



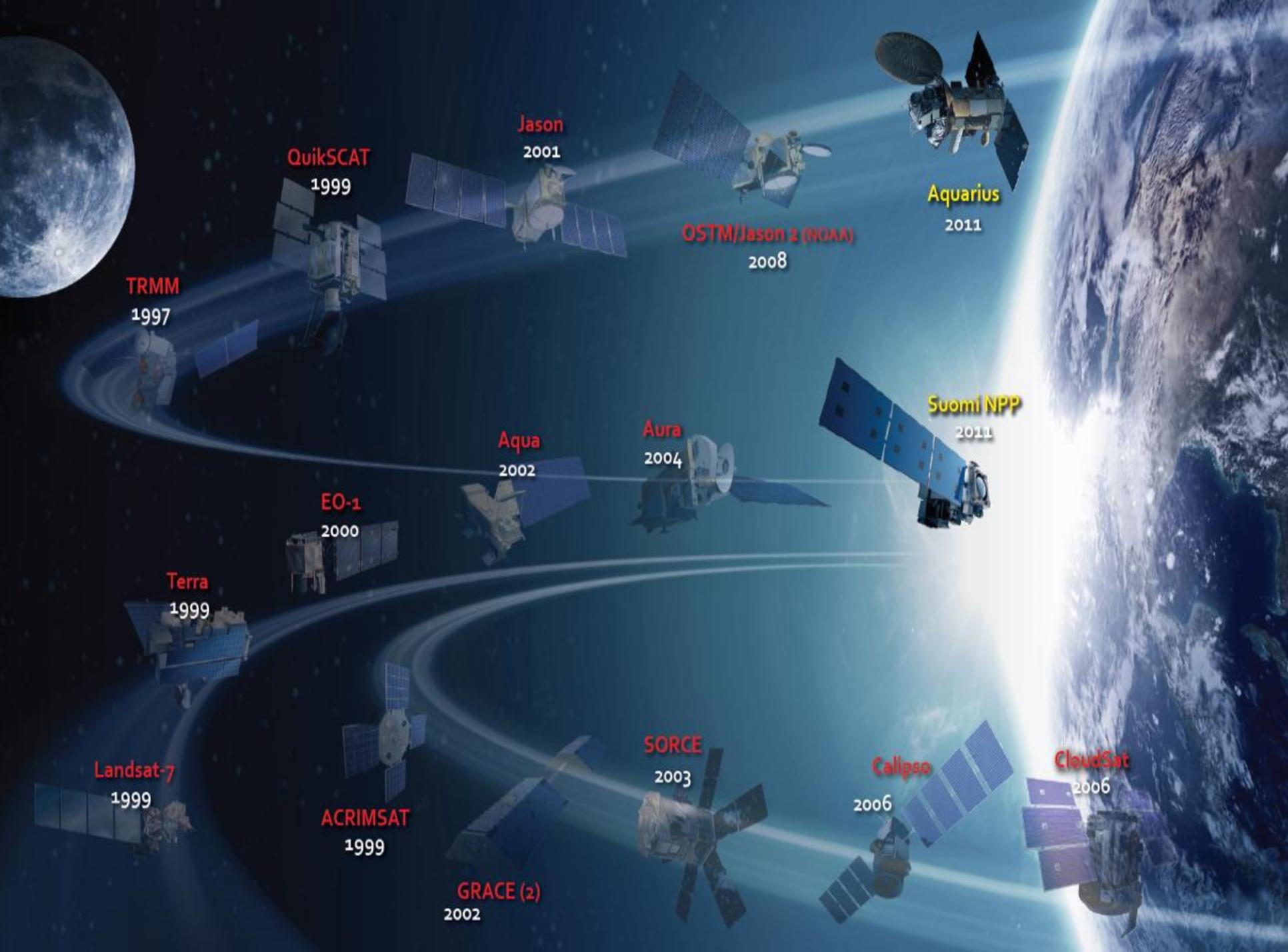
# **CMS and Decision Support Discussion Forum:** Current and Near-term Satellite Assets

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**TRMM**  
1997

**QuikSCAT**  
1999

**Jason**  
2001

**OSTM/Jason 2 (NOAA)**  
2008

**Aquarius**  
2011

**Aqua**  
2002

**Aura**  
2004

**Suomi NPP**  
2011

**EO-1**  
2000

**Terra**  
1999

**Landsat-7**  
1999

**ACRIMSAT**  
1999

**GRACE (2)**  
2002

**SOFIE**  
2003

**Calipso**  
2006

**CloudSat**  
2006



Surface Water Ocean  
Topography  
> 2020

SWOT

EV-2

EV-1

Ice, Cloud, and  
Elevation Satellite  
early 2016

ICESat II

Soil Moisture Active Passive  
late 2014

SMAP

Orbiting  
Carbon  
Observatory-3  
> 2016

OCO-2 Orbiting Carbon Observatory-  
2  
late 2014

OCO-3

Landsat Data  
Continuity Mission  
February 2013

LDCM

Active Sensing of CO<sub>2</sub>  
Emissions over Nights,  
Days, and Seasons  
> 2021

ASCENDS

SAGE-III (on ISS)

Pre-Aerosol, Clouds,  
and ocean Ecosystem  
> 2020

PACE

GRACE-FO

Gravity Recovery and  
Climate Experiment-  
Follow-on  
> 2017

Stratospheric Aerosol  
and Gas Experiment-III  
(ISS)  
late 2014

GPM  
Global Precipitation  
Measurement  
Mission  
February 2014

# Satellite Measurements of Carbon (1)



- Land Cover and Terrestrial Ecosystem Properties (systematic global time series)
  - Maps of land cover and vegetation type; quantification of land cover change, disturbance, and regrowth
  - Estimates of vegetation greenness and productivity
  - Detection of active fires, burned area, and fire emissions
- Ocean Color and Ecosystem Properties (systematic global time series)
  - Estimates of chlorophyll concentration and productivity to infer carbon uptake/export to the deep ocean
  - Estimates of phytoplankton carbon for improved estimates of carbon stocks
  - Estimates of  $p\text{CO}_2$  for air-sea  $\text{CO}_2$  fluxes
- Other Earth Surface Properties
  - Land surface freeze-thaw status (from microwave sensors) to estimate growing season length (a key control on annual carbon uptake/release) at high latitudes
  - Land surface inundation duration and extent (from microwave sensors) to estimate methane ( $\text{CH}_4$ ) fluxes from wetlands



- **Vegetation Canopy Volume, Height , and Vertical Profile**
  - Regional/global measurements of vegetation volume scattering to estimate aboveground carbon storage in low biomass vegetation types (Radar)
  - Globally distributed sampling measurements of canopy height and vertical profile to accurately estimate aboveground carbon storage (Lidar)
- **Atmospheric Carbon Dioxide (CO<sub>2</sub>) Concentration**
  - Coarse resolution estimates of CO<sub>2</sub> high in the atmosphere to improve/constrain atmospheric models
  - Accurate and precise estimates of CO<sub>2</sub> in the total atmospheric column, with good sensitivity to CO<sub>2</sub> low in the atmosphere, to locate and quantify surface sources and sinks of carbon



# NASA'S Carbon-Measuring Satellites

- **Satellites Currently in Orbit** (some missions recently ended):

**Aqua**  
**Aura**  
**Terra (MOPPITT - CO)**

**Landsat-7**  
**Terra**  
**Aqua**  
**SeaWiFS (ended)**  
**ICESat (ended)**  
**Suomi NPP**

**EO-1**  
**QuikSCAT (ended)**

- **Missions in Formulation and Implementation:**

**OCO-2**

**LDCM**  
**ICESat-2**

**SMAP**

- **Decadal Survey Missions:**

**ASCENDS**

**DESDynI**  
**ICESat-2**  
**HyspIRI**  
**ACE (also PACE)**  
**GEO-CAPE**  
**LIST**

**SMAP**  
**SCLP**

Legend:  
— Greenhouse Gases  
— Carbon Stocks  
— Supporting Observations

# Non-U.S. Satellites



- **Satellites Currently in Orbit:**

**GOSAT (JAXA)**

**SPOT/VEGETATION (CNES)**

**Resourcesat-2 (India)**

**Oceansat-2 (India)**

**CBERS (China-Brazil)**

**Metop - AVHRR (Eumetsat)**

**ALOS-2 – PALSAR (JAXA)**

**SMOS (ESA)**

**GCOM-W - AMSR (JAXA)**

- **Missions in Formulation and Implementation:**

**Sentinel-1 – SAR (ESA)**

**Sentinel-2 – HR optical (ESA)**

**Sentinel-3 – Ocean color (ESA)**

**Metop – AVHRR (Eumetsat)**

**GCOM-C (JAXA)**

**Other follow-ons . . .**

- **Missions in Pre-Formulation (early conceptual planning):**

**CarbonSat (ESA)**

**Biomass (ESA)**

**Many others . . .**

	<b>Greenhouse Gases</b>
	<b>Carbon Stocks</b>
	<b>Supporting Observations</b>

- **EDR -- Environmental Data Record (aka. L2)**
- VIIRS Ice Surface Temperature EDR
- VIIRS Imagery Band (01 to 05) EDR
- VIIRS Land Surface Temperature EDR
- VIIRS Near Constant Contrast Imagery EDR
- VIIRS Net Heat Flux EDR
- VIIRS Ocean Color/Chlorophyll EDR
- VIIRS Sea Ice Characterization EDR
- VIIRS Sea Surface Temperature EDR
- VIIRS Snow Cover/Depth Binary Map EDR
- VIIRS Snow Cover/Depth Snow Fraction EDR
- VIIRS Surface Albedo EDR
- VIIRS Surface Type EDR
- VIIRS Suspended Matter EDR
- VIIRS Vegetation Index EDR
- **VIIRS Day Night Band SDR**



# Topics for Discussion

- How well do we know our current and near-term future EO flight portfolio for carbon science?
  - Missions and Instruments
    - US: NASA and other agencies
    - Non-US: ESA, CNES, JAXA, India, China, others.
  - What would a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis look like?
- Are we generating the appropriate data products from current assets to answer important and emerging questions?
  - Data – Models – Knowledge
  - Ex: Land cover and land use are not the same. Can we generate use-based products that inform carbon and H<sub>2</sub>O modeling?
- Carbon, H<sub>2</sub>O, and Nitrogen cycles are critically linked. How well are we integrating analyses and creating EO products to inform them?
  - NPP, decomposition, biomass, methane generation etc..