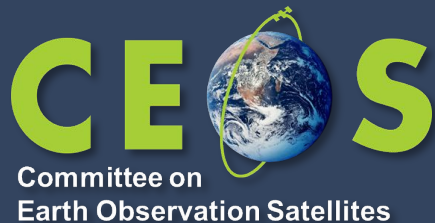


CEOS Virtual Constellations

2025 Synthesis Report



JAXA SIT Chair Team
Agenda Item 7.6
39th CEOS Plenary
Bath, United Kingdom
4th - 6th November, 2025

Objectives:

- ❖ **Coordinate** space-based, ground-based, data delivery systems
- ❖ **Meet** a common set of requirements within a specific domain
- ❖ Leverage inter-Agency **collaboration and partnerships**
- ❖ **Address observational gaps**, sustain the routine collection of critical observations
- ❖ **Minimise duplication**/overlaps
- ❖ **Maintaining** the **independence** of individual CEOS Agency contributions

- ❖ Atmospheric Composition (AC-VC)
- ❖ Coastal Observations Applications Services and Tools (COAST-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)

- ❖ **AC-VC:** Emma Knowland (NASA) *replacing Barry Lefer (NASA)*, Hiroshi Tanimoto (NIES), Ben Veihelmann (ESA)
- ❖ **COAST-VC:** Paul DiGiacomo (NOAA), Rashmi Sharma (ISRO), Aurelien Carbonniere (CNES), Merrie Beth Neely (NOAA)
- ❖ **LSI-VC:** Chris Barnes (USGS), Peter Strobl (EC), Jonathon Ross (GA), Takeo Tadono (JAXA)
- ❖ **OCR-VC:** Marie-Helene Rio (ESA), Ewa Kwiatkowska (EUMETSAT), Jeremy Werdell (NASA)
- ❖ **OST-VC:** Yannice Faugere (CNES), Estelle Obligis (EUMETSAT)
- ❖ **OSVW-VC:** Paul Chang (NOAA), Stefanie Linow (EUMETSAT), Abhisek Chakraborty (ISRO), Suchandra Aich Bhowmick (ISRO)
- ❖ **P-VC:** Chris Kidd (NASA), Takuji Kubota (JAXA)
- ❖ **SST-VC:** Misako Kachi (JAXA), Christo Whittle (CSIR)

Virtual Constellation Leadership



LSI-VC



Takeo Tadono
JAXA

Chris Barnes
USGS

Jonathon Ross
GA

Peter Strobl
EC

AC-VC



Hiroshi Tanimoto
NIES

Ben Veihelmann
ESA

Barry Lefer
NASA

Emma Knowland
NASA

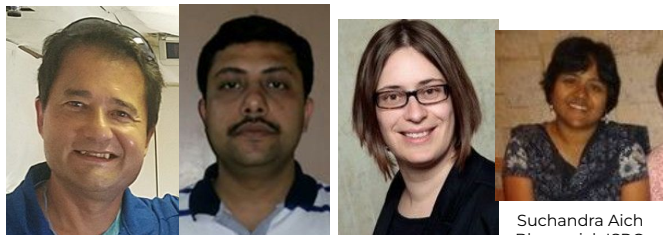
P-VC



Chris Kidd
NASA

Takuji Kubota
(JAXA)

OSVW-VC



Paul Chang
NOAA

Abhisek Chakraborty
ISRO

Stefanie Linow
EUMETSAT

Suchandra Aich
Bhowmick ISRO

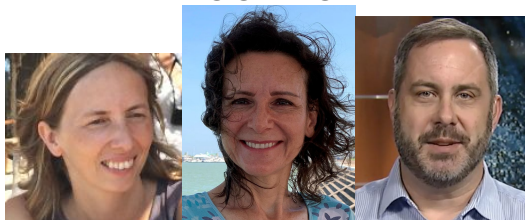
SST-VC



Misako Kachi
JAXA

Christo Whittle
CSIR

OCR-VC

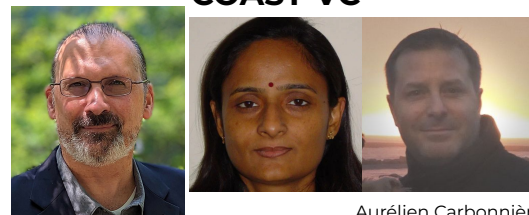


Marie-Hélène Rio
ESA

Ewa Kwiatkowska
EUMETSAT

Jeremy Werdell
NASA

COAST-VC



Paul DiGiacomo
NOAA

Rashmi Sharma
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Aurélien Carbonnière
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OST-VC



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(EUMETSAT)

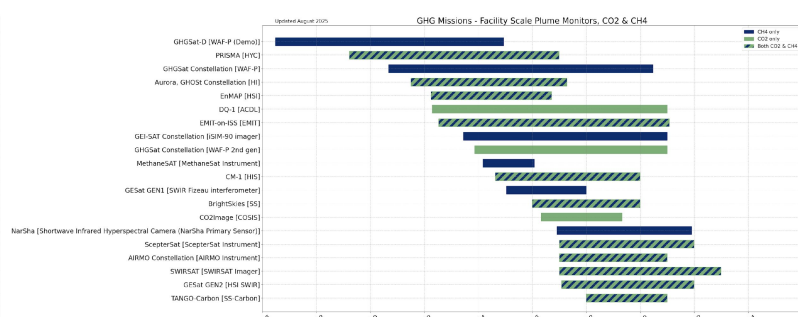
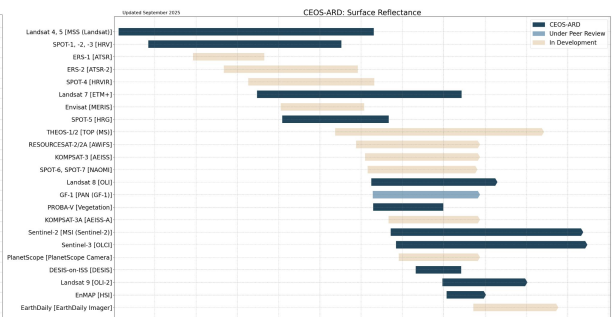
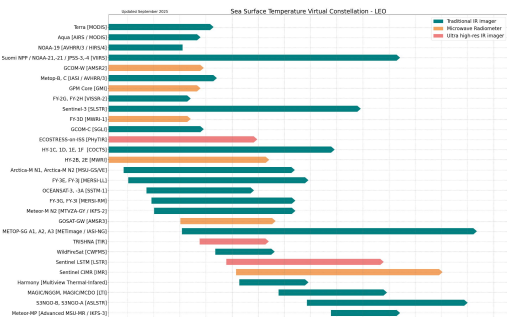
The CEOS SIT Chair has the responsibility to oversee and guide the work of CEOS Virtual Constellations

- ❖ **Leadership & Coordination:** Guiding to ensure alignment with CEOS priorities and global initiatives.
- ❖ **Strategic Oversight:** Coordination to CEOS activity areas, such as climate monitoring and SDGs
- ❖ **Facilitates Collaboration:** Integration with other CEOS entities to maximize data impact
- ❖ **Progress Monitoring:** Progress, addressing challenges and supporting new initiatives.

A Common format for VC Reporting



- ❖ At SIT Technical Workshop 2025, the VC Co-leads trialled a common format to report on VC updates and the state of the observing system. These included:
 - ❖ Timelines of key missions produced with the CEOS MIM Database
 - ❖ Planning highlights: Continuity of observations, missions, and products; potential gaps in data supply through to the 2030's
 - ❖ Issues for SIT attention: Issues engaging with satellite operators and the commercial sector; items for CEOS Principal attention / guidance
- ❖ The digestible format was well received at SIT TW, although highlighted the need to retain the VCs' flexibility



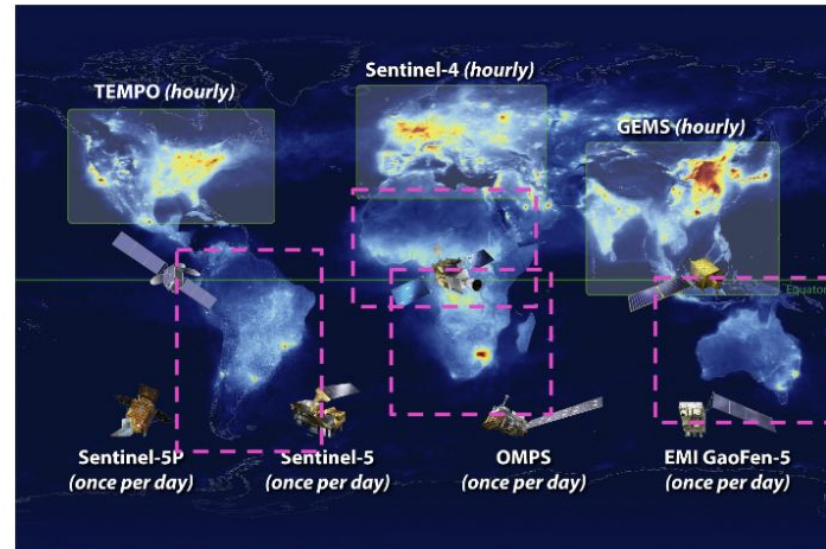
Planning highlights:

- ❖ New missions in 2025: GOSAT-GW, MicroCarb, MetOp-SG-A1, & MTG-S1. MTG and MetOp will continue the long record of space-based AC data, alongside Sentinel-4 and -5, IRS, and the geostationary AQ constellation
- ❖ There is interest to develop more operational GHG validation infrastructure, with plans to initiate a Level 2 intercomparison exercise for total column data. AC-VC submitted papers to the Phase-II Tropospheric Ozone Assessment Report (TOAR-II)
- ❖ New AC-VC Co-lead Emma Knowland (NASA) replacing Barry Lefer (NASA)
- ❖ The AC-VC *Enhancing the role of satellites in PM2.5 monitoring* white paper is at a consolidated draft stage, to be completed by the end of 2025.
- ❖ AC-VC-21 meeting June 2025 jointly with IWGGMS and WGCV-ACSG in Japan: progress on GHG, tropospheric ozone, and air quality
- ❖ AC-VC-22 meeting planned for June 2026 in Leiden, Netherlands

AC-VC White Paper: Expanding Geostationary Monitoring of Atmospheric Composition



- ❖ There is concern about the potential ending of OCO-2 and OCO-3, as well as the de-scope of GeoXO ACX providing TEMPO continuity over North America. Operational continuity of Sentinel-5P is needed, alongside Sentinel-5
- ❖ AC-VC is developing a white paper titled Expanding geostationary monitoring of atmospheric composition: Large parts of the globe are not covered by the current constellation of geostationary AC satellites. The white paper advocates for new satellites to fill gaps in coverage and complement the existing GeoAC constellation, requiring regional-level ownership and participation
- ❖ Consolidated draft expected by the end of 2025



Planning highlights:

- ❖ New COAST-VC Member: CSA
- ❖ A Coastal Satellite-Derived Bathymetry Working Group was established under COAST-VC in October, which will meet monthly
- ❖ Coastal Data Gap Analysis activity commenced in October as a contribution to the CEOS Work Plan and the Space4Ocean Alliance. Volunteers from VC and WGs are invited to sign up to the mailing list
- ❖ The Coastal Application Knowledge Hub (AKH) recently introduced improved intertidal bathymetry from GA and NOAA's marsh mapping tools.

Coastal Observations Applications Services and Tools



- ❖ COAST-VC highlights the importance of high resolution instruments for coastal observations, which also rely on OCR, OST, OSVW, and LSI measurements.
- ❖ Welcoming expressions of interest for future COAST-VC Co-leads, following NOAA's transition back to membership status in alignment with the proposed timeline

Collaboration highlights:

- ❖ OCR-VC: COAST-VC is leading the drafting of coastal segments of the CEOS Aquatic Carbon Roadmap, with first drafts completed in early November
- ❖ SST-VC: Developed the joint coastal masking recommendation
- ❖ CoastPredict: Co-chairing a special session at AGU25
- ❖ IOCCG & GOOS: Outreach and future collaboration discussions

Planning highlights

- ❖ Successful launches of Biomass and NISAR missions and start of ALOS-4 data distribution
- ❖ Compliance assessments for CEOS-ARD Surface Reflectance and SAR are being developed for NISAR (NASA & ISRO), SAOCOM-1 and SABIA-Mar (CONAE), THEOS (GISTDA), Landsat Collection 3 (USGS), and Kompsat-6 and -7 (KARI)
- ❖ CEOS and industry updating the CEOS-ARD Surface Temperature Specification
 - Increasing scope for SBT products and higher level applications (Wildfires, Climate models)
 - Kick-off meeting held on 14 October 2025, participated by Landsat, LSTM, S-3, TRISHNA teams, alongside commercial sector. Looking for additional CEOS mission representation
- ❖ PFS development for multi-source backscatter and VHR SAR to enable new product and commercial sector participation
- ❖ Supportive of developing an official LSI-VC recommendation for DGGS (Discrete Global Grid System).

Challenges:

- ❖ Land degradation neutrality efforts (GEO-LDN, UNCCD) require more long time series, global land cover data, and data harmonisation. SAR applications found for small islands, Biomass, disturbance; hyper-arid areas, and vertical profiles
- ❖ AFOLU Roadmap actions need to identify more activities beyond NASA, ESA, JAXA
- ❖ Need to map GEOGLAM EAVs to existing CEOS Agency products / activities
- ❖ Support for closer collaboration with EO community was emphasised at Ramsar COP15, as EO is key to enabling more reporting. EO featured in COP15 Resolution 13.10
- ❖ Community requests from the CEOS-ARD survey calling for additional CEOS-ARD from MODIS, PACE, NISAR, NovaSAR-1, Sentinel-1 and 3, among others, as well as better availability of high-resolution open DEMs to support RTC.
- ❖ Commercial sector is keen to engage and learn from CEOS agencies, many engaging in LSI-VC
- ❖ Review agency participation in LSI-VC: ASI, CSA, DLR, INPE, NASA, NOAA, VAST

Planning highlights:

- ❖ Progress on the Aquatic Carbon Roadmap
 - Dec 2025: a dedicated keynote, panel discussion, and breakout session at the International Ocean Colour Science Meeting (IOCS); preceded by the [Ocean Carbon From Space 2025](#) Workshop
 - SIT-41 in early 2026: current target for completion
- ❖ May 2025 endorsement of the CEOS-ARD Aquatic Reflectance PFS that covers all aquatic ecosystems, oceans, seas, coastal and inland waters
- ❖ Other OCR-VC deliverables: System Vicarious Calibration in [BAMS 2025](#); in situ measurement [protocols](#), [FRM4SOC2](#); IOCCG [training & scholarships](#), FRM4SOC2 [FICE](#)
- ❖ [IOCS 2025](#) in Darmstadt, Germany, 1-4 Dec, IOCCG meeting co-hosted by EUM & ESA
- ❖ Current IOCCG working groups and task forces
 - WGs: Benthic Reflectances, Primary Production, Optical Water Types, Lidar Applications
 - TFs: Marine Litter & Debris, Hyperspectral, Carbon, Long-Term Records, Sensor Calibration, SVC

Challenges:

- ❖ GEO-XO mission may lose the ocean colour sensor. Continuity of hyperspectral measurements needs to be seen into the future.
 - IOCCG tackling OCR requirements for consistent long-term time series. The requirements are complex and need guidance
- ❖ Support for high quality in situ Fiducial Reference Measurements is needed. There is vulnerability around funding for SVC infrastructures and risk for missions
 - Coordination with in situ instrument manufacturers, calibration labs, metrology institutes
 - End-to-end uncertainty budget for OCR products and the OCR quality label
- ❖ OCR-VC is leading the Aquatic Carbon Roadmap, and working on interfaces across the CEOS carbon roadmaps and implementing aquatic carbon in global carbon stock assessments
- ❖ Developing water quality data products: roadblocks for using EO by water quality reporting agencies, and the private and commercial sector

Planning highlights:

- ❖ The current constellation of altimetry missions has 11 in flight and 11 planned. Sentinel-6B is planned for launch on 16 November 2025, providing continuity to the MSL record started in 1992 by TOPEX/Poseidon. Missions launching in 2026 include Sentinel-3C and HY-2E & 2F
- ❖ Next generation missions: Sentinel-3 Next Generation Topography is under ESA procurement. An ad hoc expert group is in place to define user requirements for Sentinel-6 Next Generation
- ❖ The upcoming OST Science Team meeting will coincide with Sentinel-6B launch on 16 November 2025, with OSTST26 scheduled for 22-26 June 2026.
- ❖ OST-VC developed the *Coordinated International Satellite Altimetry Virtual Constellation: Toward 2050* white paper, shared as a recommendation to CEOS from the science community

Challenges:

- ❖ Sentinel-6C was identified in the EC Copernicus Long Term scenario, but there is a contribution risk to the mission.
- ❖ Key role of Chinese missions (HY2) in the Virtual Constellation □ participation of Chinese agencies in the VC would be welcome.

Planning highlights:

- ❖ Continuity of ocean surface vector wind observations, with several upcoming missions, into the 40's
- ❖ E.g. upcoming EPS-SG SCA launch in H2/2026 which will improve high-winds capabilities
- ❖ Coverage at different times during the diurnal cycle (5:00, 6:00, 7:00, 9:30 and 12:00), plus additional sampling in drifting orbits from NSOAS/CAST HY-2 series into the 30's
- ❖ OSVW observations deliver high societal impact, particularly for monitoring extreme winds, NWP, and time series. Complementarity with other instruments (e.g., SAR and microwave radiometers) should continue to be explored.

Challenges

- ❖ VC Coordination through the IOVWST:
 - International Ocean Vector Science Team meeting
 - Location is alternating between US and Europe but attendance from various countries is becoming increasingly difficult
 - NASA funding until 2024, exceptional EUMETSAT funding in 2025

Current product status:

- ❖ Agency/organisation products generally freely available in HDF5/netCDF formats.
- ❖ New products based upon AI/ML are being developed (e.g. GPROF V08 precipitation retrieval product for release in 2026).
- ❖ CEOS-ARD PFS for precipitation under development (*primary agency/organisation products already in ARD-type formats*).

Potential gaps in product availability

- ❖ Products heavily dependent on the suitability and availability of data.
- ❖ To 2030 - continued operations of core sensors (with some loss/gains).
- ❖ Commercial (high frequency microwave) data available (at a significant cost).
- ❖ Post 2030 - GPM EoL, some new missions, but dominated by sounding instruments (*which are less capable for surface precipitation estimation*).

Satellite data provides key observations for mapping, monitoring and measuring global precipitation:

- ❖ *Critical gaps*: possible (likely) lack of low inclination radar(s) and suitable low frequency radiometers for precipitation is **now critical**.
(*Precipitation-focused missions have been largely 'research' missions*).
- ❖ *Coordination required*: the continuation of a core set of precipitation-capable agency missions is vital - commercial missions are an added extra (*albeit at a cost and reduced capability*).
- ❖ *Societal impact*: a reduction in the accuracy of satellite precipitation estimates impacts many aspects of our society from natural hazard mitigation to water resource planning.

Sea Surface Temperature



Planning highlights:

- ❖ Version 3 of the GHR SST Data Specification (GDS) for SST products is planned to include ultra-high SST (sub 100 m) and sea ice surface temperature. There is interest in CEOS-ARD compliance and cloud optimisation.
 - GDS provides a common format for SST products adopted by about 20 agencies, more than 150 datasets and many more every year, and provides interoperability between GHR SST datasets and services.
- ❖ Some commercial sector participation (Ororatech) joined GHR SST26 in June 2025 and interested in engagement with the community for possible ultra high-resolution SST from their satellite

Collaboration highlights:

- ❖ Worked with COAST-VC to develop joint statement on recommended coastal coverages of future ultra high-resolution IR sensors.
- ❖ Joined CEOS-ARD Surface Temperature PFS update kick-off in October, sharing SST perspectives and the potential GDS-aligned CEOS-ARD
- ❖ Inputs to Biodiversity Study Team user needs assessment

Challenges:

- ❖ Gaps are foreseen in LEO microwave imaging capabilities beyond 2032
 - How does data supply look in 2030? – AMSR3 (2025-2032), HY-2E (2025-2028), CIMR-A (2029-2037)/-B(2034-2042)
 - How does data supply look in 2035? – Potentially CIMR-A & -B will be in operation. No confirmed successor for HY-2 nor AMSR – continuation needed
- ❖ Issues with engaging satellite operators, for testing and validation of ultra high-resolution SST of upcoming missions to analyse value of resolving significant features in coastal area
- ❖ SST-VC would benefit from coordination between parameter and area-focused VCs