CSQ-8 Summary

<table>
<tr><th>Question</th><th>Knowledge Advancement Objectives</th><th>Observables</th><th>Measurement Requirements</th><th>Tools & Models</th><th>Policies / Benefits</th></tr>
<tr><td rowspan="4">How are coastal areas contributing to the global carbon cycle, and how are they responding to climate change and human pressures?</td><td>A) Global inventory of Blue carbon ecosystems, including mangroves, tidal marshes and seagrass beds</td><td rowspan="2">- biomass
- land cover
- canopy height
- surface temperature
- coastal bathymetry
- water level/DEM
- salinity
- soil moisture
- snow depth
- Atmospheric CO_2, CH_4</td><td rowspan="4">High spatial resolution (10-50m) for SST, bathymetry, canopy height, biomass
Sentinel-1/Sentinel-2 type imaging with daily or better revisit
Multi-frequency SAR/InSAR for multiple penetration depths of dense vegetation and snow</td><td rowspan="4">Coastal to regional models
Earth System models
Climate forecasts</td><td rowspan="4">Nature-based solutions
Restoration efforts
Improve projects
Climate change adaptation and mitigation policy.
Polar region treaties
IPCC monitoring and Paris agreement</td></tr>
<tr><td>B) Determine the extent of permafrost degradation and organic carbon releases in the polar coastal ocean</td></tr>
<tr><td>C) Determine contribution and drivers of change in “Blue carbon” ecosystems, and their resilience to human and climate change pressures in different coastal regions</td><td rowspan="2">Long term datasets for comprehensive assessments, including:
- 2D surface winds vectors
- directional wave spectra including integral wave parameters (wave height, period, direction)
- 2D total surface current vectors
- sea ice (extent, fraction, thickness)</td></tr>
<tr><td>D) Determine contribution and drivers of change in permafrost in the polar coastal ocean, and its resilience to human and climate change pressures in different coastal regions</td></tr>
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CSQ-8 Narrative

"Blue carbon" ecosystems such as mangroves, seagrass beds, tidal marshes and other marine and coastal vegetated ecosystems are among the most intense carbon sinks on the planet. Coastal habitats cover less than 2% of the total ocean area but account for approximately half of the total carbon sequestered in ocean sediments (https://www.thebluecarboninitiative.org). Together with delivering valuable climate services, coastal ecosystems also offer effective nature-based solutions for coastal and estuarine protection (de Moraes et al., 2022). But there is growing evidence that these ecosystems are under theat. Amongst the top 10 science questions to set the direction for Blue Carbon research, McCreadie et al. (2019) lists the need for more accurate estimates of the global extent and temporal distribution of Blue Carbon ecosystems, notably tidal marshes and seagrass area which are poorly quantified outside industrialised countries. Estimating the net flux of greenhouse gases between Blue Carbon ecosystems and the atmosphere, accounting for fluxes of GHGs like CH4 and N2O as well as CO2, highlights the need for more comprehensive assessments of the contribution of these coastal ecosystems to the global carbon cycle.

In polar regions though, the contribution of coastal environments to the global carbon cycle could be quite different in response to climate change. Sediment cores in the Arctic indicate that degrading permafrost under the action of sea-level rise and coastal erosion led to the mobilization of terrestrial carbon, and likely contributed significantly to changes in atmospheric CO2 around 14.6 and 11.5 kyrs BP (Winterfeld et al., 2018). Projections confirm that increased coastal erosion in the Arctic under the influence of global warming, retreating sea ice and greater scouring by wind, waves and currents (Nielsen et al., 2022) could lead to significant organic carbon releases from melting permafrost.

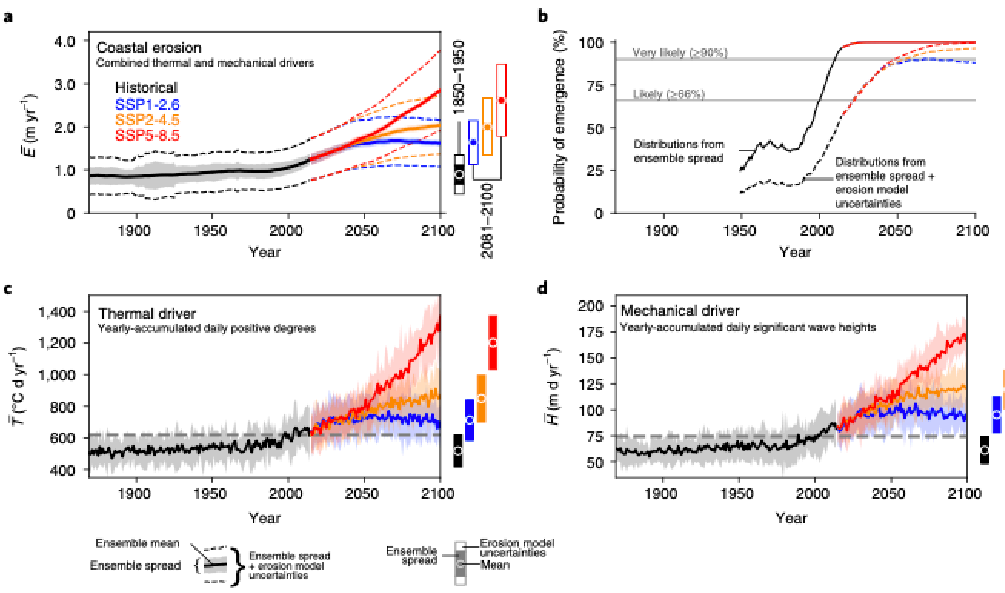

Fig. 1 | Arctic coastal erosion projections. a, Time evolution of the Arctic-mean coastal erosion rate, expressed as the combined effect of its thermal and mechanical drivers. **b**, Yearly probabilities that the Arctic-mean coastal erosion rate leaves the historical range of variability, calculated from distributions of ensemble spread and erosion model uncertainties (see Methods). In all scenarios, it is very likely (>90% probability) that the Arctic-mean erosion emerges from its historical range by mid-twenty-first century, although the exact time of emergence is sensitive to our erosion model uncertainties. **c**,**d**, The thermal (**c**) and mechanical (**d**) drivers of erosion, expressed as yearly-accumulated daily positive degrees and significant wave heights, respectively. The erosion time series depict long-term means and therefore show little interannual variability in comparison with its drivers. Dashed horizontal grey lines in **c** and **d** mark the upper bound of the historical range of variability for the erosion drivers, defined as 2σ from the ensemble mean.

From Nielsen et al. (2022)

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