

**STATEMENT OF DELIVERABLES IN SUPPORT OF THE 2015 GEOSS**  
**BY**  
**THE COMMITTEE ON EARTH OBSERVATION SATELLITES**  
(VERSION FOR INTERNAL CEOS REFERENCE)

**V1.0**  
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**INTRODUCTION & PURPOSE**

The establishment of the Group on Earth Observations (GEO) in 2005 as a strong focus for coordination among the Earth observations community provided additional impetus and direction for the Committee on Earth Observation Satellites (CEOS). CEOS was recognised as the space component of GEO, with responsibility for implementation of the space segment of the Global Earth Observation System of Systems (GEOSS).

CEOS has since aligned much of its resources and capacity in support of GEO, supporting a wide range of Tasks and Components identified in the GEO Work Plan, participating in GEO Implementation Boards, Data Sharing Working Group, Post- 2015 Working Group, and GEO Ministerial Summit Working Group.

2015 marks the conclusion of the first 10-year implementation plan for the GEOSS and it is assumed that the entire community must make the case for continued, indeed expanded support for realization of the GEOSS – including demonstration of the return on investment during the first 10 years. This paper has therefore been developed by CEOS to communicate the nature and extent of the contribution of CEOS to the GEOSS by 2015, with an emphasis on outcomes and deliverables that can be clearly recognised and understood beyond the GEO community.

**SCOPE & CONTENTS**

As a system of systems, the GEOSS is intended to make a broad range of observing assets function as a coordinated, harmonised whole that provides information products and services across valued societal benefit areas. As an organisation that comprises 31 space agencies, along with 24 national and international user organisations (as of November 2013), CEOS provides the primary coordination framework related to the planning and provision of satellite Earth observations (EO). CEOS Agency governments fund, build and operate a diverse range of EO satellite missions in support of different spheres of society, including meteorology, climate, and a diverse range of research, operational and commercial activities. CEOS Agencies are operating or planning around 260 satellites with an Earth observation mission over the next 15 years. These satellites will carry over 760 observing instruments. The full extent and scale of this contribution can be explored and understood using the CEOS EO Handbook and database, and is thus not described here.

The focus of this paper is on the outcomes and deliverables resulting from the coordination effort invested through CEOS itself, and in particular from the subsidiary groups which CEOS identifies as its ‘delivery teams’ – the Virtual Constellations and Working Groups, as well as the coordination groups dedicated to the major GEO programmes of the Global Forest Observations Initiative (GFOI), and the GEO Global Agricultural Monitoring initiative (GEOGLAM).

**The CEOS Virtual Constellations (VCs):** In support of GEO objectives and as a space component of GEOSS, in 2006 CEOS developed the concept of virtual, space-based Constellations around four prototype Constellations. A CEOS Virtual Constellation is a set of space and ground segment capabilities operating together in a coordinated manner, in effect a virtual system that overlaps in coverage in order to meet a combined and common set of Earth Observation requirements for specific domains. The individual satellites and ground segments can belong to a single or to multiple owners. The Constellation concept builds upon or serves to refocus already existing projects and activities. The Constellations effort 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. In 2013, CEOS has seven Virtual Constellations:

- Atmospheric Composition (AC-VC);
- Land Surface Imaging (LSI-VC);
- Ocean Colour Radiometry (OCR-VC);
- Ocean Surface Topography (OST-VC);
- Ocean Surface Vector Wind (OSVW-VC);
- Precipitation (P-VC);
- Sea Surface Temperature (SST-VC).

**The CEOS Working Groups (WGs):** The WGs are the other delivery mechanism within CEOS and these address: cross-cutting topics that are shared across a wide range of Earth observation domains, such as calibration/validation, improved search and access to EO data, and data portals; as well as thematic areas – such as climate applications, and disaster reduction, response, and risk management. Their activities are intimately connected with, and complementary to, the work of the Virtual Constellations and are structured to respond to requirements from GEO and other internal and external organisations. In November 2013, CEOS has five Working Groups:

- Working Group on Information Systems & Services (WGISS);
- Working Group on Calibration & Validation (WGCV);
- Working Group on Capacity Building & Data Democracy (WGCapD);
- Working Group on Climate (WGClimate) – jointly between CEOS and the Coordination Group for Meteorological Satellites (CGMS);
- Working Group on Disasters (WGDisasters).

Each of the seven VCs and five WGs have identified specific, tangible outcomes and deliverables that are expected to result from their work by the close of the GEOSS 10-year implementation period in 2015. These are reported below under the following headings:

- space segment;
- ground segment and information systems;
- products and services.

## **2015 SPACE SEGMENT**

The CEOS database (<http://database.eohandbook.com>) forecasts that by mid-2015, approximately 90 EO satellites carrying more than 270 instruments will be in operation by CEOS space agencies. The scope of GEOSS in 2015 can be expected to include many of these systems and the products and services that they provide. CEOS has placed special emphasis on the coordination of the space segment of the domains covered by the seven VCs, each with its own recognised user communities and societal benefits. Each of the VCs coordinates a diverse, yet focused, set of EO instruments/missions to enable a coherent set of information products that has value beyond the products of the individual missions. Some (such as OST-VC, OCR-VC, and SST-VC) emphasise continuity and scientific integrity of specific

measurements that require specialized observations, or combinations of observations, whilst others (including AC-VC and LSI-VC) emphasise the development of products and services for multiple applications.

The 2015 outcomes of the space segment coordination by each of the seven VCs can be summarised as follows:

**Atmospheric Composition:** The AC-VC exists to sustain a systematic capability to provide essential observations of atmospheric composition from space. The emphasis of this VC is on provision of important products and services derived from:

- a working constellation of ozone instruments;
- a working constellation of greenhouse gas instruments;
- a working constellation of instruments providing volcanic ash eruption monitoring services.

By 2015, all of the AC-VC core missions will be operating (Metop-A/B, POES series, Suomi NPP, OCO-2, ISS/SAGE-III, GOSAT & FY-3, Sentinel-5 P). A plan will also be in place by 2015 for operation of a geostationary air quality constellation. In 2015, the AC-VC can be considered as fulfilling the main user requirements with respect to observing ozone, greenhouse gases, and providing volcanic ash alert services.

**Land Surface Imaging:** The LSI-VC exists to sustain a systematic capability to provide essential observations of the global land surface from space. By 2015, the large majority of the LSI-VC core missions (which focus on those with free and open data policies) will be operating (Landsat-8, CBERS-4, Sentinel-1A, Sentinel-2A, Suomi NPP, SAOCOM-1A, ALOS-2) providing unprecedented global coverage capacity of land surface imaging observations. These systems will be operated in a coordinated way that supports the space data requirements of two major GEO initiatives – the Global Forest Observations Initiative (GFOI – whose global acquisition strategy is dependent on the LSI-VC) and the GEO Global Agricultural Monitoring Initiative (GEOGLAM – Phase 1 of which CEOS recently agreed to support).

**Ocean Colour Radiometry:** The OCR-VC exists to sustain a systematic capability to provide satellite observations of ocean colour radiometry (OCR) - the only measurement capability available that provides synoptic information for the global ocean related to ecological and biogeochemical processes, and a crucial measurement in support of ocean research and multiple applications. In 2015, the OCR-VC can be considered to be partially fulfilling the main user requirements, with a number of the current core missions predicted to have concluded operations by then (Terra, Aqua and Oceansat-2). Some follow-on systems are assumed to continue or commence operations (Suomi NPP, Oceansat-3); and some new series are hoped to have started (Sentinel-3, GCOM-C1).

**Ocean Surface Topography:** The OST-VC exists to sustain a systematic capability to observe the surface topography of the global oceans. These observations are central to understanding the dynamics of the oceans, assessing the ocean's role in climate, and sustaining a robust ocean forecast capability. The OST-VC core missions are defined around a reference mission (with higher precision and accuracy) and complementary missions to enhance the spatial/temporal sampling. In 2015, the OST-VC can be considered as fulfilling the main user requirements with the continued operation and further launches of the Jason series, complementary measurements from SARAL, Cryosat-2, HY-2 series and anticipated launch of Sentinel-3A.

**Ocean Surface Vector Wind:** The OSVW-VC exists to foster the best quality Ocean Surface Vector Wind data for applications in short, medium, and decadal time scales in the most efficient manner through international collaboration, scientific innovation, and rigor. In 2015,

the OSVW-VC can be considered as fulfilling the main user requirements with the continued operation of the VC core missions of the Metop and Oceansat series, and with the anticipated launches of the Rapidscat and CFOSat missions before then.

**Precipitation:** The P-VC exists to sustain and enhance a systematic capability to observe and measure global precipitation. Of the core missions that are the priority for coordination efforts by the P-VC, TRMM will have ended or be near the end of its operations by 2015. However, by that time, the GPM Core should be launched and well into its first year of operations bringing new capabilities for sensing light and solid precipitation, global coverage, and most importantly serving as the inter-calibration reference for improvement of the accuracy and consistency of precipitation estimates from all constellation radiometers. Additionally, DMSP F19 should be launched and operational in 2015. GCOM-W1, Megha-Tropiques, NOAA-19, MetOP-B, and S-NPP are expected to continue operations. As a result, in 2015 the P-VC can be considered to be substantially fulfilling the main user requirements.

**Sea Surface Temperature:** The SST-VC exists to foster the best quality sea surface temperature data and their availability for applications across all relevant spatial and temporal scales in the most effective and efficient manner through international collaboration, scientific innovation, and rigor. By 2015, the large majority of the missions that the SST-VC has identified as core will be operating (POES, GOES, Suomi-NPP, INSAT, Sentinel 3, Metop, GCOM-W1, Meteor, FY and HY) and the main user requirements should be fully met by the VC.

Illustrations of the 2015 state of the space segment of each of the VCs and their core systems are contained in Annex A to provide a quick reference.

In addition to the definition of these Virtual Constellations typically focused on individual, important measurements, by 2015 the CEOS Working Group on Climate will have defined and started to coordinate the implementation of a consistent Climate Monitoring Architecture to address the requirements and Essential Climate Variables (ECVs) expressed by the Global Climate Observing System (GCOS). This will provide guidance as to the space segment implementation required to satisfy these requirements.

## **2015 GROUND SEGMENT & INFORMATION SYSTEMS**

WGISS leads efforts within CEOS to generally improve the ability to discover, access and exploit the data products and services resulting from the satellite missions of CEOS Agencies, including interoperability among the main agency data systems and those of GEO and CEOS.

**The CEOS International Directory Network (CEOS IDN: <http://idn.ceos.org>)** descriptions of more than 15,000 data collections from CEOS agencies (with over 9,000 data collections tagged as “GEOSS Data Core” which means that they are easily accessible with very low impediments to access by the general user) that can be discovered from the GEO Portal, and CEOS has committed to its systematic use, update and improvement for registration of all existing and future CEOS agency datasets.

**The CEOS WGISS Integrated Catalogue (CWIC: <http://wgiss.ceos.org/cwic>)** provides access to many CEOS Agencies’ EO inventory data systems using commonly supported catalogue standards. Currently CWIC provides search and access to over 1,800 data collections, tagged as “GEOSS Data Core”, and over 50 million data granules, providing a major access point to satellite data for GEO and the GEO users. Additional data collections will continue to be made accessible from CWIC.

**The Federated Earth Observation) system (FedEO: <http://fedeo.esa.int/web/guest>)** provides access to many European agencies’ EO data.

Individual CEOS Agencies will continue to maintain their substantial data systems in support of their national programmes and these will be recognised as major contributions to the GEOSS. CEOS is undertaking a number of initiatives to optimise the accessibility and benefits of these various systems that will be realised by 2015, including **OpenSearch** – which is a collection of simple formats for the sharing of search results. The CEOS OpenSearch team is establishing a common CEOS interoperability best practice in order to allow for standardized and harmonized access to metadata and data of all CEOS Agencies.

The specific systems being enhanced and developed will improve the search and access to satellite data and will be a contribution to the GCI and these systems include IDN, CWIC and FedEO explained above. The CEOS IDN, CWIC and FedEO are being integrated in the GCI, and accessed by the GEO components (Geo Web Portal, GEO Discovery & Access Broker - DAB).

**The CEOS Missions, Instruments & Measurements database (MIM: <http://database.eohandbook.com>)** provides information on all CEOS Agency EO missions and links to data holdings.

**The CEOS Data Policy Portal (<http://www.ceos-datapolicy.org>)** is intended to capture the data access policies of CEOS Mission and Instrument combinations in order to promote improved access to data and GEOSS Data Sharing Principles.

A number of the CEOS VCs will have dedicated information portals available in service of their particular user communities. Many will also have significant activities in relation to calibration and validation support among missions and agreed methodologies.

An inventory of Essential Climate Variables (ECVs) supported by CEOS Agency activities will also be available by 2015, including through the CEOS MIM. This will be used to conduct a gap analysis of ECVs and recommend mitigation strategies. The ECV inventory was designed to gather metadata content in conjunction with the GEOSS Common Infrastructure (GCI) requirements, including discovery through the GEO DAB. An initial analysis of compatibility has already been completed and found that 60% of the ECV-related resources were registered in the GCI as GEOSS Data-CORE and provided additional important feedback to improve the compatibility of ECV inventory data sets with the GCI.

WGCV leads CEOS efforts on calibration and validation of member agency satellites and by 2015 has committed to define a series of CEOS/WGCV Test Sites for system harmonization and interoperability. Both satellite and in situ data will be collected at these sites.

## **PRODUCTS & SERVICES**

The combined list of products and services to be delivered by CEOS by 2015 in support of the GEOSS is as follows:

### **Atmosphere**

- Demonstration of a multi-sensor volcanic eruption alert service in support of the aviation community (AC-VC);
- multiple Essential Climate Variable (ECV) products, including ozone, greenhouse gases (in progress) (multiple VCs and WGClimate);
- products and services in support of society's needs for carbon-related information – being identified in the Carbon Task Force plan;
- GHG measurements for end-user applications;
- multi-sensor precipitation products for climate, water cycle, and severe weather research and for disasters, water, weather, agriculture, and health societal benefit areas. (P-VC);
- plans in place for a geostationary air quality constellation (AC-VC);

## **Land**

### *Forests*

- coordinated land surface acquisitions of the world's forested areas in support of the Global Forest Observations Initiative, 68 countries (108 Mkm<sup>2</sup>) in 2015 in a managed growth plan for global coverage by 2016;

### *Agriculture & Food Security*

- coordinated land surface acquisitions of the crop lands of the world's largest agricultural producer countries in support of GEOGLAM, 20 countries (1.7 Mkm<sup>2</sup>) for GEOGLAM Phase 1 (Phase 2 countries will be included by 2015 but are TBD), and management of scaling and phasing to a global operational system by the end of 2017;
- coordinated radar acquisitions of technical demonstrator sites (for the Asia-RiCE component of GEOGLAM to assist capacity building around rice crop monitoring and food security);
- ongoing input to the monthly food security outlook reports of the Agricultural Market Information System (AMIS) initiated by the G-20;

### *Disasters*

- new end products and services from the Floods pilot, to better deliver flood related information and to validate satellite EO data and products with end users (WGDisasters);
- a range of new products from the Seismic Hazards pilot, including maps of active faults at the global scale, continued intensive observations of GEO Supersites, and advanced science products for rapid earthquake response; (WGDisasters);
- new products from the Volcanoes pilot, including new protocols and products over active volcanoes and operational monitoring over large scale eruptions (WGDisasters);
- The CEOS Disaster Recovery Observatory will be developed to make available as much geospatial data as possible that may be of use in the immediate aftermath of a major disaster and for a period of a number of years after the event. (WGDisasters)

### *Climate*

- multiple Essential Climate Variable (ECV) products, as identified in the ECV inventory such as surface albedo and fraction of photosynthetically active radiation

The LSI-VC will provide data distribution services via the LSI Explorer for terrestrial data of CEOS Agencies.

## **Ocean**

- multiple Essential Climate Variable (ECV) products, including Sea Surface Height, Sea Surface Temperature, Sea Surface Winds, and Ocean Colour (the VCs);
- an SST Climate Data Assessment Framework (CDAF), for evaluating the characteristics of SST datasets to be designated as ECVs or Climate Data Records (CDRs);
- a range of products and services on different spatial and temporal scales for operational, industrial, and research uses resulting from the coordination efforts of the four VCs dedicated to observations of the ocean; Products include Level 2 products, gridded Level 3 datasets, and multi-sensor, gap-filled Level 4 analysis products to meet the range of user requirements;
- implementation of the INSITU-OCR (supporting an in-situ sensor calibration and data validation network for ocean colour measurements) including setting up a multi-agency INSITU-OCR Project Office (OCR-VC).

The WGCapD will also provide:

- in conjunction with the EOPOWER project, an inventory of capacity building activities focused on space-derived data and incorporate these activities into an online, searchable resource facility;
- Digital Elevation Models workshops with high resolution data

The WGCV will lead implementation of QA4EO – the CEOS Quality Assurance Framework for Earth Observation (QA4EO) and will be providing Pilots and Showcases for key GEO SBAs. QA4EO will deliver quality parameter measurement and process guidelines.

## **CONCLUSIONS**

This statement of deliverables for the 2015 GEOSS by the components and initiatives of CEOS highlights the diversity and scale of the activities in which space agencies are investing, through the CEOS framework for the benefit of GEO. It is hoped that this statement will provide insights as to the balance of output - and the substantive nature of the output - resulting from CEOS activities. It can hopefully assist the development of the first version of the new 3-year CEOS Work Plan and the establishment of future priorities for coordination by CEOS.

A second, more concise, version of this document has been prepared for the purposes of external communication by CEOS – including in support of the upcoming GEO Plenary and Ministerial.

## **ANNEX A**

CEOS Virtual Constellations: 2015 Status of the Core Missions in the Space Segment in Support of the GEOSS

# Annex A

## CEOS Virtual Constellations

2015 status of the core missions in the  
space segment in support of the GEOSS



# CEOS Virtual Constellation for Atmospheric Composition (AC-VC)

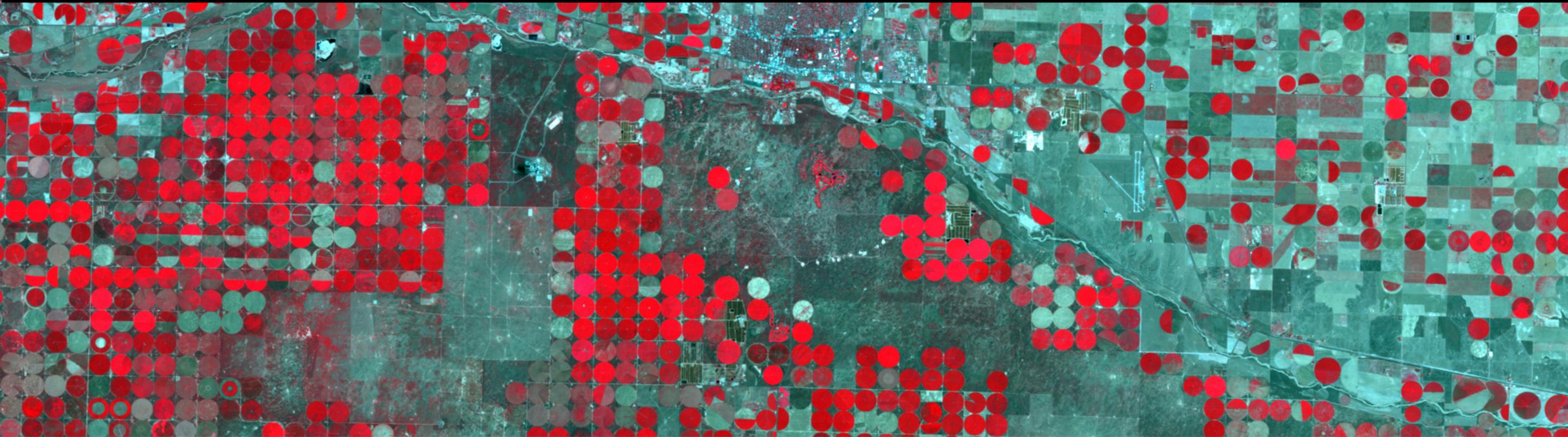
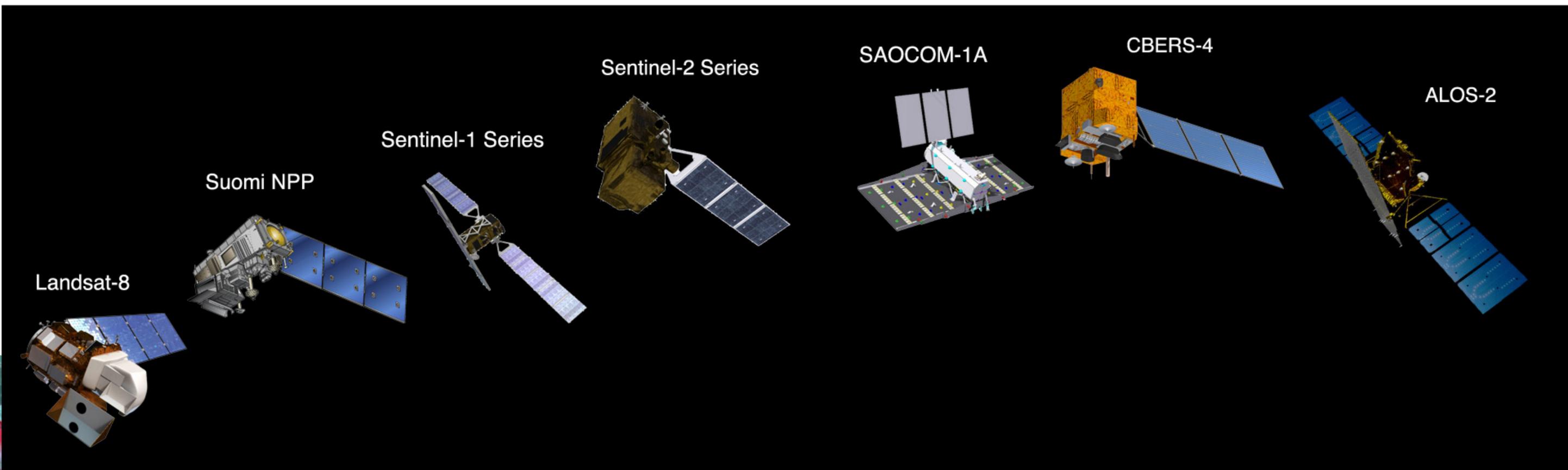
*Monitoring the ozone layer, air quality and climate-related changes in the atmosphere*



2015 status: Most core missions operating providing services in ozone, greenhouse gases & volcanic eruption alert

# CEOS Virtual Constellation for Land Surface Imaging (LSI VC)

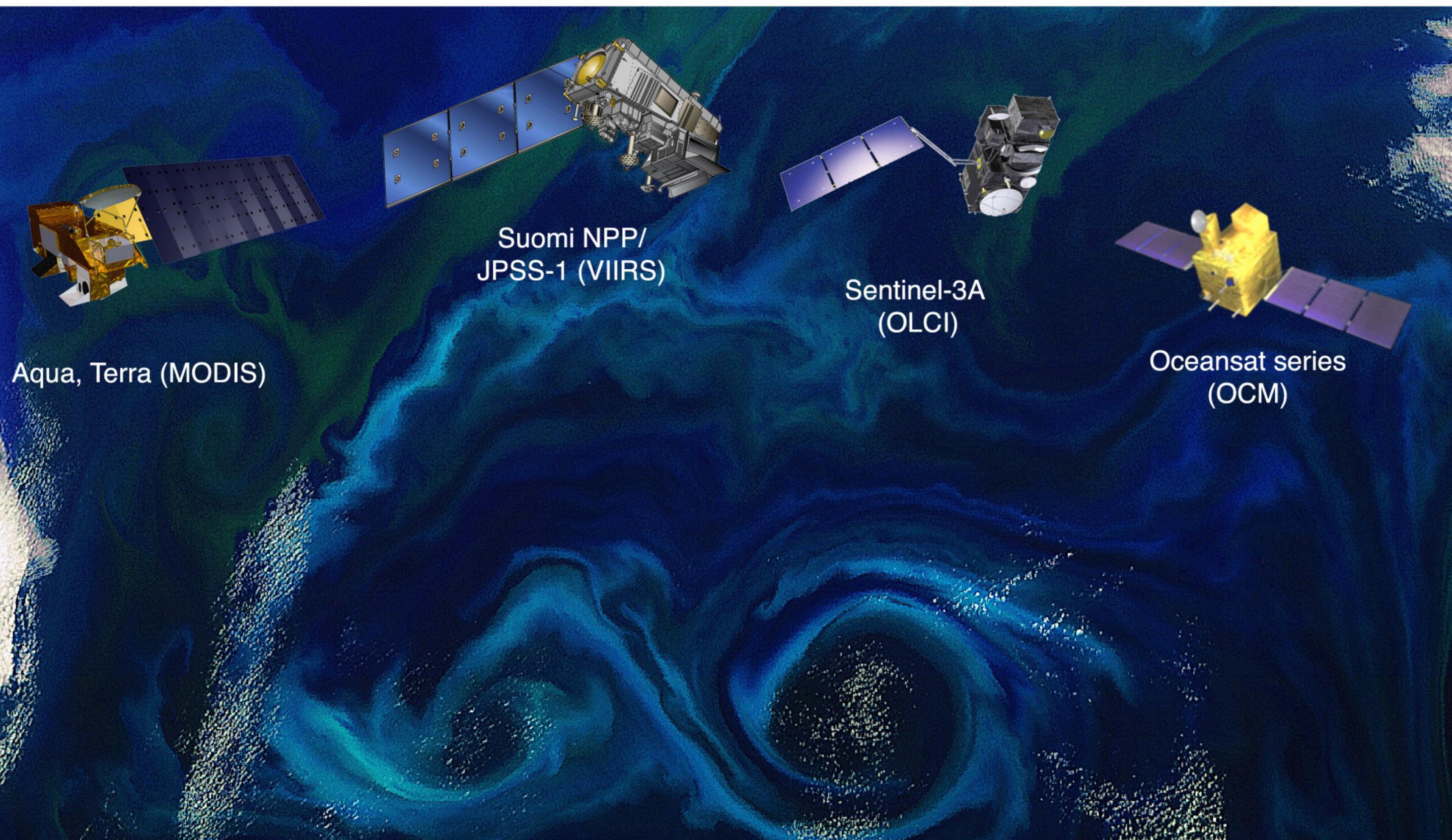
Systematic observations of the global land surface for multiple societal benefits including food security & forest management



2015 status: Most core missions operating and providing unprecedented global coverage

# CEOS Virtual Constellation for Ocean Color Radiometry (OCR-VC)

*Sustaining a systematic capability of satellite observations of ocean colour radiometry  
in support of ocean research and multiple applications*



Aqua, Terra (MODIS)

Suomi NPP/  
JPSS-1 (VIIRS)

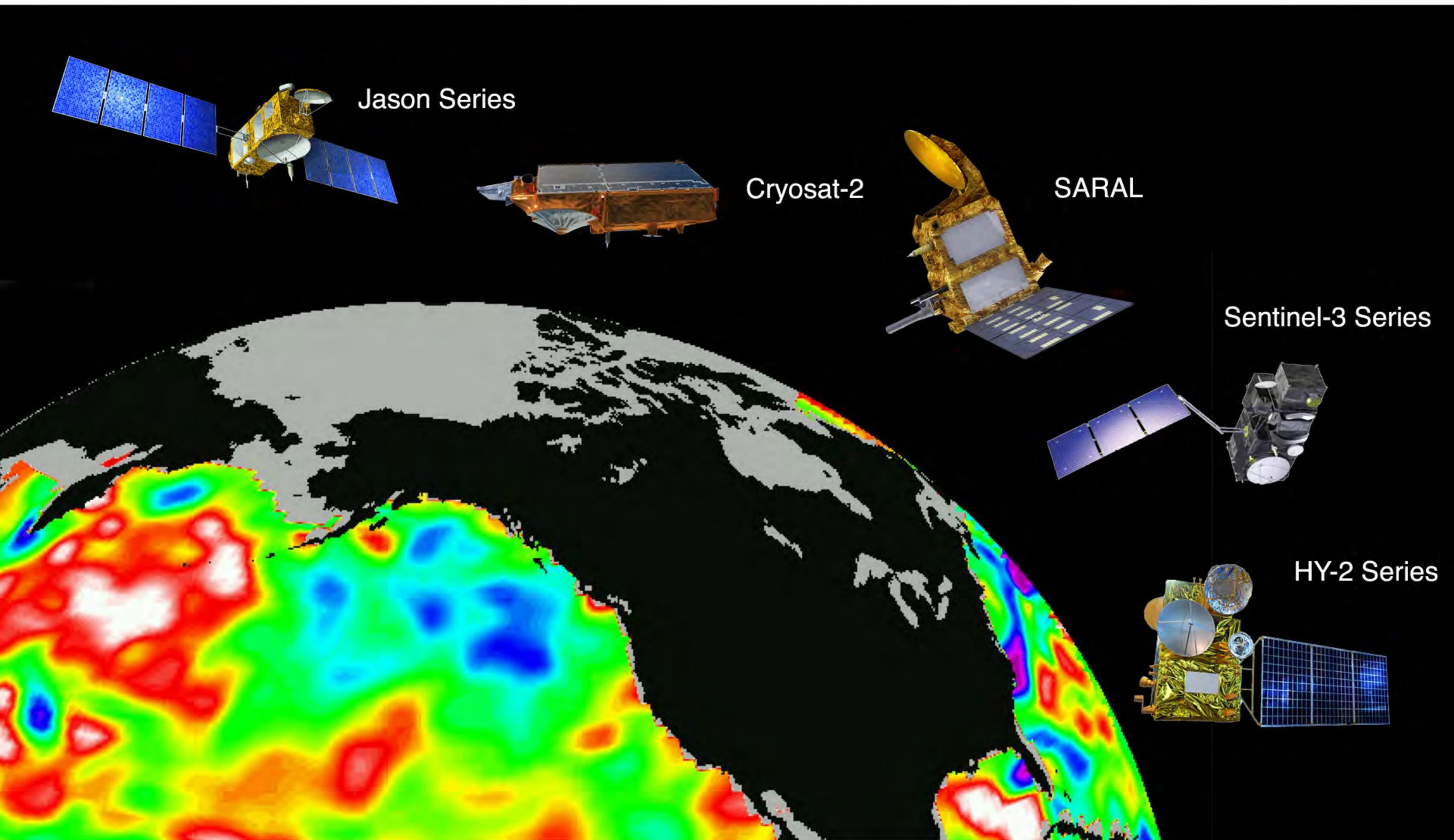
Sentinel-3A  
(OLCI)

Oceansat series  
(OCM)

*2015 status: Partially fulfilling the main user requirements - a number of core missions due to conclude prior*

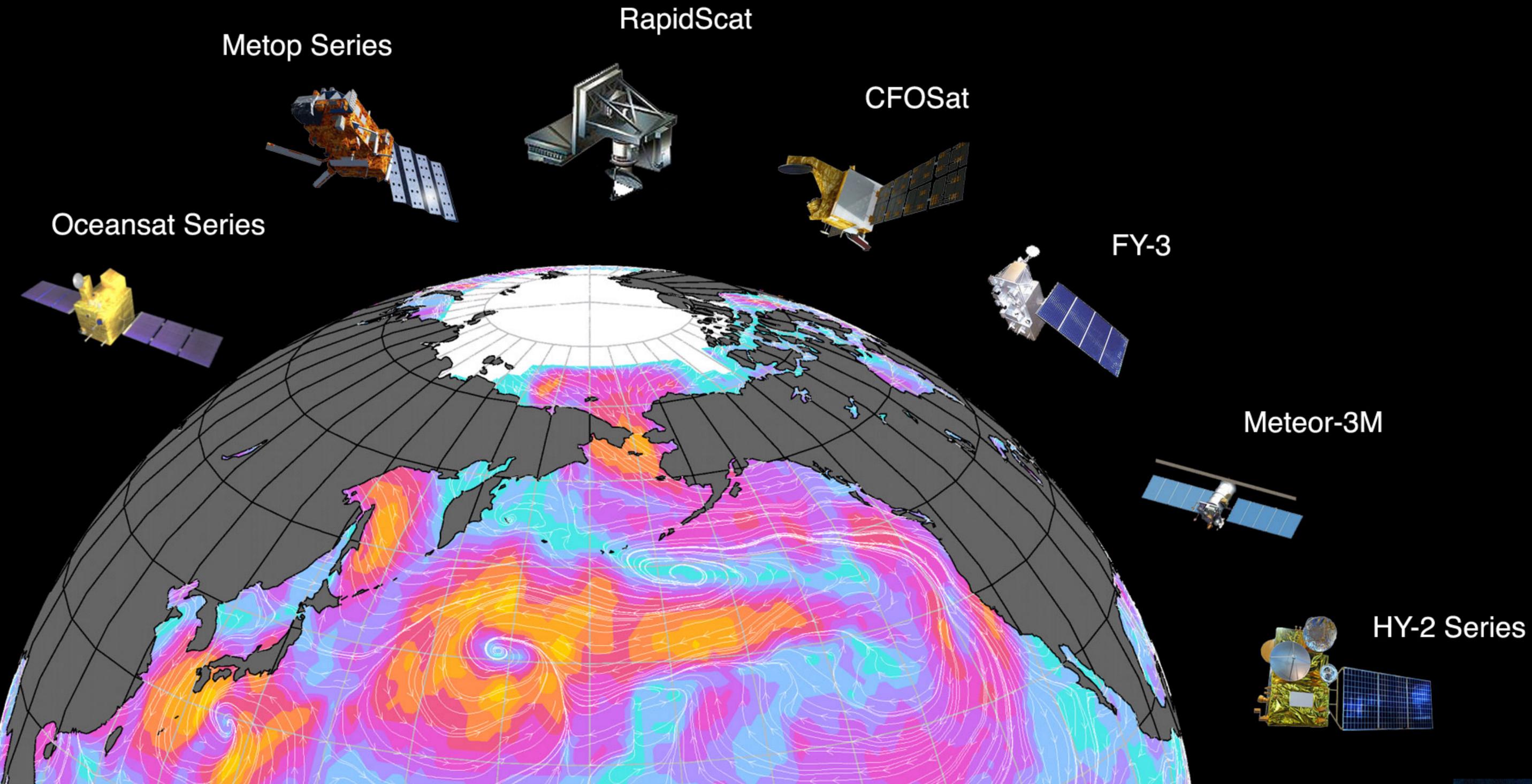
# CEOS Virtual Constellation for Ocean Surface Topography (OST-VC)

Sustained observations for understanding of ocean dynamics, climate applications & robust ocean forecasting



# CEOS Virtual Constellation for Ocean Surface Vector Wind (OSVW-VC)

Supporting the meteorology, oceanography, operational and R&D communities with sustained observations of ocean surface winds.



2015 status: Fulfilling main user requirements with continued operation of Metop & Oceansat and launches of RapidScat & CFOSat

# CEOS Virtual Constellation for Precipitation (P-VC)

Sustaining and enhancing a systematic capability to observe and measure global precipitation.



2015 status: Substantially fulfilling main user requirements with launch of GPM Core

# CEOS Virtual Constellation for Sea Surface Temperature (SST-VC)

*Providing best quality SST data for wide application through international collaboration, scientific innovation, and rigor*

Polar orbiting missions with passive microwave SST capability



Polar orbiting missions with infrared SST capability



Geostationary meteorological missions with infrared SST capability



# List of Core Missions and sponsoring agencies of the CEOS Virtual Constellations

## AC-VC

Suomi NPP (NASA/NOAA)  
POES Series (NOAA)  
FY-3 (NSMC-CMA/NRSCC)  
Sentinel-5P (ESA/NSO)  
Metop Series (EUMETSAT/  
NOAA/CNES/ESA)  
OCO-2 (NASA)  
GOSAT (JAXA/MOE/NIES)

## LSI-VC

Landsat-8 (USGS/NASA)  
Suomi NPP (NASA/NOAA)  
CBERS-3 (INPE/CRESDA)  
Sentinel-1 Series (ESA/EC)  
Sentinel-2 Series (ESA/EC)  
SAOCOM-1A (CONAE/ASI)  
ALOS-2 (JAXA)

## OCR-VC

Aqua (NASA/JAXA/INPE)  
Terra (NASA/METI/CSA)  
Suomi NPP (NASA/NOAA)  
Sentinel-3A (ESA/  
EUMETSAT/EC)  
Oceansat Series (ISRO)

## OSVW-VC

Oceansat Series (ISRO)  
Metop Series (EUMETSAT/  
NOAA/CNES/ESA)  
RapidScat (NASA)  
CFOSat (CNES/CNSA)  
FY-3 (NSMC-CMA/NRSCC)  
Meteor-3M (ROSHYDROMET  
/ROSKOSMOS)  
HY-2 Series (NSOAS/CAST)

## OST-VC

Jason Series (NASA/NOAA/  
CNES/EUMETSAT)  
Cryosat-2 (ESA)  
SARAL (CNES/ISRO)  
Sentinel-3 Series (ESA/  
EUMETSAT/EC)  
HY-2 Series (NSOAS/CAST)

## P-VC

Metop Series (EUMETSAT/NOAA/  
CNES/ESA)  
POES Series (NOAA)  
JPSS (NOAA)  
DMSP (NOAA/USAF)  
GCOM-W Series (JAXA)  
TRMM (NASA/JAXA)  
CloudSat (NASA/US DoD/CSA)  
GPM (NASA/JAXA)  
Megha-Tropiques (CNES/ISRO)  
Suomi NPP (NASA/NOAA)  
EarthCare (ESA/JAXA)

## SST-VC

TRMM (NASA/JAXA)  
WindSat (NASA/US DoD/CSA)  
GCOM-W Series (JAXA)  
Aqua (NASA/JAXA/INPE)  
HY-2 Series (NSOAS/CAST)  
Suomi NPP (NASA/NOAA)  
Sentinel-3 Series (ESA/  
EUMETSAT/EC)  
Metop series (EUMETSAT/  
NOAA/CNES/ESA)  
POES Series (NOAA)  
Aqua (NASA/JAXA/INPE)  
Terra (NASA/METI/CSA)  
GCOM-C Series (JAXA)  
FY Series (NSMC-CMA/NRSCC)  
MeteoSat Series (EUMETSAT/ESA)  
MSG Series (EUMETSAT/  
NOAA/CNES/ESA)  
MTSAT Series (JMA/JCAB)  
INSAT-3D Series (ISRO)  
GOES/GOES-R Series (NOAA/  
NASA)  
COMS Series (KARI/KMA/KORDI)