CSQ-7 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="3">How do coastal processes mediate exchanges between land, atmosphere and the open ocean ?</td><td>A) Determine the physical processes that control land-air-sea exchanges in coastal regions.</td><td rowspan="2">New and improved EO measurements of all ocean parameters in coastal regions, including:
- sea level (sea surface height)
- 2D total surface current vectors
- 2D surface winds vectors
- directional wave spectra including integral wave parameters (wave height, period, direction)
- sea surface temperature
- hyperspectral ocean colour
- salinity
- coastal bathymetry</td><td rowspan="2">Fine spatial resolution:
- sea level, currents, winds, waves, salinity: 1km or finer
- SST, ocean colour, bathymetry: 10-50 metres
Fast revisit (daily, sub-daily, hourly)
2D mapping to observe space-time variability in complex coastal setup, with swath sensors or constellations.
Measurements up to the land/water edge with uncertainty levels similar or better than offshore</td><td rowspan="2">Coastal circulation models at 1km or finer grid spacing
Numerical wave models
Coupled atmosphere-wave-ocean prediction/assimilation systems
Coastal, regional and climate biogeochemical models</td><td rowspan="3">UN Decade of the Ocean
UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources
GCOS, GOOS, and WCRP (ECVs)
IPCC, Climate mitigation policy
Food security
UN SDG Goal 2: Zero Hunger</td></tr>
<tr><td>B) Determine the interactions between physical and biogeochemistry processes and marine productivity in the global coastal ocean.</td></tr>
<tr><td>C) Reduce uncertainties in the global coastal ocean contributions to global land-air-sea fluxes of heat, nutrients, carbon, gases, and freshwater.</td><td>Global assessments</td><td></td><td></td></tr>
</table>

CSQ-7 Narrative

The coastal ocean, defined as the area between the continental slope and estuaries, links the terrestrial, marine and atmospheric environments through a multitude of physical and biogeochemical processes. Exchanges between the coastal ocean and the deep ocean control the transport of heat, nutrients, carbon, gases, and freshwater, as well as the export of pollutants such as waste water and plastic. Although the coastal zone is proportionally small, it is the most biologically productive part of the ocean, responsible for the majority of the world's fish catch (Siefert & Plattner, 2004). By absorbing anthropogenic CO2 and contributing to long-term burial of organic matter and calcium carbonate, it plays an important role in the global carbon cycle. Updated compilation of air-sea CO2 fluxes based on observations in the literature show that the global coastal ocean represents an integrated CO2 sink of −0.25 ± 0.05 Pg C year−1, confirming its role as an efficient sink for CO2, particularly at high latitudes (Dai et al., 2022). Coastal regions dominated by rivers show marked differences in exchanges, transport and intrinsic biogeochemical reactions. However, it remains unclear to what extent coastal areas around the globe are taking up or releasing carbon, how much of the carbon exported from the coastal areas enters the deep ocean and how these fluxes are changing. Constraining uncertainties and developing predictive modelling capability remains hindered by the need to resolve fine scale fast-evolving processes and the paucity of observations to validate and improve models (Mathis et al., 2022; Roobaert et al., 2019). Satellite EO has the means to provide improved and new observations of land, coastal, open ocean and atmospheric conditions to determine physical and biogeochemical processes and their interactions, improve their representation in model predictions and climate projections and reduce uncertainties in estimated contributions by the coastal ocean to global carbon, energy and water budgets.

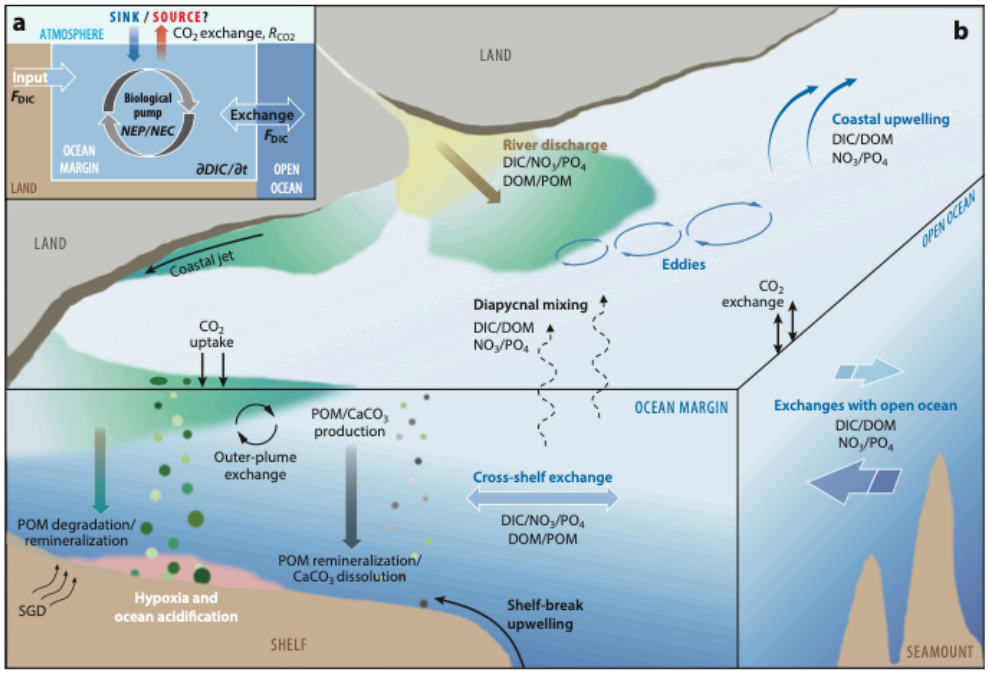

Figure 1

Conceptual schematics of air-sea CO_2 exchanges (*a*) and major physical and biogeochemical processes in the coastal ocean (*b*), highlighting the transport of matter between land, ocean margin, and open ocean. (*a*) The sea-air CO_2 flux (R_{CO2}) is balanced by the sum of DIC inputs and outputs (F_{DIC}) across the boundaries, the NEP and NEC, and the change in the amount of DIC over time ($\partial DIC/\partial t$) within the coastal system (Equation 1 in the text). (*b*) The ocean margin is bordered by the coastline on the land side and by the open ocean on the outer side. Rivers discharge DIC, NO_3, PO_4, DOM, and POM onto the continental shelf via a buoyant plume,

From Dai et al. (2022)

References

Calafat FM, Wahl T, Tadesse MG, Sparrow SN. Trends in Europe storm surge extremes match the rate of sea-level rise. Nature. 2022 Mar 31;603(7903):841-5.https://doi.org/10.1038/s41586-022-04426-5

Cazenave, A., Gouzenes, Y., Birol, F. et al. Sea level along the world's coastlines can be measured by a network of virtual altimetry stations. Commun Earth Environ 3, 117 (2022). https://doi.org/10.1038/s43247-022-00448-z

Dai M, Su J, Zhao Y, Hofmann EE, Cao Z, Cai WJ, Gan J, Lacroix F, Laruelle GG, Meng F, Müller JD. Carbon fluxes in the Coastal Ocean: Synthesis, boundary processes, and future trends. Annual Review of Earth and Planetary Sciences. 2022 May 31; 50:593-626. https://doi.org/10.1146/annurev-earth-032320-090746

Durand, F., Piecuch, C. G., Becker, M., Papa, F., Raju, S. V., Khan, J. U., & Ponte, R. M. (2019). Impact of continental freshwater runoff on coastal sea level. Surveys in Geophysics, 40, 1437-1466.

EC, 2013. The EU strategy on adaptation to climate change, European Commission

European Environment Agency, 2022. Extreme sea levels and coastal flooding. https://www.eea.europa.eu/ims/extreme-sea-levels-and-coastal-flooding

He Q, Silliman BR. Climate change, human impacts, and coastal ecosystems in the Anthropocene. Current Biology. 2019 Oct 7;29(19):R1021-35. https://doi.org/10.1016/j.cub.2019.08.042

Kirezci, E., Young, I.R., Ranasinghe, R., Muis, S., Nicholls, R.J., Lincke, D. and Hinkel, J., 2020. Projections of global-scale extreme sea levels and resulting episodic coastal flooding over the 21st Century. Scientific reports, 10(1), p.11629.

Macreadie PI, Anton A, Raven JA, Beaumont N, Connolly RM, Friess DA, Kelleway JJ, Kennedy H, Kuwae T, Lavery PS, Lovelock CE. The future of Blue Carbon science. Nature communications. 2019 Sep 5;10(1):3998. https://doi.org/10.1038/s41467-019-11693-w

Mathis, M., Logemann, K., Maerz, J., Lacroix, F., Hagemann, S., Chegini, F., Ramme, L., Ilyina, T., Korn, P. and Schrum, C., 2022. Seamless integration of the coastal ocean in global marine carbon cycle modeling. Journal of Advances in Modeling Earth Systems, 14(8), p.e2021MS002789.

Melet, A., Meyssignac, B., Almar, R., & Le Cozannet, G. (2018). Under-estimated wave contribution to coastal sea-level rise. Nature Climate Change, 8(3), 234-239.

Nielsen DM, Pieper P, Barkhordarian A, Overduin P, Ilyina T, Brovkin V, Baehr J, Dobrynin M. Increase in Arctic coastal erosion and its sensitivity to warming in the twenty-first century. Nature Climate Change. 2022 Mar;12(3):263-70. https://doi.org/10.1038/s41558-022-01281-0

Roobaert, A., Laruelle, G.G., Landschützer, P., Gruber, N., Chou, L. and Regnier, P., 2019. The spatiotemporal dynamics of the sources and sinks of CO2 in the global coastal ocean. Global Biogeochemical Cycles, 33(12), pp.1693-1714.

Siefert, Ronald L., and Gian-Kasper Plattner, 2004. The role of coastal zones in global biogeochemical cycles. Eos,Vol.85, No.45, 9 November 2004, 470-470

Singh, G. G., Cottrell, R. S., Eddy, T. D., & Cisneros-Montemayor, A. M. (2021). Governing the land-sea interface to achieve sustainable coastal development. Frontiers in Marine Science, 8, 709947.

Vousdoukas MI, Mentaschi L, Voukouvalas E, Verlaan M, Feyen L. Extreme sea levels on the rise along Europe's coasts. Earth's Future. 2017 Mar;5(3):304-23. https://doi.org/10.1002/2016EF000505

Winterfeld M, Mollenhauer G, Dummann W, Köhler P, Lembke-Jene L, Meyer VD, Hefter J, McIntyre C, Wacker L, Kokfelt U, Tiedemann R. Deglacial mobilization of pre-aged terrestrial carbon from degrading permafrost. Nature Communications. 2018 Sep 10;9(1):3666. https://doi.org/10.1038/s41467-018-06080-w

Woodworth, P.L., Melet, A., Marcos, M., Ray, R.D., Wöppelmann, G., Sasaki, Y.N., Cirano, M., Hibbert, A., Huthnance, J.M., Monserrat, S. and Merrifield, M.A., 2019. Forcing factors affecting sea level changes at the coast. Surveys in Geophysics, 40(6), pp.1351-1397.