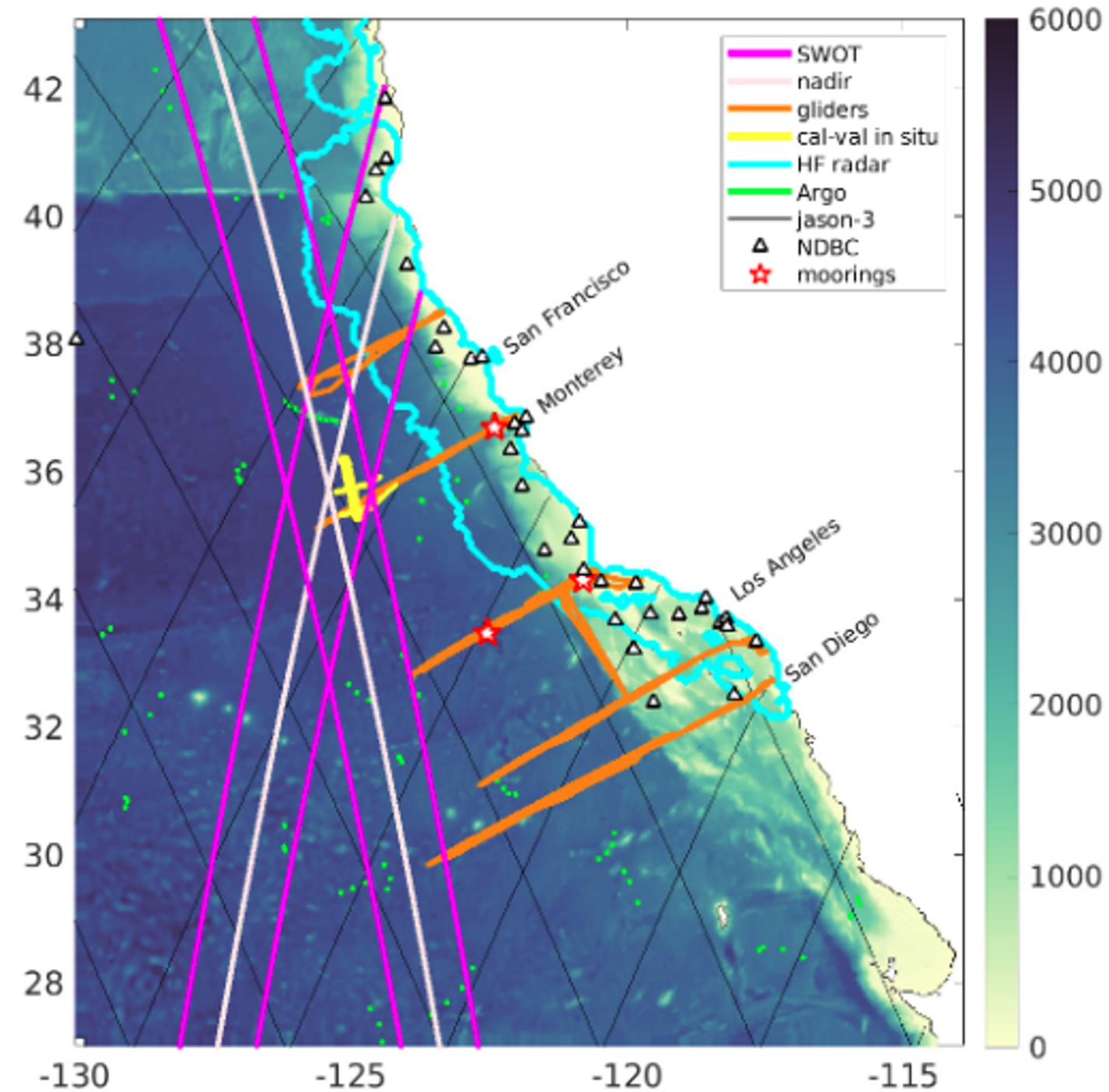


Assimilating SWOT data

Ariane Verdy
Sarah Gille
Matt Mazloff
Bruce Cornuelle

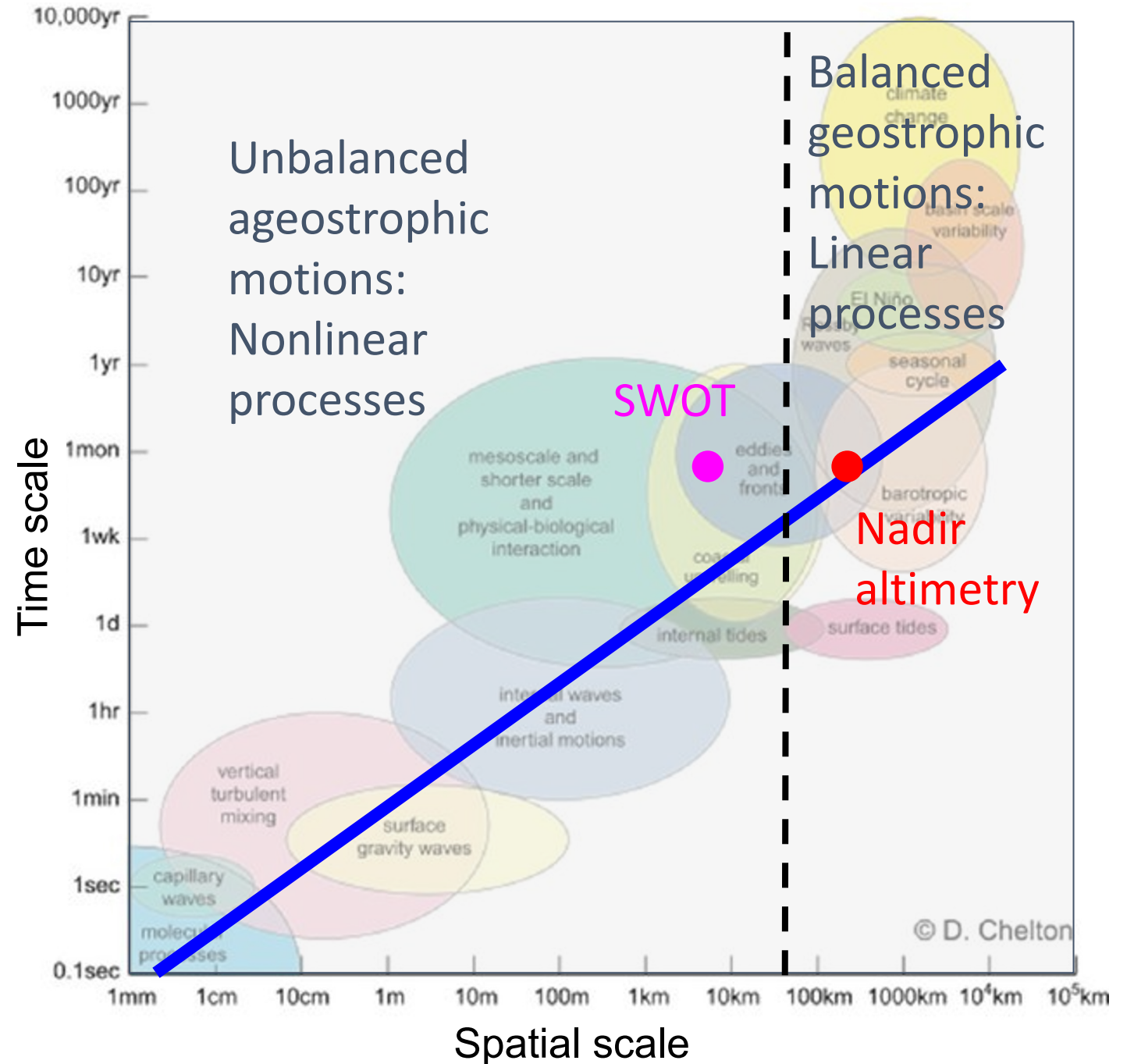
Scripps Institution of
Oceanography

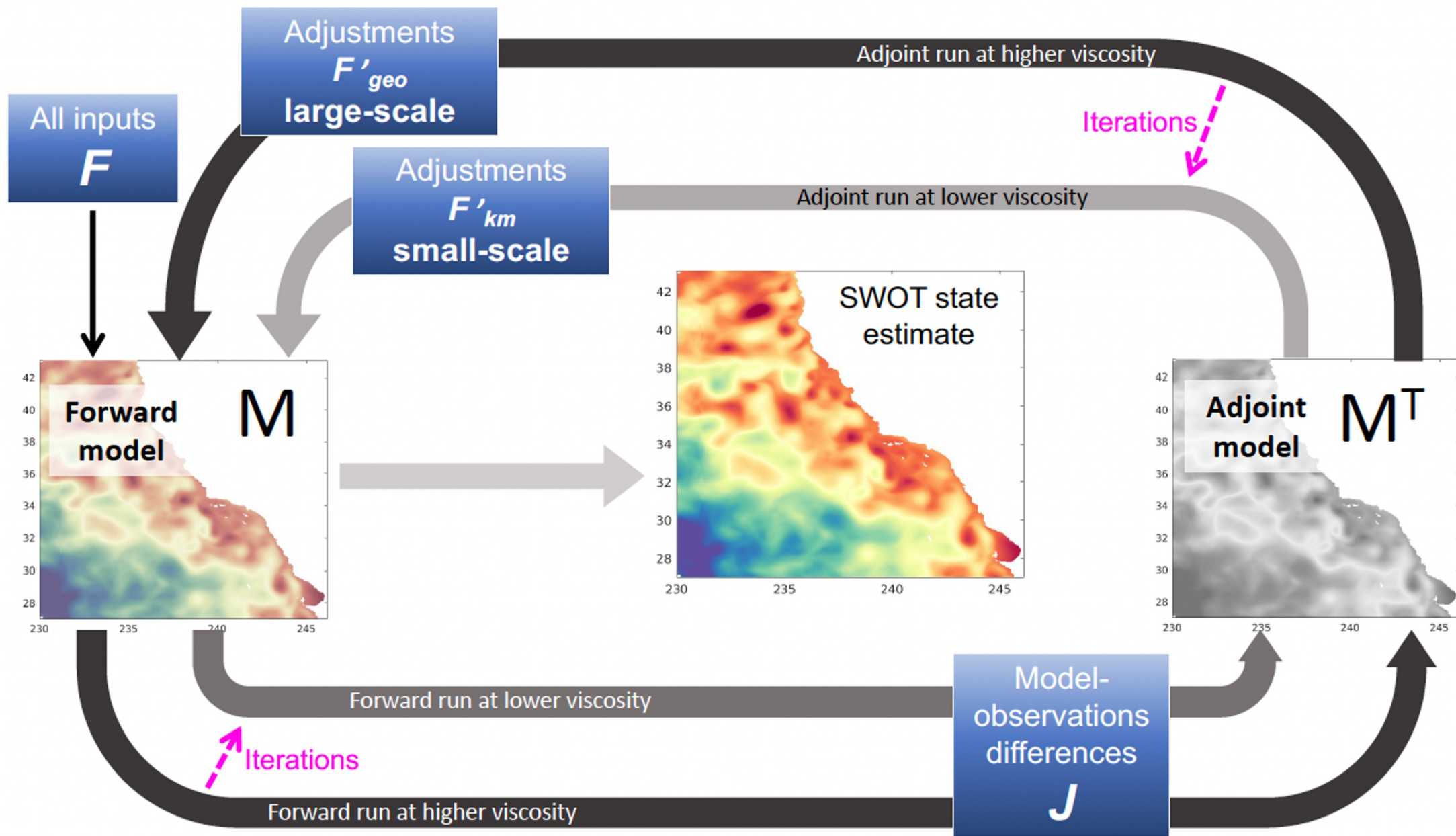
2024 ECCO meeting



The SWOT Challenge

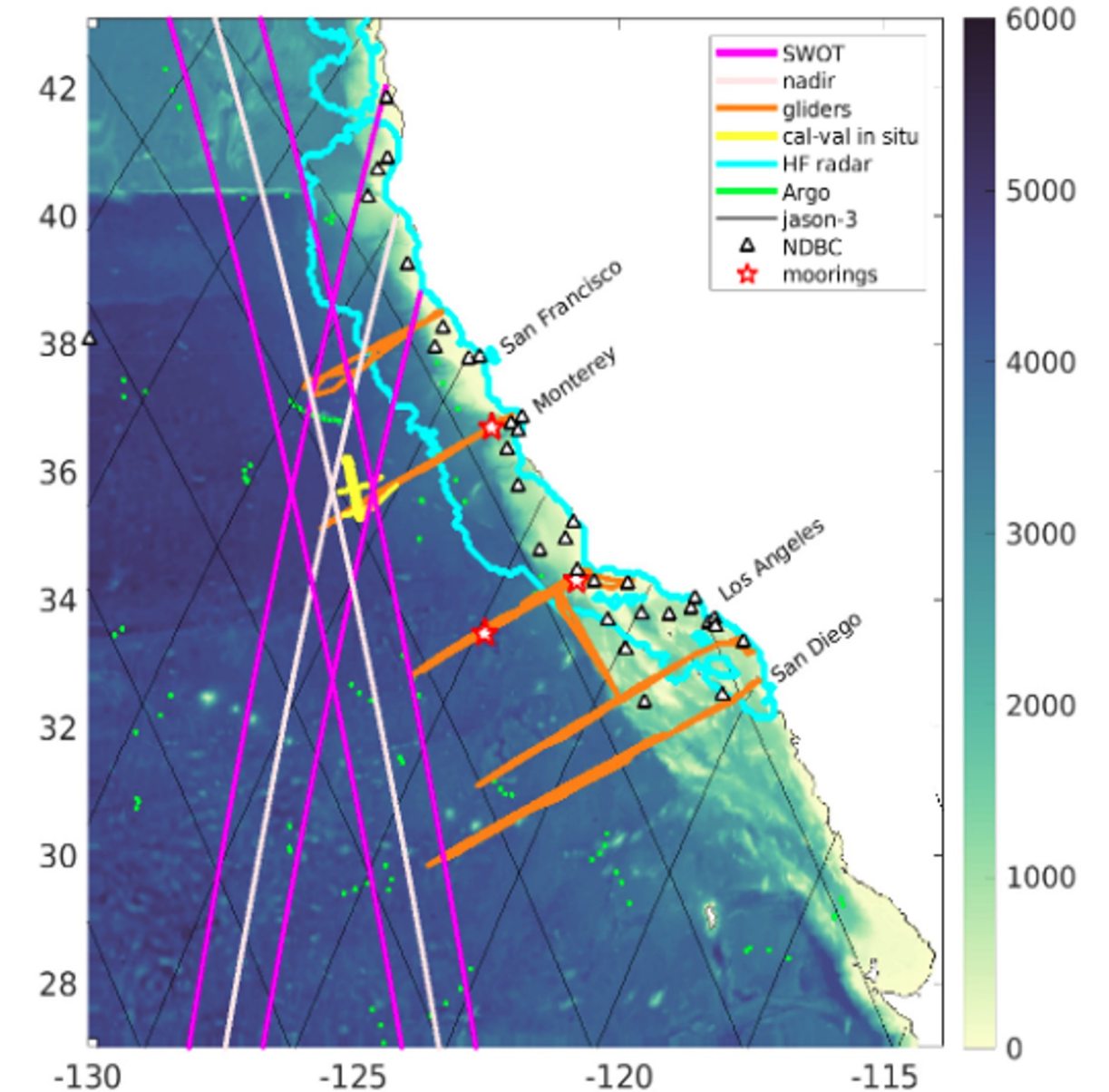
- How do we take advantage of SWOT's spatial resolution, without corresponding temporal resolution?
- Our goal: **with 4D-Var assimilation, use data to constrain dynamics**





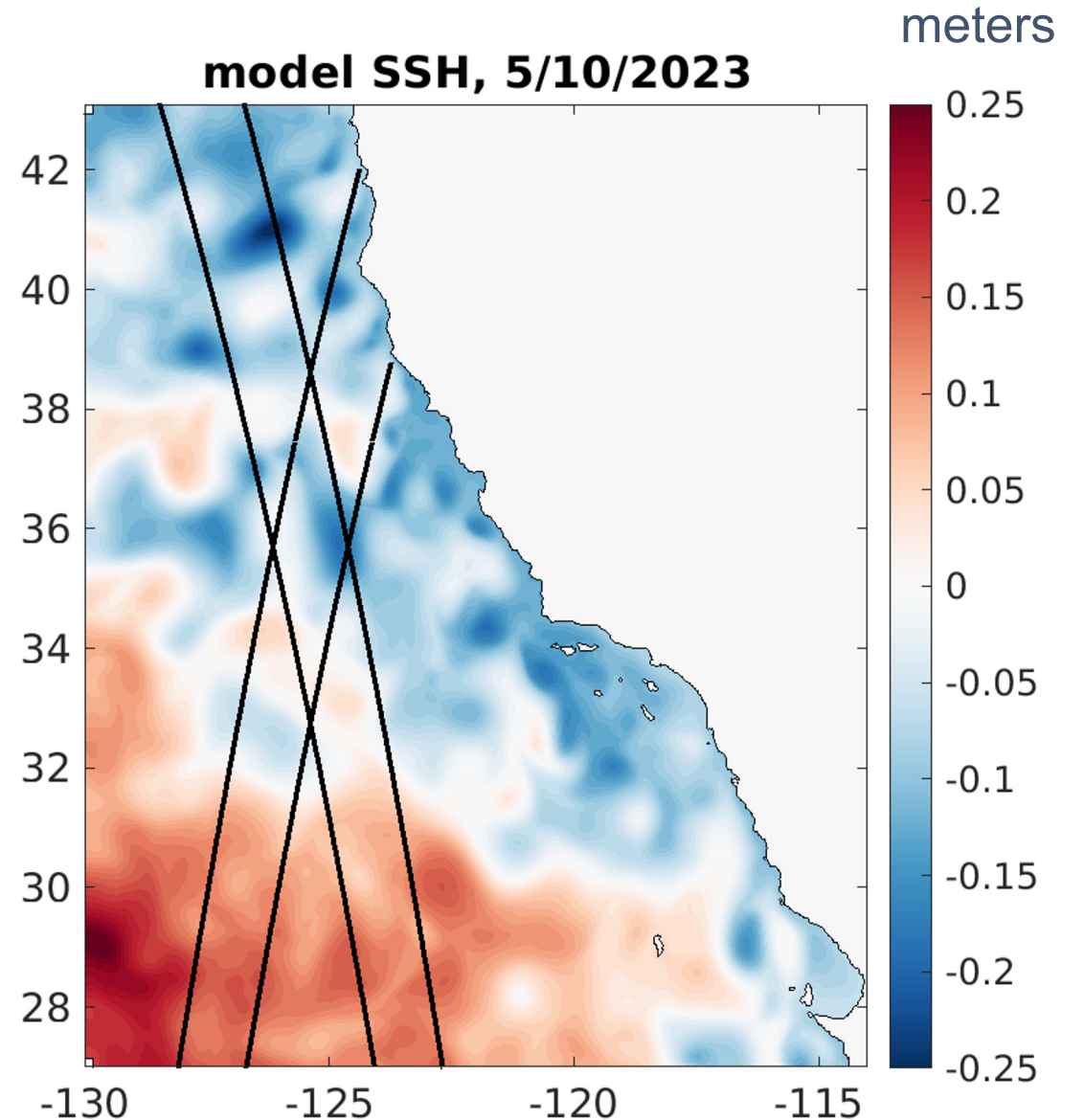
State estimate setup

- 2-km grid spacing, 100 vertical levels
- 30-day assimilation window
- Starting 1 May 2023
- ICs and OBCs from GLORYS (NRT)
- Hourly forcing from ERA5
- Viscosity = 10 in fwd run, 100 in adjoint
- Constraints: OI-SST, Nadir altimeters, Argo profiles, SPRAY glider profiles
- 2D-controls (atmospheric state):
1-day period, 20 km smoothing scale
- 3D controls (initial T and S):
10 km smoothing scale



Assimilation of SWOT data

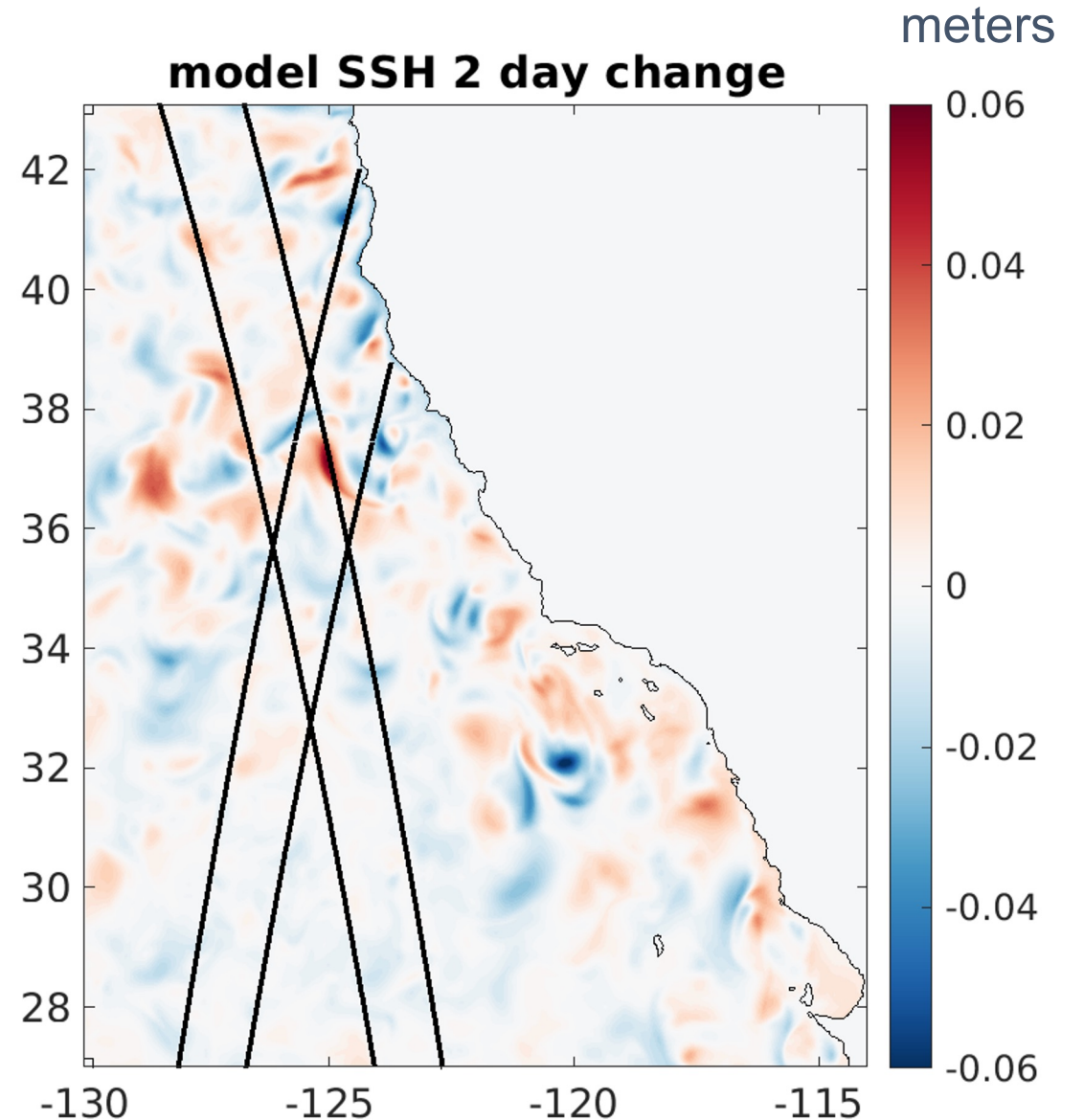
- **5-day** assimilation window
- **L3 SWOT 1-day repeat** at California crossover, SSHa+MDT
- **Uncertainty: 2 cm** (Jinbo Wang)
- In situ Cal-Val (moorings, gliders) are **independent validation**
- Uncertainty on controls is increased because of short assimilation window



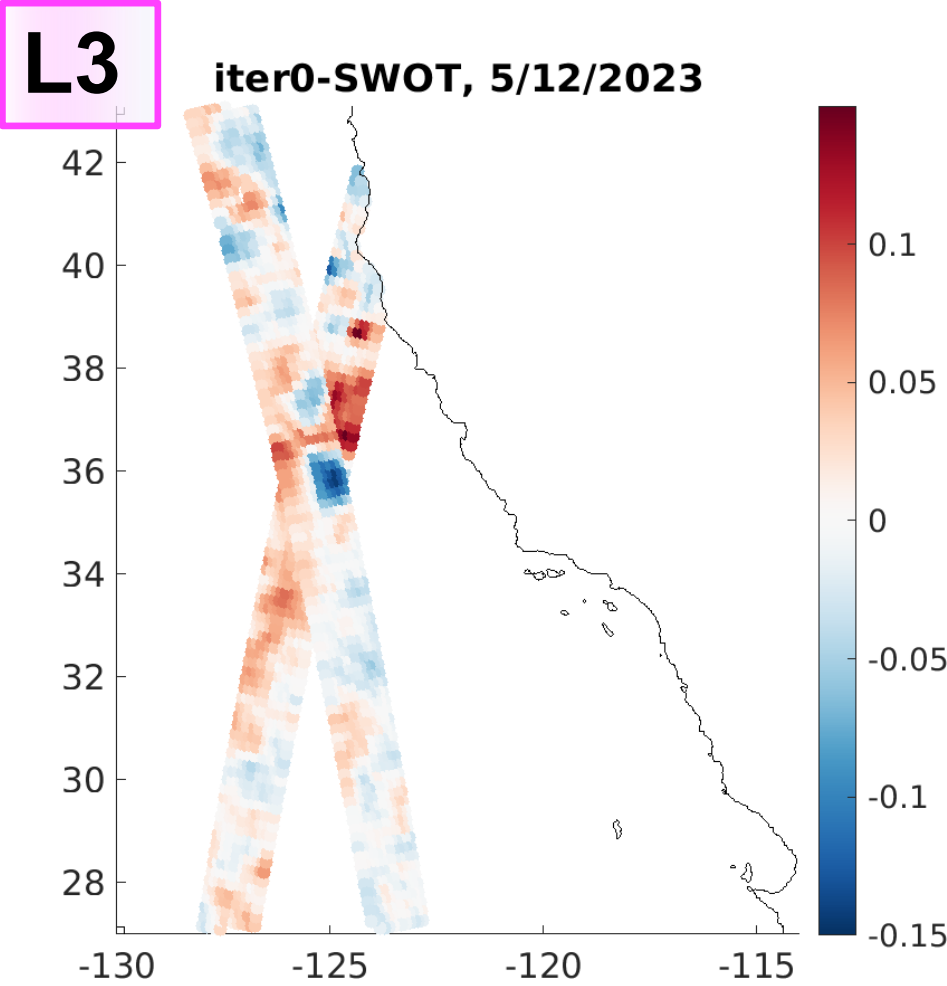
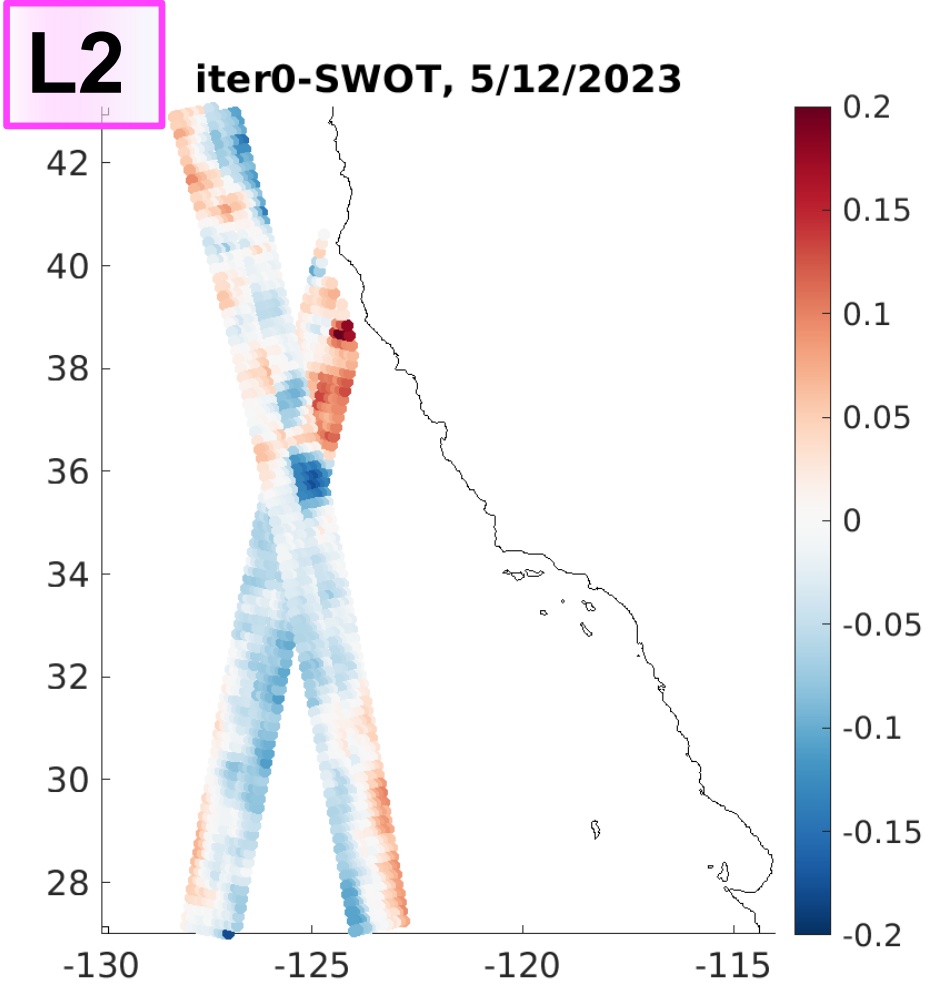
Assimilation of SWOT data

- **5-day** assimilation window
- **L3 SWOT 1-day repeat** at California crossover, SSHa+MDT
- **Uncertainty: 2 cm** (Jinbo Wang)
- In situ Cal-Val (moorings, gliders) are **independent validation**
- Uncertainty on controls is increased because of short assimilation window

On this time scale, model evolves at submesoscale



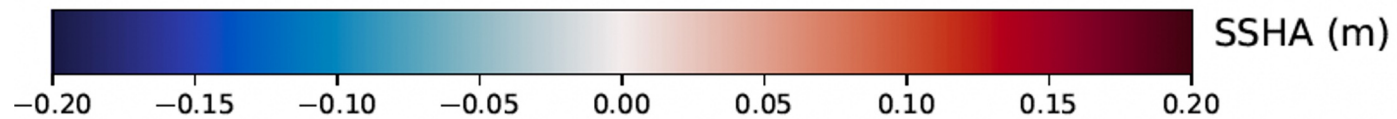
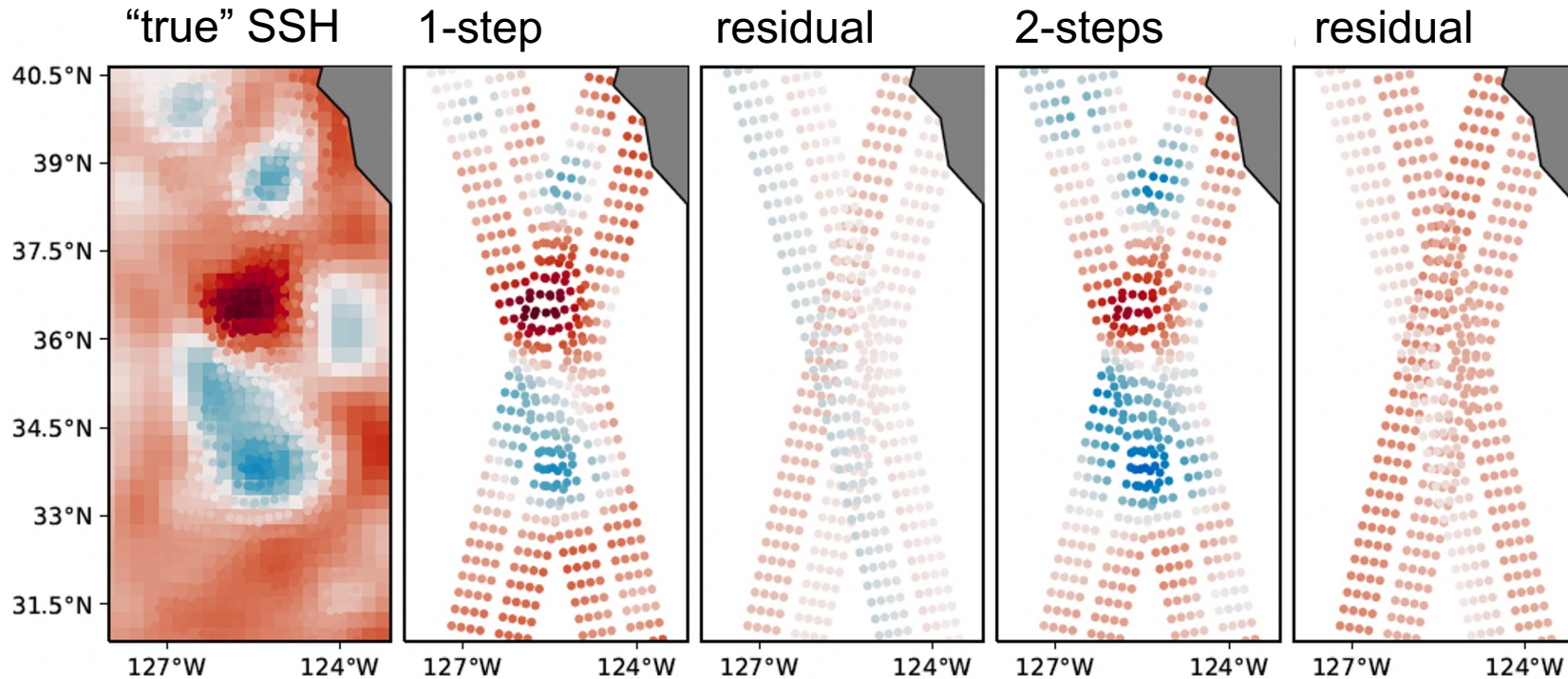
SWOT data processing



Residual roll error

Roll error correction through assimilation

Ambiguity between ocean signal (e.g. Rossby waves) and correlated errors (e.g. roll error)



2-steps: correcting for roll error separately from SSH data assimilation leads to **large residual**.

1-step: residual **reduced** by incorporating roll error correction into assimilation.

Roll error correction through assimilation

Ambiguity between ocean signal (e.g. Rossby waves) and correlated errors (e.g. roll error)

Correlated Error Model

Following Metref et al. (2020) and Esteban-Fernandez (2017), our correlated error reduction procedure considers four error terms, defined by seven (unknown) coefficients, α_i .

$$e_{\text{total}} = \alpha_0 + \alpha_1 x_c + \alpha_2 x_c^2 + [\alpha_3 + \alpha_4 x_c] \mathcal{H}(-x_c) + [\alpha_5 + \alpha_6 x_c] \mathcal{H}(x_c)$$

timing drift

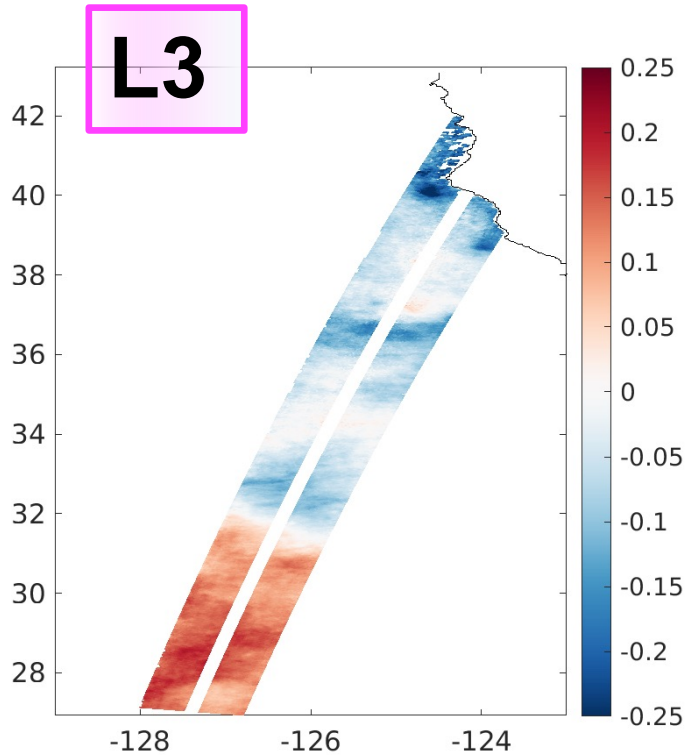
roll error

dilation error

L/R antennas phase variations

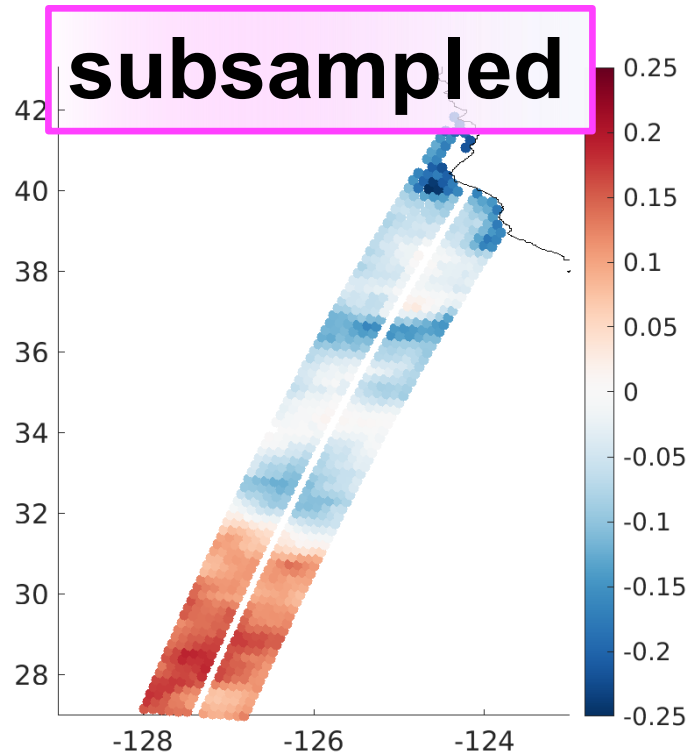
SWOT data processing

L3 SSH anomalies +
Mean Dynamic
Topography (MDT)



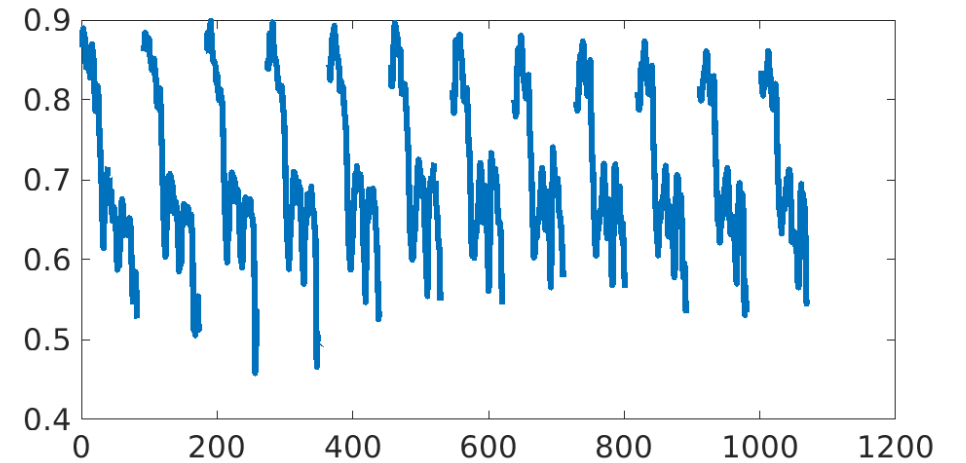
Subsampled every 10 km
across swath (12 tracks)

Averaged every 10 km
along swath



Cost calculated using
ObsFit package

ObsFit input



ObsFit [https://github.com/averdy/obsfit_mitgcm]

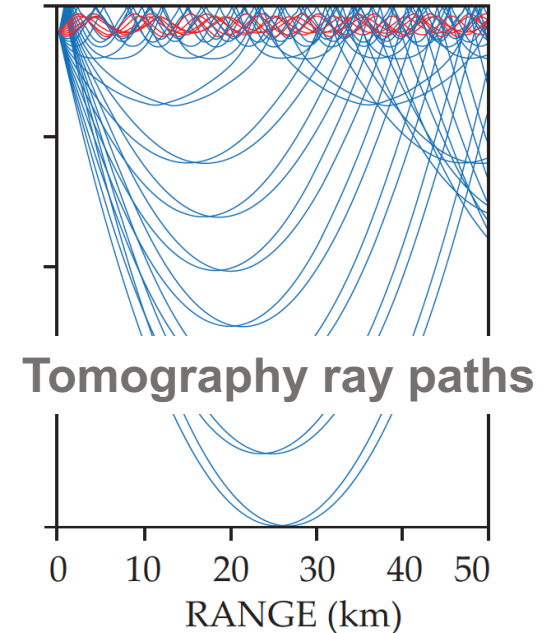
- A generalization of the profiles package
- More efficient because no “empty” depth levels
- Can handle time and space integration

For each observation, we specify:

Observed value, uncertainty, start time, duration, NP

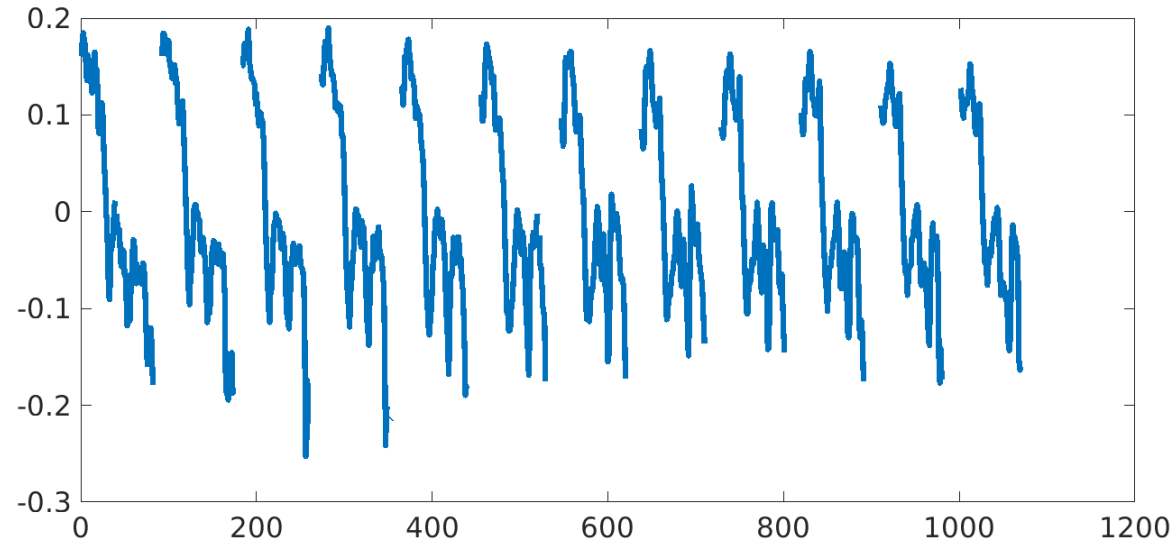
An observation is made of NP samples; for each sample we specify:

Property type (T, S, SSH, \dots), spatial coordinates (x, y, z), weight (if $NP < 1$)



ObsFit

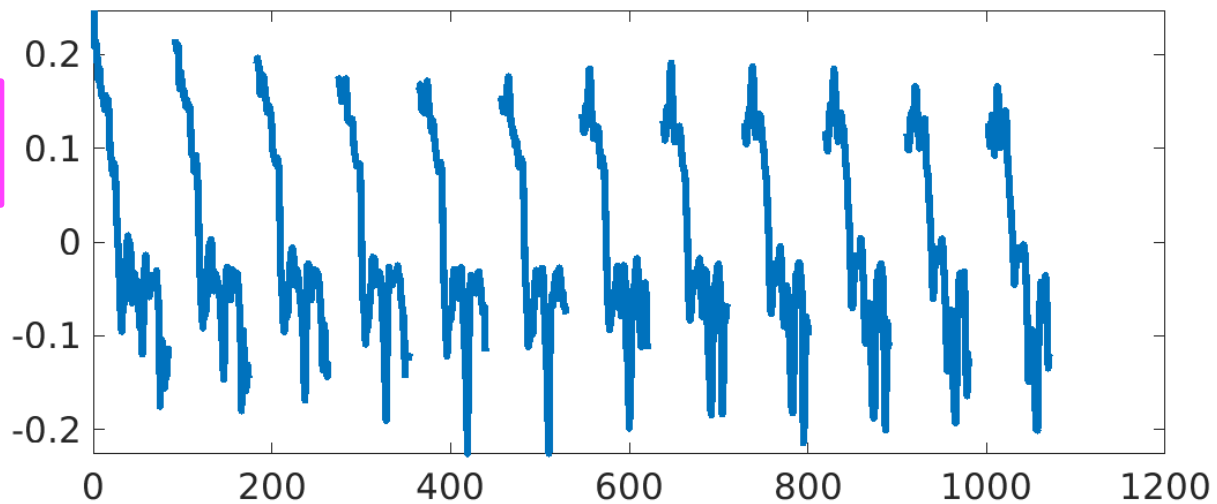
input:



example.nc

obs_val
obs_uncert
obs_time
sample_type
sample_x
sample_y
sample_z

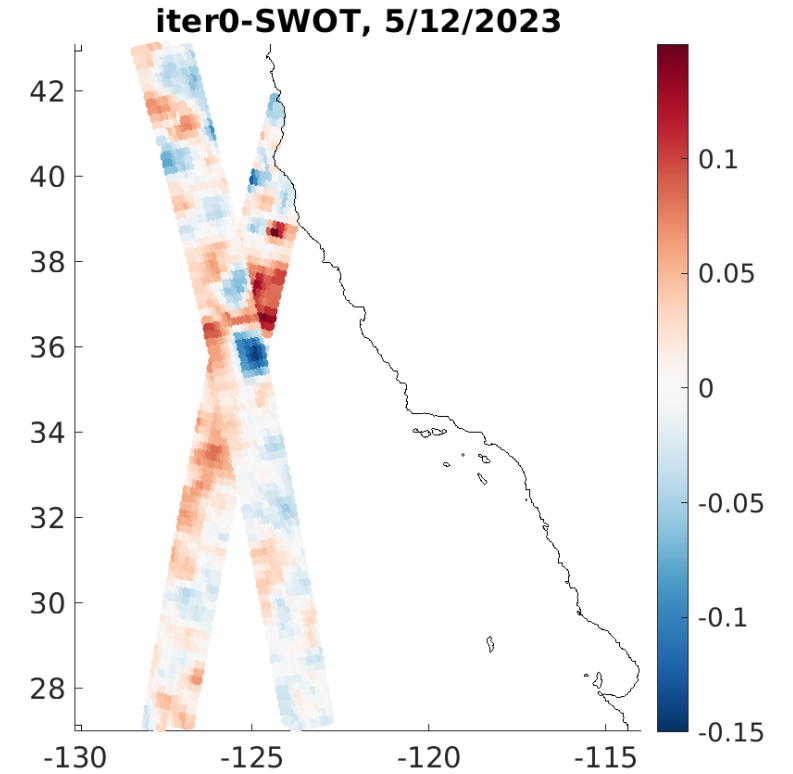
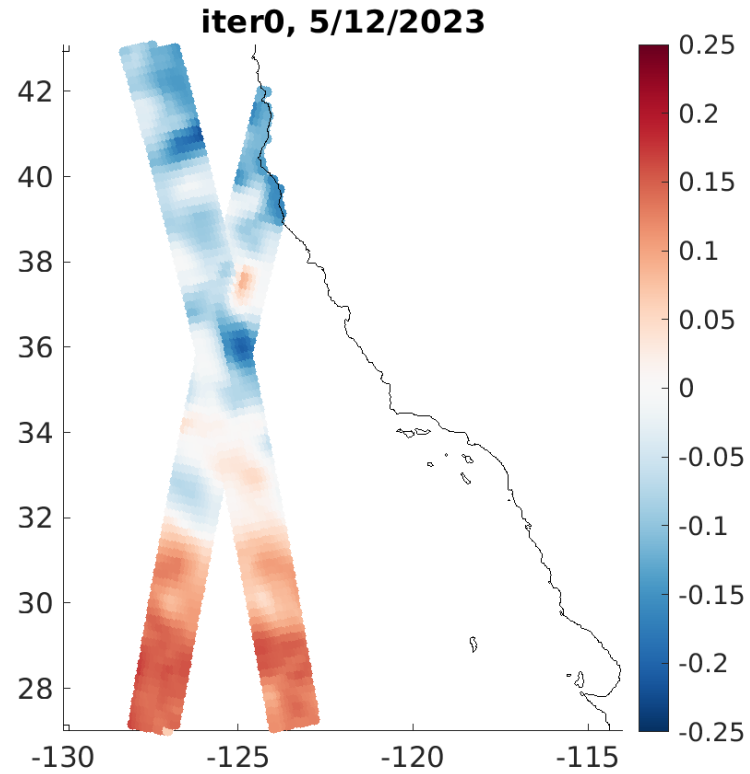
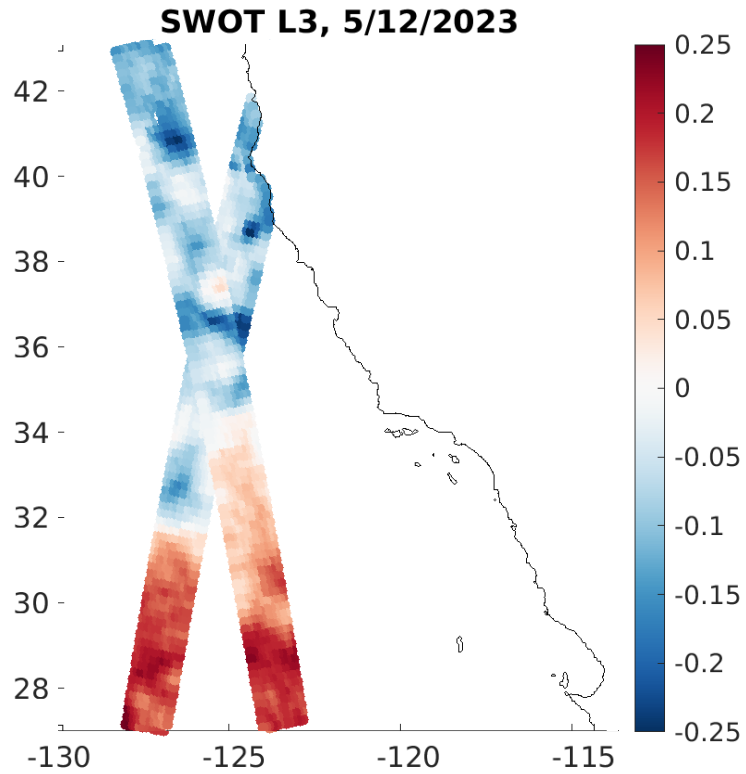
output:



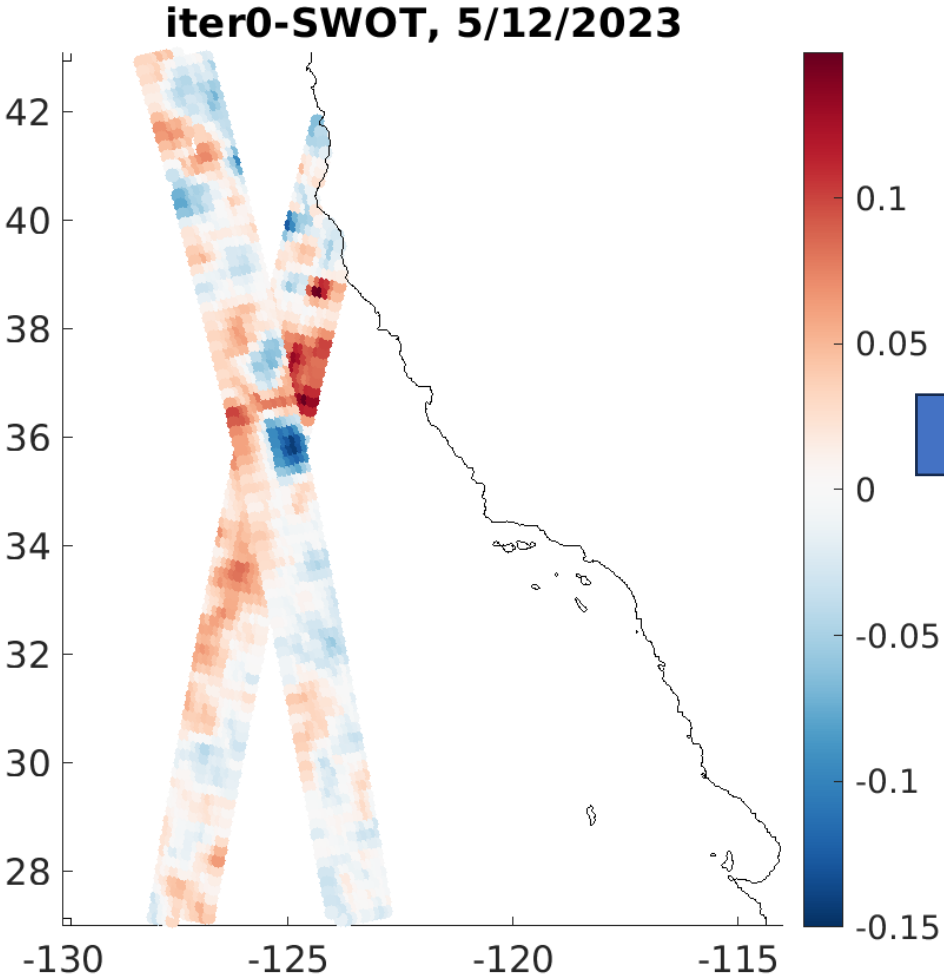
example.equi.nc

mod_val
mod_mask

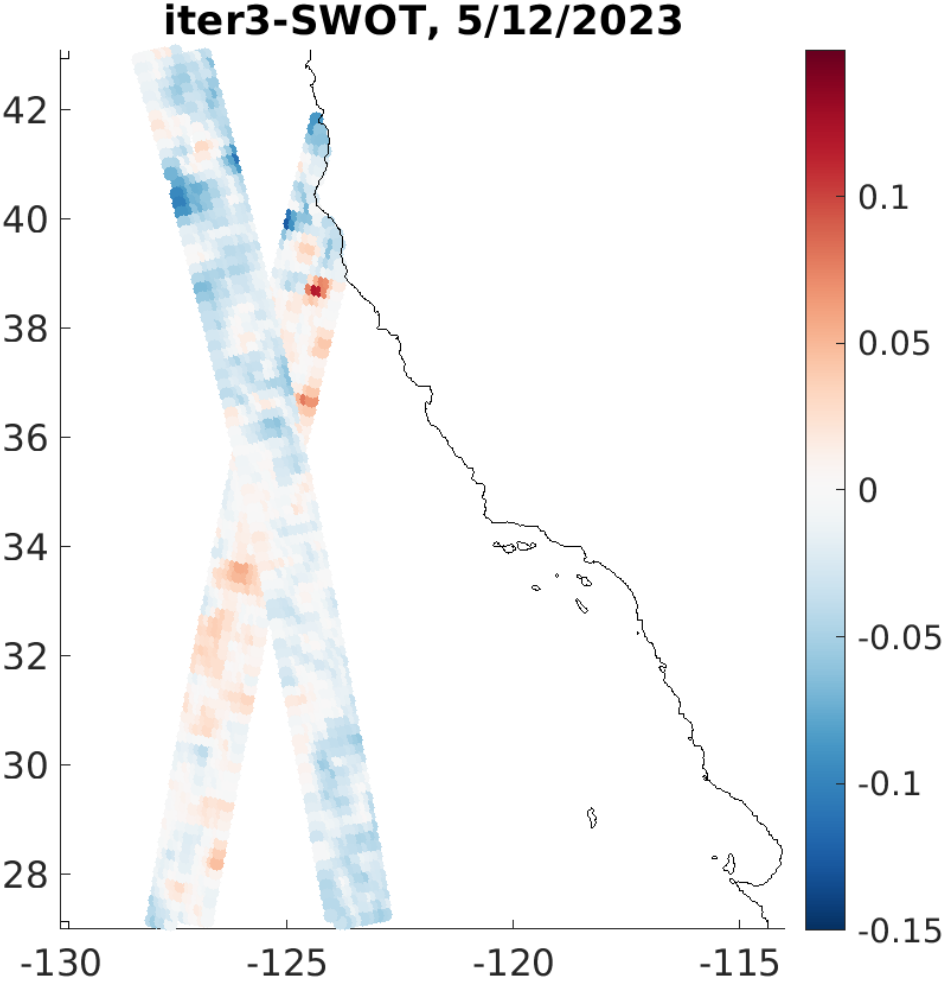
SWOT 5-day assimilation results: initial misfits



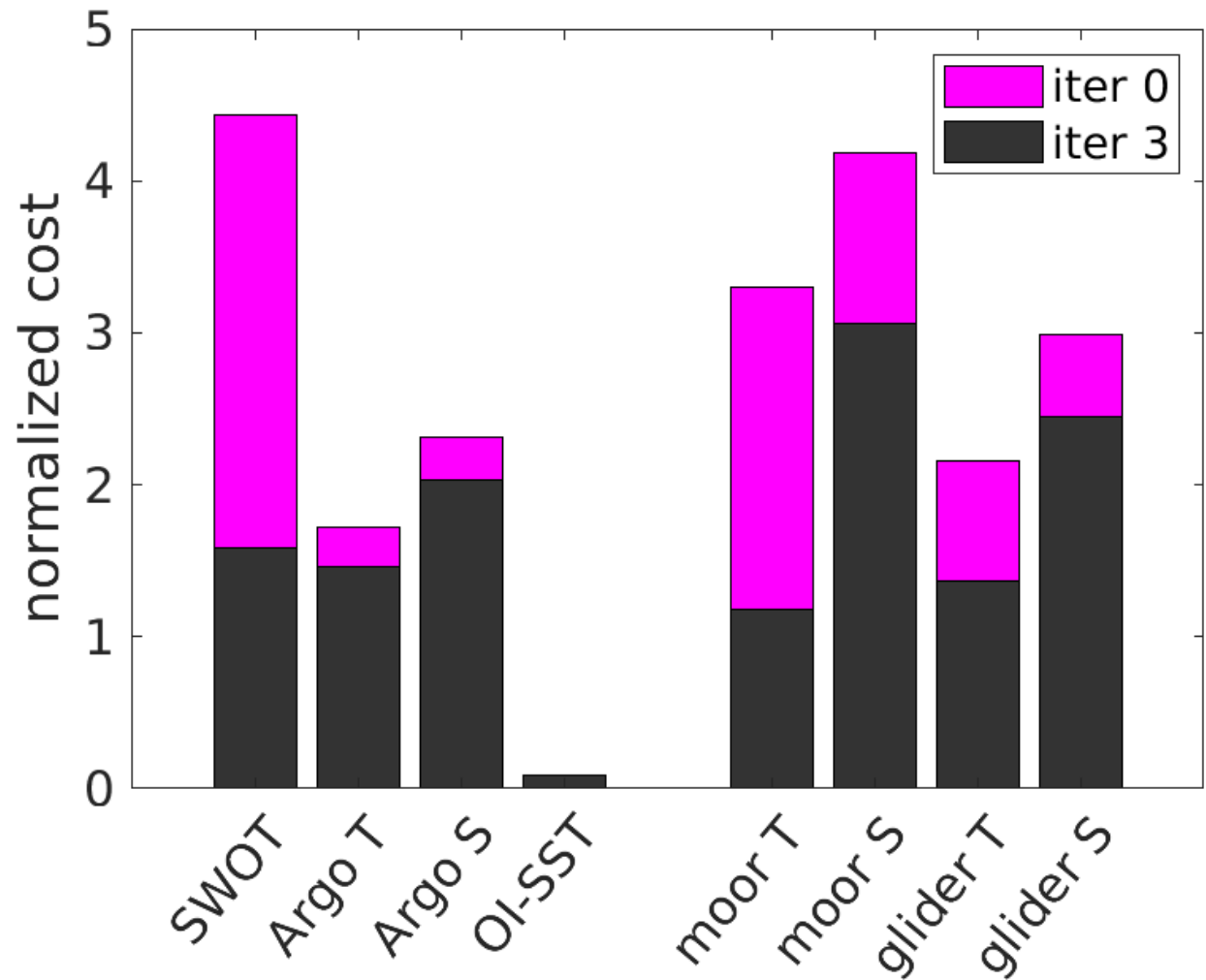
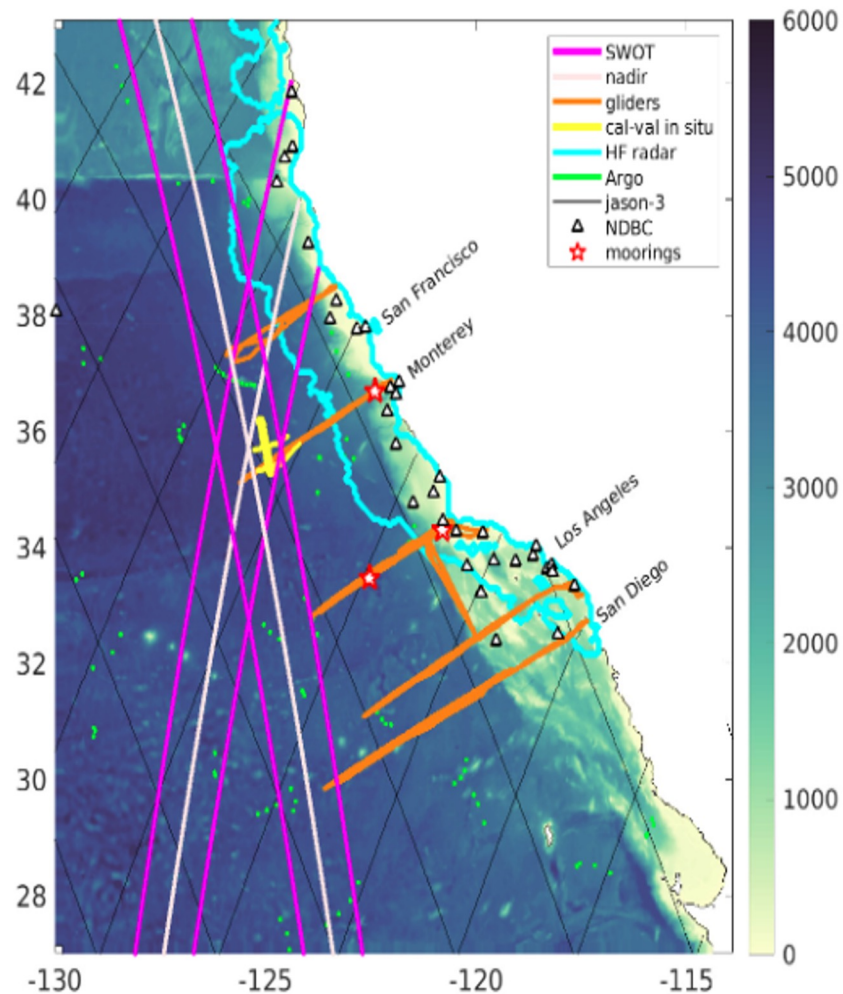
SWOT 5-day assimilation results



3 iterations

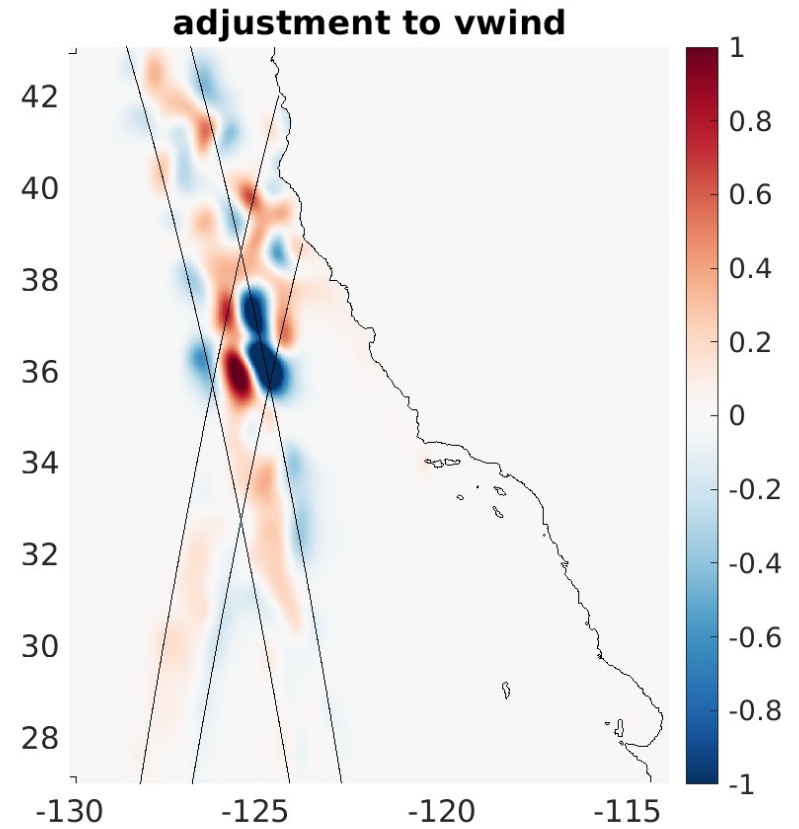
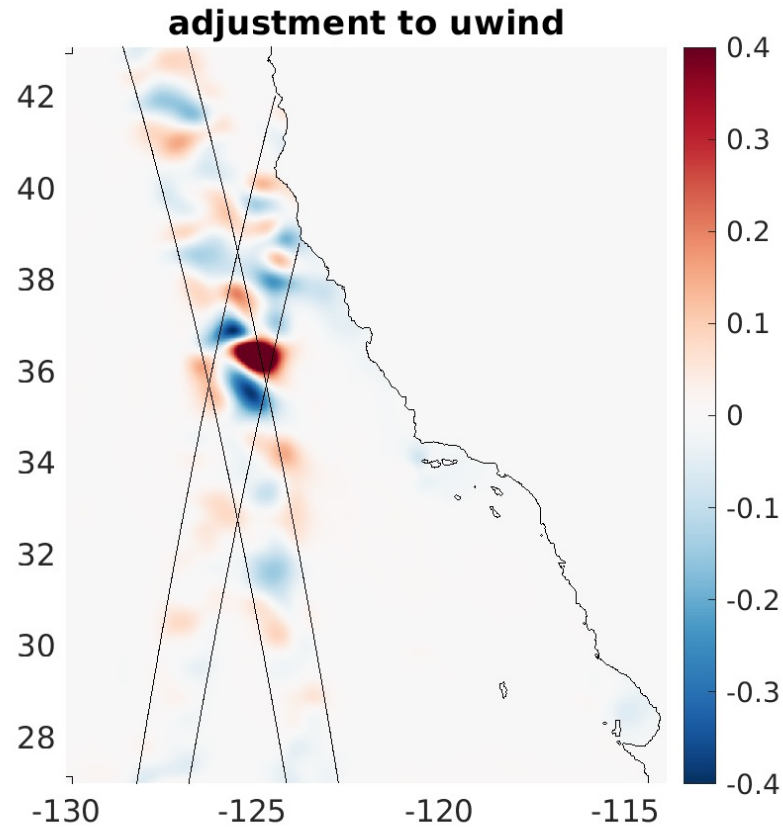
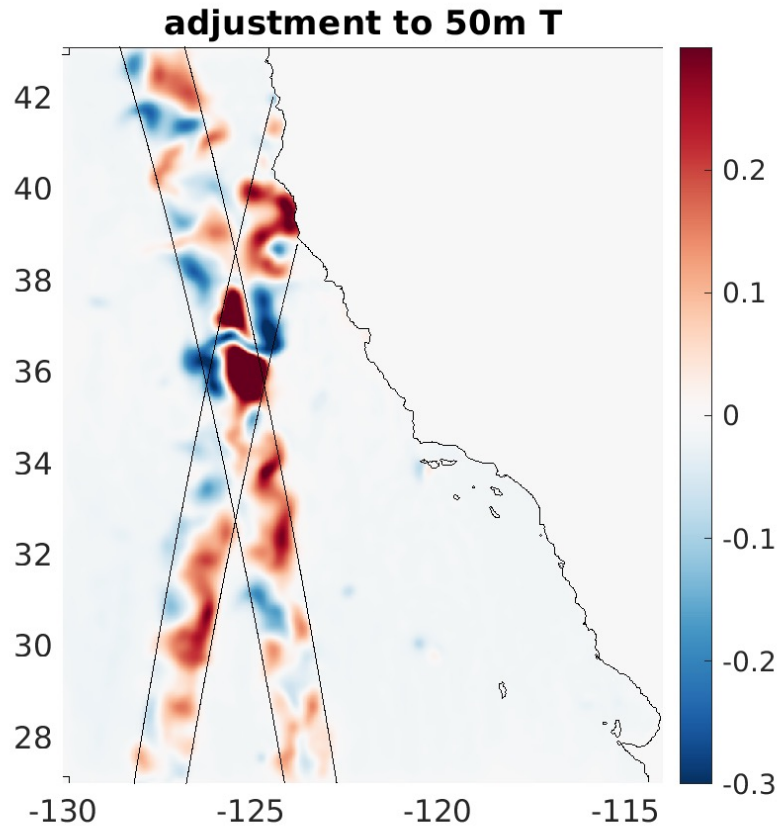


SWOT 5-day assimilation results

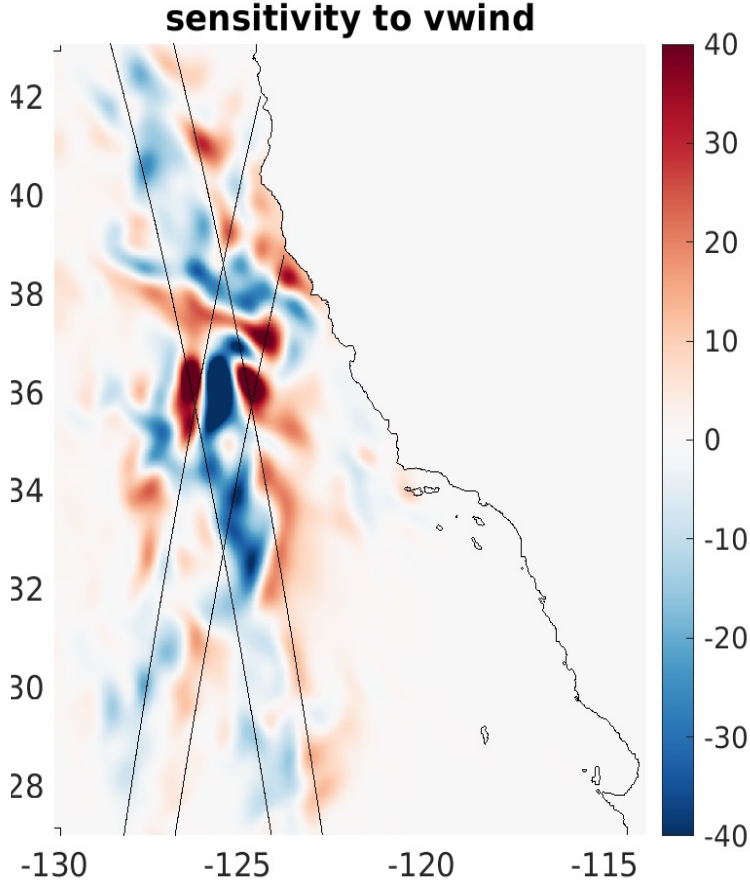
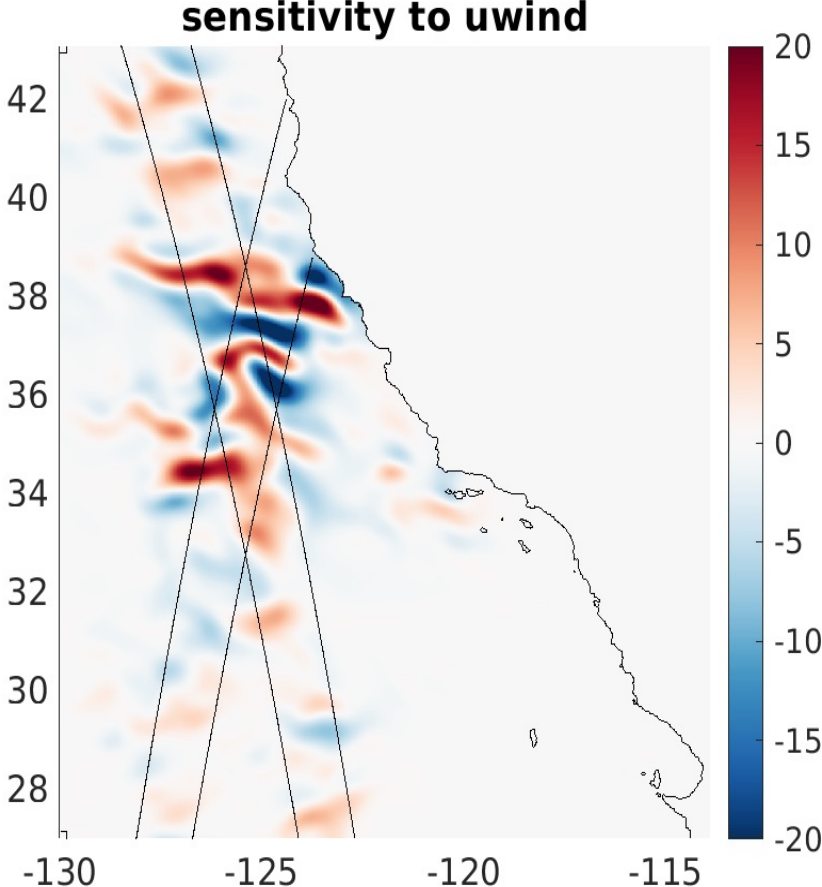
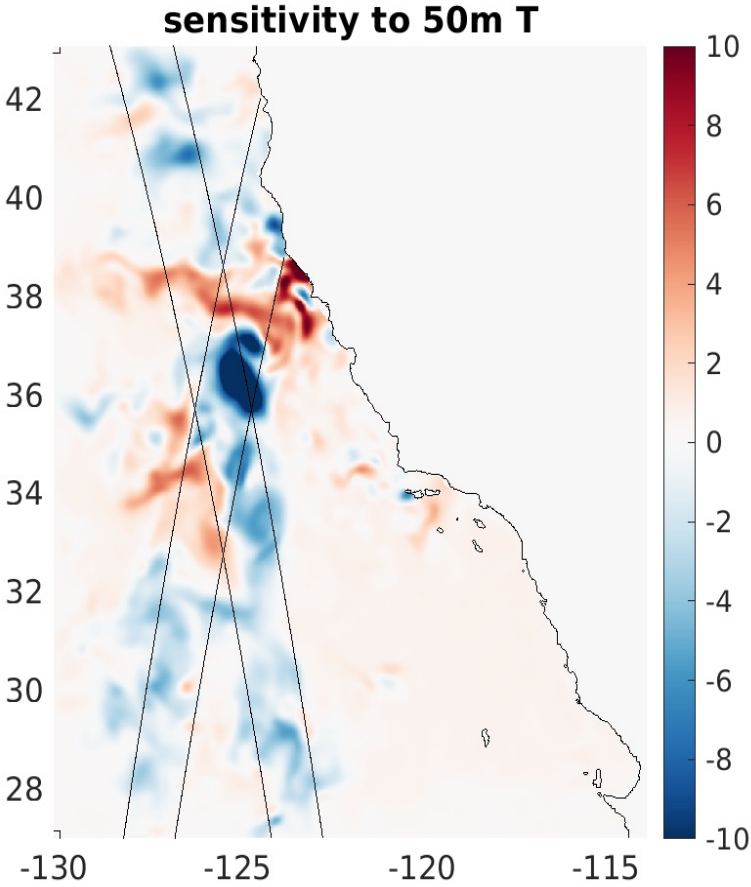


SWOT 5-day assimilation results

Examples of non-dimensional controls



Next step: 30-day assimilation



Summary

- We have a working prototype for SWOT data assimilation
- ObsFit handles SWOT data efficiently
- SWOT constrains the subsurface ocean state
- There's so much to learn!