

**TERMS OF REFERENCE FOR THE CEOS
ATMOSPHERIC COMPOSITION VIRTUAL CONSTELLATION**

VERSION 1.0

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CONSTELLATION NAME: Atmospheric Composition Virtual Constellation (AC-VC)

MISSION STATEMENT & OBJECTIVES

The AC-VC exists to sustain a systematic capability to provide essential observations of atmospheric composition from space. Key objectives include coordination of the collection and delivery of data to:

- develop and improve predictive capabilities for changes in the ozone layer;
- monitor air quality;
- monitor climate forcing associated with changes in atmospheric composition.

CHARACTERISATION OF THE MEASUREMENTS AND DATA COLLECTIONS WITHIN SCOPE

AC-VC includes a large number of geophysical parameters related to atmospheric composition within its scope. These include total and profile ozone (O₃), radiative and chemically active trace gases including constituents relevant to ozone chemistry in the troposphere and stratosphere (including hydrogen, nitrogen, chlorine, and bromine containing compounds), tropospheric constituents important to air quality (e.g., NO₂, SO₂, H₂CO, C₂H₂O₂, H₂O, aerosols, cloud parameters, and UVB radiation), greenhouse gases (e.g., CO₂, CH₄), and gases and particles emitted by volcanic eruptions (e.g., SO₂ and ash). Multi-agency ground-based measurement networks, e.g., Network for the Detection of Atmospheric Composition Change (NDACC), are important for space-based measurement characterization and validation.

The primary repositories for data from space-based missions are defined by the individual agency. Relevant archives for O₃ and CO₂ measurements include:

DLR:

- GOME-2/MetOp-A products (<http://atmos.caf.dlr.de/gome2/>)

ESA:

- Ozone_cci (<http://www.esa-cci.org/>)

JAXA/NIES:

- GOSAT (<http://www.gosat.nies.go.jp/eng/gosat/info.htm>)

NASA:

- Goddard Earth Sciences Data and Information Services Center
<http://daac.gsfc.nasa.gov/>
- SBUV merged ozone (http://acd-ext.gsfc.nasa.gov/Data_services/merged/)

NOAA:

- SBUV products (<http://www.star.nesdis.noaa.gov/smcd/spb/ozone/>)

CHARACTERISATION OF THE SPACE SEGMENT CONCERNED

The core missions (current & future) that are currently the priority for coordination efforts by the AC-VC are:

- Metop-A/B (GOME-2);
- Various NOAA POESS (SBUV-2);
- Sentinel-5P (TropOMI);
- Suomi NPP (OMPS);
- OCO-2;
- ISS (SAGE-III);
- GOSAT;
- FY-3 (SBUS).

The above missions relate to total and profile ozone and to greenhouse gas measurements, However, AC-VC activities also include coordination of capabilities of a much broader range of CEOS agency missions and instruments, particularly:

Current: Aura (OMI, MLS, TES), SciSat, Odin, Terra (MOPITT), Aqua (AIRS), Metop-A/B (IASI)

Future: EarthCARE, Sentinel-4, Sentinel-5, GEMS, TEMPO, Metop-C, MERLIN, OCO-2/3, GOSAT-2, TanSat

AC-VC activities also include data being mined from past space-based sensors (e.g., total ozone observations dating from the early 1970s).

ACTIVITIES, OUTCOMES, AND DELIVERABLES

1. **Total ozone data set validation and harmonization:** Total ozone measurements from multiple sensors are being considered by ACC. These include TOMS (NASA, ROSHYDROMET, JAXA), SBUV (NOAA, NASA), GOME and GOME-2 (ESA, EUMETSAT), OMI (NIVR, FMI, NASA), and SCIAMACHY (ESA). Near-term outcomes and deliverables include:
 - a. Common validation protocol for total ozone measurements developed;
 - b. Maintenance of a consistent error characterization of European and US total ozone data sets to be provided to the user community;
 - c. Inclusion of other total ozone data sets (e.g. from China and infrared sensors like IASI) .
2. **Geostationary Air Quality Constellation coordination:** Based on the community-developed white paper (http://ceos.org/images/ACC/AC_Geo_Position_Paper_v4.pdf), ACC is implementing an Air Quality Constellation with the following near-term outcomes:
 - a. Develop a virtual constellation of upcoming geostationary air quality missions using synergies among the instruments to enable standard constellation products.
 - b. Convene an expert group to develop best-practices recommendations for UV-Vis spectrometer pre-launch instrument characterization
 - c. Share pre-launch calibration plans (to the extent allowed by possible proprietary

- d. Share instrument characterization/calibration databases and Level 1-b data, in a common format, to allow application of common algorithms to all datasets
 - e. Develop a list of desired constellation data products
 - f. Strive for consistency in retrieval algorithms
 - g. Cross participation in ATBD reviews
 - h. Jointly improve retrieval algorithms by conducting inter-comparisons on common radiances
 - i. Develop longer term recommendations for possible common post-launch cal/val strategies (e.g. supersite instrumentation round-robins, joint airborne campaigns)
3. **Volcanic Ash Monitoring from Space:** The volcanic eruption notification project uses measurements from European and NASA polar orbiting satellites from multiple instruments capable of observing volcanic emission gases and aerosols, including OMI, GOME-2, AIRS, and IASI. These platforms yield measurements of sulphate and volcanic ash information. The main outcome is increased collaboration among US and EU volcanic ash monitoring programs to include joint workshops (virtual and in-person) and the sharing of best practices for engagement with industry and decision makers. Near-term outcomes include:
- a. Release improved dispersion forecast models (global and regional) including data assimilation, inverse modelling, and ensemble techniques to generate a measure of the uncertainty of the forecast
 - b. Develop an operational demonstration service for volcanic ash (and SO₂) monitoring and forecasting
4. **Greenhouse Gas (GHG) Constellation:** Ongoing activities (ESA CCI Greenhouse Gas (GHG) project, NASA OCO-2 mission preparations, GOSAT project (JAXA, MOE and NIES), TanSat mission preparations) will be supported and co-ordinated by an AC-VC GHG Satellite Constellation. Near-term outcomes include:
- a. Further exploration of SCIAMACHY and GOSAT CH₄ and CO₂ measurements to demonstrate their usefulness for retrieving information about regional sources and sinks and constraining GHG inversion methods (using, e.g. AIRS, IASI)
 - b. Actively tracking progress of GHG satellite missions in development (e.g., OCO-2, GOSAT-2, TanSat, and Merlin) and in planning phase (e.g., Carbonsat).
 - c. Coordination of algorithm development and calibration/validation support, and other activities consistent with the actions recommended in the CEOS Carbon Task Force report, “CEOS Strategy For Carbon Observations from Space.”

AC-VC deliverables	3-year horizon	5-years or more horizon
Space Segment	<ul style="list-style-type: none"> • Greenhouse gas (GHG) constellation in operation • Geostationary Air Quality constellation pre-launch coordination (instrument characterization, common algorithm development) • Volcanic ash constellation operational demonstration 	<ul style="list-style-type: none"> • Geostationary Air Quality Constellation in operation • Limb scattering ozone profile measurement plan and strategy
Ground Segment & Information Systems	<ul style="list-style-type: none"> • Provide coordination and support for the cross calibration and validation of XCO₂ and XCH₄ products 	<ul style="list-style-type: none"> • Develop calibration/validation methodology for Geostationary Air Quality missions.
Products & Services	<ul style="list-style-type: none"> • Multi-sensor volcanic eruption alert system for monitoring and forecasting • Total ozone ECV – validated & harmonized 	<ul style="list-style-type: none"> • Air quality application support • Delivery of GHG measurements to end-user applications (decision support) • Greenhouse gas ECV

IMPLEMENTATION AND COORDINATION ISSUES TO BE ADDRESSED BY SIT

Achievement of the AC-VC objectives requires the following implementation and coordination issues to be addressed by SIT:

1. The necessary CEOS agency participation in harmonized total ozone ECV generation.
2. Sharing of pre-launch calibration plans (to the extent allowed by possible proprietary restrictions) and cross-agency participation in reviews that cover calibration for forthcoming geostationary air quality missions to be implemented in close co-ordination with WGCV Atmospheric Composition Subgroup (ACSG).
3. CEOS agency participation in mission algorithm theoretical basis document (ATBD) reviews.
4. Adoption of AC-VC recommendations for common post-launch calibration/validation strategies (e.g. supersite instrumentation round-robins, joint airborne campaigns)
5. Endorsement of the AC-VC white paper articulating near-term community coordination recommendations for the forthcoming constellation of GHG missions.

SCHEDULE

Activity	Milestone	Target Date
Geostationary Air Quality constellation	Value assessment of air quality observations leveraging recent GCOS and GEO UIC efforts	Sep 2014
Total ozone measurement validation and harmonization	ACC-10 workshop to complete total ozone validation activities and examine progress with harmonization project	Jun 2014
Volcanic Ash Monitoring from Space	Release improved dispersion forecast models (global and regional) including data assimilation, inverse modelling, and ensemble techniques to generate a measure of the uncertainty of the forecast	Dec 2014
	Develop an operational demonstration service for volcanic ash (and SO ₂) monitoring and forecasting	Jun 2015
Greenhouse Gas Constellation	Define near-term ACC objectives for GHG measurement coordination based on recommendations of CTF report	Jun 2014

MEMBERSHIP AND LEADERSHIP

Current Co-Leads are:

- NASA, Richard Eckman (richard.s.eckman@nasa.gov)
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And the following CEOS agencies are actively involved in AC-VC:

- CNES, Carole Deniel (carole.deniel@cnes.fr)
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In addition, researchers in related research agencies (e.g., ECMWF and CNRS) and the academic community frequently participate in ACC meetings and support the constellation's projects.

RESOURCES:

ACC activities leverage funding from relevant agency mission science teams, coordinated ECV generation activities, and competed research opportunities. For the total ozone inter-comparison activity, funds are being leveraged from, inter alia, the ESA Ozone Climate Change Initiative (ozone_cci), the NASA MEaSURES program, and the NASA Ozone Trends Program. The volcanic ash advisory project is leveraging funds from the ESA VAST, SACS2 and SMASH projects and the NASA Applied Sciences Program.