

Evaluation of a Coupled Regional Reanalysis for the Mediterranean Region Covering the period 1993-2024

Chunxue Yang, Andrea Storto, Vincenzo de Toma

Italian National Research Council (CNR)

Abstract

Regional reanalyses provide physically consistent Vincenzo de Toma reconstructions of past climate, offering a powerful tool for understanding the processes that shape regional responses to climate change. Here, we introduce MESMAR-R, a newly developed coupled atmosphere-ocean-hydrology reanalysis for the Mediterranean region. The system couples state-of-the-art numerical models with data assimilation in both the ocean and the atmosphere, producing a dynamically coherent reconstruction of the 1993-2024 period. MESMAR-R shows strong performance in the ocean, particularly for sea level, sea surface salinity, and upper-layer temperature, confirming its skill in the layers most relevant for air-sea interactions. The atmospheric component performs reasonably well given its simplified assimilation based on three-dimensional nudging, yielding basin-scale fields comparable to state-of-the-art reanalyses and maintaining internally consistent coupled air-sea interactions. Sensitivity experiments show that data assimilation in both the ocean and atmosphere is essential for optimal performance: coupling alone does not necessarily improve reanalysis skill, but its benefits are relevant for salinity and surface fluxes and amplify when complemented by data assimilation. The ocean and atmospheric trends reconstructed by MESMAR-R are physically coherent and consistent with observations, reproducing basin-wide salinification, thermo-halo compensation in steric sea level, mass-driven sea-level rise, and pronounced near-surface atmospheric warming and drying. MESMAR-R therefore provides a unique, balanced reconstruction of past Mediterranean climate, suitable for investigating coupled air-sea processes, compound events, marine extremes, and other phenomena where dynamically consistent atmosphere-ocean interactions are essential.