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Using an eddy-tracking algorithm to understand the impact of assimilating altimetry data on the eddy characteristics of the Agulhas system

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ABSTRACT:

A complex and highly dynamical ocean region, the Agulhas Current System plays an important role in the transfer of energy, nutrients and organic material from the Indian to the Atlantic Ocean. Its dynamics are not only important locally, but affect the global ocean-atmosphere system. In working towards improved ocean reanalysis and forecasting capabilities, it is important that numerical models simulate mesoscale variability accurately—especially given the scarcity of coherent observational platforms in the region. Data assimilation makes use of scarce observations, a dynamical model and their respective error statistics to estimate a new, improved model state that minimises the distance to the observations whilst preserving dynamical consistency. Qualitatively, it is unclear whether this minimisation directly translates to an improved representation of mesoscale dynamics. In this study, the impact of assimilating along-track sea-level anomaly (SLA) data into a regional Hybrid Coordinate Ocean Model (HYCOM) is investigated with regard to the simulation of mesoscale eddy characteristics. We use an eddy-tracking algorithm and compare the derived eddy characteristics of an assimilated (ASSIM) and an unassimilated (FREE) simulation experiment in HYCOM with gridded satellite altimetry-derived SLA data. Using an eddy tracking algorithm, we are able to quantitatively evaluate whether assimilation updates the model state estimate such that simulated mesoscale eddy characteristics are improved. Additionally, the analysis revealed limitations in the dynamical model and the data assimilation scheme, as well as artefacts introduced from the eddy tracking scheme. With some exceptions, ASSIM yields improvements over FREE in eddy density distribution and dynamics. Notably, it was found that FREE significantly underestimates the number of eddies south of Madagascar compared to gridded altimetry, with

only slight improvements introduced through assimilation, highlighting the models' limitation in sustaining mesoscale activity in this region. Interestingly, it was found that the threshold for the maximum eddy propagation velocity in the eddy detection scheme is often exceeded when data assimilation relocates an eddy, causing the algorithm to interpret the discontinuity as eddy genesis, which directly influences the eddy count, lifetime and propagation velocity, and indirectly influences other metrics such as non-linearity. Finally, the analysis allowed us to separate eddy kinetic energy into contributions from detected mesoscale eddies and meandering currents, revealing that the assimilation of SLA has a greater impact on mesoscale eddies than on meandering currents.