Committee on Earth Observation Satellites

A Path Toward Global Air Quality Observations with a Geostationary Satellite Constellation

An Activity of the CEOS Atmospheric Composition Constellation (ACC)

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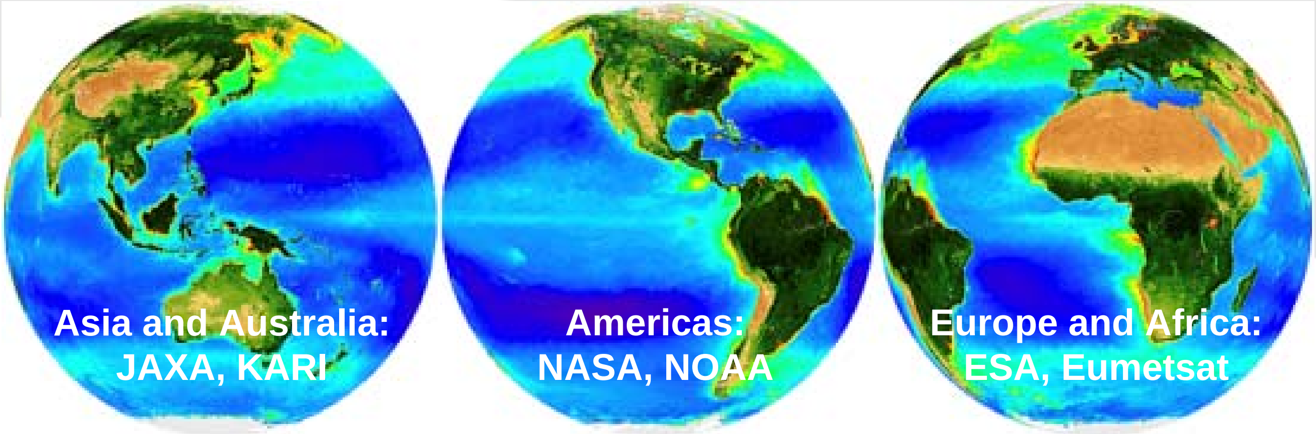
Global Observations from Geostationary Vantage: International Cooperation Required

- Geostationary orbit offers the potential for “continuous” (or many times per day) observation within the satellite field of view
- Continuous global Earth observations can in principle be provided by a constellation of at least 3 geostationary satellites positioned appropriately around the globe
  - *Precedent in operational meteorological agencies for aerosol and fire detection: NOAA GOES, Eumetsat MSG, JMA MTSAT*
- Unique considerations of geostationary access
  - *Relatively expensive cost to orbit because of high altitude*
  - *Orbit slots allocated by international agreement and are acquired ~years in advance of launch*
- Practically, geostationary constellations require International collaboration



A Geostationary Air Quality Constellation

- Harmonization of planned geostationary missions for air quality would enable an integrated global observing system fulfilling the visions of GEO/GEOSS
  - *ESA Sentinel 4, **2017***
  - *JAXA GMAP-ASIA, **2017***
  - *Korea MP-GeoSat, **2018***
  - *NASA Geo-CAPE, **2020***

- CEOS ACC sponsorship
  - *ACC-4 Meeting, June 2009, Frascati, Italy: recommendation to coordinate a real future Air Quality Constellation based on planned missions*
  - *AGU Fall Meeting, Dec 2009, San Francisco, USA: Open workshop "International Collaboration on Geostationary Air-Quality Observation", agreed to draft Position Paper*
  - *Jan 2010 CEOS Action AR-09-02a_32: "Gap assessment and co-ordination of Geostationary atmospheric composition measurement"*
    Due October 1, 2010
  - *ACC-5 Meeting, March 2010, Montreal, Canada: discussion on position paper scope and content*

Geostationary AQ mission parameters (draft, 8/2010)

	Sentinel 4	**Geo-CAPE**	**MP-GEOSAT GEMS**	**JAXA Geo**
Launch	2017-2018	2020	2017-2018	~2017
Domain	Europe and surrounding	Contiguous US and surrounding	Asia-Pacific	Japan and East China (4000 km×4000 km)
Resolution	8km x 8km (40N), revisit 1hr	8km x 8km (40N), revisit 1hr	5km x 15km, revisit 1hr	10km, revisit 1hr
Payload	UV-Vis-NIR 305-500, 750-775	UV-Vis (tbd), SWIR 2.3+4.6 micron	UV-Vis (tbd)	UV-Vis, 310-600 nm
Species	O3, NO2, SO2, HCHO, AAI, AOD, height-resolved aerosol	O3, NO2, SO2, AOD, CO (CO & O3 2 vertical DOF)	O3, NO2, SO2, AOD	O3, NO2, (SO2, HCHO, AOD)
Notes	On meteo platform. Use MTG-S TIR (expect sensitivity to large O3 and CO events); synergy with met. imager w.r.t. aerosol/PM	Includes ocean color mission. Baseline mission to include TIR and additional species: HCHO, CH4, NH3, CHOCHO, AAOD, AI, AOCH	Includes meteo and ocean color missions. Optional accommodation for small IR instrument (CO, CO2, CH4)	Includes meteo mission. Hyperspectral TIR FTS: O3, CO, HNO3

Intent of Position Paper
(as agreed during CEOS ACC-5 meeting, Montreal, March 2010)

- Suggest International collaborative activities to improve preparation for, and capabilities of, these missions
- Identify policy-relevant science and environmental services that would be enabled by common observations from each mission
  - *Improved regional emissions… over the entire industrialized Northern Hemisphere*
  - *Improved characterization of long range transport enabled by hourly observations at both source and receptor regions, linked by ~daily LEO observations over oceans*
  - *Observations would have particular relevance for East Asia, where the UN Convention on Long Range Transboundary Air Pollution has not yet been endorsed*
- Include climate aspects that are interrelated with AQ
  - *Short-lived climate forcers (O3, aerosols)*
  - *AQ/climate co-benefits*
- Also summarize the LEO missions and observations expected to be in orbit in the 2018-2022 period: critical to the constellation objectives

Recommendations: Potential Collaborative Activities

- Near-term through longer-term opportunities for collaboration
  - *Mutual participation in mission working groups*
  - *Scientific collaboration on retrieval algorithms and approaches*
  - *Refine measurement requirements, including OSSE studies*
  - *Improved quantification of societal benefits*
  - *Enhance data quality, content, access and utilization*
    - Develop common pre-launch calibration goals
    - Common cal/val strategies including field campaigns and ground networks
    - Develop data archive and distribution protocols and harmonized data product content (e.g., averaging kernel information) to enable collaborative science and applications
  - *Jointly advance air quality modeling and data assimilation capabilities*
  - *Consider aligned solicitations for Instruments of Opportunity (Earth Explorer, Venture) for complementary measurements (UV, Vis, IR)*
    - Technology demonstrations as Flights Of Opportunity
    - Possible procurement of multiple copies of single instrument designs
- These collaborations would benefit future GEO and LEO missions

Advocating at least 1-year mission overlap

- Demonstrate a hemispheric system over at least one full annual cycle
  - *Southern hemisphere coverage not planned for this first generation*
    - Reduce instrument complexity and mission costs
    - Prioritize faster regional revisit time over broader coverage
- Provides reasonable urgency for each space agency to consider best efforts for achieving planned launch dates of their piece of the constellation
- Value of CEOS is in recommending the strategy; implementation will rely on individual bilateral agreements
  - *NASA and NIER (for Korea MEST) agreement in place*
  - *ESA – NASA bilateral framework being drafted*
  - *JAXA – NASA bilateral exists*
- Next steps
  - *Any need for review external to ACC?*
  - *Highlight/present to CEOS SIT?*
  - *What actions are needed to secure support for the recommended activities?*

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Committee on Earth Observation Satellites

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Additional participation welcome!
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GEO, GEOSS and CEOS

- **The Group on Earth Observations (or GEO) coordinates international efforts to build a Global Earth Observation System of Systems (GEOSS)**
- **CEOS was established in 1984 to coordinate civil space-borne observations of the Earth in support to GEO**
    - **Currently 28 space agencies along with 20 other national and international organizations participate in CEOS planning and activities**
    - **CEOS works through a 'best efforts' approach. Funding and resources required by activities are contributed in-kind by participating CEOS agencies**
- **CEOS Atmospheric Composition Constellation (ACC) Objectives:**
    - **Establish a framework for long term collaboration 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 Societal Benefit Areas (e.g., Health, Climate, Energy, Ecosystems, Hazards)**

Geostationary observations decrease diurnal measurement bias

GOES Aerosol Optical Depth (AOD)

- **Monthly mean values from GOES AOD retrievals sampled only at 10:30 and 13:30 LST (LEO sampling)**
  - **lot of gaps (clouds)**
  - **large areas with extreme values**

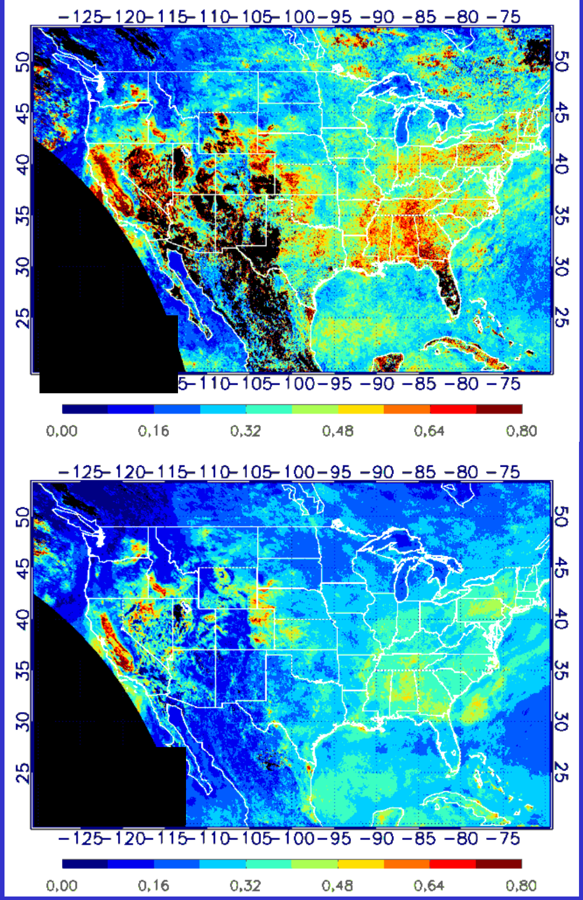
- **Monthly mean values from half-hourly GOES AOD retrievals during daytime hours (GEO sampling)**
  - **less gaps**
  - **smoother AOD field**

- **Regional errors in monthly mean AOD from LEO sampling exceed 0.3**

- **AERONET data show similar pattern**

Shobha Kondragunta,
NOAA NESDIS

July 2008



(a) Monthly avg AOD sampled at 10:30 and 13:30 LST

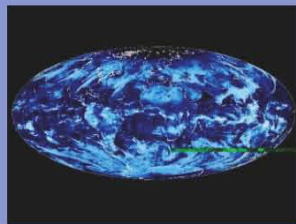
(b) Monthly avg AOD sampled from half-hourly GOES

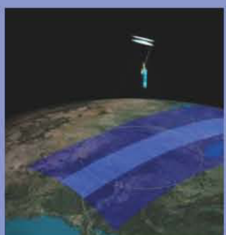
Monthly mean AOD	AERONET	GOES
LEO sampling	0.29	0.32
GEO sampling	0.51	0.4

NASA Earth Science Decadal Survey Missions

*Denotes atmospheric composition components

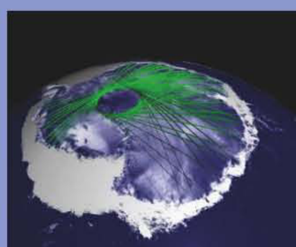
Climate Absolute Radiance and Refractivity Observatory **(CLARREO)**





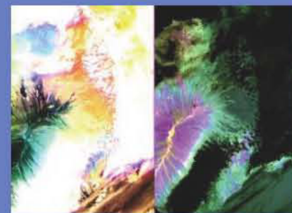
Soil Moisture Active Passive **(SMAP)**

Ice, Cloud,and land Elevation Satellite II **(ICESat-II)**



Deformation, Ecosystem Structure and Dynamics of Ice **(DESDynI)**

Tier I

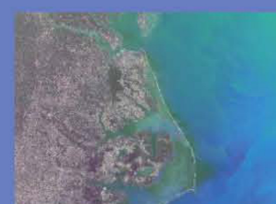


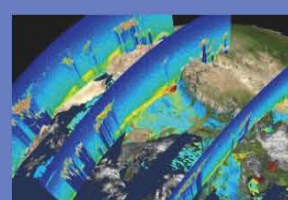
Hyperspectral Infrared Imager **(HYSPIRI)**

* Active Sensing of CO2 Emissions **(ASCENDS)**

Surface Water and Ocean Topography **(SWOT)**

* Geostationary Coastal and Air Pollution Events **(GEO-CAPE)**

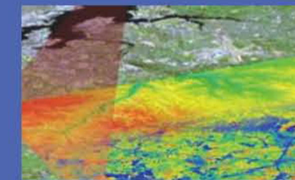




Aerosol - Cloud - Ecosystems **(ACE)** *

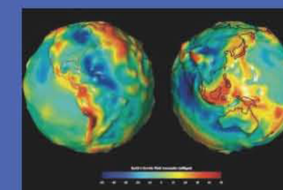
Tier II
est. 2018-2022

LIDAR Surface Topography **(LIST)**



Precipitation and All-Weather Temperature and Humidity **(PATH)**

Gravity Recovery and Climate Experiment - II **(GRACE - II)**



Snow and Cold Land Processes **(SCLP)**

Three-Dimensional Winds from Space Lidar **(3D-Winds)**

Global Atmospheric Composition Mission **(GACM)** *

Tier III
est. 2020-2025