Sub-mesoscale data assimilation in the California Current cal-val domain

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1. Twin experiment

We have developed a high-res regional model capable of assimilating SWOT-like data

a) Model run + SWOT-like sampling

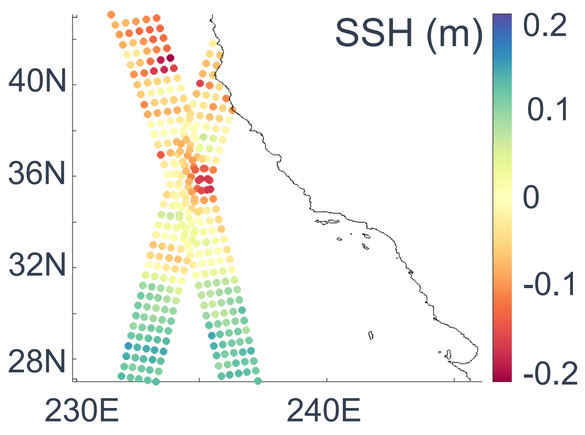


Fig 1: SSH sampled on May 15 in the forward model run.

MITgcm is set up with 2 km grid spacing and 100 vertical levels. It is run April-June 2023 with atmospheric forcing from ERA5. Initial and boundary conditions are from the CMEMS Global Ocean Physics Analysis and Forecast. The model is sampled similarly to 1-day repeat SWOT. We subsample every 10 km along-swath and 25 km across.

b) Simulated data (OSSE)

We run a 10-day assimilation May 15-24, 2023. The model initial conditions are perturbed; simulated SSH is compared to the "true" SSH sampled in the unperturbed forward run.

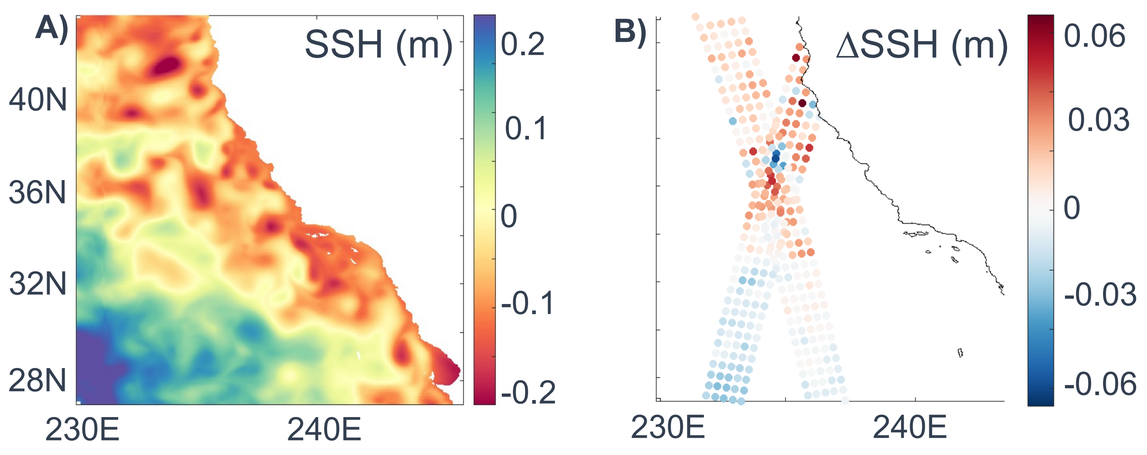


Fig 2: (a) First-guess SSH on May 15 in the assimilation model run and (b) difference between first guess and the sampled SSH (Fig. 1).

Using the adjoint method (4D-Var), we diagnose the sensitivity of the misfits (Fig. 2b) to atmospheric state (winds, shortwave and longwave heat fluxes, air temperature and humidity, precipitation), and initial conditions (temperature and salinity). Examples of inferred adjustments are shown in Fig. 3.

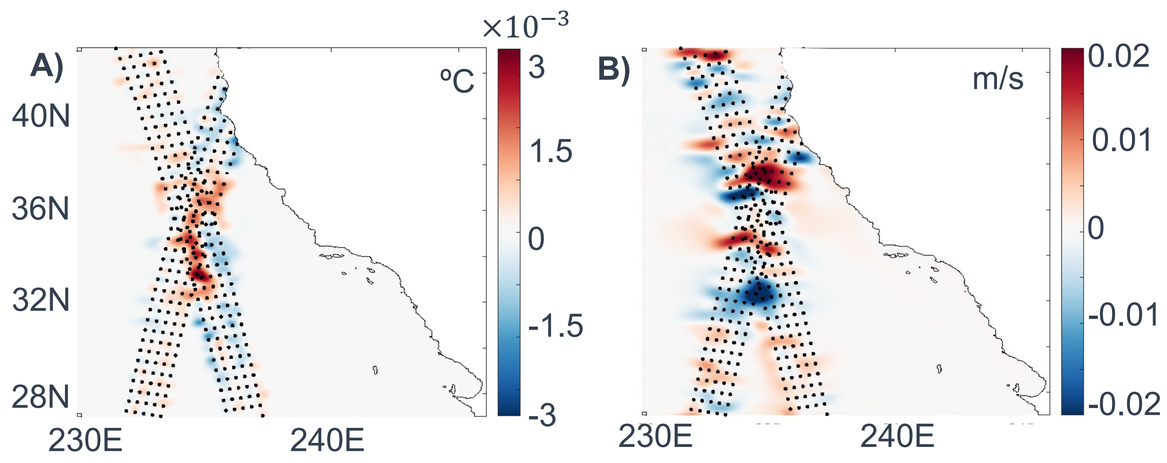


Fig 3: Adjustments to (a) initial SST and (b) zonal winds on May 16. Black dots show the location of SSH "observations".

c) Information content

The impact of observing system + data assimilation is not limited to the surface; information propagates downward (Fig, 4).

- Incremental adjustments reduce SSH misfits;
- This shows data assimilation machinery is working.

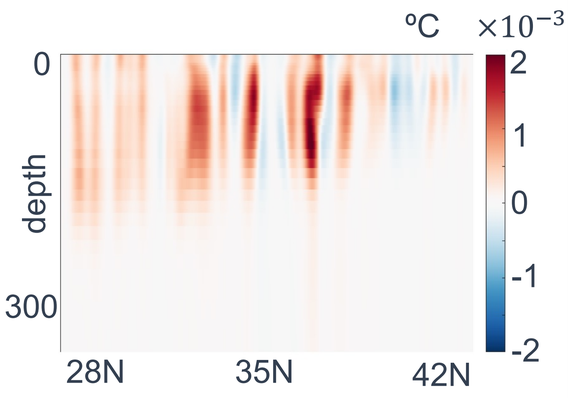
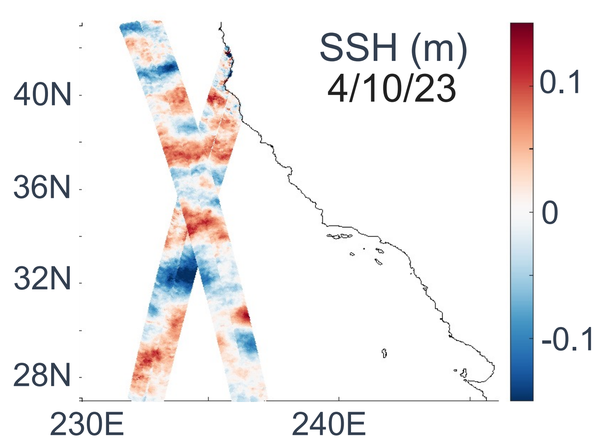


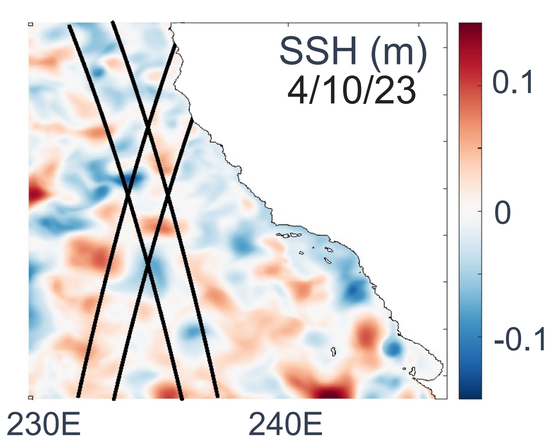
Fig 4: Adjustments to initial sub-surface temperature at 233°E

2. First look: SWOT-model comparison

Model is ready to ingest real cal-val observations; we are open to collaborations!

"beta pre-validated" SWOT KaRIn L2 SSH product





Forward model run

Next step:
data assimilation =
improve fit to obs

- **Goal: to have a data assimilation product that covers the cal-val period**
- Observations have sub-mesoscale (<10 km) features
- Data assimilation brings the model closer to observations through sub-mesoscale adjustments that are dynamically-consistent; budgets are closed over the 10-day assimilation period
- **The model physics can be used to probe the dynamics of the observed sub-mesoscale features**