CEOS Committee on Earth Observation Satellites

AQUATIC CARBON ROADMAP

The final countdown!

AQUATIC CARBON ROADMAP TIMELINE

Aquatic Carbon Roadmap Focus

Deliverable VC-23-01

CEOS commitment to demonstrate the value of Earth Observation satellite datasets to support the Global Stocktake process.

GHG and AFOLU roadmap have a strong focus on major milestones of GST1 (2023) and subsequently for GST2 (2028) and how remote sensing data can effectively support these by providing means to monitor carbon emissions and removals, based either on a top-down approach (GHG roadmap) or a bottom-up approach (AFOLU roadmap).

The Aquatic Carbon Roadmap (ACR) completes coverage of the Earth System by addressing fluxes of carbon across systems and accounting for the second largest, long-term store of carbon on Earth, second only to the Earth's core.

Roadmap concept **presented and endorsed at CEOS plenary in November 2023 as the "Aquatic leg" of the CEOS Carbon strategy**, in complement to the GHG and AFOLU roadmaps. Deadline for completion was Q1 2026; **ACR draft was delivered to CEOS April 1, 2026.**

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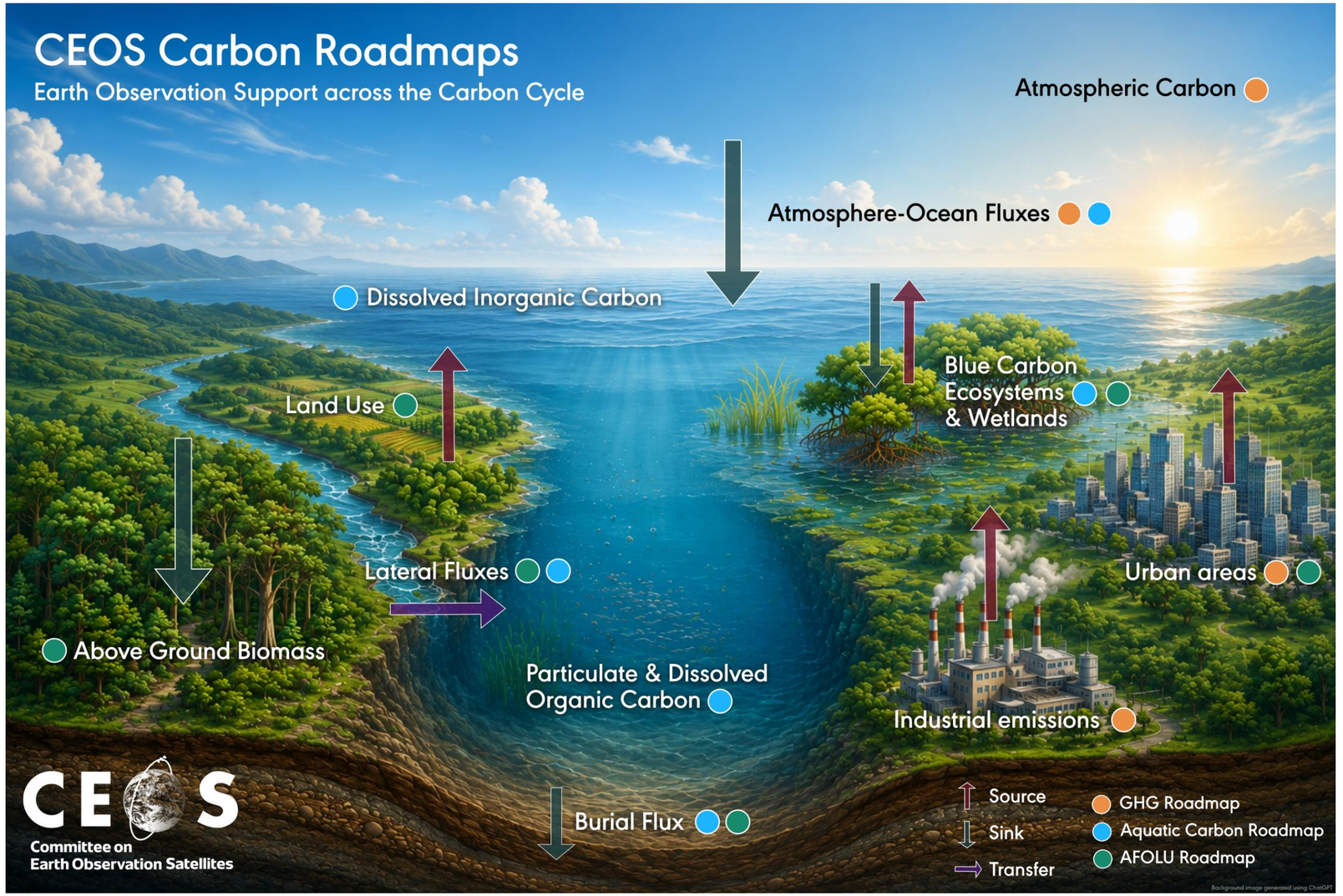

Concept image depicting how CEOS is tackling carbon observations in all domains via the Carbon Roadmaps. Image credit Liby Rose.

Roadmap highlights its contribution to a coherent Earth observation perspective of the carbon cycle and recognizes the **interconnected nature of terrestrial, atmospheric, and aquatic systems** and the need for coordinated observations of carbon exchanges across these domains.

Aquatic Carbon Roadmap Scope

Aquatic Systems: The roadmap addresses carbon dynamics across a "land-to-ocean-aquatic-continuum" (LOAC), specifically focusing on:

- **Open Oceans and Shelf Seas**: The largest aquatic environments, covering roughly 94% of the global aquatic area.
- **Coastal and Blue Carbon Ecosystems**: Specifically coastal areas and ecosystems such as seagrasses, tidal marshes, and mangroves.
- **Inland Waters**: Including lakes, reservoirs, and rivers.

Technical and Scientific Focus: The roadmap takes into consideration the following:

- **Earth Observation (EO) Capabilities**: It examines the current state of remote sensing to monitor different, relevant carbon pools (dissolved, particulate, organic, and inorganic) and fluxes (such as air-sea gas exchange and exchange across systems) and the current gaps and opportunities.
- **Prioritization of Needs**: The roadmap identifies specific priority areas and opportunities that could be executed across different timelines, leveraging existing and planned activities by the EO community.
- **Foundational Science**: While the roadmap focuses on carbon accounting, it notes that this hinges on foundational science to advance critical applications; it does not go into exhaustive scientific depth itself.
- **Global Assessments**: The document aims to support the Global Stocktake, National Greenhouse Gas (GHG) Inventories, and IPCC assessments, amongst other activities.
- **Dissemination and Capacity Building**: The roadmap includes considerations to increasing global capacity for EO data use and improving communication across communities.

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Table 1: Summary of current priorities and emerging, forward-looking topics considered in the Aquatic Carbon Roadmap.

Category	Current Priorities (Roadmap Scope)	Identified Future Gaps / Forward-Looking Priorities
Carbon Species	Focus on DIC, DOC, POC, and PIC (Dissolved/Particulate Organic and Inorganic Carbon) and air-sea CO2 flux	Methane (CH4): Detailed treatment of the aquatic methane cycle is missing. Other cycles: Nitrogen
Ecosystems	Open oceans, shelf seas, and "Blue Carbon" (mangroves, seagrass, tidal marshes).	The LOAC Loop: Inclusion of floodplains and groundwater; deeper understanding of the "Twilight Zone" and under-ice regions
Methodology	Tier 1 IPCC reporting and establishing baseline Earth Observation (EO) capabilities.	Transitioning to Tier 2 and Tier 3 reporting; narrowing model uncertainties; and validating 3D ocean carbon storage.
Social and Economic	Scientific quantification of stocks and fluxes to support the Global Stocktake.	Human Dimension: Impact of urbanization and management; Economic Valuation: Linking carbon data to monetary value.
Climate Action	Initial framework for Monitoring, Reporting, and Verification (MRV).	mCDR: Dedicated focus on the safety, efficacy, and ethical frameworks of Marine Carbon Dioxide Removal technologies.
Policy and Data	Improving global data access and standardizing definitions for EO products.	Addressing "policy latency" (the speed at which science is adopted) and aligning products with specific legal/regulatory needs.

Table 2: Stakeholders/benefits of the roadmap.

Stakeholders	Variable of Interest	Product Needed	Users	Specifications
UNFCCC	Blue Carbon mitigation targets in Nationally Determined Contributions (NDCs) ***reporting blue carbon in national GHG Inventory is a prerequisite to include BC under NDC mitigation commitments. Not needed for adaptation. Baseline areas of seagrasses and tidal marshes in 1990 (minimum 30m spatial resolution)	Baseline areas of seagrasses and tidal marshes in 1990 (minimum 30m spatial resolution). Multitemporal area changes for seagrasses and tidal marshes (ideally annually starting 1990 and until now)	Blue carbon countries (support to reporting Blue Carbon in Nat GHG Inventories and mitigation targets)	Minimum 30-meter maps usable at local (municipal) level. Enough detail for jurisdictional nesting If different satellites/sensors are used, data harmonization is needed to make data consistent along time.
Global Carbon Budget	Global estimates of the main stocks and fluxes of aquatic carbon from space, for use to help quantify global carbon emissions and sinks.	Global products of key pools (particulate and dissolved, organic and inorganic), and fluxes (primary production, export production, air-sea flux, land-sea flux, calcification) of aquatic carbon, that can be derived from space measurements, over as long a duration as feasible.	Primary use to track emissions, evaluate models, and inform climate action. Key users include: scientists, policymakers, climate assessment bodies, NGOs, and private sector.	Carbon budget models are typically coarse (0.5–2°, monthly), motivating global satellite products of aquatic carbon stocks and fluxes at comparable resolution, at as long as duration as feasible (through use of climate data records). Openly available data products.
mCDR	Direct satellite observations of mCDR efficacy and impacts, including medium and high resolution hyperspectral biogeochemical and physical data, and data-driven, operational models of the ocean state to build twin models for assessing mCDR.	More accurate measurements of DOC (CDOM) and DIC from remote sensing. Canopy extent for seaweed and seagrass, blue carbon health and extent for above-water species.	Scientists, policymakers, climate assessment bodies, NGOs, and private sector.	Minimum 30-meter spatial resolution for blue carbon ecosystems; global hyperspectral capabilities for OAE, OIF experiments. Global SST, SSS, SSH data
Ocean Carbon Models	Data to improve understanding and parametrization of air-sea gas exchange, biological pump efficiency, deep ocean carbon transport, ocean acidification feedbacks. Data need to be collected and analyzed using standardized methodologies. and representative of diverse locations.	Carbon export and variables involved in the carbon cycle at various depth, diverse location, carbon exchange with atmosphere and land to ocean transfer.	Primary use to track emissions, evaluate models, and inform climate action. Key users include: scientists, policymakers, climate assessment bodies, NGOs, and private sector.	Ocean and land carbon models carry uncertainty ranges of 10–20% or more. Complex climate-carbon feedbacks (e.g., how warming affects ecosystem carbon uptake) are not fully understood.
GHG inventories/ Inventory Agencies	Extent, conversion, degradation and restoration of blue-carbon ecosystems; associated CO_2, CH_4 and N_2O emissions and removals; carbon stocks and stock changes; activity data and emission/removal factors required for national GHG inventories and NDC mitigation accounting.	Inventory-ready blue-carbon activity data and emission/removal-factor support products, including historical and current ecosystem extent, land-cover change, degradation and restoration, carbon-stock information and, where possible, spatially explicit estimates of emissions and removals.	National GHG inventory agencies and technical teams; environment and climate ministries; forestry and coastal agencies; national carbon-accounting institutions; subnational/jurisdictional authorities; technical experts supporting NDC and IPCC reporting.	Minimum 30 m spatial resolution, suitable for local/municipal applications and jurisdictional nesting. Consistent ecosystem classification and change detection across sensors and over time. Products should be compatible with IPCC inventory methodologies, include documented accuracy and uncertainty, provide clear metadata/provenance, and be readily aggregable to national inventory units.

Recommendations

Key priority areas – short term

a. Continue support of and expand aquatic carbon basic research and advanced products (7 recommendations)

b. Leverage existing observational platforms and models to gap fill aquatic carbon flux priority areas (5 recommendations)

c. Support science that will advance aquatic carbon markets (3 recommendations)

Key priority areas – medium term

a. Coordinate and plan future observational needs that will address gaps in aquatic carbon flux estimates (4 recommendations)

b. Support science that will advance aquatic carbon markets (3 recommendations)

c. Support community standards and capacity building (2 recommendations)

Key priority areas – long term

a. Support and sustain the provision of satellite datasets for ocean carbon and further develop satellite-based climate data records so that they may continue to be used in global carbon assessments

b. Equitably coordinate and support the fiducial in situ infrastructures and best practices that climate measurements require, so the tracking of changes in Earth's environmental health continues and further evaluation of the impact on the Environment of policy decisions.

c. Invest in technology maturation and frontier research that furthers the information extracted from EO signals and the different carbon pools in aquatic systems, as well as process-based understanding of aquatic carbon cycling.

Other Sections of Interest

5.0 Demonstrating the power of aquatic carbon Earth observation to inform diverse stakeholders

6.0 Complementarities and linkages to the GHG and AFOLU and other roadmaps (expanded)

7.0 Expanding visibility, utilisation and capacity development

8.0 Forward Look

Aquatic Carbon Roadmap: What's Next

Roadmap was delivered as planned April 1, 2026.
Community comment and feedback period was open until June 30, 2026.
Roadmap authors and editors reviewed feedback and incorporated it in the final draft.
Final draft was delivered as planned August 25, 2026.
Final final (final) document to be delivered to CEOS 2 weeks prior to Plenary.
Expectation for ☑ at Plenary November 3rd-6th 2026

CEOS OCR-VC WP 2026: Metrics will be developed to track implementation of actionable Priority Areas and Areas of Opportunity, in coordination with other CEOS and non-CEOS stakeholders.