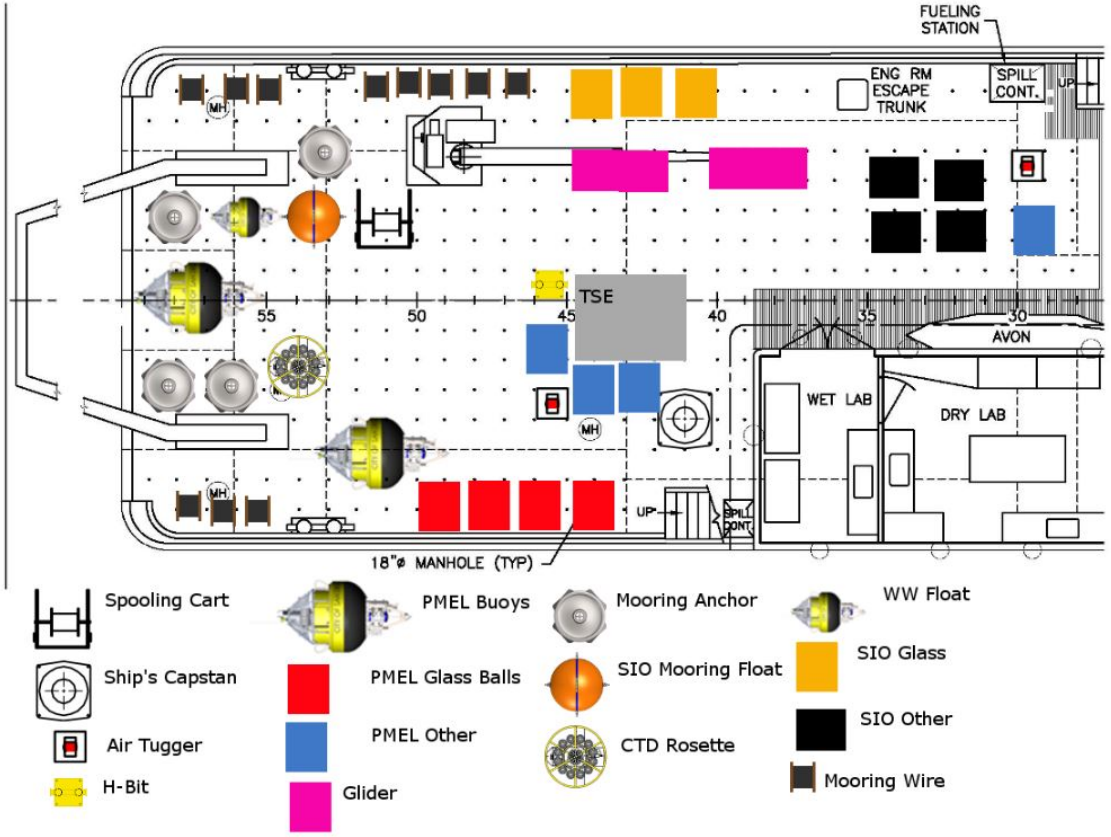
California Pre-Launch Campaign deployment booked

September 3-8 on SIO ship "R. G. Sproul"

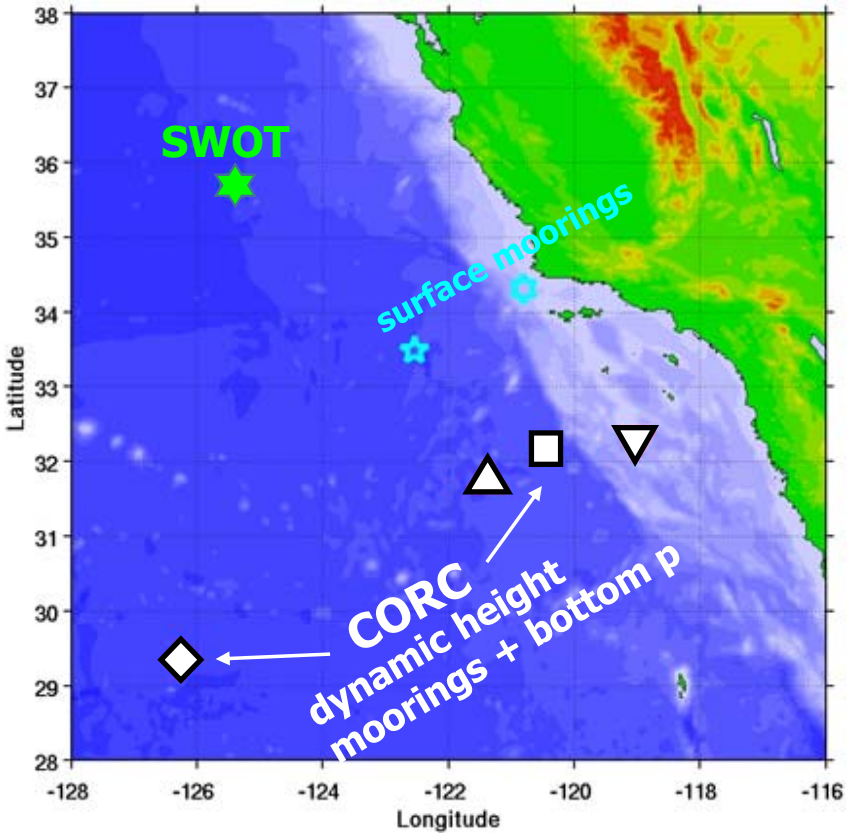
SWOT Mooring Operations Cruise
by Paul Chua



Hybrid CTD-Wirewalker mooring for SWOT cal/val

Send lab with Lucas & Pinkel lab

Scripps Institution of Oceanography



geodetic and oceanographic !

Goal: Use in-situ measurements of dynamic height from moorings to determine SSH…

← integrate specific volume anomaly (from density) vertically, relative to a bottom pressure reference.

Multiple years of mooring data from same oceanographic regime which allow simulation of many of the signals and measurement accuracies (NOAA project "CORC")

How deep do we need to measure to infer surface dynamic height ?

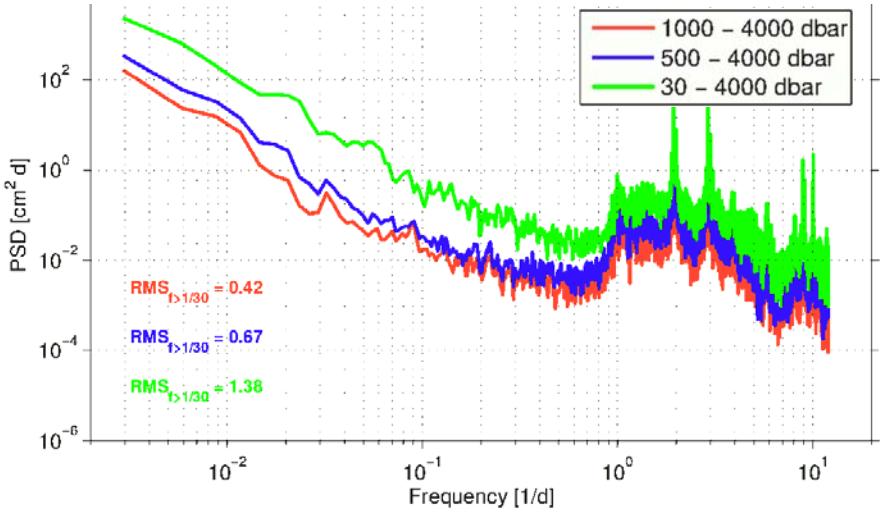
Analyzing periods < 1month (target for SWOT cal/val) from existing CORC data:

single point

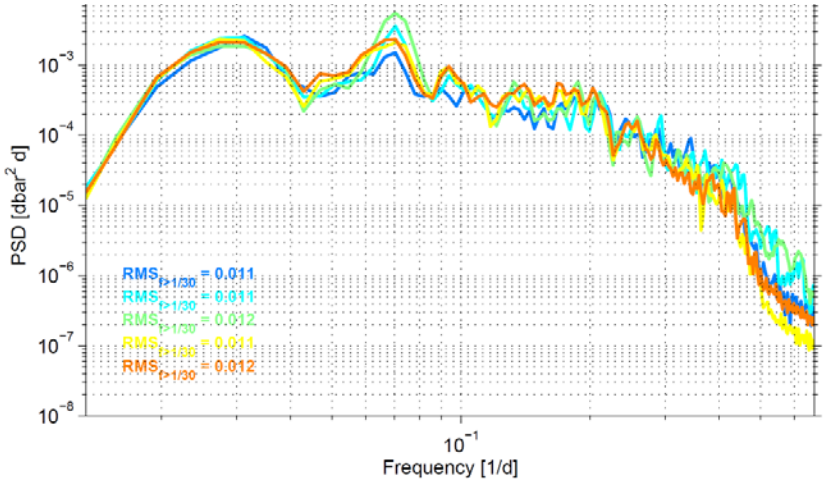
Dynamic height variability at a single-point:
→ 1.4cm rms for full water column
→ **0.4cm rms <u>below 1000m</u>**

Bottom-pressure variability at a single point:
→ 1cm rms without tides
→ 40cm with tides

Dynamic height spectra from CORC moorings



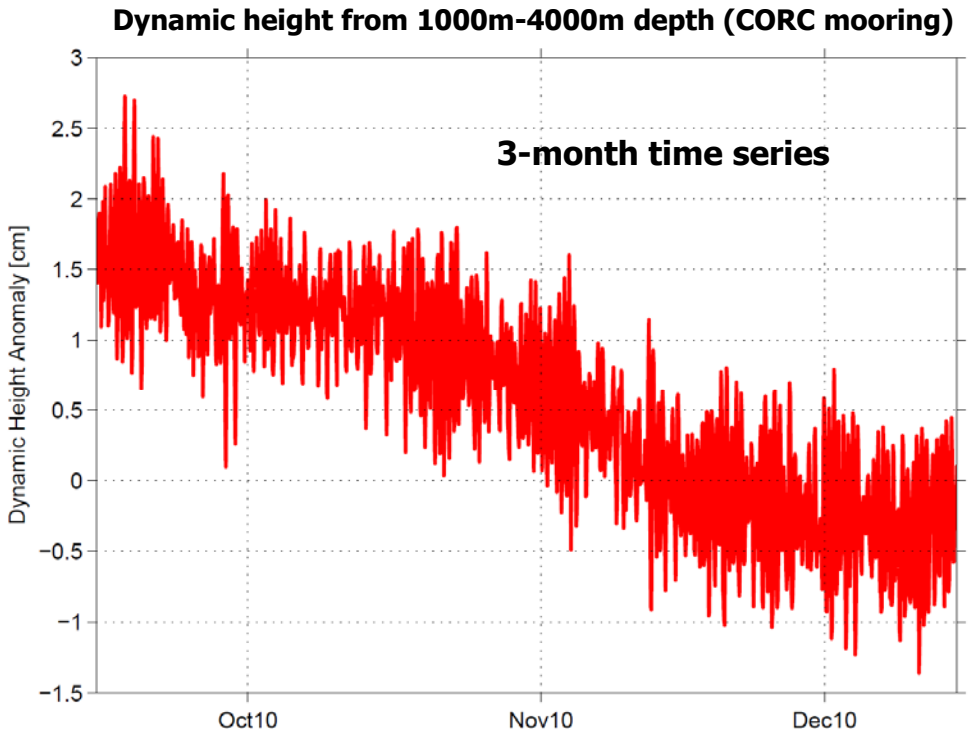
Bottom-pressure spectra from 5 CORC PIES (detided)



How deep do we need to measure ?

Dynamic height below 1000m also has large signals on 1-3 month time scales (several cm).

In order to extract variability/spectra < 1month and validate SWOT, need to know and remove this longer variability (since time series are too short).

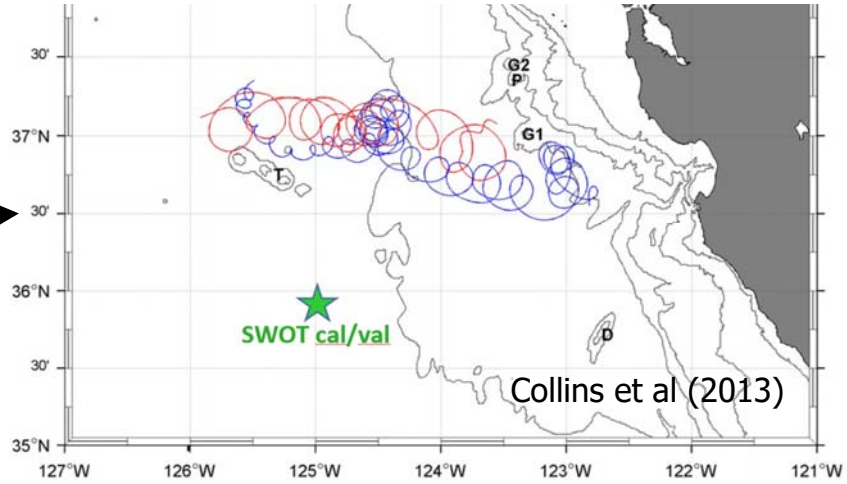


Essential for SWOT cal/val to measure ocean below 1000m and bottom pressure (if these signals are present on the SWOT horizontal scales)

Horizontal scales of SSH signal from the deep ocean:

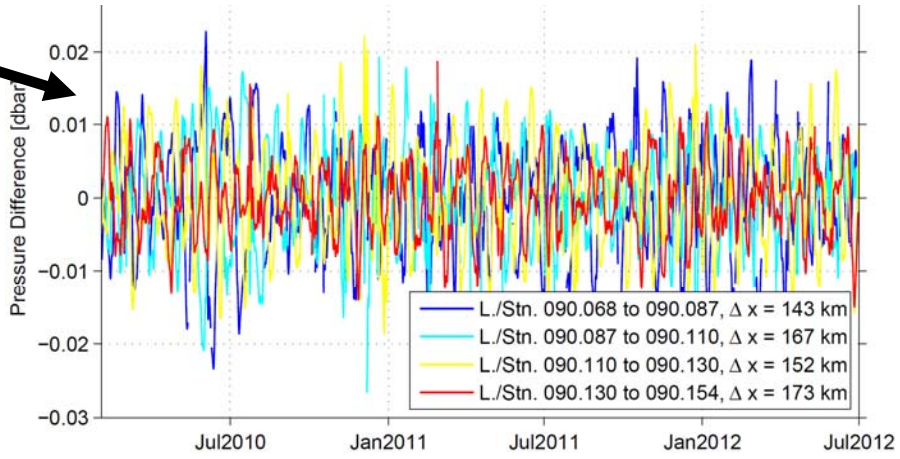
Directly observed deep float trajectories in the SWOT region show dynamic height gradients of 1.5-5cm over scales of 30-60km, **below 1000m** (changes occurring over 2-4weeks)

Deep float trajectories (directly observed)



CORC bottom pressure gradients over 140km seperation show changes of 2cm over 1 week, **0.7cm rms** at periods < 1month

CORC bottom pressure differences (detided)



suggests that ocean below 1000m needs to be observed for SWOT cal/val

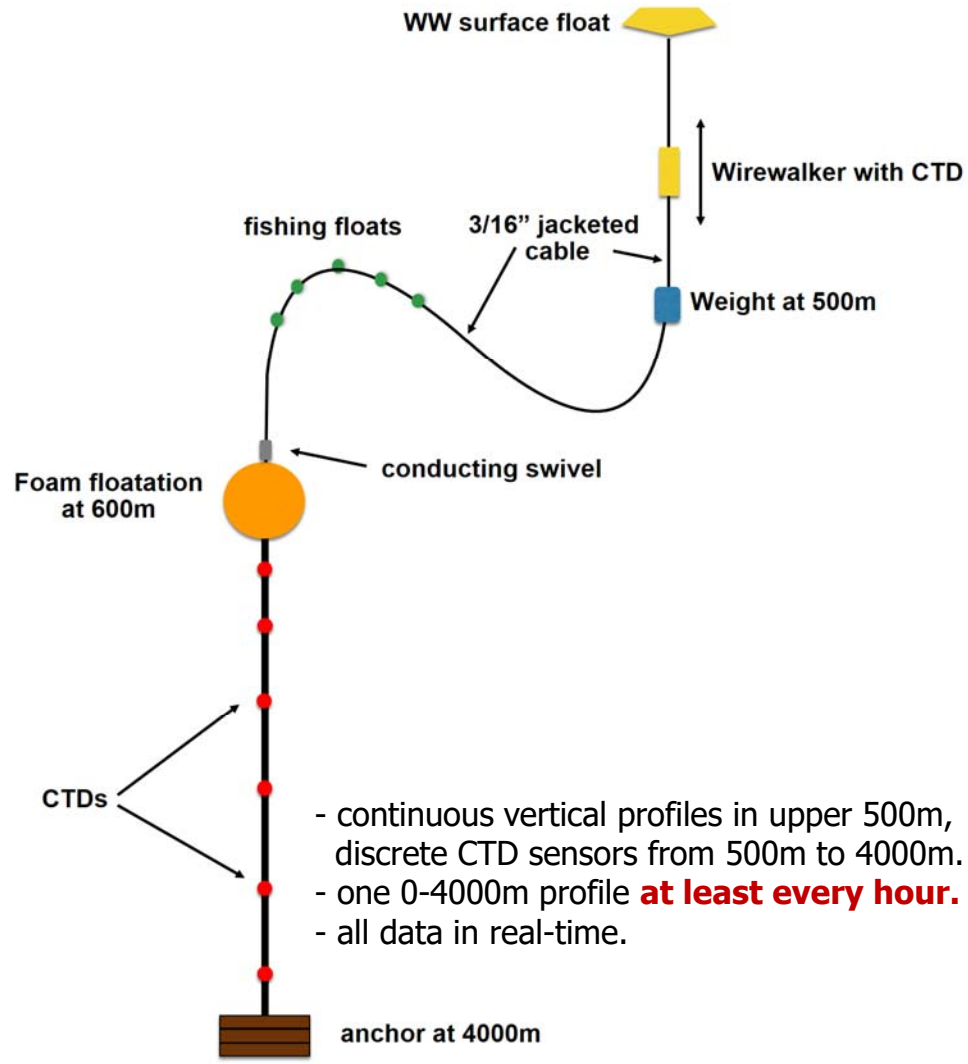
California pre-launch campaign in 2019 will measure

- full water column (i.e. below 1000m)

- bottom pressure

- full-depth dynamic height (and bottom) pressure at two locations

SIO mooring design for SWOT cal/val (used at one of the dynamic height sites)



- continuous vertical profiles in upper 500m, discrete CTD sensors from 500m to 4000m.
- one 0-4000m profile **at least every hour.**
- all data in real-time.

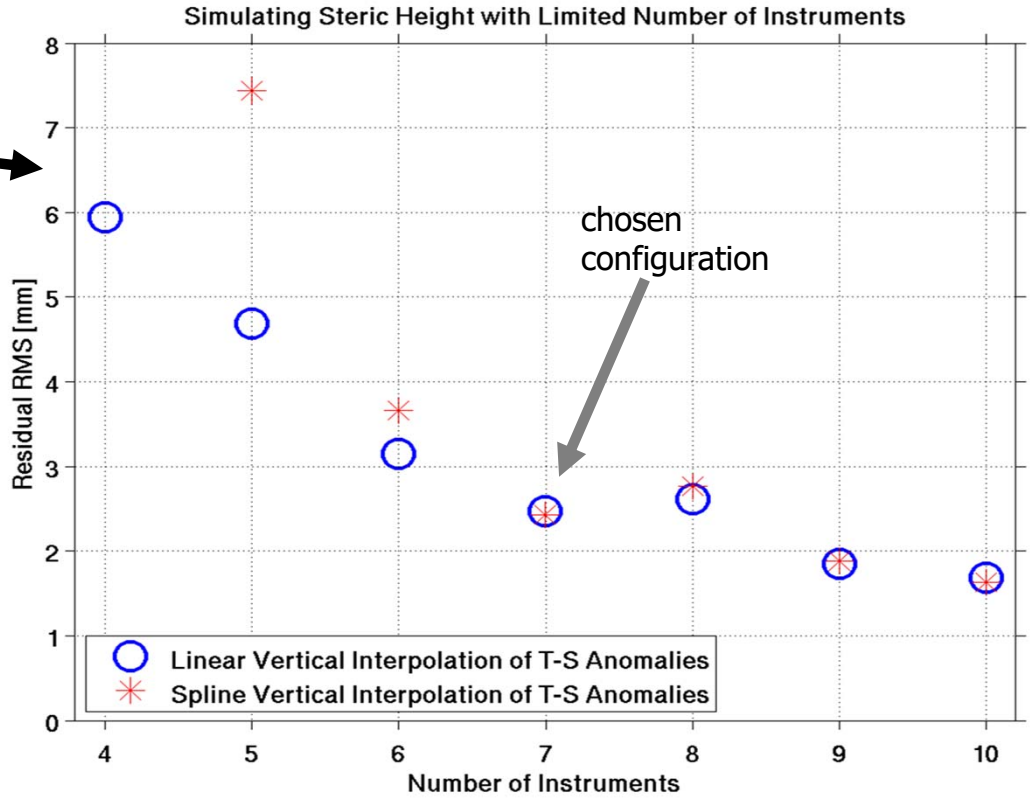
- **Has required accuracy (see below)**
- **Samples full water column**
- **Real-time data from ALL sensors**
- **Tight position-keeping (approx. 1km radius watch circle)**
- **Builds on extensive experience with dynamic height moorings and with moored profilers**

- **New hybrid design exploits the advantages of each and merges proven technologies from each**
- **Cost-effective for pre-launch but also for larger-scale post-launch deployment since substantial existing equipment merged from multiple labs reduces need for new purchases**

Accuracy of dynamic height measurements with the SIO design

Single-point SWOT target is 0.1cm^2 variance, or 0.3cm rms

SSH error due to discrete sampling below 500m, simulated using a large number of continuous CTD profiles from the same region.



The proposed design will use continuous profiling above 500m (Wirewalker) and seven SBE-37 (microcat) CTDs at optimized depths below that.

The sampling error in dynamic height is < 0.3cm rms.

- also tested contribution from sensor error/noise → even less
- bottom pressure can be measure to 0.3cm accuracy

Time resolution of dynamic height measurements

For cal/val analyses where simultaneous observations are needed, we can estimate error from temporal delays:

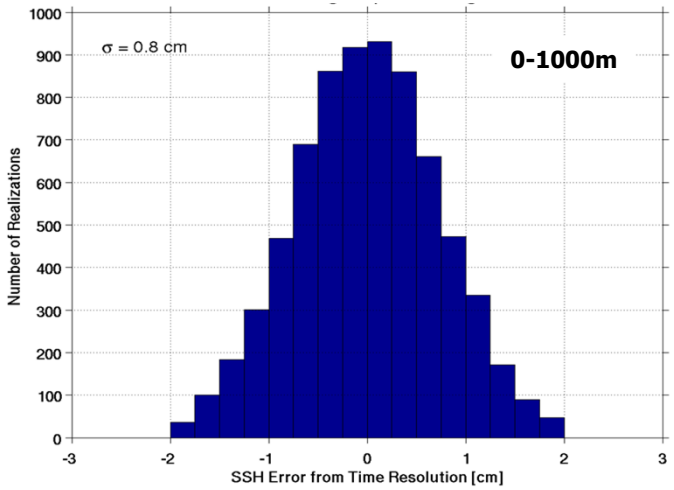
CORC mooring data allow estimate of rms error from delaying measurements by given time interval.

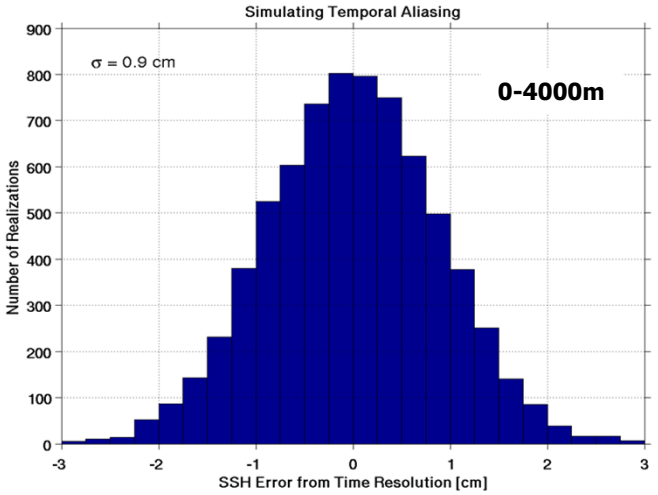
→ If data are non-simultaneous by 3hrs, RMS error in dynamic height is 0.8cm for upper 1000m, 0.9cm for full water column.

The proposed hybrid mooring can generate full ocean profile data which are simultaneous to within ±8 minutes.

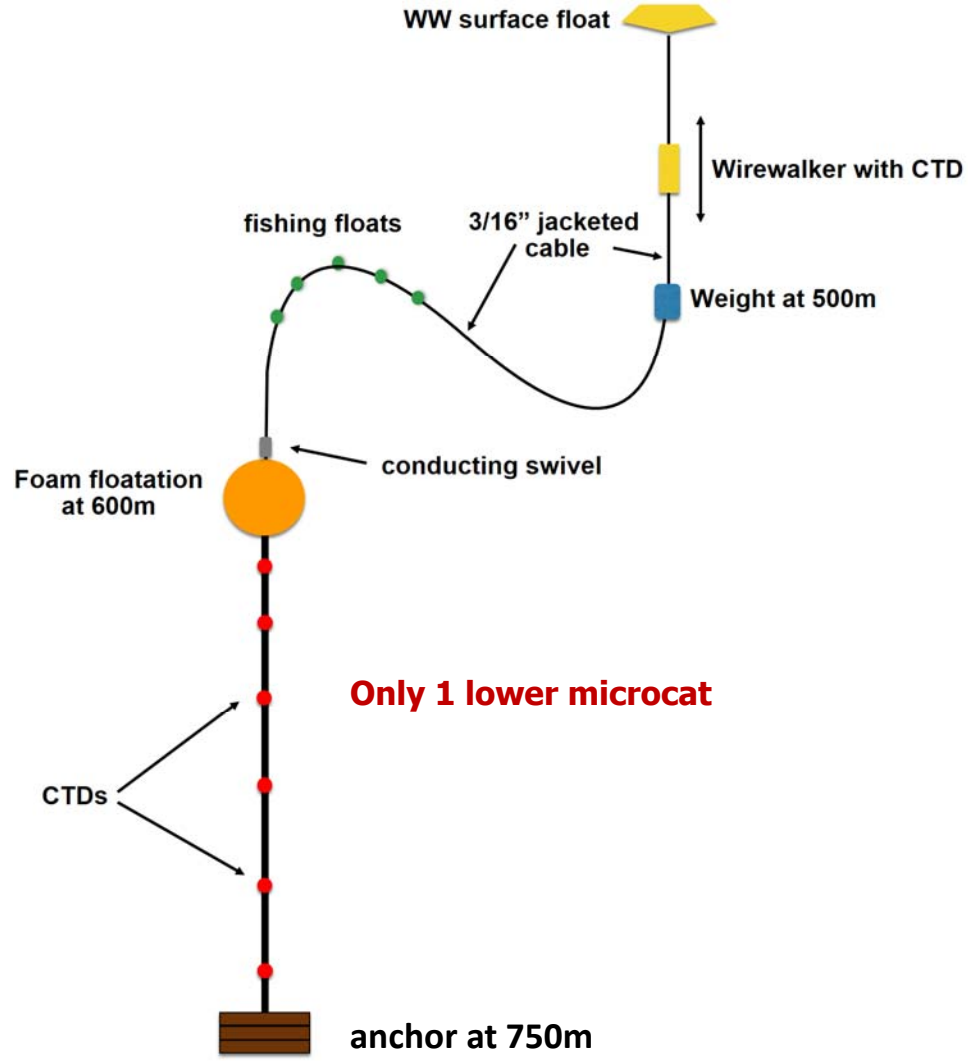
Temporal resolution of full-ocean profile data with the proposed mooring is better than 1hr, essential for resolving tides which need to be removed in the ocean cal/val measurements.

Dynamic height error due to 3hr delay

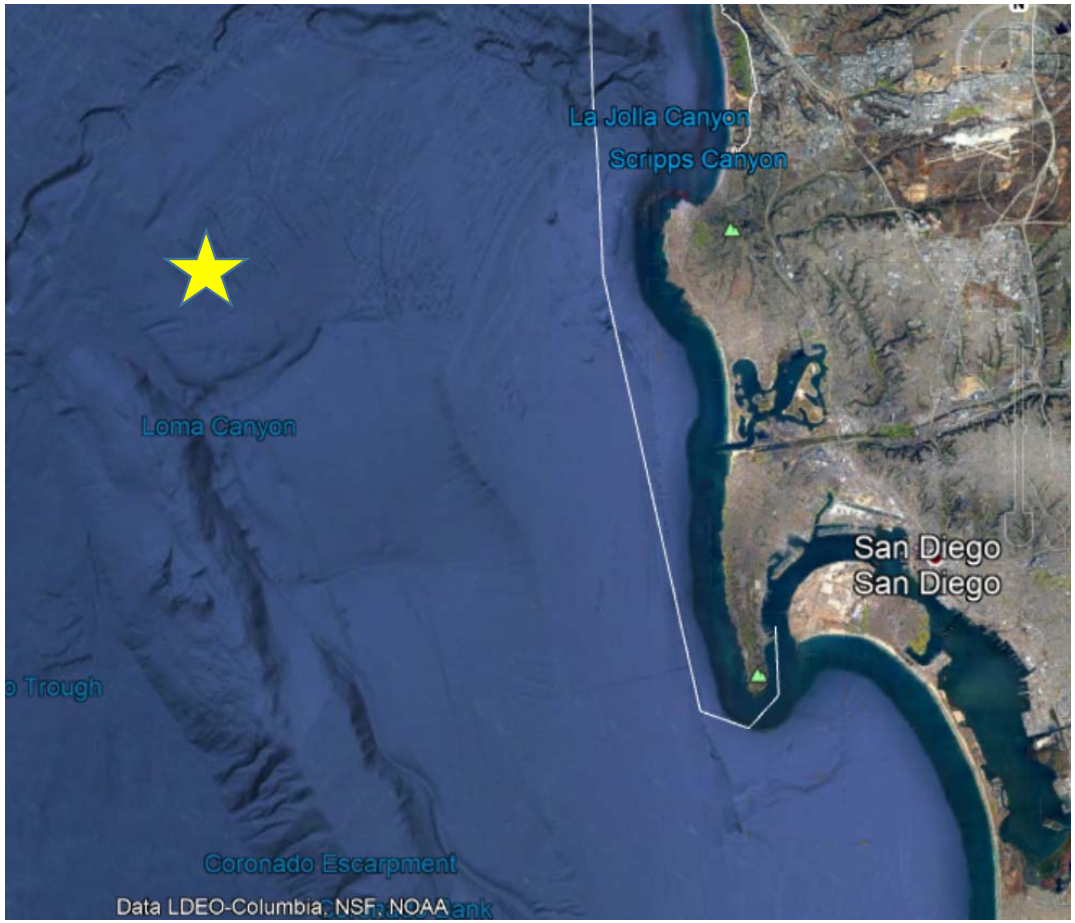




Test deployment off San Diego planned for 1 week from now



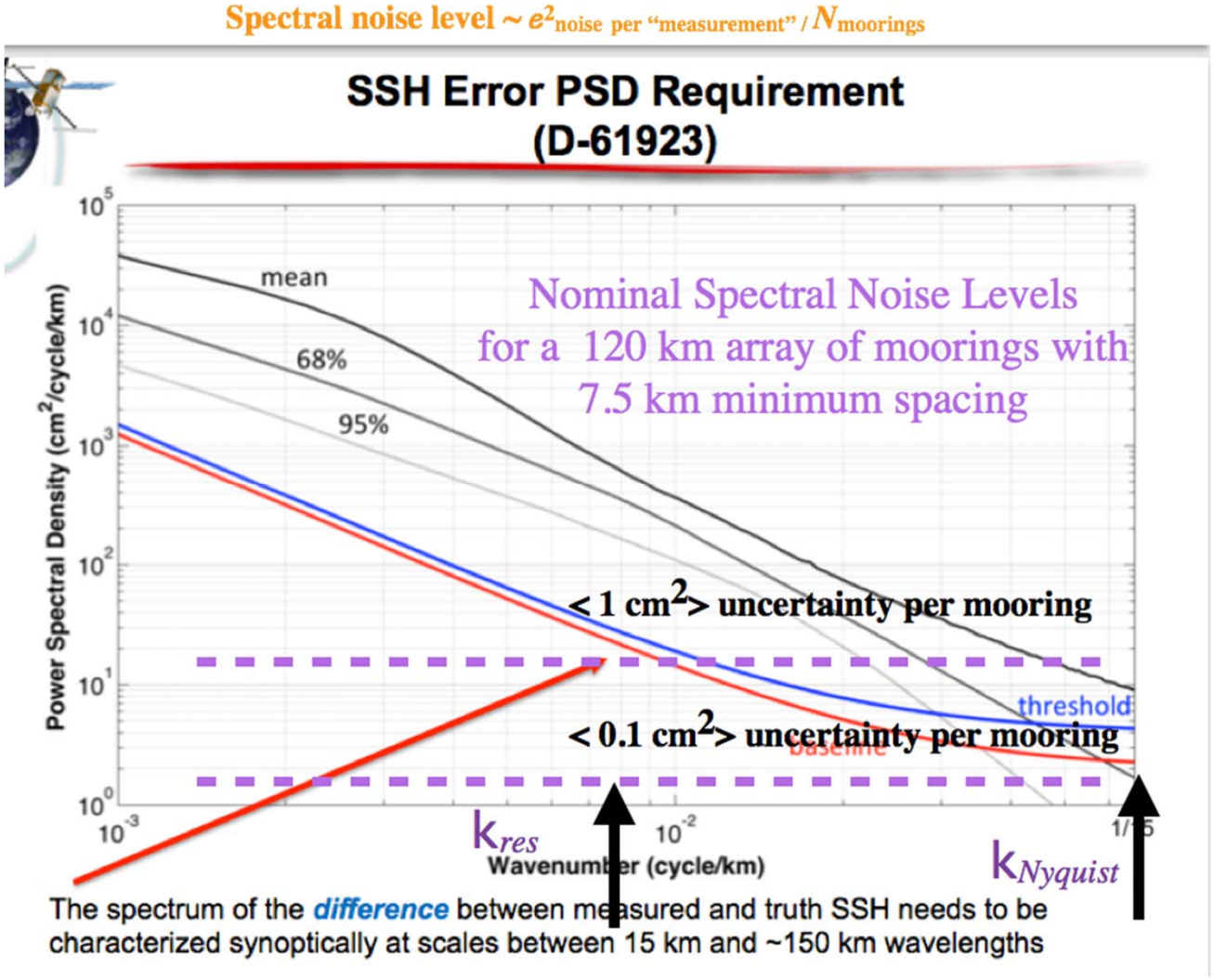
- **Water depth 750m, 15nm from San Diego Bay**
- **Deployment for 2-3 weeks**



Performance of such moorings for post-launch SWOT cal/val

Past slides:
prior data and past experience demonstrate ability of the hybrid moorings to determine SSH with an uncertainty level of 0.1cm^2.

This meets the SWOT cal/val requirements, e.g. for an array of 12 such moorings spaced 7.5km apart.



Horizontal spacing of the two pre-launch dynamic height moorings

We know very little about SSH energy at small spatial scales. But we need to know the size of variability (hours to months) at tens of kilometers scales, in order to design the post-launch cal/val sampling…..

The California Pre-Launch campaign can test the gradients at one spatial lag, over many timescales.

Should this lag be the minimum scale (10km) or some intermediate scale (30-50km) ?

Horizontal spacing of the two pre-launch dynamic height moorings

Some thoughts (for discussion):

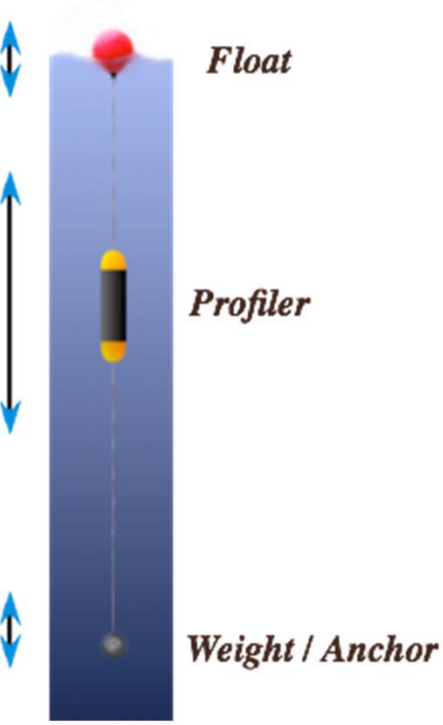
- If the spectrum is red, signals would be larger at longer lags - so maybe 10km would show nothing measurable, but 40km would
- Some of the moorings may move by +/- 4km: larger error impact in determining 10km differences than 40km differences ?

Also: Should the GPS/Prawler mooring be co-located with the SIO dynamic height mooring for **GPS validation** ?

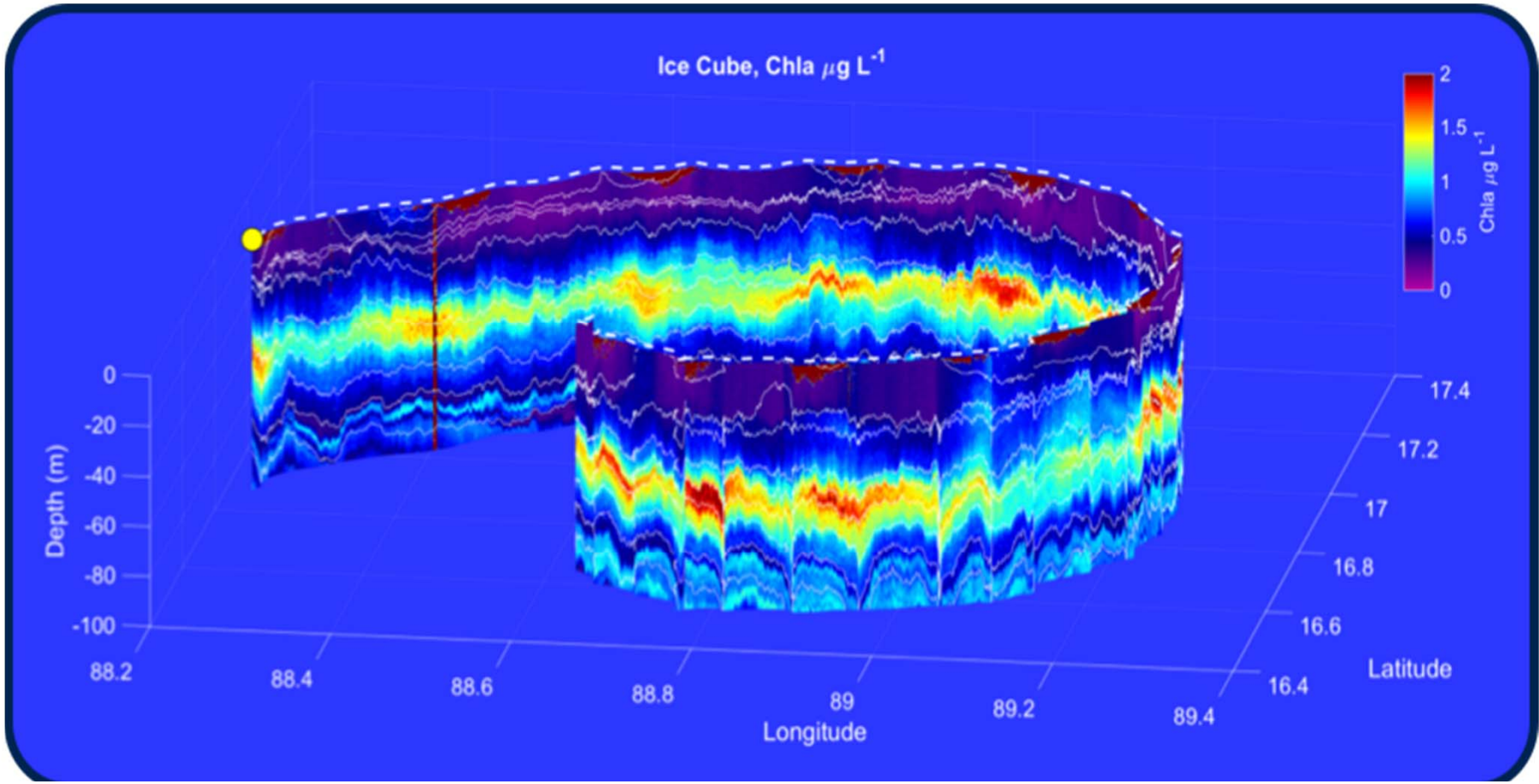
Does the Science Team have a recommendation for mooring spacing ?

Technologies used:

a) The Wirewalker, a rapid vertical profiler powered by ocean waves.



Indian Ocean Drift Data courtesy Drew Lucas, SIO

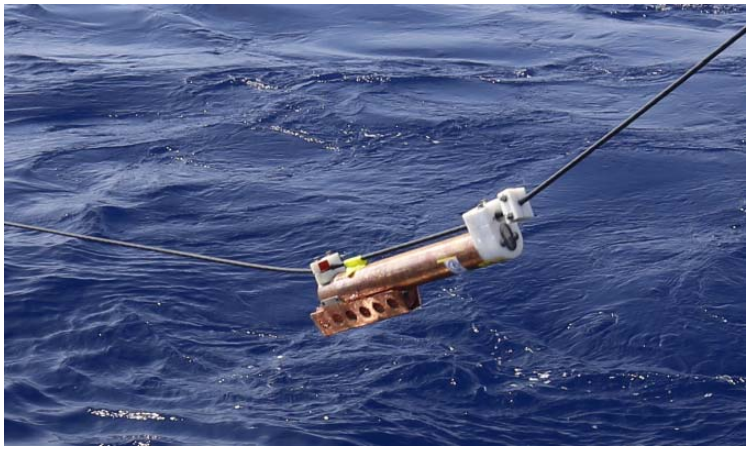


Wirewalker specs

~10 m / minute round-trip profiling speed:
➔ 50 minute profiles to 500m
~ 0.5m/s rise rate

Technologies used:

b) High-accuracy dynamic height moorings & bottom pressure

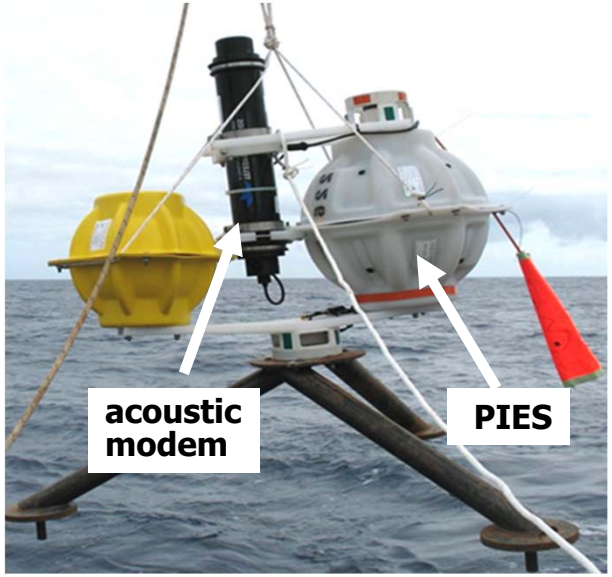


Typical mooring: 15-20 fixed inductive SBE-37 CTDs, calibrated to absolute accuracy of 0.002°C and 0.003psu

→ absolute error in dynamic height < 0.5cm

Error from discrete vertical sampling < 0.5cm

Send lab owns over 150 microcats and has been doing this for many years in the Atlantic (MOC array), also in the California Current, Solomon Sea, Labrador Sea, etc.



Bottom pressure from PIES with Paroscientific sensor

short-term precision of few millimeters as demonstrated by arrays of PIES, long-term adjustment with GRACE satellite data.