variables were added to the WMS);
    - WIGOS Metadata Standard variables to be harmonized with the OSCAR/Requirements Database (not started although Application Areas and SoGs have been reviewed in the view to bring more consistency). It was noted that OSCAR/Requirements is only looking at sub-set of variables, which are required by AAs (some variables may be observed but not required, and vice-versa).

3.3.3. Thorsteinn Thorsteinsson made a presentation on Glaciers and glacier variables, mass balance measurements and related applications.

3.3.4. The world is divided into 19 glaciated regions used by the World Glacier Monitoring Service (WGMS) and the Randolph Glacier Inventory. There are about 200.000 glaciers worldwide (outside the two large polar ice sheets) and mass loss is observed in all glaciated regions of the world. Melting of glaciers, ice caps and ice sheets is the largest contributor to ongoing sea-level rise.

3.3.5. Mr Thorsteinsson highlighted parameters characterizing individual glaciers where the World Glacier Monitoring Service (WGMS), GLIMS Glacier Database[4] and the US National Snow and Ice Data Centre (NSIDC) operate with slightly different versions. It was noted that two definition of glaciers existed[5]. He also explained about recommended and desired variables to be measured at CryoNet stations.

3.3.6. Based on the Icelandic experience concerning ice caps, Mr Thorsteinsson then explained about Glacier mass balance measurements, including long-term monitoring of changes in the natural environment, studies of glacier response to climate change, and knowledge of meltwater delivery to rivers harnessed for hydropower production. Projected warming until 2200 and resulting glacier volume changes and runoff changes in Iceland were presented. It was noted that such analysis appears to be an application directly relying on observations.

[4] https://nsidc.org/glims

[5] A. Physically based definition: A glacier may be defined as a perennial mass of ice, and possibly firn and snow, originating on the land surface by the recrystallization of snow or other forms of solid precipitation and showing evidence of past or present flow. B. Remote sensing definition: A glacier or perennial snow mass consists of a body of ice and snow that is observed at the end of the melt season, or, in the case of tropical glaciers, after transient snow melts. This includes, at a minimum, all tributaries and connected feeders that contribute ice to the main glacier, plus all debris covered parts of it. Excluded is all exposed ground, including nunataks. An ice shelf shall be considered as a separate glacier.

3.3.7. The workshop concurred with the following next steps as proposed by the GCW Project Manager:

- Terminology and Semantics: consensus on definitions and metadata with providers of cryosphere data: 2019-2020:
  - one variable at a time!
- Engage with AA leads re cryosphere variables in OSCAR: 2019-2020.
- Input to WIGOS Metadata Standard:
  - Snow and glacier variables: partially: 2018
  - Additional snow and glacier variables: 2020
  - sea ice, permafrost, 2019
  - GCW Data Portal interface to facilitate the registration of GCW stations in OSCAR: 2019

3.4. **Review of Atmospheric Composition variables**

3.4.1. The meeting considered the methodology adopted under agenda item 3.1, started from the spreadsheet reviewed by the *ad hoc* review Group on Atmospheric Composition variables, applied the methodology and recorded its results in the updated spreadsheet provided in ***Annex V***. The latest version of this spreadsheet is provided in the Google Drive[6].

4. **LIST OF VERTICAL LAYERS**

4.1. **Methodology for the review of vertical layers during workshop**

4.1.1. The meeting reviewed status of various discussions related to the review of vertical layers in OSCAR/Requirements. Currently, the following layers are used:

- Lower troposphere (LT)
- Upper troposphere (UT)
- Lower stratosphere (LS)
- Upper stratosphere and mesosphere (US&M)

4.1.2. The workshop considered whether we could split the top layer into separate upper stratosphere (US) and mesosphere (M), but this would only be useful if there are genuinely different observations requirements for the 2 layers.

4.1.3. The workshop also considered the option of introducing a superset of layers, from which each Application Areas would pick & select but agreed that this was not necessary at this stage.

4.2. **Review of vertical layers**

4.2.1. After discussion, the workshop agreed on the following proposal for vertical layers:

- Planetary boundary layer (PBL)
- Free troposphere (FT)
- Upper troposphere / lower stratosphere (UTLS)
- Mid-upper stratosphere (MUS)

[6] https://drive.google.com/open?id=1-TQuzIsdDG4nIISVELq25I2XnjyqqdlVvXBC0Vnw5HE

– Mesosphere (M)

4.2.2. The Secretariat was asked to implement the new layers in the database, assign the requirements values as follows (***action***), and the ask the Points of Contact to check the requirements again, change assignment of the layers to them, and adjust figures as needed (***action***).

Existing Layers	***Assign existing requirement values to new Layer(s)***
Lower troposphere (LT)	● Planetary boundary layer (PBL)
Upper troposphere (UT)	● Free troposphere (FT)
Lower stratosphere (LS)	● Upper troposphere / lower stratosphere (UTLS)
Upper stratosphere and mesosphere (US&M)	● Mid-upper stratosphere (MUS) ● Mesosphere (M)

5. ANY OTHER BUSINESS

WIGOS Metadata Standard list of variables

5.1.1. The workshop noted that the ICG-WIGOS Task Team on the WIGOS Metadata Standard (TT-WMD) will look at the OSCAR/Surface list, and break it down by sub-lists for review by specific user groups. The result of this exercise will also feed into a baseline list of variables in the Codes registry, with controlled process for evolution of the list, to also include consideration of OSCAR/Requirements list. IPET-OSDE member, John Eyre, will be included in the distribution list for the review of variables in the next few weeks (***action***).

Review of variables by ICT-IOS

5.1.2. The workshop agreed that there was the need to re-activate the ICT-IOS *ad hoc* Group on the review of Variables (***action***). The ICT-IOS Spreadsheet will have to be reviewed according to this workshop outcome. Variables for which there is no conflict, should be taken up by the WMS.

6. NEXT STEPS & CLOSURE OF THE WORKSHOP

6.1.1. Actions decided by the workshop, are recorded in ***Annex II***.

6.1.2. The Chair thanked the workshop participants and the Secretariat for contributing to the successful outcome of the meeting.

6.1.3. The meeting closed at 16:00 on Tuesday 4 December 2018.

ANNEX I

LIST OF PARTICIPANTS

(IPET-OSDE OSCAR/Requirements Workshop, Geneva, Switzerland, 3-4 December 2018)

1. IPET-OSDE MEMBERS

ANDERSSON, Erik (chair)	European Centre for Medium-Range Weather Forecasts Shinfield Park Reading RG2 9AX United Kingdom of Great Britain and Northern Ireland Tel: +44 118 949 9060 Fax: +44 118 986 9450 Email: erik.andersson@ecmwf.int
EYRE, John (core-member)	Met Office FitzRoy Road EXETER EX1 3PB Devon United Kingdom of Great Britain and Northern Ireland Tel: 44-1392-885175 Fax: Not Applicable Email: john.eyre@metoffice.gov.uk
MA, Lijuan (associate-member)	Now with WMO Secretariat (see below)

2. INVITED EXPERTS

KLAUSEN, Jörg Chair, ICG-WIGOS TT-WMD (by teleconference)	MeteoSwiss Switzerland Email: Joerg.Klausen@meteoswiss.ch
ORPHAL, Johannes Representing GCOS	Karlsruher Institut fur Technologie Germany Emaiul: Johannes.orphal@kit.edu
THOMAS, Werner Representing CAS and GAW	DWD Germany Email: Werner.Thomas@dwd.de
THORSTEINSSON, Thorsteinn Representing GCW	Icelandic Meteorological Office Iceland Email: thor@vedur.is

3. SECRETARIAT

WMO SECRETARIAT

7 bis, avenue de la Paix
CH-1211 Geneva 2
Switzerland

BRAATHEN, Geir Atmospheric Environment Research Division Research Department	Tel: +41-22 730 8235 Fax: +41 22 730 8036 E-mail: GBraathen@wmo.int
CHARPENTIER, Etienne Chief, Observing Systems Division (OSD), OBS Department	Tel.: (+41 22) 730 8223 Fax: (+41 22) 730 8478 E-mail: echarpentier@wmo.int
EGGLESTON, Simon **GCOS Secretariat**	Tel: +41 22 730 8272 Fax: +41 22 730 8052 Email: seggleston@wmo.int http://gcos.wmo.int
MA, Lijuan GCW Project Office	Tel: + 41 22 730 8225 Fax: (+41 22) 730 8478 Email: lma@wmo.int
NITU, Rodica Project Manager, GCW OBS Department	Tel: + 41 22 730 8482 Fax: (+41 22) 730 8478 Email: Rnitu@wmo.int
NUNES, Luis Scientific Officer, WIGOS Office	Tel.: +41 22 8138 Fax: +41 22 730 8021 Email: lfnunes@wmo.int
PROESCHOLDT, Timo WIGOS Project Office	Tel: +41 22 8176 Fax: +41 22 730 8021 Email: tproescholdt@wmo.int
TASSONE, Caterina GCOS Secretariat	Tel: +41 22 730 8218 Fax: +41 22 730 8052 Email: ctassone@wmo.int http://gcos.wmo.int

ANNEX II

ACTION SHEET RESULTING FROM THE IPET-OSDE OSCAR/REQUIREMENTS WORKSHOP

Note: The full list of IPET-OSDE Actions, including from previous IPET-OSDE meetings, sorted by topic and with status is available on the Team's shared Google Drive[7], and has been updated with the list of actions from this meeting (note that the action numbers are different in the version of the Google drive).

No.	*Ref.*	*What*	*By whom*	*Deadline*
1	3.1.2	To include the 31 new variables proposed by ICT-IOS in the WIGOS Metadata Standard	Secr. & TT-WMD	asap
2	3.2.2.	to further complete the table in Annex IV of the OSCAR/Requirements workshop by adding corresponding names and definitions of WIGOS Metadata Standard variables in the dark blue columns	GCOS Secr.	asap
3	3.2.7(1)	to look at the GCOS requirements from the GCOS IP (with assistance from GCOS Secretariat, Simon Eggleston) and identify how cryospheric variables and their requirements can be considered	GCW PM	Jan. 2019
4	3.2.7(2)	to feedback and discuss IPET-OSDE OSCAR/Requirements Workshop comments with AOPC concerning Variable names and definitions. It was noted that a teleconference of AOPC is planned in January, and will be discussing this issue.	GCOS Secr.	Jan. 2019
5	3.2.7(3)	to translate the current GCOS IP requirements into requirements that can be readily uploaded in OSCAR, once there will be sufficient convergence between GCOS and OSCAR/Requirements variable names	Secr.	Apr. 2019
6	3.3.2(1)	to coordinate action with the Points of Contact and GCW Experts to address the issue of further updating the GCW spreadsheet of Cryospheric Variables, seeking agreement on the way forward with regard to clarifying variable names and definitions, how cryospheric variables are reflected in the Statements of Guidance, as well as how observational user requirements are recorded in the OSCAR/Requirements database.	GCW PM	Mid- 2019
7	3.3.2(1)	to invite the PoCs to collaborate with GCW on this issue of updating OSCAR/Requirements, taking into account the IGOS Cryopshere Theme report, which includes observational user requirements, which relate to specific socio-economic areas with priority observations.	Chair	asap
8	3.3.2(3)	to work together on the specifics of Cryospheric variables, noting that while GCOS IP is regarded as SoG for Climate Monitoring, GCOS still needs to provide and update user requirements in OSCAR/Requirements	GCOS Secr. & GCW PM	Mid-2019
9	4.2.2.	to implement the new layers in the database, assign the requirements values as follows and ask the Points of Contact to check the requirements again, change assignment of the layers to them, and adjust figures as needed	Secr.	asap
10	4.2.2.	to check the requirements again, change assignment of the layers to them, and adjust figures as needed	PoCs	asap
11	5.1.1.	To contribute to the TT-WMS exercise which will be looking at the OSCAR/Surface list, and break it down by sub-lists for review by specific user groups.	J. Eyre	Early 2019
12	5.1.2.	to re-activate the ICT-IOS *ad hoc* Group on the review of Variables	Secr.	asap
13	3.2.7(6))	to address pending questions and actions regarding Atmospheric Composition variables (see Spreadsheet in Annex V, and Annex VII)	Secr. (G. Braathen)	asap

[7] https://drive.google.com/open?id=17OGPiNlmfcd-jCXKvsAHpY5EFRZpASGMUU7iLGHCxZo

ANNEX III

LINKS TO PREPARATORY DOCUMENTS AND PRESENTATIONS OF THE WORKSHOP

All documents are available from the dedicated Google space at:
https://drive.google.com/open?id=0BzxtAFnFpjaRQ2RYc2RDOGNfREU

1. DOCUMENTS

No.	*Title*	*Author*	*Link*
0	Workshop programme (this document)	Secretariat	here
1	Variables Comparison Spreadsheet with WIGOS Metadata Standard, OSCAR/Surface, and OSCAR/Requirements (v 0.5 dated 31 January 2018) (outcome of work of ICT-IOS *ad hoc* Review Group on Variables) - see also ppt#3 below	ICT-IOS Review Group on Variables	here
2	Reports of Teleconferences of the ICT-IOS *ad hoc* Review Group on Variables - see also ppt #3 below	ICT-IOS Review Group on Variables	here
3	Outcome of IPET-OSDE-3 Breakout Group on the Review of Variables	IPET-OSDE-3	here
4	OSCAR variables – resolving conflicts and additional comments	J. Eyre	here
5	Atmospheric Composition Variables review (variables for which there are obs. requirements) - Spreadsheet v4 20181129 (outcome of *ad hoc* review group per doc 6) - see also ppt#2 below	E. Andersson, J. Eyre, G. Braathen, E. Charpentier, T. Proescholdt, J. Klausen	here
6	Pending issues regarding GAW related OSCAR/Requirements requirements - see also ppt#2 below	E. Andersson, J. Eyre, G. Braathen, E. Charpentier, T. Proescholdt, J. Klausen	here
7	GCOS relevant documents Doc#7.1: Atmosphere ECV Definitions Doc#7.2: Table of names and requirements from the GCOS IP (AOPC work in progress)	AOPC	doc#7.1 doc#7.2
8	GCW Spreadsheet of variables with information on how they link with Statements of Guidance and related issues	GCW	here
9	Variables approved by EC-69 as part of WIGOS Metadata Standard	EC-69	here

2. PRESENTATIONS

No.	*Title*	*Author*	*Link*
1	Management of observational user requirements within OSCAR/Requirements	E. Charpentier	here
2	Outcome of discussions on Atmospheric Composition Variables (2018 *ad hoc* review Group on Pending issues regarding GAW related OSCAR/Requirements requirements) - This is summary of document #6 above.	E. Andersson, J. Eyre, G. Braathen, E. Charpentier, T. Proescholdt, J. Klausen	here
3	Outcome of discussions of the ICT-IOS *ad hoc*	E. Andersson , K.	here

	review group on Variables - This is summary of documents #2 and #3 above	Monnik, J. Klausen, A. Rea, J. Eyre, L. Freydier, M. Schultz, L. Ma, S. Goldstraw, S. Elliott	

ANNEX IV

REVIEW OF ATMOSPHERIC DOMAIN ESSENTIAL CLIMATE VARIBLE

(As reviewed by AOPC-23, Darmstadt, 6-9 March 2018, and the IPET-OSDE OSCAR/Requirements Workshop, Geneva, 3-4 December 2018)

Note: Latest version of this table is provided in the Google Drive at:
https://drive.google.com/open?id=15xBivia4h3lxw3yW2WAF08UsHfsUtsECcRlHjRtS7W8

Green: revised ECV products and definition by AOPC; Blue: OSCAR definitions; Yellow: comments provided by AOPC-23; Pink: Comments provided by IPET-OSDE OSCAR/Requirements workshop; Dark blue: WIGOS Metadata Standard (WMS).

Surface ECV

ECV	*Revised ECV product*	*Definition*	*WMS Name*	*WMS Definition*	*OSCAR variable*	*Definition in OSCAR*	*IPET-OSDE workshop comment*	*Comments from AOPC*
Surface Wind Speed and direction	Wind speed over the surface	Speed of air at a known height above the surface which is to be specified in the metadata (m/s)			Wind speed over the surface (horizontal)	Module of the horizontal component of the 3D wind vector(m/s)	GCOS def. better. Name: Wind speed (near surface)	Different definition
	Wind direction over the surface	Direction from which wind is blowing at a known height above the surface which is to be specified in the metadata (degree true)[8]					Can be added in OSCAR with definition. Name: Wind direction (near surface)	No equivalent variable in OSCAR
	Horizontal wind vector over the surface	Horizontal wind vector wind vector, at a known height above the surface which is to be specified in the metadata (m/s)[9]			Wind vector over the surface (horizontal)	Horizontal vector component (2D) of the 3D wind vector, conventionally measured at 10 m height (m/s).	Use OSCAR name, and GCOS definition, with "wind vector" duplication removed. Name: Wind vector (near surface)	Recommendation to change definition in OSCAR to take into account that not all surface measurements will be at

[8] As defined in WMO 360

[9] Need to say this is NS/EW and which is +, page 288 of WMO 308 defines the convention in the footnotes

								10 m.
Precipitation	Accumulated solid and liquid precipitation (over 24h)	Integration of precipitation rate reaching the ground over several time intervals. The reference requirement refers to integration over 24 hr (mm)			Accumulated precipitation (over 24h)	Integration of precipitation rate reaching the ground over several time intervals. The reference requirement refers to integration over 24 h (mm)	Solid+liquid needs to be in the definition. Period over which it is accumulated is variable and can be specified in the requirements Name: Accumulated Precipitation Definition: Integration of solid and liquid precipitation rate reaching the ground over a time period defined in the metadata.	The name of the ECV product includes "solid and liquid". This is not included in the name or definition of the OSCAR variable
	Accumulated solid and liquid precipitation (over 1h)	Integration of precipitation rate reaching the ground over several time intervals. The reference requirement refers to integration over 1 hr (mm)					To be deleted	No equivalent variable in OSCAR
Temperature (surface)	Air temperature (near surface)	Air temperature at a known height above the surface, with the height specified in the metadata (K)			Air temperature (at surface)	Air temperature measured at 2 m above surface (K)	GCOS name and definition better Name:	Recommendation to change definition in OSCAR to

							Atmospheric Temperature (near surface)	take into account that not all surface measurements will be at 2m.
Pressure (surface)	Near surface air pressure	Pressure of the air column at a known height above the surface with the height specified in the metadata (hPa)			Air pressure (at surface)	Pressure of the air column measured at 2 m above surface (hPa)	Name: Atmospheric pressure (near surface) Definition: Pressure at a known height above the surface with the height specified in the metadata	Recommendation to change definition in OSCAR to take into account that not all surface measurements will be at 2m.
	Pressure reduced to mean sea level	Pressure reduced to mean sea level (hPa)					Not an observation	No equivalent variable in OSCAR
Water vapour (surface)	Air specific humidity (near surface)	Air specific humidity at a known height above surface, with the height specified in the metadata. Specific humidity is the ratio of the mass of water vapour and the mass of moist air (g/Kg)			Air specific humidity (at surface)	Air specific humidity measured at 2 m above surface. The specific humidity is the ratio between the mass of water vapour and the mass of moist air. (g/kg)	Name: Atmospheric specific humidity (near surface) Definition: Atmospheric specific humidity e at a known height above surface, with the height specified in	Recommendation to change definition in OSCAR to take into account that not all surface measurements will be at 2m.

							the metadata. Specific humidity is the ratio of the mass of water vapour and the mass of moist air	
	Relative humidity	Relative humidity at a known height above surface, with the height specified in the metadata. Relative humidity is the ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated (%)					Add in OSCAR Name: Relative Humidity (near surface) Definition: Relative humidity at a known height above surface, with the height specified in the metadata. Relative humidity is the ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated with respect	No equivalent variable in OSCAR

							to water or ice to be specified in the metadata	
	Dew Point temperature	Temperature to which air must be cooled to become saturated with water vapor at a known height above surface, with the height specified in the metadata (K)					Name: Dew point temperature (near surface) Use GCOS definition.	No equivalent variable in OSCAR
Surface Radiation budget	Downward long-wave irradiance at Earth surface	Flux density of radiation emitted by the gases, aerosols and clouds of the atmosphere to the Earth's surface (W/m2)			Downward long-wave irradiance at Earth surface	Flux density of radiation emitted by the gases, aerosols and clouds of the atmosphere to the Earth's surface	No changes	
	Upward long-wave irradiance at Earth surface	Flux density of terrestrial radiation emitted by the Earth surface (W/m2)			Upward long-wave irradiance at Earth surface	Flux density of terrestrial radiation emitted by the Earth surface	No changes	
	Downward short-wave irradiance at Earth surface	Flux density of the solar radiation at the Earth surface (W/m2)			Downward short-wave irradiance at Earth surface	Flux density of the solar radiation at the Earth surface	No changes	

This table has been edited and reviewed by Phil Jones and Elizabeth Kent.
Liz Kent looked at the WIGOS metadata standard (https://library.wmo.int/opac/doc_num.php?explnum_id=3653), which defers to the manual on codes for variables and units (http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/VolumeI.2.html) and has tried to make things consistent with that (which OSCAR should also be). Her notes on this are reported on the table as footnotes.

Upper-air ECV

ECV	***Revised ECV product***	***Definition***	***WMS Name***	***WMS Definition***	***OSCAR variable***	***Definition in OSCAR***	***IPET-OSDE workshop comment***	***Comments from AOPC***

Wind speed and direction (upper-air)	Horizontal Wind Vector in the Boundary layer	3D field of the horizontal vector component (2D) of the 3D wind vector (m/s)			Wind (horizontal)	3D field of the horizontal vector component (2D) of the 3D wind vector (m/s)	Change layers according to new proposal Name: Wind Vector (horizontal).	Recommendation to change definition in vertical levels in OSCAR for Wind, Temperature and Humidity
	Horizontal Wind Vector in the free troposphere							
	Horizontal Wind Vector in the free tropopause layer (UTLS)							
	Horizontal Wind Vector in the stratosphere							
	Horizontal Wind Vector in the mesosphere							
	Vertical Velocity (geometric) in the Boundary layer	3D field of the vertical component of the 3D wind vector (cm/s)			Wind (vertical)	3D field of the vertical component of the 3D wind vector (cm/s)	Change layers according to new proposal. Delete "(geometric)" from name.	Recommendation to change definition in vertical levels in OSCAR for Wind, Temperature and Humidity
	Vertical Velocity (geometric) in the free troposphere							
	Vertical Velocity (geometric) in the free tropopause layer (UTLS)							
	Vertical Velocity (geometric) in the							

	stratosphere							
	Vertical Velocity (geometric) in the mesosphere							
	Vertical Velocity (pressure) in the Boundary layer	3D field of the vertical component of the 3D wind vector in the pressure coordinate (Pa/s)					Delete as it duplicates	No pressure coordinates in OSCAR variables
	Vertical Velocity (pressure) in the free troposphere							
	Vertical Velocity (pressure) in the free tropopause layer (UTLS)							
	Vertical Velocity (pressure) in the stratosphere							
	Vertical Velocity (pressure) in the mesosphere							
Temperature (upper-air)	Temperature in the Boundary layer	3D field of the atmospheric temperature (K)			Atmospheric Temperature	3D field of the atmospheric temperature (K)	No change	Recommendation to change definition in vertical levels in OSCAR for Wind, Temperature and
	Temperature in the free troposphere							
	Temperature in the free tropopause							

	layer (UTLS) Temperature in the stratosphere Temperature in the mesosphere							Humidity
Water vapour	Integrated Water Vapour (IWV)	Total amount of water vapour present in a vertical atmospheric column (Kg/m2)			Integrated Water Vapour (IWV)	Total amount of water vapour present in a vertical atmospheric column.	No change	
	Specific humidity in Boundary layer Specific humidity in the troposphere Specific humidity in the free tropopause layer (UTLS) Specific humidity in the stratosphere Specific humidity in the mesosphere	3D field of the specific humidity in the atmosphere. The specific humidity is the ratio between the mass of water vapour and the mass of moist air (g/Kg)			Specific humidity	3D field of the specific humidity in the atmosphere. The specific humidity is the ratio between the mass of water vapour and the mass of moist air.		Recommendation to change definition in vertical levels in OSCAR for Wind, Temperature and Humidity
	Relative humidity in Boundary layer Relative humidity in the troposphere Relative humidity in the free	Ratio of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated (%)					Definition: 3D field of Ratio of the amount of atmospheric moisture present relative to the amount that would be present if	No equivalent variable in OSCAR

	tropopause layer (UTLS)						the air were saturated with respect to water or ice to be specified in the metadata.	
	Relative humidity in the stratosphere							
	Relative humidity in the mesosphere							
Earth Radiation Budget	Upward long-wave irradiance at TOA	Flux density of terrestrial radiation emitted by the Earth surface and the gases, aerosols and clouds of the atmosphere at the top of the atmosphere (W/m2)			Upward long-wave irradiance at TOA	Flux density of terrestrial radiation emitted by the Earth surface and the gases, aerosols and clouds of the atmosphere at the top of the atmosphere (W/m2)	No change	
	Upward short-wave irradiance at TOA	Flux density of solar radiation, reflected by the Earth surface and atmosphere, emitted to space at the top of the atmosphere(W/m2)			Upward short-wave irradiance at TOA	Flux density of solar radiation, reflected by the Earth surface and atmosphere, emitted to space at the top of the atmosphere (W/m2)	No change	
	Downward short-wave irradiance at TOA	Flux density of the solar radiation at the top of the atmosphere (W/m2)			Downward short-wave irradiance at TOA	Flux density of the solar radiation at the top of the atmosphere (W/m2)	No change	
	Solar spectral irradiance	Total Solar Irradiance (TSI); when measured as a function of wavelength it is the spectral irradiance (W/m2/µm)					To be added in OSCAR. Typo in name (Solar spectral irradianc)	No equivalent variable in OSCAR
	Radiation Profile	Vertical profile of upward and downward LW and SW radiation components (W/m2)					To be added	No equivalent variable in OSCAR
Lightning	Total lightning stroke density (gridded)	Total number of detected strokes in the corresponding time interval and the space			Total lightning density	Total number of detected flashes in the corresponding time interval and the space	Use GCOS name and definition but remove	Recommendation to change name and

		unit. The space unit (grid box) should be equal to the horizontal resolution and the accumulation time to the observing cycle.				unit. The space unit (grid box) should be equal to the horizontal resolution and the accumulation time to the observing cycle.	(gridded) Consult Nowcasting & VSRF PoC for confirmation	definition in OSCAR
Cloud properties	Cloud cover	Fraction of sky filled by clouds (%)			Cloud cover	2D field of fraction of sky filled by cloud	Use OSCAR definition	
	Cloud top height	Height of the top of the cloud (highest cloud in case of multi-layer clouds) (Km)			Cloud top height	Height of the upper surface of the cloud	Use GCOS definition	Different definitions
	Cloud Top Temperature	Temperature of the top of the cloud (K)			Cloud Top Temperature	Temperature of the upper surface of the cloud	Use similar definition as of row above	Different definitions
	Cloud Optical Depth	Effective depth of a cloud from the viewpoint of radiation extinction. OD = exp(-K.Δz) where K is the extinction coefficient [km-1] and Δz the vertical path [km] between the base and the top of the cloud (dimensionless)			Cloud Optical Depth	Effective depth of a cloud from the viewpoint of radiation extinction. OD = exp(-K.Δz) where K is the extinction coefficient [km-1] and Δz the vertical path [km] between the base and the top of the cloud	Concept of reference wavelength missing (to be part of metadata)	
	Cloud liquid Water Path	Total amount of liquid water in depth from top of cloud to surface (g/m2)			Cloud liquid water (CLW) Note: this is not the correct OSCAR equiv. variable	3D field of atmospheric water in the liquid phase (precipitating or not).	See note in blue column Current equivalent in OSCAR = Cloud liquid water (total column) Definition: need to add ref. to total column Retain 3D variable and add total column	Different names and definitions

							variable	
	Cloud ice Water Path	Total amount of ice water in depth from top of cloud to surface (g/m2)			Cloud ice Note: this is not the correct OSCAR equiv. variable	3D field of atmospheric water in the solid phase (precipitating or not).	See note in blue column OSCAR equivalent: Cloud ice (total column) Retain 3D variable and add total column variable	Different names and definitions
	Cloud drop effective radius	Ratio of integral of water droplets size distribution in volume divided by integral in area (Mm)			Cloud drop effective radius	Size distribution of liquid water drops, assimilated to spheres of the same volume. Considered as both a 3D field throughout the troposphere and a 2D field at the top of cloud surface	OSCAR definition needs to be changed. GCOS definition better. Two variables needed: one for 3D field and one for 2D cloud-top variable	Different definitions

Wind: Validated by Shinya Kobayashi. Additional comments from Shinya : add vertical pressure velocity, which is what most global reanalyses provide as they are based on hydrostatic models. The relevant document is (IPCC AR5 WG1, Chapter 2, Figure 2.39); https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter02_FINAL.pdf
Temperature : Validated by Peter Thorne (23/03/2018)
Radiation Profile: definition by Peter Thorne. Reference: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012GL052087
Lightning: Task Team on Lightning. Ref: ATBD,MTG EURD, Nag et al, 2015

Composition

ECV	*Revised ECV product*	*Definition*	*WMS Name*	*WMS Definition*	*OSCAR variable*	*Definition in OSCAR*	*IPET-OSDE workshop comment*	*Comments from AOPC*
Carbon Dioxide, Methane and other Greenhouse gases	Total column CO2	Total molecules of CO2 in the atmosphere from surface to TOA (Molecules/cm2)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	CO2	Dry air mole fraction of CO2 (Mol/mol)			CO2	3D field of dry air mole fraction of CO2 = Carbon dioxide	Follow what workshop recommended for AC Variables	Different definitions
	Total column CH4	Total molecules of CH4 in the atmosphere from surface to TOA (Molecules/cm2)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	CH4	Dry air mole fraction of CH4 (Mol/mol)			CH4	3D field of dry air mole fraction of CH4 = Methane	Follow what workshop recommended for AC Variables	Different definitions
Ozone	Total column ozone	Total molecules of O3 in the atmosphere from surface to TOA (Dobson units)			O3(Total column)	Field of total column of Ozone.	Follow what workshop recommended for AC Variables	Different definitions
	O3	Dry air mole fraction of O3 (Mol/mpol)			O3	3D field of mole fraction of O3 (Ozone)	Follow what workshop recommended for AC Variables	Different definitions
	Tropospheric Ozone column	Total molecules of O3 in the atmosphere from surface to tropopause (Dobson units)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Stratospheric Ozone column	Total molecules of O3 in the atmosphere from tropopause to TOA (Dobson units)					Follow what workshop recommended for AC	No equivalent variable in OSCAR

							Variables	
Precursors (supporting the aerosol and ozone ECV)	Total column NO2	Total molecules of NO2 in the atmosphere from surface to TOA (Molecules/cm2)			NO2 (Total column)	2D field of Total Column NO2 = Nitrogen dioxide	Follow what workshop recommended for AC Variables	Different definitions
	Total column SO2	Total molecules of SO2 in the atmosphere from surface to TOA (Molecules/cm2)			SO2 (Total column)	2D field of Total Column SO2 = Sulfur dioxide	Follow what workshop recommended for AC Variables	Different definitions
	Total column HCHO	Total molecules of HCHO in the atmosphere from surface to TOA (Molecules/cm2)			HCHO (Total column)	2D field of Total Column HCHO = Formaldehyde.	Follow what workshop recommended for AC Variables	Different definitions
	Total column CO	Total molecules of CO in the atmosphere from surface to TOA (Molecules/cm2)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Tropospheric CO column	Total molecules of CO in the atmosphere from surface to tropopause (Molecules/cm2)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	CO	Dry air mole fraction of CO (Mol/mol)			CO	3D field of dry air mole fraction of CO = Carbon monoxide	Follow what workshop recommended for AC Variables	Different definitions
Aerosols properties	Aerosol optical depth	The AOD is the spectral dependent aerosol extinction coefficient integrated over the geometrical path length (dimensionless)			Aerosol optical depth	The AOD is the effective depth of the aerosol column from the viewpoint of radiation propagation: Vertical column integral of spectral aerosol extinction coefficient AOD = exp(-K. Δz) where K is the extinction coefficient [km-1] and	Follow what workshop recommended for AC Variables	Different definitions

						Δz the vertical path [km]		
	Aerosol single-scattering albedo	The spectrally dependent ratio of the aerosol scattering to the aerosol extinction (dimensionless					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Aerosol layer height	Height of vertically localized aerosol layer in the free troposphere above sea level (Km)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Aerosol Extinction coefficient	Spectrally dependent sum of aerosol scattering and absorption by a population of aerosol particles per unit of geometrical path length (1/m)			Aerosol Extinction coefficient	3D field of spectral volumetric extinction cross-section of aerosol particles	Follow what workshop recommended for AC Variables	Different definitions
	Aerosol size distribution	Specification of particle size though the distribution of aerosol number (or mass, or area, or volume) concentration of differential diameter (Number: cm-3; Area: μm2 cm−3 Volume: μm3 cm−3 Mass: μg m−3)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Aerosol Composition	Chemical composition of aerosol particles defined by the relative abundance of different chemical components of aerosol particles (Mass/volume fraction)					Follow what workshop recommended for AC Variables	No equivalent variable in OSCAR
	Aerosol Refractive index	Spectrally-dependent optical constraint defined by the particle					Follow what workshop recommende	No equivalent variable in

		composition where the real part is responsible for the particle scattering and the imaginary part is responsible for the particle absorption (dimensionless)					d for AC Variables	OSCAR

Comments from Dale Hurst:
Tropospheric Column CO2 (and CH4, NO2, SO2, HCHO) were changed to Total Column CO2 (and CH4, NO2, SO2, HCHO) because the Total Column is basically the same as the Tropospheric Column (everything is in the troposphere)
Stratospheric CH4 was strange ECV so it was removed.
Definitions of total, tropospheric and stratospheric Column Ozone were changed to ones that make more sense.
The three ozone column ECVs listed above take care of the important regions of the atmosphere for climate.
Total Column and Tropospheric Column CO are important ECVs. Their definitions were changed to ones that make more sense.

Aerosols definition – Olga Kalashnikova

ANNEX V

REVIEW OF ATMOSPHERIC COMPOSITION VARIABLES

(As reviewed the IPET-OSDE OSCAR/Requirements Workshop, Geneva, 3-4 December 2018)

Dark green: Variable matches with one variable in OSCAR/Requirements
Orange: Propose renaming variable in OSCAR/Requirements
Light Green: Propose adding variable in OSCAR/Requirements
White: Solution remains to be proposed

Variable in GAW requirements	***Original question / comment***	***OSCAR/Requirements status***	***ignore this column***	***Name in OSCAR/requirements***	***Proposed action***	***Workshop proposal for name of variable***	***Comments***	***Remaining question to be solved***	***Proposal for remaning question***
Fire Radiative Power		YES: 61	fire radiative power	Fire radiative power	map to existing variable	Fire radiative power			
Cloud cover		YES: 27	cloud cover	Cloud cover	map to existing variable	Cloud cover			
Albedo	of what?	?			map to existing variable	Earth surface albedo			
HCHO total column		YES: 22	hcho total column	HCHO (Total Column)	Rename variable in OSCAR/Req.	HCHO Total Column	Indicate in definition that it is 2D field requirement, integrated over column		
SO2 total column		YES: 147	so2 total column	SO2 (Total column)	Rename variable in OSCAR/Req.	SO2 Total Column	Indicate in definition that it is 2D field requirement, integrated over column		

OH		YES: 120	oh	OH	Rename variable in OSCAR/Req.	OH Amount of substance fraction	Indicate in the definition that it is 3D field requirement.		
NO2 total column		YES: #106	no2 total column	NO2 (Total column)	Rename variable in OSCAR/Req.	NO2 Total Column	Indicate in definition that it is 2D field requirement, integrated over column		
HNO3 mixing ratio		Closest = #84 mole-fraction	hno3 mixing ratio	HNO3	Rename variable in OSCAR/Req.	HNO3 Amount of substance fraction	Indicate in definition that this is 3D field requirement		
CO2 mixing ratio		Closest = #39 mole-fraction	co2 mixing ratio	CO2	Rename variable in OSCAR/Req.	CO2 Amount of substance fraction	Indicate in definition that this is 3D field requirement		
CO mixing ratio		Closest = #38 mole-fraction	co mixing ratio	CO	Rename variable in OSCAR/Req.	CO Amount of substance fraction	Indicate in definition that this is 3D field requirement		
CH4 mixing ratio		Closest = #23 mole-fraction	ch4 mixing ratio	CH4	Rename variable in OSCAR/Req.	CH4 Amount of substance fraction	Indicate in definition that this is 3D field requirement		
HCHO mixing ratio		Closest = #21 mole-fraction	hcho mixing ratio	HCHO	Rename variable in OSCAR/Req.	HCHO Amount of substance fraction	Indicate in definition that this is 3D field requirement		
SO2 mixing ratio		Closest = #146 mole-fraction	so2 mixing ratio	SO2	Rename variable in OSCAR/Req.	SO2 Amount of substance fraction	Indicate in definition that this is 3D field requirement		
PAN mixing ratio		Closest = #122 mole-fraction	pan mixing ratio	PAN	Rename variable in OSCAR/Req.	PAN Amount of substance fraction	Indicate in definition that this is 3D field requirement		
Ozone mixing ratio		Closest = #108 mole-fraction	ozone mixing ratio	O3	Rename variable in OSCAR/Req.	Ozone Amount of substance fraction	Indicate in definition that this is 3D field requirement		

NO2 mixing ratio		Closest = #105 mole-fraction	no2 mixing ratio	NO2	Rename variable in OSCAR/Req.	NO2 Amount of substance fraction	Indicate in definition that this is 3D field requirement		
NO mixing ratio		Closest = #104 mole-fraction	no mixing ratio	NO	Rename variable in OSCAR/Req.	NO Amount of substance fraction	Indicate in definition that this is 3D field requirement		
CO2 total column		Add	co2 total column		add variable to OSCAR/requirements	CO2 Total Column	Indicate in definition that it is 2D field requirement, integrated over column	2D	
CH4 total column		Add	ch4 total column		add variable to OSCAR/requirements	CH4 Total Column	Indicate in definition that it is 2D field requirement, integrated over column	2D	
14CO2	means 14CO2 ?	Add	14co2		add variables to OSCAR/requirements	(14)CO2 Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
C18OO		Add	c18oo		add variables to OSCAR/requirements	(18) CO2 (18)	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	

13CH4		Add	13ch4		add variables to OSCAR/requirements	(13)CH4 Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
14CH4		Add	14ch4		add variables to OSCAR/requirements	(14)CH4 Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
CH3D		Add	ch3d		add variables to OSCAR/requirements	CH3D Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
13CO		Add	13co		add variables to OSCAR/requirements	(13)CO Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	

14CO		Add	14co		add variables to OSCAR/requirements	(14)CO Number Concentration	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, not Delta, concentration	
C18O		Add	c18o		add variables to OSCAR/requirements	C(18)O Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
N15NO		Add	n15no		add variables to OSCAR/requirements	N(15)NO Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
N218O		Add	n218o		add variables to OSCAR/requirements	N2(18)O Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	

13C18O16O		Add	13c18o16o		add variables to OSCAR/requirements	(13)C(18)O(16)O Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
C17O16O		Add	c17o16o		add variables to OSCAR/requirements	C(17)O(16)O Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D, Delta	
H2		Add	h2		add variables to OSCAR/requirements	H2 Amount of substance fraction	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D	
NH3 mixing ratio		Add	nh3 mixing ratio		add variable to OSCAR/requirements	NH3 Amount of substance fraction	Indicate in definition that this is 3D field requirement	Add also NH3 Total Column (not at the moment) ?	
CO total column		Add	co total column		add variable to OSCAR/requirements	CO Total Column	Indicate in definition that it is 2D field requirement, integrated over column	2D	
Glyoxal mixing ratio		Add	glyoxal mixing ratio		add variable to OSCAR/requirements	Glyoxal Amount of substance fraction	Indicate in definition that this is 3D field requirement		

Downwelling UV spectrally resolved irradiances		Add	downwelling uv spectrally resolved irradiances		add variable to OSCAR/requirements	Downwelling UV Spectrally Resolved Irradiances		2D (at the surface?; Geir to check and confirm)	
Downwelling UV erythemally weighted irradiances		Add	downwelling uv erythemally weighted irradiances		add variable to OSCAR/requirements	Downwelling UV Erythemally Resolved Irradiances		2D (at the surface?; Geir to check and confirm)	
13CO2 delta	means 13CO2 ?	?			add variable to OSCAR/requirements	(13) CO2 Delta	In definition, make link to: https://en.wikipedia.org/wiki/%CE%9413C		
N15NO-\u03b1	what is -\u03b1?	?			add variables to OSCAR/requirements	N(15)NO-Alpha Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D	
N15NO-\u03b2	what is -\u03b2?	?			add variables to OSCAR/requirements	N(15)NO-Beta Delta	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D	
NO3, N2O5 mixing ratio	why together ?	?			add variable to OSCAR/requirements	NO3 Amount of substance fraction	There is equilibrium between the two NO3 - N2O5 molecules in the atmosphere, measured together. Indicate in definition that this is 3D field requirement.		

DMS	should these be separated?	?			add variables to OSCAR/requirements	DMS Amount of substance fraction	2D field at surface		
OCS mixing ratio					add variable to OSCAR/requirements	OCS Amount of substance fraction; layer=near surface	This is a molecule between CO2 and CS2. Indicate in definition that this is 3D field requirement		
Actinic fluxes	needs explanation	?			add variables to OSCAR/requirements	Actinic fluxes	This is radiation integrated over sphere, in all directions. Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	3D	
Hox	total column?	?			add variables to OSCAR/requirements	Hox amount of substance fraction	It is the combination of two variables, HO2, OH, measured together. Indicate in the definition: for total column that is is 2D field requirementt, integrated over column, and for Amount of substance fraction that it is 3D field.	3D	

aerosol MSA	should these be separated?	?			no match in OSCAR/Requirements	MSA Amount of Substance Fraction	It is a molecule needed in the context of Aerosols. Amount of substance fraction; 2D at surface. Pending also feedback from GAW SAG on how to deal with Aerosols	Geir to check with Aerosol Group and propose	
organic nitrates mixing ratio	all species together?	?			no match in OSCAR/Requirements		This is a group of variables. Corresponds to a category of variables; to be clarified whether they need to be split, or can be kepts as such	Geir to check and propose. Remove this variable for now.	
Tracers (Rn, SF6) mixing ratio	should these be separated?	?			no match in OSCAR/Requirements	Tracer ??? Amount of Substrance Fraction	Dynamical tracer Amount of substance fraction (Geir to check; layer=near surface)	Could be proposed as many variables. To be specificed more clearly. Geir to check.	
Total and individual PM1	needs explanation	?			no match in OSCAR/Requirements		Variable=PM1	Not clear. Consider removing or explaining what it is and why it's required. Geir to check and propose	
VOC mixing ratio		Add	voc mixing ratio		add variable to OSCAR/requirements ???	VOC Amount of substance fraction	Indicate in definition that this is 3D field requirement	Geir to check what the requirement is about.	

CO2 tropospheric column	how defined?	?			add variable to OSCAR/requirements	CO2 Total Column	Indicate in definition that it is 2D field requirement, integrated over column	Geir to check reality of requirement	
CO2 mixing ratio [BG]	what is BG?	?			add variable to OSCAR/requirements	CO2 Amount of substance fraction (BG)	Indicate in definition that this is 3D field requirement. Reference to clear definition of BG must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	
CO2 mixing ratio [SR]	what is SR?	?			add variable to OSCAR/requirements	CO2 Amount of substance fraction (SR)	Indicate in definition that this is 3D field requirement. Reference to clear definition of SR must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	
CH4 tropospheric column	how defined?	?			add variable to OSCAR/requirements	CH4 Total Column; layer=tropospheric column	Indicate in definition that it is 2D field requirement, integrated over column	Geir to check reality of requirement	
HD	Should this be HDO?	?			add variables to OSCAR/requirements	HD Delta	Hydrogen-Deuterium molecule. Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	Geir to check whether this is HD or HDO or both	

NO2 tropospheric column	how defined?	?			add variable to OSCAR/requirements	NO2 Total Column; layer = tropospheric column	Indicate in definition that it is 2D field requirement, integrated over column	Geir to check reality of requirement	
CO tropospheric column	how defined?	?			add variable to OSCAR/requirements	CO Total Column; layer=tropospheric column	Indicate in definition that it is 2D field requirement, integrated over column	Geir to check reality of requirement	
HCHO tropospheric column	how defined?	?			add variable to OSCAR/requirements	HCHO Total Column; layer=tropospheric column	Indicate in definition that it is 2D field requirement, integrated over column	Geir to check reality of requirement	
Glyoxal tropospheric column	how defined	?			add variable to OSCAR/requirements	Glyoxal Total Column; layer=tropospheric column	Indicate in definition that it is 2D measurement, integrated over column	Geir to check reality of requirement	
CH4 mixing ratio [BG]	what is BG?	?			add variable to OSCAR/requirements	CH4 Amount of substance fraction (BG)	Indicate in definition that this is 3D field requirement. Reference to clear definition of BG must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	
CH4 mixing ratio [SR]	what is SR?	?			add variable to OSCAR/requirements	CH4 Amount of substance fraction (SR)	Indicate in definition that this is 3D field requirement. Reference to clear definition of SR must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	

N2O [BG]	what is BG?	?			add variable to OSCAR/requirements	NO2 Amount of substance fraction (BG)	Indicate in definition that this is 3D field requirement. Reference to clear definition of BG must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	
N2O [SR]	what is SR?	?			add variable to OSCAR/requirements	NO2 Amount of substance fraction (SR)	Indicate in definition that this is 3D field requirement. Reference to clear definition of SR must be given in the definition of the variable.	Pending feedback from CAS with regard to use of sub-applications for BG vs. SR	
O2/N2		Add	o2/n2		add variables to OSCAR/requirements	O2/N2 per meg	Indicate in the definition: for total column that is is 2D field requirement, integrated over column, and for Amount of substance fraction that it is 3D field.	Geir to check (O2 divided by N2 vs. reference) - % - 3D	

ANNEX VI

GCW SPREADSHEET OF VARIABLES WITH INFORMATION ON HOW THEY LINK WITH STATEMENTS OF GUIDANCE AND RELATED ISSUES

Latest version of the Spreadsheet is available from the Google shared space at:

https://drive.google.com/open?id=1qqNGA_rBIDmtgvSDu307UZluJPvRP8g_O4LGQI9tmi0

This document summarizes the reflection of cryosphere observation needs as documented in the Statement of Guidance of Application Areas which have made such references, and does not include the GCOS Implementation Plan.
** Column A: reflects the cryosphere variables, as defined for the CryoNet Observing Program, and Column B indicates whether these are Recommended of Desirable;
** Columns C to G: reflect an analysis on the presence of these variables in the current version of WIGOSMetadata Standard and OSCAR database.
** Columns I to O reflect the analysis on the reflection on cryosphere variables, by Application Area.

Recommended Measurements for CryoNet Stations and how they compare with WMO Code Registry, WIGOS and OSCAR														
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**
Variable (primary source is the GCW variable list)	**Recommended/Desired**	**Included in the WMO Code Registry (y/n)**	**WMO Identifier**	**Included in OSCAR**	**Is it defined (Y/N, WIGOS, OSCAR)**	**Definition: agreement with GCW cryosphere terms database definitions?**	**Comments**	**Hydrology and Water Res SoG**	**Climate SoG**	**Ocean SoG**	**High Resolution NWP SoG**	**Global NWP SoG**	**Nowcasting, etc SoG**	**Sub-Seasonal to Longer Predictions SoG**
SNOW/SOLID PRECIPITATION								A general note that "snow and ice" observations are "expected to improve after the launch of CRYOSAT II (p 12, Summary of Hydrology SoG).	A general note: "there is a large and acknowledged gap internationally in the ability to reliably measure solid precipitation at high latitude or mountain locations" (p 5, under "Fitness for purpose in extreme conditions")				Generally referenced as "snow observations" which are "important for road and railway maintenance and operation, snow load estimation for electrical grids." (p 11).	
Snow on the ground	R	No	n/a	n/a	No	Not defined in GCW cryosphere terms database	Could be an alternate term for snow cover or snow cover extent; GCW experts to clarify the term Snow on the Ground					Indirectly referenced as "snow and ice surfaces", which affect 3D temperature data collected by infra-red		

												sounders in polar orbirts -- a measurement which has been "under-utilised" (p 4). Could be referring to "snow cover extent"?		
Snow depth (including stake farms and snow courses)	R	Yes	629	Yes	Yes, W,O. Vertical distance from the snow surface to the underlying surface (ground, glacier ice or sea ice).	6 def's in GCW cryosphere terms database plus 1 called "depth of snow" (AMS). WIGOS/OSCAR definitions are in agreement.	Note distance from "ground" is specified in most definitions in GCW cryosphere terms database, while WMO codes includes both ground and ice. Can it also include both snow and ice depth?	"Snow Depth", referenced directly as a required variable for GCOS/HWRP, and is lumped in with snow cover, water equivalent and glaciers (p 2). Referenced as "regularly worked snow depth measurement courses" as a "conventional terrestrial observation method" which is "generally adequate" but is lacking representativeness (p 7). Referenced again on p12 as a passive microwave measurement used to estimate thickness of dry snow, which is considered a "snow cover measurement" that is acceptable for mesoscale modelling and snowmelt runoff forecasting.	Directly referenced as "snow depth", indicating a need for accurate measurements (p 5). Indirectly referenced as "snow and ice loading", p17 and 18. Also referenced as (seasonal) "snow melt" as related to the hydrological cycle, in turn affecting hydro-electricity (p 18). Referenced as "snow amount and extent", and its impact on tourism, where "basic averages" of these "key climate parameters" would answer questions on this (p 21, 22).		Directly referenced as "snow depth", a variable important for describing surface fluxes and the atmospheric boundary layer in high resolution models (p 8).	Directly referenced as a "surface SYNOP" measurement with good accuracy and temporal resolution, however "many SYNOP messages omit the observations when snow is not present on the ground" (p 5). Also the number of stations is "sparse". It's noted that making "snow data available to the NWP community would be very useful", which is the "objective of GCW".(p 5). "Snow depth" is referenced as a variable that Global NWP would benefit from if it was available in a more timely and wider manner (p 10).	Indirectly referenced as "snow cover" (which could also be a reference to "snow depth"), where temporal resolution of automated measurements is good, but manual measurements are not -- an issue over complex terrain (p 11). Directly referenced as "snow depth" as it relates to soil moisture which is "very important for processes describing the surface fluxes and the atmospheric boundary layer", which is also "needed to compute forest fire risk indices" (p 12). Indirectly referenced as "snow layer" (but could also be referring to "snow depth"), which is a "key variable for which observational data are required" (p 15). Referenced as "snow depth", which along with "snow layer" and "snow profile of the snow pack" has insufficient "spatial and temporal resolution for urban areas and	Directly referenced as a variable (along with "snow cover") that has "major effects on surface albedo and energy balance" (p 6). Referenced as having "insufficient (poor)" coverage of observations, although the "surface SYNOP stations report measurements of local snow depth with high accuracy" (p 6).

													along major highways" (p 17).	
Snow depth (including stake farms and snow courses)	D						There are two variables for snow depth (differentiated by where and when the measurement is taken). Maybe clarify this by adding a pronoun to the name?							
Snow Water Equivalent	R	Yes	631	Yes	Yes, W,O. Vertical depth of the water that would be obtained by melting a snow layer. Linked to snow depth through the density of the snow layer .	Somewhat; GCW cryosphere terms database has 5 related definitions, but agreement is needed (IPCC def looks clearest).	WIGOS/OSCAR definition is comprehensive but reference to density may need clarification?	"Water equivalent", referenced directly as a required variable for GCOS/HWRP, and is lumped in with snow cover, snow depth and glaciers (p 2). It is noted that "snow water equivalent" along with snow depth are "dynamic" hydrologic variables that "must be updated fairly frequently" (p 2). Referenced as important to seasonal snow cover (p7) -- as measured by snow pillows, snow profile densities, and satellite. Also captured in p 9, Table 3.10.1 as a variable-derived product (gridded data, temporal and spatial resolution TBD). Captured in p11, Table 3.10.2 as a variable used for "applications". Referenced again on p12 as a product of snow depth and snow density, under a point describing dry snow measurements via passive microwave sensors (this seems to allude to using these measurements to derive SWE?).	Referenced as an estimate from snow depth if density is known, which is an "important feature in the hydrological cycle affecting fresh water supply" -- monitoring the variability of this is "vital" (p 19).		Directly referenced as "equivalent water content", "snow water content" and "snow equivalent water content" -- important for high resolution models but not always easily measured (p 7). Also referenced as "snow equivalent water content", a critical atmospheric variable that is " not adequately measured by current or planned systems" (p 10).	Referenced as "snow mass", which looks to be the same as SWE, measured via microwave imaging but with data interpretation difficulties (p 5). Also noted that "snow equivalent water content" is a "critial atmospheric variable that is currently not adequately measured" (p 10).	Referenced as "snow water content", which is not measured by visible / near infrared satellite imagery (p 11). Also referenced as "snow equivalent water content", which is used to estimate runoff when coupled to hydrological models (p 11).	Indirectly referenced where it is noted that "microwave imagery has the potential for improvement of snow mass assessment in the land analysis" (p 6).

Solid Precipitation	R	No	n/a	No	No	n/a	One definition in the GCW cryosphere terms database	The term, "Precipitation (liquid/solid)" is referenced directly as a required variable for GCOS/HWRP, and both "liquid" and "solid" precip are lumped together (p 2). Also captured in p 9, Table 3.10.1 as a variable-derived product for hydrology, water resources, and weather and climate applications (point data).	Indirectly referenced as observations of "ice accretion"/ "ice storms" (p 5, 17, 24) for studies in climate change and its impacts. Also reference to "freezes" (p 20, 24) and "blizzards" (p 24, 25) as information to capture relating to disasters/extreme events. The phenomena, "frost" is mentioned as a non-GCOS climate variable (p 2).		Indirectly referenced as a "precipitation type" that includes "hail, snow, species of ice particles", as measured by radar (p 6)		Indirectly referenced as "snow, ice, glazed frost and blizzards", which are wintertime weather phenomena that nowcasting and VSRF techniques can be applied to (p 2). Indirectly referenced as "light snow", a variable measured by radar, which provides excellent horizontal and temporal resolution (p 6, section on Gap Analysis). Also indirectly referenced as "snowfall line" as estimated by surface stations in "complex terrrain" (p 8).	
Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature)	R	No	n/a	No	No	n/a	Recommend to change from “profiles” to “profile”. There are two CryoNet variables for snow profiles (differentiated by where and when the measurements are taken). Maybe clarify this by adding a pronoun to the name? There is one definition for "snow profile" in the GCW cryosphere terms database and one for "snow pit". Will this include several variables, to be defined separately? Would salinity go under snow chemistry?	Indirectly referenced on p7 as "snow densities" in relation to seasonal snow cover and as "snow grain size" in relation to passive microwave measurements. Indirectly referenced on p12 as "snow density" which is used to derive SWE (this seems to allude to using snow depth measurements to derive SWE?).						

Snow profiles (density, grain shape & size, hardness, liquid water content, salinity, temperature)	D	No	n/a	No	No	n/a	See comment above. This CryoNet variable is for Manual profiles of snow on sea ice and lake/river ice.						Maybe indirectly referenced as "snow layer" but could also mean "snow depth", which is a "key variable for which observational data are required" (p 15). Referenced as "snow layer and "snow profile of the snow pack", along with "snow depth", has insufficient "spatial and temporal resolution for urban areas and along major highways" (p 17).	
Depth of snowfall	D	Yes; labeled "Depth of fresh snowfall"	627	Yes	No; in description: "definition to be provided"	n/a. Not defined in WMO codes registry.	This variable name differs slightly from WMO code registry, where it is called "Depth of fresh snowfall". It is not defined in WMO code registry. In the GCW cryosphere terms database, there are 7 definitions for "snowfall" but none for "depth of snowfall".	Indirectly referenced on p7 as "snow gauges" in relation to seasonal snow cover as a requirement for hydrology and water resources.	Indirectly referenced as "snowfall", as an extreme measurement of precipitation required for the energy industry. Referenced as a manual measurement (p 27) -- not sure if it is referring to depth. Also indirectly referenced as "snow and ice loading", p17 and 18. Does the term "blizzard" (p 24, 25) fit into this category?				Indirectly referenced as "snow", a winter weather phenomena that can be predicted through nowcasting and VSRF techniques (p 2). Indirectly referenced as "snowfall level" (p 8), which is a high resolution forecast variable that may be "adjusted" with 3D temperature observation data. Indirectly referenced as "snow amount", a variable that can be estimated "with good precipitation, temperature and humidity data." (p 12). Also referenced as "fresh snow layer", in which spatial and temporal resolution is considered to be insufficent for urban areas and along major highways (p 17).	

Water equivalent of snowfall	D	No	n/a	No	n/a	n/a	Similar to "snow water equivalent" above. Need to clarify what "snowfall" is?	The term "water equivalent" is referenced as a required variable for GCOS/HWRP and is lumped in with snow cover, snow depth and glaciers (p 2).	Indirectly referenced as "snowfall" and "rain water equivalent" (p5, 18, 27), in relation to point measurements of preciptation.					
Snow cover extent	D	Yes [label: snow cover(fraction of area)]	628	Yes	Yes, W,O. Fraction of a given area which is covered by snow.	Somewhat, although the WMO codes registry specifies "fraction" in the variable name and definition.	Is this the same as "snow cover (fraction of area)"in the WMO codes registry? The GCW cryosphere terms database includes one variable for "snow cover extent" and one for "snow coverage", plus 6 for "snow cover". "Snow cover extent" is likely the most clearly defined, although the term "extent" isn't defined.	The term "snow cover" is referenced as a required variable for GCOS/HWRP and is lumped in with snow depth, water equivalent and glaciers (p 2). It is noted that "Snow cover" along with SWE are "dynamic" hydrologic variables that "must be updated fairly frequently" (p 2). Also referenced as "snow cover" as an important for water storage and its effect on hydrology (p7) . Also noted on p 7 is that current measurements of "snow extent" are of high quality, are accurate and are acceptable for mesoscale modelling and snowmelt runoff forecasting. Plus measurements of areal extent of "snow cover", as measured via passive microwave instruments, are "acceptable" (p 12).	Referenced as "snow amount and extent", and its impact on tourism, where "basic averages" of these "key climate parameters" would answer questions on this (p 21, 22).	Indirectly referenced as "snow cover", as a visual estimate via aerial observation (p 7). Also indirectly referenced as "snow cover" which is a "complicating factor" for satellite observation of sea ice (p 8).	Directly referenced as "snow cover", however, the document refers to "surface stations" measuring this variable, therefore it may be more accurate to say the variable in question is actually "snow depth" (p 7). Also referred to as a satellite measurement with good horizontal and temporal resolution/accuracy (p 7). Again, indirectly referenced as "Snow cover over sea-ice", a variable that "presents data interpretation problems" (p 7).	Indirectly referenced as "ice and snow cover", as a key atmospheric model variable (p 1). Indirectly referenced as "snow and ice surface" data, collected by infra-red sounders -- a measurement which has been "under-utilised" (p 4). Could this sounding data be referring to "snow on ground"? Also, referenced as "snow cover extent", measured by infra-red satellite imagery, which is "accurate and has good horizontal and temporal resolution".	Indirectly referenced as "snow cover", where temporal resolution of automated measurements is good, but manual measurements are not, which is an issue over complex terrain (p 11) -- could also be referring to "snow depth". Also reference to "snow cover" as measured via satellite (p 11). May also relate to "snow cover over sea-ice", which "presents data interpretation problems" (p 11)	Directly referenced as a variable (along with "snow depth") that has "major effects on surface albedo and energy balance" (p 6). As a visible and near infra-red satellite measurement, it has good horizontal and temporal resolution and accuracy but only available during daytime and in cloud-free areas (p 6)
Snow chemistry	D	No	n/a	No	n/a	n/a	Not available in the GCW cryosphere terms database. What ions/variables are measured?							
Snow surface temperature	D	No	n/a	No	n/a	n/a	Not available in the GCW cryosphere terms database. What does "surface" refer to?							
Snow temperature	D	No	n/a	No	n/a	n/a	Not available in the GCW cryosphere terms database. Does this refer to a profile?							
Drifting snow	D	No	n/a	No	n/a	n/a	8 definitions available in the GCW cryosphere terms database. The METEOTERM definition is clear. How is this measured -- is there a scale or just yes/no?							
Specific surface area	D	No	n/a	No	n/a	n/a	Not available in the GCW cryosphere terms							

							database. Is this measurement very common? Remotely sensed and/or measured? Related to "equilibrium growth" and "kinetic growth" (both listed in GCW cryosphere terms database)?							
GLACIERS and ICE CAPS								A general note that "snow and ice" observations are "expected to improve after the launch of CRYOSAT II (p 12, Summary of Hydrology SoG).	Indirectly referenced as "ice cores" as an observation type related to Paleoclimatic data (p 25). Applies to ice sheets as well?					
Surface accumulation (point)	R	No	n/a	No	No	n/a	One definition for "surface accumulation" and 9 for "Accumulation" in the GCW cryosphere terms database. Plus an additional 11 that include adjectives such as "snow and ice", "area", "season", "zone", "ratio" and "annual".							
Surface ablation (point)	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database there is one definition for "surface ablation" and 14 for "ablation". Plus an additional 13 that include adjectives such as "area", "zone", "cone", "hollows", "season" and "moraine".							
Surface mass balance (glacier wide)	R	No	n/a	No	No	n/a	There is one variable in the GCW cryosphere terms database called "surface mass balance". A few other mass balance variables exist with adjectives such as: "budget" and "climatic".		Indirectly referenced as "glacier extent and mass" as related to "storage measurements" needed for the energy industry (p 18). Also "mass balance studies based on sound historical records" should be used to determine long-term glacial runoff (p 19).					
Surface mass balance (point)	R	No	n/a	No	No	n/a	Variable name is slightly different in							

							GCW cryosphere terms database ("point mass balance").							
Glacier area (glacier wide)	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. Is this similar to the WIGOS/OSCAR/WMO Codes variable named "glacier cover" (610)? It is defined as "Fraction of land area covered by permanent ice".		Indirectly referenced as "glacier extent and mass" as related to "storage measurements" needed for the energy industry (p 18). Also indirectly referenced as "glaciers", which are "vulnerable areas" that need to be "augmented by much denser national and regional networks that truly reflect climate variability" (p 27).					
Surface accumulation (glacier wide)	D	No	n/a	No	No	n/a	There is one definition in the GCW cryosphere terms database. There are 9 definitions for "accumulation" in the GCW cryosphere terms database that apply to glacial accumulation, of which the METEOTERM one seems the clearest.							
Surface ablation (glacier wide)	D	No	n/a	No	No	n/a	There is one definition in the GCW cryosphere terms database, 4 definitions for "ablation area", one for "ablation area/zone", two for "ablation zone". The GCW cryosphere terms database also includes 14 definitions for the singular term "ablation", 9 of which refer to "glacier" in the definition. METEOTERM definition available.							
Basal Ablation (point)	D	No	n/a	No	No	n/a	there is one definition in the GCW cryosphere terms database. There are also 14 defintions for the singular term "ablation", 9 of which refer to "glacier" in the definition and one of which includes "basal" in the definition.							
Surface mass balance (glacier wide)	D	No	n/a	No	No	n/a	One definition in GCW cryosphere terms database. Other variables in the GCW cryosphere terms database include: "climatic mass							

							balance", "climatic-basal mass balance", "mass balance", "mass balance/budget", "mass flux" and "point mass balance".							
Glacier thickness (point)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database, however there is one variable for "thickness" and one for "thickness change".							
Glacier volume (glacier wide)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database, however, there is one variable for "volume" that applies to glaciers.		Indirectly referenced as "glacier extent and mass" related to "storage measurements" needed for the energy industry (p 18).					
Glacial runoff	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database, however, there is one variable for "meltwater discharge" and one for "meltwater runoff", both of which apply to glaciers.	Indirectly referenced as "glaciers" (p 2), a required GCOS/HWRP variable, and is lumped in with snow cover, depth and water equivalent.. Indirectly referenced on p7 as "water stored in snow and ice, especially in mountain regions" as related to seasonal snow cover and water storage.	Indirectly referenced as "glacier melt" (p 18, 19) as related to the hydrological cycle affecting hydro-electricity and fresh water supply.					
Calving flux (point)	D	No	n/a	No	No	n/a	One definition in the GCW cryosphere terms database.							
Ice velocity (point)	D	Yes (labeled Glacier motion)	611	Yes	Yes, W,O: Velocity of the ice measured at the surface of a glacier	No	The WMO code registry variable name is "glacier motion". Is this the same as "ice velocity"? Neither "ice velocity" nor "glacier motion" are defined in the GCW cryosphere terms database.							
Ice/firn temperature profile (point)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
ICE SHEETS									Indirectly referenced as "ice cores" as an observation type related to Paleoclimatic data (p 25). Applies to ice sheets as well?					
Surface accumulation (point)	R	No	n/a	No	No	n/a	Not defined specifically for ice sheets in GCW cryosphere terms database (only for							

							glaciers).							
Surface ablation (point)	R	No	n/a	No	No	n/a	Not defined specifically for ice sheets in GCW cryosphere terms database.							
Surface mass balance (point)	R	No	n/a	No	No	n/a	Not defined specifically for ice sheets in GCW cryosphere terms database. One definition is available for a variable called "mass balance/budget (of glaciers or ice sheets)" in the GCW cryosphere terms database.							
Ice sheet thickness (point)	D	No	n/a	No	No	n/a	Not defined in GCW cryosphere terms database. Note that the variable "ice sheet topography" (613) is available in WIGOS/OSCAR and the WMO code registry. Is this similar to "ice sheet thickness"? The WMO code registry defines it as "ice sheet height over land", whereas WIGOS/OSCAR defines it as "map of ice sheet height over land".							
Ice velocity (point)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Ice/firn temperature profile (point)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
							Not defined in the GCW cryosphere terms database.							
ICE SHELVES														
Basal Ablation	R	No	n/a	No	No	n/a	One definition in the GCW cryosphere terms database.							
Ice velocity	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
ICEBERGS										Indirectly referenced as "floating ice", which is an observation that depends on instrumental and				

										visual observations (p 6).				
Iceberg position	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Iceberg form, size	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Concentration (distance) of icebergs	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Iceberg motion	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Iceberg height (above the sea)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database. However, there are variables for "very large", "large", "medium" and "small" icebergs which are defined by height above sea level and length.							
Iceberg width, length (at waterline)	D	No	n/a	No	No	n/a	Not available in GCW cryosphere terms database. However, there are variables for "very large", "large", "medium" and "small" icebergs which are defined by height above sea level and length.							
Iceberg draft	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Underwater 3-D form	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database. What is the definition for this variable?							
PERMAFROST														
Ground temperature	R	No	n/a	No	No	n/a	There is a WMO code for "soil temperature" but not one for "ground temperature". This isn't defined in the GCW cryosphere terms database but there are two definitions for "soil temperature".							
Active layer thickness	R	No	n/a	No	No	n/a	One definition in the GCW cryosphere terms database.							
Rock glacier creep velocity	D	No	n/a	No	No	n/a	No definition in the GCW cryosphere terms database, however there are three for "active rock glacier".							
Rock glacier discharge	D	No	n/a	No	No	n/a	No definition in the GCW cryosphere terms							

							database, however there are three for "active rock glacier" and 8 for "rock glacier".							
Rock glacier spring temperature	D	No	n/a	No	No	n/a	No definition in the GCW cryosphere terms database, however there are three for "active rock glacier" and 8 for "rock glacier".							
seasonal frost heath/subsidenc	D	No	n/a	No	No	n/a	No definition in the GCW cryosphere terms database. Is the word "heath" supposed to be "heave"? There are three definitions in the GCW cryosphere terms database for "frost heave", two for "frost heave extent" and one for "frost action".							
surface elevation change	D	No	n/a	No	No	n/a	Not in the GCW cryosphere terms database.							
ground ice volume	D	No	n/a	No	No	n/a	Not in the GCW cryosphere terms database.							
coastal retreat	D	No	n/a	No	No	n/a	Not in the GCW cryosphere terms database.							
soil moisture	D	No	n/a	No	No	n/a	One definition in the GCW cryosphere terms database, but not specific to permafrost.							
SEASONALLY FROZEN GROUND														
Ground temperature	R	No	n/a	No	No	n/a	There is a WMO code for "soil temperature" but not for "ground temperature". This isn't defined in the GCW cryosphere terms database, but there are two definitions for "frozen ground".							
SEA ICE							Note that "sea ice" is hyphenated ("sea-ice") in the WMO code registry and in WIGOS/OSCAR.		Referenced as "sea ice" as being "priority information" in regards to tourism impacts (p 22). "Microwave sensing of sea ice extent" is referenced as an example of an observation type (p 25) that is "climatically-significant".	Referenced as a variable to be measured in support of predictions/forecasting (p 1, Introduction). Also referenced as a phenomena that affects coastal modelling (p 12).	Indirectly referenced as "in-situ high resolution (sea-ice) observations over sea areas upstream of populated areas, or of high-impact weather areas" (p 10).	"Sea-ice" is referenced as an NWP forecast variable to be "coupled" with the atmosphere, and to be used for "timely initialization" of the models (p 2). Indirectly referenced as "snow and ice surfaces", which affect 3D temperature	Referenced as having the "same requirements as SoG High-Resolution NWP" (p 11), although no further elaboration.	Referenced as a component "coupled in some CGCMs" and is also "important for seasonal prediction" (p 1). Sea ice is mentioned as a hindrance to Argo floats (free-drifting floats which provide temperature

												data collected by infra-red sounders in polar orbirts -- a measurement which has been "under-utilised" (p 4).		and salinity profile info) but new floats deployed in Antarctic sea ice areas have been successfully deployed (p 4, 8). It is also noted that satellite measurements of radiative fluxes are not used "on a routine basis in assimilation for sub-seasonal to seasonal predictions, due to some technical difficulty in use over sea ice areas" (p 5). Sea-ice observations are also mentioned as having "potential benefit for the multi-annual prediction in the future" (p 5).
Sea ice thickness	R	Yes (labeled Sea-ice thickness)	406	Yes	Yes: Thickness of an ice sheet	No	There are many variables for sea ice in the GCW cryosphere terms database but not one for "sea ice thickness". In the GCW cryosphere terms database, the term "thickness" applies to glaciers.			Directly referenced as a sea ice parameter measured in support of marine operations, model validation and climatological studies (p 6).	Directly referenced as "ice thickness", a variable that is required in the longer term but is not planned to be monitored operationally (p 7).	Referenced as "ice thickness", which is an operational measurement that will be required in the longer term, and also as an "inferred estimation" that is of increasing interest (p 5). Also, it is noted that Global NWP "would benefit from more ice thickness data" (p 10).		"Sea-ice thickness" is directly referenced as a satellite-based product that has "overall poor to marginal accuracy" and is an area of ongoing research (p 5). It is "required to better determine the sea-ice initial state and the conductive heat fluxes through the ice" but in-situ measurements are limited (p 5).

Sea ice freeboard	R	Yes? (available as sea-ice elevation)	402	Yes	Yes, W,O; Elevation of the surface of the sea-ice sheet above sea level	No, the variable name is "sea-ice elevation" in WMO/WIGOS/OSCAR but the GCW variable name is "freeboard". The definitions are similar however.	The term, "freeboard" is available in the GCW cryosphere terms database but not "sea-ice elevation".							
Sea ice concentration	R	Yes? (labeled as sea ice cover)	401	Yes	Y, W,O: fraction of an area where ice is present	No, the variable name is "sea-ice cover" in WMO/WIGOS/OSCAR but the GCW variable name is "sea ice". The definitions are similar, however.	In the GCW cryosphere terms database, one of the "sea ice" variables includes information on "concentration" in its definition, however there isn't a variable specifically called "sea ice concentration".			Referenced as "sea ice coverage/concentration", measured in support of marine operations, model validation and climatological studies (p 6). The term "sea-ice extent" is mentioned as having been totally revolutionized by satellite imagery, yet point observations are still of "great importance in establishing ground truth" of satellite observations. Possibly indirectly referenced as "ice report" or "ice cover" (p 7), a visual observation, 7-20km in radius (from a ship, settlement or lighthouse), in which the "total area of ice being reported is very small" or "not really adequate" however reports from the air are noted as having "much better coverage". Would "Ice report / ice cover" fit in better as a separate CryoNet variable? Indirectly referenced as "distribution of ice" as measured by	Referenced as "sea-ice cover", observed via microwave instruments on polar satellites (p 7), which has "good horizontal and temporal resolution and acceptable accuracy".	Referenced as "sea-ice cover and type", observed by passive microwave instruments and scatterometers on polar satellite (p 5).		Indirectly referenced as "sea-ice cover", which is important for high and mid-latitudes and has "acceptable accuracy and temporal resolution and good coverage" (p 5). EUMETSTAT OSI SAF is mentioned as a valuable sea-ice concentration product, derived from SSMIS brightness teperatures, however the "presence of melt ponds and young ice" create uncertainties (p 5).

										aerial SLAR and SAR observations (p 7) and also as "ice boundary and concentration" (p 8).				
Sea ice class (pack, fast ice)	R	No	n/a	No	No	The GCW cryosphere terms database seems to list each ice class as a separate variable.								
Sea ice type (level/rafted/ridged & floe descriptor)	R	Yes; labeled Sea Ice type	407	Yes	Y, W,O: categorization of the type of sea ice	Does the GCW cryosphere terms database list each sea ice type as a separate variable? Specifically, there are variables for "rafting", "ridging" and "rough ice".	Does "type" mean the same thing in the WMO Codes and WIGOS/OSCAR? WMO codes definition refers to a "categorization" in its definition.			Directly referenced as a sea ice parameter measured in support of marine operations, model validation and climatological studies (p 6). Indirectly referenced as "nature of ice" as measured by aeral SLAR and SAR observations (p 7).	Directly referenced as "sea-ice type", observed via microwave instruments on polar satellites (p 7), which has "good horizontal and temporal resolution and acceptable accuracy".	Referenced as "sea-ice cover and type", observed by passive microwave instruments and scatterometers on polar satellite (p 5).		
Form of ice (floe size)	R	No	n/a	No	n/a	n/a	Variables for this in the GCW cryosphere terms database are unclear.			Indirectly referenced as "floating ice" (p 6), as measured by instruments and/or visually.				
Stage of ice development	R	No	n/a	No	n/a	n/a	There is one definition for "sea ice development stage" in the GCW cryosphere terms database. The term, "ice forecast" in the GCW cryosphere terms database also includes stage of ice development in its definition.			Directly referenced as a satellite observation (p 8) of less accuracy "including the First-Year/Multi-Year ratio and its surface morphology".				
Sea ice phenomena (dates of freeze-up, fast-ice formation/break out, melt onset, break-up)	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database. However, the term, "ice forecast" in the GCW cryosphere terms database includes sea ice phenomena in its definition.			Possibly indirectly referenced as "ice report" or "ice cover" (p 7), a visual observation, 7-20km in radius (from a ship, settlement or lighthouse), in which the "total area of ice being reported is very small" or "not really adequate"				

										however, reports from the air are noted as having "much better" coverage -- could this also be referring to "sea-ice concentration"? Would "Ice report / ice cover" fit in better as a separate CryoNet variable?				
Sea ice stage of melting	R	No	n/a	No	No	n/a	Doesn't seem to be included in the GCW cryosphere terms database.							
Sea ice openings (leads, polynyas, cracks)	D	No	n/a	No	No	n/a	Not included in the GCW cryosphere terms database. However several related variables are, including: one for "lead", 6 for "polynya", two for "flaw polynya", two for "fracture", one for "latent heat polynya", two for "recurring polynya", one for "sensible heat polynya" and two for "shore polynya". The variables: "flaw"(?), "open drift", "pack ice" and "open pack ice" also refer to sea ice openings in their definitions.			Indirectly referenced as "presence or absence of leads" which can be measured by space-borne sensors, especially radars, providing precise data (p 8).				
Sea ice velocity	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.			Indirectly referenced as "movement", a sea ice parameter measured in support of marine operations, model validation and climatological studies (p 6). Indirectly referenced as "flow motion" which can be "determined through the use of imagery from sequential orbits" (p 8).				

Sea ice deformation (divergence/convergence)	D	No	n/a	No	No	n/a	Not specifically defined in the GCW cryosphere terms database. However, there are some variables that refer to deformation or divergence/convergence in their definitions including: "pack ice", "multi-year ice", "compacting", "compression of ice", "deformed ice", "fracture", "fracturing", "hummock", "ice under pressure", "internal deformation", "internal ice stress", "level ice", "rafted ice", "ridging", "shearing" and "shear ridge".							
Sea ice ridge height	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. However similar variables include: "aged ridge", "consolidated ridge", "deformed ice", "hummock", "hummocked ice", "new ridge", "pressure ice", "pressure ridge", "ridge", "ridge (ice)", "ridged ice", "ridged ice belt", "ridged-ice zone", "ridging", "sail"(?), "sastrugi"(?), "zastrugi"(?), "shear ridge", "stamukhi", "very weathered ridge", "weathered ridge".			Referenced as "height and frequency of ridges" observed via airborne measurements (p 7).				
Sea ice ridge cover (concentration of ice ridges)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. See comment above for ridge related variables.			Directly, but slightly differently, referenced as and airborne measurment of "height and frequency of ridges" (p 7).				
Sea ice draft	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Sea ice salinity profile (vertical)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Sea ice stratigraphy	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Surface temperature (surface-air interface)	D	Yes: labeled Sea-ice surface temperature	405	Yes	Y, W,O: temperature of the surface of sea-ice	Not available in GCW cryosphere terms database?	Not defined in the GCW cryosphere terms database.				Indirectly referenced as "sea-ice surface skin temperature" (p. 8)	Referenced together as "land and lake-sea-ice surface skin temperature" as measured by satellite infra-red	Referenced as "lake-sea-ice surface skin temperature" which is valuable for producing high resolution	

												and microwave imagers and sounders, but not without difficulty (p 6).	forecasts (p 12).	
Sea ice temperature profile (vertical)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
LAKE ICE														
Ice thickness	R	Yes: labeled Lake Ice thickness	725	Yes	No, W,O: in the description: "definition to be provided".	Not defined in the GCW cryosphere terms database, however there are 6 different definitions of "lake ice" in the GCW cryosphere terms database.	Not definition available in the WMO code registry. Is this a measurement or a category or both? Also, there are a variety of variables similar to lake ice thickness in the GCW cryosphere terms database. Some of these include: "river/lake ice", "thin lake ice", "thick lake ice", "very thick lake ice", "medium lake ice", "new lake ice", "pressure ice" and "floating ice".							
Ice concentration	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database for lake ice, however, there is a definition that refers to sea ice.							
Ice class (pack, fast ice)	R	No	n/a	No	No	n/a	Is there a standard classification system for lake ice? See comment for "Ice thickness" above.							
Ice type (level/rafted/ridged & floe descriptor)	R	No	n/a	No	No	n/a	See comment for "Ice thickness" above. Also, there are variables defined for "rafting", "ridging" and "rough ice", although they seem to apply to sea ice.							
Form of ice (floe size, fast ice width)	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database, these variables seem to be mainly associated with sea ice.							
Stage of ice development	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database, there is a variable for "sea ice development stage" but not one specifically for lake ice.							

Ice phenomena (dates of freeze-up, fast-ice formation/break out, melt onset, break-up)	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. Specify an adjective for a temporal measurement? Otherwise this may be confused with "stage of ice development", "ice thickness", etc?							
Ice stage of melting	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Areal extent of floating/grounded ice	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Ice surface temperature	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.					Referenced together as "land and lake-sea-ice surface skin temperature" as measured by satellite infra-red and microwave imagers and sounders, but not without difficulty (p 6).	Referenced as "lake-sea-ice surface skin temperature" which is valuable for producing high resolution forecasts (p 12).	
Ice openings (leads, polynyas, cracks)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. However, the variables named "fracture" and "lead" may apply to lake ice. Do the variables "polynya" and "crack" normally apply to sea ice only?							
Ice velocity	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database.							
Ice deformation (divergence/convergence)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. Not sure if the following variables are normally applied to lake ice: "pack ice", "multi-year ice", "compacting", "compression of ice", "deformed ice", "fracture", "fracturing", "hummock", "ice under pressure", "internal deformation", "internal ice stress", "level ice", "rafted ice", "ridging", "shearing" and "shear ridge".							
Ice ridge height	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice ridge cover (concentration of ice ridges)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							

Ice stratigraphy	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.								
Ice temperature profile (vertical)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.								
	D	No	n/a	No	No	n/a									
RIVER ICE		Yes	10110	Yes	No, W,O	n/a	In the GCW cryosphere terms database, there are 4 different definitions for "river ice".								
Ice thickness	R	Yes; labeled "River Ice thickness"	726	Yes	No, W,O: in the description "definition to be provided"	n/a	Not defined in the GCW cryosphere terms database.								
Ice concentration	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database for lake ice, however, there is a definition that refers to sea ice.								
Ice class (pack, fast ice)	R	No	n/a	No	No	n/a	Is there a standard classification system for river ice class?								
Ice type (level/rafted/ridged & floe descriptor)	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database there are variables defined for "rafting", "ridging" and "rough ice", although these seem to apply to sea ice. Definitions in the GCW cryosphere terms database for "anchor ice", "black ice", "floating ice", "flooded ice", "frazil ice" and "ice floe" make reference to river ice in their definitions.								
Form of ice (floe size, fast ice width)	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database, these variables seem to be mainly associated with sea ice. The definition for the variables "ice edge" and "ice jam" applies to river ice in the GCW cryosphere terms database.								
Stage of ice development	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database, there is a variable for "sea ice development stage" but								

							not one specifically for river ice. The variables "complete freeze-up" and "ice regime phase" make reference to river ice in their definitions in the GCW cryosphere terms database.								
Ice phenomena (dates of freeze-up, fast-ice formation/breakout, melt onset, break-up)	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. Specify an adjective for a temporal measurement? Otherwise this may be confused with GCW cryosphere terms database variables called "stage of ice development" and "ice thickness", etc?								
Ice stage of melting	R	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. Are there any other variables that apply to this one?								
River ice jams and dams	R	No	n/a	No	No	n/a	There are many variables related to this one in the GCW cryosphere terms database. There are 10 definitions for "ice jam", some of which apply to sea ice as well. There are also two definitions for "breakup jam" and two for "freezeup jam". The term "ice dam" seems to apply to glaciers in the GCW cryosphere terms database.								
Flooding extent caused by jams and dams	R	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.								
River icings (aufeis)	R	No	n/a	No	No	n/a	In the GCW cryosphere terms database, there are 7 definitions for "icing" and one for "aufeis" but not one for "river icings". There seems to be a need to distinguish between atmospheric deposition icing and icing due to seeping.								
Maximum level		No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.								

Areal extent of floating/grounded ice	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice surface temperature	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice openings (leads, polynyas, cracks)	D	No	n/a	No	No	n/a	Not defined in the GCW cryosphere terms database. However, the variable named "fracture" may apply to lake ice. Do the variables "lead", "polynya" and "crack" normally apply to sea ice only?							
Ice deformation (divergence/convergence)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice ridge height	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice ridge cover (concentration of ice ridges)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice stratigraphy	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
Ice temperature profile (vertical)	D	No	n/a	No	No	n/a	Not available in the GCW cryosphere terms database.							
SURFACE METEOROLOGY														
Air temperature		Yes	224	Yes	Yes, O,W?	n/a	Not available in the GCW cryosphere terms database.					Indirectly referenced as "temperature profile over the poles", which is identified as a critical atmospheric variable that is not adequately measured by current or planned systems (p 10).		
Air humidity		Yes	10100	Yes	No, W,O	Not available in GCW cryosphere terms database	Variable names are not consistent: is it "land surface humidity" (10100) or "humidity (at specified distance from reference surface)" (251)? The latter doesn't appear in the WMO codes but is listed in the OSCAR variables table. Not available in the GCW cryosphere terms database.					Indirectly referenced as "humidity profile over the poles", which is identified as a critical atmospheric variable that is not adequately measured by current or planned systems (p 10).		

Wind speed		Yes	309	Yes	Yes, W,O	Not available in GCW cryosphere terms database	In the WMO codes registry the variable name is "atmosHorizontalSurfaceWind" (309) and includes both direction and speed. However, in the OSCAR variable table, the variable name is "Horizontal wind speed at specified distance from reference surface" (12006).							
Wind direction		Yes	309	Yes	Yes, W,O	Not available in GCW cryosphere terms database	In the WMO codes registry the variable name is "atmosHorizontalSurfaceWind" (309) and includes both direction and speed. However, in the OSCAR variable table, the variable name is "Horizontal wind direction at specified distance from reference surface".							
Air pressure		Yes	216	Yes	Yes, O,W?	Not available in GCW cryosphere terms database	Variable names in the WMO code registry and OSCAR variable table are in agreement, but the definitions are different.							
Incoming shortwave radiation				Yes	No, W,O	Not available in GCW cryosphere terms database	Variable names are not consistent.							
Reflected shortwave radiation				Yes	No, W,O	Not available in GCW cryosphere terms database	Variable names are not consistent.							
ADDITIONAL VARIABLES Referenced in SoGs														
Frost									Referenced as a non-GCOS climate variable (p 2). Referenced as an extreme event impacting human society and ecosystems (p 15, 20, 25).				Referenced as "glazed frost", a winter weather phenomena that can be predicted through nowcasting and VSRF techniques (p 2).	
Ice									Indirectly referenced as "freezes" and "ice storms" (p 24), related to disasters/extreme events.				Referenced as "ice", a winter weather phenomena that can be predicted through nowcasting and	

													VSRF techniques (p 2).	
Blizzard									Indirectly referenced as "blizzards" (p 24), related to disasters/extreme events.				Referenced as "blizzards", a winter weather phenomena that can be predicted through nowcasting and VSRF techniques (p 2).	
Avalanche													Referenced as "avalanches", a winter weather phenomena that can be predicted through nowcasting and VSRF techniques (p 2).	
Snowfall line													An unclear reference to the term, "snowfall line" in the "surface air temperature and humidity" section under "Gap Analysis" (p 7)	
Ice accretion									Indirectly referenced as "ice storms" (p 24), related to disasters/extreme events.					
Sea-ice coverage/extent										As measured via satellite imagery and other (p 6, 7). Referenced as "ice report" or "ice cover" (p 7), a visual observation, 7-20km in radius (from a ship, settlement or lighthouse), in which the "total area of ice being reported is very small" or "not really adequate" however, reports from the air are noted as having "much better" coverage. Variable names include: ice cover, sea-ice coverage, extent of sea-ice (p 7).				

ice particles											As measured by weather radars (p 6)			
snow mass														Noted that microwave imagery has the "potential for improvement of snow mass assessment in land analysis" (p 6). Also see "snow water equivalent".

ANNEX VII

METHODOLOGY FOR THE REVIEW OF VARIABLES

The workshop agreed with the following methodology for reviewing Variables in OSCAR/Requirements:

Use of "mole fraction" vs. "mixing ratio"

- The two are almost equivalent, and differences in terms of requirement values will be negligible
- "Amount of substance" is one of the seven base quantities upon which the SI is founded. The workshop therefore proposed using: "Amount-of-substance fraction". It relates to the amount of molecules, and measurement units are mol/mol (i.e. dimensionless)(units of uncertainty could differ)
- We need to refer to amount- of substance fraction with respect to dry air in the definition;
- For traditional meteorological variables such as Specific Humidity, we can continue using a mass fraction, with uncertainty requirements expressed in %.

Column measurements

- Distinction between 2D and 3D field observations, should be given as part of the variable name and definition, e.g. "Ozone total column", which definition will explain that it is 2D field observation vertically integrated. Current qualifiers used in DB:
    - (at surface): 2D field (surface level)
    - (total column): 2D field, integrated vertically in considered layer
    - (quasi-horizontal): 2D field (non-surface level, e.g. tropopause, cloud top)
    - None: 3D field
- The workshop agreed to continue working as above as a first step (short term solution);
- As a second step (longer term solution), the workshop agreed that we'll have to consider separating the concepts of 2D/3D (at surface, total column etc.) from the variables, and attach this to the requirement values.

Variables and their units

- Principle: One variable cannot have two different units, except for scalings (e.g. metres, millimetres). However, different units can be used to express measuring units (g/kg) and uncertainty units (e.g. %) in the requirements.
- We need to separate the concept of molecule from the one of a measured variable related to a molecule. For example, CO2 is not a variable, it is the name of a molecule; "CO_2 concentration" (g/kg) is a variable; "CO2 amount-of-substance fraction" (dimensionless) is a variable.
- Classification scheme for names of molecules could be introduced (long term solution). In the short term, the workshop agreed to use the name of the molecule as part of variable name.
- We need to avoid duplication, noting that units can be converted.

BG vs. SR measurements

- BG stands for "background", and refers to measurements made in remote areas far away from pollution.
- SR stands for "source region" and refers to measurements made within or close to polluted areas.
- Options discussed:

(1) BG and SR are considered as the same variables and

(1.a) can be addressed by using concept of AA and sub-AA;

(1.b) BG and SR are attached to the requirement values (i.e. not to the variable);

(1.c) use the concept of horizontal coverage to introduce BG and SR;

(2) Add (BG) or (SR) as part of variable name. Clear definition of BG and SR should be given in OSCAR/Requirements;

- The Workshop agreed that sub-options under option (1) were preferable. CAS was invited to investigate sub-options under (1) and to recommend one (***action***).

Types of molecules, use of scripts and sub-scripts

- Isotopes (e.g. HD):
  - Isotopes can be represented by either using the name of the isotope (e.g. D=Deuterium for ^{2}H) or by giving explicitly the number of nucleons of the atom as follows: (13)C for ^{13}C.
  - Variables will only be created in OSCAR/Requirements where observational user requirements exist, e.g.
    - H_2 (hydrogen molecule) – requirements exist
    - D_2 (Deuterium) - no requirements exist a priori
    - HD - requirements exist
    - H_2O (water molecule)
    - HDO (water molecule with 1 Deuterium atom)
    - D_2O (water molecule with 2 Deuterium atom) - no requirements exist a priori
- Use of "Delta":
  - e.g. $\delta^{13}C$ (pronounced "delta c thirteen") is an isotopic signature, a measure of the ratio of stable isotopes $^{13}C/^{12}C$, reported in parts per thousand (per mil, ‰). See Wikipedia[10].
  - This needs to be explicitly explained as part of the variable definition.
  - Proposed naming convention pending implementation of Greek letters and superscripts/subscripts in OSCAR/Requirements (example for "$\delta\ ^{13}CO_2$ Amount of Substance Fraction") :
    - "(13)CO2 – Amount of Substance Fraction Delta"
- We need to make OSCAR/Requirements system evolve to allow for ingesting & recording requirements, as well as for displaying variable names. It was noted that HTML may not be appropriate for the exchange of information.
- The workshop proposed using the above naming convention for the short term, hence allowing variable names to be adjusted or created in OSCAR/Requirements and uploading requirements values into the database.
- The workshop proposed using the WIGOS Metadata Standard (WMS) solution in the medium term – in future WMS list will be structured with sub-lists. Jörg to make proposal for the missing variable names, e.g. Isotopes (HD, HDO, $\delta^{13}CO_2$) (***action***).
- For the longer term, the issue ought to be brought at higher WMO level as molecule names are also used in other contexts:
  - CF Convention[11] can be used as solution for simple molecules. However, CF

[10] https://en.wikipedia.org/wiki/%CE%9413C

[11] http://cfconventions.org/Data/cf-standard-names/60/build/cf-standard-name-table.html

uses units within variable name. Uses Carbon Dioxide for CO2.

- BUFR Common Table C-14[12] also provides for names of molecules.
- The Chemical Abstract Services (CAS) is using Numbers for identifying molecules.

Aerosols

- Aerosols cover many Applications Areas; they are not gas of molecules (i.e. they are solid of liquid chemicals composed of many molecules);
- Aspects to be considered (from John Eyre's email dated 5 July 2018):
  - 3D field and total column (2D field), as for other "substances", but the units will need to be different – Kg/m^3 and Kg/m^2 ?
  - Aerosol type or types, or dominant type, e.g. desert dust, burnt biomass, volcanic ash, sea salt, etc.
  - Size distribution – how to specify it? modal radius?
  - Radiative characteristics, e.g. – aerosol optical depth – for total extinction and for absorption.
- Aerosol group published a paper[13] (A. Benedetti *et al*., Status and future of numerical atmospheric aerosol prediction with a focus on data requirements), and the workshop invited the Secretariat (Geir Braathen) to contact the Chair of the Aerosol Scientific Advisory Group (SAG) (***action***) and ask about requirements for representing Aerosols observational user requirements and variables in OSCAR/Requirements.

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[12] http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_CommonTable_en.pdf
[13] https://www.atmos-chem-phys.net/18/10615/2018/

AA	Application Area
ABOS	Aircraft-Based Observing System
AMDAR	Aircraft Meteorological Data Relay
AntON	Antarctic Observing Network
AOPC	GCOS Atmospheric Observation Panel for Climate
asap	As soon as possible
ASAP	Automated Shipboard Aerological Programme
AWS	Automatic Weather Station
CAeM	Commission for Aeronautical Meteorology
CAgM	Commission for Agricultural Meteorology
CAS	Commission for Atmospheric Sciences
CBS	Commission for Basic Systems
CCl	Commission for Climatology
CD	Capacity Development
CEOS	Committee on Earth Observation Satellites
Cg	Congress
CGMS	Coordination Group for Meteorological Satellites
CHy	Commission for Hydrology
CIMO	Commission for Instruments and Methods of Observation
CM	Climate Monitoring
CMA	China Meteorological Administration
CryoNet	Core network of GCW surface measurement sites/stations
DAOS	Data Assimilation and Observing Systems working group
DPFS	Data Processing and Forecasting System
DRR	Disaster Risk Reduction
E-AMDAR	EIG EUMETNET AMDAR programme
E-ASAP	EIG EUMETNET Automated Shipboard Aerological Programme
EC	Executive Council
ECMWF	European Centre for Medium-Range Weather Forecast
EC-PORS	Executive Council Panel of Experts on Polar Observations, Research and Services
ECV	Essential Climate Variable
EGOS-IP	Implementation Plan for the Evolution of Global Observing Systems
E-GVAP	EIG EUMETNET GNSS water vapour programme
EIG	Economical Interest Group
E-PROFILE	EIG EUMETNET Radar Wind Profilers and Backscatter Lidars programme
E-SURFMAR	EIG EUMETNET Surface Marine observation programme
ET-ABO	OPAG-IOS Expert Team on Aircraft Based Observing Systems
ET-AO	CIMO Expert Team on Aircraft Based Observations
ET-EGOS	Former OPAG-IOS Expert Team on the Evolution of Global Observing Systems
ET-ODRRGOS	Former OPAG-IOS Expert Team on Observational Data Requirements and Redesign of the Global Observing System
ET-OPSLS	CBS/CCl Expert Team on Operational Predictions from Sub-Seasonal to Longer-Time Scales
ET-SAT	OPAG-IOS Expert-Team on Satellite Systems
ET-SBO	OPAG-IOS Expert Team on Surface-Based Observing Systems
EUMETNET	EIG Grouping of European Meteorological Services
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
E-WINPROF	EIG EUMETNET Operational Networking of Wind Profilers in Europe
FAO	Food and Agriculture Organization of the United Nations
FSO	Forecast Sensitivity to Observation
GAW	Global Atmosphere Watch
GAWSIS	GAW Station Information System
GCOS	WMO-IOC-UNEP-ICSU Global Climate Observing System
GCOS-IP	GCOS Implementation Plan
GCW	Global Cryosphere Watch

GCW-IP	GCW Implementation Plan
GEO	Group on Earth Observations
GEO	Operational geostationary satellites
GFCS	Global Framework for Climate Services
GHGs	Greenhouse gases
GLAS	GEWEX Global Land/Atmosphere System Study
GNSS	Global Navigation Satellite System
GNSSRO	GNSS for Radio Occultation
GNWP	Global NWP
GOOS	IOC-WMO-UNEP-ICSU Global Ocean Observing System
GOS	Global Observing System
GPCs	Global Producing Centres of Long-Range Forecasts
GPS	Global Positioning System
GPSRO	GPS Radio Occultation
GRUAN	GCOS Reference Upper Air Network
GSG	GCW Steering Group
GSICS	Global Space-Based Inter-Calibration System
GSN	GCOS Surface Network
GSNMC	GSN Monitoring Centre
GTN-P	Global Terrestrial Network for Permafrost
GTS	Global Telecommunications System
HR	Horizontal Resolution
HRNWP	High Resolution NWP
IBCS	Intergovernmental Board on Climate Services
ICAO	International Civil Aviation Organization
ICG-WIGOS	Inter-Commission Coordination Group on WIGOS
ICSU	International Council for Science
ICT-IOS	CBS Implementation Coordination Team on Integrated Observing Systems
ICT-SW	WMO Inter-Programme Coordination Team on Space Weather
ID	Identification Number
IGOS	Integrated Global Observing Strategy
IMOP	Instrument and Methods of Observation Programme
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IPET	Inter-Programme Expert Team
IPET-OSDE	OPAG-IOS IPET on the Observing System Design and Evolution
IPET-SUP	OPAG-IOS IPET on Satellite Utilization and Products
IPET-WIFI	OPAG-IOS IPET on WIGOS Framework Implementation Matters
IPT-SWISS	Inter-Programme Team on Space Weather Information, Systems and Services
IPWG	International Precipitation Working Group
ITU	International Telecommunication Union
IWWG	International Winds Working Group
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JMA	Japan Meteorological Agency
KAA	Key Activity Area
KNMI	Royal Netherlands Meteorological Institute
LAM	Limited Area Model
LEO	Operational low-Earth orbit satellites
LT	Lower-Troposphere
MHEWS	Multi-Hazard Early Warning Systems
MoU	Memorandum of Understanding
NASA	National Aeronautics and Space Administration
NCEP	NOAA National Centers for Environmental Prediction
NFP	National Focal Point
NMHSs	National Meteorological and Hydrological Services
NOAA	US National Oceanic and Atmospheric Administration
NVSRF	Nowcasting and Very Short Range Forecasting
NWP	Numerical Weather Prediction

OC	Observing Cycle
OCG	JCOMM Observations Coordination Group
OND	Observing Network Design
OOPC	Ocean Observations Panel for Climate (GCOS/GOOS/WCRP) (also known as GOOS Physics and Climate panel)
OPA	JCOMM Observations Programme Area
OPACE	Open Panel of CCl Experts
OPAG	Open Programme Area Group
OPAG-DPFS	CBS OPAG on DPFS
OPAG-IOS	CBS OPAG on Integrated Observing Systems
OPERA	EIG EUMETNET Operational Programme for the Exchange of Weather Radar Information
OSCAR	Observing System Capability Analysis and Review tool
OSCAR/Requirements	Observational user requirements component of OSCAR
OSCAR/Space	Space-based observing systems capabilities component of OSCAR
OSCAR/Surface	Surface-based observing systems capabilities component of OSCAR
OSDW	IPET-OSDE Observing System Design Workshop
OSE	Observing System Experiment
OSND	Observing system network design
OSSE	Observing System Simulation Experiment
PoC	Point of Contact
QM	Quality Management
R&D	Research and Development
RA	Regional Association
RBCN	Regional Basic Climatological Network
RBON	Regional Basic Observing Network
RBSN	Regional Basic Synoptic Network
R-MAR	OPAG-IOS Rapporteur on Marine Observing Systems
RRR	Rolling Review of Requirements
R-SEIS	OPAG-IOS Co-Rapporteur on Scientific Evaluation of Impact Studies undertaken by NWP centres
RTH	Regional Telecommunication Hub
R-WIP	Regional WIGOS Implementation Plan
SAG	Scientific Advisory Groups
SAON	Sustained Arctic Observing Network
SG-OD	IPET-WIFI Sub-Group on OSCAR Development
SG-RFC	OPAG-IOS Steering Group on Radio-Frequency Coordination
SIAF	Seasonal to Inter-Annual Forecasting
SLWC	Super Cooled Liquid Water Content
SOC	Science Organizing Committee
SoG	Statement of Guidance
TAMDAR	Tropospheric Airborne Meteorological DAta Reporting
TAO	Tropical Atmosphere Ocean
TBD	To be defined
TC	Technical Commission
TDCF	Table Driven Code Form
TECO	Technical Conference
TOPC	GCOS Terrestrial Observation Panel for Climate
ToR	Terms of Reference
TPOS	Tropical Pacific Observing System project
TRITON	Triangle Trans-Ocean Buoy Network
TT-ACV	GAW Task Team on Atmospheric Composition Vocabulary
TT-SOGON	CCl Task Team on the Statement of Guidance on Observational Needs
TT-WDP	Task Team on WIGOS Data and Partnerships
U	Uncertainty
UK	United Kingdom of Great Britain and Northern Ireland
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change

UR	User Requirement
USA	United States of America
VCP	Voluntary Cooperation Programme
VOC	Volatile Organic Compound
VolA	WMO No. 9, Weather Reporting, Volume A, Observing Stations and WMO Catalogue of Radio-sondes
VR	Vertical Resolution
WAM	West African monsoon
WCRP	WMO-IOC-ICSU World Climate Research Programme
WDQMS	WIGOS Data Quality Monitoring System
WG-GRUAN	Working Group on GRUAN
WHOS	WMO Hydrological Observing System
WIGOS	WMO Integrated Global Observing System
WIP	WIGOS Framework Implementation Plan
WIR	WIGOS Information Resource
WIS	WMO Information System
WMO	World Meteorological Organization
WPP	WIGOS Pre-operational Phase
WRF	Weather Research and Forecasting
WWW	World Weather Watch

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