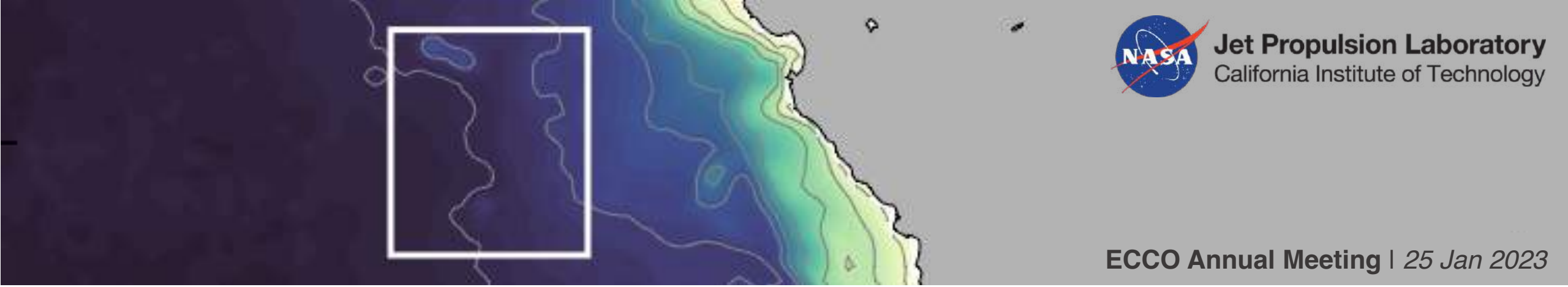

Jet Propulsion Laboratory
California Institute of Technology

ECCO Annual Meeting | *25 Jan 2023*

ECCO-SWOT

A regional implementation of MITgcm-ECCO 4DVAR for direct support of the SWOT CalVal in the California Current system

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ECCO + SWOT

The big picture

- Combine ECCO's powerful machinery with SWOT's novel data
- Assimilate fine-scale observations into a submesoscale-permitting model
- A dynamically-consistent state estimate within each assimilation window allows us to ask science questions, e.g. what can SWOT tell us about the ocean interior?
- Use model physics to fill the SWOT observational gaps

But first…

SWOT CalVal

Satellite 'Calibration & Validation' (CalVal): satellite orbit repeats twice-per-day in the California Current system

Objective: Create the best 4-D ocean state estimate we can for validation and understanding

Two state estimates:

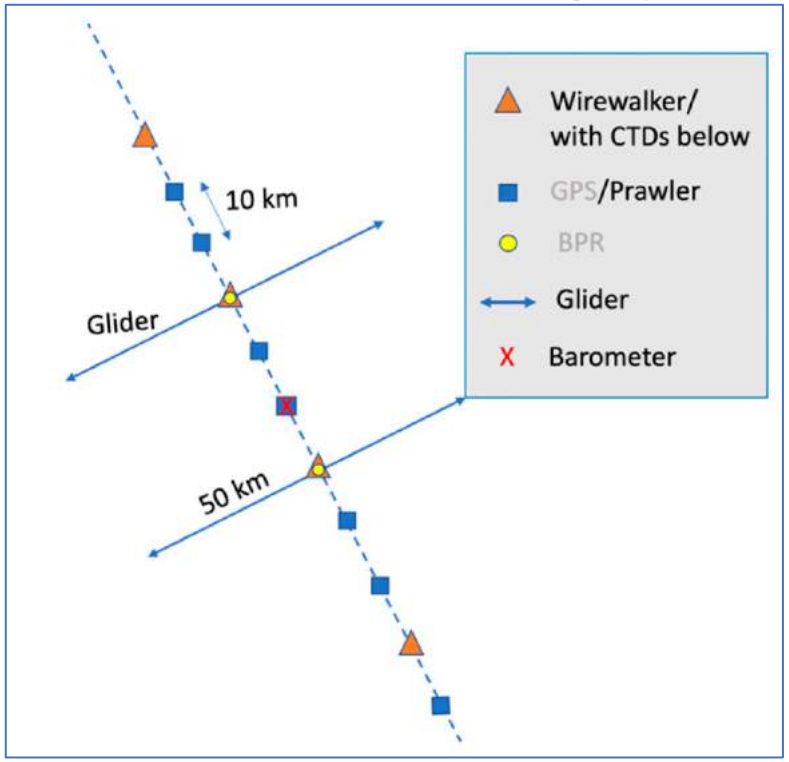
'Small domain' assimilates *in situ* and routine data products

→ ***4D ground truth to understand the independent SWOT observations***

'Large domain' assimilates SWOT and routine data products

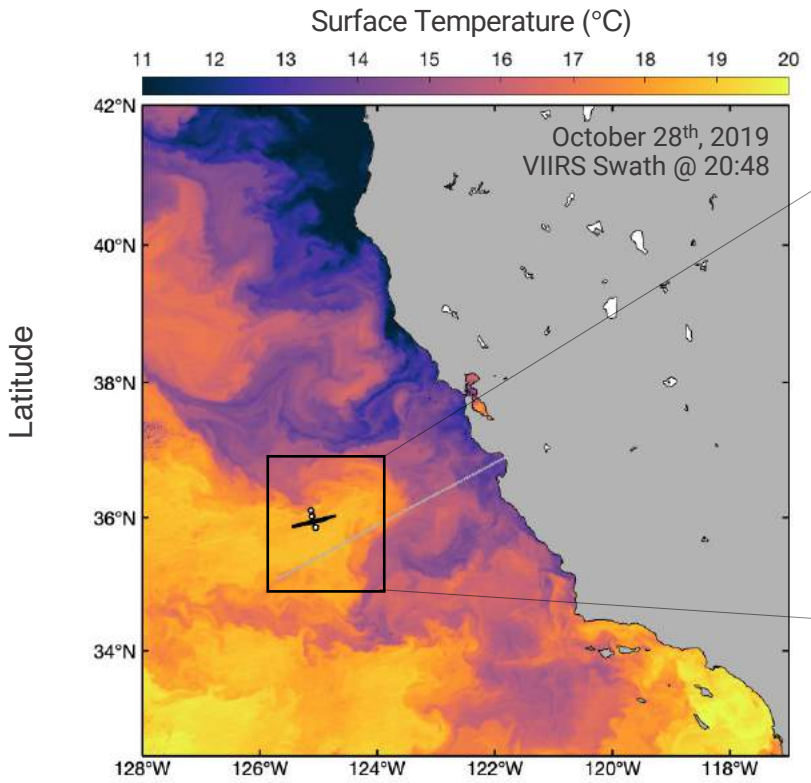
→ ***Evaluate against independent CalVal* in situ *observing system***

CalVal *in situ* observing system

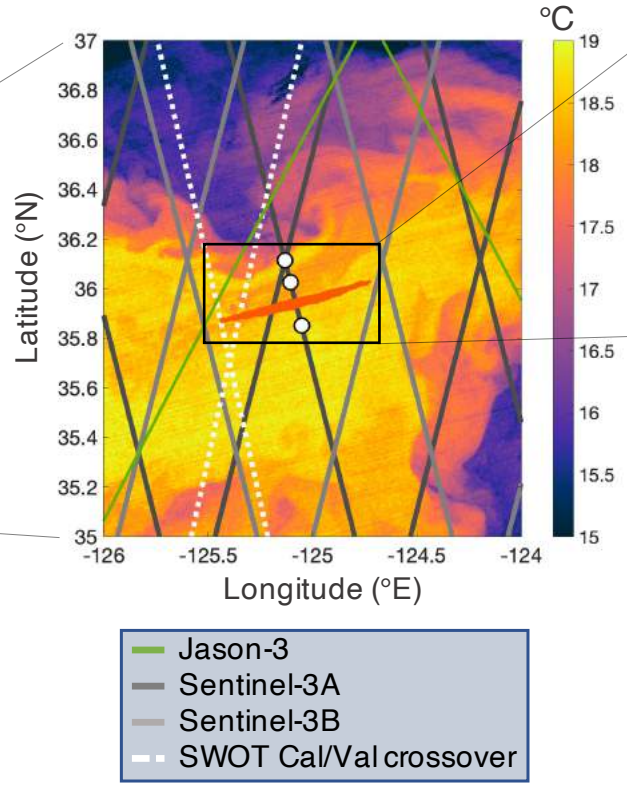


2019 pre-launch field experiment

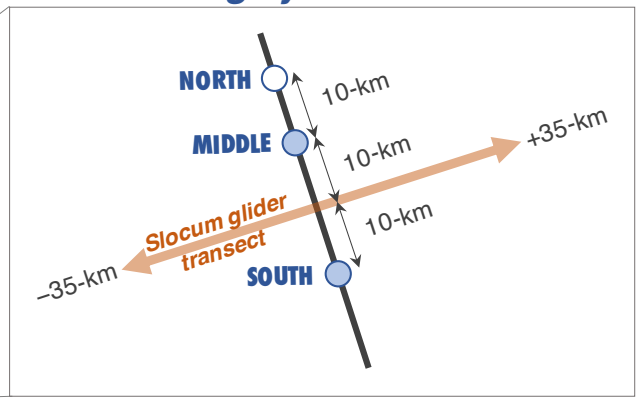
California Current system



SWOT CalVal Site



Observing system schematic



- **North mooring**

18 x fixed CTDs

- **Middle mooring**

0 to 500-m profiling CTD ‘Prawler’

- **South mooring**

0 to 500-m profiling CTD ‘WireWalker’
8 x fixed CTDs

- **Slocum glider**

Pumped CTD, 500-m and 1000-m dives

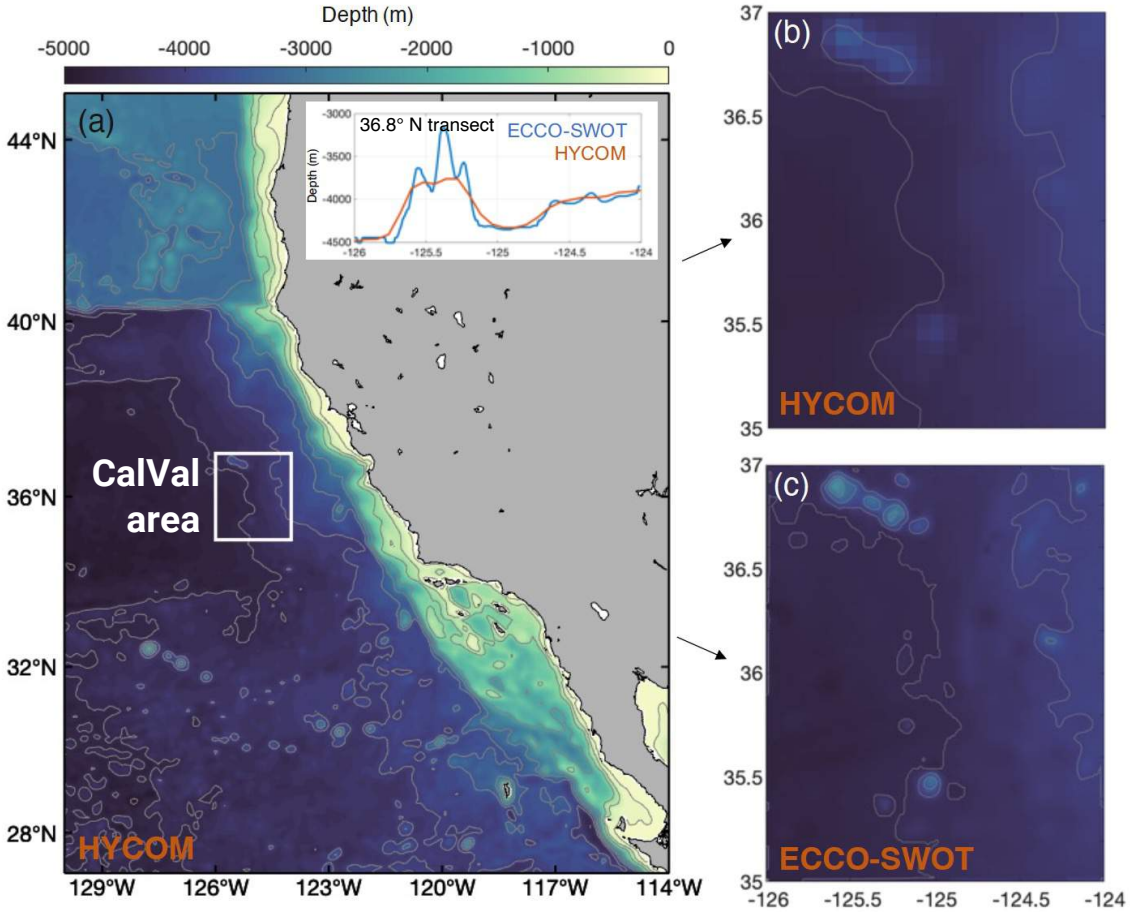
Not used in this study:
2 x Bottom Pressure Recorders (BPRs)
2 x GPS buoys

Wang, J., Fu, L. L., Haines, B., Lankhorst, M., Lucas, A. J., Farrar, J. T., et al. (2022). **On the development of SWOT in-situ Calibration/Validation for short-wavelength ocean topography.** Journal of Atmospheric and Oceanic Technology. https://doi.org/10.1175/JTECH-D-21-0039.1

ECCO-SWOT ‘small domain’

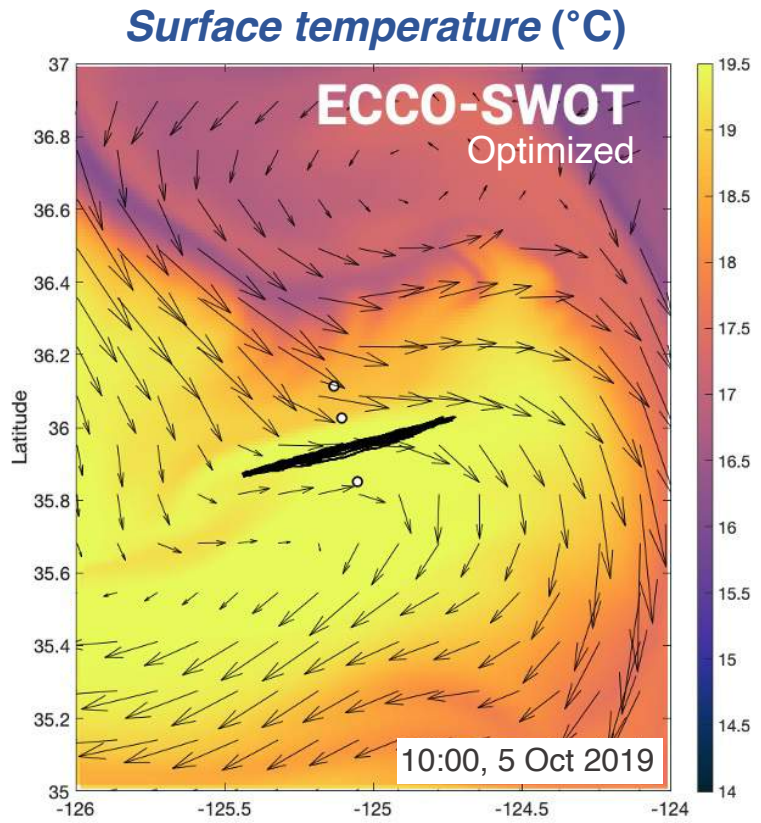
- Set-up for the 2019 pre-launch field campaign
- 2° x 2° domain centered on the SWOT CalVal site
- 1-km horizontal spacing, 72 vertical *z* levels
- Nested into the HYCOM + NCODA Global 1/12° analysis (no tides)
- Atmospheric forcing from ECMWF ERA5 reanalysis (30-km, 1-hr)

Bathymetry and Domain Size



‘Small domain’ production run

- September–December, 2019
- 7 day assimilation window (27x)
- 3 day overlap
- 2-day spin up to mitigate initialization shock
- ***Reference*** run = forward run
- ***Optimized*** run = assimilates 3 moorings



→ geostrophic currents of ECCO-SWOT

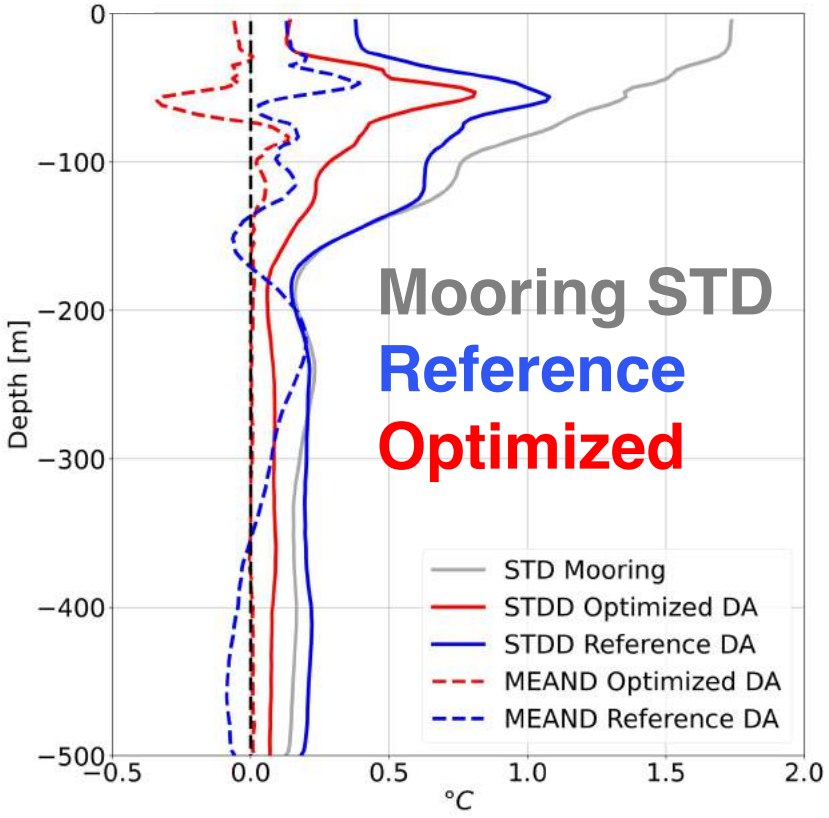
Computation

- NASA Pleiades supercomputer
- 7-day window ~1.5 hrs
- Window optimization ~17 hrs
- Total cost descends by 75% in 10 iterations
- Control cost dominated by initial condition (T0/S0)
- Wall-clock time approx. 9-days to complete 3.5-month production run (3 windows run simultaneously)

‘Small domain’ performance

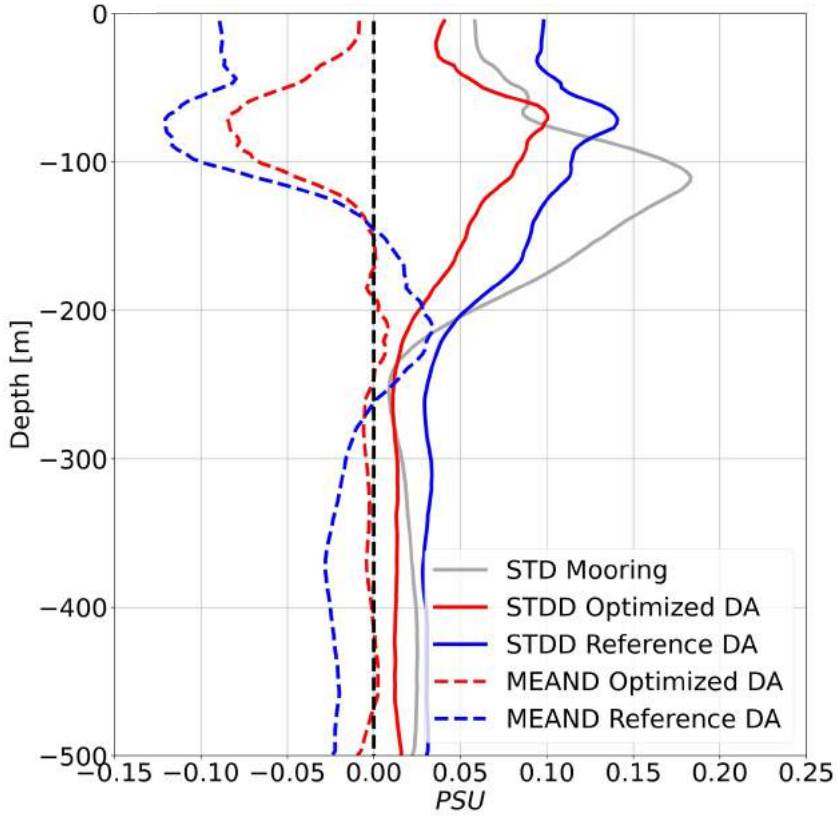
Temperature

Mean and STD Differences



Salinity

Mean and STD Differences

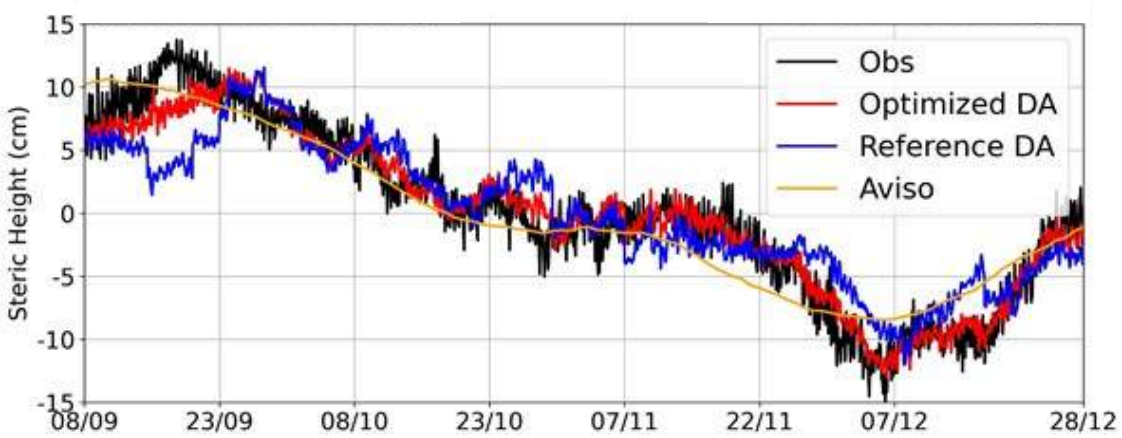


Tchonang, B., Archer, M. R., Gopalakrishnan, G., Cornuelle, B., Mazloff, M. R., Wang, J., and Fu, L-L (submitted to JTECH, Dec 2022).
Evaluation of a 4DVAR assimilation system in the California Current at the SWOT Calibration/Validation site based on the pre-launch oceanography field experiment.

‘Small domain’ performance

Steric Height Timeseries

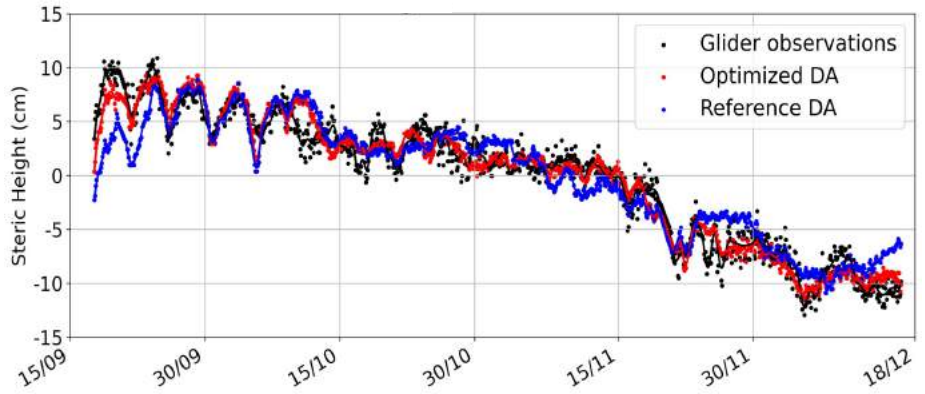
North mooring
Assimilated



RMSD
Reference = 3.2 cm
Optimized = 1.7 cm

Error/signal
Reference = 47%
Optimized = 26%

Glider
Independent



RMSD
Reference = 2.4 cm
Optimized = 1.5 cm

Error/signal
Reference = 40%
Optimized = 25%

Tchonang, B., Archer, M. R., Gopalakrishnan, G., Cornuelle, B., Mazloff, M. R., Wang, J., and Fu, L-L (submitted to JTECH, Dec 2022).
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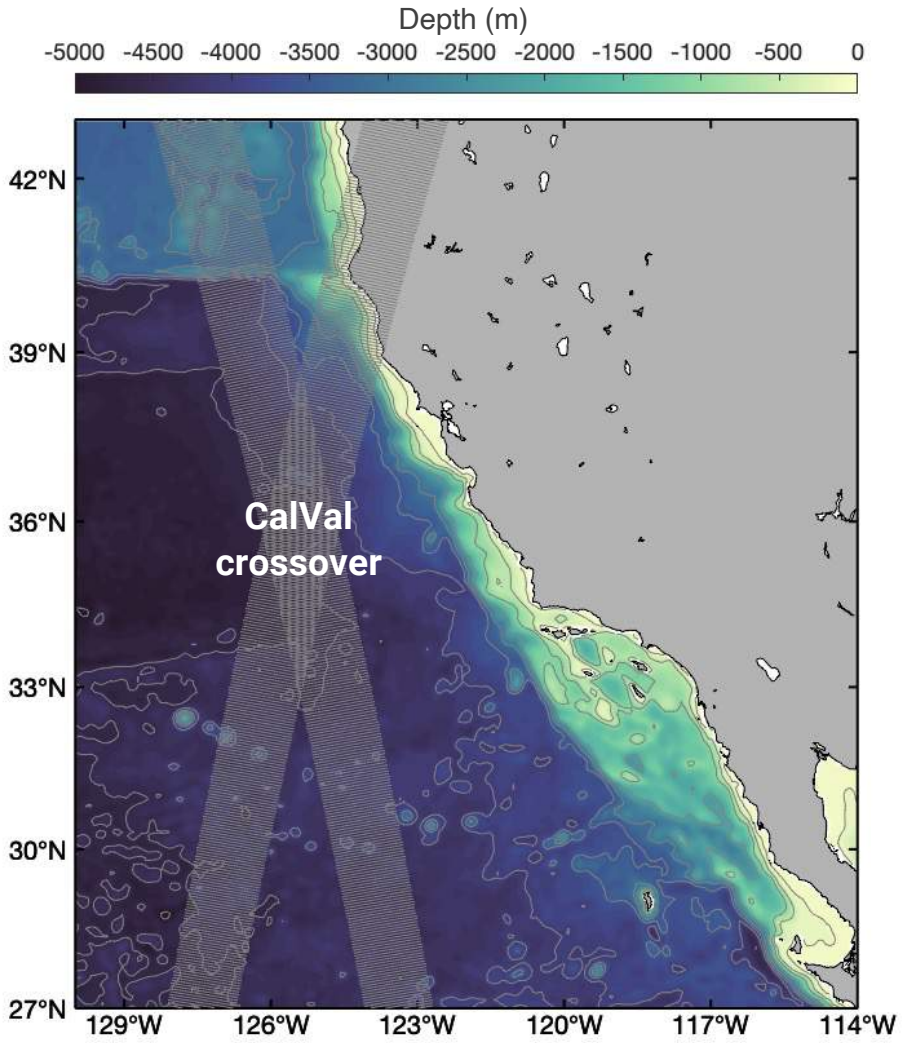
‘Large domain’ for SWOT swath assimilation

- Set-up a ‘large domain’ run for SWOT SSH assimilation, including tidal forcing as required
- 27 to 43 N, -130 to -114 E
- 2-km grid spacing, 100 vertical *z* levels

Large domain bathymetry



Ongoing Work

ECCO-SWOT ‘small domain’

- Finish preparations for CalVal campaign assimilation (based on ‘OSSE’s – observing system simulation experiments)
- Assimilate the *real* CalVal campaign observations (Apr–June, 2023) to produce a high-fidelity state estimate!

ECCO-SWOT ‘large domain’

- Preparing the machinery to assimilate SWOT SSH swaths based on a twin-experiment OSSE

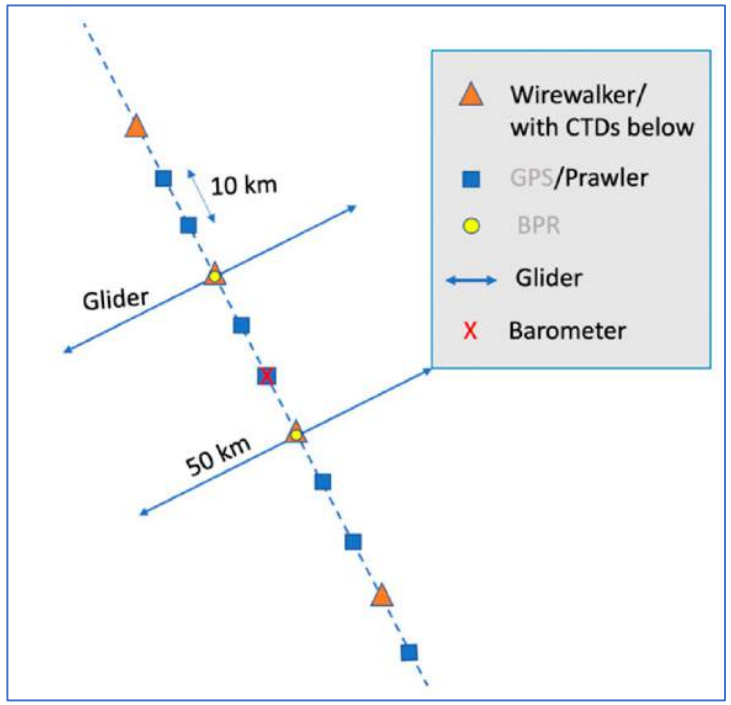
Potential Future Direction

- Demonstrate feasibility of SWOT-driven high-resolution state estimate. Produce ECCO-SWOT regional state estimates for the California Current and other strategically important regions such as US east and west coastal areas

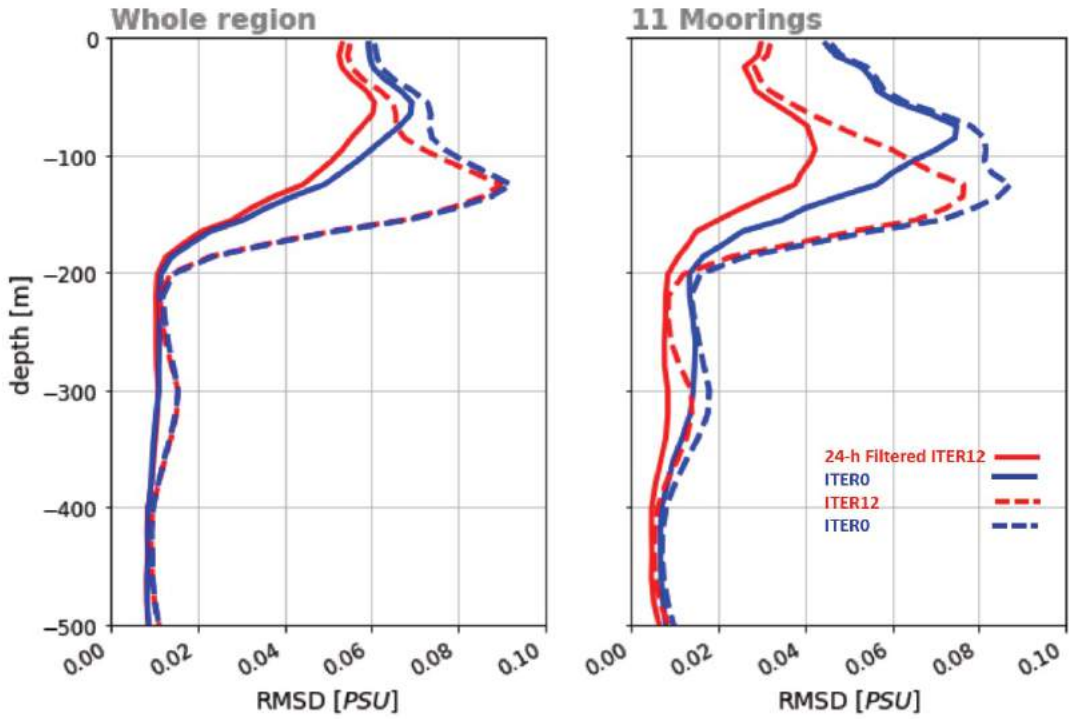
Extra Slides

Observing System Simulation Experiments

- Observing system simulation experiments (OSSEs):
  - LLC4320 was used as a Nature run
  - Assimilating 11 *synthetic* moorings from the CalVal observing system design



Salinity RMSD(z)



Perturbation Experiments

Following method of **Verdy et al.** (2012) and **Swiezek et al.** (2019)