2026 State of the CEOS Virtual Constellations

Report by the Committee on Earth Observation Satellites

Authored by the SIT Chair Team and the CEOS Virtual Constellations

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The 2026 State of the CEOS Virtual Constellations Report was produced by the Committee on Earth Observation Satellites (CEOS) Strategic Implementation Team (SIT), with inputs from the CEOS Virtual Constellations. The document was presented for information to CEOS Principals at the 2026 CEOS Plenary (November, 2026).

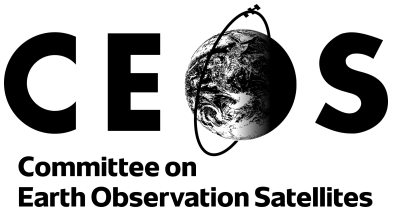


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1. Executive Summary

The following topics are highlighted for Principal attention:

- Atmospheric Composition: There are gaps in the coverage of geostationary reactive trace gas observations, with the only current sensors covering Asia (GEMS), North America (TEMPO) and Europe (Sentinel-4). There are no geostationary observations for most of the tropics and southern hemisphere. And post TEMPO, there is no dedicated operational mission covering North America.
- Biodiversity: More research has been conducted on terrestrial ecosystems overall. Observation and monitoring gaps exist in the marine domain. Overall, there is clear future capability and continuity to meet global science and application needs for biodiversity. Further development of harmonised MODIS equivalent products from new missions is required to facilitate users transition and applications continuity.
- Coastal Observations Applications Services and Tools (COAST): SWOT has shown the value of two-dimensional sea surface height in the coastal zone and some draft products are currently being generated but there are no follow-on wide-swath capabilities planned. COAST-VC is currently leading subject matter experts in a Gaps and Limitations analysis across coastal regions. This is a CEOS contribution to other international initiatives such as the Space4Ocean Alliance.
- Land Surface Imaging: There is no continuity planned for P-band observations beyond ESA's Biomass mission (also mentioned by SAR-VC). These long wavelength band SAR observations are critical to understanding structure in high biomass forests and hence the amount of carbon stored by such forests. Overall, there is unclear future capability and continuity to meet global science and application needs for active wildfire observations. Commercial and philanthropic wildfire satellite EO data providers are providing new opportunities, however care needs to be taken with regard to data quality and equitable access for all global users.
- Ocean Colour Radiometry: A measurement gap in global, 1-2 day revisit, hyperspectral observations of ocean colour is looming. Beyond the NASA PACE Ocean Color Instrument (OCI) which currently provides this capability from LEO, no missions are planned in the 2030 timeframe. Furthermore, no emergent network of / collaboration on geostationary ocean colour radiometry currently exists. A collection of geostationary instruments could provide both hyperspectral observations and sub-daily revisit times.
- Ocean Surface Topography (OST): For Ocean Surface Topography, the main area of concern relates to the continuity of the reference altimetry missions, that started with Topex-Poseidon: there is a risk of discontinuity considering Sentinel-6B's nominal lifetime and the availability of the first Sentinel-6 Next Generation unit.
- Ocean Surface Vector Wind: Backscatter from both pencil-beam Ku-band and fan-beam C-band suffers saturation where backscatter loses sensitivity above wind speed of 30 m/s. Thus retrieval of high winds is difficult, limiting study of cyclonic winds.

- Precipitation: Persistent limitations in overall sampling continuity and continuous surface reference observations. Commercial sources (e.g., Tomorrow.io, WeatherStream) are beginning to be leveraged to address sampling needs, however linkages to GSICS activities need to be strengthened to assess data quality, calibrate outputs, and ensure cross-constellation interoperability.
- Sea Surface Temperature: There is a potential upcoming gap in global microwave Sea Surface Temperature measurements from 2032, following the conclusion of the HY-2 and AMSR series.
- Synthetic Aperture Radar (SAR): The current S-band sensors are predicted to end around 2035, and no future missions carrying S-band sensors are planned. The impact of S-band observations on science and applications remains to be assessed and quantified. Furthermore, the value of X-band sensors for science applications would be greatly improved by the availability of consistent archives, supported by systematic background observation plans.

2. Introduction

This report is compiled by the Strategic Implementation Team (SIT) Chair, on behalf of and using inputs from the CEOS Virtual Constellations and other thematic experts across the CEOS Community. The report aims to highlight the state of core Virtual Constellation observations. The purpose of this report is to communicate to CEOS Principals in a structured and systematic fashion the state and continuity outlook of the Virtual Constellation (VC) observables as one input to aid CEOS Agencies in planning of future missions. A second goal is to provide to the broader Earth observation community expert insights on the status of the virtual constellations. By offering such insights on subtle details, such as granularities related to revisit frequency, data availability, analysis-readiness status, or spatial resolution, this report acts as a complement to existing gap analyses, such as those executed by the World Meteorological Organization (WMO) and those conducted by the Coordination Group on Meteorological Satellites (CGMS).

The timelines presented here are generated through the CEOS Missions, Instruments and Measurements (MIM) Database, using the mission dates and other information provided by Agencies during the annual MIM Database survey, conducted in June - September 2026. MIM Database outputs are supported and augmented with additional thematic input from Virtual Constellation experts. In instances where a Virtual Constellation does not have a singular observable focus, select thematic areas are chosen by the Virtual Constellation experts as the focus of the report.

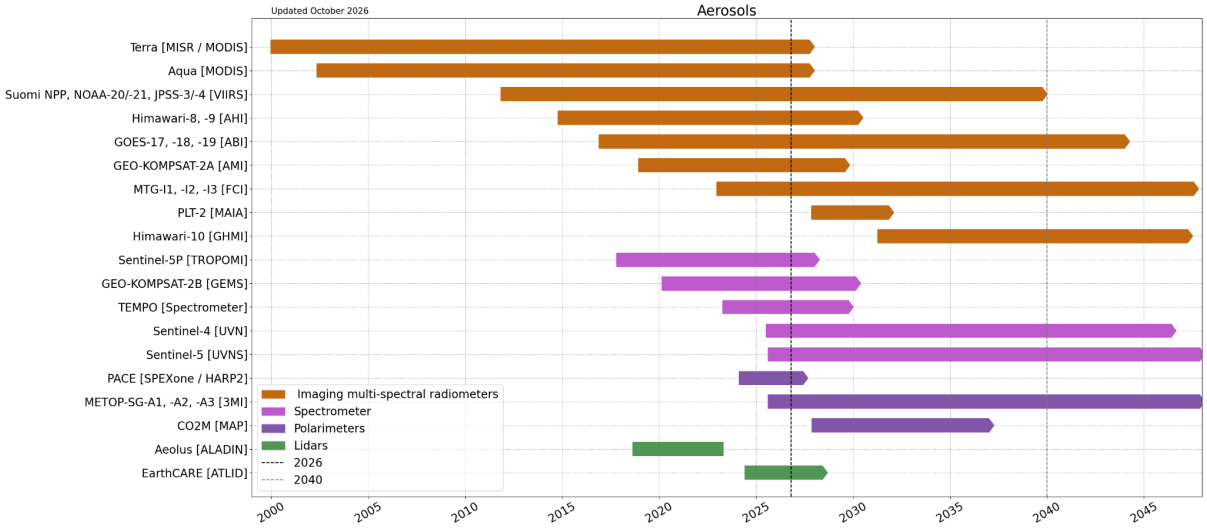
3. Virtual Constellations

CEOS has nine Virtual Constellations, each with a focus on a specific observation, or a set of observations. Synthetic Aperture Radar (SAR) Virtual Constellation is also included in this report, even if this VC is not official yet as of the writing of this report.

3.1. Atmospheric Composition

Prepared by: Ben Veihelmann, ESA; Emma Knowland, NASA; Hiroshi Tanimoto, NIES; Charles Miller, JPL; Diego Loyola, DLR; Shobha Kondragunta, NOAA; Yasjka Meijer, ESA

3.1.1. Aerosols



A host of sensors on polar-orbiting and geostationary satellites observe aerosols (interchangeably called as particles or fine particles) for air quality, weather, and climate monitoring and predictions. Given the health hazards of particle pollution and a lack of dense ground monitoring network, satellite sensors have evolved as a viable observing tool. However, satellite sensors provide optical measurements that need to be converted to mass measurements at the surface. AC-VC has been focusing on the exploitation of satellite data for various applications with a thorough understanding on the strengths and weaknesses of retrieval algorithms, data errors, and how synergies can be designed to combine data from various sensors to optimize the utility of satellite data. It is essential to maintain satellite aerosol observational capabilities not only because aerosols impact human health, weather, and climate but also because long-term monitoring shows the efficacy of policies. In an increasingly drying and warming planet, smoke from fires is emerging as the main source of pollution. AC-VC initiated fires and smoke as a new thematic area to understand extreme fires, especially those in the Wildland Urban Interface that are more hazardous to human health.

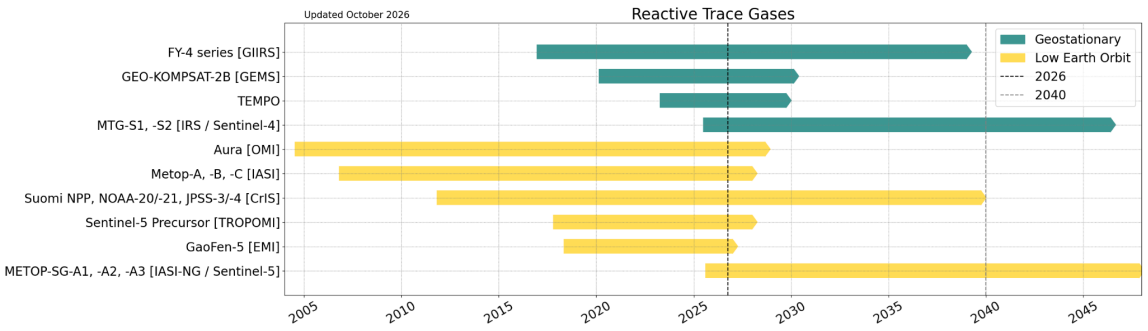
Gaps:

- There are currently no operational satellite missions that provide an aerosol vertical profile. Some information on aerosol layer height is available from satellite sensors with oxygen absorption spectral coverage but those measurements are not adequate to truly characterize aerosol vertical profile.
- No operational follow-on to hyperspectral UV-Vis spectrometers that enhance aerosol retrieval information of the Visible Imagers on operational geostationary and polar-orbiting satellites for the western hemisphere (particularly for the United States).
- Sensors that can quantitatively derive aerosol composition information.
- Satellite missions that can provide hourly to sub-hourly aerosol information in the southern hemisphere where pollution levels are anticipated to grow due to the emerging megacities by 2050.

Opportunities:

- Proactive engagement with NWP centers in the utilization of satellite aerosol observations in operational models. This could potentially be achieved via CEOS-CGMS joint activities.
- Explore instrument synergies to optimize air quality information for real time applications and decision support systems.
- Design satellite data exploitation studies to understand photochemical processes in the atmosphere.
- Engage commercial satellite data providers to develop aerosol observational capabilities with low cost small satellite missions.
- Engage GSICS in aerosol data validation studies.
- Explore the joint use of aerosol and trace gas data from satellites to understand emissions associated with fire dynamics (biome, fuel load, phase, etc.).
- Develop new algorithms (synergistic if needed) to derive 3D aerosol information needed for monitoring and forecasting of air quality.

3.1.2. Reactive Trace Gases



The reactive trace gases missions (see figure above) focus on those with retrievals sensitive in the troposphere and not stratosphere. Missions are grouped by orbit, with the Geostationary Satellite Constellation for Observing Global Air quality (2011 white paper) realized with GEMS, TEMPO and Sentinel-4 all now operating with the addition of the GIIRS as part of the FY-4 series. There is also a long history of low-earth orbiting satellites with instruments that measure reactive trace gases. Many of these satellites are reaching the end of their mission life, such as IASI on the Metop-A, -B, -C series and OMI on NASA's Aura satellite, while next generation satellite instruments are coming online, such as IASI-NG and Sentinel-5, following launch in 2025.

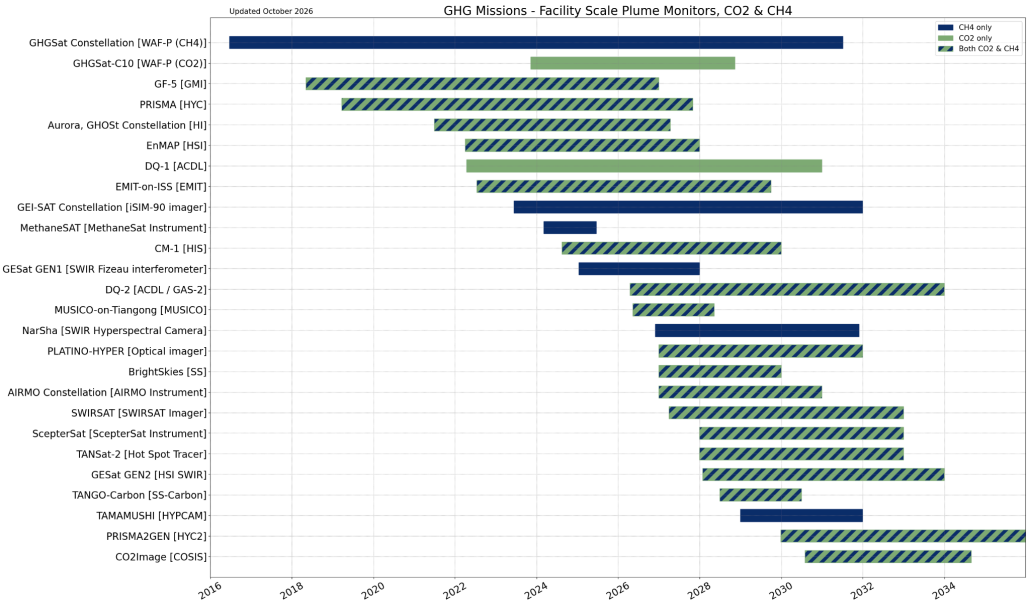
Gaps:

- There are geographical gaps between geo-stationary satellites over Asia (GEMS), North America (TEMPO) and Europe (Sentinel-4).
- No geostationary satellites in most of the tropics and southern hemisphere
- No continuity of measurements in the afternoon orbit after Sentinel-5P reaches its end of life.

Opportunities:

- Sentinel-5P/TROPOMI is in excellent condition and is expected to provide high-quality data for another 10 more years up to 2035, extending the long-term afternoon data record.
- Sentinel-5P/TROPOMI is the standard for the CEOS air quality constellation: From low Earth orbit, TROPOMI observations overlap with geostationary observations from Sentinel-4 (Europe), GEMS (Asia) and TEMPO (North America), together forming the CEOS virtual constellation for air quality.
- Currently, Sentinel-5P/TROPOMI data serve as the 'travelling standard' for establishing and verifying consistency of the geostationary sensor data. In the future, Sentinel-5 will also provide this function, however in a morning orbit instead of the afternoon overpass of Sentinel-5P, though experience shows that it may take several years to establish the required data quality.
- Retrieval algorithm consistency across the different platforms for the same reactive gas species.

3.1.3. Greenhouse Gases - Facility Scale



Facility scale mappers include a wide range of mission operators, including public, commercial and non-governmental organisations. Many of the relevant sensors are multi-purpose hyperspectral imagers, which can track intense plumes of carbon dioxide and methane. Sensors assigned to this category must have a spatial resolution of 1 square km or finer, but do not require the precision, accuracy, or coverage of the wide area mappers described below. These missions are tracked and monitored through the CEOS GHG Portal (ceos.org/ghg).

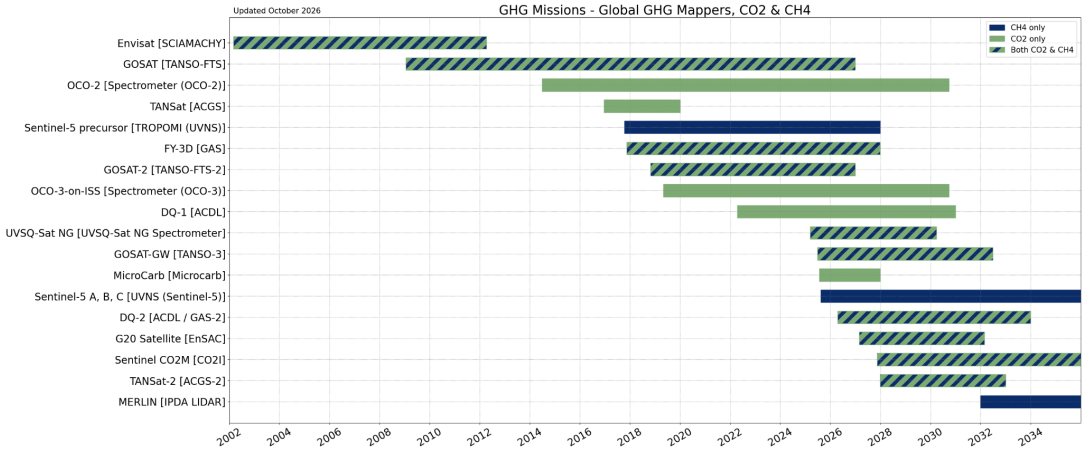
Gaps and Challenges:

- Validation and fiducial standard measurement are challenges of the facility-scale satellites in the GHG observing and analysis system.

Opportunities:

- The number of facility-scale GHG observing satellites has increased by commercial and philanthropic satellites.
- The capability of plume detection, in particular, for methane, has improved dramatically.
- More facility-scale satellites will be launched in the near future, for both carbon dioxide and methane.

3.1.4. Greenhouse Gases - Wide Area



Typically undertaken by CEOS Agencies, the wide area mappers missions are the most important sources of information for tracking emissions and removals of GHGs from natural as well as anthropogenic sources and sinks on spatial scales spanning large urban areas to nations. These missions are tracked and monitored through the CEOS GHG Portal (ceos.org/ghg).

The GHG virtual constellation has continued to grow while the original members, GOSAT and OCO-2, remain in good health and delivering high-quality data. Sentinel-5P/TROPOMI is in excellent condition and can provide high-quality data for another 10 more years up to 2035.

Gaps and challenges:

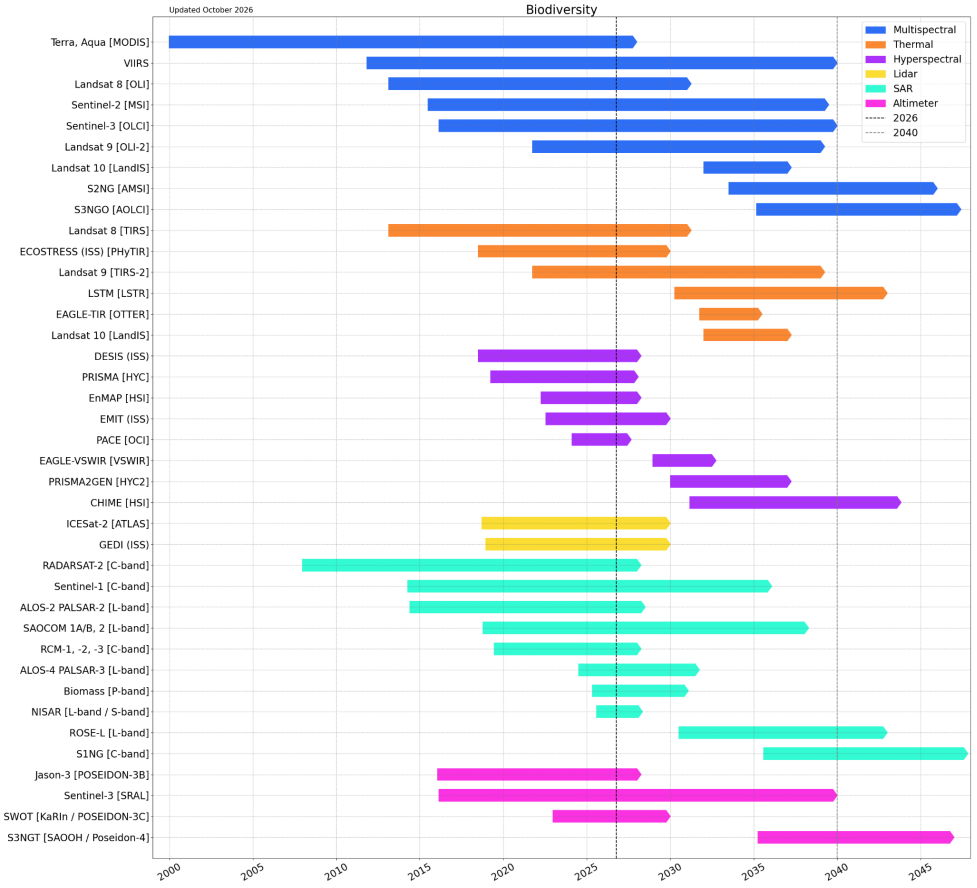
- Long-lived satellites including GOSAT and GOSAT-2 will terminate their planned operation by the end of 2028.
- No geostationary satellites are currently in operation nor planned for launch. Capabilities of current operational geostationary satellite imagers to observe large methane plumes not fully exploited.
- Extending validation networks and fiducial standard measurement is essential for the GHG observing and analysis system.

Opportunities:

- New missions such as GOSAT-GW, MicroCarb, and Sentinel-5 were launched in 2025 and are expected to operate through the early 2030s.
- Combined use of these satellites will provide data from morning (9:30LT, Sentinel-5; 10:30LT, MicroCarb) to early-afternoon (13:30LT, GOSAT-GW and Sentinel-5P/TROPOMI), which could help diagnose diurnal variations of GHGs.
- The CO2M mission will provide low-latency (<24 hours) data for GHGs.

3.2. Biodiversity

Prepared by: Lucie Viciano, Canadian Space Agency (CSA); Yoseline Angel, NASA



The missions in the Biodiversity-VC timeline (see figure above) are grouped by sensor technology. This visualization is non-exhaustive and does not attest to the relative dominance (dependency) of certain satellites over others. Biodiversity being a broad topic, it also provides a very general view of needs; more detailed views for given remote sensing products and indicators are aimed to be developed over the B-VC's timeframe to align with the United Nations Global Biodiversity Framework (GBF)'s Monitoring Frameworks'headline, component and, where relevant, national indicators.

An important dataset used as core background information comes from high to moderate resolution (10-30m) multispectral sensors like Landsat and Sentinel-2. Their long-term continuity and breadth of global coverage enable the analysis of land cover changes, which are key for deriving Essential Biodiversity Variables (EBVs), particularly those related to Ecosystem Function. Complementarily, MODIS has provided a range of widely used, consistent, long-term global products, including vegetation indices, land cover classification, and measures of vegetation phenology. These products have been instrumental in biodiversity monitoring and large-scale ecosystem assessments, particularly through the characterisation of ecosystem dynamics and seasonal patterns. Maintaining continuity with these established products by developing harmonised, comparable products from successor or complementary missions, such as VIIRS and

PACE, is essential to facilitate user transition, preserve the value of existing time series, and minimise disruptions to established workflows and downstream applications. Such continuity does not necessarily require identical spatial resolutions or sensor characteristics; rather, it depends on maintaining consistency in key variables and geometric representation, ensuring temporal comparability, and documenting uncertainties and methodological differences. These efforts are critical to enabling users to transition to new datasets while preserving the integrity of long-term biodiversity assessments and the operational value of existing products.

Similarly, a number of legacy L-band (e.g., ALOS-PALSAR) and C-band missions (e.g., Sentinel-1, RADARSAT-2), combined with the recently launched NISAR, Biomass, and the upcoming ROSE-L sensors will continuously provide long-term observation for characterising ecosystem structure and extent, which are required for monitoring the condition of key ecosystems, particularly wetlands. Other sensors are increasingly being used in complementarity to refine EBVs, often in combination with airborne and ground-based datasets. These include thermal sensors, used for deriving ecosystem disturbance and phenology EBVs, and LiDAR, which provides vertical information relevant for the assessment of ecosystem structure. Similarly, the advent of hyperspectral missions such as EAGLE-VSWIR, CHIME, PRISMA2GEN, will make the direct remote sensing of certain aspects of biodiversity increasingly feasible, refining the EO satellite products required for unlocking EBVs such as species traits and distribution, notably.

<u>Gaps and challenges</u>:

- Product continuity: Limited harmonisation and interoperability between legacy (e.g., MODIS) and new satellite products can compromise long-term data consistency and comparability.
- Sensor complementarity: Existing satellite observations do not fully capture all biodiversity-relevant ecosystem properties, highlighting the need for better integration of complementary multi-sensor products.
- More research has been conducted on terrestrial ecosystems overall. Observation and monitoring gaps exist in the marine domain.
- The transition to new satellite products can be hindered by the lack of comparable analogues and the expertise and processing resources required to handle complex datasets, particularly SAR and hyperspectral data, limiting their accessibility and uptake by users.
- General adoption of standards: From common terminology and understanding of EBVs to varying needed levels of ARD can lead to a heterogenous end user

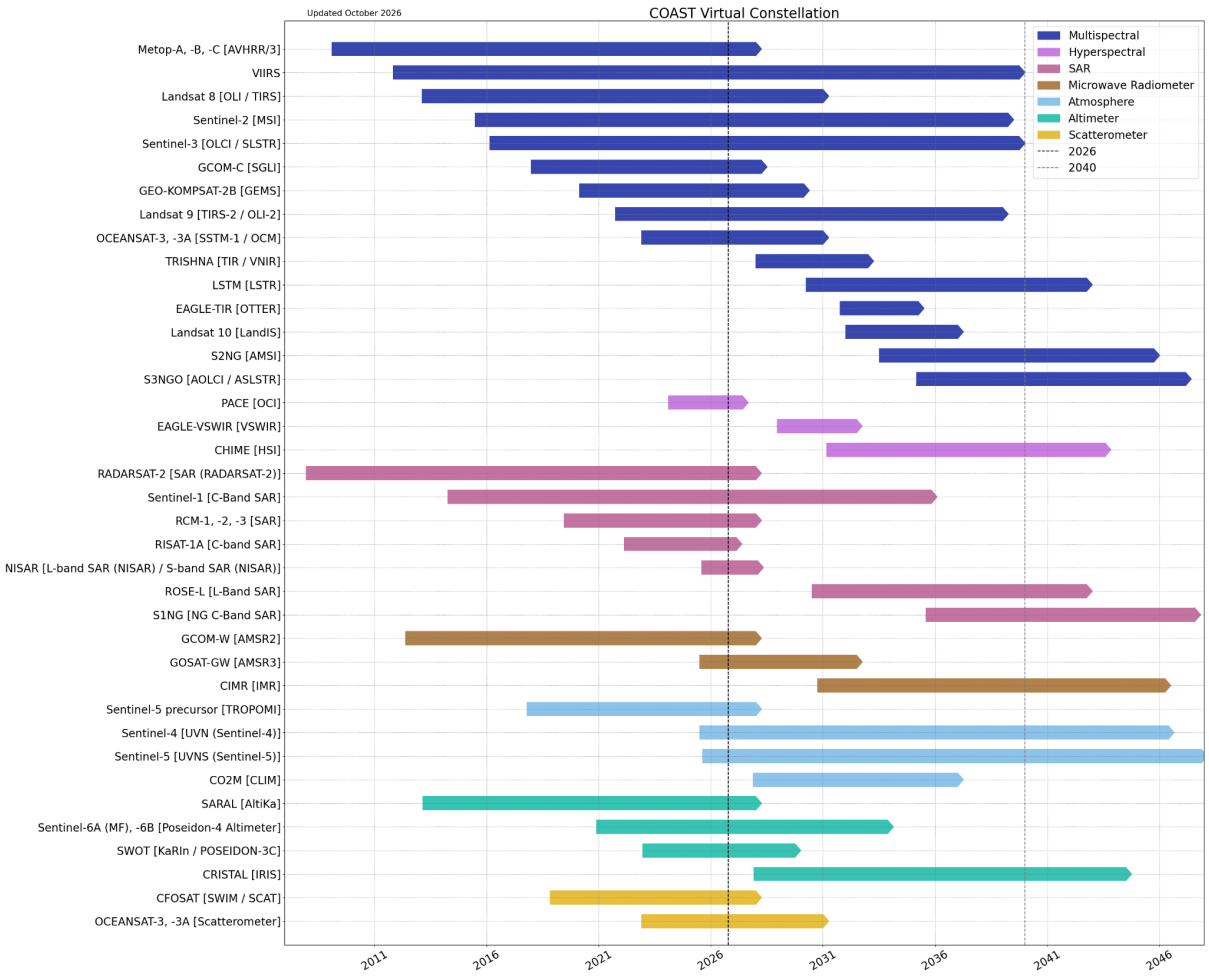
landscape. This renders the field rather large, especially given overlaps with many drivers and other groups, requiring prioritisation of B-VC focus areas over time.

Opportunities:

- Further development of harmonised analogue products from new missions to preserve long-term data consistency (e.g. post-MODIS) and facilitate user transition is needed for product continuity.
- Further sensor agnostic and multisensor algorithm development is needed to improve the characterisation of biodiversity-relevant ecosystem properties and EBVs.
- The uptake of emerging hyperspectral and SAR data through CEOS-ARD Product Family Specifications (PFS) should be promoted, as well as simplified processing workflows, quality assurance, and outreach to support their integration into EBV assessments and unlock new insights into biodiversity.

3.3. Coastal Observations, Applications, Services and Tools (COAST)

Prepared by: Neeraj Agarwal, ISRO; Aurelien Carbonniere, CNES; Nima Pahlevan, NASA. Supported by Alex Christensen; NASA JPL



The missions in the COAST-VC timeline (see figure above) are grouped by sensor technology. Moderate-resolution ocean colour and sea surface temperature observations are anchored by Sentinel-3 and VIIRS to around 2040, while Landsat, Sentinel-2 and their successors sustain the high-resolution imagery needed in the nearshore zone. Several ocean colour missions, including GCOM-C, PACE and GOCI-II, reach the end of their planned lifetimes between 2027 and 2031, ahead of next-generation missions such as CHIME and S3NGO. SAR continuity is provided by Sentinel-1, NISAR, ROSE-L and S1NG, and coastal altimetry by Sentinel-6 and SWOT.

COAST-VC (in conjunction with other CEOS entities) is currently leading subject matter experts in a Gaps and Limitations analysis across coastal regions. This is a CEOS contribution to other international initiatives such as the Space4Ocean Alliance. There are 80+ SMEs participating in four sub-groups: In Situ Validation, Products and Algorithms, High Latitudes, Tools. The report is due to the SIT Chair in Q2 2027.

Gaps:

- Wide-swath altimetry: SWOT has shown the value of two-dimensional sea surface height in the coastal zone and some draft products are currently being generated (to be presented next year) but no follow-on wide-swath capability appears in the timeline after about 2030.
- Ocean colour continuity: redundancy thins between 2027 and 2031 as several missions reach end of life, and no geostationary ocean-colour mission appears after about 2030.
- Nearshore winds: scatterometer winds degrade within a few tens of kilometres of the coast; routine SAR-derived wind products could help fill this zone.
- Bathymetry: satellite-derived bathymetry (SDB) increasingly relies on ICESat-2 lidar for reference depths, and lidar continuity is not reflected in the timeline. Optical data (e.g. from Sentinel-2) are also being processed to retrieve shoreline estimates (intertidal topography). To sum-up, assessing bathymetry from satellites is currently assessed using three methods (water color; underwater stereophotogrammetry; and wave-kinematics-based depth inversion);

Opportunities:

- More in situ reference observations are needed (bio-optical, water quality and bathymetry) along turbid tropical coastlines such as the North Indian Ocean, which remain sparsely sampled. A pilot study along the North Indian Ocean coastline could demonstrate this.
- Through NASA CSDA, COAST-VC is assessing flood mapping methods from commercial data.
- Dedicated tools could support the uptake and adoption of EO products by the commercial sector.

- Community engagement in COAST-VC member meetings has decreased recently and institution knowledge needs to be rebuilt. Looking for opportunities for in-person engagement at upcoming meetings and conferences.

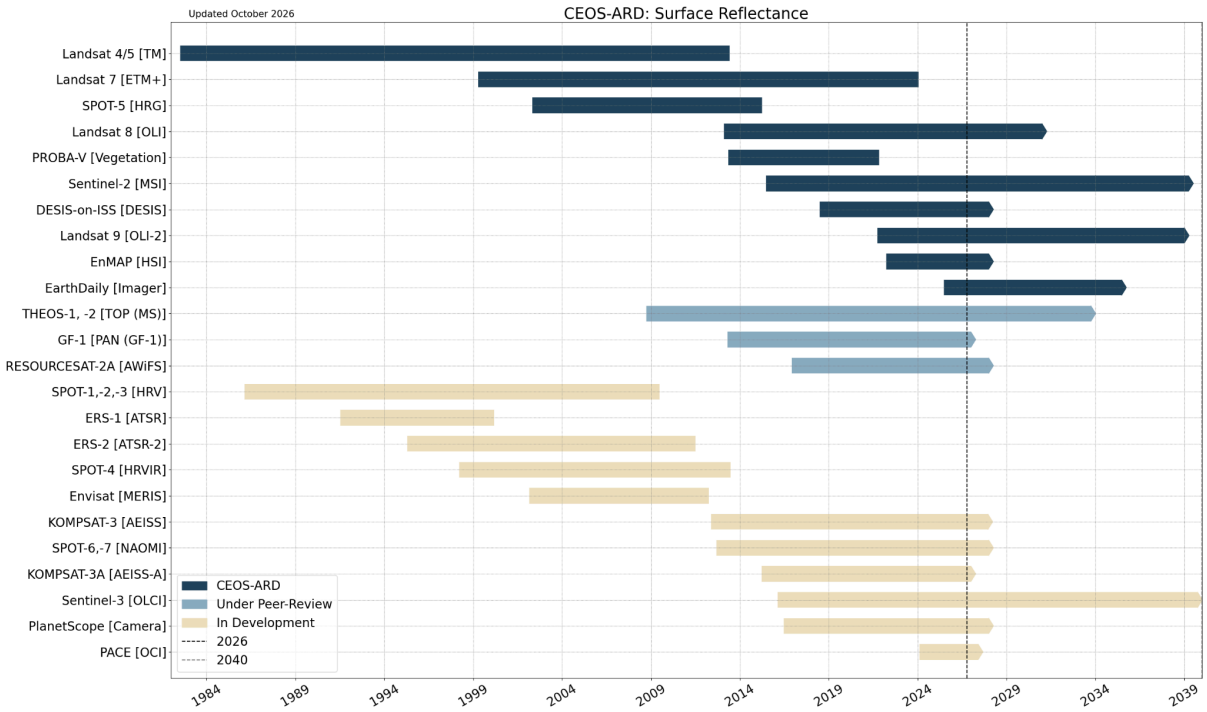
3.4. Land Surface Imaging

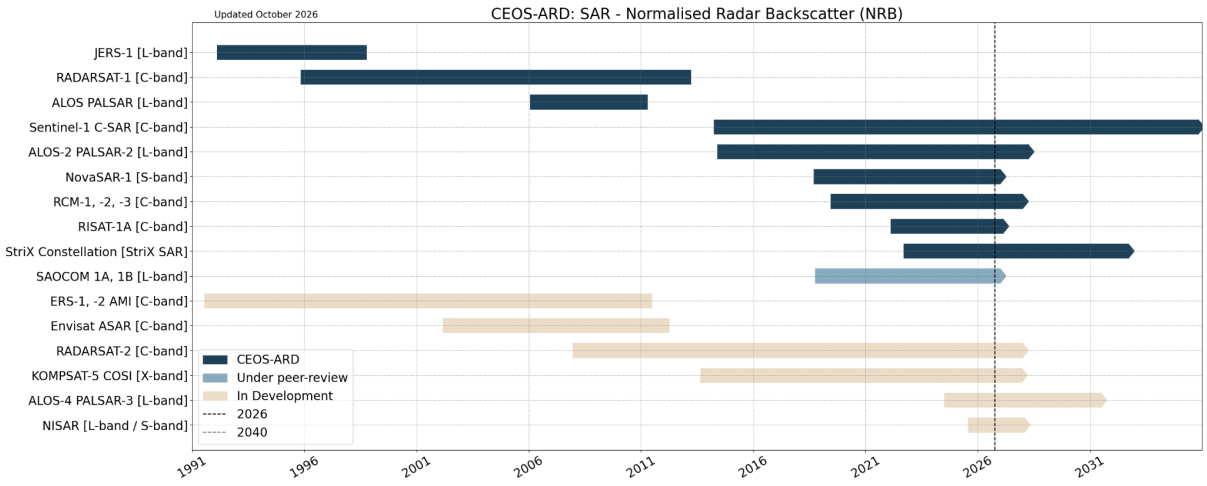
Prepared by: Chris Barnes, USGS/KBR; Matt Steventon, LSI-VC Secretariat; Ake Rosenqvist, JAXA

The Land Surface Imaging Virtual Constellation (LSI-VC) exists to maximize the value derived from CEOS Agency land surface imaging assets and activities by providing an overarching coordination role. LSI-VC is central to the development of CEOS Analysis Ready Data (CEOS-ARD) which is one critical piece of the response to this mission statement.

The Surface Reflectance and SAR Normalised Radar Backscatter CEOS-ARD Product Family Specification (PFS) are foundational to CEOS-ARD. The following charts demonstrate the continuity of missions that produce compliant products.

Note that this is an imperfect representation of 'continuity' since missions will be added or even subtracted as products undergo assessment or specifications evolve. Additionally, CEOS-ARD tolerates different approaches for deriving the measurand, and as a result they are not inherently consistent / comparable across data sources. This impacts the ability to harmonise multi-sensor products, limiting utility for applications requiring time-series data from several sources. This is a topic currently being addressed jointly by the LSI-VC and WGCV through the *Surface Reflectance Quality and Consistency Project*.



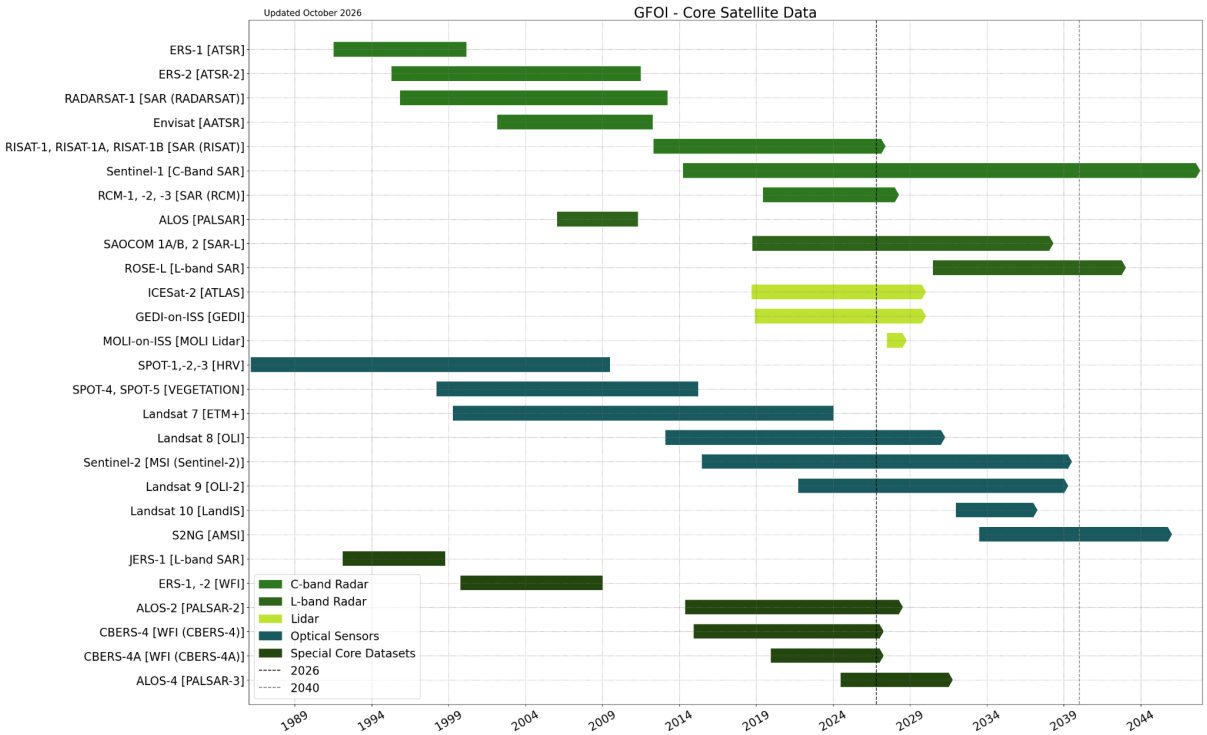


In the remainder of this report we focus on the thematic side of the LSI-VC, the work of the three subgroups under LSI-VC: Forests & Biomass, Agriculture (GEOGLAM), and Wildfires.

Given the broad nature of land surface imaging, there is not one single observable to report on in terms of continuity and gaps, even when restricting scope to these subgroups. Therefore, we highlight just a few specific topics for the attention of CEOS Principals and the community.

3.4.1. Forests & Biomass

Core Satellite Data for the Global Forest Observation Initiative (GFOI)



These are the longstanding core data streams that can be shared openly and acquired free-of-charge for GFOI purposes. They provide systematic and sustained wall-to-wall

acquisitions of forested areas, globally repeated on timescales consistent with national reporting commitments and the requirements of national forest information systems.

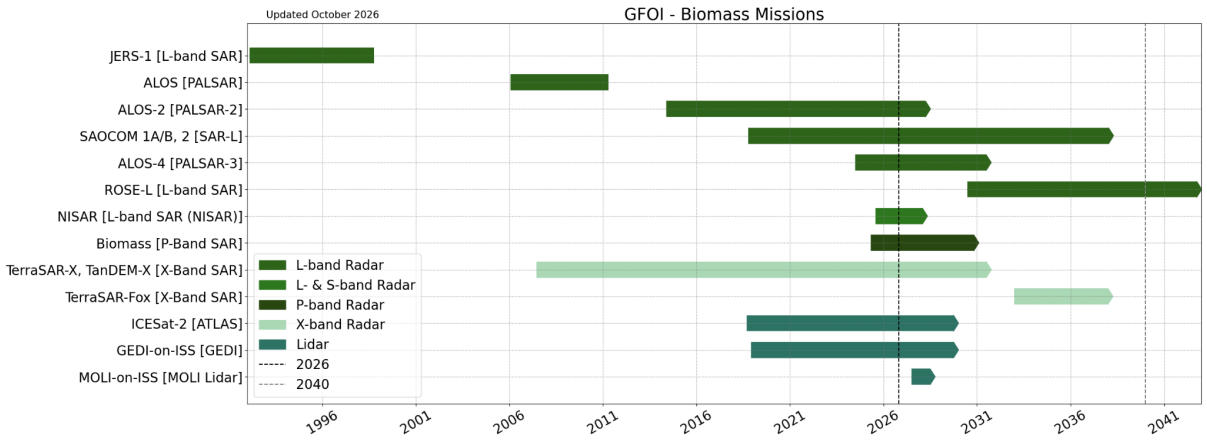
Gaps:

- The core optical satellite coverage supporting GFOI continues to rely heavily on Landsat and Sentinel-2 missions. The NASA-USGS SLI Commercial Transition Initiative outlines a potential transition toward increased use of commercially provided data sources that can be harmonized with the historical Landsat archive while preserving the long-term value of the Landsat data record. As the future architecture and implementation approach continue to evolve, it will be important to assess potential implications for GFOI and the broader forestry community to ensure their observational and data continuity requirements remain adequately addressed.

Opportunities:

- NISAR will provide strong continuity for L-band SAR alongside ALOS-4, SAOCOM-1A/B and ROSE-L. Activities around harmonisation and consistency of these missions with a view to establishing a very long historical time series could be worthwhile.
- The Earth Dynamics Geodetic Explorer (EDGE) was selected for continued development as part of NASA's Earth System Explorers Program. EDGE will be the first global swath-imaging lidar, and continue the measurements of ICESat-2 and GEDI.

Above Ground Biomass (AGB)



Gaps:

- There is no continuity planned for P-band observations beyond ESA's Biomass mission. These very long wavelength band observations are critical to understanding structure in high biomass forests, especially in the tropical and sub-tropical zones, and hence the amount of carbon stored by such forests.

Opportunities:

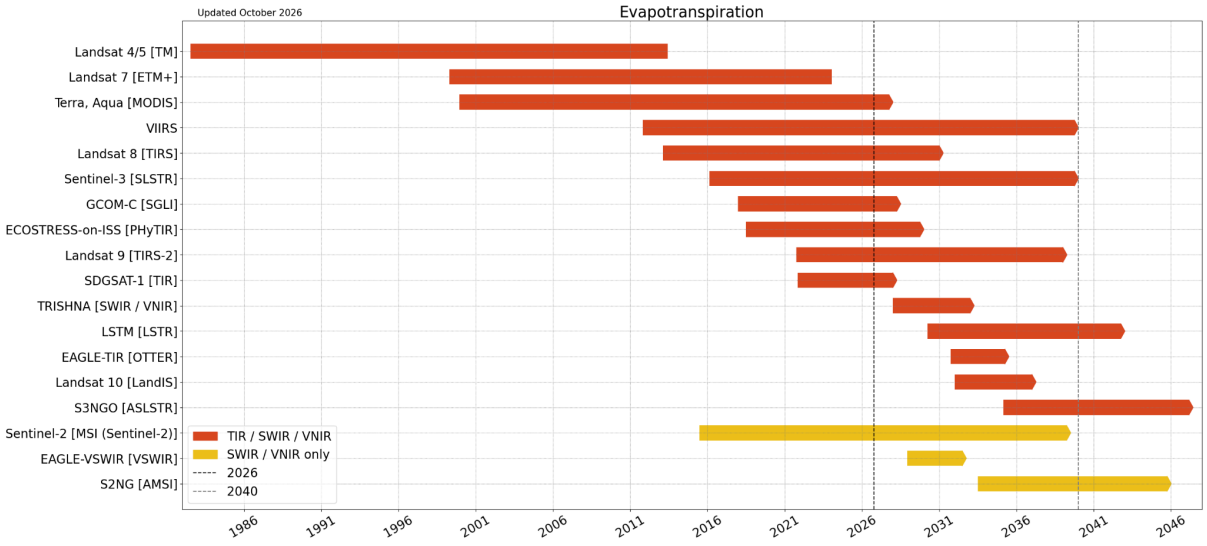
- Efforts to produce a harmonised biomass product from CEOS Agency missions started in 2022 with ESA, NASA, and JAXA participating. By 2023-2024, a consensus was reached that harmonizing products for a general/unspecified end use was inefficient. It might be useful to consider a CEOS-ARD Product Family Specifications for Above-Ground Biomass as a means to provide some level of commonality between products without going as far as harmonisation.

3.4.2. Agriculture – Evapotranspiration

The Essential Agricultural Variables for GEOGLAM are Earth observation-based building blocks that in combination with one another or with other non-EO information provide insight into the GEOGLAM Agricultural Indicators which themselves provide actionable information on the state, change, and forecast of agricultural land use and productivity.

The LSI-VC Subgroup for GEOGLAM (Agriculture) is working with GEOGLAM on a phased stocktake of the EAVs, looking to catalogue the CEOS Agency activities relevant to each of the EAVs, covering missions, instruments, products, and tools. The goal is to provide visibility of the state of the space-based observing system and available end-products for agriculture, and analyse gaps and needs, facilitating more comprehensive and systematic agency planning as well as opportunities for collaboration.

Evapotranspiration was covered in the first phase of the EAV stocktake (see slides here) and has been selected as a near-term focus activity for the LSI-GEOGLAM subgroup. With upcoming missions such as Trishna, SBG/EAGLE, Landsat 10, and the Copernicus Land Surface Temperature Monitoring mission on the horizon, there are new opportunities for coordinated coverage and collaboration.



Evapotranspiration will be a focus activity for the LSI-VC GEOGLAM Subgroup due to it being a key EAV and having opportunities for cross-agency collaboration. The WGCV Land Product Validation subgroup is also collaborating with GEOGLAM on an

evapotranspiration workshop aimed at developing good practices for validation of ET products (February 2027).

Gaps:

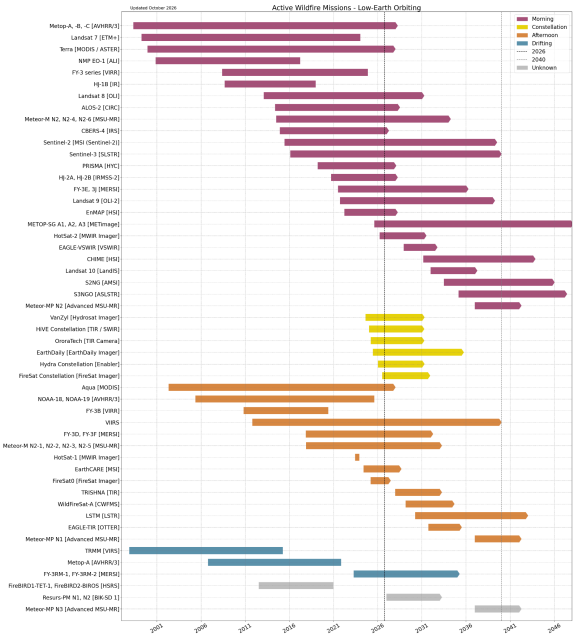
- MODIS Terra and Aqua reaching end-of-life in 2026/2027, and products will most likely transition to using VIIRS data. More work may be required to support the transition for thermal products.

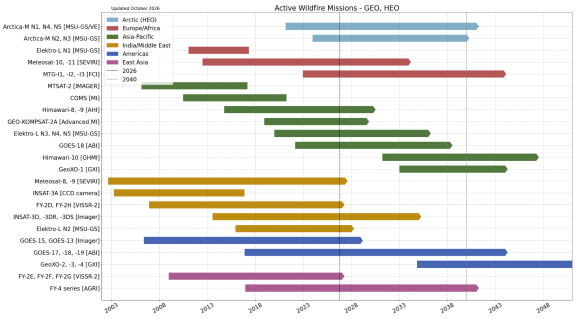
Opportunities:

- New missions such as Trishna, SBG/EAGLE, and the Copernicus Land Surface Temperature Monitoring mission.
- More comprehensive coverage of agricultural variables in the CEOS MIM Database, using the EAVs and stocktake results as input.
- Potential CEOS LSI-GEOGLAM activities on evapotranspiration include comparison of different model approaches to ET across CEOS agencies; Efforts to increase harmonisation/interoperability across agencies' evapotranspiration products; Collaborative efforts on validation/accuracy assessment.
- Full harmonisation of evapotranspiration products across agencies is likely not feasible; a CEOS-ARD Product Family Specification for evapotranspiration may be a way to provide a suitable common ground / point of reference. LSI-VC recently endorsed an updated Surface Temperature and new Surface Brightness Temperature CEOS-ARD specifications which should prove useful.

3.4.3. Wildfires

The following charts list missions potentially capable of active fire observations across LEO, GEO, and HEO orbits, including some from philanthropic and commercial organisations. While they carry hardware that is theoretically possible for supporting active wildfire products, their practical application is unconfirmed. Widely used space agency supported operational active fire products are derived from VIIRS, MODIS, Landsat, S3-SLSTR (LEO) and GOES, MSG/MTG, Himawari (GEO). These charts can be found in full size on the CEOS MIM Database Wildfire Portal, which was developed to provide a comprehensive and up-to-date list of all current and planned satellite missions with the potential to monitor active wildfires. The work is built on WGDisasters' Wildfire Pilot I.





In terms of observation continuity, analysis carried out under WGDisasters' Wildfire Pilot I in 2024 showed that global monitoring capabilities are unstable out to the mid-2030s, and that coverage (revisit times) does not improve in future. Coverage could be improved by better leveraging existing and committed capabilities of CEOS Agencies that are capable of active fire monitoring but are not currently used to provide operational products. It is not guaranteed that global coverage from civil space agency missions over the next decade will be maintained at the levels experienced in the early-to-mid 2020s, either in terms of observation availability or with respect to data accessibility, transparency, and calibration and validation practices.. Better global coordination, access and interoperability of data from existing and future missions could help alleviate these issues. This was the motivation behind the establishment of the LSI-VC Wildfire subgroup as an international wildfire EO coordination working group to ensure coordination between the various EO data producers who generate (or could generate) wildfire products and the science and applications community.

<u>Gaps</u>:

- While many users have now adopted JPSS VIIRS active fire data as a replacement for MODIS Aqua data, many operational fire management and air quality systems have been built around MODIS, and may not yet have made the transition. The nearest replacement for MODIS Terra active fire observations is provided by S3-SLSTR. SLSTR active fire products are more recently established compared to those provided by VIIRS and, as such, have yet to achieve comparable levels of adoption in downstream applications.
- Overall, there is unclear future capability and continuity to meet global science and application needs.
- There is a need for an internationally agreed fire EO product endorsement/accreditation process. The barrier to making wildfire products is

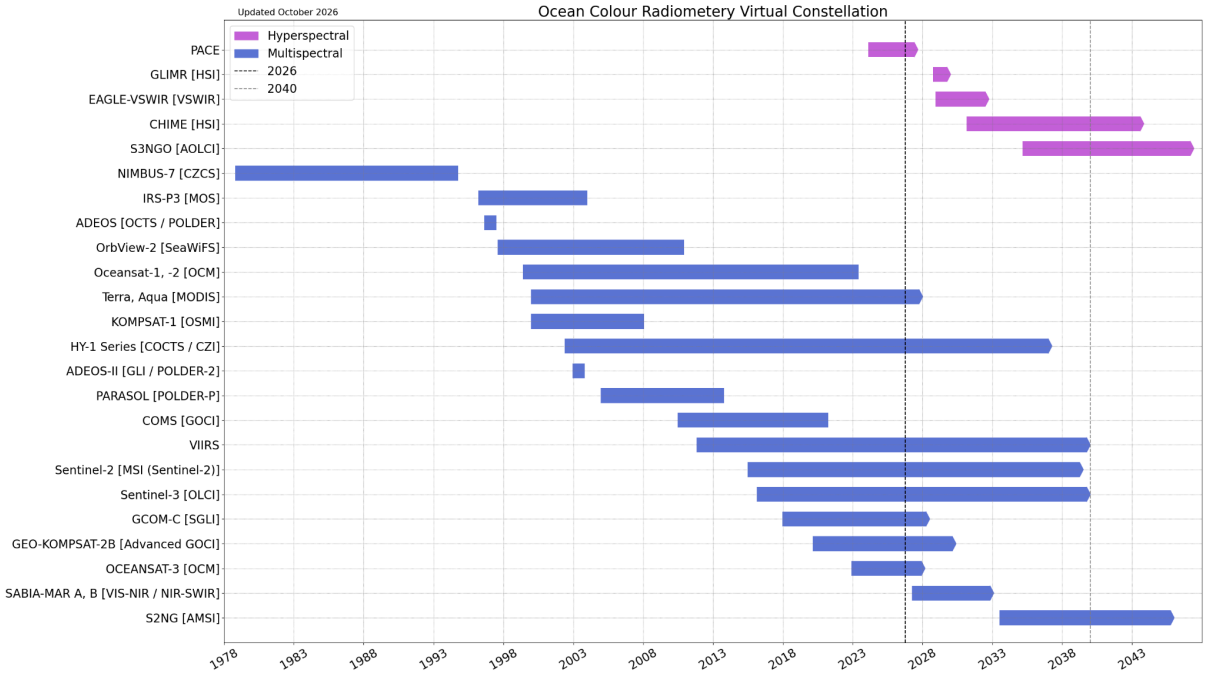
now low and there are an increasing number of relevant private sector missions being launched, but quality assessment of those products needs to be standardised.

Opportunities:

- WildFireSat: a purpose built, government funded wildfire monitoring mission will provide free and open global active fire monitoring and Level 1B data from ~2029.
- New opportunities from commercial and philanthropic wildfire satellite EO data providers, but this needs to be navigated carefully, e.g., with regard to data quality (referenced above), and equitable access for all global users.
- CEOS-ARD Product Family Specifications (PFS) for wildfire related products is a priority for the LSI-VC Wildfires subgroup. There is a logical path for derivative/higher level CEOS-ARD products. For example, an Active Fire PFS could be built off the Surface Temperature PFS, while a Burnt Area PFS might be built off the Surface Reflectance PFS.
- Improved interoperability of fire EO data and missions, and the development of harmonised user and mission requirements for wildfire monitoring.

3.5. Ocean Colour Radiometry

Prepared by: Jeremy Werdell, NASA; Ewa Kwiatkowska, EUMETSAT; Marie-Helene Rio, ESA



The missions in the ocean colour radiometry constellation timeline are primarily categorized as multispectral and hyperspectral, where the former indicates a collection of discrete, discontinuous wavebands across the UV-NIR/SWIR spectrum and the latter indicates continuous spectral sampling across this spectrum. While not indicated in the timeline, it should also be noted that: (1) the spectral ranges, resolutions, and sampling

vary within these categories and (2) the instrument ground sample distances, swath widths and, thus, temporal revisit times vary with these categories. The International Ocean Colour Coordinating Group (IOCCG; https://ioccg.org), an associate member of CEOS, maintains a useful mission timeline and annotated list of current and scheduled satellite ocean colour radiometers. Overall, the ocean colour radiometry observing system is expanding, with increasing focus on the tradeoffs between and needed balance of hyperspectral capabilities with daily (or better) revisit times.

Gaps:

- A measurement gap in global (1-2 day revisit) hyperspectral observations is looming. The NASA PACE Ocean Color Instrument (OCI) currently provides this capability from LEO, but was launched in 2024 with a 3 year design life. No other global (1-2 day) hyperspectral missions are planned in the 2030 timeframe and few regional (7+ day coverage) missions will be available. The EC Copernicus S3NGO A-OLCI, implemented by ESA/EUMETSAT, may provide global (1-2 day) hyperspectral coverage in the 2035 timeframe, but mission requirements for spectral coverage have yet to be codified. Commercial instruments cannot provide the required spatial coverage, stability, or accuracy to fill this gap.
- Related to the above, no emergent network of / collaboration on geostationary ocean colour radiometry currently exists. User needs are evolving and include event-scale monitoring and rapid response to water hazards, which makes current water services increasingly constrained by temporal sampling gaps from LEO. A collection of (e.g., 3-4 positioned globally) of GEO instruments could provide both hyperspectral observations and sub-daily revisit times.

Opportunities:

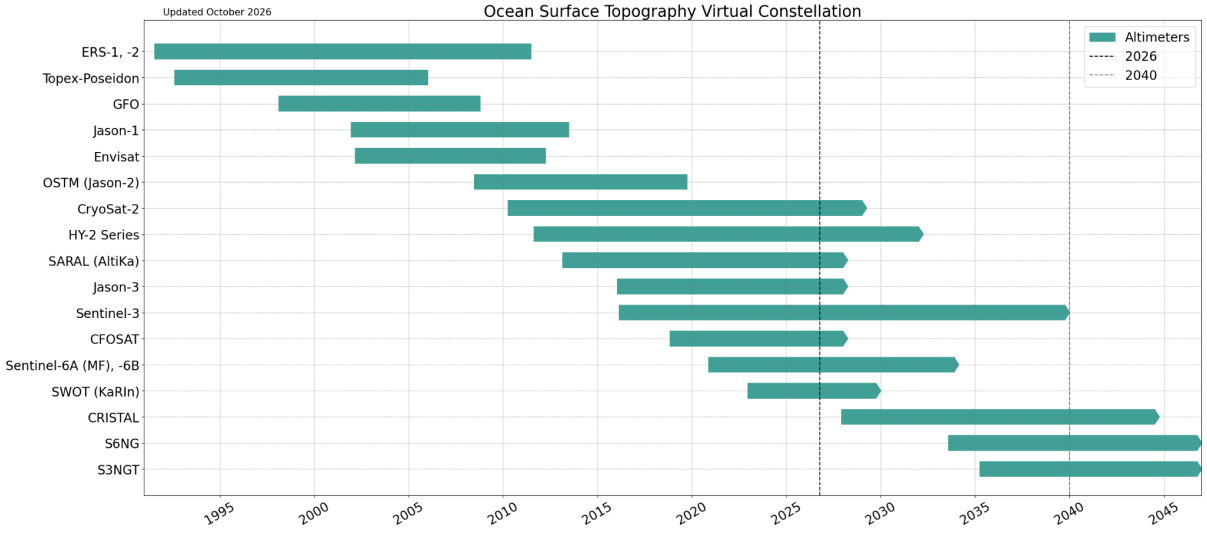
- The availability of the CEOS-ARD aquatic reflectance products lowers the barrier to entry for the use of this core (foundational) product. Agencies are encouraged to conduct self-assessments for relevant missions. CEOS is encouraged to work with missions that have conducted self-assessments to revise and refine the ARD as necessary.
- Recommendations from the science community were published as an IOCCG report (#22) titled "A scientific roadmap of aquatic hyperspectral remote sensing: Overview of status, challenges and future perspectives". Agencies are invited to review this report and to consider the recommendations in their future planning. A second version of this report is anticipated in early 2028.
- Agencies are invited to digest the Aquatic Carbon Roadmap produced by this VC and colleagues.
- There are an increasing number of in situ instruments and data streams used in ocean colour radiometry satellite validation. System Vicarious Calibration

capacities are also being developed. Communication across this VC and WGCV is encouraged.

- As previously indicated, while commercially-provided ocean color radiometry has become increasingly available and shows promise to be suitable for some applications, it cannot yet address all relevant applications across Earth system science and applications. Cataloging strengths, weaknesses, opportunities, and threats in this domain is encouraged.

3.6. Ocean Surface Topography

Prepared by: Estelle Obligis, EUMETSAT; Yannice Faugère, CNES



The ocean surface topography observing system remains broadly operational with the following in-flight mission Sentinel-3A/B, Sentinel-6A/Michael Freilich, Jason-3, SWOT, AltiKa, CFOSAT, CryoSat and HY-2 series. Sentinel-6B and Sentinel-3C have been successfully launched in November 2025 and September 2026 respectively, and commissioning activities are progressing according to plan. CRISTAL mission is in Phase C and Sentinel-3 Next Generation Topography is under development. SARAL/AltiKa remains particularly relevant for high-latitude coverage and for its unique Ka-band capabilities, mission extended up to end 2027.

Gaps:

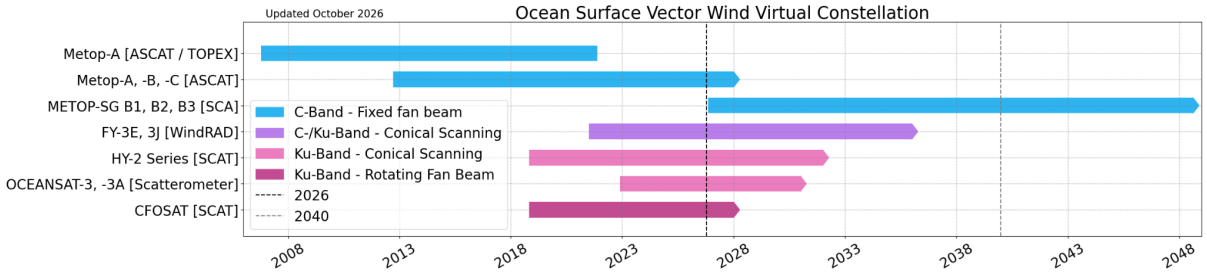
- The main area of concern relates to the continuity of the reference altimetry missions, that started with Topex-Poseidon. Due to the cancellation of Sentinel-6C, the EU is implementing an accelerated scenario for Sentinel-6 Next Generation. But there is a risk of discontinuity considering Sentinel-6B's nominal lifetime and the availability of the first Sentinel-6 Next Generation unit.

Opportunities:

- Following the success of the SWOT mission, several swath altimetry missions are set to be launched in the coming years, notably Sentinel-3 Next Generation Topography. These new missions will significantly improve our ability to observe and monitor small- and meso-scale phenomena in ocean dynamics.

3.7. Ocean Surface Vector Winds

Prepared by: Suchandra Aich Bhowmick, ISRO; Stefanie Linow, EUMETSAT; Paul Chang, NOAA



Scatterometers provide all-weather, day-night measurements of ocean surface backscatter, which are inverted using geophysical model functions to retrieve high-resolution wind vector over global oceans. These observations serve as a critical backbone for operational Numerical Weather Prediction (NWP) through direct data assimilation, substantially enhancing initial state analyses. It facilitates the early tracking, structure characterization, and intensity forecasting of tropical cyclones and mid-latitude storms. Scatterometer data also provides the vital boundary momentum flux like ocean wind stress and wind-stress curl that is required to force coupled ocean circulation and wave models. These model simulations help diagnose air-sea gas exchange, track sea-ice edge and evaluate climate variability such as El Nino/Southern Oscillation (ENSO). International coordination through OSVW-VC and the WMO Integrated Global Observing System (WIGOS) is essential to harmonize data from diverse C- and Ku-band instruments. Maintaining this coordinated constellation across varied local solar crossing times is imperative to secure sub-daily revisit capabilities, avoid coverage gaps as legacy missions reach end-of-life, and advance emerging research in the field of coastal processes and diurnal cycle dynamics.

<u>Gaps:</u>

- Ku-band rotating scatterometers suffer atmospheric attenuation and volumetric raindrop scattering, causing wind speed overestimation in moderate winds. In the absence of an operational co-located multi-frequency radiometer or dual-frequency radar channel on single platforms, decoupling rain-induced surface splattering from pure wind-stress roughness remains a persistent grey area in GMF inversion.
- Backscatter from both pencil-beam Ku-band and fan-beam C-band suffers saturation where backscatter loses sensitivity above wind speed of 30 m/s. Thus retrieval of high winds is difficult, limiting study of cyclonic winds.

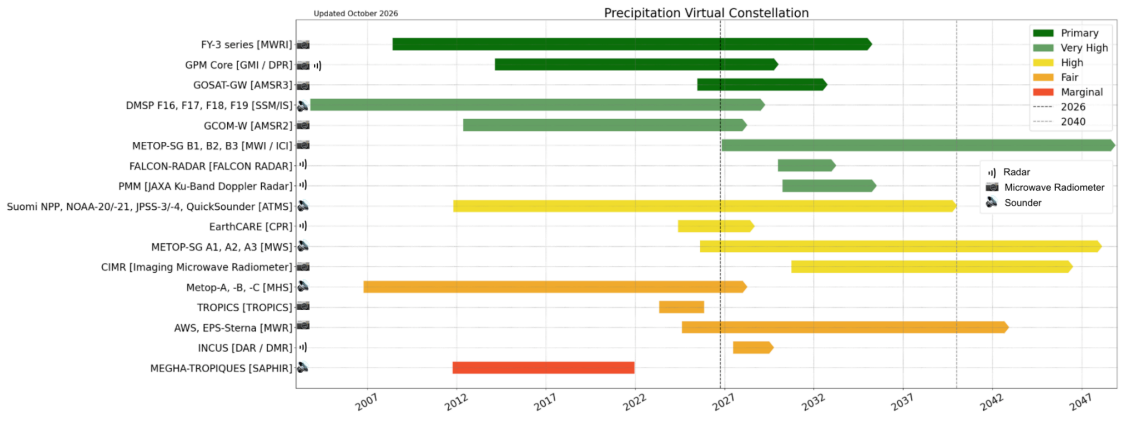
- Operational scatterometers assume standard neutral atmospheric stratification to invert backscatter to Equivalent Neutral Wind. However, radar backscatter responds strictly to surface capillary-gravity waves governed by friction velocity and surface stress.
- Under strong ocean currents, complex swell-wind-sea misalignment, and intense thermal air-sea gradients like cold wakes, western boundary currents etc. the wind retrieval becomes increasingly difficult. This encourages dual band scatterometer that can measure both wind and currents together. NWP model predictions can improve substantially if wind information are available at all pressure levels. Scatterometers can only provide wind vector data at surface level.

Opportunities:

- Constellation Coordination (Oceansat-3/3A, HY-2, FY-3): Establishing harmonized inter-calibration and synchronized orbital phasing (e.g., 12:00 LST vs. morning/evening crossings) between Oceansat-3A, HY-2, and FY-3/WindRAD series would enable sub-6-hour revisit intervals over the tropics. This would offer an unprecedented opportunity to resolve the diurnal cycle of coastal sea-breezes and track rapid tropical cyclone intensification phases.
- Frequency Fusion (Ku/Ka) with dual band scatterometers to resolve simultaneous ocean current for better retrieval of wind.
- Addition of cross-polarised channels on EPS-SG SCA to increase sensitivity to high and extreme wind conditions.
- Space-borne Doppler Wind Lidar (DWL) for the wind profile over ocean for better NWP predictions is a critical requirement. Similar to the Aeolus satellite carrying ALADIN (Atmospheric Laser Doppler Instrument), such innovation in scatterometers would unveil future opportunities.

3.8. Precipitation

Prepared by: Will McCarty, NASA; Takuji Kubota, JAXA



The missions in the precipitation constellation are categorised (primary, and very high through low) based on their importance to the global system, based on WMO OSCAR categorisation. The Global Precipitation Mission (GPM) Core Observatory has now been operational for 12 years, and is predicted to last until the early 2030s. It continues to operate alongside the FY-3 series of China, also considered a Primary reference.

There are several new missions ready to provide continuity as a primary reference, including the recently launched GOSAT-GW. FALCON-RADAR and PMM missions are planned to launch in 2029 and the early 2030s, respectively. Both are currently categorised as Very High relevance.

Overall, the precipitation observing system is expanding, with increasing Doppler, microwave, and commercial capabilities:

- GPM DPR/GMI: Version 8 products released in March 2026.
- AMSR3: Data publicly available since June 2026.
- EarthCARE CPR observations have been operationally integrated into ECMWF NWP systems since June 2026, demonstrating the direct contribution of science missions to operational forecasting.
- GSMaP: Version 9 planned for October 2026, incorporating additional NWP information and AI/ML techniques to improve passive microwave precipitation retrievals.
- INCUS: Trio of Ka-Band precipitation radars are set for launch in 2027.

Gaps:

- Need for improved, validated surface snowfall/precipitation products.
- Persistent limitations in overall sampling continuity and continuous surface reference observations.
- Current “Nowcast” products frequently rely on non-real-time observations (often up to 4 hours old), impacting real-time operational utility.
- Legacy algorithms are not currently optimised to automatically ingest new sensor data, while emerging AI-driven products currently require standardised metrics for proper validation.

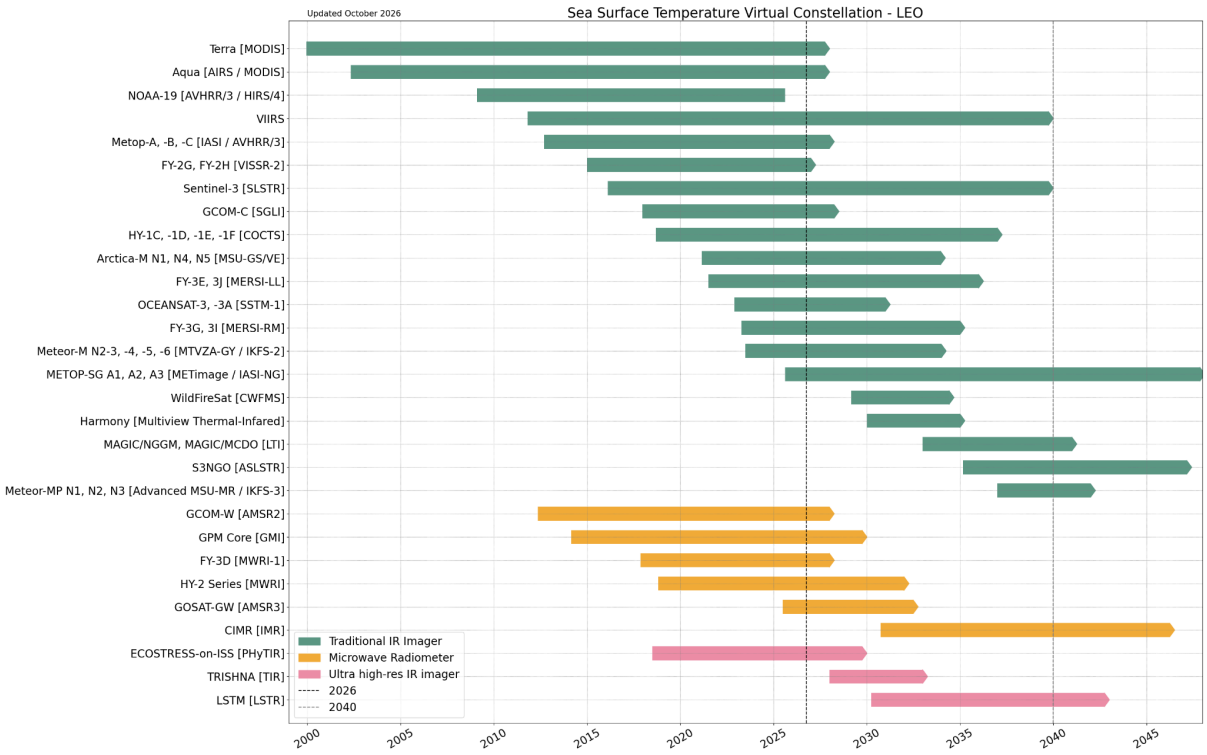
Opportunities:

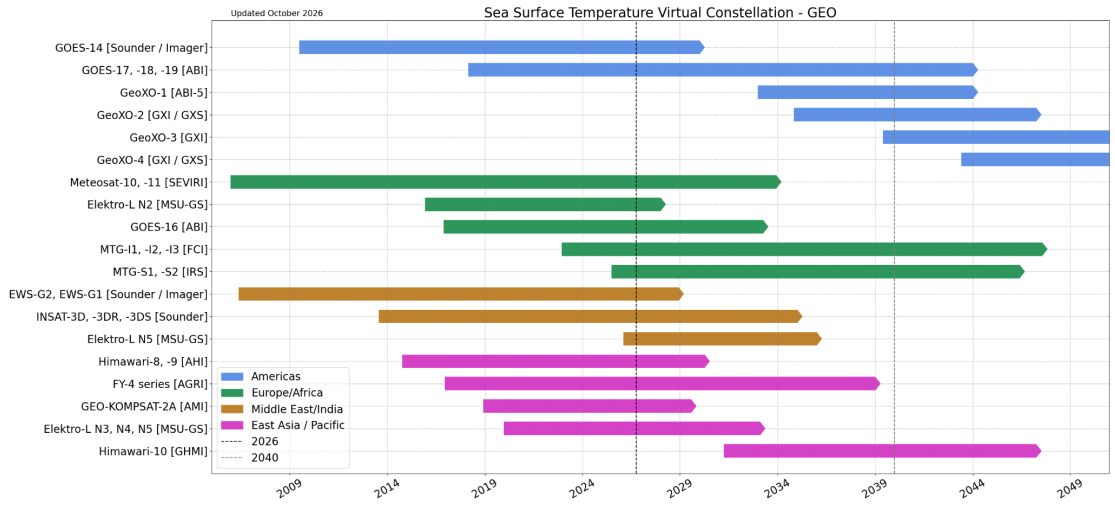
- Further algorithm development using high-quality surface observations in mountainous regions is required to improve retrievals over such complex terrains.
- Provision of more ground observations in the Himalayan and northeastern regions of India to increase reference observations for precipitation retrieval and validation.

- Use of Direct Broadcast and DBNet to reduce data latency, although coverage of these technologies remains limited.
- Leverage commercial sources (e.g., Tomorrow.io, WeatherStream) to address sampling needs. Strengthen linkages to GSICS activities to assess data quality, calibrate outputs, and ensure cross-constellation interoperability.
    - Develop consistent quality metrics and a framework to support integration of commercial sources
- Constructing commercial licensing agreements of individual CEOS agencies to support re-use of data by the international community.
- Maintain continuous, high-quality reference systems (like active radar/passive radiometer combinations) to prevent sensor inconsistencies and support robust intercalibration frameworks that support integration of new commercial sources.
- Develop next-generation system simulators to accurately evaluate the real-world performance variables (frequency channels, spatial resolution, latency) of proposed satellites before deployment.

3.9. Sea Surface Temperature

Prepared by: Misako Kachi, JAXA; Christo Whittle, CSIR





Missions of Sea Surface Temperature (SST) are categorized to two tables, LEO SST missions (upper) and GEO SST missions (lower).

In the LEO SST mission table, they are further categorized to "traditional IR imager (green)", "microwave radiometer (orange)", and "ultra high-resolution IR imager (pink)". Traditional IR imager indicates 1-km resolution IR imager that can retrieve SST outside the clouds in fine resolution with good accuracy. Microwave radiometers with 6-10 GHz channels can observe SST under the clouds with coarse spatial resolution (30-100 km). Microwave imagers that do not have 6 GHz but have 10 GHz may observe SST higher than ~10 degC because of smaller brightness temperature sensitivity for 10 GHz brightness temperature to lower SST range. Ultra high-resolution IR imager is a recently available IR imager with spatial resolution less than 100 m. It shows great potential in coastal SST observations, but its coverage is not global.

In the GEO SST table, missions and their IR imagers are categorized to four regions, Americas (blue), Europe/Africa (green), Middle East/India (brown) and East Asia/Pacific (pink).

Gaps:

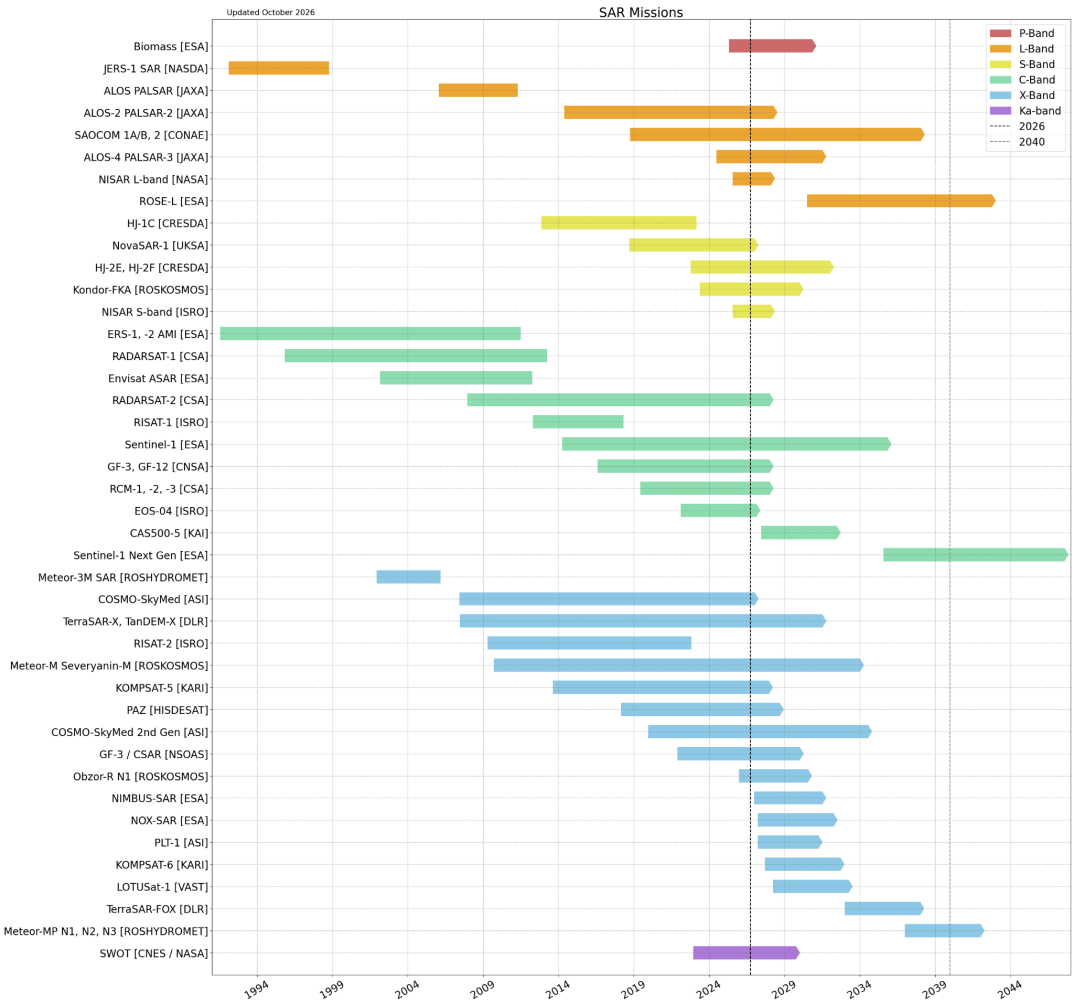
- Microwave SST: Major gaps are found in microwave radiometer SST missions. As of 2026, there are only two missions (GCOM-W/AMSR2, GOSAT-GW/AMSR3) that have capability to observe global SST with 6 GHz channels in 50 km spatial resolution. HY-2/MWRI also has 6 GHz channels but its spatial resolution is ~100 km due to smaller antenna diameter compared to the AMSR series. CIMR is planned to be launched around 2030 and will provide microwave SST in 15 km spatial resolution, but after 2032, there will be a gap since there is no confirmation of a successor of the HY-2 and AMSR series.
- Ultra high-resolution SST: Fewer ultra high-resolution IR missions are operating and/or planning in upcoming years. They are highly expected for coastal SST observations.

Opportunities:

- Close collaboration with the Group for High Resolution SST (GHRSST) in both science and operational applications.
- Development and implementation of GHRSST Data Specification (GDS) V2.1/2.2 and updates to planned GDS V3.0 in collaboration with GHRSST and in alignment with activities conducted by CEOS-ARD for the Surface Temperature PFS.
- Further algorithm improvements for microwave SST through intercomparison of microwave SST products, in-situ observations, and IR SST products, in collaboration with GHRSST.
- Collaboration with COAST-VC, especially by contribution of ultra high-resolution IR SST for providing coastal SST less than 100 m.
- Collaboration with Biodiversity VC, for potential interests in coastal areas, seascapes, coral reef, heat wave, etc.

3.10. Synthetic Aperture Radar

Prepared by: Paul Rosen, NASA; Malcolm Davidson, ESA; Takeo Tadono, JAXA; Ake Rosenqvist, JAXA; Elizabeth Nuncio Quiroz, DLR



The SAR Virtual Constellation includes sensors operating in a wide range of wavelength bands including P-, L-, S-, C-, X- and Ka-band (wavelengths of approximately 69.0, 23.5, 9.4, 5.5, 3.1, 0.8 cm, respectively). Continuity of observations is assured to 2040 for L-, C- and X-band wavelengths - the most commonly used bands for science and operational applications. Further continuity for C-band is also planned through the Canadian RADARSAT+ programme, however operational dates for the planned platforms are yet to be announced.

Operating modes differ between the missions, meaning each mission has unique capabilities. In 2026, the MIM Database Team conducted an exercise to collect extended information on SAR missions. This data will allow for more detailed gap analysis exercises, considering aspects such as polarisation, swath width and spatial resolution across imaging modes.

The number of commercial SAR providers (omitted from the above chart for simplicity) is increasing, with most commercial companies focusing on very-high resolution X-band sensors. Future work for SAR-VC includes to better understand the landscape of commercial SAR providers, and how they can complement CEOS Agency data.

Gaps:

- There is no continuity planned for P-band observations beyond ESA's Biomass mission. These very long wavelength band observations are critical to understanding structure in high biomass forests and hence the amount of carbon stored by such forests. Teams are currently working to assess if the information products gathered via Biomass' observations can be gathered using alternative methods, such as with the use of higher frequency radar, companion satellites, and airborne campaigns.
- The current S-band sensors are predicted to end around 2035, and no future missions carrying S-band sensors are planned. The impact of S-band observations on science and applications remains to be assessed and quantified. It is too early to say what the outcomes from NISAR S-band will be. As the wavelength band is located between C- and L-band for which continuity of data is secured, S-band provides a potential additional information source which as yet remains unexplored.
- Polarimetric (PolSAR/PolInSAR) research and applications are still underdeveloped, caused by a general scarcity of consistent time-series of polarimetric data for R&D over key global biomes and land cover types. The CEOS PolSAR activity was initiated under LSI-VC in 2025/2026 to engage with CEOS Agencies to collect polarimetric time-series data over dedicated PolSAR reference sites to progress the development of polarimetric R&D. CEOS Agencies are encouraged to continue supporting the PolSAR activity. Coordination of the activity is from November 2026 to be transitioned from LSI-VC to SAR-VC.

Opportunities:

- There are an increasing number of commercial SAR sensors, with many focusing on very high resolution X-band observations. CEOS Agencies are encouraged to continue purchasing this data for science applications, to supplement the CEOS Agency data available.
- There is limited availability of consistent X-band acquisitions to support science applications. As commercial sensors often provide targeted observations, institutional X-band missions are recommended to collect systematic acquisitions to support science applications.
- The availability of CEOS-ARD SAR products lowers the barrier to entry for the use of these complex products. Agencies are encouraged to continue developing CEOS-ARD SAR products, to help enable interoperability between missions.
- Recommendations from the science community were published in *Earth and Space Science* in 2026, in a paper titled *Observation and Coordination Needs for Current, Near-Future, and Next Generation Earth-Observing SAR Systems*. Agencies are invited to review this paper, and consider the recommendations in their future SAR mission planning.