US CLIVAR | Broadening Earth System Research Across Scales with High-Resolution Modeling

High-resolution coupled simulations for the Northern Adriatic region

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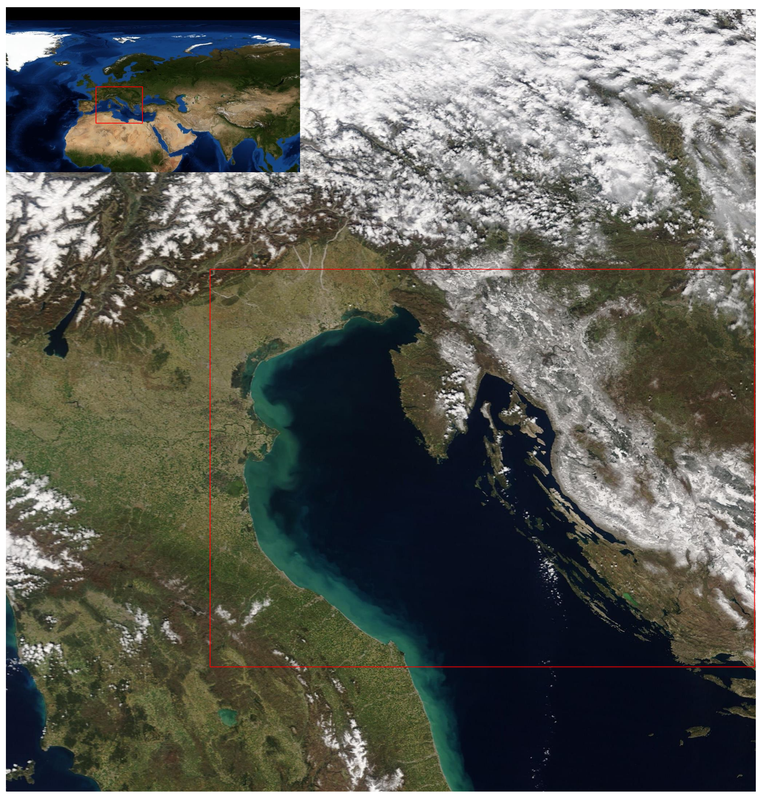
Does kilometre-scale resolution in both the atmosphere and ocean always matter for simulating physical and biogeochemical dynamics in a region of freshwater influence (ROFI)?

A preliminary qualitative assessment

01 Why resolution matters here

A shallow shelf, complex coastline, intense air–sea exchange and river inputs create sharp gradients over short distances (Giordano et al., 2026)



Northern Adriatic (in red) during spring · Terra/MODIS, 8 April 2021 · NASA GSFC

02 A hierarchy of coupled models

1/8° NEMOMED8 / OGSTM-BFM (Solidoro et al., 2022)

Ocean: 1/8° horizontal resolution
Atmosphere: 50 km forcing (CNRM-CM)
River: Freshwater flux at surface (2 Rivers), climatology (biogeochemical properties, Ludwig et al., 2009); BASIN SCALE-A2
Solidoro et al. (2022)

1/128° RegCM4.7 / MITgcm-BFM

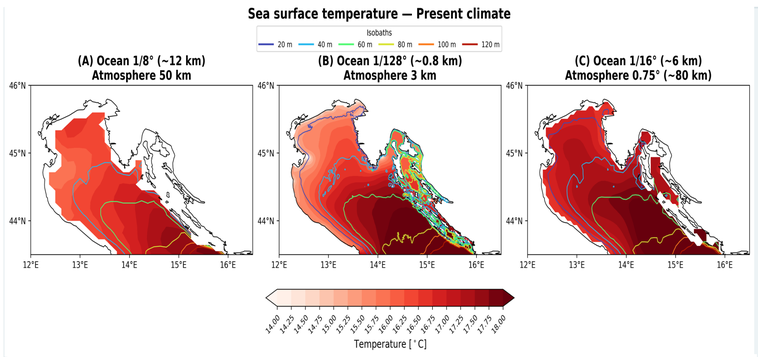
Ocean: 1/128° (~800 m)
Atmosphere: 3 km convection-permitting (from HadGEM2-ES)
River: CHyM open-boundary discharge (15 Rivers); climatology (biogeochemical propertues, Perseus)
RCP8.5 (ocean BCs from Reale et al., 2022)
Cossarini et al. (2017); Pichelli et al. (2021)

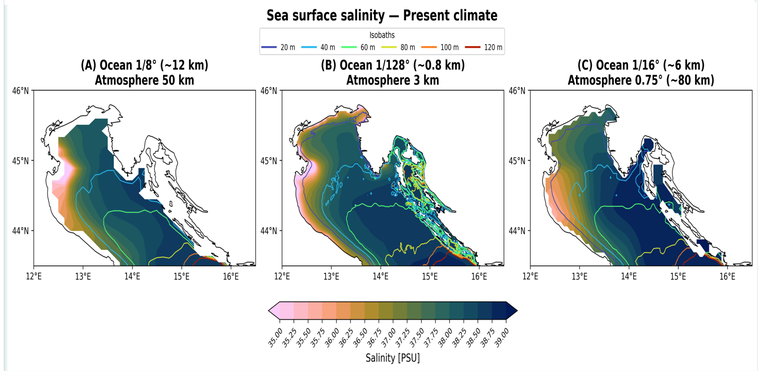
1/16° MFS16 / OGSTM-BFM (Reale et al., 2022)

Ocean: 1/16° horizontal resolution
Atmosphere: approximately 80 km forcing (CMCC-CM)
River: Freshwater flux at surface (9 Rivers), climatology (biogeochemical properties, Perseus)
BASIN SCALE-RCP8.5

03 Finer grids reveal spatial structure

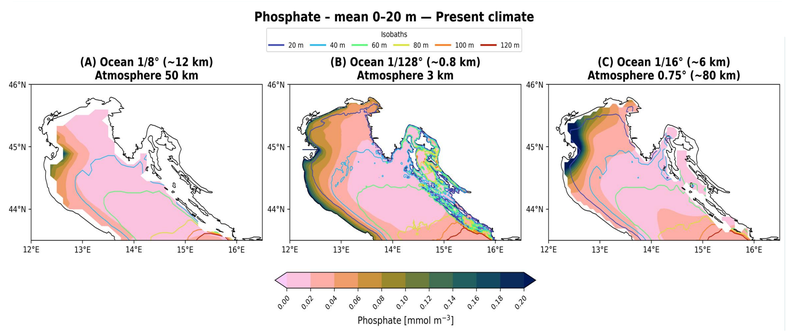
SST, SSS and 20–120 m isobaths

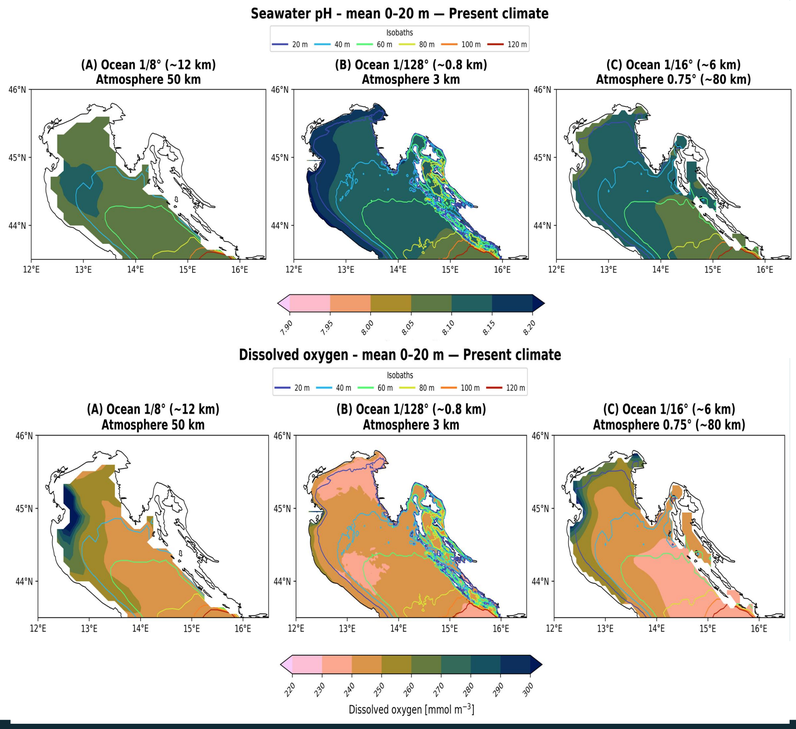




The combined refinement of the ocean and atmosphere reveals coastal gradients and river-influenced structures that remain smoothed in the coarser configurations.

Biogeochemistry

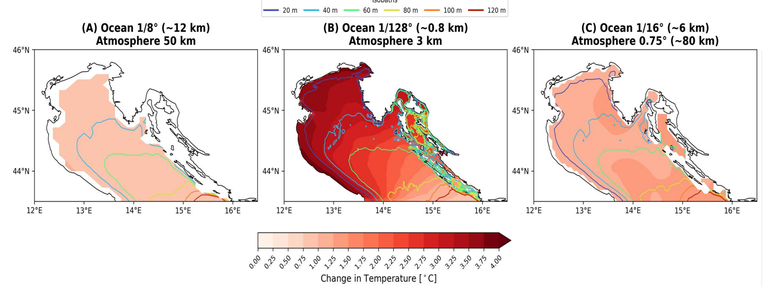


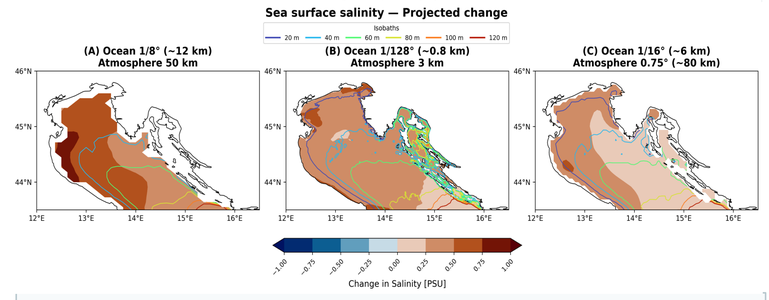


04 Finer grids reveal localized climate change signals

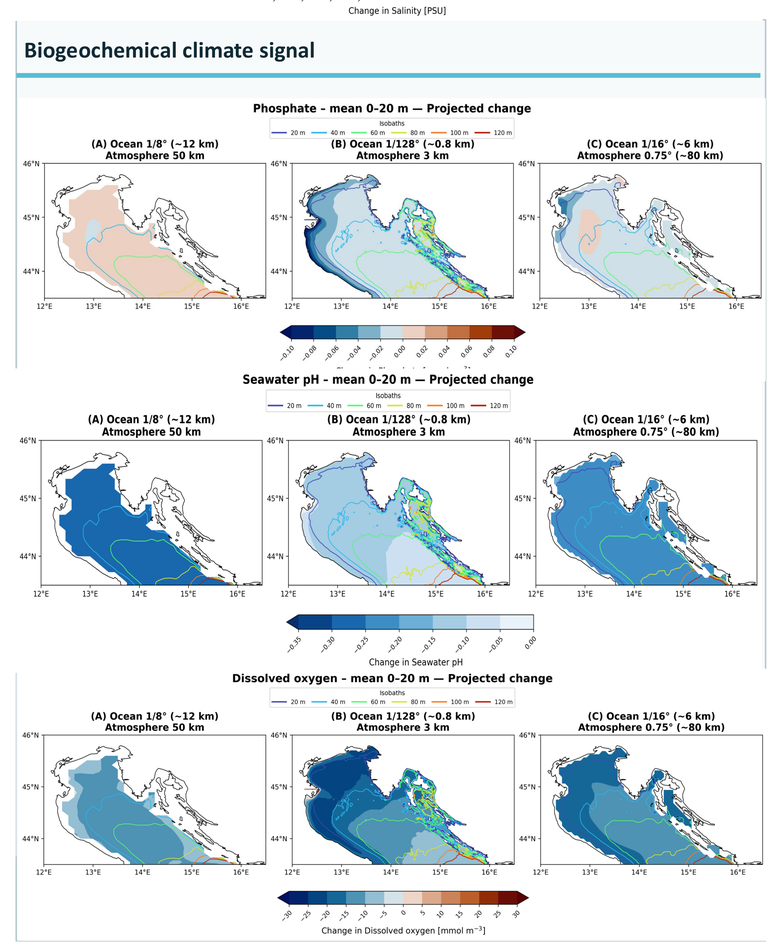
Qualitative comparison at GWL2

Physical climate signal





Biogeochemical climate signal

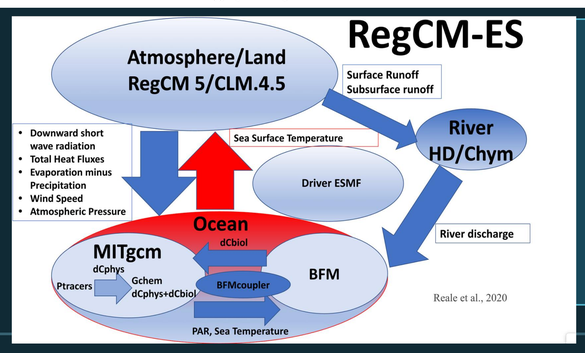


05 What high resolution adds

- Sub-kilometre ocean resolution reveals finer coastline, shelf and river-influenced structures
- Added spatial detail is clearest in temperature, oxygen, salinity and phosphate
- Basin-scale pH patterns remain comparatively stable across configurations
- The benefit of refining both atmosphere and ocean depends on the variable and process

NEXT STEP

The 3 km atmosphere and 800 m ocean provide the physical backbone for an integrated atmosphere–ocean–river-biogeochemistry framework designed to investigate coastal climate processes, extremes and ecosystem responses in the Northern Adriatic.



TAKE-HOME MESSAGE

Resolution sensitivity varies by variable. The high-resolution coupled configuration reveals the clearest additional spatial structure in temperature, salinity, oxygen and phosphate, while basin-scale pH patterns remain comparatively robust.