

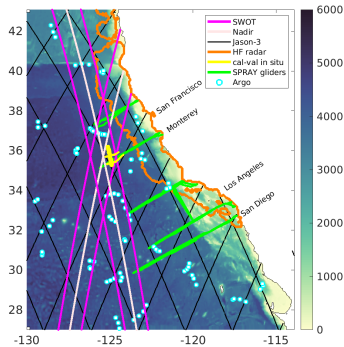
4D-Var and SWOT: Producing a month-long state estimate of the California Current System during the Cal/Val period

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1) We run a **2-km regional configuration of the MITgcm ocean model and its adjoint**. It is constrained to fit observations by adjusting initial conditions and atmospheric state, while remaining dynamically-consistent.



• 31-day window (May 1-31, 2023)

Constraints:

• Global Ocean Observing System (GOOS): OI-SST, Nadir altimeters, Argo & SPRAY glider profiles

• SWOT: L3 1-day repeat

• In situ Cal-Val for independent validation

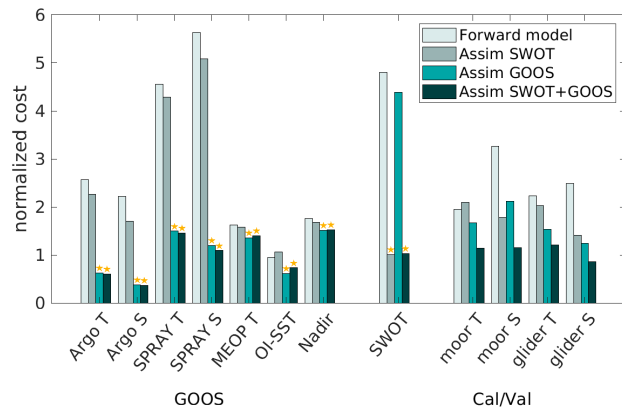
Controls:

• Atmospheric state: 1-day period, 20 km smoothing scale

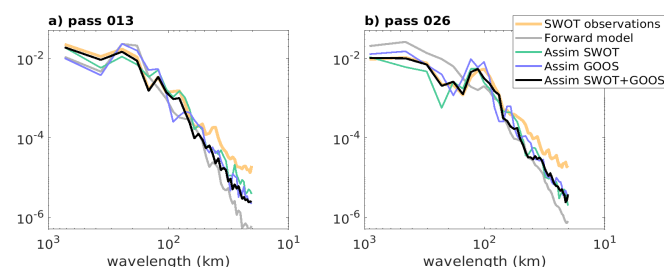
• Initial T and S: 10 km horizontal, 10 m vertical smoothing scales

A new cost function package for MITgcm, ObsFit, was created for SWOT data assimilation (github.com/averdy/obsfit_mitgcm/)

3) Three assimilations are performed: one with SWOT constraints only, one with GOOS only, and one with SWOT+GOOS. Model-observation **misfits are reduced for assimilated and non-assimilated datasets**.

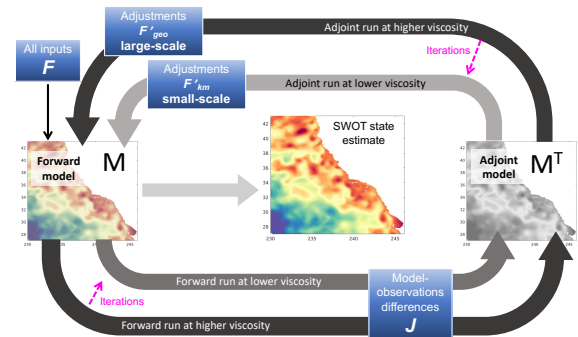


5) **Wavenumber spectra show that the agreement is good for scales up to 70 km for the SWOT+GOOS assimilation**. Withholding SWOT or GOOS reduces the assimilation skill.

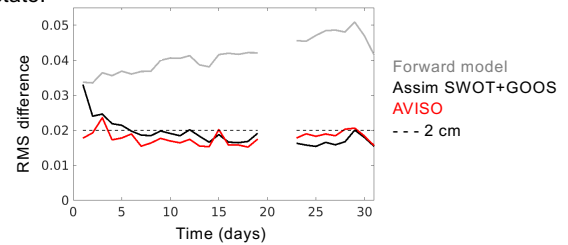


Forward model (iteration 0) is run with high viscosity, hence the low energy at small scales.

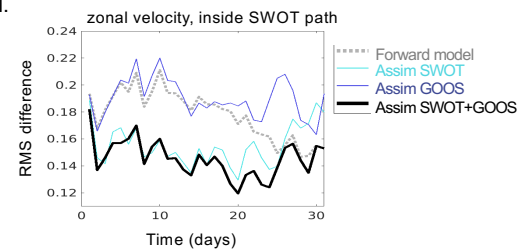
2) We start with high viscosity to damp the small scales and **fit the balanced motions first, then reduce the viscosity** to begin fitting the submesoscale.



4) The optimized model **fits SWOT data within the assigned 2 cm uncertainty** (mostly), performing similarly well to the AVISO product while also simulating the 3D ocean state.



6) Independent high-frequency radar observations of coastal surface currents are **better fit by the optimized model**.



7) **SWOT data constrain vertical motions, which are critical for biogeochemistry (BGC)**, e.g. through nutrient delivery, enabling future BGC data assimilation.

