National Aeronautics and Space Administration

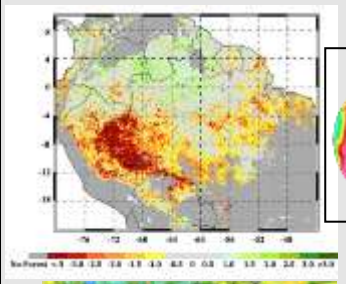
NASA Earth Science Division Overview

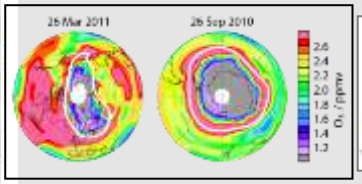
CESAS Meeting

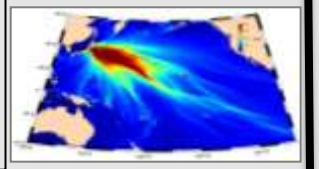
March 28, 2017

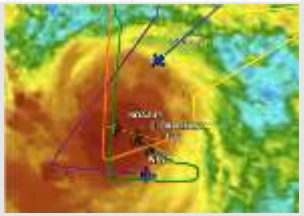
NASA's Earth Science Division

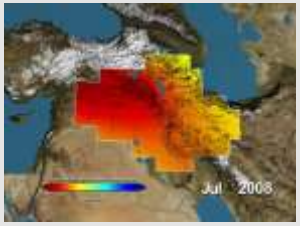
Research





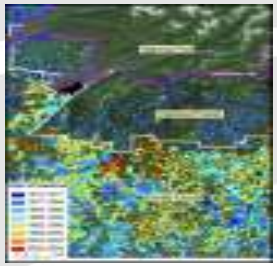


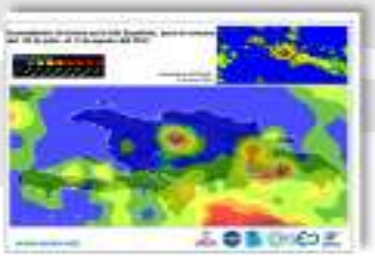


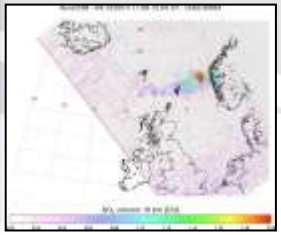


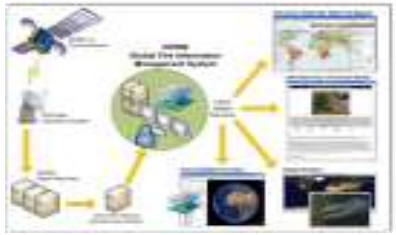
Flight

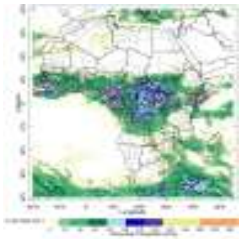
Applied Sciences











Technology

NASA/ESD Funding/Appropriation Timeline

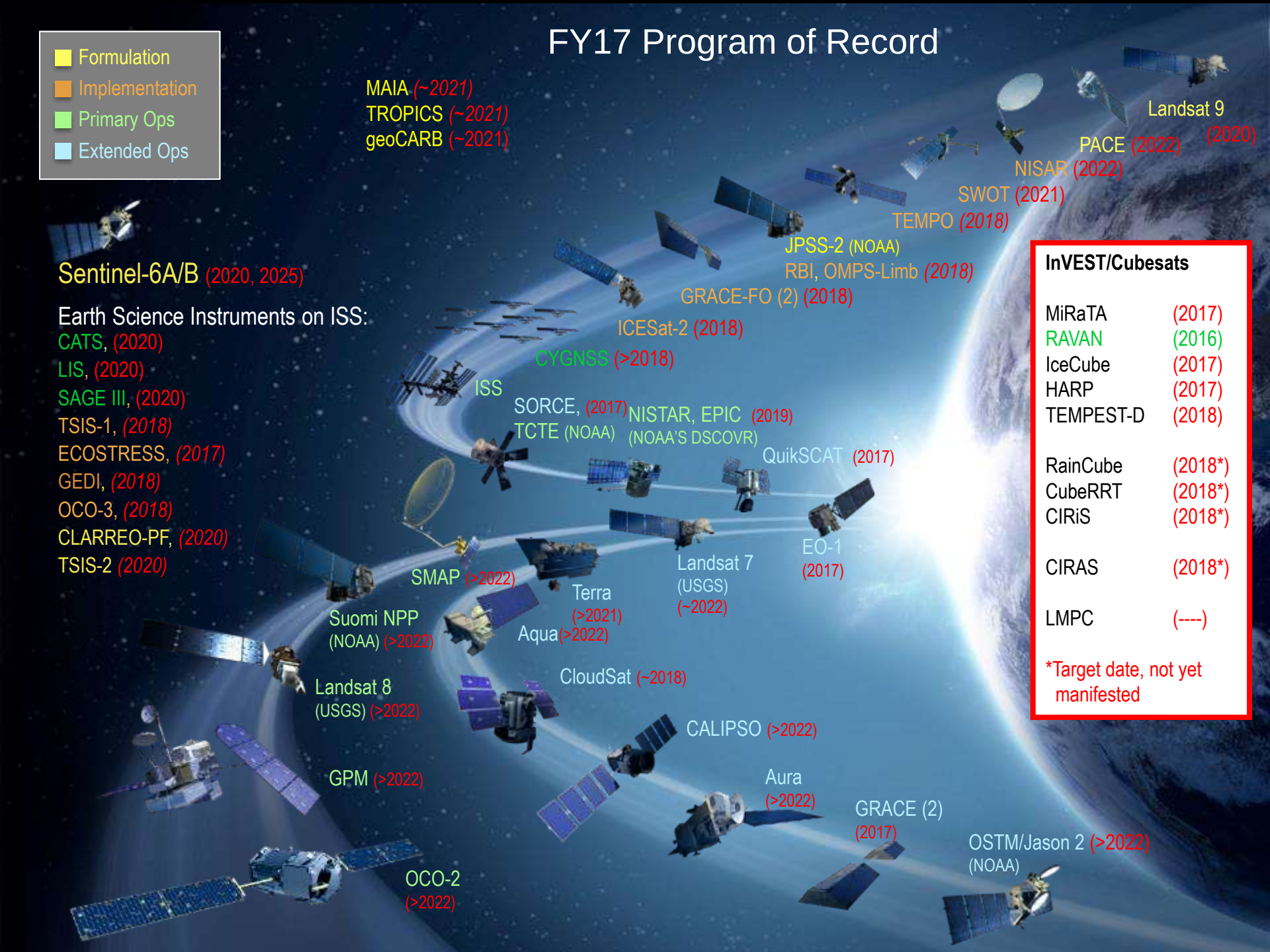
- FY17 (1 Oct 2016 – 30 Sept 2017) funding at FY16 level through 28 April 2017

- President's FY18 budget proposal **blueprint/overview** released **16 March 2017**
  - Proposes **FY18 ESD funding at $1.8B**
  - Proposes **termination** of analysis activities for **DSCOVR** EO instruments **EPIC, NISTAR**
  - Proposes **termination** of development activities for **OCO-3, PACE, CLARREO-PF**
  - Proposes **reduction** of ESD **research** activities for FY18

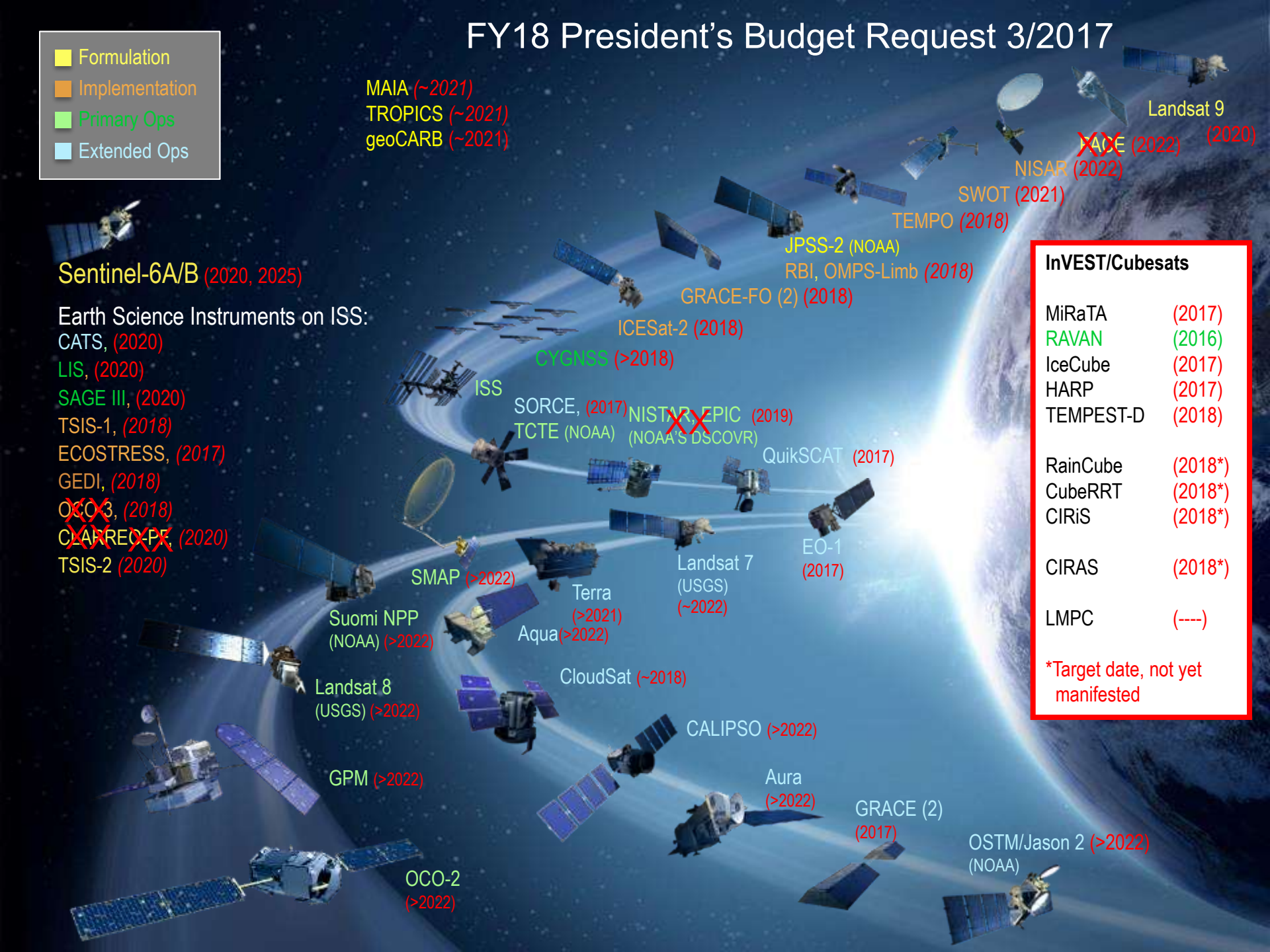
- President's ***detailed*** FY18 budget proposal to Congress expected **early-mid May, 2017**
  - Expected to be consistent with top-line ESD level and direction in the March blueprint

- ***CONGRESS*** must pass an appropriation for FY18, and it must be signed by the ***President***, by **1 Oct 2018** (or short-term *continuing resolutions* must be passed and signed)
  - Actual passed/signed appropriation is informed by – but possibly modified from – the President's detailed budget proposal

- **Decadal Survey report expected by 31 December 2017**


Formulation
Implementation
Primary Ops
Extended Ops
FY17 Program of Record
MAIA (~2021)
TROPICS (~2021)
geoCARB (~2021)
Landsat 9 (2020)
PACE (2022)
NISAR (2022)
SWOT (2021)
TEMPO (2018)
JPSS-2 (NOAA)
RBI, OMPS-Limb (2018)
GRACE-FO (2) (2018)
ICESat-2 (2018)
CYGNSS (>2018)
Sentinel-6A/B (2020, 2025)
Earth Science Instruments on ISS:
CATS, (2020)
LIS, (2020)
SAGE III, (2020)
TSIS-1, (2018)
ECOSTRESS, (2017)
GEDI, (2018)
OCO-3, (2018)
CLARREO-PF, (2020)
TSIS-2 (2020)
ISS
SORCE, (2017)
TCTE (NOAA)
NISTAR, EPIC (2019)
(NOAA'S DSCOVR)
QuikSCAT (2017)
EO-1 (2017)
Landsat 7 (USGS) (~2022)
SMAP (>2022)
Terra (>2021)
Aqua (>2022)
Suomi NPP (NOAA) (>2022)
CloudSat (~2018)
Landsat 8 (USGS) (>2022)
CALIPSO (>2022)
GPM (>2022)
Aura (>2022)
GRACE (2) (2017)
OSTM/Jason 2 (>2022) (NOAA)
OCO-2 (>2022)
InVEST/Cubesats
MiRaTA (2017)
RAVAN (2016)
IceCube (2017)
HARP (2017)
TEMPEST-D (2018)
RainCube (2018*)
CubeRRT (2018*)
CIRiS (2018*)
CIRAS (2018*)
LMPC (----)
*Target date, not yet manifested

FY18 President's Budget Request 3/2017



InVEST/Cubesats

MiRaTA	(2017)
RAVAN	(2016)
IceCube	(2017)
HARP	(2017)
TEMPEST-D	(2018)
RainCube	(2018*)
CubeRRT	(2018*)
CIRiS	(2018*)
CIRAS	(2018*)
LMPC	(----)

*Target date, not yet manifested

Mission Status

- ATLAS instrument delivered to Orbital-ATK on 5 Nov 2016.
- Integration with the spacecraft is complete and observatory testing is underway (EMI recently completed, dynamics testing starting).
- ATLAS will be removed and shipped back to GSFC for laser replacement in mid-July, with instrument-level testing continuing until Feb 2018.
- ATLAS will then be returned to Orbital-ATK, for a second round of limited observatory testing.
- Currently working toward a Sep 2018 launch readiness date.
- Ongoing discussion of possible CryoSat-2 orbit alignment with the post-launch ICESat-2 reference ground track to optimize coincident retrievals for estimation of sea ice thickness.
- Wednesday talk by Javier Sanchez: *Possible Extensions for the ESA Ice Mission CryoSat-2: Exploiting the CryoSat-2/ ICESat-2 Synergies.*

Earth Venture Overview

EVS
Sustained Sub-Orbital Investigations
(~4 years)

EVM Complete, self-contained, small missions
(~4 years)

EVI
Full function, facility-class instruments
Missions of Opportunity (MoO)
(~18 months)

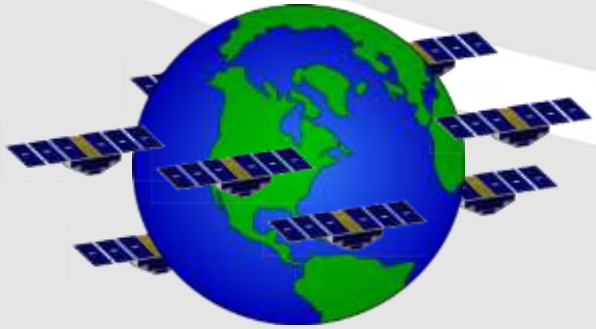
Mission	Mission Type	Release Date	Selection Date	Major Milestone
EV-1, aka EVS-1	5 Suborbital Airborne Campaigns	2009	2010	N/A
EVM-1, CYGNSS	Smallsat constellation	2011	2012	Launched December 2016
EVI-1, TEMPO	Geosynchronous hosted payload	2011	2012	Delivery NLT 2017
EVI-2, ECOSTRESS & GEDI	Class C & Class D ISS-hosted Instruments	2013	2014	Delivery NLT 2019
EVS-2	6 Suborbital Airborne Campaigns	2013	2014	N/A
EVI-3, MAIA & TROPICS	Class C LEO Instrument & Class D Cubesat Constellation	2015	2016	Delivery NLT 2021
EVM-2, geoCARB	Geostationary hosted payload	2015	2016	Launch ~2021
EVI-4	Instrument Only	2016	2017	Delivery NLT 2021
EVS-3	Suborbital Airborne Campaigns	2017	2018	N/A
EVI-5	Instrument Only	2018	2019	Delivery NLT 2023
EVM-3	Full Orbital	2019	2020	Launch ~2025
EVI-6	Instrument Only	2019	2020	Delivery NLT 2024

Open solicitation - In Review
Completed solicitation

CYGNSS: EVM-1 Homogeneous CONSTELLATION

Cyclone Global Navigation Satellite System (CYGNSS)

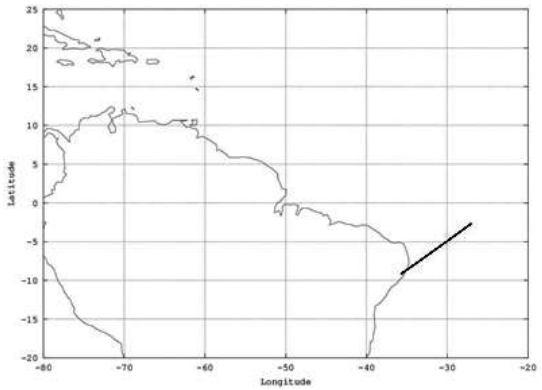
- Selected under Earth Venture Mission-1 AO
- 8-satellite Microsat Constellation measuring winds and air-sea interactions in tropical storms, using reflected GPS



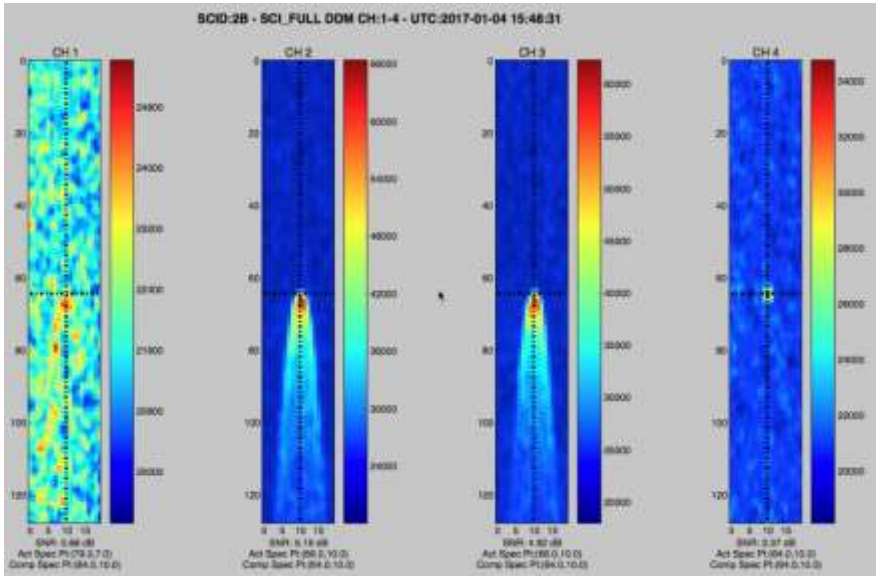
- **Launched successfully 15 Dec 2016**
- **All satellites working well – PLAR successful 23 March**
- PI-led (C. Ruf, U. Michigan, plus SWRI)

First Light DDM
Generated in Real Time by on-board processor

- **Delay Doppler Map measured by FM03 on 4 January 2017 at 15:48:31 UTC in the South Atlantic Ocean east of Brazil**
  - Channel 1: ocean DDM with low antenna gain
  - Channels 2-3: Good ocean DDMs
  - Channel 4: land DDM over Brazil

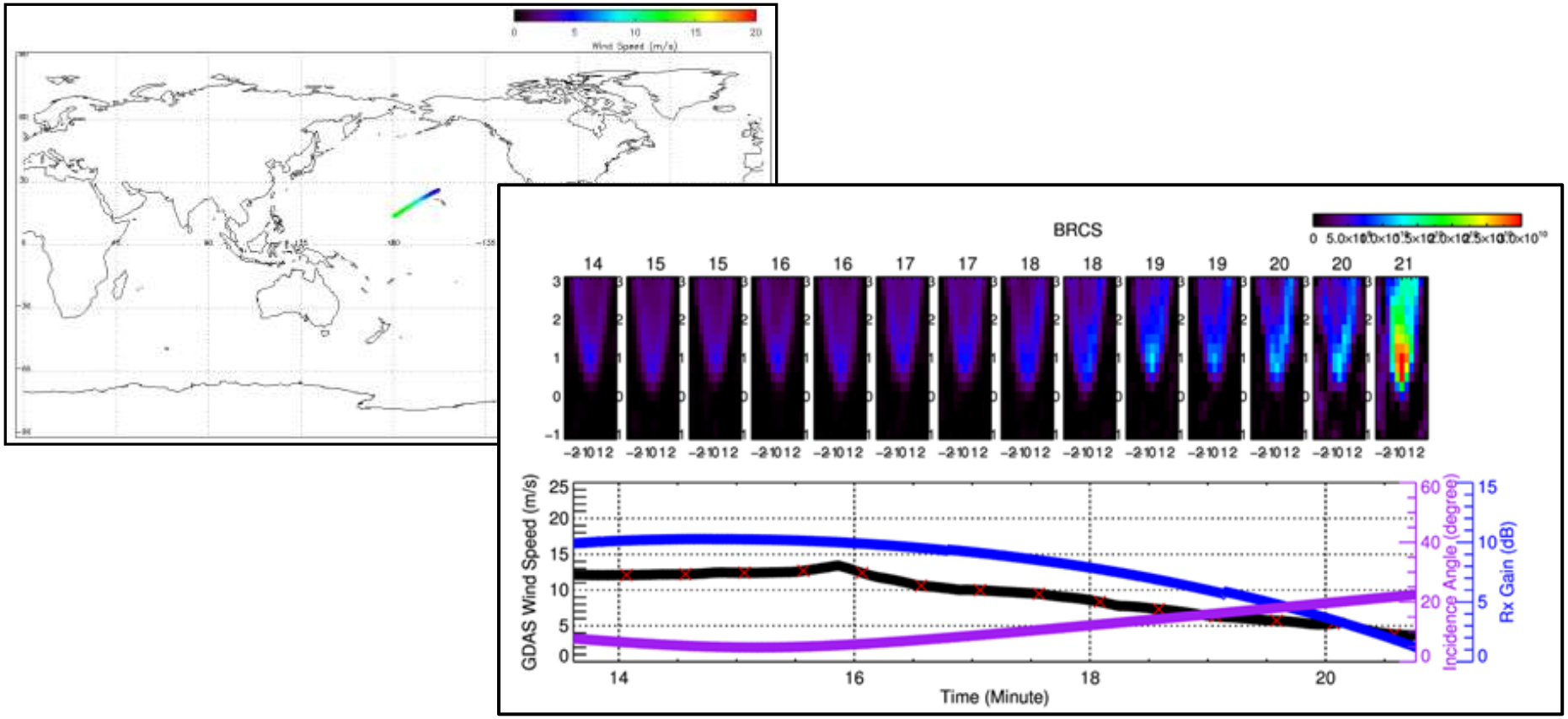


Specular point transect



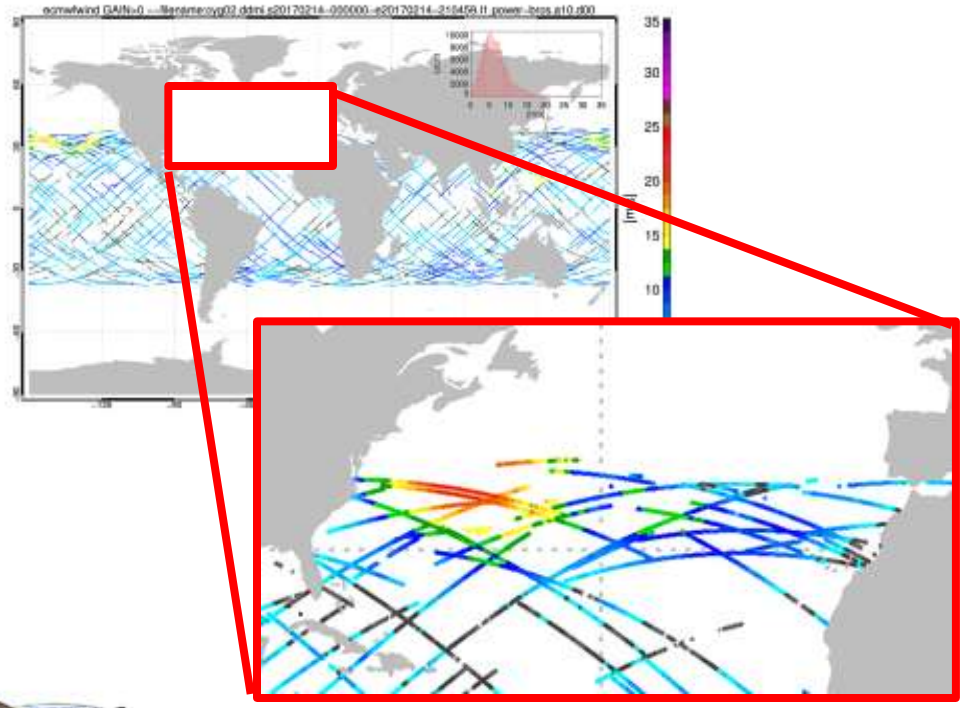
First DDM Matchups with Ground-truth Surface Winds

- FM06 on 21 Jan 2017; ECMWF wind speeds

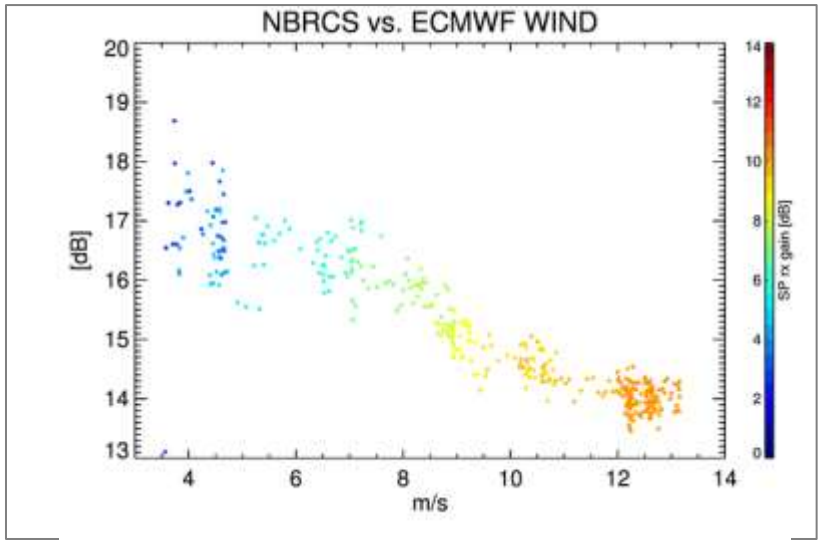


Early Cal/Val Data

- **Cal/val matchups over Atlantic extra-tropical storm**
- **Preliminary GMF looks very promising**



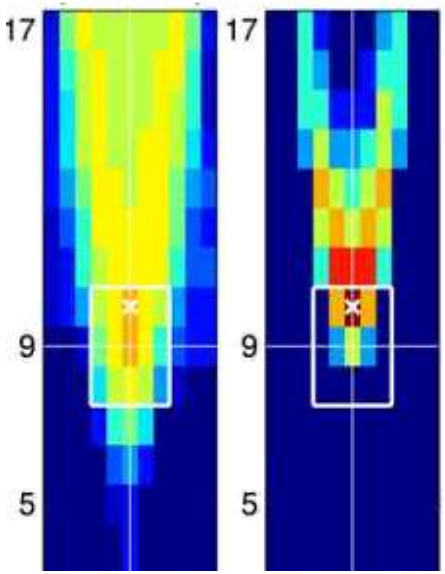
14 Feb 2017, ECMWF u_{10} @ FM02 track

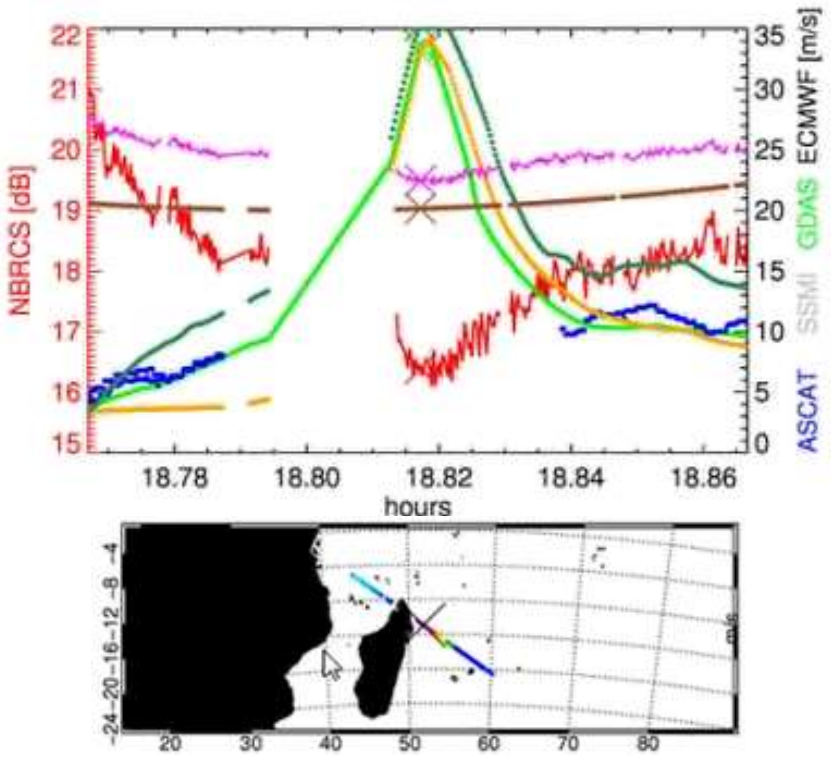


14 Feb 2017, FM02/ECMWF u_{10}

Direct Overpass of TC Enawo near Madagascar

- FM02 overpass of Tropical Cyclone Enawo on 6 March 2017 at 18:47 – 18:52 UTC
- Normalized bistatic radar scattering cross section (NBRCS, Level 1B science data product) along storm transect matched against GDAS ground truth winds
- JTWC reported Vmax = 56 m/s on 7 March at 06:00 UTC
- GDAS V_{max} = 34 m/s probably too low by 25-50%





BRCS (left)
Scattering Area (right)

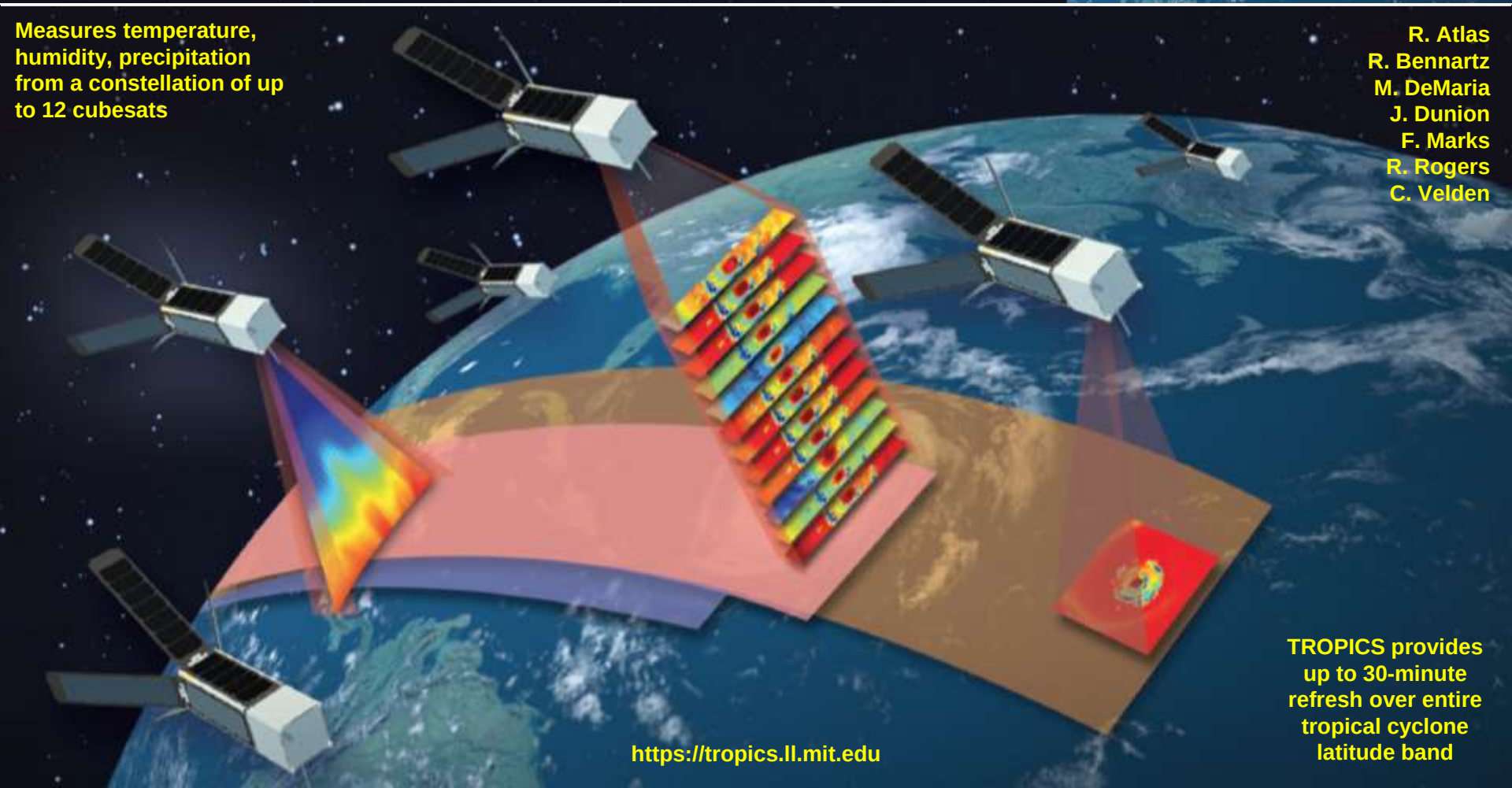
Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

MIT Lincoln Laboratory (lead organization)

William J. Blackwell, Principal Investigator. Scott Braun (NASA GSFC), Project Scientist

Measures temperature, humidity, precipitation from a constellation of up to 12 cubesats

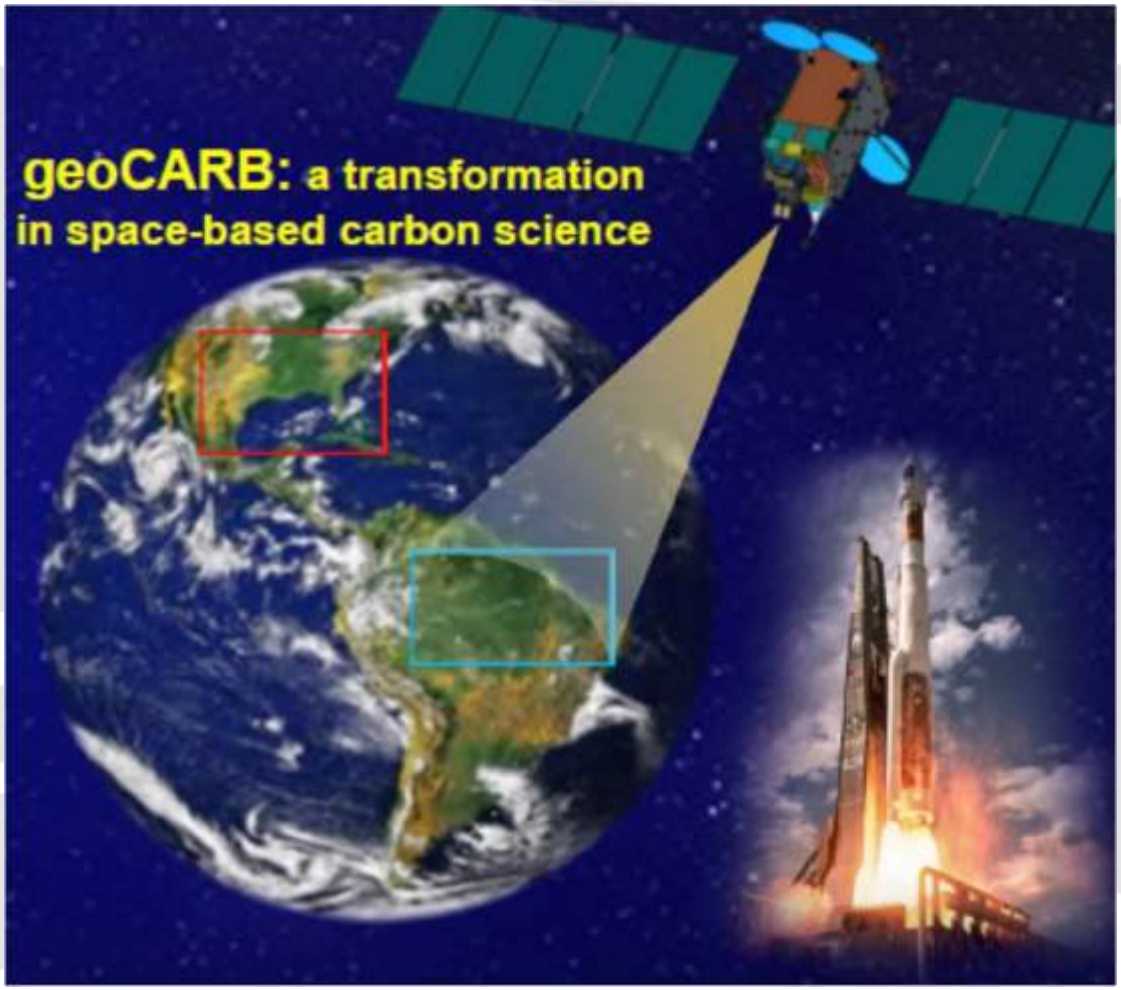
R. Atlas
R. Bennartz
M. DeMaria
J. Dunion
F. Marks
R. Rogers
C. Velden



https://tropics.ll.mit.edu

TROPICS provides up to 30-minute refresh over entire tropical cyclone latitude band

GeoCarb Selected by NASA for EVM-2



Berrien Moore, PI
University of Oklahoma

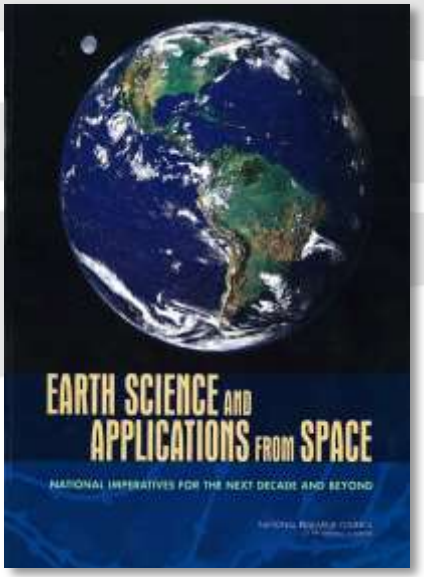
- First geostationary measurements of CO_2, CO, CH_4, and Solar Induced Fluorescence; 5-10 km resolution
- Hosted payload on an SES commercial communication satellite (PI-arranged hosting)
- Lockheed Martin Advanced Technology Center (Palo Alto);Colorado State University (Fort Collins); ARC; GSFC; JPL

2017 EARTH SCIENCE & APPLICATIONS DECADAL SURVEY

The Decadal Survey remains on track for completion in late December, 2017

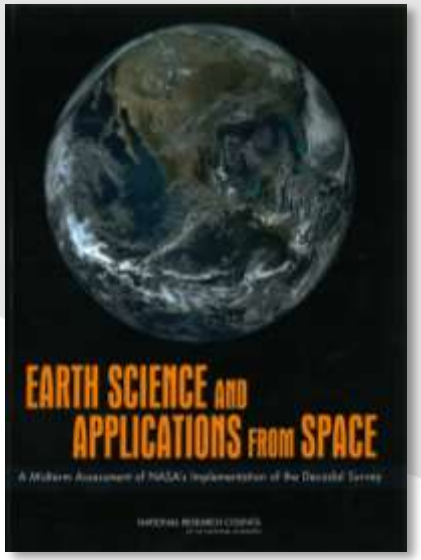
- Addresses NASA, NOAA, and USGS
- Likely to recommend science priorities rather than named missions with specific capabilities

- Anticipate NASA road-mapping studies for several years to define the realistic resulting mission suite and partnerships



2007

2010



2012