SWOT mapping/assimilation discussion: Challenges for mapping all of the signal

SSH

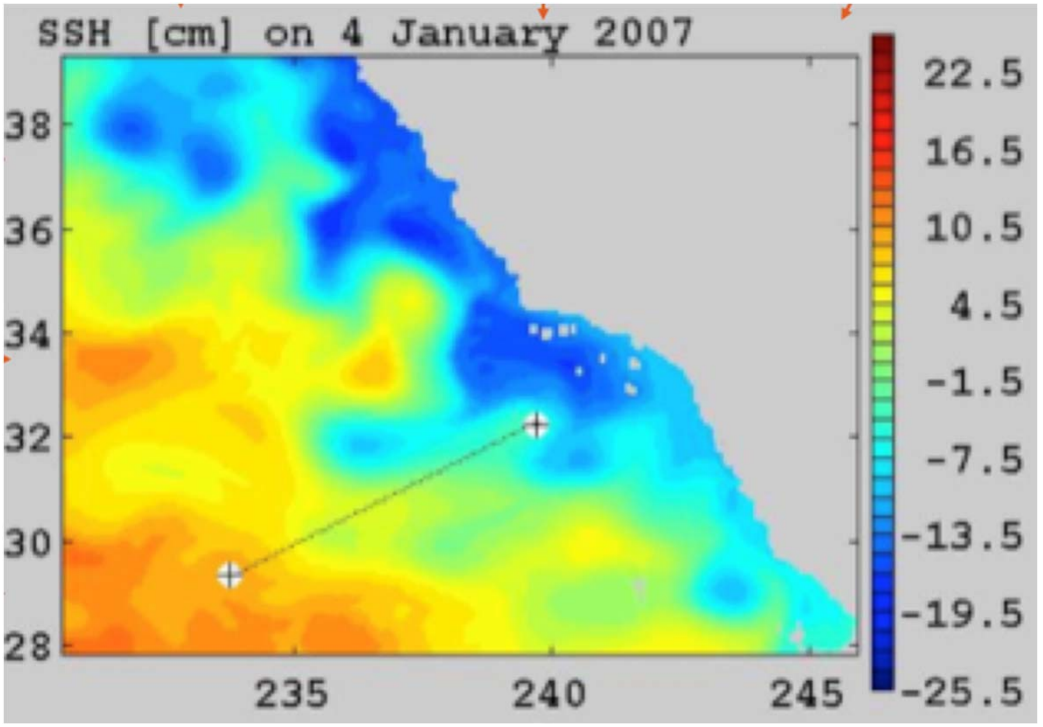
Surface waves

Tides

Internal waves

Mixing

Errors

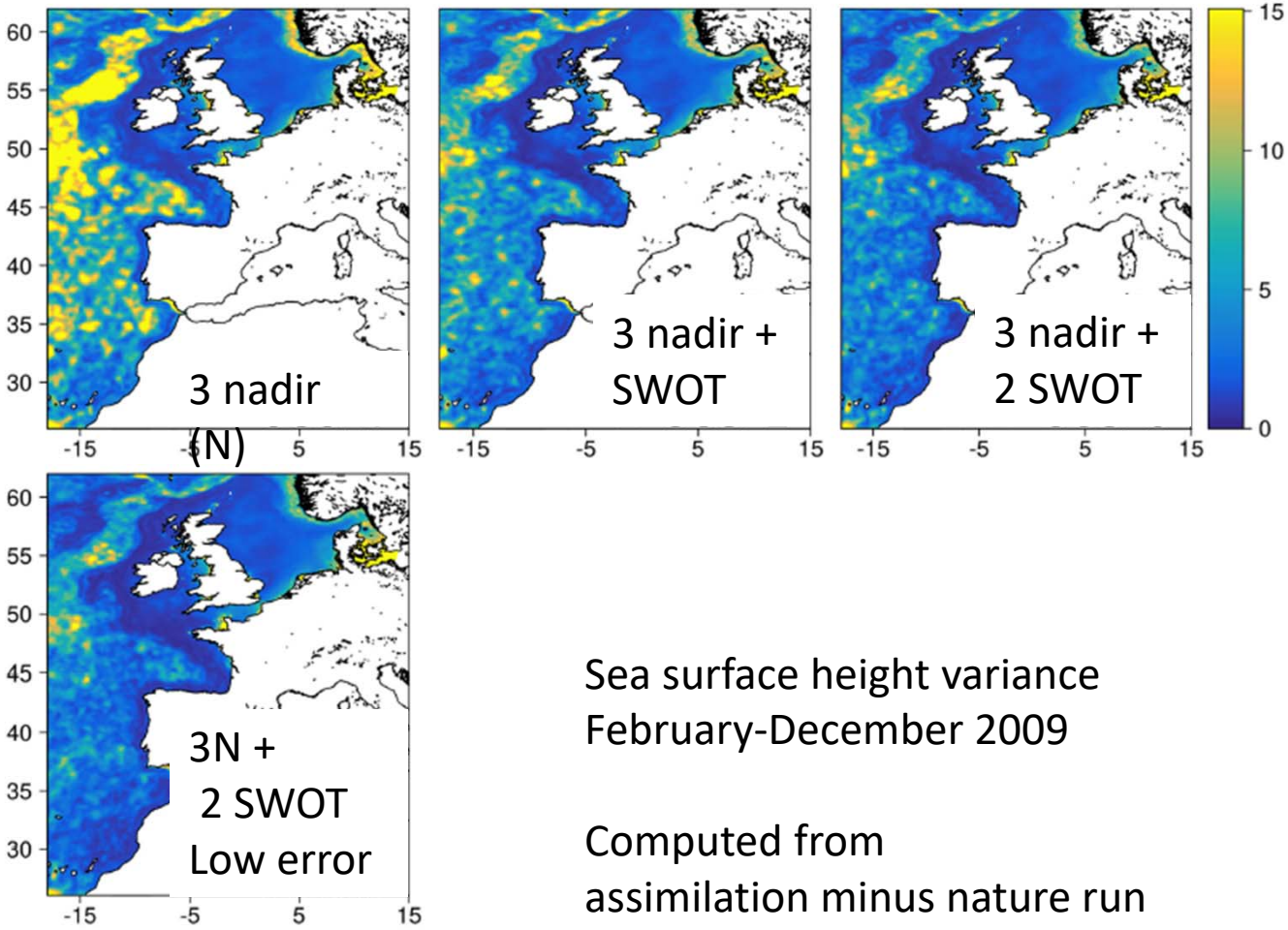


High-resolution implies high computational cost → regional model and multi-scale assimilation

Key challenges

- Mapping: Balanced (geostrophic) motions for scales > 50 to 70 km, following from methods developed by AVISO
- Mapping with dynamics (state estimation/assimilation) with possibility of capturing smaller scales:
  - Geostrophy/quasi-geostrophic advection
  - Baroclinic (non-stationary) tides
  - Internal waves/mixing
  - Surface waves
  - Error budget
  - High-resolution: computational requirements → regional domain

Where we stand: NEMO 3DVar (Bonaduce et al, 2018)



Sea surface height variance February-December 2009

Computed from assimilation minus nature run

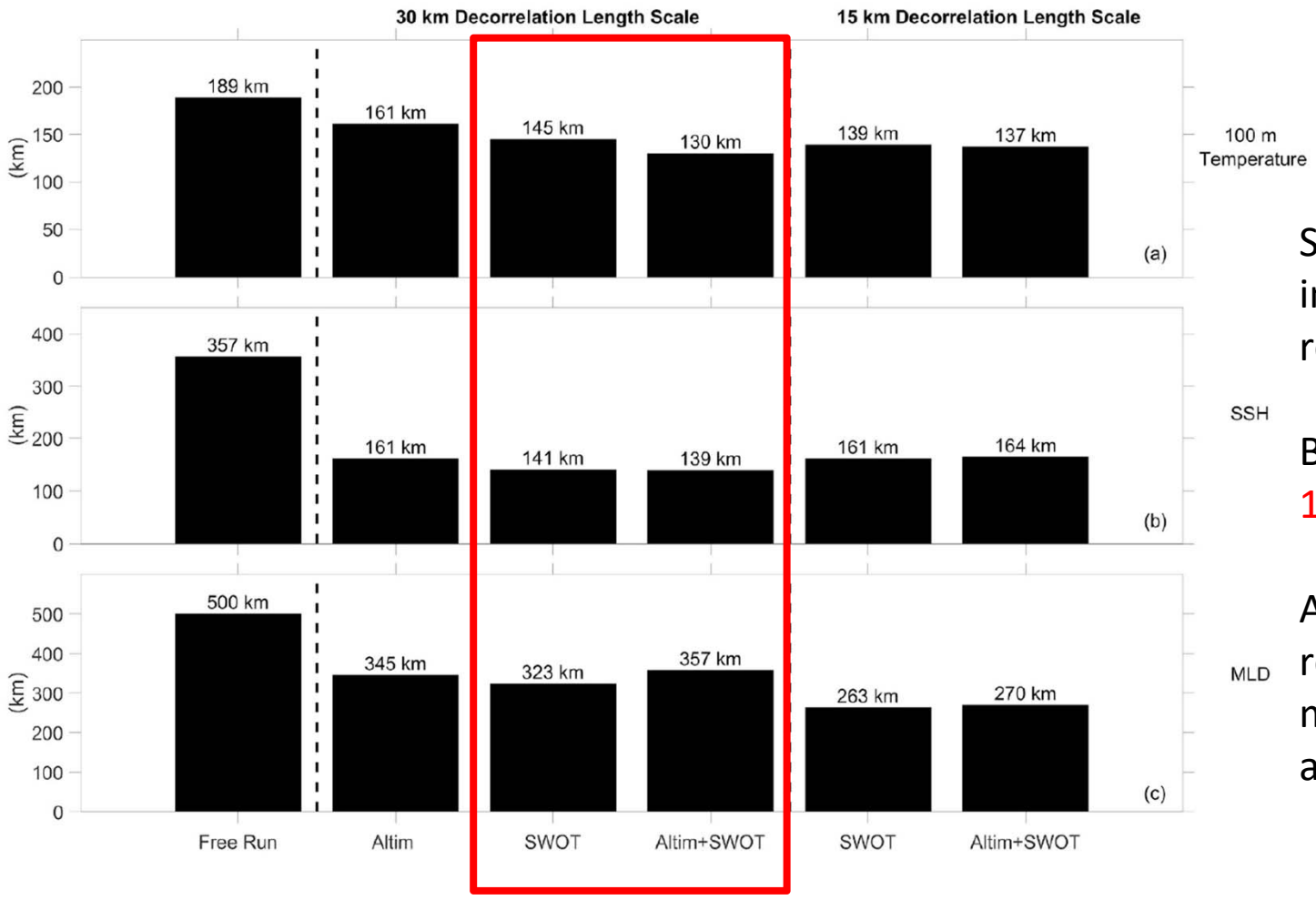
Assimilating more data leads to smaller errors

Two SWOTs would be better than one.

Authors recommend evaluating high mesoscale variability regions and full characterization of SWOT noise.

Iberian-Biscay-Ireland regional assimilation

Where we stand: NRL 3DVar (D'Addezio et al, 2019)



SWOT assimilation improves spatial resolution …

But only to 130-140 km scales

Authors recommend trying multi-scale approach.

Western Pacific regional simulation

Future steps (For the next science team)

- Common test environment to test multiple schemes trade-offs
  - Focus on California Current? Mediterranean?
  - Include internal waves and tides (e.g. llc4320)?
  - Include surface waves? (What will SWOT resolution be for wave information?)
  - Prioritize mapping balanced motions? What scales can we resolve?
  - Regional model boundaries? How do we set open boundaries to include realistic baroclinic tidal effects and/or Garrett/Munk background spectrum?

Discussion questions

- Balanced motion challenge
  - Existing OSSE with SWOT says SWOT will increase resolution from 170 km to 130 km. Can we do better, and how? Will multi-scale approaches that focus on smaller scales help?
- High-wavenumber assimilation challenges:
  - Increase predictability for non-stationary tide?
  - Increase predictability for internal wave spectrum?
- 2Dvar (simple mapping, krigging), 3Dvar (JPL ROMS), 4Dvar (ECCO state estimation)? What are the pros and cons?
- Can we coordinate some intercomparison scenarios?

Discussion questions (SWOT cal/val)

- Balanced motion challenge
  - Can we use Cal/Val period to better link SWOT measurements to ocean circulation? (e.g. vertical heat flux, relative vorticity)
- High-wavenumber assimilation challenges:
  - Increase predictability for non-stationary tide? Increase predictability for internal wave spectrum?
- 2Dvar (simple mapping, krigging), 3Dvar (JPL ROMS), 4Dvar (ECCO state estimation)? What are the pros and cons? Coordinate for California Current region.
- Coordination of other instrumented regions? Share research plans for targeted mapping regions

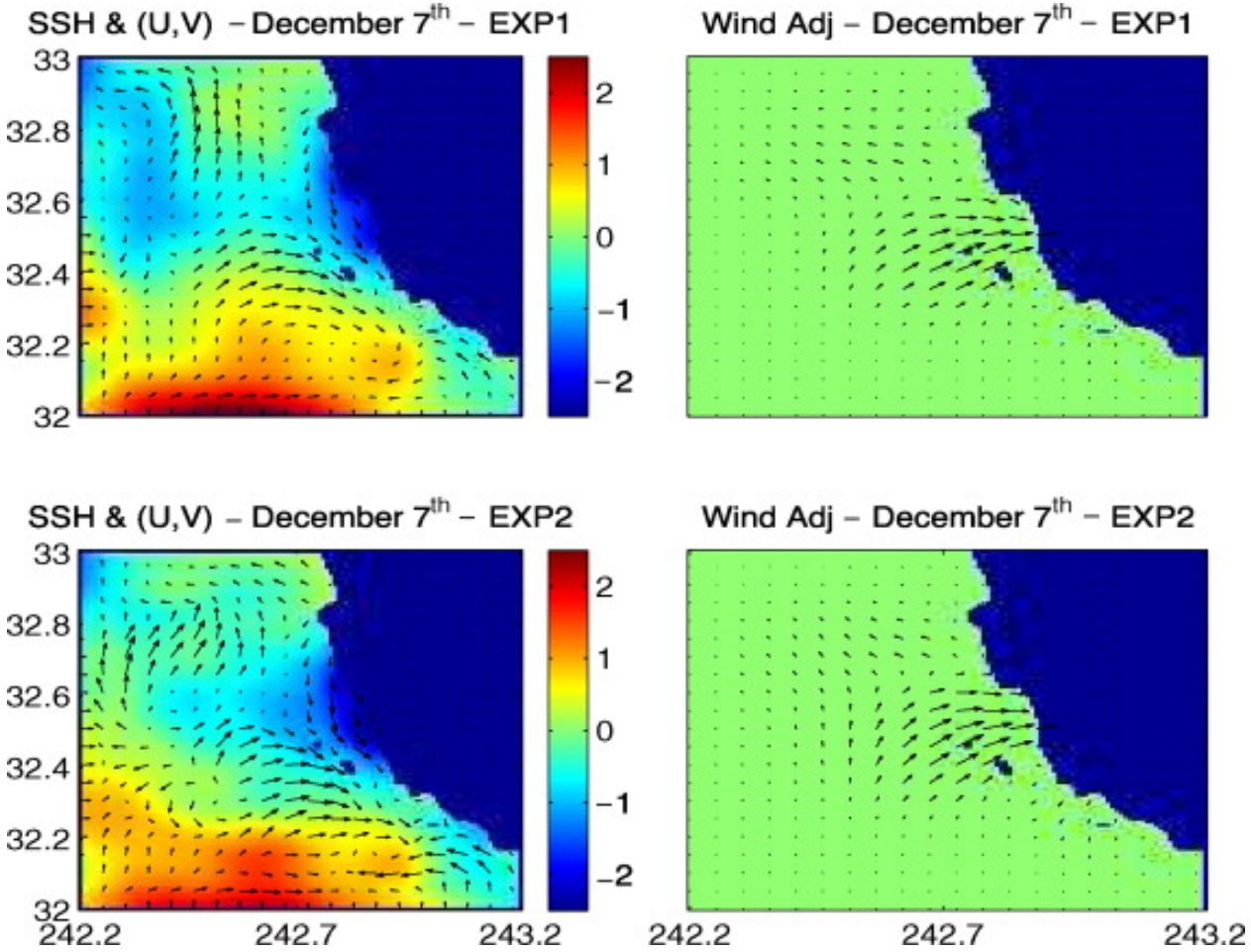
Potential recommendations

- Applaud diversity of 2dVar, 3dVar, and 4dVar methods
- Common test problems/intercomparisons would be useful for next science team
  - Workshop or one-day add-on to SWOT meeting?
  - Types of benchmarks for comparing mapping?
  - Regions? Data sets?
  - Someone (postdoc) funded to coordinate intercomparison?

Time-scales matter

Assimilation starts December 1: System in geostrophic balance, with wind forcing dominating

Assimilation starts December 6: System still adjusting, with initial conditions and wind forcing both important. Short windows make it hard to project information into other variables.



Hoteit et al, Dynamics of Atmospheres and Oceans, 2009

Stray slides

Assimilation for SWOT science

- High-resolution implies high computational cost → regional domains, multi-scale assimilation
- Surface waves → use currents to drive Wave Watch III; couple wave and ocean models
- Tides → include tide model in ocean model
- Internal waves → use O(100) vertical levels; *explore impact of open boundaries*
- Mixing → *refine turbulent mixing in ocean model?*
- Errors → *ensemble approach or use gradient descent information from adjoint?*

Assimilation for SWOT science

- Tools under development to assimilate SWOT-scale processes: waves, tides, vertical resolution for internal waves, biogeochemistry, multi-scale assimilation and regional domain for speed
- What can assimilation offer SWOT? Dynamical approach to fill gaps between observations, building on Cornuelle et al (2000) QG assimilation to capture westward eddy propagation plus e.g. eastward internal wave propagation. Using 4Dvar, budgets close (e.g. PV, heat, carbon).
- How can the SWOT help us refine modeling/assimilation? Constraints on vertical velocity and upper ocean processes will help us refine model parameterizations ultimately for sub-seasonal-to-seasonal forecasting.