Towards a sustainability process for GEOSS Essential Variables

11-12 June 2015, Bari-Italy

Societal Benefit Area: Atmospheric Composition Related Services

Greg Carmichael
Representing WMO-GAW

Coordinating an Observation Network of Networks EnCompassing saTellite and IN-situ to fill the Gaps in European Observations

Status of existing EVs in the domain

- Is your community developing a set of area-specific EVs? **Yes**
  - **How do you define EV?** **In the context of their use in supporting priority applications *(either directly in the prediction or in the evaluation)*.**

- If not, is the community planning to start this in the near future?
  - Have you attended previous meeting? **No**
  - Are you considering reference documents from other domains? **Yes**

The process underlying EV definition

- What criteria, methodology, and process are used to identify EVs?
  - Top-down: from what the application area (e.g., predictive modeling) requires as inputs and to address prioritized environmental issues (e.g. climate forcing agents, pollutants, ozone depletion).
  - Several GAW networks are recognized by GCOS as networks for Essential Climate Variables
- Do you have a template to document a EV?
  - See next slides for some details

RRR in GAW

- The Global Atmosphere Watch (GAW) Programme in its Addendum for the Period 2012 – 2015 to the WMO Global Atmosphere Watch (GAW) Strategic Plan 2008 – 2015 tasked each of its Science Advisory Groups (SAGs) to establish the Rolling Review of Requirement (RRR) process in each focal area (Ozone, Greenhouse gasses, reactive gasses, atmospheric wet deposition, UV radiation and Aerosols) as well as consider the requirements within GURME.

RRR in GAW

- WMO's 16th Congress recommended for GAW to set up an ad-hoc Task Team to review the needs for GAW regarding satellite measurements and the IGACO recommendations on these that date back to 2004. Congress further recommended for this work to be done in coordination with the CBS Expert Team on Satellite Systems (ET-SAT) and the Expert Team on Evolution of the Global Observing Systems (ET-EGOS), the Committee on Earth Observation Satellites (CEOS) Atmospheric Composition Constellation group and the Coordination Group for Meteorological Satellites (CGMS) and also taking into consideration GCOS requirements and the vision for the GOS in 2025.

TT on Obs. Requirements

- The GAW Task Team on Observational Requirements and Satellite Measurements was established in 2014 with these members:
  - WMO/GAW and user representatives:
  - Greg Carmichael, WMO EPAC SSC Chair. (Chair of the TT)
  - Ben Veihelman, ESA / ESTEC
  - Claire Granier, LATMOS-IPSL and NOAA/ERSL & CU/CIRES, France
  - Sander Houweling, SRON, Netherlands (GHG SAG)
  - Randall Martin, Dalhousie Univ., Canada
  - Terry Nakajima, CESD/AORI, Japan
  - Vincent-Henri Peuch, ECMWF, (Copernicus and MACC-II)
  - Sandro Fuzzi, CNR, Italy
  - As requested by WMO Congress
  - John Eyre, UKMO, chair IPET-OSDE
  - Richard Eckman, CEOS (NASA), USA
  - Rosemary Munro, CGMS (EUMETSAT)
  - Claus Zehner, ESA/ESRIN

Application Areas – Background

WIGOS Applications:

- Global numerical weather prediction (GNWP);
- High-resolution numerical weather prediction (HRNWP);
- Nowcasting and very short range forecasting (NVSRF);
- Seasonal and inter-annual forecasting (SIAF);
- Aeronautical meteorology;
- **Atmospheric composition** *(forecasting, monitoring, urban)*
- Ocean applications;
- Agricultural meteorology;
- Hydrology;
- Climate monitoring (as undertaken through the Global Climate Observing System, GCOS);
- Climate applications; and
- Space weather.
- In addition, the observational requirements for WMO polar activities and the Global Framework for Climate Services (GFCS) are also to be considered under WIGOS.

Application Areas

- **Forecasting Atmospheric Composition in NRT (F)**
  - Covers applications from global to regional scales (with horizontal resolutions similar to global NWP (~ 10 km and coarser) with stringent timeliness requirements (NRT) to support operations such as sand and dust storm and chemical weather forecasts.
- **Monitoring Atmospheric Composition (M)**
  - Covers applications related to evaluating and analysing changes (temporally and spatially) in atmospheric composition regionally and globally to support treaty monitoring, climatologies and re-analyses, assessing trends in composition and emissions/fluxes, and to better understand processes, using data of controlled quality (and with less stringent time requirements (not needed in NRT)), and used in products such as Ozone and Greenhouse Gas Bulletins, and State/Health of the Atmosphere reports.

TT on Obs. Requirements

- **Providing Atmospheric Composition information to support services in urban and populated areas (U)**
  - Covers applications that target limited areas (with horizontal resolution of a few km or smaller and stringent timeliness requirements to support services related to weather/climate/pollution, such as air quality forecasting. (The GURME SAG will review all related entries).

Key parameters needed for Forecasting

- 1. **All Global NWP variables**
  (e.g., PBL + Tropopause height) and others yet to be determined by WMO/GAW
- 2. **Aerosols**
  (aerosol mass, size distribution (or at least mass at 3 fraction sizes: 1, 2.5 and 10 micron), speciation and chemical composition, AOD at multiple wavelengths, AAOD, water content, ratio of mass to AOD, vertical distribution of extinction).
- 3. **Reactive Gases, Trace gases (incl GHG), Ozone Precursors**
  (Total ozone, profile ozone, surface ozone, NO, NO_2 (surface, column, profile), PAN, HNO_3, NH_3, CO, VOC (isoprene, terpenes, alcohols, aldehydes, ketones, alkanes, alkenes, alkynes, aromatics), SO_2 (surface and column), CH_4, CO_2, N_2O, HCHO, HO_x, Cl_x, ClO, BrO, OClO, $ClONO_2$, HDO, CFCs, HCFCs, HFCs, Rn, SF_6)
- 4. **Others**
  Actinic flux, fire radiative power, land proxies, lightning, dry and wet deposition, pollen (key species), OCS

EVs validation and use

- To what extent these EVs (if any) are validated and used – Extensive protocols (CCLs, WCCs), many used in trend and assessment analyses
- Are the EVs linked to applications and users? yes
- **Who the users are? Varied** – general public, the media, the scientific community (including satellite people and modellers), conventions and protocols.
- How is a community agreement reached?
- Is a community review process in place? Yes …
- Are the EVs linked to an international body (i.e. a UN convention or similar) and is this body involved in accepting the EVs? WMO, UNEP, WHO

Describing the monitoring networks currently operational

- Do you have a database with information on the EVs? OSCAR (*Observing Systems Capability Analysis and Review Tool* http://www.wmo-sat.info/oscar/)
- Do you know network currently operational for medium-term/long-term monitoring? GAW and networks contributing to or collaborating with GAW. Such as: TCCON; IMPROVE-Optical; EARLINET; ALINET; Ad-NET; NADP; IDAF (http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html)
- Are the current operational networks operated by your community measuring the EVs? Yes

GAW Facts

- Partnership involving contributors from 100 countries, coordinated under WMO Commission for Atmospheric Sciences
- End-to-end approach from observations through research to the delivery of products and services
- Use of observations from global stations, regional stations, and satellite data
- Applications: climate monitoring, air quality forecasting, NWP, Protocol monitoring

GAW Global Stations

GAWSIS
STATION INFORMATION SYSTEM

http://gaw.empa.ch/gawsis/

GAW focal areas

- Stratospheric Ozone and vertical ozone distribution
- Greenhouse Gases (*CO_2 and its isotopes, CH_4 and its isotopes, N_2 / O_2 ratio, N_2O, SF_6, H_2O, CFCs, halons and substitutes*)
- Reactive Gases (*O_3, CO, VOCs, NO_x, SO_2*)
- Precipitation Chemistry and Total Atmospheric Deposition
- Aerosols (*chemical and physical properties, AOD*)
- UV Radiation
- GAW Urban Meteorology (GURME) project
- Global to regional modelling applications (GAW-Aps)

Evs for climate studies: GHG, aerosols, ozone, water vapour

Assessing EV observational needs and readiness

- For some Use Case, have you already focused on EVs' features: Yes see next slides

  - Temporal frequency
  - Spatial resolution
  - Accuracy
  - etc.;

- Challenges and how these are addressed (if any) Yes many, e.g., need for prioritization, expert and end user input,…

Initial quantitative observation requirements of GAW

Variables	Attribute #1	Attribute #2	Vertical region	Application	Responsible SAG
Aerosol mass concentration	Size distribution in 3 classes (less than 1 μm, less than 2.5 μm, less than 10 μm)	Total, Sulphate, Dust, Nitrate, ammonium, BC, OC, SOA, OM, Sea Salt, H2O	NS	F, M, U	Aerosol
Pollen grain counts	Species: birch, ambrosia, olive, grass…		NS	F, M, U	Aerosol
Black Smoke			NS	M	Aerosol
Aerosol mass concentration	Size distribution (continuous)		Profile	F, M, U	Aerosol
Aerosol Optical Depth	A few wavelengths		TC	F, M, U	Aerosol
Absorbing Aerosol optical Depth	A few wavelengths		TC	F, M, U	Aerosol
Ozone			TC	F,M	Ozone
Ozone			Profile	F,M	
Ozone mixing ratio			NS	F,M,U	RG
NO2			TC, TrC, Profile	F,M,U	Ozone, RG
NO2			TrC	U	RG
NO2 mixing ratio			NS	F,M,U	RG
NO mixing ratio			Profile	F,M	Ozone, RG
HNO3 mixing ratio			Profile	F,M	Ozone, RG
PANs mixing ratio			Profile	F,M	Ozone, RG
…	…	…	…	…	…

Variable	Application Area	Layer(s)	Uncertainty G	Uncertainty B	Uncertainty T	…
Ozone mixing ratio	U	NS	1 ppb	2 ppb	5 ppb	…
Ozone mixing ratio	F	NS	1 ppb	2 ppb	5 ppb	…
Ozone mixing ratio	M	NS	1 ppb	2 ppb	5 ppb	…
Ozone mixing ratio	F	PBL	1 ppb	2 ppb	5 ppb	…
Ozone mixing ratio	M	PBL	1 ppb	2 ppb	5 ppb	…
Ozone mixing ratio	F	FT	2%	5%	10%	…
Ozone mixing ratio	M	FT	2%	5%	10%	…
Total and individual PM1	U	NS	max(1 $\mu g.m^{-3}$, 10%)	max(3 $\mu g.m^{-3}$, 30%)	max(5 $\mu g.m^{-3}$, 50%)	…
Total and individual PM1	F	NS	max(1 $\mu g.m^{-3}$, 10%)	max(3 $\mu g.m^{-3}$, 30%)	max(5 $\mu g.m^{-3}$, 50%)	…
Total and individual PM1	M	NS	max(0.5$\mu g.m^{-3}$, 10%)	max(1$\mu g.m^{-3}$, 30%)	max(2$\mu g.m^{-3}$, 50%)	…
…	…	…	…	…	…	

Gaps and requirements

- Have you already carried out a gap analysis utilizing the EVs to identify gaps and priorities in terms of:
  - EO data availability
  - In-situ data availability
  - Models (algorithms) for EV extraction: direct measurements or proxies
  - Data repositories for the long term preservation of EVs
  - Infrastructure for EVs publication
- minimize gaps in the measurement networks in data-poor regions and with respect to “local” stations
- allow near real-time provision of GAW data
- support integration of surface, vertical profile and column datasets from different platforms to provide a unified understanding of aerosol and gas distributions

Timeline 2015-2016

Task Team to engage the GAW Scientific Advisory Groups and other users, to:

- Have the observation requirements fully developed for the three application areas by autumn 2015,
- Identify requirements for a set of priority variables that cut across application areas
- Populate the WMO RRR database (part of OSCAR) for the above applications by the end of 2015

Next steps

- Review the Statements of Guidance (gap analyses)
- Inform the Vision for WIGOS surface/space components in 2040, and subsequent update of CGMS baseline
- GAW to assist other WMO application areas in reviewing atmospheric composition requirements
- GAW to regularly update the requirements for the three application areas (F, M, U), as part of the WMO Rolling Review Requirements process

Thank you for your attention!

Contact information:
Oksana Tarasova
Chief AER/RES WMO
otarasova@wmo.int

Greg Carmichael
WMO EPAC SSC Chair
gcarmich@ngineering.uiowa.edu

Conclusions

- Overlapping with EVs in other domains (SBA)
- Priorities for EVs operational monitoring
- Recommendations for GEO/GEOSS
- Future work

Backup Slides

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4].
Oceanic	**Surface:**[5] Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

[1] Including measurements at standardized, but globally varying heights in close proximity to the surface.

[2] Up to the stratopause.

[3] Including nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs).

[4] In particular nitrogen dioxide (NO_2), sulphur dioxide (SO_2), formaldehyde (HCHO) and carbon monoxide (CO).

[5] Including measurements within the surface mixed layer, usually within the upper 15m.

Key parameters needed for monitoring

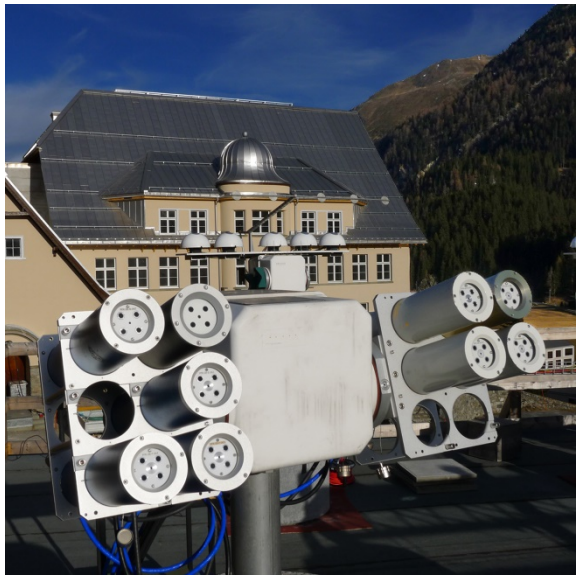
- 1. All Global NWP variables (e.g. PBL + tropopause height) and others we want to add: SST, deep ocean temperature, solar variability, albedo, land use, soil moisture, precipitation, sea ice cover, snow cover, PSC occurrence
- 2. Aerosols (aerosol mass, number, size/surface distribution (1, 2.5, 10 micron), speciation and chemical composition, AOD at multiple wavelengths, AAOD, water content, ratio of mass to AOD, vertical distribution of extinction), stratospheric aerosol backscatter coefficient, PSC composition, concentration of metals, chemical composition of PM (sulphate, nitrate, ammonium, BC, OC, OM, dust, sea salt, BS, SOA) aerosol index, refractive index, precipitation chemistry composition, Hg, POPs, primary biological particles

Key parameters needed for monitoring

- 3. Total ozone, profile ozone, surface ozone, NO, NO_2 (surface, column, profile), PAN, HNO_3, NH_3, CO, VOC (isoprene, terpenes, alcohols, aldehydes, ketones, alkanes, alkenes, alkynes, aromatics), SO_2 (surface, column), CH_4, CO_2, N_2O, N_2O_5, NO_3, HCHO, HOx, Cly, ClO, BrO, OClO, $ClONO_2$, HDO, CFCs, HCFCs, HFCs, Halons, CH_3Br, CH_3Cl, $BrONO_2$, Rn, SF_6, glyoxal, methyl chloroform, H_2O, H_2O_2, H_2, O_2 / N_2 ratio, DMS, MSA, OCS
- 4. Isotopes of CO_2, methane, N_2O, CO, (D, ^{13}C, ^{14}C, ^{17}O, ^{18}O, ^{15}N) also in the aerosol phase
- 5. Actinic flux, fire radiative power, land proxies, lightning, dry and wet deposition, pollen (key species), ocean colour, chlorophyll-A, LAI, PAR, FPAR, fluorescence, vegetation maps, land use maps, burned areas, night light, fire counts, wet lands, ship routes, forest inventory, biomass density, crop lands

The Mission of GAW

- Perform systematic global, long-term **observations** of the chemical composition and selected physical characteristics of the atmosphere with emphasis on quality assurance
- Deliver integrated products, services and assessments in support of **International Conventions and users.**
- Development of air pollution, weather and climate **Predictive Capability**



TT on Obs. Requirements

- The Task Team met in November 2014
- The Task Team discussed what application areas should be used instead of the placeholder “Atmospheric Chemistry” application area currently identified used in WMO, taking into consideration the WMO strategic plan, CAS priorities , and the upcoming GAW Implementation Plan (IP) for the period 2016-2023.
- Three recommended applications areas were identified that encompasses major elements of GAW research that is data driven and in line with the theme “GAW – Research Enabling Services”:

Populating OSCAR

The Task Team developed a strategy to begin the RRR process and to populate the OSCAR data base for the above applications. The process will engage the SAGs and the SSC. The committee started the process of identifying the atmospheric composition and related parameters needed to support the applications and began to fill out an Excel table with user requirements that will be used to populate the OSCAR data base after evaluation by the SAGs. The SAGs will be asked to discuss the application areas, including the sorts of specific applications that are important within the overarching application, and the parameters needed for the applications (making suggestions for adding and/or removing parameters) and continue filling out the tables of user requirements for the parameters that fall in their domain.