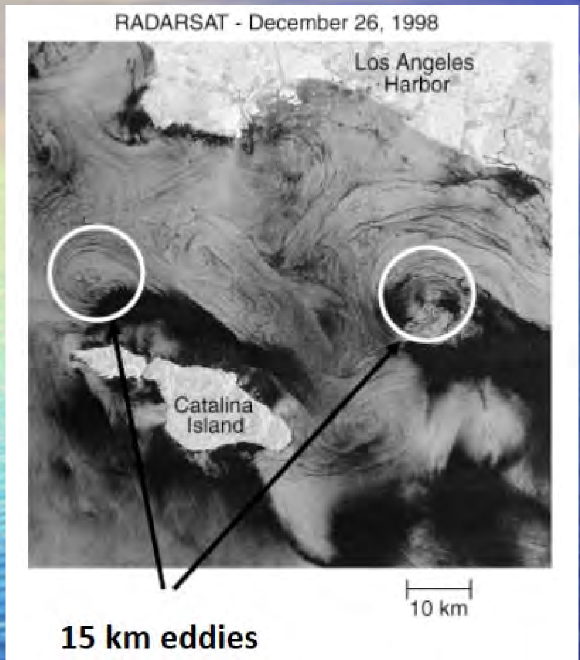
Observing the ocean surface topography at high resolution by the Surface Water Ocean Topography (SWOT) Mission

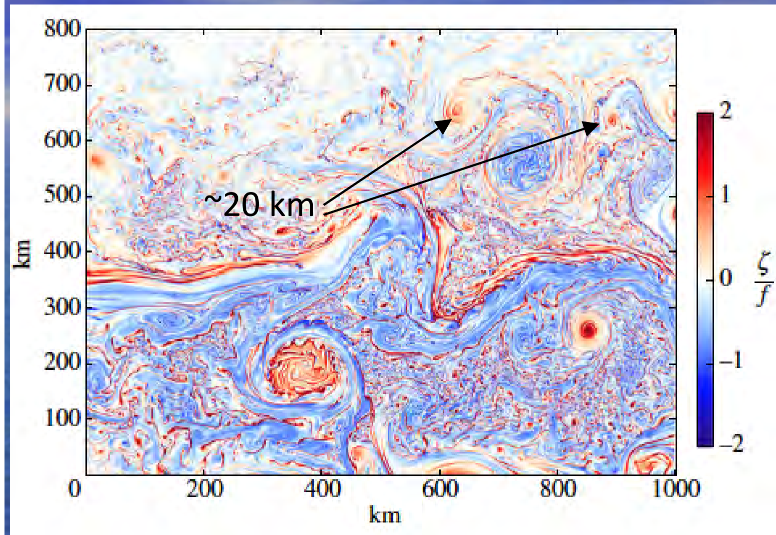
Lee-Lueng Fu
Jet Propulsion Laboratory, California Institute of Technology
Pasadena, CA, USA

Rosemary Morrow
LEGOS/OMP, Toulouse, France

2019 OSTST Meeting
October 24, 2019
Chicago, USA

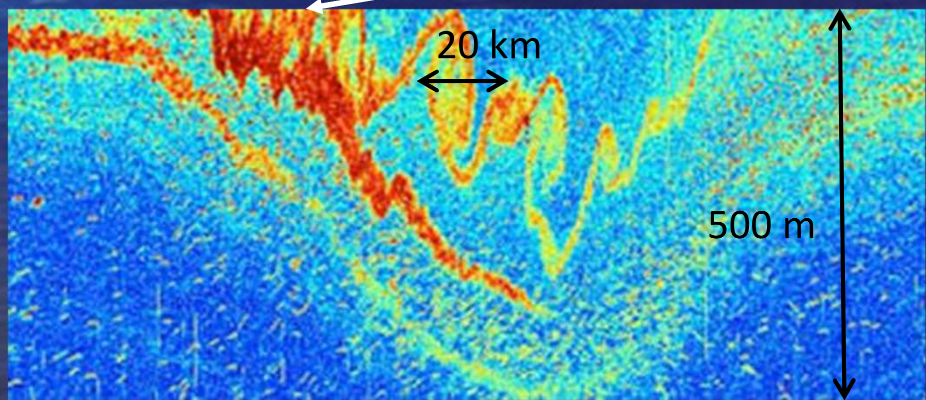
SWOT oceanographic objectives:
SSH-> horizontal velocity and transport->vertical velocity/vorticity and transport of heat and water properties in the ocean





Vertical vorticity at the surface in the Gulf Stream (McWilliams, 2016)

Sea surface height variations to be observed by SWOT

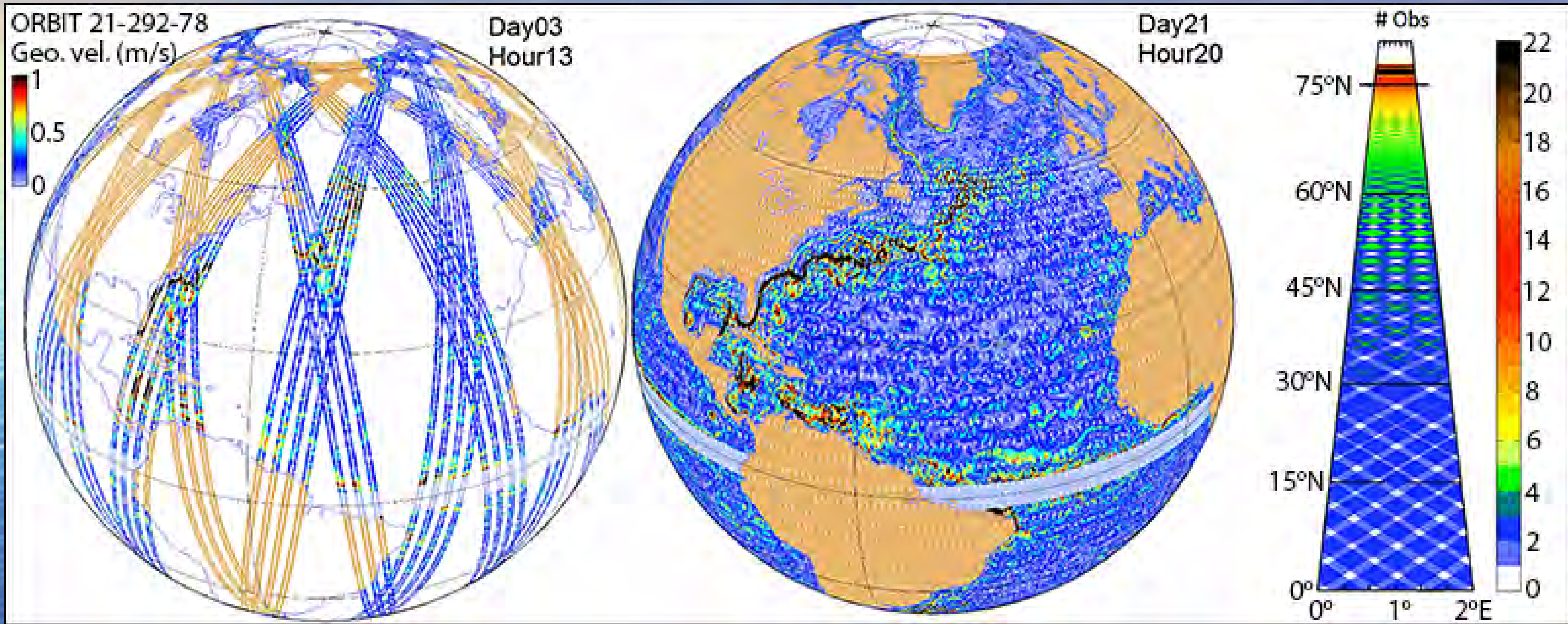


NOAA/GFDL

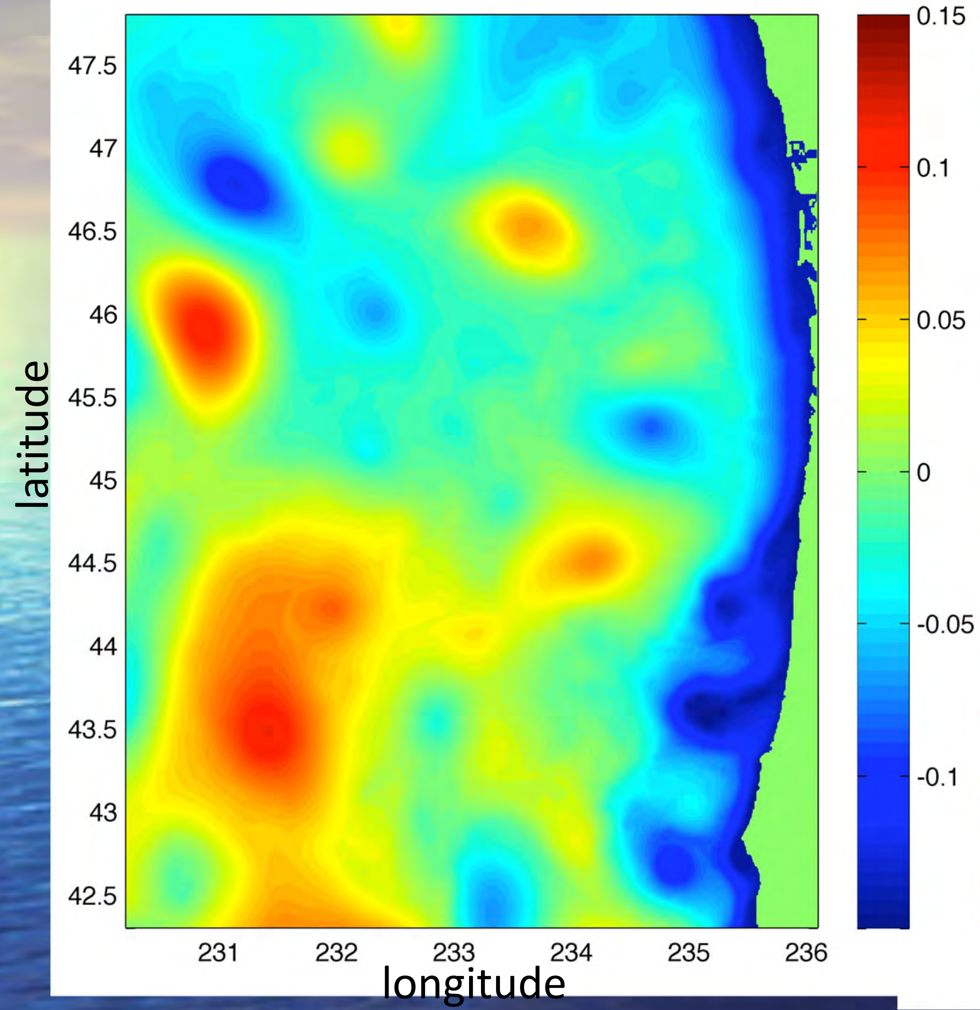
Two challenges come from:

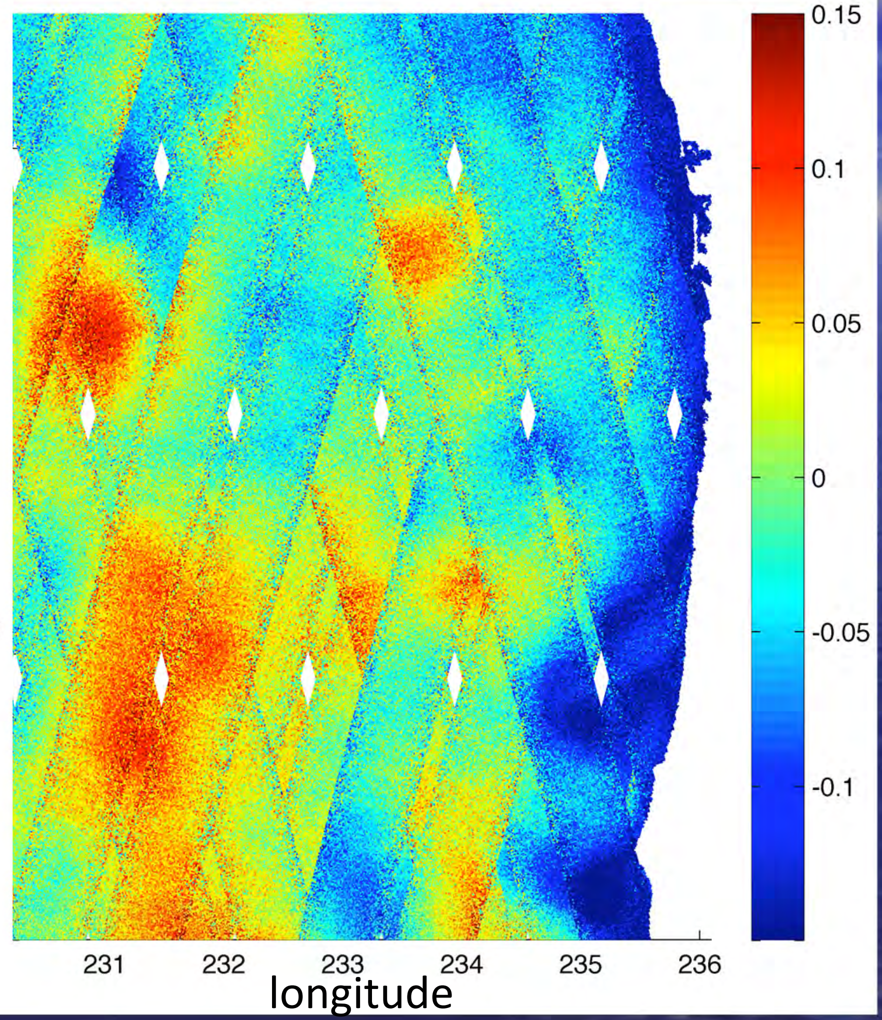
1. Measurement noise and errors and irregular sampling, especially in time,
2. Entanglement between fast evolving internal waves and balanced motions in SSH snapshots.

Sampling pattern of the 21-day orbit



Challenge #1: Reconstruction of ocean state from irregular sampling

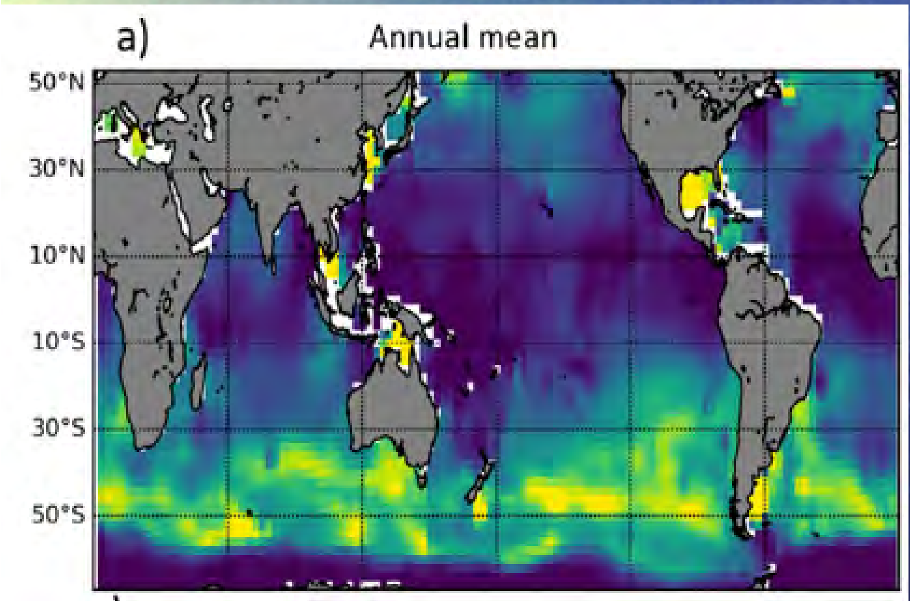




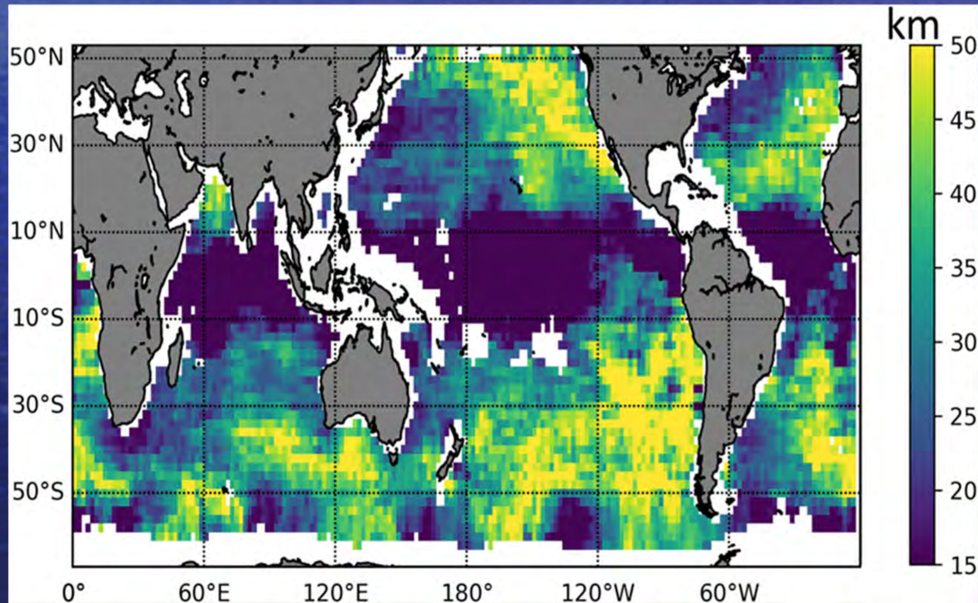
A software tool available for simulating SWOT-like observations for studying reconstruction methodology

Spatial resolution (in wavelength)

SWOT
Wang et al, 2019

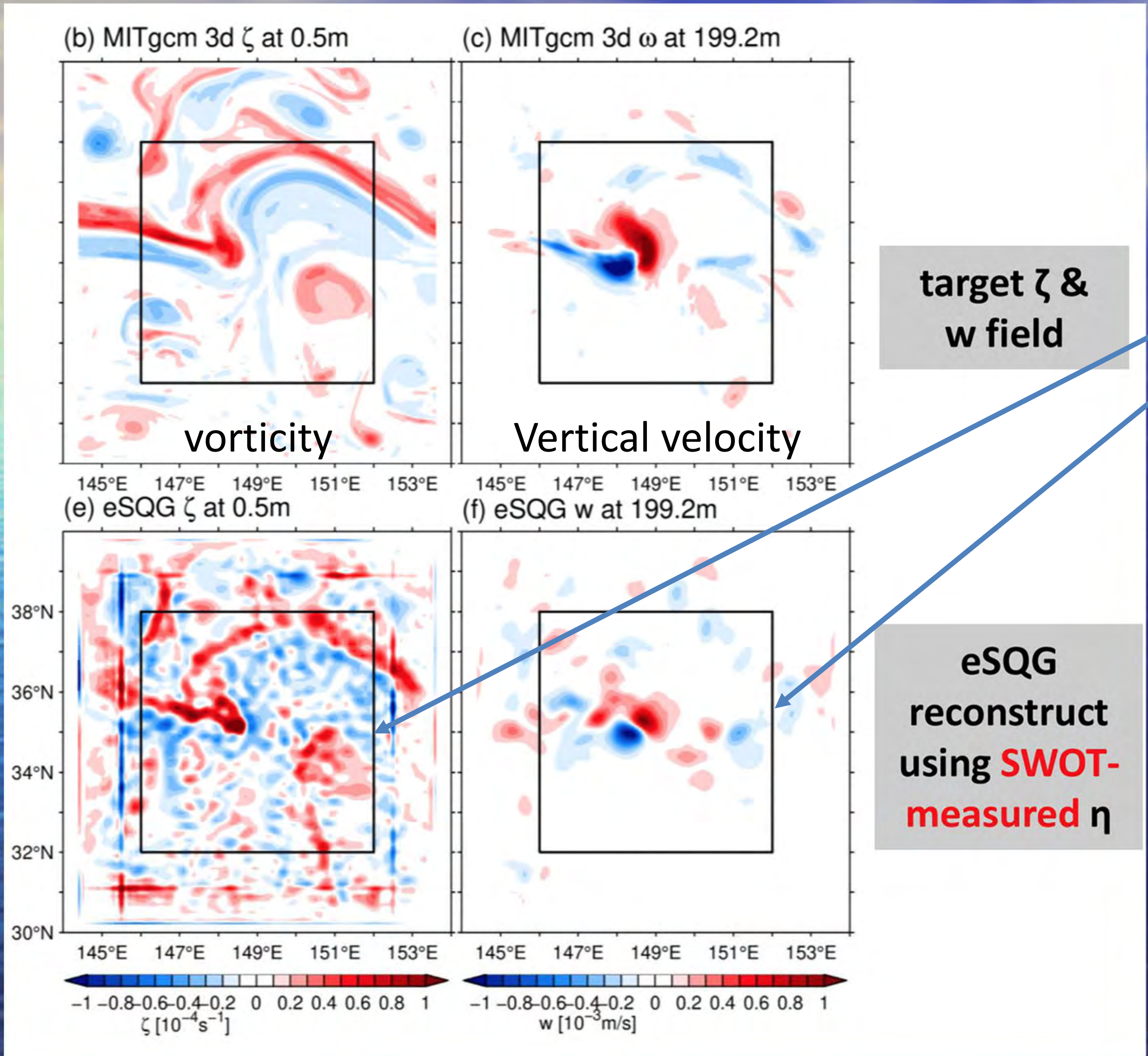


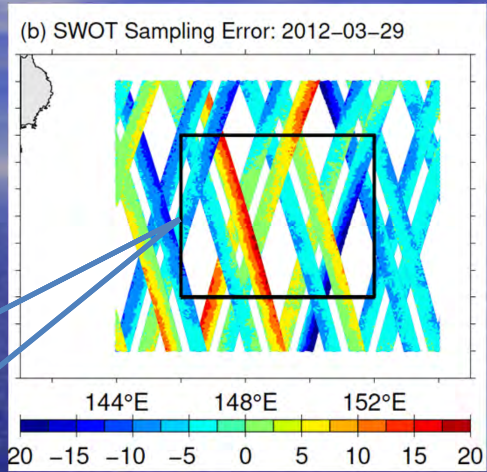
Conventional altimetry
(Dufau et al. 2016)

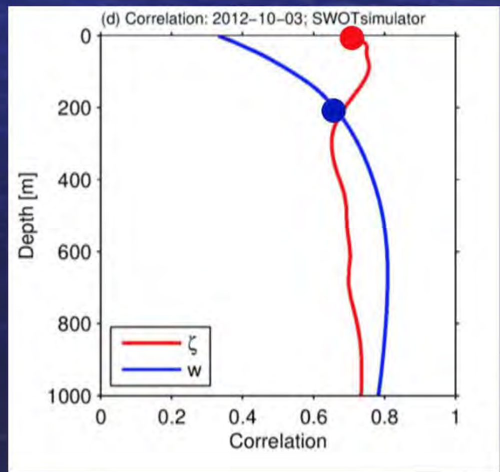


Surface Vorticity and Vertical Velocity

A Grand Challenge for Ocean Remote Sensing

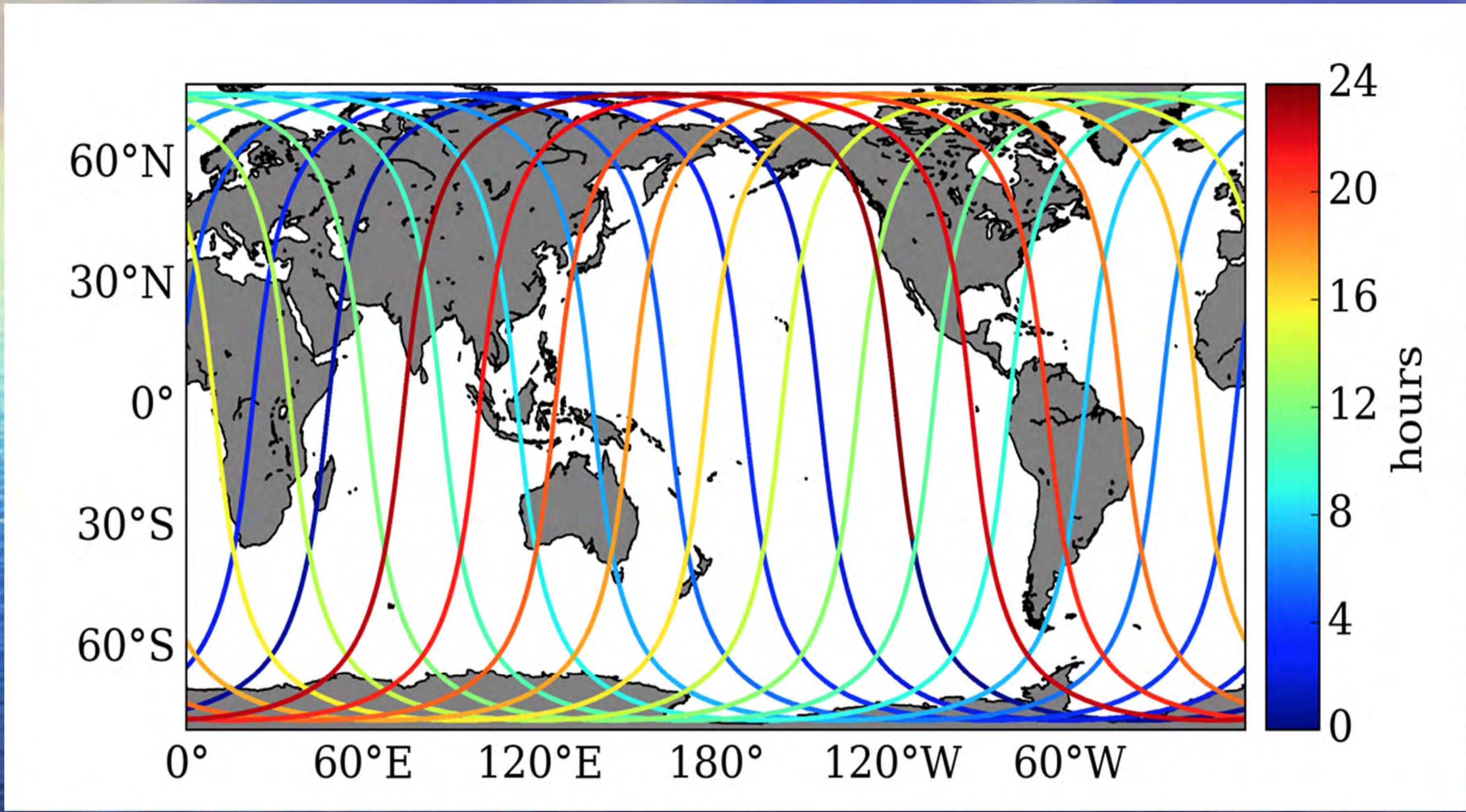






(Qiu et al, 2019, in revision)

1-day repeat orbit for the initial fast sampling phase (90 days)
2 overflights /day at the crossover points

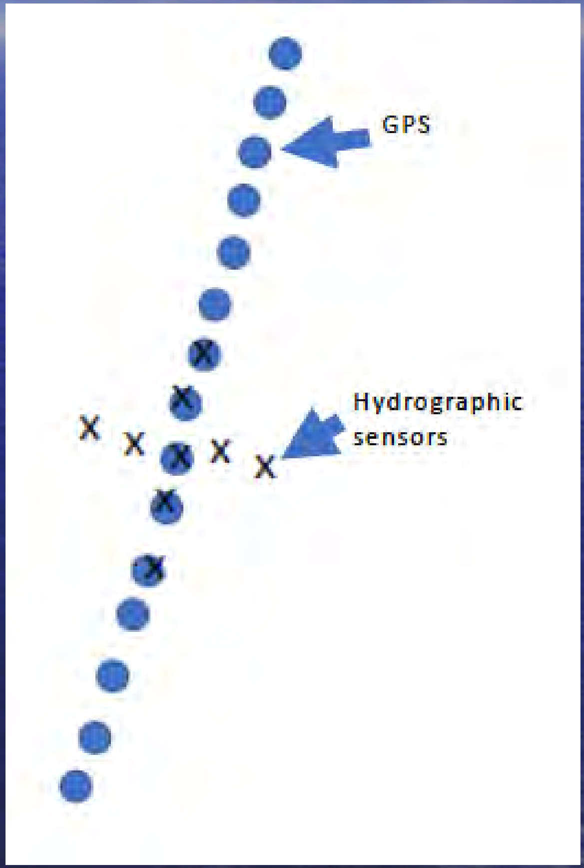


An initiative of adopt a crossover by the international community

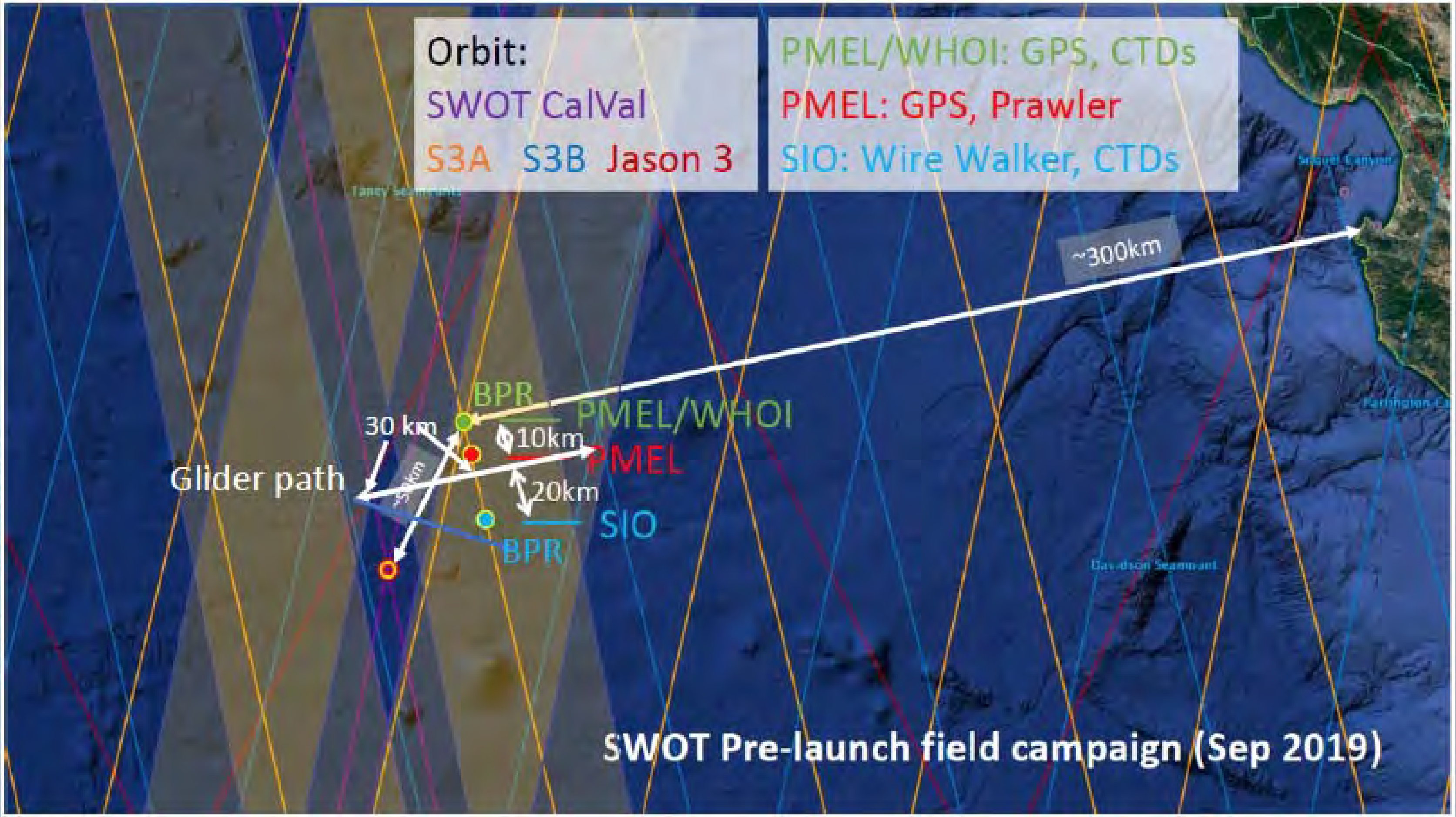
Meeting the challenges of CalVal with an in-situ observing system

A strawman design for post-launch CalVal (pending on the findings from the pre-launch campaign):

1. Geodetic component: An along-track array of GPS buoys for SSH validation
   The minimum length of the GPS array needs to be ~ 120 km, according to a modeling study of the long-wavelength calval by the SWOT nadir altimeter.
2. Oceanographic component: A two-dimensional array of hydrographic sensors (gliders, moored wire walkers/CTDs, etc.) for oceanographic understanding and validation.

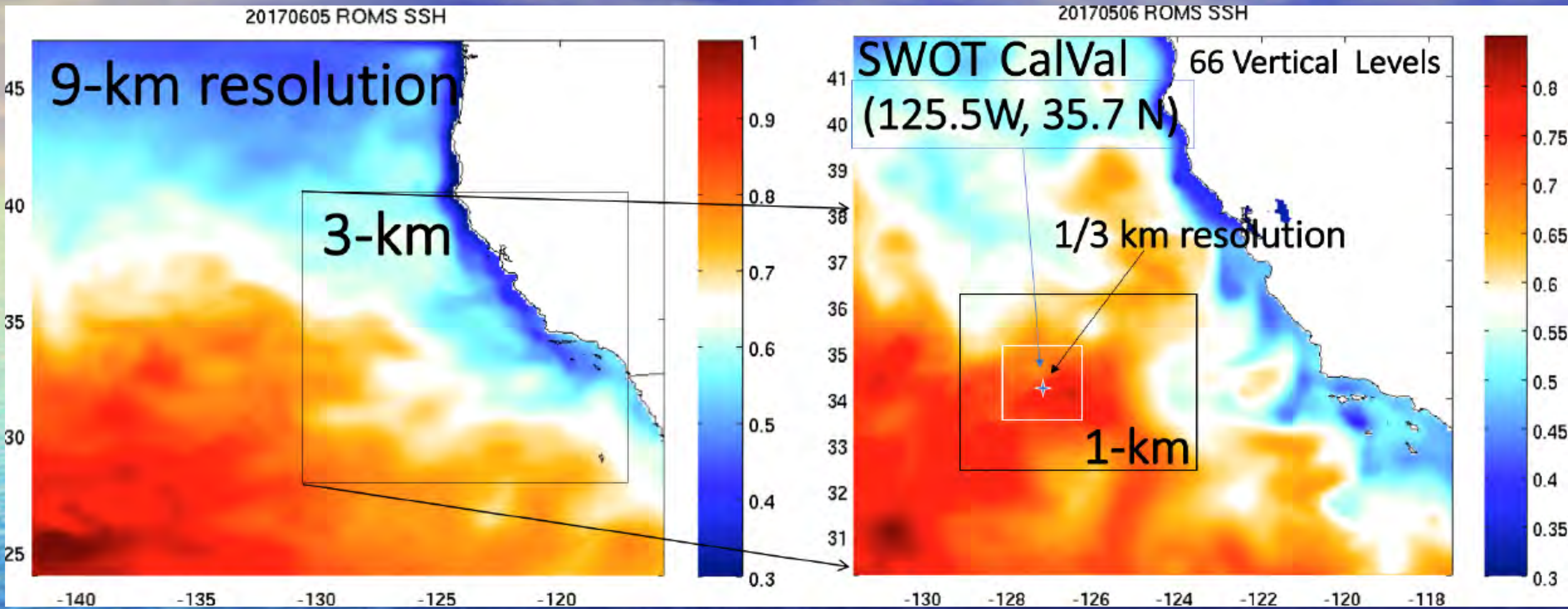


Toward designing the post-launch CalVal: a pre-launch experiment



Evaluate the reconstruction of the upper ocean circulation

Provide information for the design of the post-launch in-situ observing system.

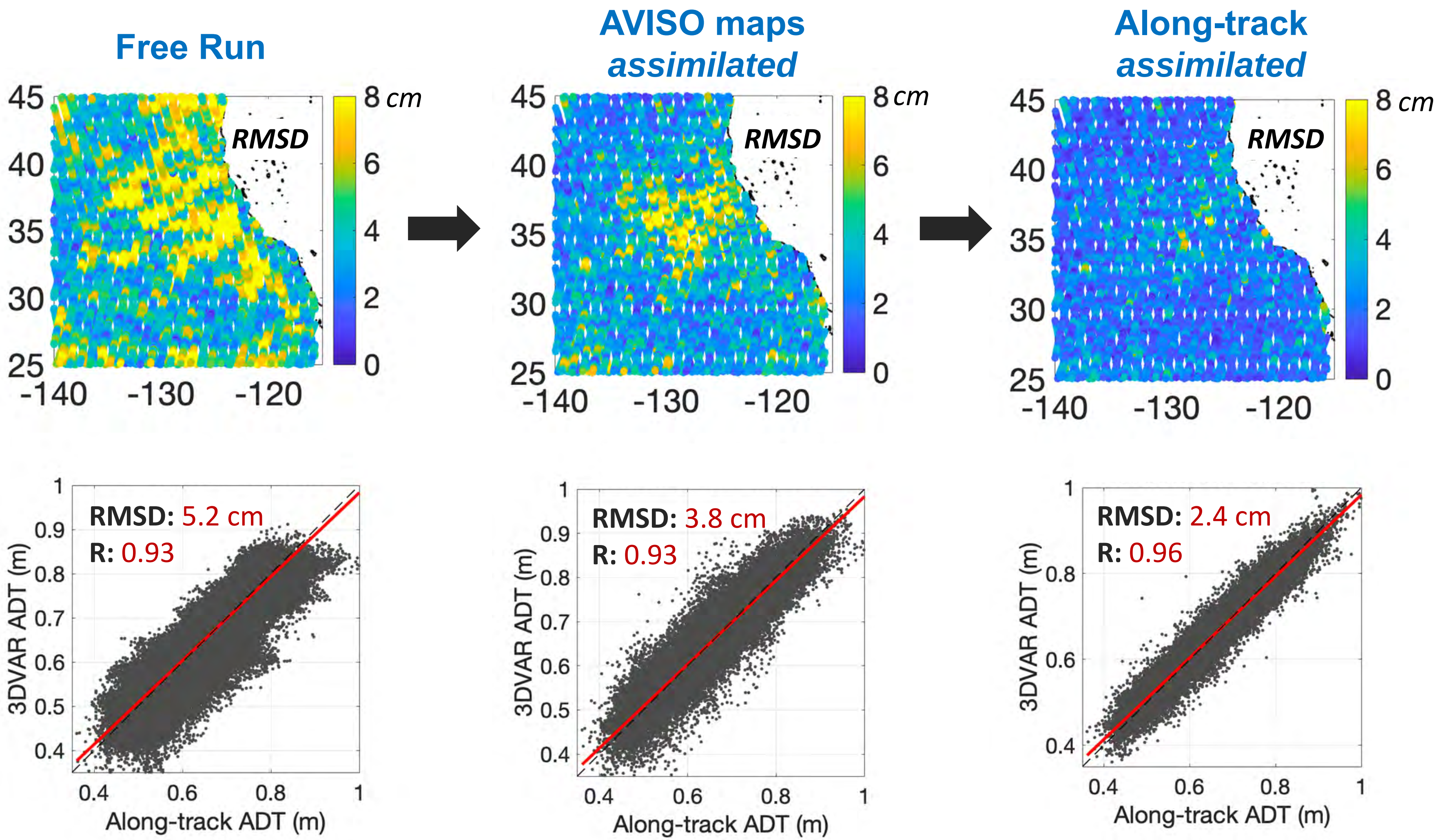


Data assimilation

- Assimilate all SSH data from the present altimetry constellation.
- Assimilate other available routine observations (SST, SSS, and Argo).
- Evaluate the difference with and without assimilation of the in-situ observations.
- Assessment of the reconstruction of the upper ocean circulation. Comparison with the withheld glider data, and any other available high-resolution data.

Preliminary evaluation of the data assimilation system

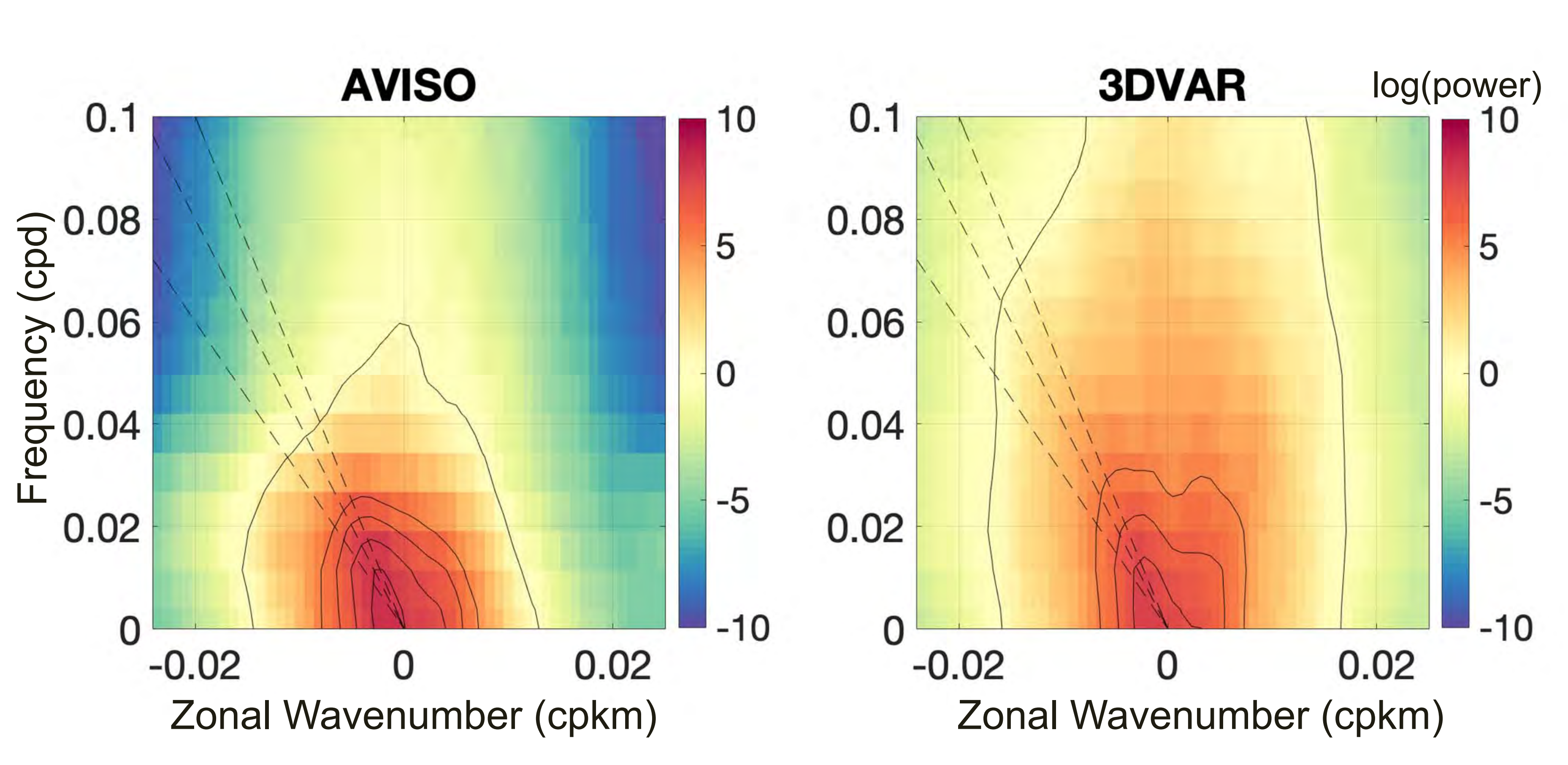
Comparison to filtered along-track data



Contributions of Z. Li and M. Archer

Preliminary evaluation of the data assimilation system

Frequency-wavenumber spectrum



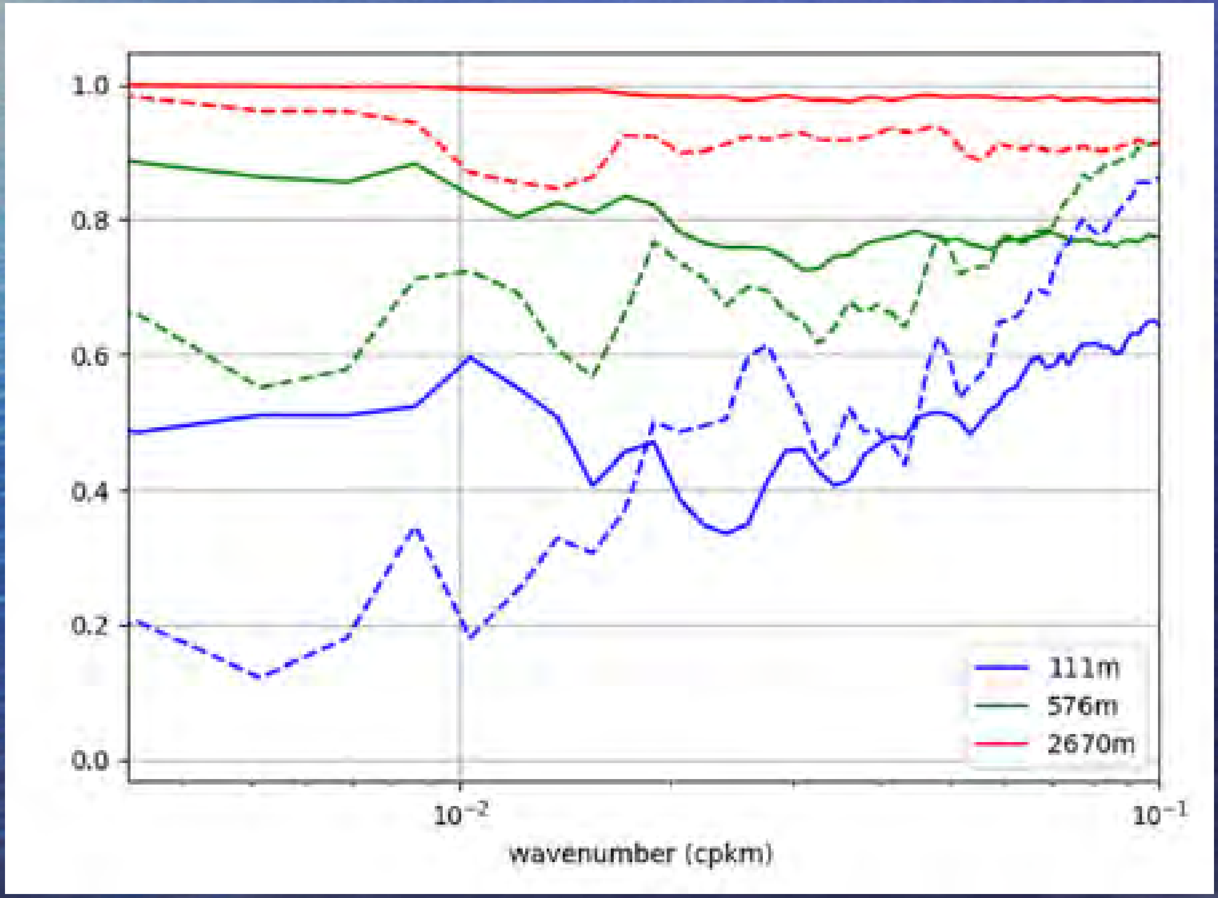
Contributions of Z. Li and M. Archer

Concluding Remarks

- A fundamental challenge of SWOT is insufficient temporal sampling.
- Oceanographic validation and understanding will require thoughtfully designed in-situ observing systems.
- The twice-per-day sampling at crossovers during the fast sampling phase will provide the best opportunities for oceanographic validation.
- SWOT Project will deploy an in-situ observing system at the California calval site.
- A prelaunch campaign has been conducted since September 2019 at the California site to collect data for the design of the post-launch observing system.
- Data assimilative modeling is important for the ocean calval efforts and overall utilization of SWOT data.

#3. Evaluate the vertical scale of the upper ocean circulation that can be determined by SSH at the SWOT scales for different frequency bands.

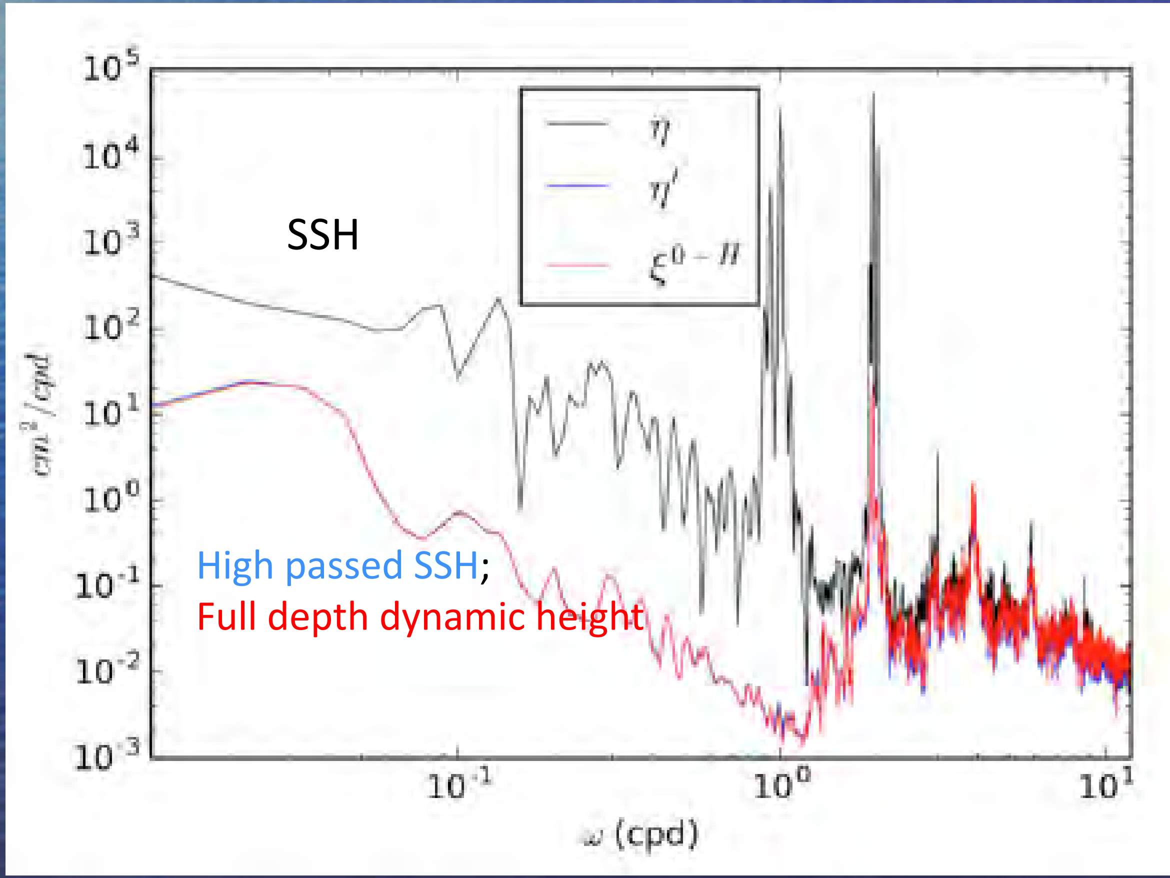
Previous OSSE studies suggest that the upper ocean accounts for ~80% of the SSH variance.



Wang et al, 2018

#4. Evaluate the roles of bottom pressure in SWOT SSH signals.

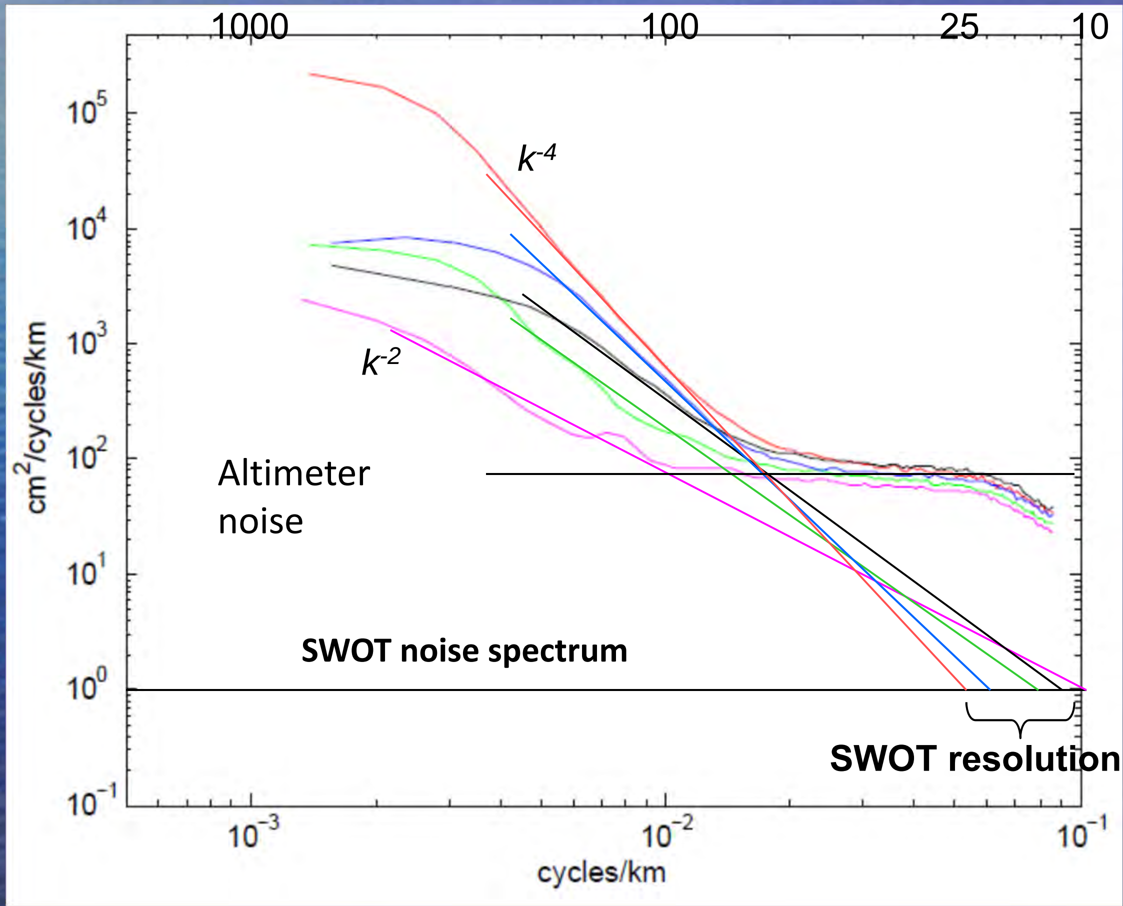
- The previous OSSE studies suggest that SSH at wavelengths less than 150 km is dominated by dynamic height, with little contributions from bottom pressure.
- By placing the two BPRs ~30 km will evaluate the bottom pressure signals at the SWOT scales.



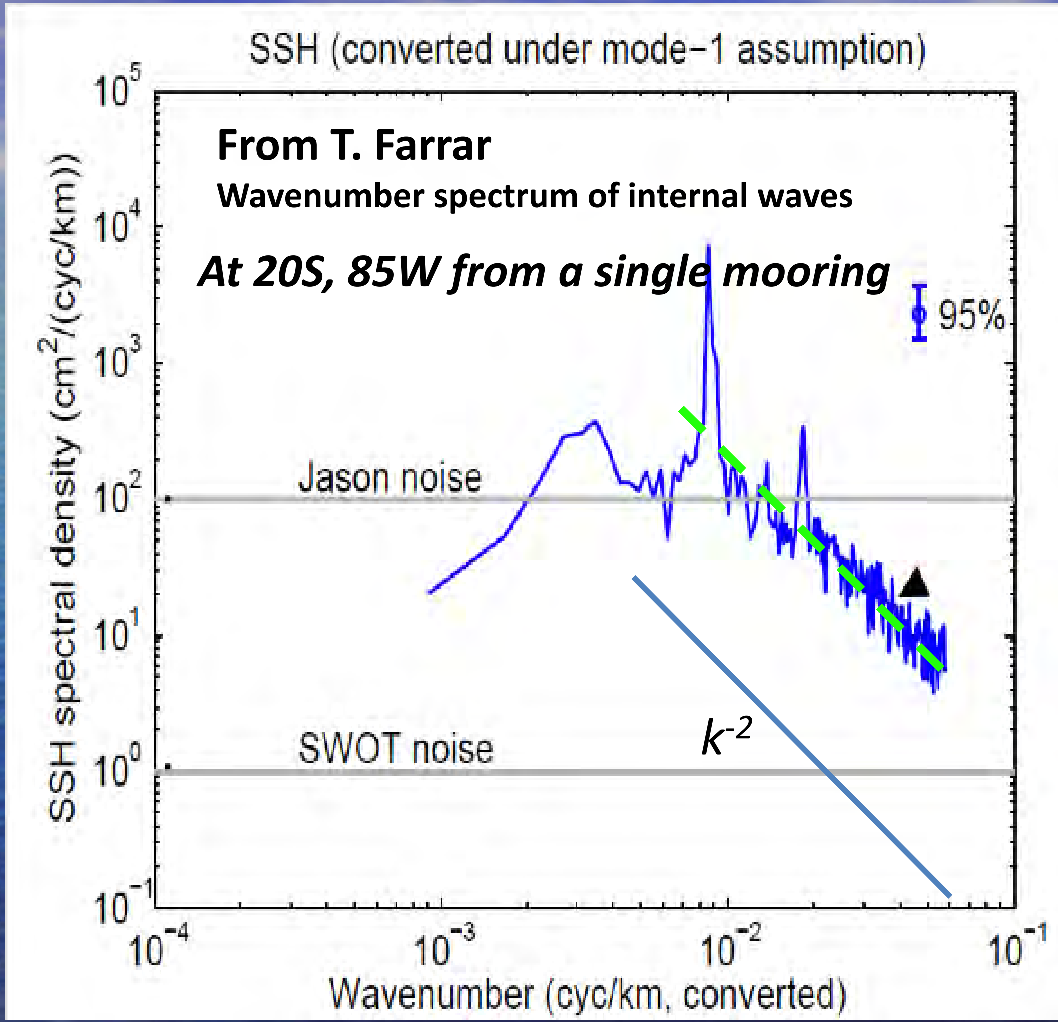
Wang et al, 2018

#2. Test the sampling of the scales of SSH variability not resolved by conventional altimeters such as Sentinel 3A (S3A).

SSH wavenumber spectra



Challenge #2: Dealing with Internal tides and internal waves



Need to confirm the spectral density level using a true wavenumber spectrum