NASA's Plans for Greenhouse Gas Observations from Space

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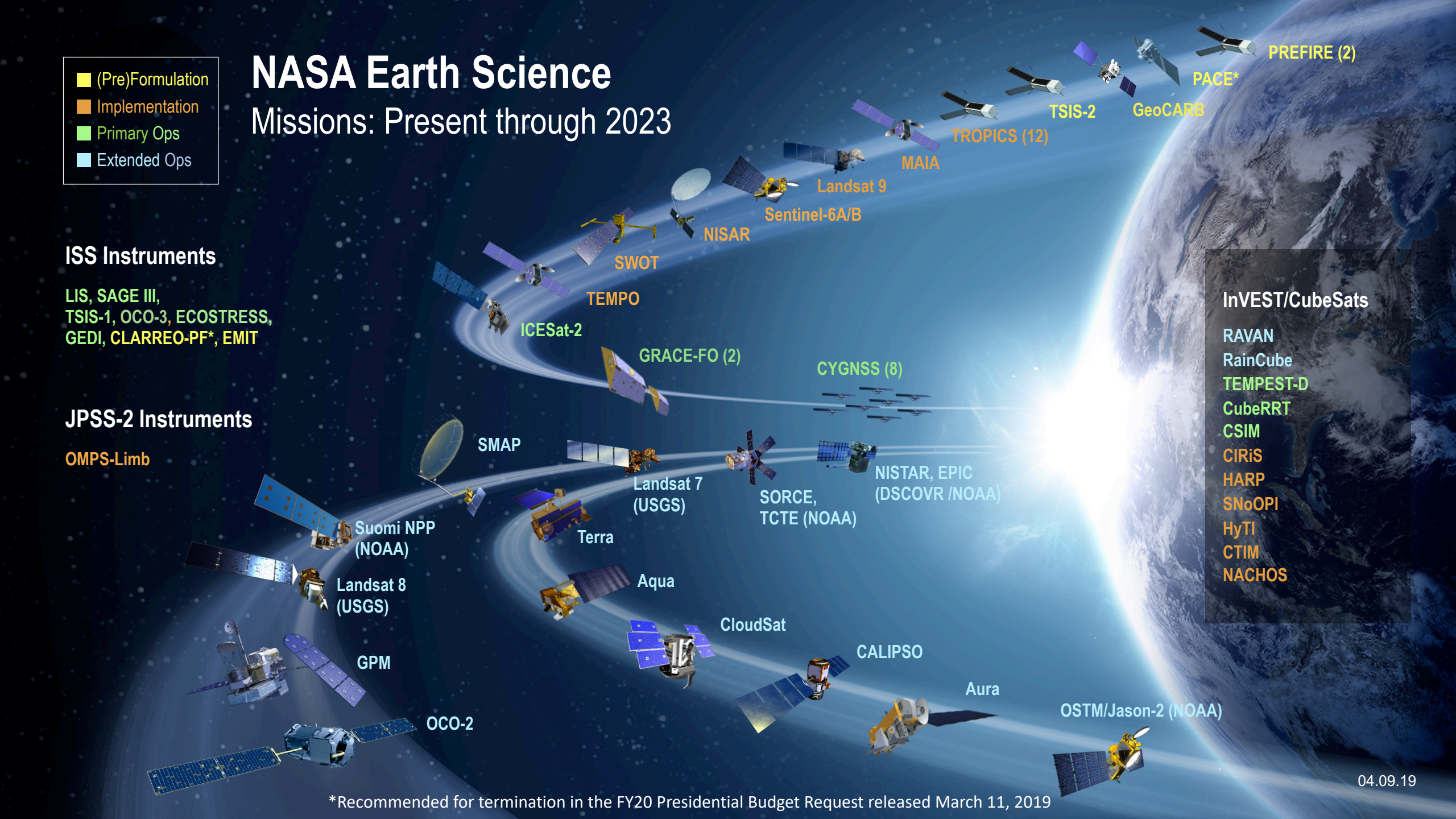
NASA Headquarters

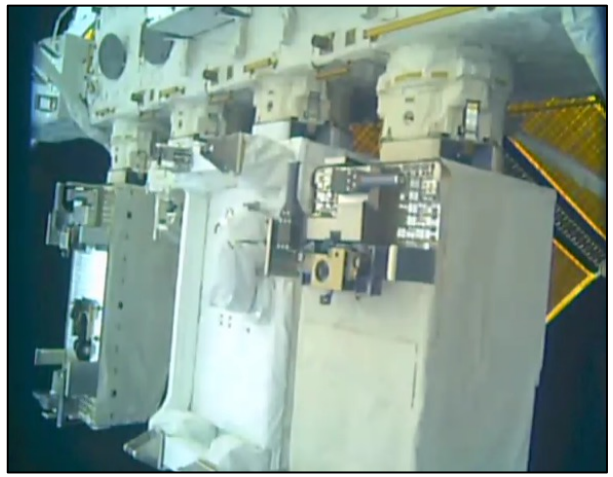

(Pre)Formulation
Implementation
Primary Ops
Extended Ops
NASA Earth Science
Missions: Present through 2023
ISS Instruments
LIS, SAGE III,
TSIS-1, OCO-3, ECOSTRESS,
GEDI, CLARREO-PF*, EMIT
JPSS-2 Instruments
OMPS-Limb
PREFIRE (2)
PACE*
GeoCARB
TSIS-2
TROPICS (12)
MAIA
Landsat 9
Sentinel-6A/B
NISAR
SWOT
TEMPO
ICESat-2
GRACE-FO (2)
CYGNSS (8)
SMAP
Landsat 7
(USGS)
SORCE,
TCTE (NOAA)
NISTAR, EPIC
(DSCOVR /NOAA)
Suomi NPP
(NOAA)
Terra
Aqua
Landsat 8
(USGS)
CloudSat
CALIPSO
GPM
Aura
OCO-2
OSTM/Jason-2 (NOAA)
InVEST/CubeSats
RAVAN
RainCube
TEMPEST-D
CubeRRT
CSIM
CIRiS
HARP
SNoOPI
HyTI
CTIM
NACHOS
04.09.19
*Recommended for termination in the FY20 Presidential Budget Request released March 11, 2019

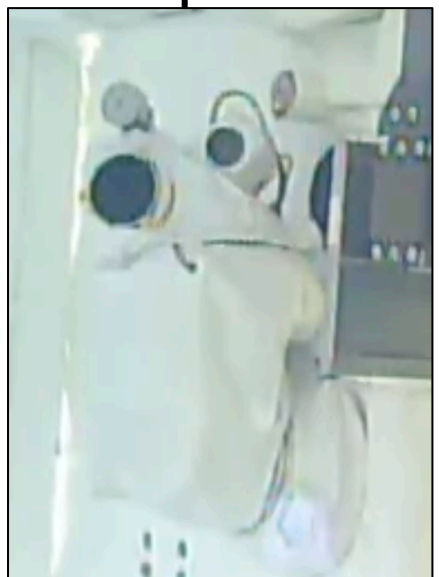
OCO-2 and plans for the future

- OCO-2 has officially outlived its planned lifetime.
- OCO-2 WILL be proposing for continuation of ”Extended” operations as part of the NASA Earth Science Senior Review process in 2020.
  - The assumption is that, if the satellite is still returning science quality data, NASA will approve continued operations.
  - Science quality data are demonstrated **BEST** by published papers!
  - OCO-2 went through this process in 2017 as well.
- The observatory is now starting to show its age.
  - A reaction wheel is quickly “dying”. The spacecraft can operate in star tracker mode to maintain pointing capability.

OCO-3 is NOW on the ISS

- OCO-3 is approaching the end of its decontamination phase of IOT.
- All systems tested to date have been nominal.
- The detectors are cooled VERY soon, at which time, we will see First Light!
- IOT will complete some time in July, then 3+ years of operations!





GeoCARB

- GeoCARB successfully passed the criteria for the Preliminary Design Review in February of 2019.
  - This was delayed because the US Government decided to give US Federal employees a WELL deserved paid vacation, whether we wanted one or not…
- The next step is the Key Decision Point-C (or KDP-C) review at Headquarters.
  - Passing this gate commits the agency budget for the mission, allowing the project to proceed toward payload build and launch. It's a BIG deal!
  - The challenge for the project is to convince Science Mission Directorate officials (my bosses) that is has sufficient budget and schedule reserve to finish the project.
  - There ARE challenges ahead!

Where does NASA go next with regards to GHG observations?

- Does anyone know? If so, can you tell me? Please?
- The future has been ”defined” for us by the recently released Decadal Survey.
  - It affirms, yet replaces, the Decadal Survey released in 2007.
- This DS did not recommend missions with a coarse outline of what the mission should look like. Instead it defines observables that are required to address important science questions.
  - Each science question came with a prioritization ”value”, which helped to define the priority for the various observables.
  - 5 of these observables were given the 5 highest priority for NASA over the next decade.

What happened to the “missions” recommended by the past Decadal that NASA did not get to?

- In particular for GHG observations…What about ASCENDS?
- All “Pre-Formulation” activities from the last DS were concluded with summaries of the findings presented in reports for each “mission”.
- The ASCENDS report can be found at: https://ntrs.nasa.gov/search.jsp and search for ASCENDS.
- Any ”continuation” of these pre-formulation activities depends on the level of recommendation of the observable “priority”.
- Which brings us to GHGs and the next DS…

GHG gases were places in the 2nd tier of priority for NASA

- The 5 “Designated Observables”, given the highest priority for NASA to do over the next decade are: Aerosols; Clouds, Convection and Precipitation; Mass Change, Surface Biology and Geology, and Surface Deformation.
- In the “Earth System Explorer” class were: Greenhouse Gases, Ice Elevation, Ocean Surface Winds and Currents, Ozone and Trace Gases, Snow Depth, Terrestrial Ecosystem Structure, Atmospheric Winds.
  - These are PI-led, competitively selected, complete missions.
- With NASA’s current budget, an Explorer Class mission solicitation won’t be released for at least 3 years.
  - Budgets are expected to be in the $350M (full mission) range.

These are the “descriptions” of the 5 Directed Observables and the 6 Explorer Class (now 7) “Observables”.

We are Here!

Targeted Observable	Science/Applications Summary	Candidate Measurement Approach	Designated	Explorer	Incubation
Aerosols	**Aerosol properties, aerosol vertical profiles, and cloud properties** to understand their effects on climate and air quality	Backscatter lidar and multi-channel/multi-angle/polarization imaging radiometer flown together on the same platform	X		
Clouds, Convection, and Precipitation	**Coupled cloud-precipitation state and dynamics** for monitoring global hydrological cycle and understanding contributing processes including cloud feedback	Radar(s), with multi-frequency passive microwave and sub-mm radiometer	X		
Mass Change	**Large-scale Earth dynamics** measured by the changing mass distribution within and between the Earth’s atmosphere, oceans, ground water, and ice sheets	Spacecraft ranging measurement of gravity anomaly	X		
Surface Biology and Geology	**Earth surface geology and biology,** ground/water temperature, snow reflectivity, active geologic processes, vegetation traits and algal biomass	Hyperspectral imagery in the visible and shortwave infrared, multi- or hyperspectral imagery in the thermal IR	X		
Surface Deformation and Change	**Earth surface dynamics** from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	X		
Greenhouse Gases	**CO_2 and methane fluxes and trends,** global and regional with quantification of point sources and identification of sources and sinks	Multispectral short wave IR and thermal IR sounders; or lidar**		X	
Ice Elevation	**Global ice characterization** including elevation change of land ice to assess sea level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar**		X	
Ocean Surface Winds and Currents	**Coincident high-accuracy currents and vector winds** to assess air-sea momentum exchange and to infer upwelling, upper ocean mixing, and sea-ice drift	Doppler scatterometer		X	
Ozone and Trace Gases	**Vertical profiles of ozone and trace gases** (including water vapor, CO, NO_2, methane, and N_2O) globally and with high spatial resolution	UV/Vis/IR microwave limb/nadir sounding and UV/Vis/IR solar/stellar occultation		X	
Snow Depth and Snow Water Equivalent	**Snow depth and snow water equivalent** including high spatial resolution in mountain areas	Radar (Ka/Ku band) altimeter; or lidar**		X	
Terrestrial Ecosystem Structure	**3D structure of terrestrial ecosystem** including forest canopy and above ground biomass and changes in above ground carbon	Lidar**		X	

So, where does that leave us?

- We STILL have THREE missions measuring Greenhouse Gas concentrations!!!
  - OCO-3 will go for at least 3 years.
  - OCO-2 will operate for as long as it is STILL returning science quality data.
  - GeoCARB will launch in the 2023(ish) time frame.
- Groups can wait until an Explorer solicitation is released, hope they win among the 6 science areas that may be solicited, then wait the 5-6 years for their mission to go through formulation and development.
- Or…

There is ALWAYS the Earth Venture Class route

- That is EXACTLY how we got GeoCARB!
- There is a 4th class of Venture Class that has been recommended by the Decadal Survey, Earth Venture Continuity (EVC).
  - The thought is that these solicitations will be interlaced with the Earth Venture Instrument solicitations.
  - CO_2 observations have gone on long enough now that they would certainly qualify for a science argument of data record continuity.
- EVM and EVI will continue, though EVI solicitations may be released at a lower time rate now that we have EVC.

- The challenge for doing GHGs through the EV route is the limited budgets for each of these. **ALL** the EVs we have put through development have had significant budget pressures.

What about other agency missions?

- These provide both an opportunity and a hinderance for those who want a new GHG mission in the distant future.
- Because most space agencies now are adopting an open data policy, the data are MUCH more open to the entire scientific community, which means the data are open to YOU!
  - Given the timing of GHG missions being discussed by other agencies, the community should have effective continuity of observations for quite some time!
- But, for those who want to propose their own missions, the existence of these missions COULD dilute the urgency of NASA selecting another GHG mission within the next decade.

- So, my advice is, to help increase the urgency of continuing such observations is to…

Publish Your Results!!!