Committee on Earth Observation Satellites

The CEOS Atmospheric Composition Constellation: Enhancing The Value Of Space-based Observations

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What is CEOS?

- **The Committee on Earth Observation Satellites (CEOS) coordinates civil space-borne observations of the Earth.**
- **Currently, 55 members and associate members made up of space agencies, national, and international organizations participate in CEOS planning and activities.**
- **CEOS coordinates the Global Earth Observation System of Systems (GEOSS) space segment.**

CEOS Virtual Constellations

- **CEOS Virtual Constellation:** Set of space and ground segment capabilities operating together in a coordinated manner to meet a combined and common set of Earth Observation requirements.
- Provides a unique forum to achieve political visibility and increase mutual benefit among space and other environmental agencies in support of cross-cutting GEO Tasks and Targets.
- Offer opportunities to share experience in the development of algorithms, standardize data products and formats, exchange information on the calibration and validation of measurements, and facilitate timely exchange of and access to data products.

Atmospheric Composition Constellation

- **CEOS Atmospheric Composition Constellation (ACC) exists to sustain a systematic capability to provide essential observations of atmospheric composition from space.**

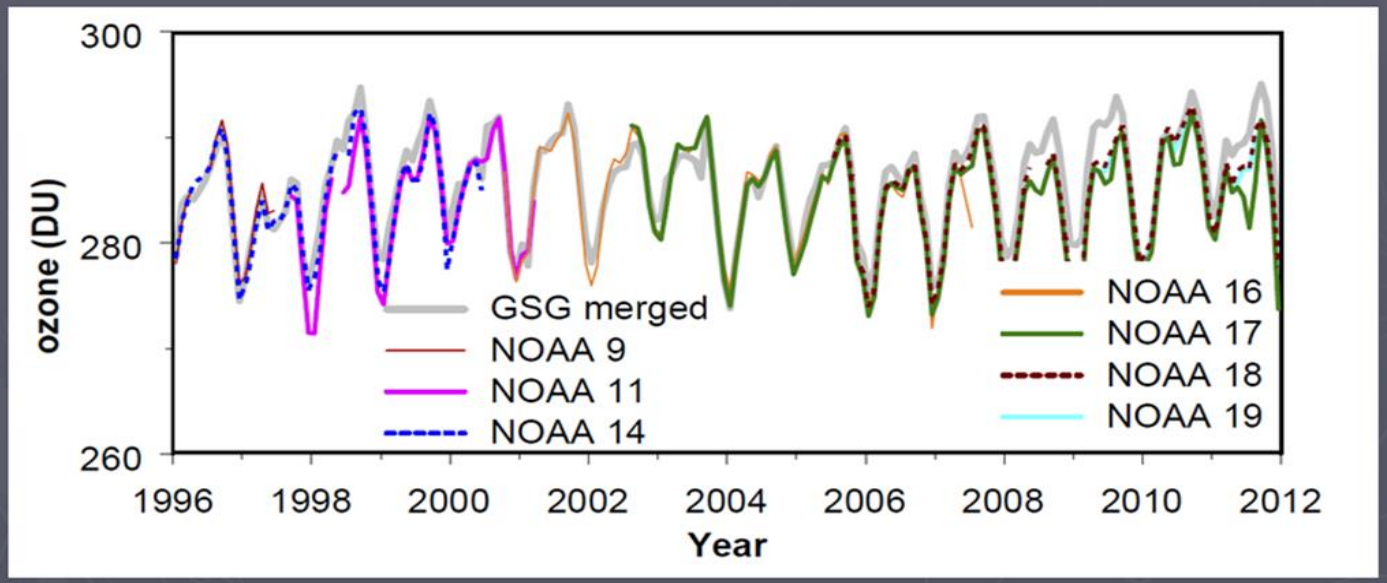
- **Key Objectives:**
  - **Develop and improve predictive capabilities for changes in the ozone layer,**
  - **Monitor air quality,**
  - **Monitor climate forcing associated with changes in atmospheric composition**

Total Ozone Dataset Harmonization

- **Total ozone measurements from multiple sensors are being considered by ACC. Including TOMS, SBUV,GOME, GOME-2, OMI, and SCIAMACHY.**
- **Leverage funded efforts like the ESA Ozone Climate Change Initiative.**
- **Near-term outcomes and deliverables include:**
  - **Common validation protocol for total ozone measurements developed,**
  - **Consistent error characterization of European and US total ozone data sets to be provided to the user community,**
  - **Inclusion of other total ozone data sets (e.g., infrared sensors like IASI, AIRS) to fill in gaps in polar regions.**

Total Ozone Dataset Harmonization

Compare with GOME and SCIAMACHY



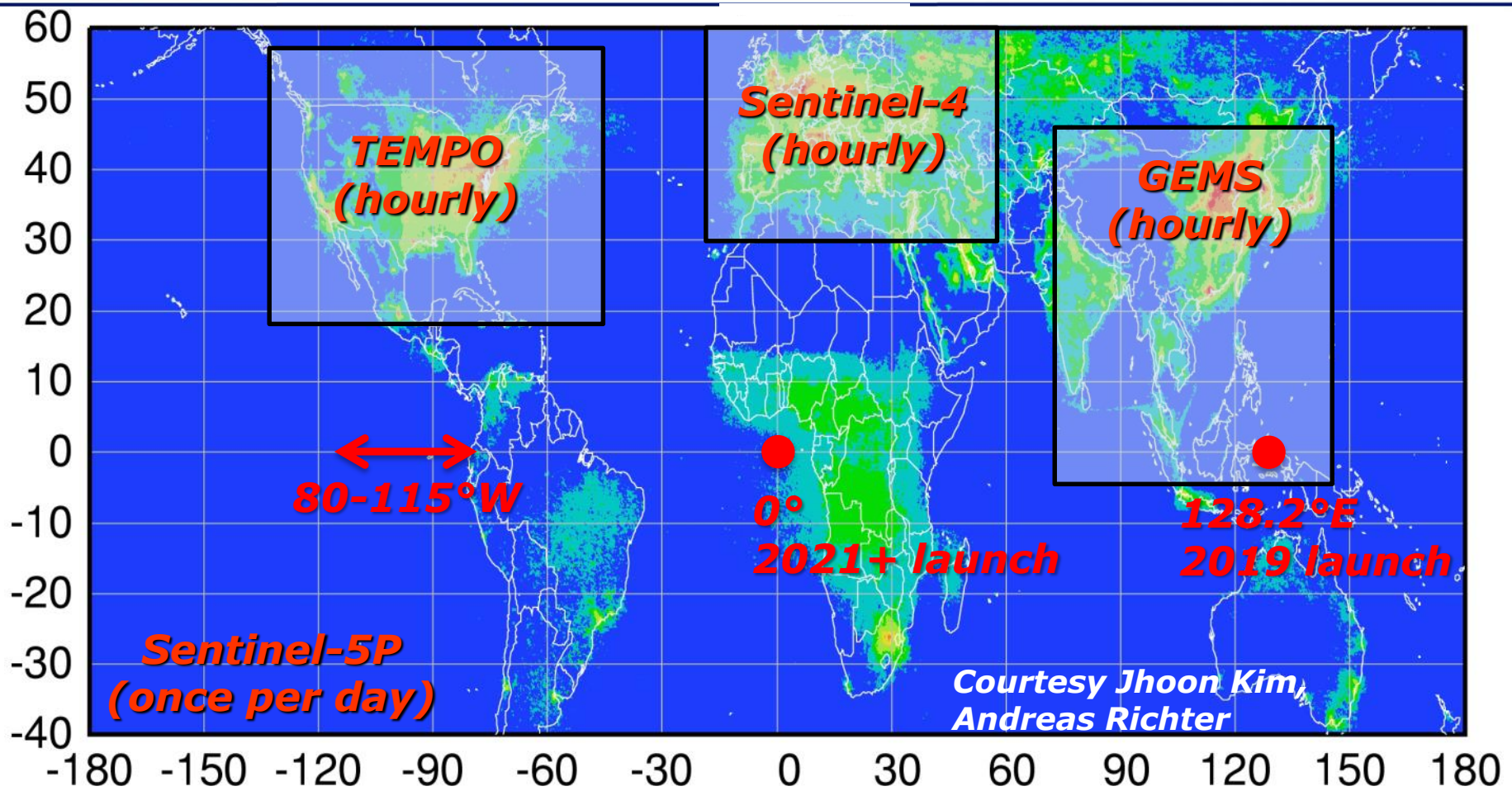
Global average ozone (60°S – 60°N) from the GOME-SCIAMACHY-GOME2 (GSG) merged ozone data set plotted over v8.6 individual time series.

Richard McPeters, ACC-9

Geostationary Air Quality Constellation

- **Europe Sentinel 4, Korea GEMS, NASA TEMPO, and Europe Sentinel 5P (LEO orbit) will be launched from 2016-2021 with likely temporal overlap, yielding near-global coverage (in Northern hemisphere).**
- **Measure ozone, ozone precursors, NO_2, CO, aerosols.**
- **Harmonizing these geostationary missions to have common observing capabilities and data distribution protocols would synergistically enable critically needed understanding of the interactions between regional and global atmospheric composition and of the implications for air quality and climate.**

Geostationary AQ Constellation



Policy-relevant science and environmental services enabled by common observations

- Improved emissions, at common confidence levels, over industrialized Northern Hemisphere
- Improved air quality forecasts and assimilation systems
- Improved assessment, e.g., observations to support United Nations Convention on Long Range Transboundary Air Pollution

Geostationary AQ Constellation: Outcomes

✔1. Coordinate one or two key people per mission to be part of mutual mission science or advisory teams with a focus on common science and collaborative data products.
   - Points of contact for each mission have been named

✔2. Facilitate scientific collaboration on retrieval algorithms and chemical Observing System Simulation Experiment (OSSE) studies. Organize a workshop on air quality OSSE activities.
   - "Cooperation to define, conduct, and analyze common OSSE scenarios… align and extend ongoing regional studies and systematically incorporate them into global studies."
   - CEOS/MACC-II International OSSE Workshop held 22-24 October 2012 at ECMWF *http://www.ecmwf.int/newsevents/meetings/workshops/2012/OSSE/*

3. Coordinate societal benefit assessment of satellite air quality observations, leveraging recent GCOS and GEO health community of practice efforts
   - Requires interaction with economists and health effects communities

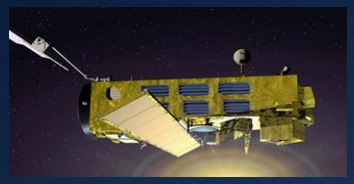
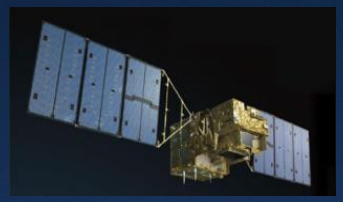
Geostationary AQ Constellation: Outcomes

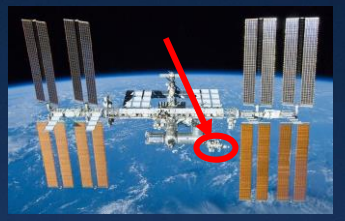
4. Agree on an **open data policy** for AQ-relevant data and support establishment of **common cal/val standards**
   - Data sharing protocol should include Level 1-B data to enable reprocessing of all data with common algorithms
   - ✔ **Initial workshop** to compare cal/val plans and identify collaborative opportunities
5. Organize a workshop on AQ model intercomparison
   - The ongoing Air Quality Modelling Evaluation International Initiative (AQMEII) has already made much progress among European and North American groups
6. ✔ Undertake best efforts to overlap planned GEO AQ missions by at least 1 year
   - Given the expected 2018-2019 launches of S4, GEMS, and TEMPO, this will be achieved for the baseline products beginning with the first-generation missions!
   - The existence of these missions is enabling stronger international collaborations
7. Support evaluation of strategies for extending coverage, including possible approaches for common instrumentation

Greenhouse Gas Constellation

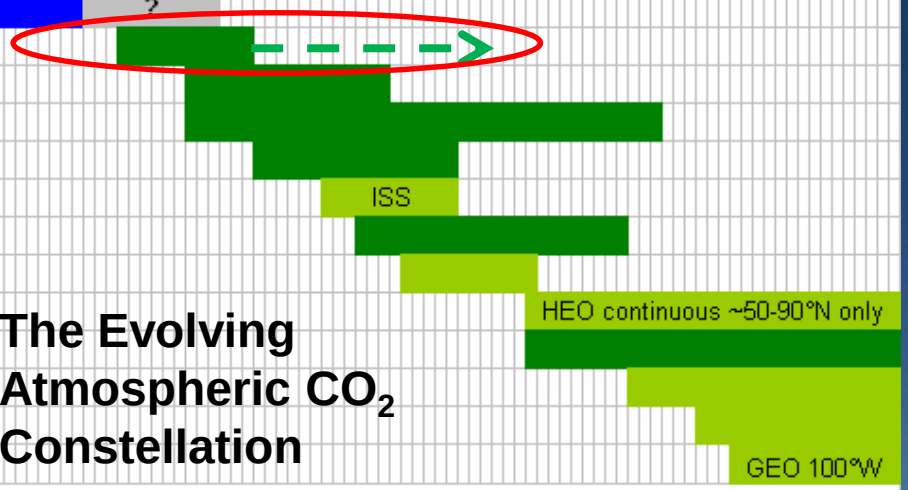
- **CEOS Strategy for Carbon Observations from Space (2014) identified high-priority needs for CEOS to better coordinate existing and future capabilities to monitor greenhouse gases.**
- **ACC is providing a forum to coordinate algorithm development, calibration/validation support, and other activities consistent with the CEOS Strategy report.**
- **Will mirror the successful implementation of the Air Quality Constellation.**

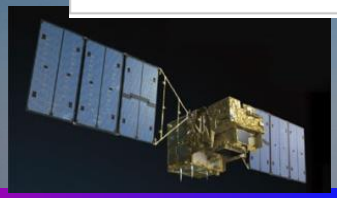
International Constellation of Greenhouse Gas Satellites

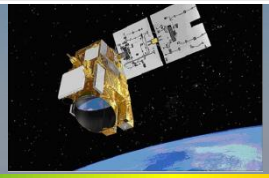
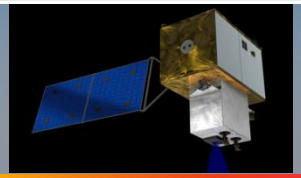
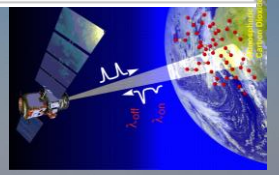



Satellite, Instrument (Agencies)	CO_2	CH_4	FOV
ENVISAT SCIAMACHY (ESA)	•	•	30x60 km^2
GOSAT TANSO-FTS (JAXA-NIES-MOE)	•	•	10.5 km (d)
OCO-2 (NASA)	•		1.25x2.26 km^2
TanSat (CAS-MOST-CMA)	•		1x2 km^2
Sentinel-5P TROPOMI (ESA)		•	7x7 km^2
MERLIN (DLR-CNES)		•	0.135 km (w)
OCO-3 (NASA)	•		~3 km^2
GOSAT-2 TANSO-FTS (JAXA-NIES-MOE)	•	•	3-4 km (d)
MicroCarb (CNES)	•		~25 km^2
PCW-PHEOS-FTS (CSA)	?	•	10x10 km^2
MetOpSG Sentinel-5 (ESA-EUMETSAT)		•	7x7 km^2
CarbonSat (ESA)	•	•	2x2 km^2
ASCENDS (NASA)	•		0.100 km (w)
GEO-CAPE (NASA)		•	4x4 km^2
Based on information from various sources			*d = diameter w = width of a narrow strip along orbit track*





Continuity of Limb Sounding

Timeline of Atmospheric Composition Limb Sounding Spectrometry Missions

Instrument	Rating	Satellite	Orbit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SAGE-III	5	ISS SAGE-III	51.6 °							X	X	X	X	X	X									
ACE-FTS	5	SCISAT-1	73.9 °	X	X	X	X	X																
MAESTRO	5	SCISAT-1	73.9 °	X	X	X	X	X																
TIDI	1	TIMED	74 °	X	X	X	X	X																
SABER	4	TIMED	74 °	X	X	X	X	X																
OMPS-limb	1	Suomi-NPP	13:25 asc		X	X	X	X	X	X														
OMPS-limb	1	JPSS-2	13:30 asc													X	X	X	X	X	X	X	X	
TES-limb	2	EOS-Aura	13:45 asc	X	X	X	X	X																
MLS (EOS-Aura)	3	EOS-Aura	13:45 asc	X	X	X	X	X																
HIRDLS	4	EOS-Aura	13:45 asc	X	X	X	X	X																
ACS-limb	1	Meteor-MP N1	15:30 asc															X	X	X	X	X	X	
OSIRIS	1	Odin	06:00 desc	X	X	X	X	X																
OMS-limb	1	FY-3E	06:00 desc									X	X	X	X	X	X							
OMS-limb	1	FY-3G	06:00 desc													X	X	X	X	X	X			
SMR	3	Odin	06:00 desc	X	X	X	X	X																
ACS-limb	1	Meteor-MP N2	09:30 desc																X	X	X	X	X	X
POAM	5	SPOT-4	10:30 desc	X	X	X	X																	

"Rating" is on scale from 1 (most capable, best areal coverage) to 5 (fewer samples, limited coverage)

Data Source: WMO OSCAR Database

Limb sounding continuity

- **ACC has highlighted the looming gap in limb sounding data following the demise of the currently operating but aging instruments**
- **Only three limb sounding instruments are planned for launch prior to 2021**
- **SPARC is considering a community white paper to raise awareness**
- **ACC will work to co-organize a community workshop on limb sounding continuity in conjunction with CEOS member agencies, the CEOS/CGMS Working Group on Climate and WMO-Global Atmosphere Watch.**

Summary

- **ACC provides a forum for researchers and program managers from CEOS-member agencies and academia to coordinate efforts relevant to ozone, air quality, greenhouse gas monitoring, and related issues.**
  - **Has leveraged agency activities to better characterize and harmonize total ozone datasets.**
  - **Continues to coordinate a soon to be implemented set of air quality missions from geostationary and low-Earth orbits.**
  - **Coordinates volcanic ash monitoring from space and developing an operational demonstration service for volcanic ash (and SO_2) monitoring and forecasting.**
  - **Highlighting the looming gap in limb sounding observations relevant to atmospheric composition.**