CEOS Virtual Constellations:
Atmospheric Composition

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UN Symposium on Space Tools and Solutions for Monitoring the Atmosphere in Support of Sustainable Development

11-14 September 2007

Institute for Space Research
Graz, Austria

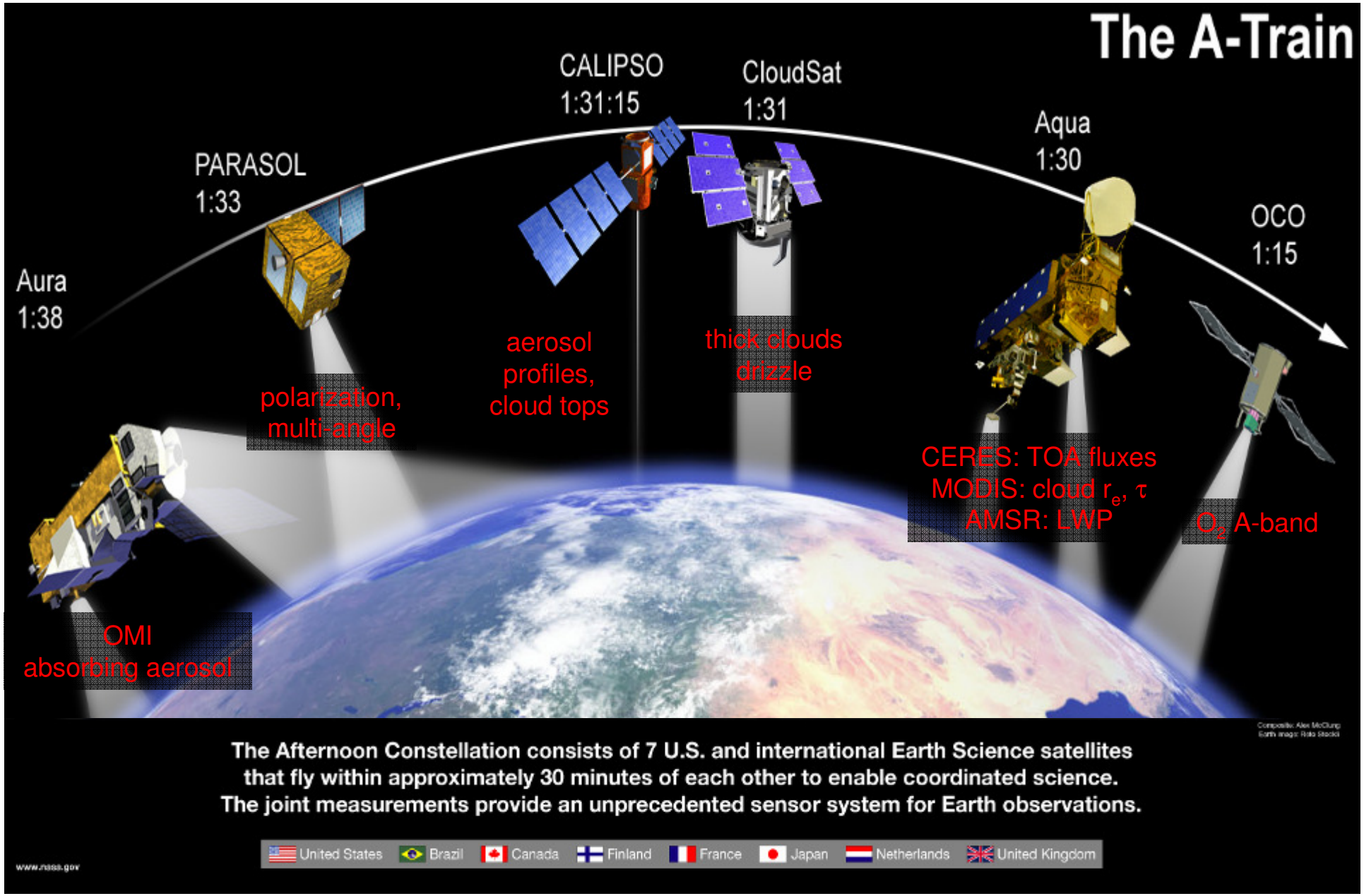
CEOS Virtual Constellations

Four “Virtual” Constellations

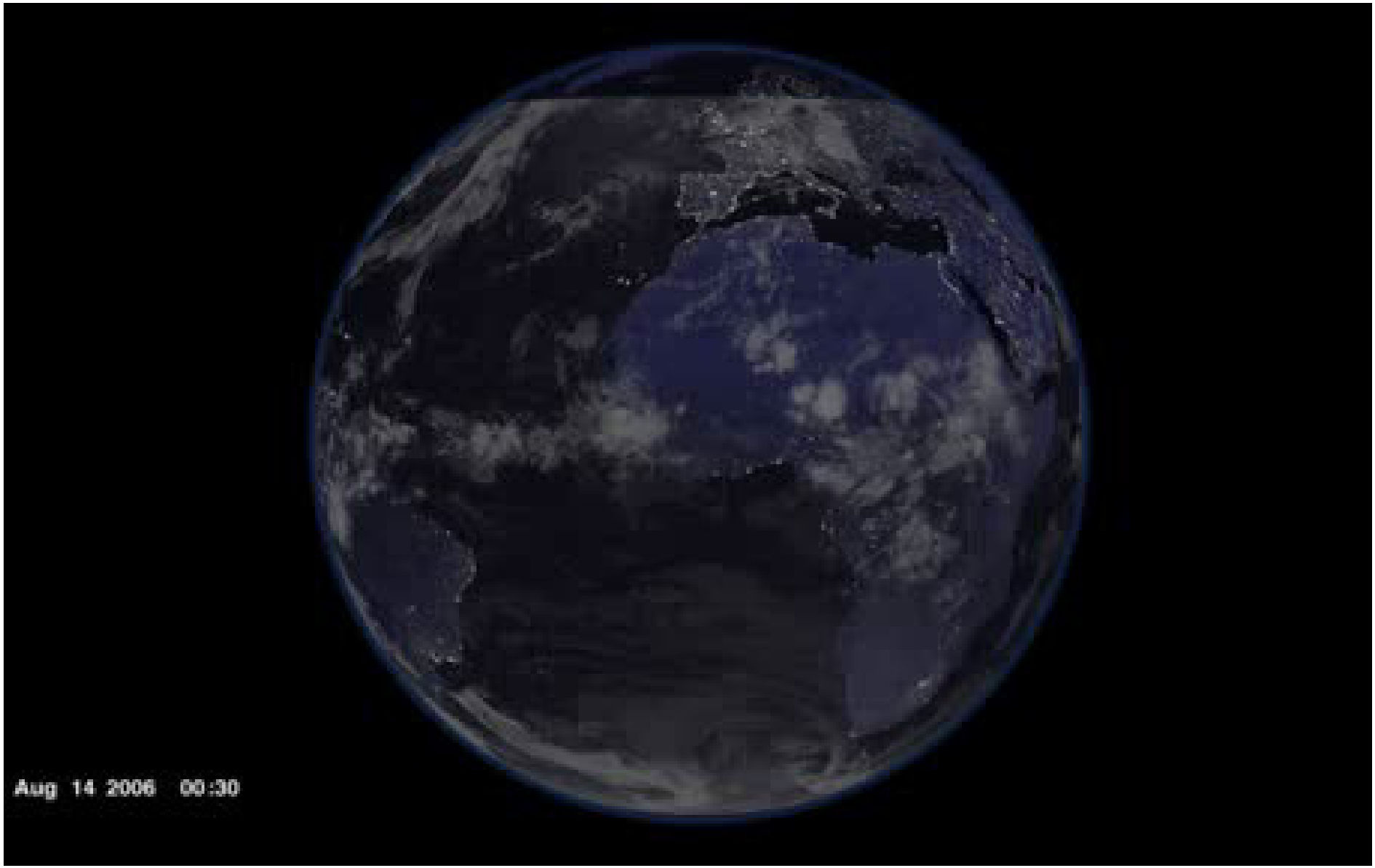
- Land Surface Characterization (Leads: USGS & ISRO)
- Precipitation (Leads: JAXA & NASA)
- Ocean Surface Topography (Leads: NOAA & EUMETSAT)
- Atmospheric Composition (Leads: NASA & ESA)

The Atmospheric Composition Constellation is a ‘pathfinder’ for the other constellations.

"A-Train" Satellite Systems



A-Train Constellation



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The Atmospheric Composition Constellation is a ‘pathfinder’ for the other constellations.

CEOS Virtual Constellations

- Four pilot projects to bring about technical/scientific cooperation and collaboration among space agencies that meet GEO objectives and also support national priorities

- Constellations will identify missions or data delivery that serve the science and applications communities that can be advocated by the CEOS agencies

- Constellation studies will prioritize user requirements and define missions or a "virtual" system consisting of space and ground segments to include archives and data distribution systems that meet science and application user requirements
  - *The AC Constellation considers only the space component of atmospheric composition science and applications, but recognizes the need for complimentary ground based measurements and modeling to fully address science and application priorities*

CEOS Virtual Constellations - Outline

- CEOS Virtual Constellations
  - Goals and benefits
  - Traceability to requirements
- Atmospheric Composition Constellation (ACC)
  - Participants and assets
  - Science and societal benefits
  - Links to GEO Tasks
- Workplan
  - Status & Milestones

AC Constellation: Participants

- The developing NASA Science Plan recognizes that partnerships are essential, "...because of the complexity and breadth of these issues and that the atmosphere links all nations".
- US National Academy of Sciences Decadal Survey recommended: "…leverage international efforts, ..teaming...missions…data access"
- Participants have major assets for AC missions
  - USA: NASA ..... *Lead*
  - ESA..... *Co-lead*
  - USA: NOAA ..... *Paticipant*
  - Netherlands: NIVR..... *Participant*
  - Canada: CSA, MSC..... *Participant*
  - France: CNES..... *Participant*
  - EUMETSAT..... *Participant*
  - EU/GMES..... *Participant*
  - Japan: JAXA..... *Participant*
  - China: NSMC, CSSAR, CAST..... *Contacted*

Canadian Space Agency | Agence spatiale canadienne

NIVR

cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

esa

JAXA

EUMETSAT

NOAA

NASA

ACC – Requirements and Goals

- Requirements for Atmospheric Composition measurements have been developed by national and international agencies and panels
  - IGOS/IGACO, US Decadal Survey, CAPACITY, GMES, GAW, NASA Science Plan, ESA Living Planet, etc
  - Consistent with GEO SBA's and GEOSS

- Requirements are mature and are supported by CEOS agencies by ongoing and planed mission and definition studies.

- The AC Constellation goal is to collect and deliver data to develop and improve predictive capabilities for coupled changes in the *ozone layer, air quality, and climate forcing* associated with changes in the environment.

- Three specific users types:
  - Forecast services: National weather and environmental protection agencies
  - Assessments: IPCC, Montreal Protocol, USCCSP
  - Monitoring: Montreal and Kyoto Protocols, IPCC, GCOS, CCSP, PROMOTE (GMES)

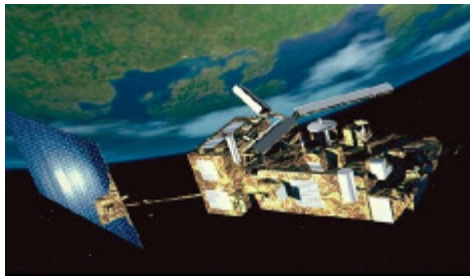
Atmospheric Composition: Space Capabilities

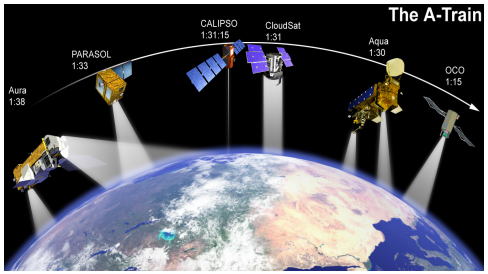
- Existing: Aura, Envisat, ACE, ODIN, CALIPSO, Cloudsat, Terra/MOPITT/CERES, Aqua/AIRS/CERES, POESS/SBUV-2, POLDER, Metop/GOME-2/IASI

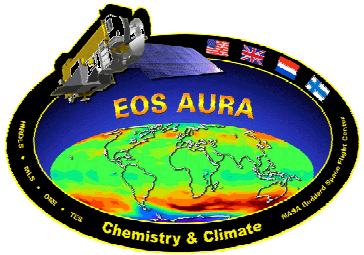
- Upcoming approved: OCO, GLORY, NPP/NPOESS (aerosol and ozone, no chemistry), EarthCARE, ADM-Aeolus, GOSAT, FY-3/SBUS-TOU, SWIFT

- ESA EE Pre-Phase A: TRAQ (AQ), PREMIER (UT/LS), A-SCOPE (CO_2)

- Under Consideration: High resolution multispectral nadir and limb imagers in coordinated orbits: GMES and US Decadal Survey missions, NASA Mission Concepts for LEO & GEO



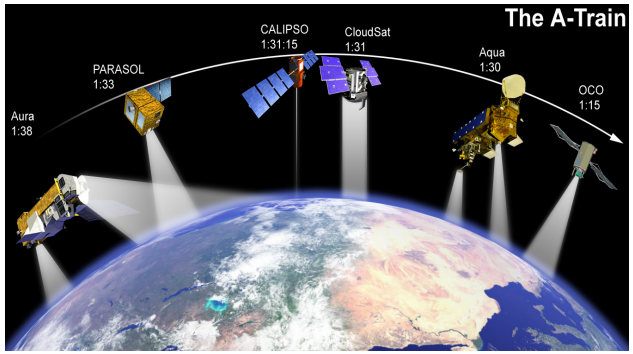




ACC Constellation Synergy

Unique opportunity for conducting AC science and providing Societal Benefits using multiple instruments across international platforms

- Collaboration efficiency: take advantage of each instrument's unique capability
- Cross instrument validation
- Improved spatial and temporal coverage: e.g. different equator crossing times
- Enhanced data products: e.g. aerosol and cloud characteristics, pollution and its transport for assessments and forecasting
- More accurate trends by comparing and combining data sets

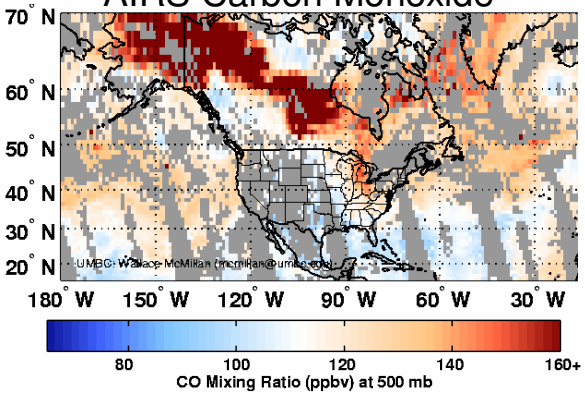


A-train is a good example of Constellation Science

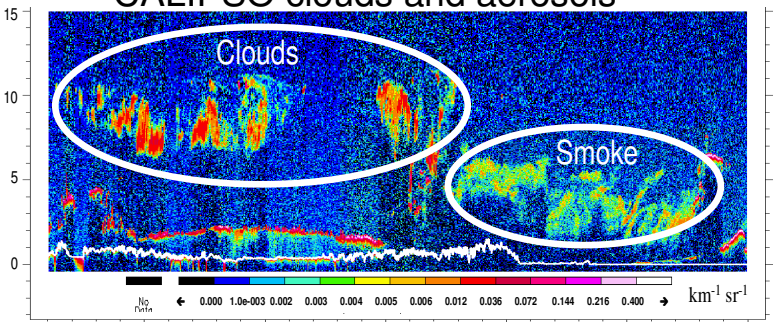
CEOS provides an opportunity to extend collaboration internationally

Example:
Geographic extent of CO from biomass burning in combination with vertical distribution of smoke improves assessment of total emissions and downstream impacts

AIRS Carbon Monoxide



CALIPSO clouds and aerosols



ACC Traceability to Five GEO SBAs

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.

AC Constellation Implementation

- Establish a framework for long term coordination among the CEOS agencies where the “Constellation” concept will identify specific opportunities for meeting science and application requirements
- Assemble international Study Team consisting of CEOS Agencies with Atmospheric Composition interests and assets and authorized to commit resources
- Complimentary advisory group from science and application community to insure requirements are being considered. Participate in establishing priorities
  - Develop a consensus for priorities based on and established user requirements and emerging societal needs from both operational and research communities
  - Evaluate existing and upcoming missions, both operational and research and compare with requirements
  - Establish how existing and approved missions could work synergistically to meet the international user community requirements and in particular the GEO Societal Benefit Areas
  - Define enhancement in the area of cal/val, quality control, and data accessibility and interoperability, major rolls for *WGISS and WGCV (ACSG and GEO/CEOS Cal/Val WS)*
  - Develop rationale, strategy and standards for new mission(s) to meet requirements not being met and for possible new requirements. *Strategy to include architecture, schedule, and possibly costs*

ACC Implementation - Status

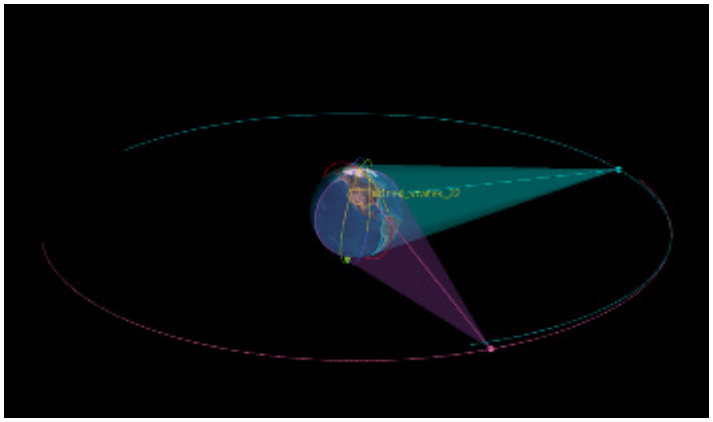
- First ACC Workshop (March 2007 in Washington)
  - Agree on the AC Constellation concept and its objectives
  - Agreement of space agencies and users to participate
  - Agree on goals and projects (CEOS definitions parallel GEOSS):
    - Near term: Available today or very soon
      Concentrate on refinement, use, access to and distribution of existing data products - *combined and synergistic data set*
    - Medium-term: Feasible within a few years
      Extends product specification and interoperability - *improved data product. Also define new mission architecture leading to a Constellation*
    - Long-term: Achievable within ~10 years
    - AC Constellation proposed project and demonstration in time for GEO Summit

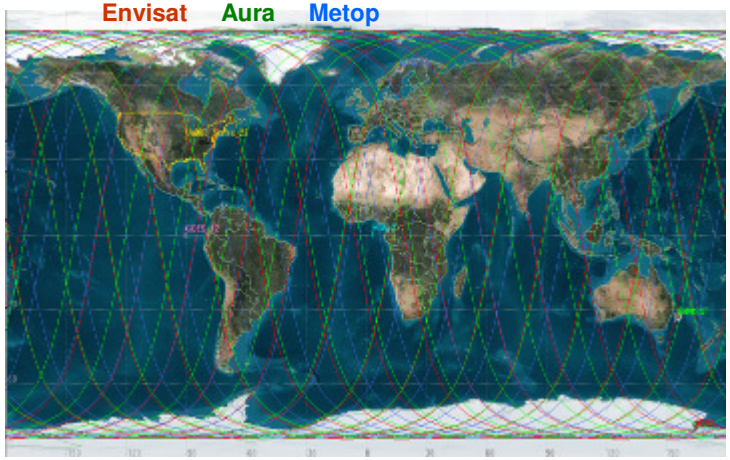
- ACC Work Plan (2nd Draft in Review by Study Team):
  - Objectives (in terms of GEO SBA's and GCOS)
  - Participants -- Space assets
  - Assessments -- Projects

- Next ACC Workshop – September 12-13, 2007 in Europe

Work Plan - Assessments

- Prepare an ACC system priorities and requirements report to include "standards" (RT/algorithm, end-to-end cal/val, data interoperability), resulting in "virtual" or real mission requirements including architecture:
  Draft by November 2007 CEOS Plenary
- Preliminary assessment and gap analysis report of existing and near-term planned AC missions by CEOS agencies against user requirements (Forecasting, Scientific assessment and Climate monitoring):
  Draft by November 2007 CEOS Plenary
- NASA's AC Program is supporting four studies (OSSE) to investigate AQ current capabilities and assess future measurement requirements and mission design: *Status report for CEOS Plenary*

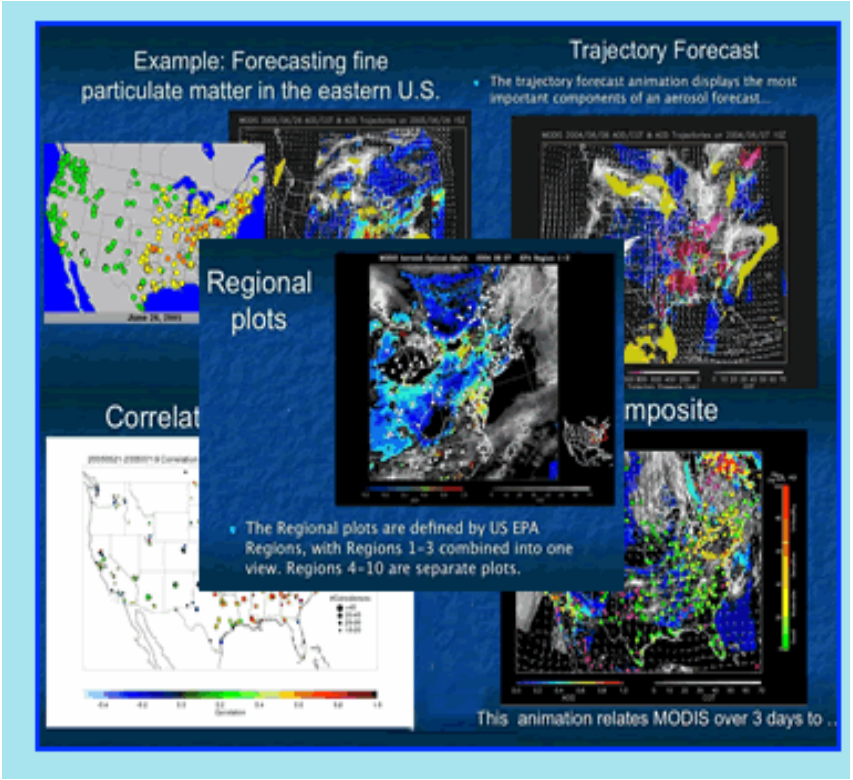




Work Plan - Near Term Projects

- Short term ACC projects have been selected emphasizing synergistic and enhanced data products from multiple missions and include a component for outreach and capacity building
- Demonstration and implementation plan for CEOS Plenary and GEO Summit

1. Air-Quality from multiple instruments for improved forecast and assessments. Envisat/Metop are in morning orbits, Aura/Aqua/Parasol/CALIPSO/Cloudsat are in afternoon orbits provide diurnal variation of tropospheric species and 3-D view .clouds and aerosols tointerpre AQ data (BL height, transport).
2. Aviation alert and control for volcanic eruptions. ESA and NASA support development of SO2 and ash products from Envisat and Aura which cover the Pacific Rim and Europe and Africa for distribution to VAACS through the meteorological service to the ICAO. CEOS proposes to support combined services resulting in more timely data and global coverage.
3. Global fire and aerosol data products for forecasts and assessment. Use the IDEA (Infusion of Satellite Data for Environmental Applications) project which is now operational http://idea.ssec.wisc.edu/). Extending the capability of developing fire, aerosol, and subsequent forecast products for global operational purposes



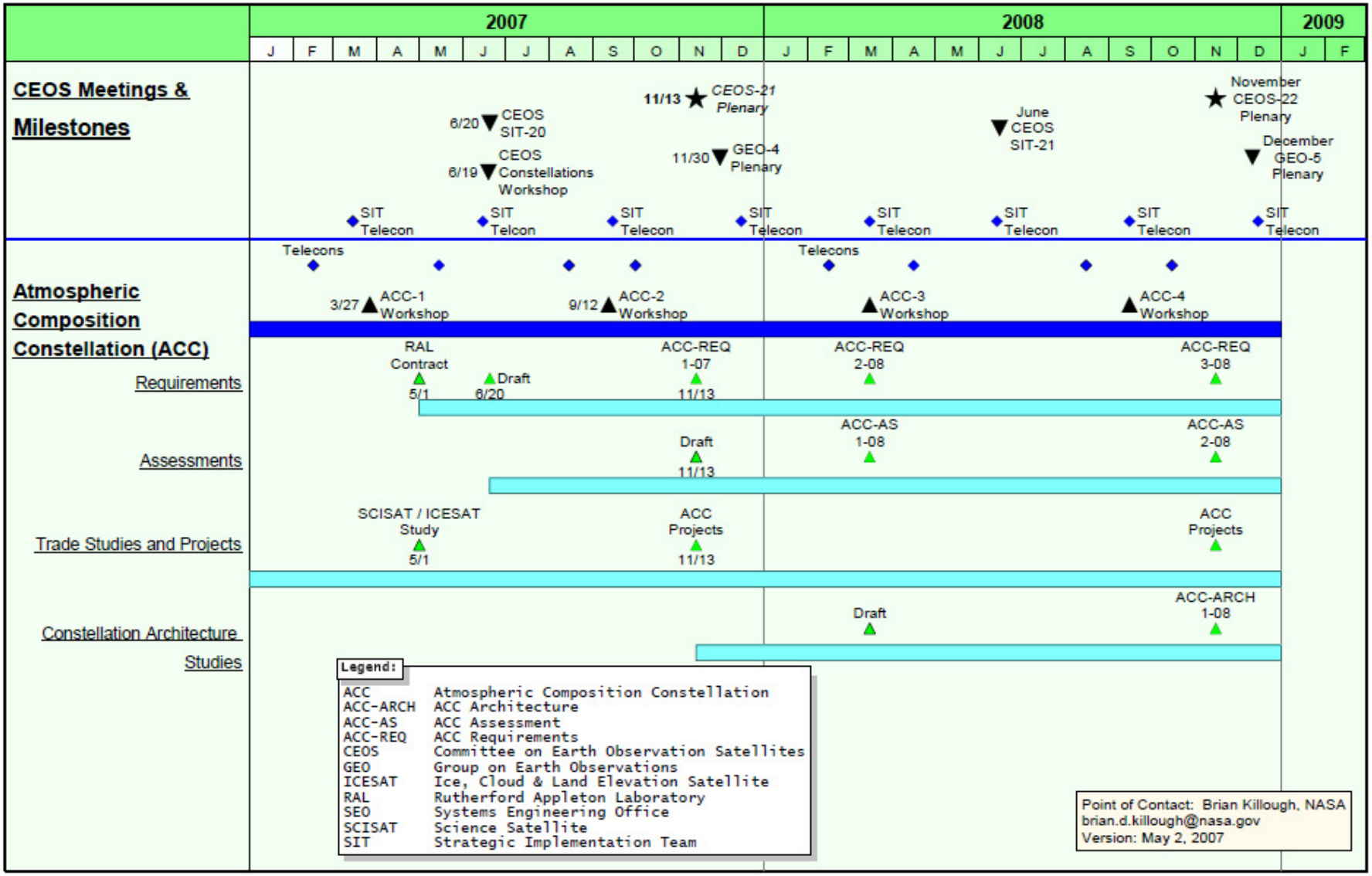
Work Plan – Mid-Term Projects

1. High-quality tropospheric ozone products using two methods to be compared with each other. Total column ozone from TOMS, GOME, SCIAMACHY, OMI, GOME-2 minus stratospheric column ozone from SAGE, SCIAMACHY, MIPAS, MLS. Assimilation/ joint retrieval of radiances measured by nadir UV sensors and nadir IR sensors (AIRS, TES, IASI). *GCOS Requirement*

2. Long-term aerosol data set. This project will employ several international satellites where aerosol properties are measured in different ways with some overlap. These data will be of value assets for climate modeling, pollution inventories, and monitoring. Ground based observations will play a key role in validation and providing additional aerosol parameter. *GCOS Requirement*

3. Assemble and array of AC products being developed CEOS agencies for near real time distribution. The products will 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 Goal*

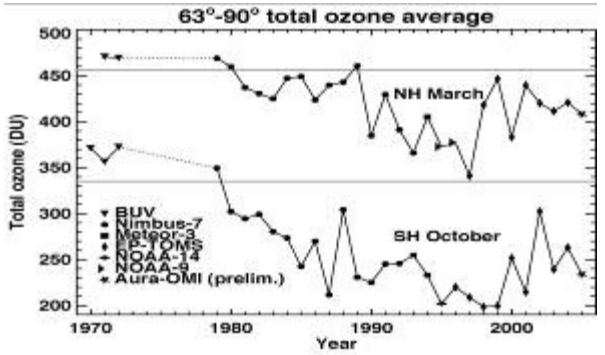
Work Plan - Milestones and Schedule

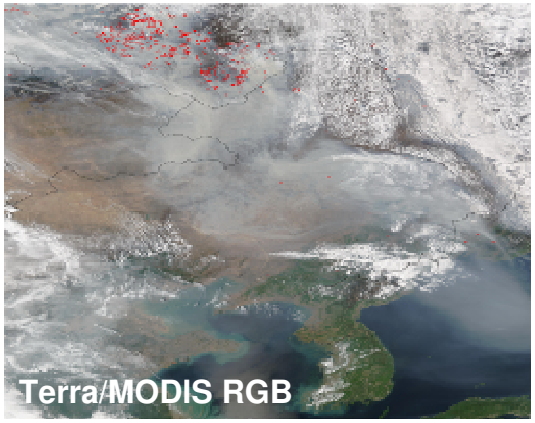


AC Constellation – Science Questions

- **How is stratospheric ozone responding to the Montreal protocol and what are the effects of climate change on expected ozone recovery?**
- **What are the impacts of long range transport of pollution on local and regional air-quality? How do changes in air quality effect ecosystems?**
- **How do changes in atmospheric composition (radiatively active gases and aerosols) affect climate? How does climate change affect atmospheric composition?**

"***Observations have clearly shown that human activities are changing the composition of the Earths atmosphere. Research has demonstrated that there are important consequences of such changes for climate, human health, and the balance of ecosystems..*** **", IGOS/IGACO, 2004**





CEOS Atmospheric Composition Constellation

Back-up Slides

GCOS Priorities for AC

- **GCOS (http://www.wmo.ch/web/gcos/gcoshome.html) has established a set of requirement for Global Climate Observations endorsed by WMO, UNEP, ICSU and the space agencies.**
- **GCOS data requirements can be mapped into the AC Constellation (encouraging international collaboration)**

Essential Climate Variable	Characteristic	Action required
Ozone mapping	Profiles, columns	– Reprocessing to remove biases and gaps, improved algorithms, integrated product – Employ Data Assimilation for data homogeneity and integration – Research observations enhanced and standardized for upcoming operational missions
Aerosol characteristics	Profiles, columns	
Water vapor content	Profiles, columns	
Cloud characteristics	Profiles	

- **GCOS specifically recommends deployment of "advanced observations" for Atmospheric Composition using multi-view and multi-spectral systems**