Development of a Global Fire/Aerosol Operational Product as Part of the CEOS Atmospheric Composition Constellation

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CEOS Virtual Constellations

- Committee on Earth Observation Satellites (CEOS) has agreed to provide the space component for the Global Earth Observation System of Systems (GEOSS), in support of the overall goals of the Group on Earth Observations (GEO).
- The GEO Work Plan calls for “Virtual Constellations” to provide value-added satellite data products for the Societal Benefit Areas.
- The Atmospheric Composition Constellation (ACC), led by NASA & ESA, is 1 of 4 CEOS Pilot Constellation Projects. Pilots are intended to bring about technical/scientific cooperation and collaboration among space agencies that meet GEO objectives and also support national priorities.
- The “Global Fire/Aerosol Product” is 1 of 3 ACC Demonstration Projects, supporting Health Societal Benefit Tasks HE-07-02 and HE-07-03.

CEOS Pilot Constellation Projects

1) Atmospheric Composition
   I. Global Fire and Aerosol for Air Quality
   II. Volcanic SO2 & Ash for Aviation
   III. Diurnal NO2 for Air Quality
2) Land Surface Characterization
3) Precipitation
4) Ocean Surface Topography
MODIS/Calipso Retrospective Case Study:

September 1, 2006
MODIS AOD (colored) and clouds

Forward trajectories initialized in global model grid cells containing MODIS active fire detections
MODIS/Calipso Retrospective Case Study:

September 4, 2006
MODIS AOD (colored) and clouds

Forward trajectories initialized from Sep. 1 active fire detections
MODIS/Calipso Retrospective Case Study: South African Biomass Burning, early September 2006

CALIPSO observations verify trajectory-predicted smoke altitudes on 4 Sept.

Sept 1-8, 2006

Trajectories suggest some smoke intercepts Cape Town 6-7 Sept.

Smoke rises as it exits Africa
Demonstration of Global Fire and Aerosol Product

- Use satellite observations of fire and aerosol distributions, in conjunction with trajectory models, to produce air quality guidance related to large-scale aerosol events (e.g., IDEA system, Al-Saadi et al., *BAMS* 2005, [http://www.star.nesdis.noaa.gov/smcd/spb/aq/](http://www.star.nesdis.noaa.gov/smcd/spb/aq/)).
  - Develop global warnings on instances of **potential degradation of air quality due to long-range transport of aerosols** from widespread burning as well as from naturally occurring dust storms.
  - Initial satellite products include aerosol optical depth and active fire detections from MODIS and GOES, and aerosol height from Calipso
  - Explore international extensions by seeking distribution through existing delivery systems (IMAPP, SERVIR) and by working with international partners to create regional implementations using data from other geostationary satellites (e.g. MSG/SEVIRI, INSAT-3D, etc.).

- Initial demonstration in conjunction with joint NASA (ARCTAS) and NOAA (ARCPAC) field missions during 2008 International Polar Year.
  - Rapid availability of additional satellite products, including Calipso
  - Take advantage of science team focus on identification of wildfire events, particularly during the summer phase of ARCTAS (boreal fire)
Global aerosol/smoke forecast products during 2008 IPY Field Missions

Inputs

Satellite Data
- Terra MODIS AOD
- Aqua MODIS AOD
- GOES East AOD
- GOES West AOD
- Terra MODIS Fire Detect
- Aqua MODIS Fire Detect
- Calipso Orbital Predicts & Expdt. Imagery

Meteorology Data
- NOAA GFS 0.5x0.5 Grib2
- LDM3 CIMSS/UW Madison, WI

Models
- NASA LaRC Trajectory Model
- NASA LaRC NRT Biomass Burning Emissions
  (Data server, trajectory forecasts, and visualizations conducted at CIMSS4)

Outputs
- Automated 48-hr AOD Prediction (RDF5)
- Automated 5-day Wildfire Trajectory Prediction
- Automated/Manual 5-day Calipso Trajectory Prediction6

1Abstract Data Distribution Environment
2Fire Information for Resource Management System
3Unidata Local Data Manager
4Cooperative Institute for Meteorological Satellite Studies
5Reverse Domain Filling
6Automated trajectories based on orbit predicts, manual selection/analysis based on “Expedited” Calipso browse imagery
On July 1, visible smoke plume extending over 30 degrees longitude in Southern Canada
Calipso 532 nm backscatter 07/01 shows features 3.5-7 km
Calipso 532 nm depolarization 07/01 suggests features are aerosol (spherical)
CEOS Automated **Forward trajectories** initialized from MODIS fire detections
Ending 12Z 07/06

**Colored by** Estimated CO Emission Flux
CEOS Automated **Global AOD Prediction**
Reverse Domain Filling (RDF) technique using MODIS and GOES observations
Valid 12Z 07/03
CALIPSO observations and trajectory analysis suggest that the smoke plume A was transported across N. Atlantic Ocean at altitudes between 5 km and 7 km and reached W. Europe on 7/4 (plume D). It continued moving eastward (plume E on 7/5).

No AQ impact expected on Western Europe during this period.
MODIS (Terra) Northern Hemisphere AOD (provided by Allen Chu, UMBC)

7/1/2008
7/2/2008
7/3/2008
7/4/2008
Moderate enhancement, possibly from lower altitude SK smoke plume experiencing slower transport.
One more case study… with surface data and relation to US operational systems

Smoky Sunset For Southern Wisconsin

Smoky Sunset For Southern Wisconsin

July 26, 2008

NOAA’s National Environmental Satellite, Data, and Information Service (NESDIS), has a Fire Detection Program. They monitor most of North America for fires and the resultant smoke plumes. Here is how they analyzed the situation across Canada and the northern United State at around 4AM Saturday morning.

The smoke quickly moved southeast across the Badgerland during the day:

The red circles are satellite detected hot spots (fires). The gray area is a detected smoke plume.
CEOS Automated AOD Prediction, zoom in to US Great Lakes region
Reverse Domain Filling (RDF) technique using MODIS and GOES observations
Valid 12Z July 26, 2008

RDF forecast agrees with the smoke plume subsequently detected in the NOAA operational smoke analysis.
Calipso observations show that aerosol extends from the surface to 3km in the region of the smoke plume. Aerosol layers aloft further to the south.
PM2.5 concentration increases during several hour period at many monitors within the region. Need to look at speciation to verify contribution of smoke.

*Total atmospheric deposition; preliminary/ not quality-assured
Summary… and plans for moving forward

• Have demonstrated the potential of combined satellite aerosol observations for informing air quality associated with large-scale transport events
  – Need experienced analysts, familiar with characteristics of each data product
  – Large amount of data to sift through to identify and analyze “relevant” events, particularly with a global focus

• Need for verification of these developmental products
  – Statistical evaluation of forecast products with subsequent satellite observations
  – Broader inclusion of data from surface monitoring networks

• Begin the next phase of the Demonstration Project
  – Identify international partners for infusion of additional satellite aerosol and fire products (MSG SEVIRI, MTSAT-1R) and surface network measurements
  – Continue to mature enabling science (e.g., CALIPSO to verify plume height models)
  – Identify appropriate international delivery/distribution mechanism(s)
    • Global vs. regional (e.g., Direct Broadcast/ Direct Readout) analyses
    • Coordination with ongoing Information Systems activities

In summary, the challenge is to continue evolving from individual demonstration projects (labor intensive!) toward routine application of these assets for monitoring and forecasting - particularly within constellations of disparate sensors.

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The views, opinions, and findings contained in this talk are those of the authors and should not be construed as official position, policy, or decision of the National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, or U.S. Government.

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