World Meteorological Organization

Weather • Climate • Water

Requirements of the Global Atmosphere Watch – GAW

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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**

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

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

Updating GAW requirements

- WMO Observation Requirements for “Atmospheric chemistry” are from IGACO report (2004)

- WMO’s 16th Congress (2011) recommended for GAW to set up an ad-hoc Task Team to review
  - Observation requirements for atmospheric composition
  - Satellite missions contributing to such requirements
- Take into consideration GCOS and other requirements for atmospheric composition observations
- In coordination with WMO CBS, CEOS, CGMS

TT on Observation Requirements

- The 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)
  - 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, Istituto di Scienze dell'Atmosfera e del Clima, CNR Italy

  - As requested by WMO Congress
  - John Eyre, UKMO, chair IPET-OSDE
  - Richard Eckman, CEOS (NASA), USA
  - Rosemary Munro, CGMS (EUMETSAT)
  - Ben Veihelmann, ESA/ESTEC
  - Claus Zehner, ESA/ESRIN

TT on Observation Requirements

- The Task Team met in November 2014
- The Task Team took into consideration:
  - The WMO strategic plan,
  - Priority areas of the Commission for Atmospheric Sciences,
    - high impact weather;
    - water;
    - Integrated Global Greenhouse Gas Information System;
    - aerosols;
    - urbanization; and
    - new technologies, including geo/climate engineering.
  - GAW Implementation Plan (IP) for the period 2016-2023.

- **Three applications areas for atmospheric composition observations were identified** :
  - Forecasting atmospheric composition
  - Monitoring atmospheric composition
  - Providing Atmospheric Composition information to support services in urban and populated areas

TT on Observation Requirements

GAW

1. **Forecasting Atmospheric Composition (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.
2. **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 Observation Requirements

3. **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.

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

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)
- 3. **Reactive gases, Trace gases (incl GHGs), 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, 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

Key parameters needed for Monitoring

- 4. **Trace gas isotopes**
  CO_2, methane, N_2O, CO, (D, ^{13}C, ^{14}C, ^{17}O, ^{18}O, ^{15}N) also in the aerosol phase

- 5. **Others**
  (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)

Key parameters needed for Urban applications

- (Under development)

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 µg.m^{-3}, 10%)	max(3 µg.m^{-3}, 30%)	max(5 µg.m^{-3}, 50%)	…
Total and individual PM1	F	NS	max(1 µg.m^{-3}, 10%)	max(3 µg.m^{-3}, 30%)	max(5 µg.m^{-3}, 50%)	…
Total and individual PM1	M	NS	max(0.5µg.m^{-3}, 10%)	max(1µg.m^{-3}, 30%)	max(2µg.m^{-3}, 50%)	…
…	…	…	…	…	…	

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!

BACKUP SLIDES

CAS-16 priorities

A TEN-YEAR FUTURE VIEW:

- High Impact Weather and its socio-economic effects in the context of global change
- Water: Modelling and predicting the water cycle for improved DRR and resource management
- Integrated GHG Information System: Serving society and supporting policy
- Aerosols: Impacts on air quality, weather and climate
- Urbanization: Research and services for megacities and large urban complexes
- Evolving Technologies: Their impact on science and its use

Global Atmosphere Watch Programme

- WMO/GAW was established 1989 by merging GO_3OS and BAPMoN.
- GAW is a partnership involving contributors from 100 countries.
- GAW implements an end-to-end approach from observations through research to the delivery of products and services
- GAW observations can be used for different applications, including climate studies, air quality forecasting, NWP etc.
- GAW is coordinated by the Research Department of WMO under the purview of WMO Commission for Atmospheric Science (CAS)

DQOs for Ozone

Total ozone measurements –
total combined uncertainty <1%

Vertical ozone profiles - 5-7%

Ozone observations within GAW are limited to:

-Brewer and Dobson instruments for total ozone

-Ozone sondes for vertical ozone distribution

DQOs for Reactive Gases

Surface Ozone	▪ combined measurement uncertainty of ± **0.5 nmol/mol** (one sigma) or ± 1.0 nmol/mol (two sigma) ▪ NRT applications require a combined uncertainty of less than ± **5 nmol/mol** (one sigma) for hourly values of unvalidated data and routine submission of preliminary data within 72 hours after sampling
CO	▪Compatibility levels for different laboratories is **±2 nmol/mol** (k=2) for 1 hour averages; ▪Standards should be compatible to **±1 nmol/mol or 0.5%** (whichever is greater, k=2); ▪ mole fractions between 40 and 250 nmol mol/mol should be determined with a maximum uncertainty of **±2 nmol/mol** (k=2); ▪ mole fraction above 250 nmol/mol should be determined with a maximum uncertainty of **±5 nmol/mol** (k=2);
VOC	varies for different components in the group
SO_2	not assigned
NOx	varies different for different pollution levels

DQOs for NOx

Level	1 (basic)	2 (enhanced)	3 (high)
Site characteristics	Continental	Continental background, marine	Pristine, marine background
LDL	NO: 100 ppt NO_2:150 ppt	NO: 15 ppt NO_2:30 ppt	NO: 1 ppt NO_2:5 ppt
measurement uncertainty	NO: 100 ppt or 10% NO_2:150 ppt or 15%	NO: 15 ppt or 3% NO_2:30 ppt or 5%	NO: 1 ppt or 3% NO_2:5 ppt or 5%
temporal data coverage	60%	70%	70%
suggested method	CLD / PLC	CLD / PLC	CLD / PLC
alternative method (backup or QC reasons)	passive sampling / potassium iodide	CRD	LIF ; DOAS ; TDLAS

Low mole fraction stable standards are needed to satisfy DQOs for background measurements of NOx

Priority Volatile Organic Compounds (VOCs) and their Data Quality Objectives (DQOs)

Compound	Accuracy	Precision
Ethane	10%	5%
Propane	10%	5%
Acetylene	15%	5%
Isoprene	20%	15%
Formaldehyde	20%	15%
Monoterpenes	20%	15%
Acetonitrile	20%	15%
Methanol	20%	15%
Ethanol	20%	15%
Acetone	20%	15%
Dimethylsulphide (DMS)	20%	15%
Benzene	15%	10%
Toluene	15%	10%
Iso-/n-Butane	10%	5%
Iso-/n-Pentane	10%	5%
mole fraction <0.1 ppb	±20 ppt	±15 ppt