National Aeronautics and Space Administration

NASA WGCV38 Update

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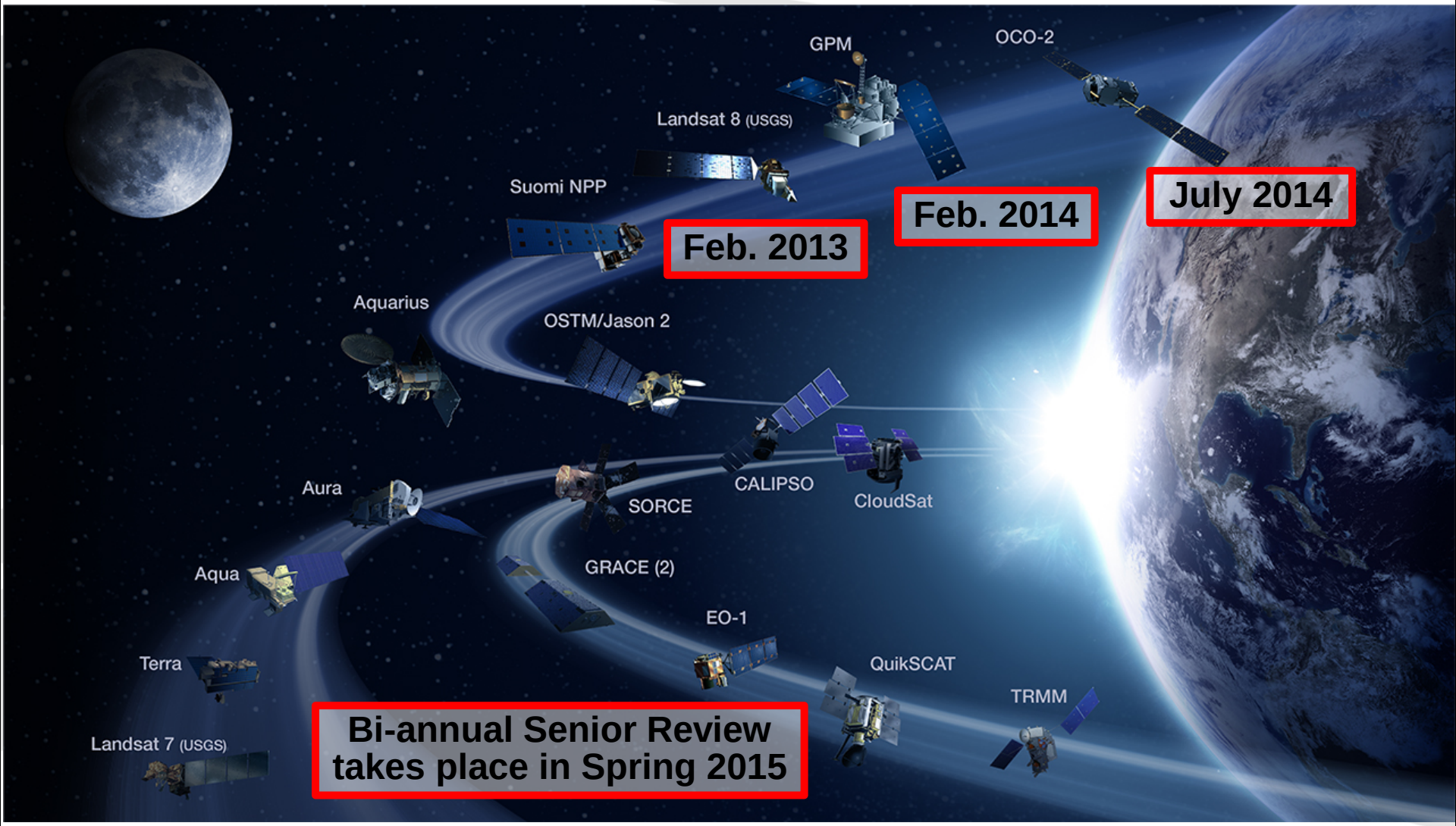
Earth Science Division, Science Mission Directorate

September 2014

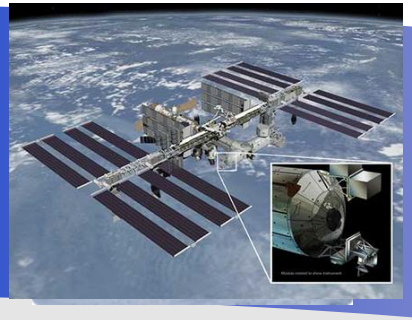
NASA Operating Missions



Operating Satellite Status

Mission	Launch	Phase	Design Life (yr)	Current Life (yr)	Expected End
Terra	18-Dec-99	Extended	5	14	2017
ACRIMSat	20-Dec-99	Extended	5	14	2020
Aqua	03-May-02	Extended	5	12	2022
SORCE	25-Jan-03	Extended	5	11	2015
Aura	15-Jul-04	Extended	5	9	2018
Cloudsat	28-Apr-06	Extended	3	8	2015
CALIPSO	28-Apr-06	Extended	3	8	2016
OCO - 1	24-Feb-09	Launch Failure	2	N/A	N/A
Glory	04-Mar-11	Launch Failure	3	N/A	N/A
Suomi-NPP	25-Oct-11	Prime till Oct 2016	5	3	TBD

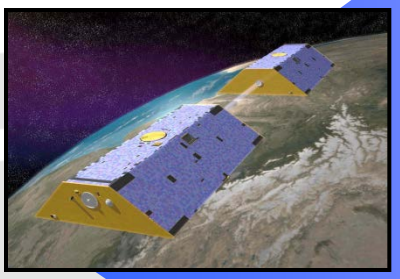
Near-Term Formulation & Development Missions



RapidScat
Sept. 2014
w/ ISS
Ocean winds
Falcon-9

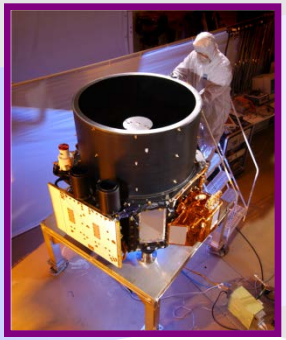
CATS
Nov 2014
w/ ISS
Aerosol & Cloud
Falcon-9

SMAP
Jan 2015
w/CSA
Soil Moist., Frz/Thaw
Delta II



GRACE FO
Aug 2017
w/Germany; Global Mass & Water Variation
German-supplied Dnepr LV

CYGNSS
2016-2017
Tropical Cyclone Generation, Air-sea Interaction in Extreme Conditions

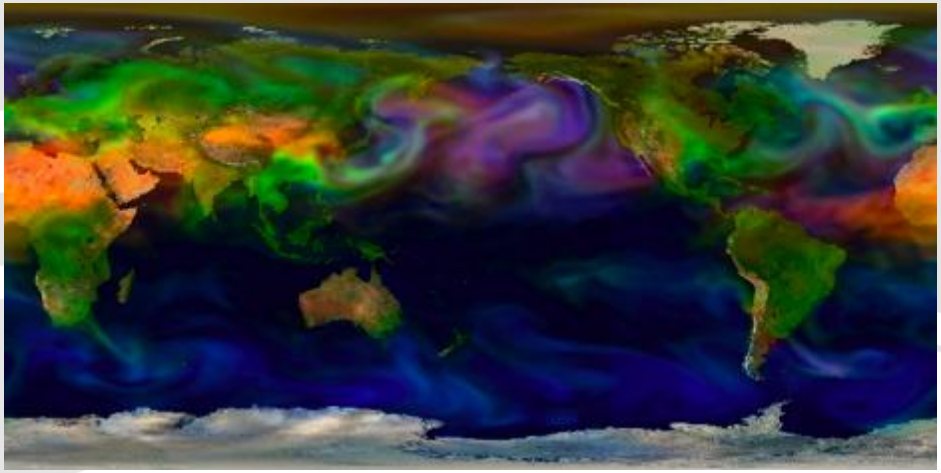


ICESat-2
Dec 2016 (TBR)
Ice Dynamics
Delta II

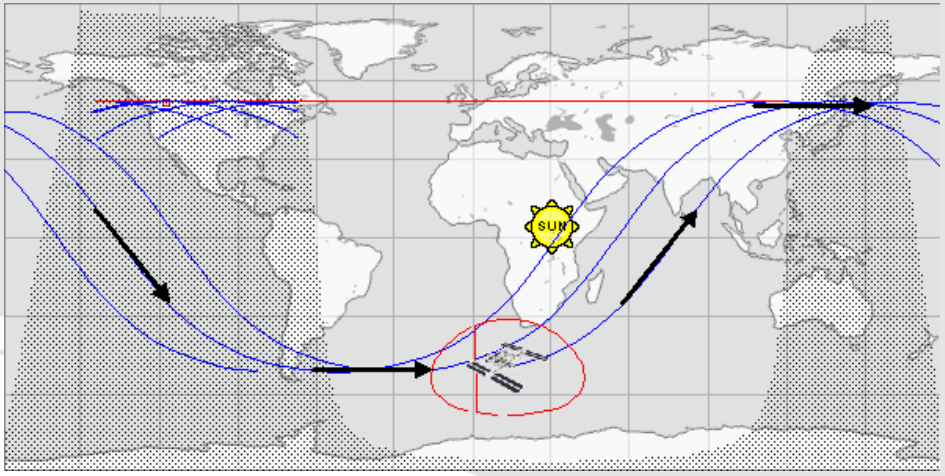
SAGE III
NET Mar 2015 (TBR)
Ozone & Trace Gases
Falcon-9

Cloud-Aerosol Transport System (CATS): Key Science Objectives

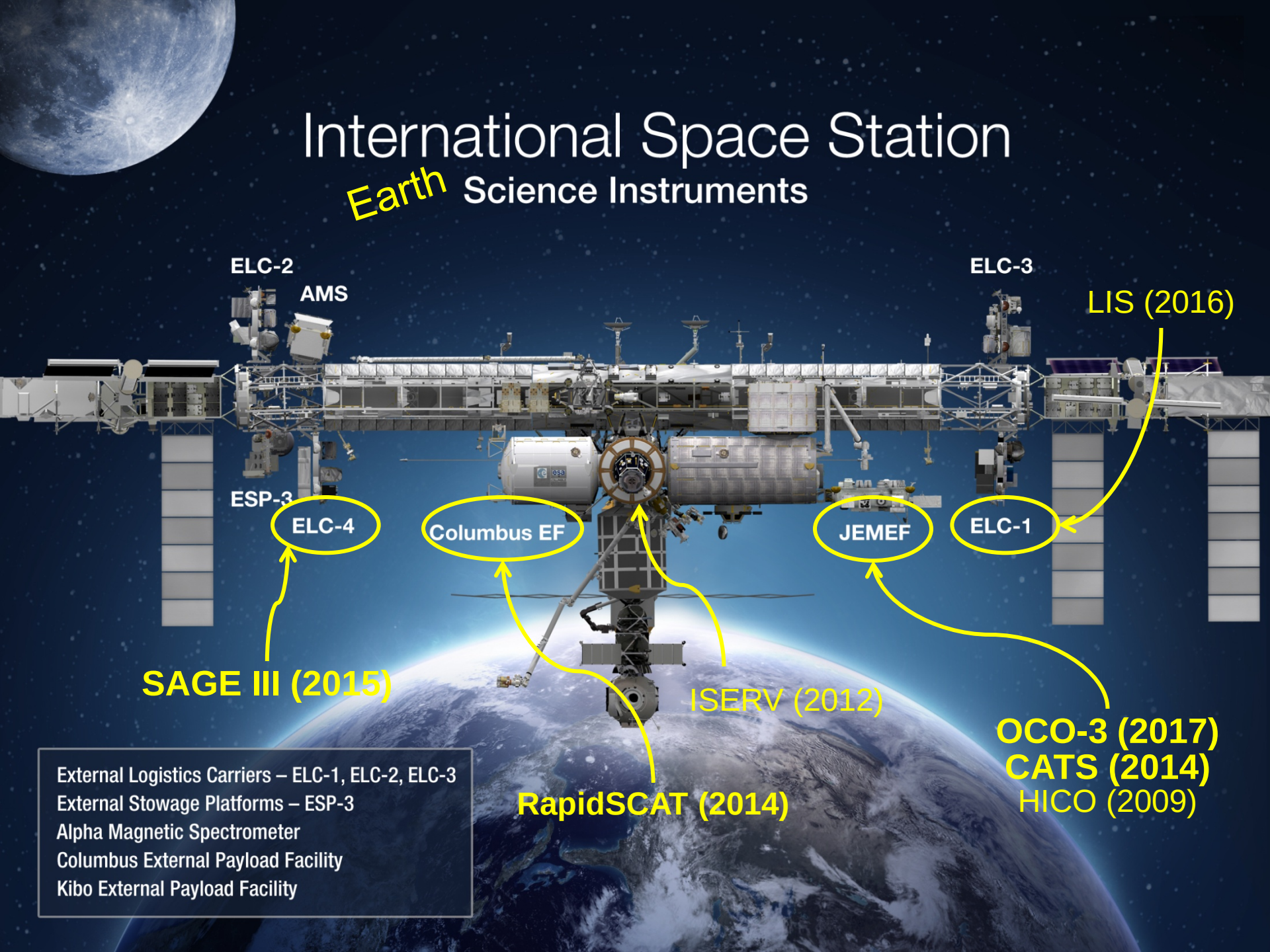
- Demonstrate multi-wavelength aerosol and cloud retrievals.
- Provide cloud and aerosol data to help bridge the gap between CALIPSO and future missions.
- Enable aerosol transport models with real-time data downlink from ISS
- ISS orbit is intriguing for tracking of plumes and study of diurnal effects (something not possible with A-Train orbit).



Snapshot of GEOS-4 model global aerosol distribution forecast for March 20, 2006
Orange = dust; Blue = sea salt; Green = smoke and sulfate; Saturation ~ species column amount



ISS orbit. The low-inclination orbit permits extensive measurements over aerosol source and aerosol transport regions.


International Space Station
Earth Science Instruments
ELC-2
AMS
ELC-3
LIS (2016)
ESP-3
ELC-4
Columbus EF
JEMEF
ELC-1
SAGE III (2015)
ISERV (2012)
OCO-3 (2017)
CATS (2014)
HICO (2009)
RapidSCAT (2014)
External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

Venture Class Activities

- EVS ("EV-1" - Suborbital, Airborne; solicited every 4 years)
  - All 5 investigations are well into their sustained field campaigns
  - ***Second EV-S solicitation proposals received 10 Jan 2014***

- EVM ("EV-2" - Small-sat; solicited every 4 years)
  - CYGNSS successful moved to phase C in July 2013 with planned launch readiness date for October 2016 – April 2017
  - ***FY14 budget proposal includes EV-M/2 solicitation on-schedule in June 2015***

- EVI (Instrument; solicited every 18 months)
  - TEMPO selected for geo-synchronous orbit on hosted payload opportunity (early FY18 launch)
  - ESD making progress on formal host selection
  - **Second "EV-I/2" solicitation released July 2013 with selections July 2014**
    - **GEDI vegetation lidar**
    - **ECOSTRESS thermal IR imager**
    - **Both to operate from ISS**

NASA ESD Flight Portfolio 2015 - 2022

- **ICESat-2** (12/2016) – Precision Ice Topography, Ecosystem monitoring
- **CYGNSS [EVM-1]** (late 2016)
- **GRACE-FO** (8/2017) – Gravity/Ice Mass/Ground Water, w/GFZ & DLR
- **OCO-3/ISS** (Fall 2017) – CO_2 continuity, from ISS, OCO-2 spares
- **TEMPO [EVI-1]** (2019) – Tropospheric Emissions from geosynchronous
- **SWOT** (2020) – Wide-swath ocean altimetry, land water, w/CNES
- **GEDI [EVI-2]** (2019) – Vegetation lidar on ISS
- **ECOSTRESS [EVI-2]** (2018) – High resolution thermal IR imager on ISS
- **PACE** (2020) – Ocean Color, possibly Aerosols
- **L-band SAR** (2021) – Solid Earth, Cryosphere, Ecosystems, w/ISRO
- **CLARREO** (2022?) – Precise global radiation balance, possibly w/UK
- **EVM-2** (NLT 2022)
- **EVI-3** (NLT 2022)
  - Significant studies ongoing for all other Tier-2 Decadal Survey missions

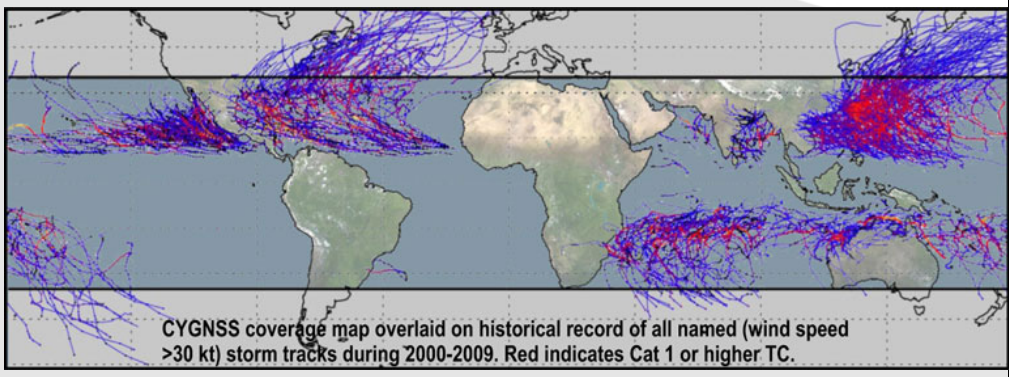
- ***<u>And on the horizon:</u>***
  - ***Sustained Land Imaging program for the U.S. for 2018 – 2038***
  - ***Solar Irradiance, Ozone profiles, and Earth Radiation Budget measurements for beyond 2020***

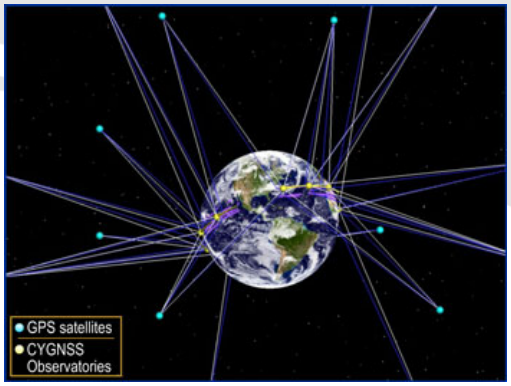
CYGNSS:
Cyclone Global Navigation Satellite System

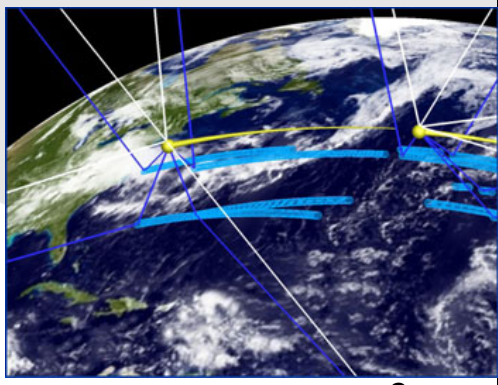
PI: Chris Ruf, University of Michigan
Instrument Development: Surrey Satellite Tech.
Project Management/Science: SW Research Inst.
Other Institutions: NASA Ames, Sierra Nevada Corp.

Features:

- 2016 launch
- Measure ocean surface wind speed in the tropical cyclone inner core with sufficient frequency to resolve genesis and rapid intensification
- Measure ocean surface wind speed in all precipitating conditions, including those experienced in the tropical cyclone eyewall
- Scatterometer approach with GPS receivers of direct and reflected signals from GPS satellites


CYGNSS coverage map overlaid on historical record of all named (wind speed >30 kt) storm tracks during 2000-2009. Red indicates Cat 1 or higher TC.





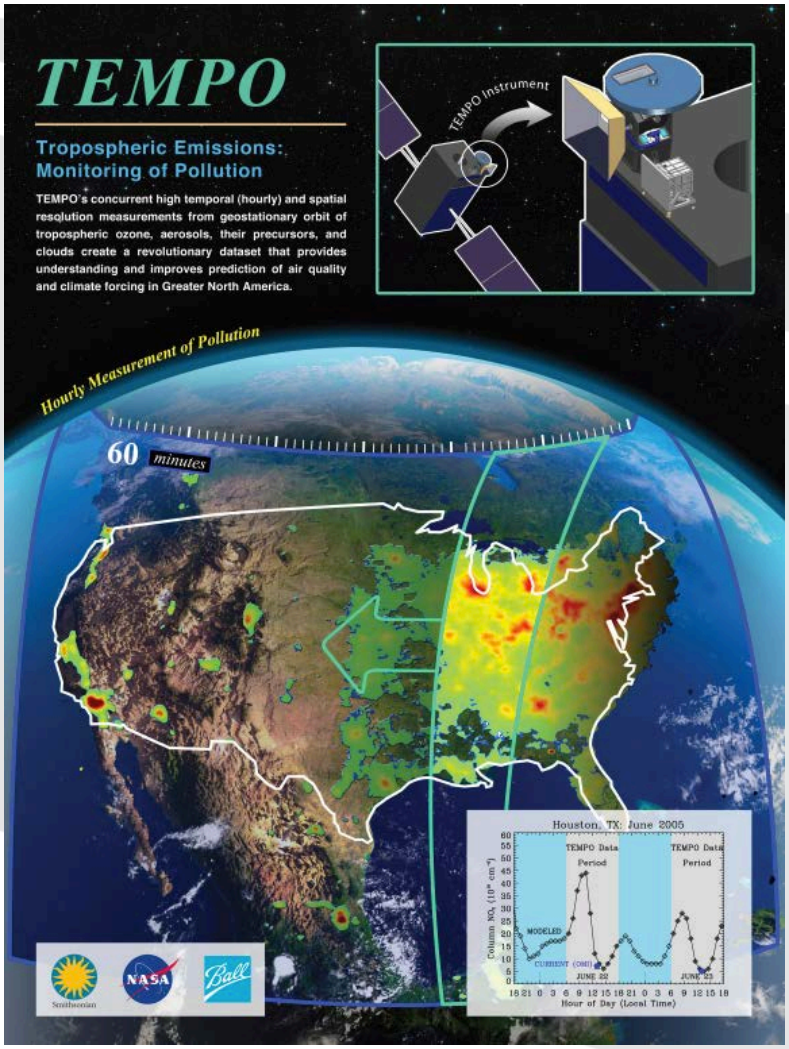
TEMPO Tropospheric Emissions: Monitoring of Pollution

Hourly atmospheric pollution observations from geostationary Earth orbit

PI: Kelly Chance, Smithsonian Astrophysical Observatory
Instrument Development: Ball Aerospace
Project Management/Science: NASA LaRC
Other Institutions: NASA GSFC, NOAA, EPA, NCAR, Harvard, UC Berkeley, SLU, UAH, Nebraska

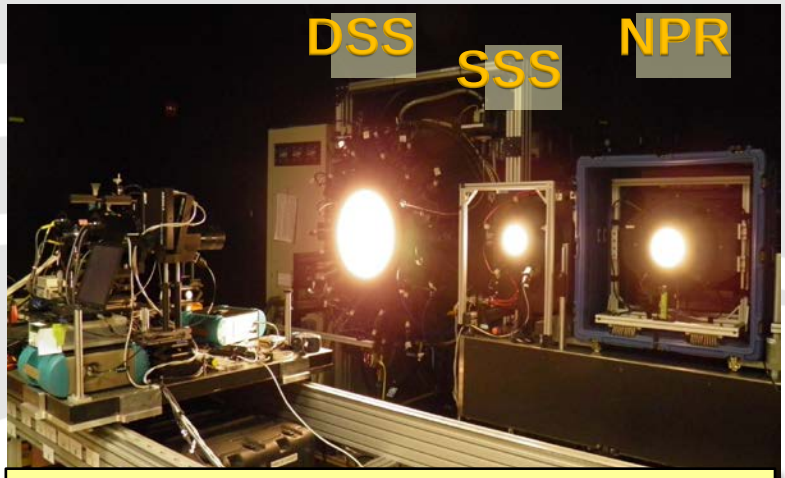
Features:

- Delivery 52 months from Authority to Proceed
- NASA will arrange hosting on commercial geostationary communications satellite with expected ~2018 launch
- Provides hourly daylight observations to capture rapidly varying emissions & chemistry
- UV-Vis grating spectrometer to measure key elements in tropospheric ozone & aerosol
- Distinguishes boundary layer from free tropospheric & stratospheric ozone
- North American geostationary component of an international constellation for air quality monitoring



Landsat/Sentinel Intercalibration

- Many users will benefit from using the Sentinel-2 Multispectral Instruments (MSI) and the Landsat-8 OLI data together such as from higher frequency coverage
- NASA and ESA joint effort to inter-calibrate data
  - Pre-launch calibration source comparison
  - Diffuser sample round robin
  - On-orbit inter calibration (with CNES)
- NASA and ESA are circulating MSI diffuser witness and reference samples between Centre Spatial de Liege (CSL) and US facilities



Only one source measureed at a time

OLI - January 2011 -- @ BATC

- Initial radiometric differences as large as 15% reduced to less than 5%

NASA Earth science Highlights

- GPM, OCO-2, RapidScat launched earlier in 2014
- CATS and SMAP scheduled to launch in next four months
- Continued Venture-Class competitions and implementing selected missions
- Operation funding for QSCAT, Jason-1, CloudSat, GRACE, SORCE in FY14 – ends all by FY18
- Advanced development of SAGE III/ISS, GRACE-FO, SWOT, CYGNSS, OCO-3, TEMPO, GEDI, RapidScat, and ICESat-2 for launch before 2021
- Pre-formulation studies continued for PACE, L-band SAR, and other US NAS Decadal survey-recommended and climate architecture missions