

The CEOS Atmospheric Composition Constellation (ACC)

*An Example of an Integrated
Earth Observing System for GEOSS*

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What are the Drivers from the Atmospheric Composition Perspective?

- May 2003: Earth Summit

“Improved coordination of strategies and systems for observations of the Earth and identification of measures to minimize data gaps, with a view to moving toward a comprehensive, coordinated, and sustained Earth observation system or systems”

IGOS already established to provide guidance for measurement strategy

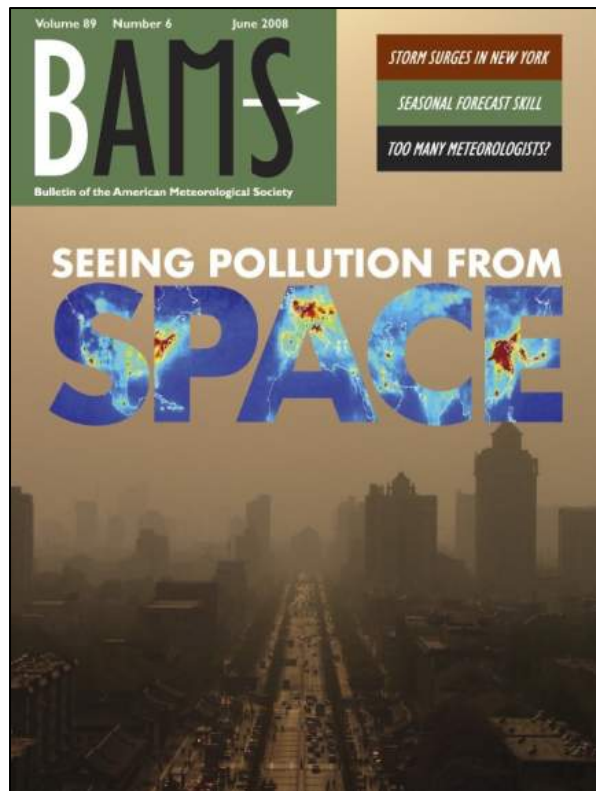
- September 2004: IGACO Report

Satellite instrumentation should be from a combination of GEO and LEO satellites to provide measurements with the temporal and spatial resolution for sufficient coverage.

- February 2006: Air Quality Workshop in Boulder, Colorado
- January 2007: NRC Decadal Survey

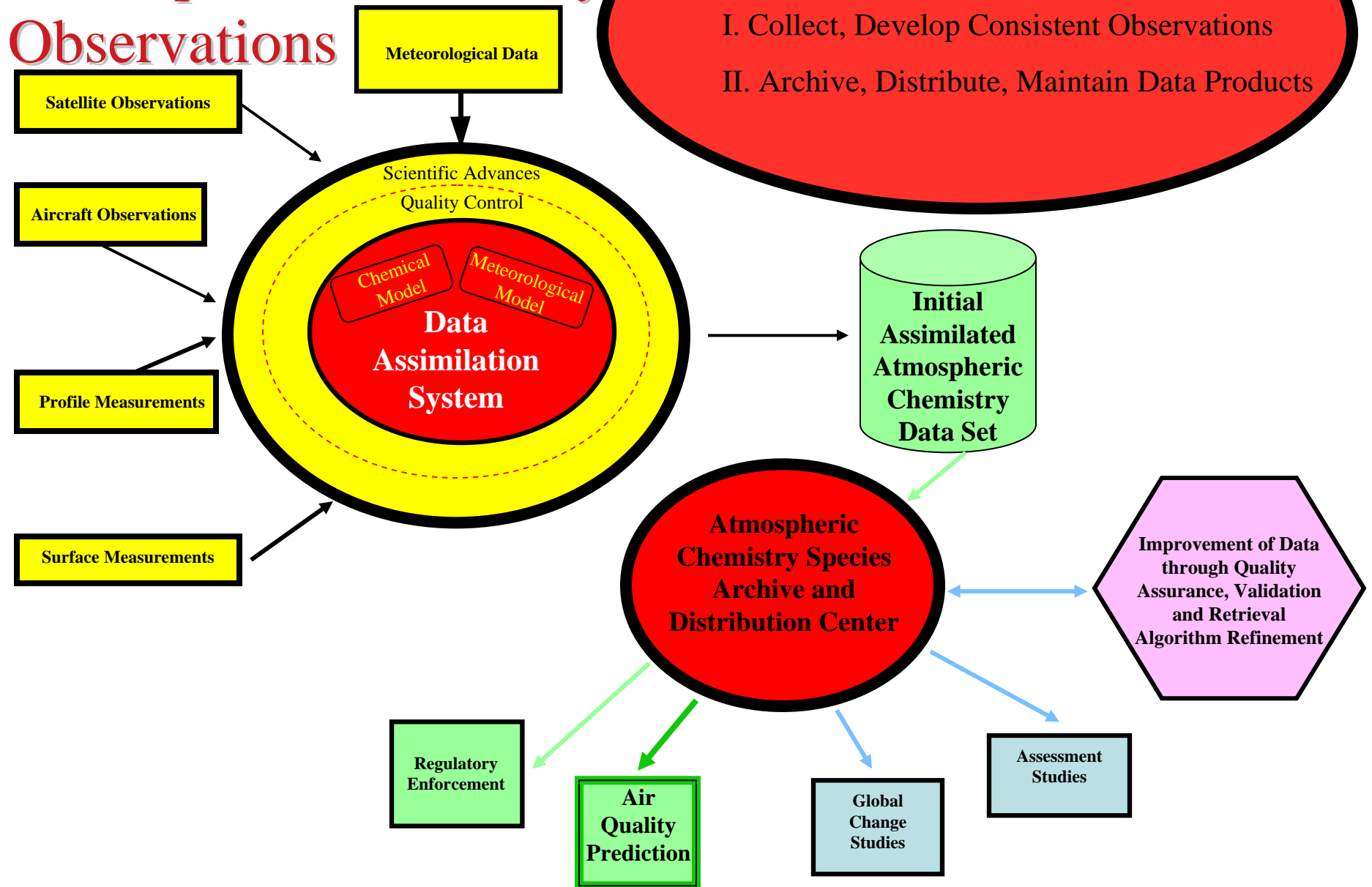
The Theme in the 21st Century is that Satellite Observations Should Provide “Societal Benefits”

The IGOS/IGACO “Grand Challenge”



- Develop satellite instrumentation to provide measurements with sufficient temporal and spatial resolution to understand the globalisation of tropospheric pollution
- Develop a comprehensive data modelling system capable of combining data for the chemical and aerosol species with meteorological and other ancillary parameters
- Assimilation techniques for chemical species currently in the demonstration phase need to be developed into operational procedures

Integrated Global Atmospheric Chemistry Observations



Future Satellite Measurements Must Be Relevant to Societal Benefits

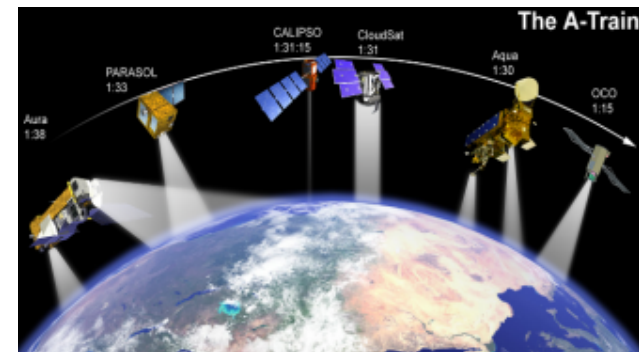
- **Ground Rules for Satellite Development are Different**

- Making measurements only for science is not acceptable
- Planning should involve users of measurements (i.e., other agencies)
- Satellite measurements should be a component of integrated systems
 - Integrated with other satellites (CEOS)
 - Integrated with other observing networks (GEOSS)

- Establish a framework for long term coordination among the CEOS agencies where the “Constellation” will identify specific opportunities for meeting science and application requirements
- Collect and deliver data to improve predictive capabilities for coupled changes in the *Ozone Layer, Air Quality, and Climate Forcing* associated with changes in the environment.
- Objectives meet participating Agency priorities and are aligned to the GEO SBA’s
- Objectives will be achieved through the following steps:
 - Develop a Requirements and Gap Analysis based on in-orbit and up-coming missions collecting AC data
 - Demonstrate how Constellation data can add value to data products serving the GEO SBA’s through Projects
 - Develop rationale, strategy, and standards for collaboration to meet requirements not being met and remain open for possible new requirements.

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

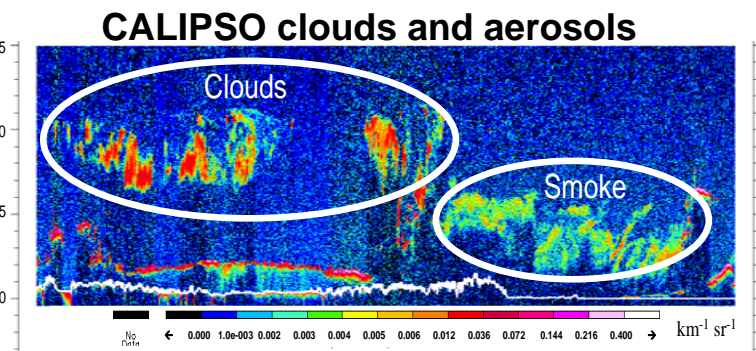
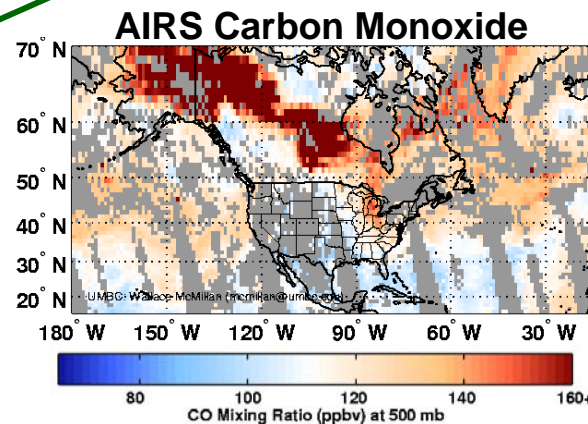
- Collaboration efficiency: take advantage of each instrument's unique capability
- Cross instrument validation
- Improved spatial and temporal coverage: e.g. different equator crossing times
- Enhanced data products: e.g. aerosol and cloud characteristics, pollution and its transport for assessments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



- ACC initiated four near term projects to demonstrate the Constellation concept. Projects involve its international partners using seven different instruments. Projects were selected for near term results and aligned with the GEO SBAs
- Projects are showing added value using constellation data over data used separately. Now in their implementation phases
 - *Pollution prediction using Envisat and Aura: Health/Air Quality (NOAA lead)*
 - *Aircraft volcanic ash warning using Envisat and Aura: Hazards (ESA lead)*
 - *Smoke prediction from biomass burning using Aura, Aqua, CALIPSO: Hazard and Health (NASA lead)*
 - *Algorithm and cal/val collaboration between GoSAT (JAXA) and OCO (NASA): Climate*
- *Requirements and Gap Analysis* is underway and draft report is expected in June 2008, Cross-cutting
- Longer term projects will engage more satellites and international partners *focused toward GCOS Climate objectives*. Planning with **CSA, JAXA, ESA, and EC** Climate

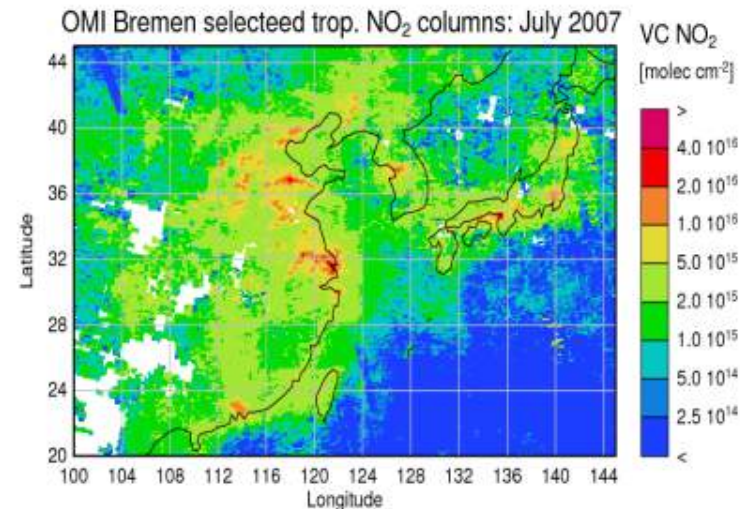
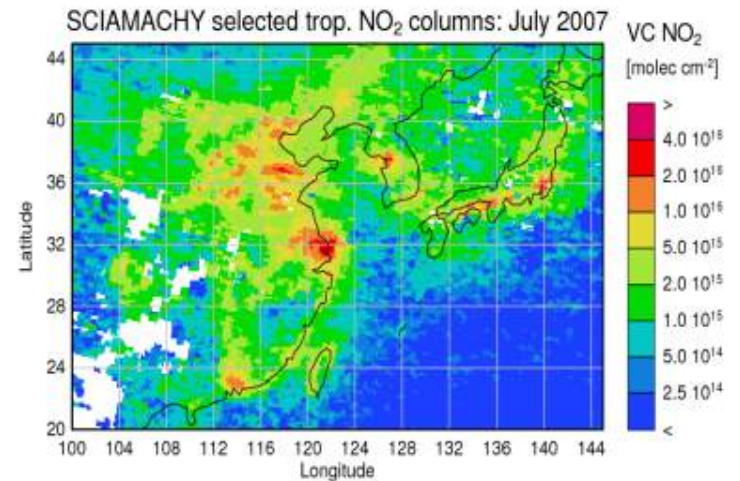
- **Objective**
 - Survey the requirements for AC measurements over the next two decades
 - Summarize capabilities of existing and planned missions
 - Identify mission gaps
- **Status - Collated Requirements**
 - US NRC Decadal Survey 2007
 - GMES, ESA and EUMETSAT (IGACO and CAPACITY reports, post-EPoS, MTG and Sentinel 4 & 5 MRDs)
 - GCOS ECVs
- **Final Report – Draft June 2008**
 - Mission summaries and AC instrument capabilities
 - Gap assessment in capabilities and time domain
 - Recommendation to CEOS (Agencies): *September 2008*

| Programme | Source | Requirement Type | Height Domain | Horizontal | Vertical | Sampling Interval / Revolt Time | Accuracy | Coverage | Stability |
|-------------------------------|-------------------------------|-----------------------------------|---------------|-----------------|-----------------|---------------------------------|----------|-------------------|-----------|
| | | | | Resolution (km) | Resolution (km) | | | | |
| GMES | Sentinel 4/5 MRD | Ozone layer - Protocol Monitoring | Total Column | 50/100 | | 24/24/3 | 3% | global | |
| | | Ozone layer - MRT Data | UT | 20/100 | 0.5/2 | 6/24/3 | 20% | global | |
| | | | LS | 50/100 | 0.5/2 | 6/24/3 | 20% | | |
| | | | MS | 100/200 | 2/3 | 6/24/3 | 20% | | |
| | | | US-MI | 100/200 | 3/5 | 12/24/7 | 20% | | |
| | | | Trop Col | 10/50 | | 6/24/3 | 20% | | |
| | | | Total Column | 50/100 | | 6/24/3 | 5% | | |
| | | Ozone layer - Assessment | UT | 20/100 | 1/3 | 6/24/3 | 20% | global | |
| | | | LS | 50/100 | 1/3 | 6/24/3 | 10% | | |
| | | | MS | 100/200 | 2/3 | 6/24/3 | 20% | | |
| | | | US-MI | 100/200 | 3/5 | 6/24/7 | 20% | | |
| | | | Trop Col | 10/50 | | 6/24/3 | 20% | | |
| | | | Total Column | 50/100 | | 6/24/3 | 10% | | |
| | | Air Quality - Protocol Monitoring | PBL | 5/20 | | 0.5/2 | 10% | global & regional | |
| | | | FT | 5/50 | 1/3 | 0.5/2 | 20% | | |
| | | | Trop Col | 5/20 | | 0.5/2 | 25% | | |
| | | | Total Column | 50/100 | | 24/24/3 | 3% | | |
| | | Air Quality - MRT Data | PBL | 5/20 | | 0.5/2 | 10% | global & regional | |
| | | | FT | 5/50 | 1/3 | 0.5/2 | 20% | | |
| | | | Trop Col | 5/20 | | 0.5/2 | 25% | | |
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| | Trop Col | 5/20 | | 0.5/2 | 25% | | | | |
| | Total Column | 5/20 | | 0.5/2 | 3% | | | | |
| Climate - Protocol Monitoring | Troposphere | 10/50 | 2/5 | 12/24/3 | 20% | global | | | |
| | Trop Col | 10/50 | | 12/24/3 | 25% | | | | |
| | Total Column | 50/100 | | 24/24/3 | 3% | | | | |
| Climate - MRT Data | PBL | 5/50 | – | 6/24 | 30% | global | | | |
| | Trop Col | 10/50 | – | 6/24/3 | 25% | | | | |
| | LS | 50/100 | 0.5/2 | 6/24/3 | 10% | | | | |
| | MS | 50/200 | 1/3 | 6/24/7 | 20% | | | | |
| | US-MI | 50/200 | 3/5 | 6/24/7 | 20% | | | | |
| | Total Column | 50/100 | – | 6/24/3 | 5% | | | | |
| Climate - Assessment | Troposphere | 10/50 | 1/3 | 6/24/3 | 30% | global | | | |
| | Trop Col | 10/50 | – | 6/24/3 | 25% | | | | |
| | UT | 20/100 | 0.5/2 | 6/24/3 | 20% | | | | |
| | LS | 50/100 | 0.5/2 | 6/24/3 | 20% | | | | |
| | MS | 50/100 | 2/3 | 6/24/3 | 20% | | | | |
| | US-MI | 100/200 | 3/5 | 6/24/7 | 20% | | | | |
| | Total Column | 50/100 | – | 6/24/3 | 3% | | | | |
| NASA | US Decadal Survey | Health - Ozone & Surface UV | Stratosphere | 5 | 2-3 | | | global | |
| | | | Troposphere | 5 | 2 | | | | |
| | | Health - Air Pollution | Trop ac-PBL | 10 | 1 | hours-days | | regional & global | |
| | | Chemical Weather - Air Pollution | Trop Col | 5 | | hourly | | regional <500km | |
| | Chemical Weather - Trop Ozone | Troposphere | | 2 | | | global | | |
| GCOS | GCOS Satellite Requirements | ECV Ozone | Troposphere | 5-50 | 0.5 | 3hr | 10% | 1% | |
| | | | Stratosphere | 50-100 | 0.5-3 | 3hr | 5% | 0.0% | |

NO₂ is precursor to ozone and an EPA criteria pollutant

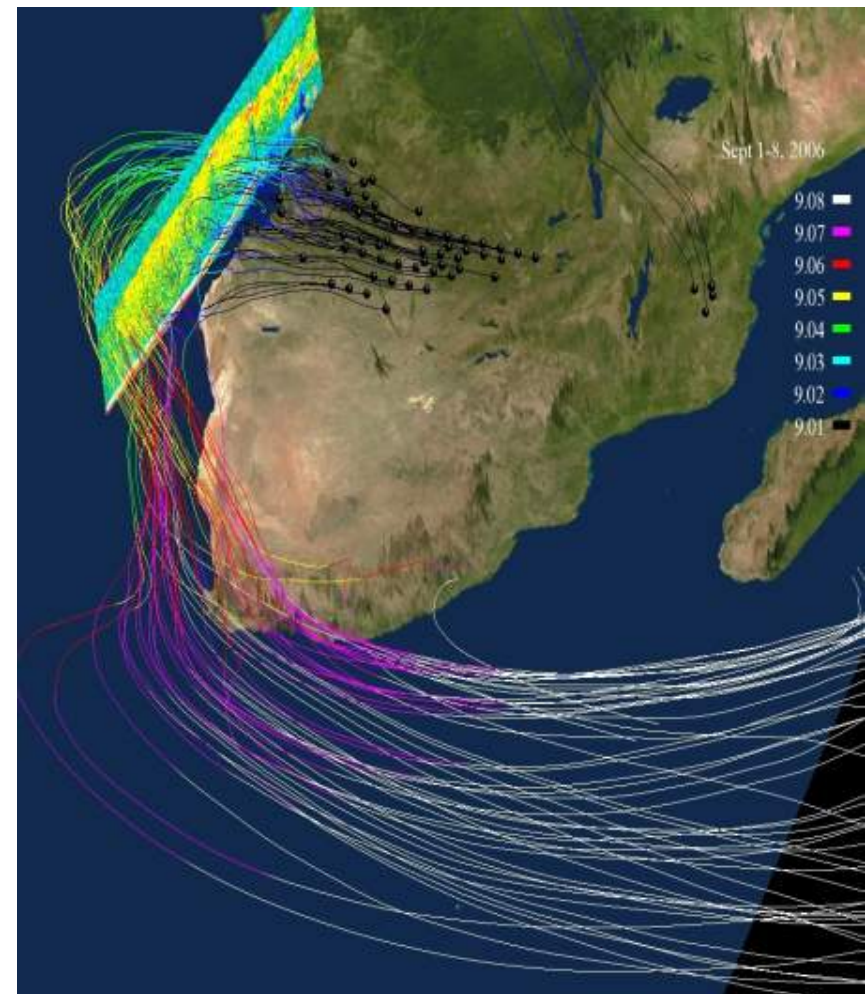
- **NOAA provides AQ forecast :**
 - Improve emissions inventories
 - Characterize long range transport
 - Model and forecast improvements
 - Compliance and clean air rules

- **Improvement using combined Metop and Aura NO₂ data sets**
 - Common algorithm now running on both data sets (NRT)
 - Six month data set for evaluation
 - Compare with models
 - *Make operational - 2009*

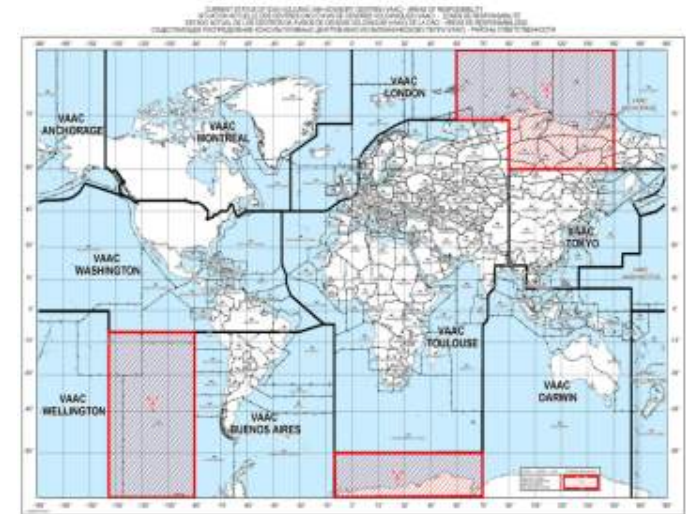


A. Richter, University of Bremen

- **Smoke dust Forecast NASA, NOAA, and EPA collaboration**
 - Automated fire detection algorithm for MODIS
 - AOD algorithm from MODIS and AVHRR
 - Employ trajectory model to predict distribution and location and smoke
 - Possibly include vertical aerosol distribution from CALIPSO
 - NRT ability still to be implemented
 - *Demonstrated aerosol forecast feasibility*
- **Extend to MSG/SEVIRI (Eumetsat)**
- **Deploy service on: *TBD***
<http://servir.nsstc.nasa.gov>
<http://idea.ssec.wisc.edu/>
- **Potential collaboration with PROMOTE/GMES Service**

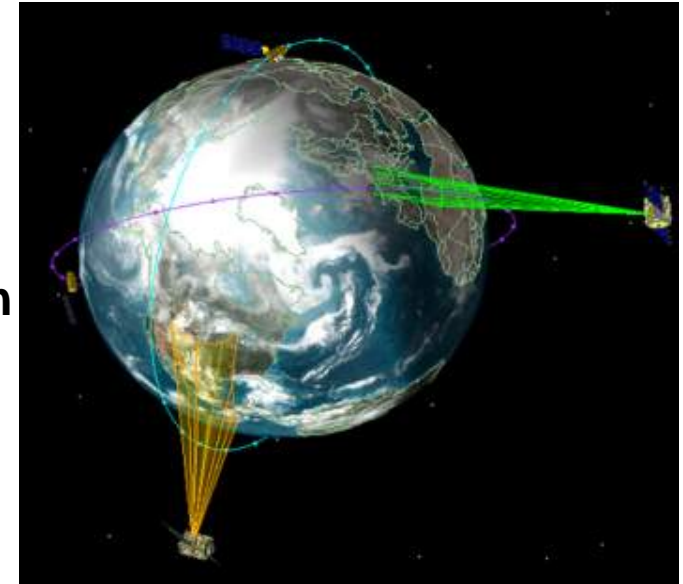


- Volcanic eruptions impact aviation safety; engine, window and skin damage
- The US (NASA, USGS, and NOAA) and ESA (PROMOTE) support national VAACs by providing alerts based on satellite data
- National services coordinated and extended to provide global service using enhanced capabilities through US and ESA combined efforts
 - Aura, Envisat, and MSG
 - Improved latency and accuracy of SO₂ and ash detection
 - Global alerts
- ESA sponsored workshop in October 2007 and conducted AO solicitation to focus activities via its PROMOTE program *in 2009*



- Both **GEO and GCOS (ECVs)** have requirements for long term data records to establish the connections between AC trends and climate needed for assessment and predictions
- **NASA and other agencies are supporting development of data sets (ECVs) for Trends**
 - Ozone (TOMS, SBUV, UARS, SAGE, Aura, GOME, Envisat, ACE, Metop, NPP/NPOESS)
 - Stratospheric Constituents (UARS, SAGE, Aura, Envisat, ACE, POAM)
 - Water Vapor (UARS, Aura, Envisat, SAGE, balloon soundings)
 - Aerosol (TOMS, AVHRR, SeaWiFS, MODIS, MERIS, OMI, METOP < NPP/NPOESS)
 - Surface Reflectivity: (TOMS, SBUV, SeaWiFS, Aura, Metop, NPP/NPOES)
 - NO₂ and SO₂ are now being investigated using OMI, GOME-1/2 and SCIAMACHY
- **Workshop planned at GISS: October 2008**
 - **Bring together investigators producing long term data sets (ECVs) and climate modelers**
 - **Quantify the impact of data gaps on climate model validation and forecast accuracy**
 - **Resolution of drifts and biases is a major effort. Maintaining cal/val data base is crucial and ca/val capabilities must be sustained**
- **Launch of GoSat (JAXA) and OCO (NASA) for carbon emission and sinks is next major challenge for ACC coordination via CEOS**
 - MoU between NASA and JAXA being negotiated: Inter-calibration
 - Algorithm and Cal/Val workshop at JPL: *May, 2008*

- **NASA and Europe will be launching both GEO and LEO AC missions after ~2015**
 - **NASA: DS GEO-CAPE and GACM**
 - **Europe: GMES Sentinels 4 and 5**
Possible “Precursor” or gap filler mission
- **All five missions have UV/VIS/NIR/TIR instruments with very similar objectives and capabilities with regard to spatial and temporal resolution**
- **A post Aura and Envisat “Constellation” can provide atmospheric composition data to address remaining requirements for Monitoring, Assessment, and Predictions:**
 - **Continuity in upper troposphere and stratosphere**
 - **High vertical resolution monitoring in the UT/LS**
 - **Improved accuracy and coverage in the boundary layer**
 - **Short and long term temporal and spatial variation measurements**
 - **Accurate tracking trans-continental and -oceanic transport of pollution and precursors**



Article on Satellites and Air Pollution Appeared in BAMS



Available at: <http://ams.allenpress.com/archive/1520-0477/89/6/pdf/i1520-0477-89-6-805.pdf>