Committee on Earth Observation Satellites (CEOS)
Atmospheric Composition Constellation (ACC)

2007 Work Plan

May 3, 2007

Introduction

The satellite constellation concept consists of a series of projects initiated by CEOS to bring about technical and scientific cooperation and collaboration among space agencies that broadly meets some of the objectives of the international Group on Earth Observations (GEO) as well as CEOS agencies in accordance with their national objectives. The constellation concept promotes a mission (or missions) or data delivery that serves the broader science and applications community. The constellation concept has also been endorsed by the "GEO Work Plan, 2007-2009". The purpose of the constellations is not to develop a new set of requirements but to develop a "virtual" or "ideal" system consisting of space and ground segments including distribution systems meeting endorsed user requirements.

NASA has been selected as the lead CEOS space agency for developing an Atmospheric Composition Constellation (ACC) and has agreed to provide resources for planning and implementation. ACC major discipline themes will focus on observations needed for understanding and improved predictive capabilities for changes in the ozone layer, climate forcing, and air quality. Because of the complexity and breadth of these issues, and that the atmosphere links all nations, this ACC plan recognizes that partnerships are essential for its successful implementation. In order to develop a plan for the ACC and achieve its goals, a study team was assembled in accordance with the CEOS Process Paper consisting of CEOS Agencies with Atmospheric Composition interests and assets and authorized to commit resources. The Study Team also includes a complementary advisory group from the science and applications community to insure requirements and priorities are being adequately considered. The Study Team will define how the ACC can focus its capabilities to support the GEO Societal Benefit Areas (SBA) and the Global Climate Observing System (GCOS) Essential Climate Variables (ECV) as well as support the CEOS Agencies' national priorities.

Consistent with the guidance provided by the CEOS Constellations Process Paper and to aid in the accomplishment of ACC goals and objectives, the ACC team will prepare an annual Work Plan to guide its activities for each year directed toward achieving the Constellation goals. The Work Plan will identify assessments and projects to be accomplished. It is recognized that the definition and commencement of an ACC implementation plan may take several years to accomplish although near term opportunities to achieving SBAs will be emphasized. This ***2007 Work Plan*** is the first annual Work Plan prepared by the ACC team.

ACC Participation

The following Agencies are participating in the ACC: ESA, EC, Eumetsat, JAXA, NIVR, CSA, CNES, NOAA and NASA. Other agencies will be asked to participate at appropriate times. At the present time, the ACC is not asking for Agency formal agreements as they may involve the various bureaucratic hurdles that may hinder rapid response to SBA and GCOS requirements and at the present time the ACC is operating on the Agencies' good faith response and support to CEOS. In addition to the Agency members, the Constellation Study group will include an advisory group representing the broad range of atmospheric science and application users. This group may include permanent members as well as experts who will be supported by the ACC, as needed.

Goals

The ACC Work Plan is driven by the long-term goals (see below) established by the CEOS partners and reviewed and approved by the CEOS Strategic Implementation Team (SIT) in September 2006. Short-term assessments and execution of projects that contribute to GEO SBAs and GCOS objectives and additional long-term initiatives will address the critical atmospheric composition issues facing the world. Cooperation among the international ACC team will contribute to the completion of these tasks and ultimately the accomplishment of tangible societal benefits.

Long-Term Goals

1. Develop a consensus for priorities based on emerging societal benefit areas and established user requirements from both operational and research communities,
2. Determine if there are inconsistencies or deficiencies among the various requirements and reconcile the differences if necessary,
3. Evaluate existing and upcoming missions, both operational and research and compare with requirements established by GEO and GCOS,
4. Define enhancement in the area of calibration / validation, quality control, and data accessibility and interoperability,
5. Establish how existing and approved missions could work synergistically to meet the international user community requirements and in particular the GEO Societal Benefit Areas (SBA).
6. Develop rational and strategy for new mission(s) to meet existing requirements not being met and for possible new requirements. The strategy to include architecture, schedule and possibly costs (depending on how much time and resources are available for developing the "AC Constellation")

These goals will recognize the Constellation member's national plans for implementing their respective Earth observing programs (e.g. the U.S. Decadal Survey and ESA's Living Planet Program). Each goal will consider how SBA and GCOS requirements would be met through multi-agency synergies and development of standards for their participation. The development of standards will be an evolving process since the ACC cuts across various SBA's and varies with users. The development of standards will be considered in a system approach starting with user requirements to the observational parameters. The ACC has at least three types of users which likely have varying standards. These include: (1) Services for operational agencies such as Eumetsat and the U.S. Environmental Protection Agency (EPA) which consider short term data latency and interoperability as the highest priorities with less emphasis on long term archivability and high accuracy (e.g., Air quality forecasting), (2) Assessments which requires a deeper understanding of processes where measurements of high spatial and temporal resolution are the highest priority (tropospheric chemistry and long-range transport processes), and (3) Protocol Monitoring which requires long term accuracy with high precision (e.g. Montreal, Kyoto, etc). Assessment and Protocol Monitoring are the focus for GCOS. For each, definition of standards include; calibration / validation, before and after launch; compatibility of radiative transfer models and retrieval algorithms, spectroscopic databases; spatial and temporal resolution; and data interoperability. Strong collaboration with the CEOS Working Group on Calibration and Validation (WGCV) and the CEOS Working Group on Information Systems and Services (WGISS) is expected to enhance the development of various aspects of these standards.

Requirements

Group on Earth Observations (GEO)

The ACC plans to directly address five of the nine GEO Societal Benefit Areas (SBAs). These SBA's are shown in the table below, including the science focus, measurement parameters, and the 2-year, 6-year, and 10-year plans for each SBA as found in the CEOS Analysis of the Global Earth Observing System of Systems (GEOSS) 10-year Implementation Plan (November 2006). In addition, the ACC efforts are related to 15 tasks from the GEO 2007-2009 Work Plan that are directly linked to the SBAs and 9 other tasks in various categories, including: User engagement (US-07-01: Nowcasting and Forecasting User Applications, US-07-03: Environmental Risk Management), Architecture (AR-07-01: Interoperability Arrangements for GEOSS, AR-07-04: GEOSS Components Commitment), Data management (DA-06-01: GEOSS Data Sharing Principles, DA-07-03: Virtual Constellations, DA-07-05: Higher Level Data Product Tools), and Capacity building (CB-06-04: GEONETCast, CB-07-01: Capacity Building Strategy Implementation).

SBA	Science and Measurements	GEO 2007-2009 Work Plan	GOESS 2-year Plan	GEOSS 6-year Plan	GEOSS 10-year Plan
Disaster	**Fires**: smoke and ash **Seismicity:** volcanic ash aerosols, SO2 **Pollution events:** emissions, mapping	**DI-06-07:** Multi-hazard zonation and maps **DI-06-09:** Use of Satellites for Risk Management **DI-06-13:** Implementation of a Fire Warning System a a Global Level	Strengthening the International Charter on Space and Major Disasters and similar supporting activities. Production of an inventory of hazards zonation maps.	Facilitating real-time monitoring of volcanic activities. Expansion of the production of an inventory of hazards zonation maps.	Hyper-spectral capability for monitoring smoke and pollution plumes.
Climate	**Atmospheric Composition:** CO2, CH4, Trop O3, other GHG, and Aerosol Properties **Long term measurements:** IGOS and GCOS connections	**CL-06-02:** Key Climate Data from Satellite Systems **CL-07-01:** Seamless Weather and Climate Prediction System	Adhere to the GCOS Climate Monitoring Principles and commit to the suite of instrument, supporting research program to support development of observational capabilities for ECV's.	Development and operation of new instruments. Establishment of data archive centers for all ECVs, institutional commitment to provide integrated global analysis of all ECVs, data integration facilities for exchanging data, products and information between climate sectors and socio-economic benefit areas need to be coordinated.	New and extended re-analysis programs for atmospheric domains and implementation of an integrated observing system for atmospheric composition monitoring in support of climate policy through an optimal combination of ground-based networks, LEO and GEO satellites and models are ultimate goals.
Health	**Air Quality:** ozone precursors, particulates, SO2, allergens **Stratospheric:** ozone and UV radiation	**HE-06-03:** Forecast Health Hazards **HE-07-01:** Strengthen Observation and Information Systems for Health **HE-07-02:** Environment and Health Monitoring and Modeling **HE-07-03:** Integrated Atmospheric Pollution Monitoring, Modeling and Forecasting	New, high-resolution Earth observations relevant to health needs are advocated. Facilitating development of products and systems that integrate the Earth science database with health information	Monitoring methods and systems to detect health-related change	Early detection and control of environmental risks to human health through improvements in the sharing and integration of Earth observations, and early warning systems are required.
Energy	**Chemical forecasting:** aerosols, GHGs **Climate statistics:** aerosols, GHGs, radiation	**EN-06-04:** Using New Observation Systems for Energy **EN-07-01:** Management of Energy Sources **EN-07-02:** Energy Environmental Impact Monitoring **EN-07-03:** Energy Policy Planning	New generation of operational observing systems.	An evaluation of the observing system progress and its revision.	Implementation of operational observing systems and provision of timely data in support of energy operations.
Ecosystem	**Carbon fluxes/exchange:** CO, CO2, CH4 **Solar radiation**: UV radiation	**EC-06-01:** Integrated Global Carbon Observation (IGCO) **EC-07-01:** Global Ecosystem Observation and Monitoring Network	Facilitating full implementation of the IGOS-P Carbon (IGCO) Theme report. Facilitating a globally agreed classification scheme.	Implementation of a global nitrogen observing system.	Facilitating globally agreed spatial-resolved information on ecosystem change.

Global Climate Observing System (GCOS)

The ACC recognizes that Climate is a key GEO SBA specifically addressed by the Global Climate Observing System (GCOS). The GCOS Implementation Plan major goals include:

- Characterize the state of the global climate system and its variability;
- Monitor the forcing of the climate system, including both natural and anthropogenic contributions;
- Support the attribution of the causes of climate change;
- Support the prediction of global climate change;
- Project the information provided by global climate models down to regional and national scales;
- Characterize extreme events important in impact assessment and adaptation, and to assess risk and vulnerability.

CEOS has generated a Response to the Global Earth Observation System (GCOS) Implementation Plan (October 2006) and included several specific actions linked to three Essential Climate Variables (ECVs), ozone, aerosols and greenhouse gases (shown below). These ECVs are described in the Systematic Observation Requirements for Satellite-Based Products for Climate (September 2006, GCOS-107) document.

- **Ozone:** Ensure the continuity of ozone measurements (total and profile). Reprocessing to include instrument and orbit biases, improved algorithms, and data gaps. *An integrated data product is supported by the ACC*
  Action A-8: CEOS agencies will participate in re-planning, by 2007, the OMPS limb instrument removed from the planned payload of NPOESS. T*he OMPS limb instrument has been re-manifested for NPP but its deployment on NPOESS is still being negotiated.*
- **Aerosol:** Ensure calibrated space-based aerosol measurements. Aerosol data sets over long term and integrated products by combining various space instruments and the use of data assimilation.
  Action A-9: CEOS agencies will participate in re-planning, by 2007, the APS instrument removed from the planned payload of NPOESS.
- **Greenhouse Gases** (GHG): Ensure continuity of GHG measurements. GHGs from current "research" observations should be enhanced to be consistent with upcoming missions and consider data assimilation for harmonizing data.
  Action A-10: CEOS agencies will participate in planning, by 2011, the operational follow-on to current chemistry missions and those planned for the next 5 to 7 years.

The ACC Work Plan recognizes that GCOS has not addressed requirements for long monitoring of key chemically important atmospheric constituents that contribute to ozone and climate change in the stratosphere. These were highlighted in the IGACO (IGOS theme report of Atmospheric Composition, 2004). For example, it remains important to trace source, radical, and reservoir gases (N_2O, NO_2, ClO, HCl) to understand the impact of climate change and the effects of the Montreal Protocol on ozone trends. Once Envisat, Aura, and SciSat/ACE complete their missions (~2012) these measurements will end. The ACC will pursue flying an ACE on a suitable platform.

In addition recognizing the continuing challenge for improved accuracy and precision for ECV observations with higher spatial and temporal resolution, GCOS strongly recommends deployment of "advanced observations" for Atmospheric Composition using multi-view and multi-spectral systems.

Implementation Plan

Existing Assets

Numerous existing assets and capabilities will be exploited for ACC applications in support of GEO and GCOS (see below). The European Space Agency has agreed to, or is currently formulating, plans with Eumetsat and the EC's GMES program for a broad range Earth observation and applications relevant to Atmospheric composition.

Orbiting Assets, in place, and planned

- ESA's continued operation of Envisat until approximately 2011
- ESA launch of AD-Aeolus and EarthCare
- Pre-Phase A studies of TRAQ, PREMIER, and A-SCOPE
- NASA's continued operation of include Aqua, CALIPSO, Cloudsat, Aura
- NASA launch of GLORY, OCO, and NPP
- JAXA launch of GoSAT
- The US Decadal Survey has recommended three missions related to AC through 2020

Validation, development and support of science and applications, and product validation

- ESA/EC GMES – PROMOTE, etc
- NASA Mission science team support
- NASA Science Applications programs
- NASA Research and Applications Programs
- Multiagency support of CEOS Working Groups for Cal/Val and Information Systems service utilization and product standard development.
- Multi-National development of data sets suitable for Forecasting, Assessments, and Monitoring in support of national and international requirements (IPCC, Protocols, etc)

Assessments

At the present time seven space agencies each have multiple assets in orbit for conducting AC observations serving both the research and application/operational communities. Early in the next decade research missions will end where some requirements will be taken on by operational systems. At the present time there is no assurance that "research grade" data needed for assessments and protocol monitoring will be in place. In order to ascertain and document this gap, user and capability assessments will be conducted by the ACC study team taking into account national notional studies and recommendations, e.g., U.S. National Academy of Sciences (NAS) Earth Science Decadal Study and ESA and NASA mission concept studies.

(1) Develop ACC systems requirements and standards. Include a consensus for priorities based on emerging societal benefit areas and established user requirements from both operational and research communities. The requirements and standards will address: end-user (policy, decisions, SBA, applications, forecasting, trending), data-user (calibration/validation, accessibility, interoperability, compatibility), science (focus areas, constituents), measurement (instrument, technology, calibration/validation), and mission (LEO, GEO, spatial, temporal) requirements. A draft format and preliminary content will be completed by June 2007 for the CEOS SIT-20 meeting. A further refined

draft will be completed by November 2007 for the CEOS Plenary.

(2) Preliminary assessment and gap analysis of the existing and near-term planned ACC missions against the systems requirements. These analyses will include: end-user, data-user, science, measurement and mission parameters, as noted above. A draft of this analysis is planned by November 2007 for the CEOS Plenary.

Projects

At the first ACC Workshop (ACC-1) several projects were considered that would support the user communities, as well as the GEO SBA and GCOS objectives. The projects are under development at the present time with the guidance that, data products are substantially enhanced (using multiple platforms is highly encouraged) through higher level of standards (calibration/validation,, interoperability, etc.) and include a component for outreach and capacity building, which are major GEO goals. Each of these projects will be considered with anticipation that at least one will be formally planned for presentation and demonstration at the CEOS Plenary in November 2007.

(1) Develop a high quality enhanced global tropospheric ozone product using two methods which can be compared with each other: (a) Total column ozone from a nadir UV sensor (TOMS, GOME, SCIAMACHY, OMI, GOME-2) minus stratospheric column ozone from a limb sensor (SAGE, SCIAMACHY, MIPAS, MLS) and (b) Assimilation/ joint retrieval of radiances measured by nadir UV sensors (OMI, GOME, SCIAMACHY) and nadir IR sensors (AIRS, TES, IASI).
GEO Work Plan: HE-07-03

(2) Conduct an air quality study from multiple international missions: ENVISAT/METOP (am orbits) and Aura/Aqua/Parasol (pm orbits). These missions provide twice-daily coverage for reflected sensors and 4 times daily coverage for IR sensors which can provide diurnal variation of tropospheric species. In addition, CALIPSO/CLOUDSAT provides a 3-D view of clouds and aerosols to help in the interpretation of air quality data (boundary layer height and transport). Utilize NO2 from SCIAMACHY and OMI to demonstrate this capability.
GEO Work Plan: HE-07-03

(3) Assemble an array of atmospheric composition products being developed by CEOS agencies for near real time distribution. The products will be relevant to GEO SBAs and meet the following criteria; Availability, Quality and Functionality. A user workshop will be assembled to define data enhancements and distribution.
GEO Work Plan: DA-06-01, CB-07-01

(4) Develop a global data product for fires and aerosols. This project will make use of the IDEA (Infusion of Satellite Data for Environmental Applications) project which is now operational. Extending the capability of developing fire, aerosol, and subsequent forecast guidance products for global operational purposes can use the IDEA prototypes and apply them to instruments multiple platforms.
GEO Work Plan: HE-07-03, DI-06-13

(5) Develop a long-term aerosol data set. This project will employ many international satellites where aerosol properties are measured in different ways with some overlap. These data will be valuable assets for climate modeling, pollution inventories and monitoring. Ground based observations will play a key role in validation and providing additional aerosol parameters.
GEO Work Plan: CL-06-02, EN-07-02

Long-term Plans

- Define enhancements in calibration/validation, quality control, and data access and interoperability that would increase the benefit of existing and future ACC missions.
- Develop future architecture options for an ACC that satisfy the approved and prioritized requirements. Work with international end-users and mission implementation organizations to facilitate the planning and implementation of these options. Careful consideration must be given to cost, schedule, technology, data systems, calibration / validation, and user benefits.
- Conduct campaign analyses to assess the impact of cost, technology readiness, launch delays, loss of missions, or other variables on the ACC architecture options.

Schedule

The following schedule outlines the milestones for the ACC Work Plan and is tuned to major CEOS and GEO events. The Work Plan will be reviewed and updated at regular meetings of the ACC Study Team. These meetings, held about every six months, will provide a forum to review progress of the Assessments and Projects outlined in this Plan. The meetings will also provide the venue for Agency reports and communication with the CEOS-SIT and international entities relevant to ACC (e.g. GCOS, IGACO and WMO).