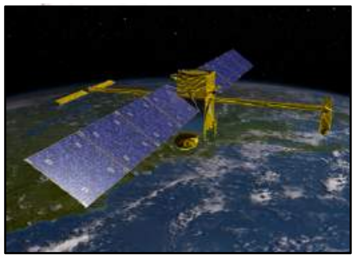

The application of the LLC4320 in the SWOT prelaunch activities

Jinbo Wang, Lee-Lueng Fu
Jet Propulsion Laboratory
ECCO workshop @ Caltech
11/07/2017

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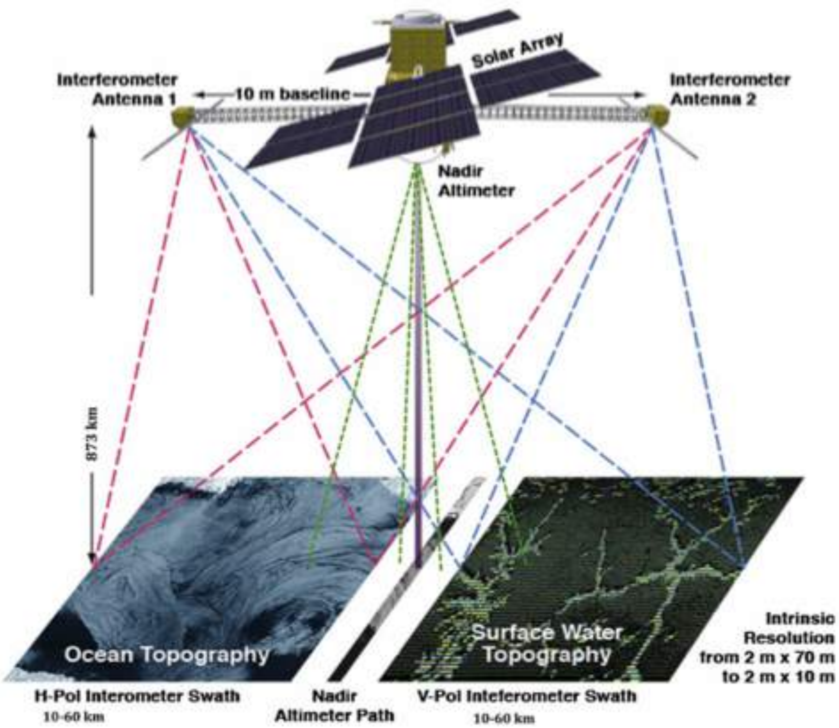
Outline

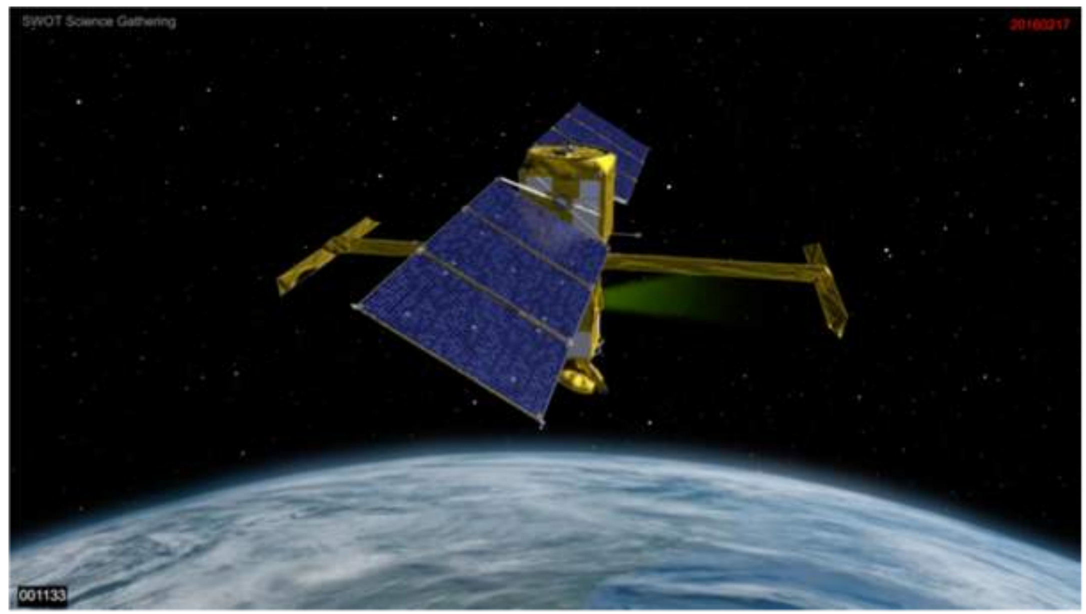
1. Introduction to SWOT
2. Understand the advancements and face the challenges
3. Use LLC4320 in SWOT-related work at JPL, one example

What is SWOT? Surface Water and Ocean Topography

NASA+CNES+CSA



2D swath spans 120km-wide with a 20km gap in the middle.



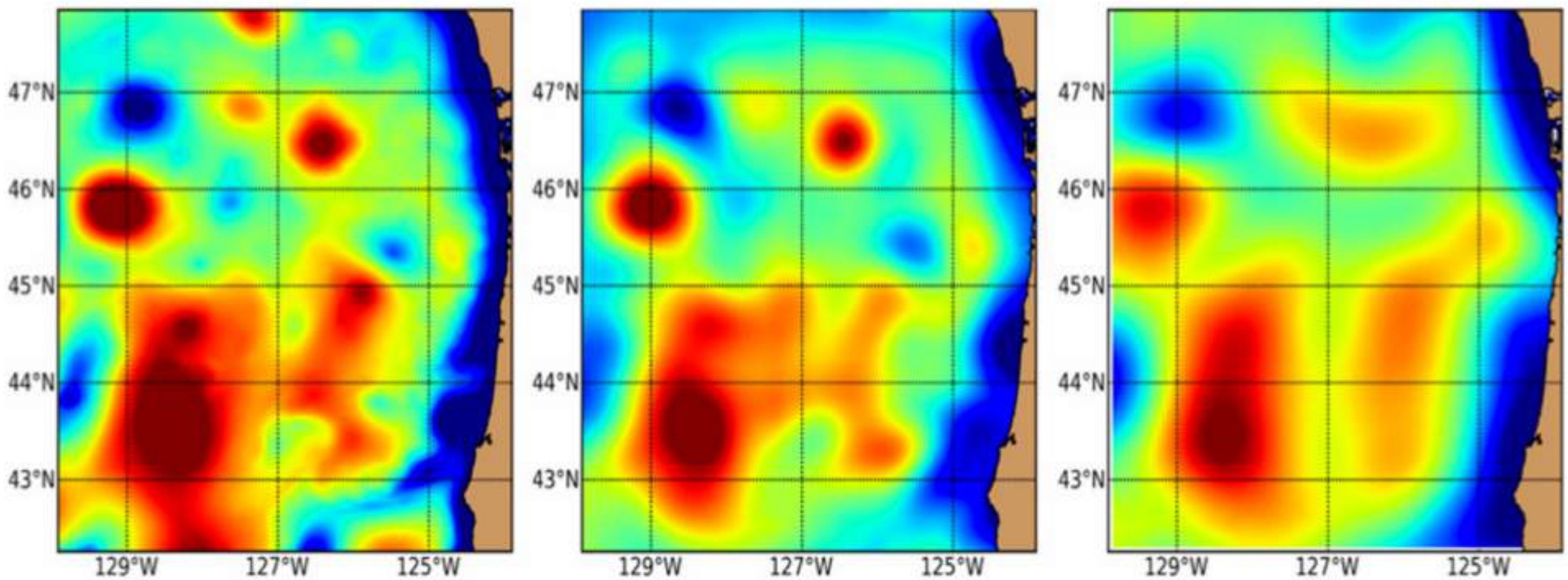
2x2 km resolution

21-day repeat cycle

Due to launch in 2021

SWOT advancement: high resolution 2D SSH map

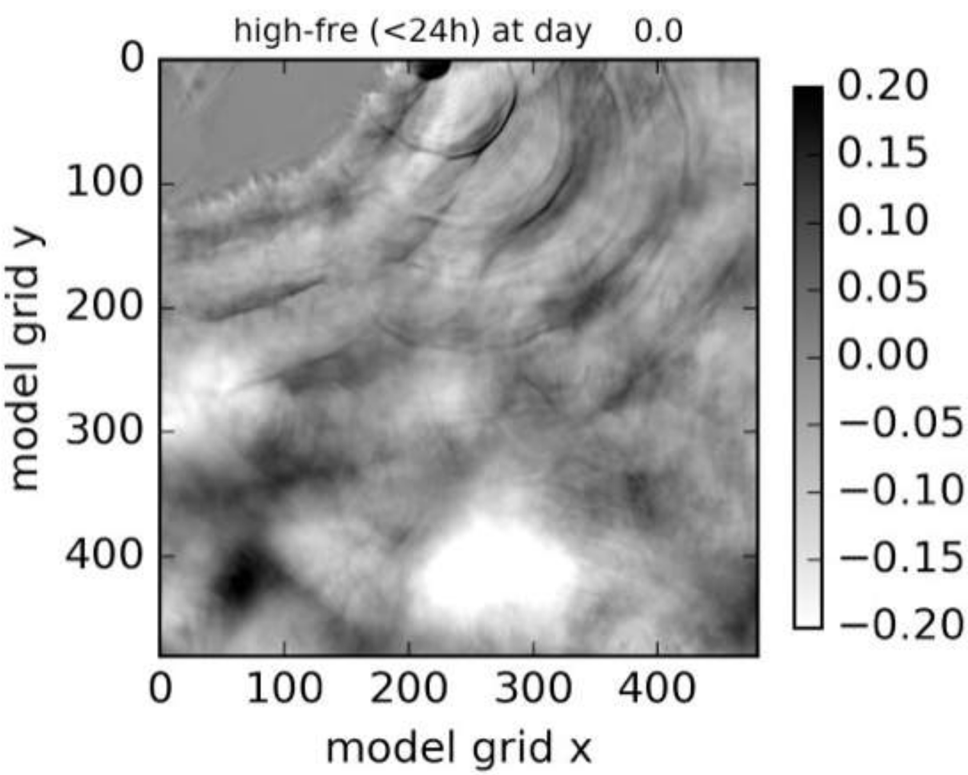
- resolving ocean eddies with an unprecedented level of details. However …



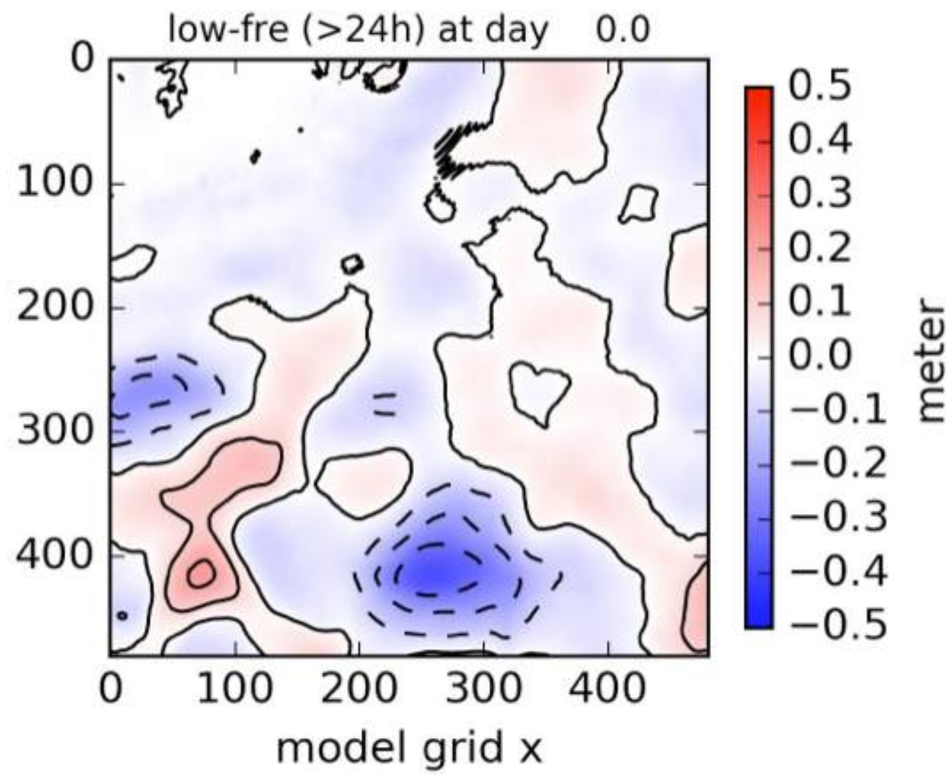
(a) Truth (b) Mapped SWOT (c) Mapped nadir

Gaultier et al. (2016)

… high frequency internal waves entangle in meso- and submeso-scale eddies …



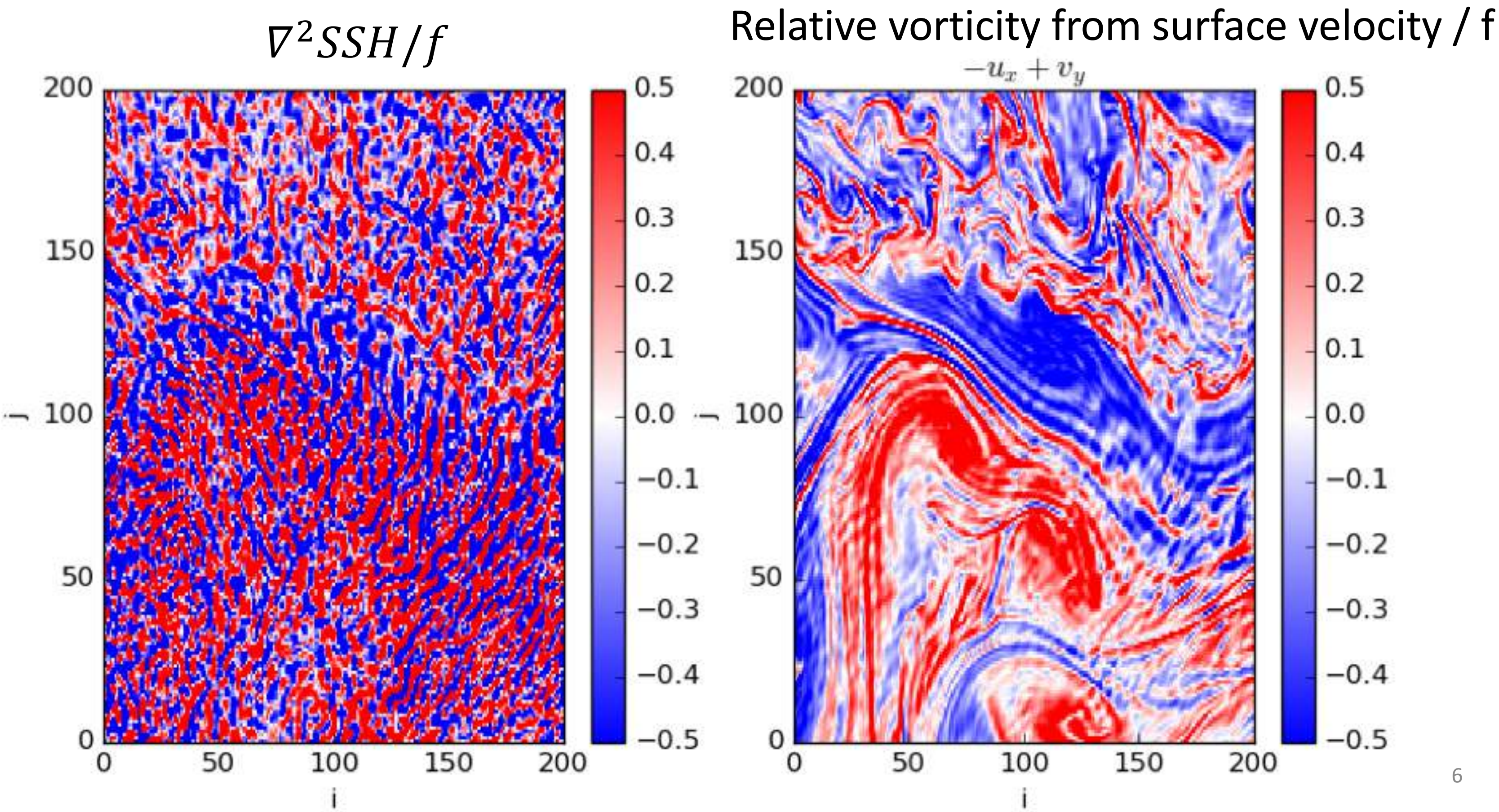
Super-inertial



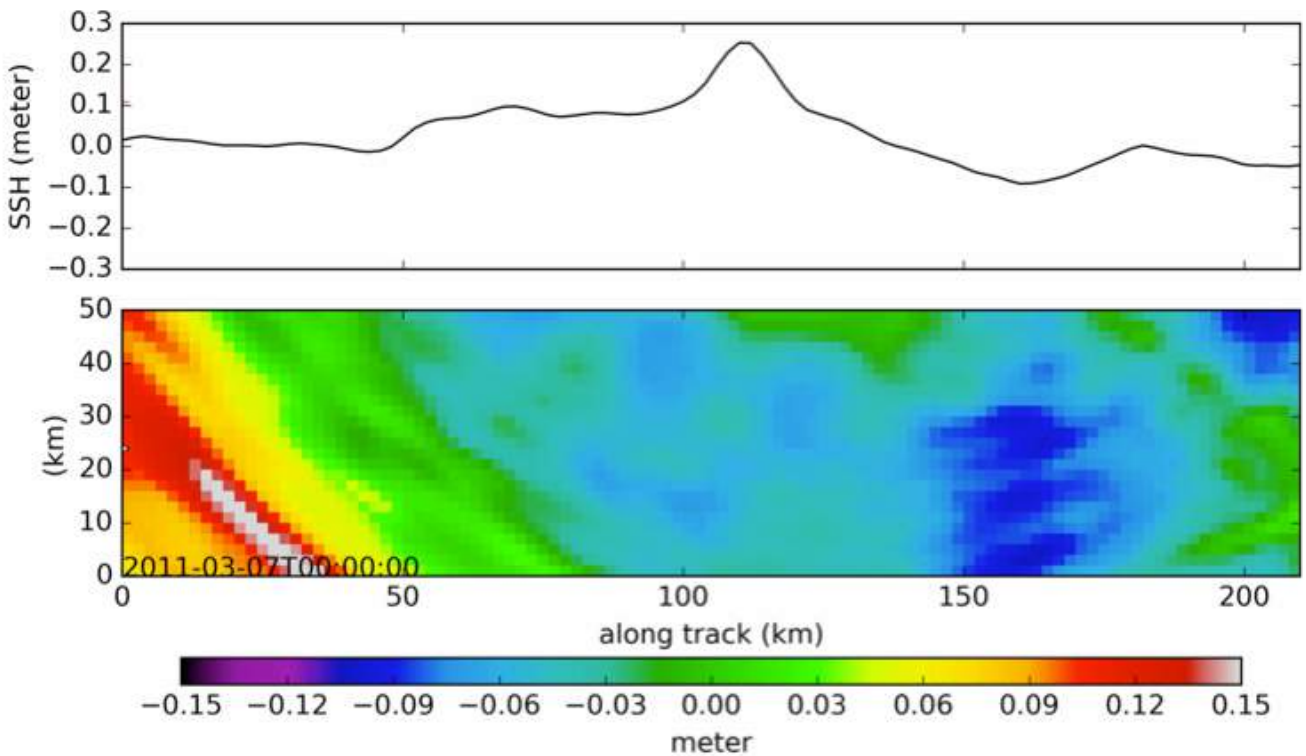
Sub-inertial

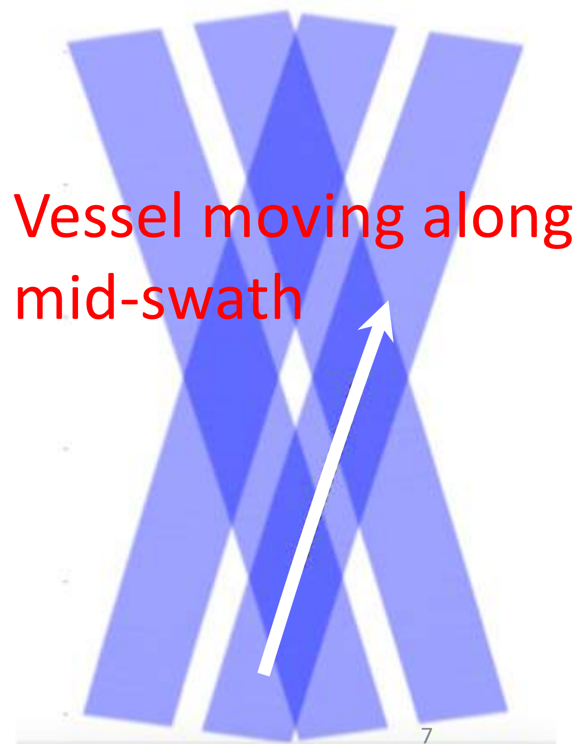
Based on LLC4320

… causing difficulty in interpreting SWOT SSH.



Also cause difficulty in in-situ Calibration/Validation (CalVal): one R/V is too slow to capture a synoptic SSH field over 100-150km distance





Summary

- SWOT is designed to resolve ocean topography with an unprecedented high horizontal resolution.
- But we are facing great challenges in
    1. separating wave-induced and eddy-induced SSH components for scientific applications.
    2. capturing synoptic ground truth SSH using in-situ instruments for the CalVal purpose

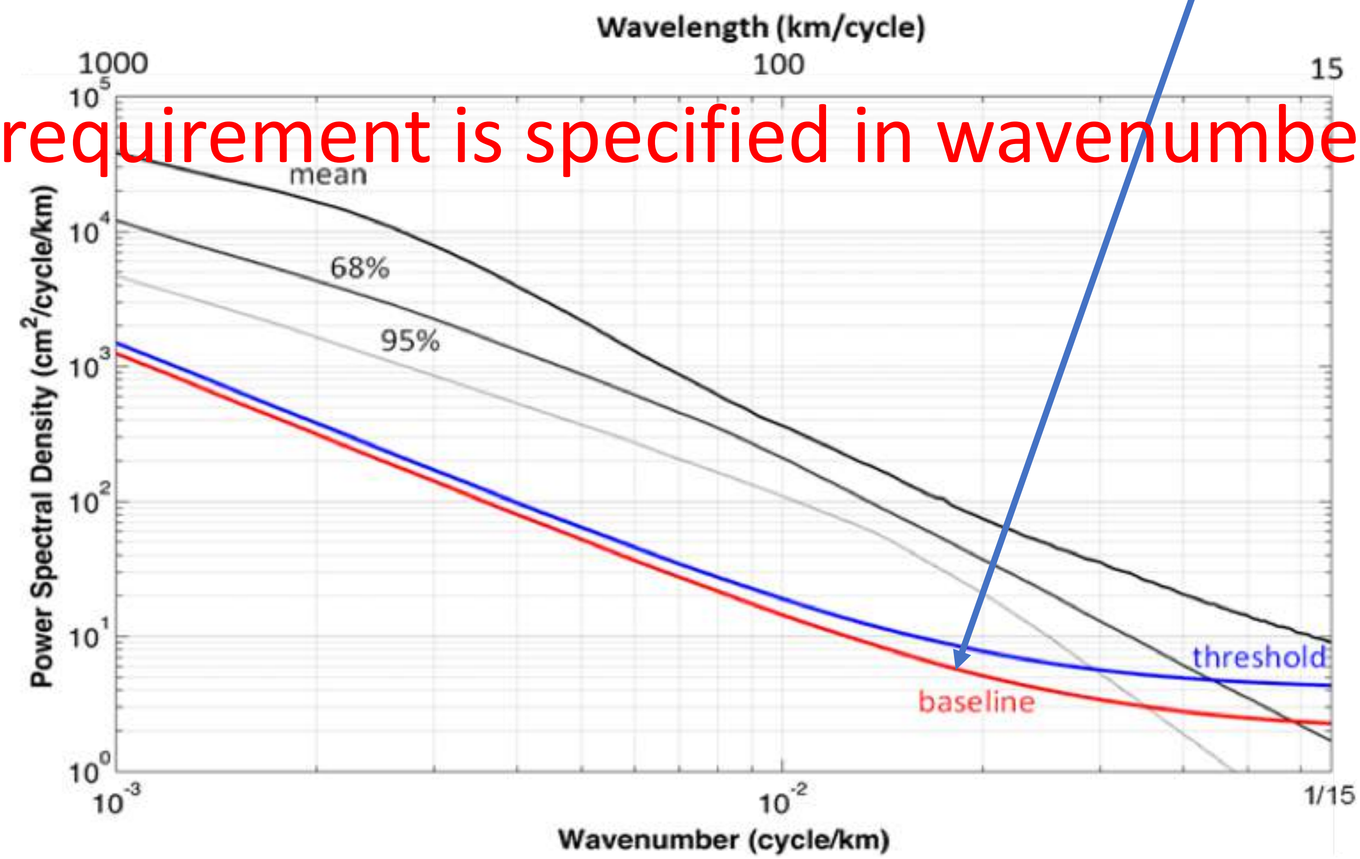
Facing the challenges

1. Separating wave-induced and eddy-induced SSH components for future scientific applications.
2. Capturing synoptic SSH field using in-situ instruments for the SWOT CalVal purpose. How? (the rest of this presentation)
3. Also see Zhijin's poster (a data assimilation approach).

What is SWOT CalVal?

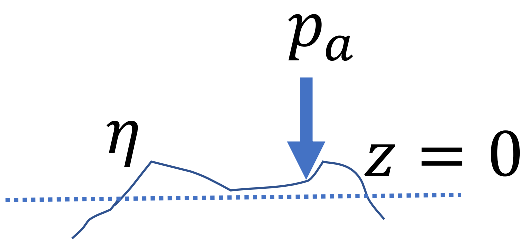
The ground truth should have errors (satellite – ground truth) smaller than baseline requirement (red line)

The requirement is specified in wavenumber space.



Reconstruct SSH using in-situ measurements (based on hydrostatic approximation)

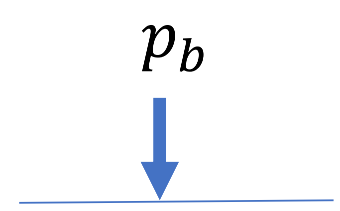
1. Barotropic component measured by bottom pressure
2. Steric component measured by density profile
3. Inverted-Barometer effect by atmospheric pressure



$$p = \rho g z$$

$$\eta = \frac{p'_b}{\rho_o g} - \frac{p_a}{\rho_o g} - \int_{-H}^{0} \frac{\rho'}{\rho_o} dz,$$

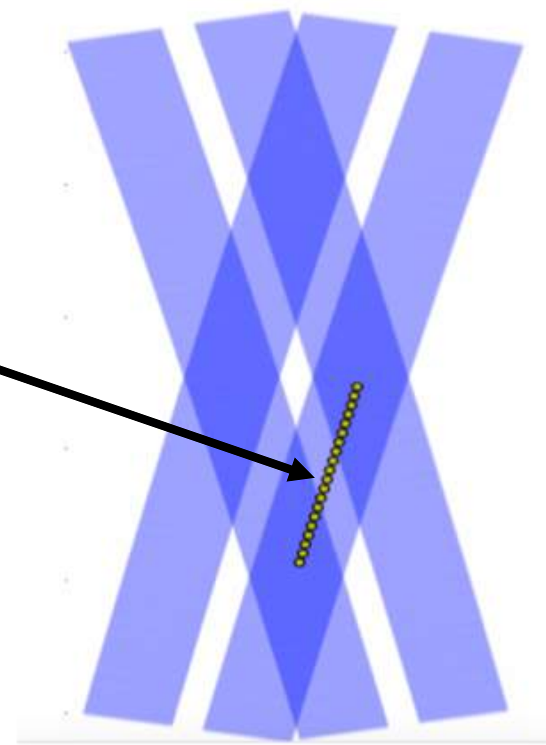
Bottom pressure Barotropic component	Atmosphere loading	Steric height Baroclinic component



Baseline design

Resolving 15-150km wavelengths:

20 locations, 7.5km apart



η_i i=1, 20 True SSH without measurement errors

ξ_i Steric height

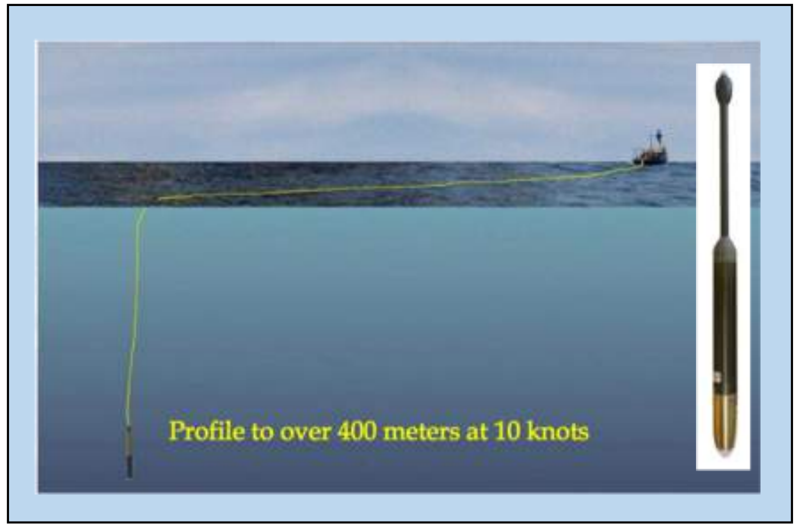
$\eta_i - \xi_i$ Reconstruction error:

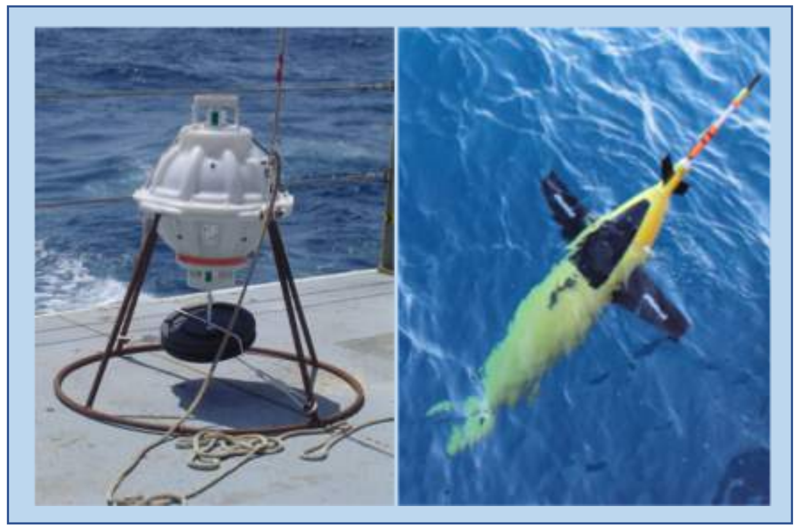
Compare the spectrum of $\eta_i - \xi_i$ to the baseline requirement

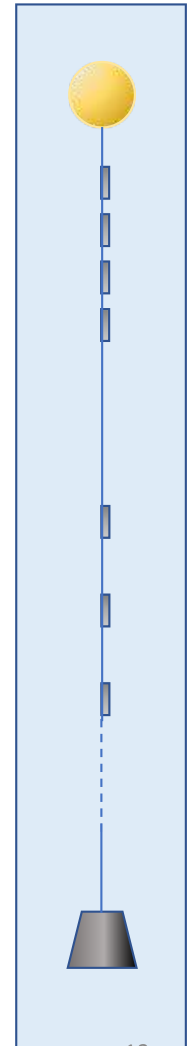
An OSSE using the LLC4320 as the nature

Tested four instruments

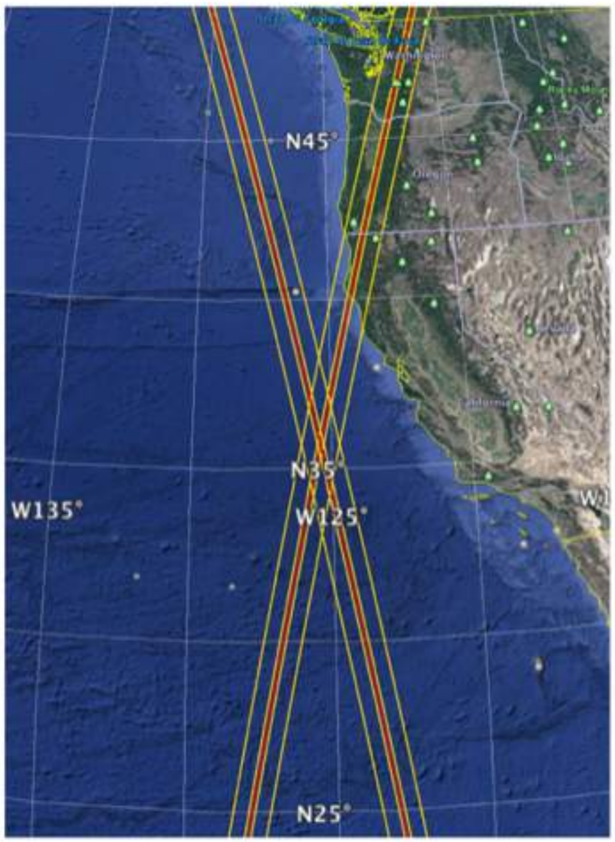
- UCTD (Under-way CTD)
  - Fast upper ocean T/S sampling
  - Compact and portable
  - Needs ship time
  - Finite boat speed
- PIES (Pressure, Inverted Echo Sounder)
  - High frequency sampling
  - Low cost
  - Long duration, easier for logistics
  - Not enough accuracy
- Mooring
  - High frequency sampling
  - Long duration
  - Single point measurement
  - High cost, needs ship time of large-RVs
- Glider
  - Low cost, easy logistics
  - Real-time data transfer
  - Semi-Lagrangian

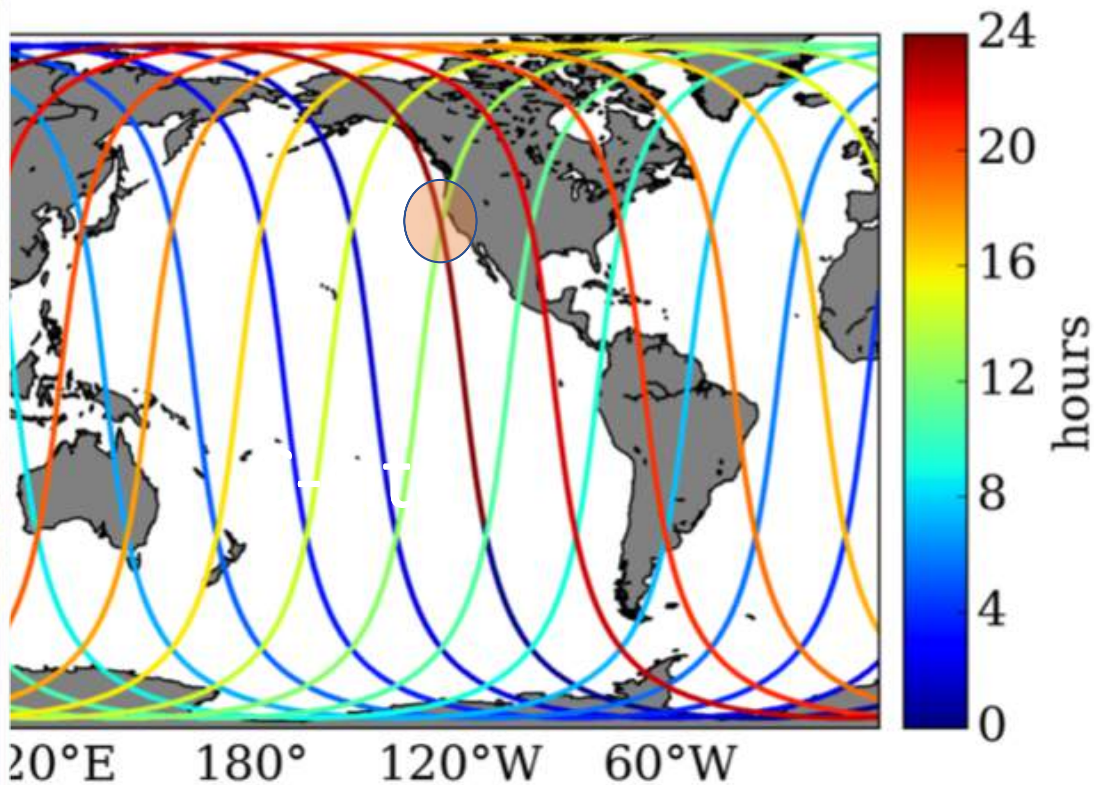






CalVal [Cycle: 1 day; duration: 90 days] most likely in the California current

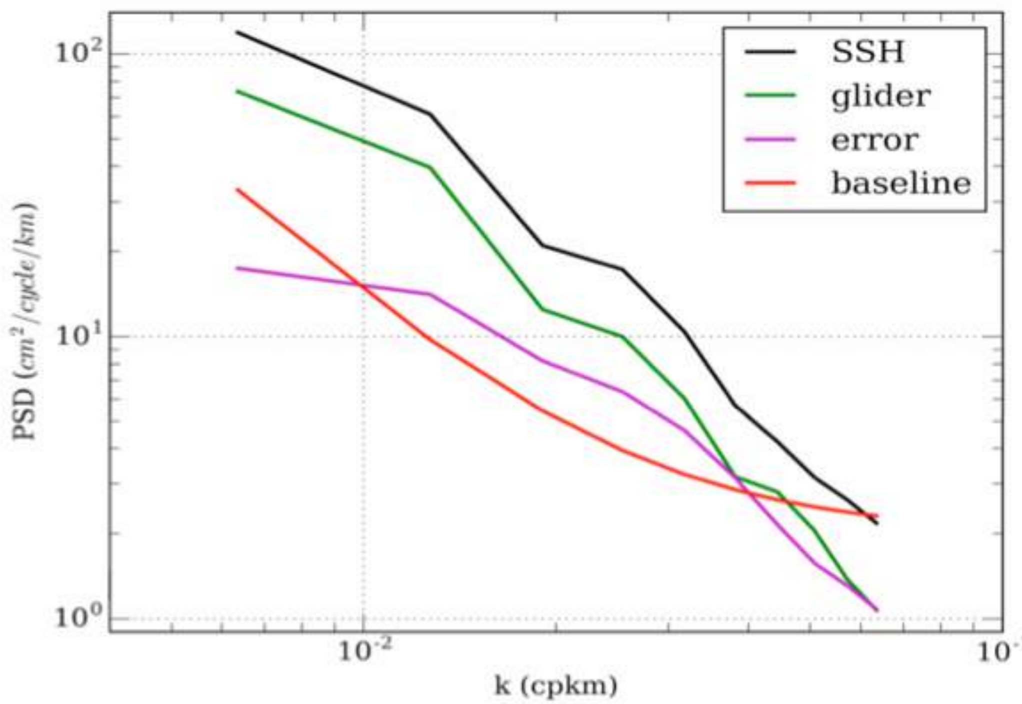




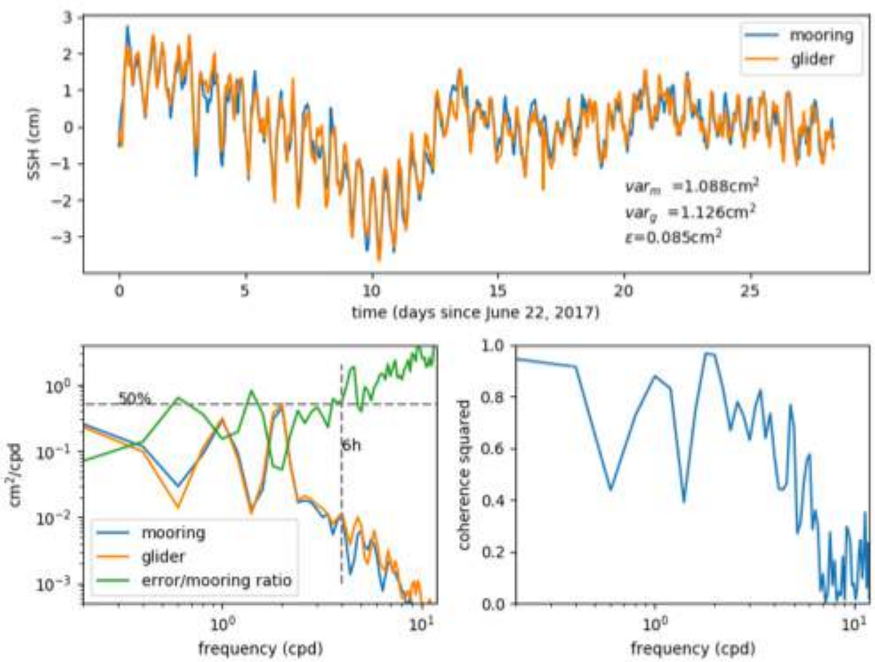
PIES👎, UCTD👎, Mooring👍, Glider 🤞

- PIES does not have enough accuracy (~5cm uncertainties)
- Single-boat-UCTD is too slow to capture the synoptic SSH
- Moorings with enough CTDs are robust
- Gliders yield an error that is a factor of 2 larger than requirement.

Glider results



Results led to the first real ocean experiment



Glider matches mooring down to 6 hours.

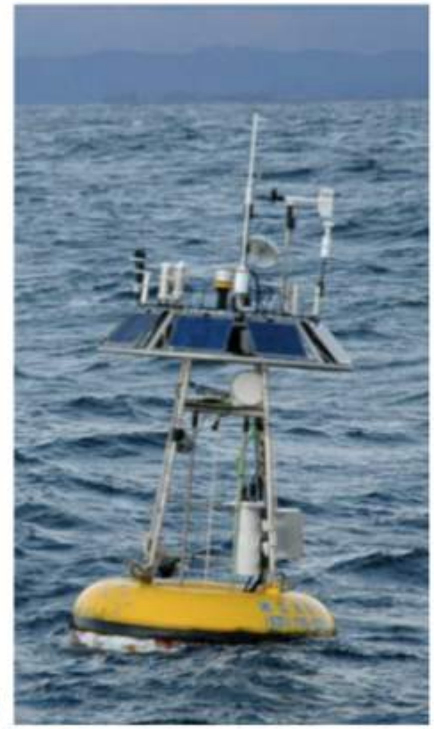
Monterey Bay June-September 2017

Primary objective:

– To test the capability of gliders to retrieve the upper ocean dynamic height time series derived from the M1 mooring covering the upper 300 m of the water column (11 CTDs)

Secondary objective:

– To make simultaneous measurement of the SSH via a GPS buoy and the bottom pressure via a bottom-pressure recorder



M1 mooring operations since 1990

Summary and perspectives

1. LLC4320 plays an important role in the SWOT prelaunch activities. The results have direct influence on the decision making. We will continue to use it.
2. Need more vetting by comparing to observations to gain more confidence in the existing and future results.
3. Two more years' simulation? It will help tidal analyses on the synthetic SWOT measurements.