Surface Water and Ocean Topography (SWOT)

Jet Propulsion Laboratory
California Institute of Technology

SWOT Ocean Topography in-situ campaign for small wavelength Cal/Val

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SWOT Science Team meeting (virtual), 09/14/2021

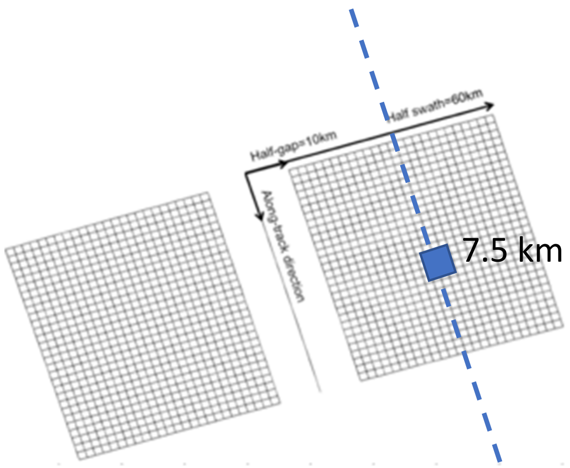
1. Jet Propulsion Laboratory
2. Scripps Institution of Oceanography
3. NOAA Pacific Marine Environmental Laboratory
4. Remote Sensing Solutions Inc.
5. Rutgers University
6. Woods Hole Oceanographic Institution
7. NASA Goddard Space flight center
8. Caltech
9. University of Hawaii

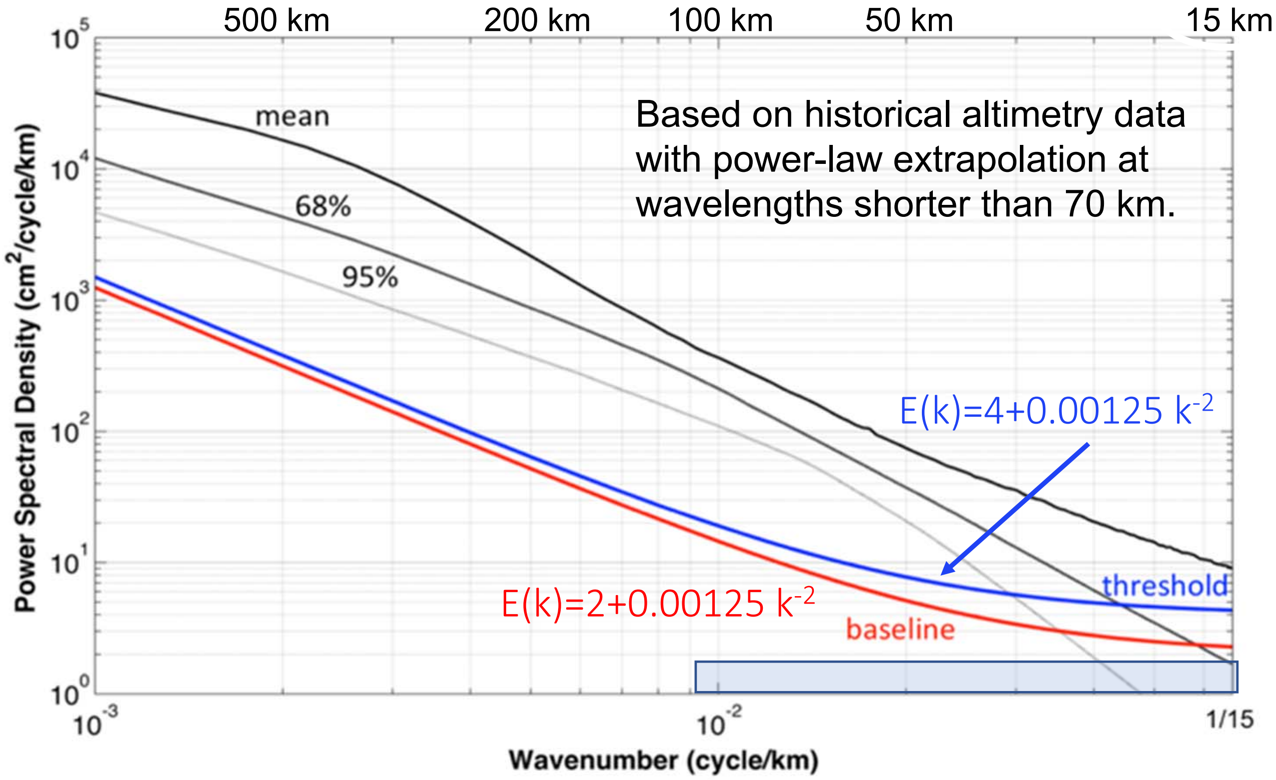
Outline

1. Mission objectives and requirements
2. Recap of the past development
3. 2019-20 prelaunch field campaign
4. The SWOT postlaunch field campaign (2023)

SWOT Ocean Cal/Val objectives

Geodetic validation – validate the measurement of SSH to meet the wavenumber spectrum requirement
Oceanographic validation – validate the utility of the SSH measurements to meet the science objectives





- **The error variance is dominated by the random noise at small wavelengths.**

Recap of the development

- 2016-2017 Observation System Simulation Experiment
  - Identified the utility of steric height
  - An array of 20 mooring will be sufficient, but too expensive
  - Array of station-keeping gliders marginally meet the requirement
  - Underway CTDs and PIES does not meet the requirement
- 2017-2018 Pilot field campaign near MBARI M1 mooring
  - Station keeping gliders can reconstruct mooring steric height for periods longer than 6 hours
  - Could not match GPS-BPR with mooring steric height partially due to the local large spatial gradient in geoid
- 2019-2020 pre-launch field campaign (planning, execution)
  - California Xover location, deep ocean
  - GPS-BPR matches steric height with 1-3 cm rms difference
  - Quantification of the steric height composition
  - Demonstrated the feasibility of an array of moorings as the baseline
- 2020-2021 (post-launch calval campaign planning)
  - Create baseline
  - Team formation
  - Plan execution

Steric height is a hydrographic approach to measuring SSH with no impact from surface process other than the correction for the inverted barometer effects and barotropic signals.

$$\frac{dp}{dz} = \rho g$$

$$p'(H) = \int_H^0 g\rho'\,dz + \rho_0 g\eta' + p'_a$$

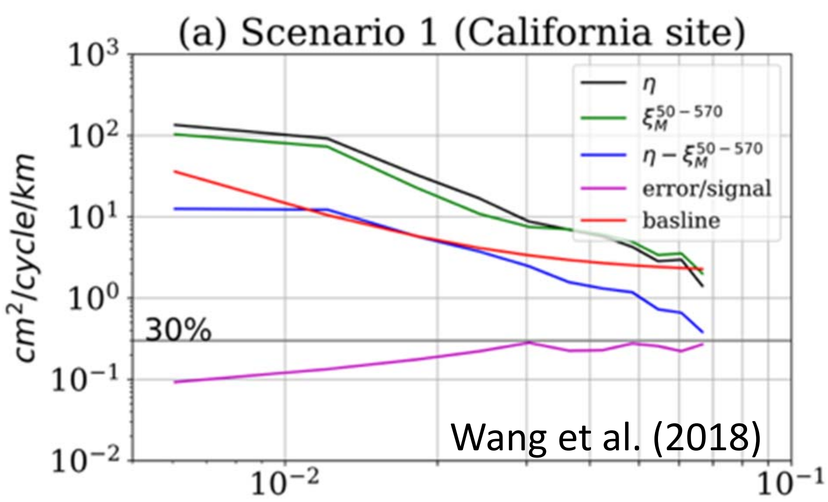
Bottom pressure recorder

CTD mooring

GPS/SWOT

Barometer/reanalyses

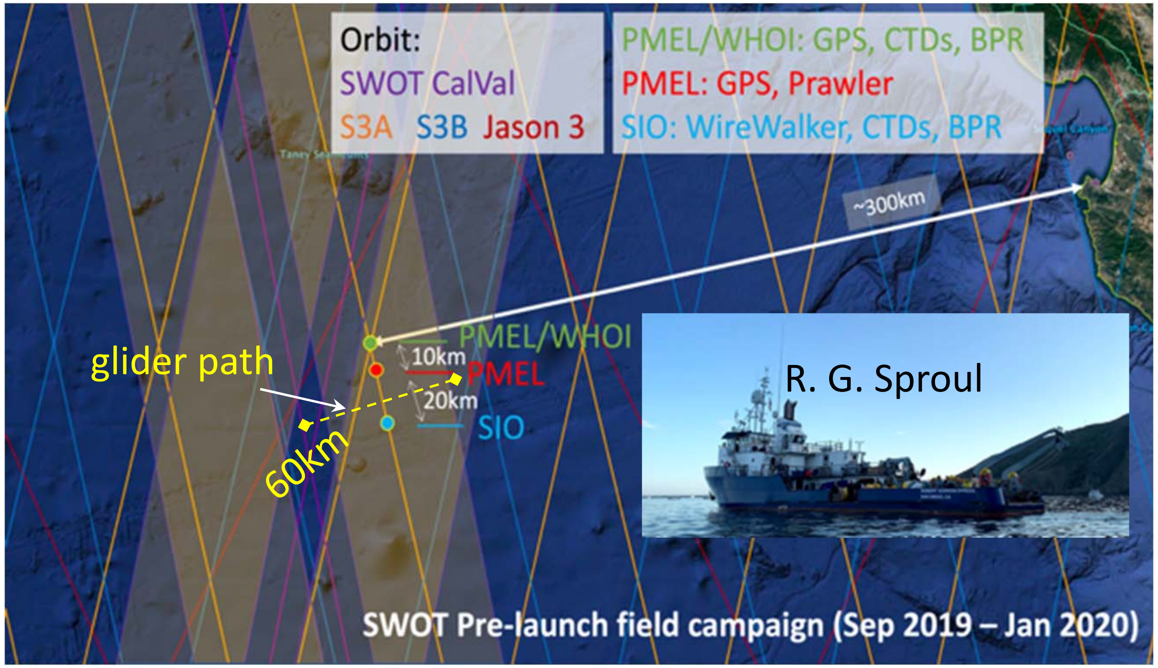
An OSSE of an array of 20 moorings



2019-20 SWOT pre-launch Campaign

objectives

1. Test the SSH closure with GPS buoy, CTD mooring, and bottom pressure recorder (BPR)
2. Evaluate the vertical scale of the steric SSH at the SWOT scales for different frequency bands
3. Evaluate the roles of bottom pressure in SWOT SSH signals
4. Assess the information content of the in-situ observations
5. Continuation of the SSH wavenumber spectrum from Sentinel 3A to SWOT regime
6. Evaluate the reconstruction of the upper ocean circulation
7. Provide information for the design of the post-launch in-situ observing system.



Campaign participants: Christian Meinig, Scott Stalin, Mike Craig, Danny Devereaux, **Yi Chao**, **Oscar Schofield**, John Kerfoot, David Aragon, **Uwe Send, Andrew J. Lucas**, Rob Pinkel, Matthias Lankhorst, Jeff Sevadijan, Ethan Morris, Riley Baird, Romain Heux, Tyler Hughen, Paul Chua, Drew Cole, Bofu Zheng, **J. Thomas Farrar**, Sebastien Bigorre, Ray Graham, Emerson Hasbrouck, Ben Pietro, and Al Plueddemann, **Bruce Haines, Lee-Lueng Fu**, Jinbo Wang

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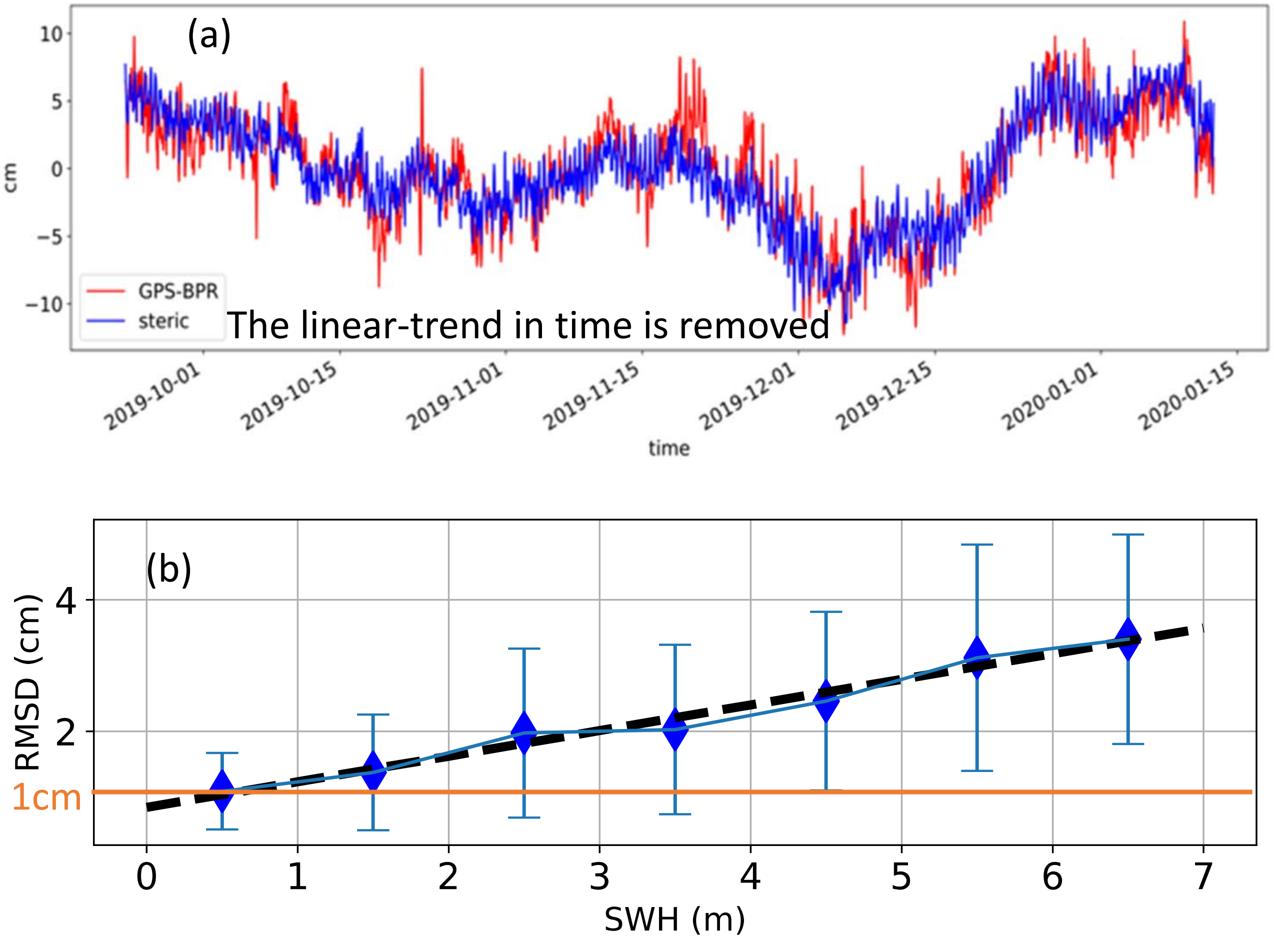
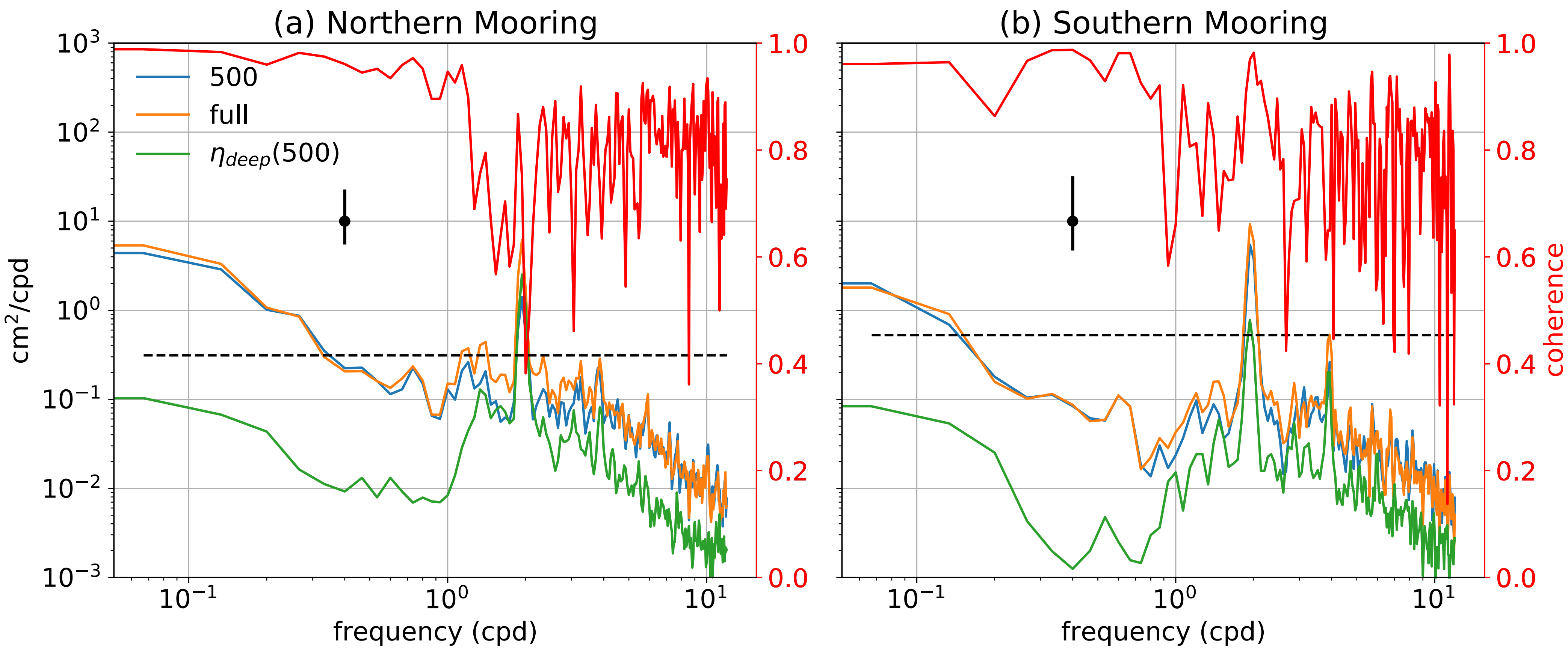
SSH budget can be closed with ~ 1-3 cm RMSD

$$\frac{-p'_b}{g\rho_b} + \eta'_{GPS} - \eta_{IB}$$

$$\int_H^0 \frac{-g\rho'}{\rho_0} dz$$

1. The hydrostatic equation is closed with GPS, BPR, and CTDs, confirming the SSH equation and the utility of CDTs in reconstructing the truth.
2. The differences between blue and red is a function of significant wave height, indicating the error source from GPS retrieval, which is believed to be of long wavelengths and less relevant to <100km scales. On-going investigation.

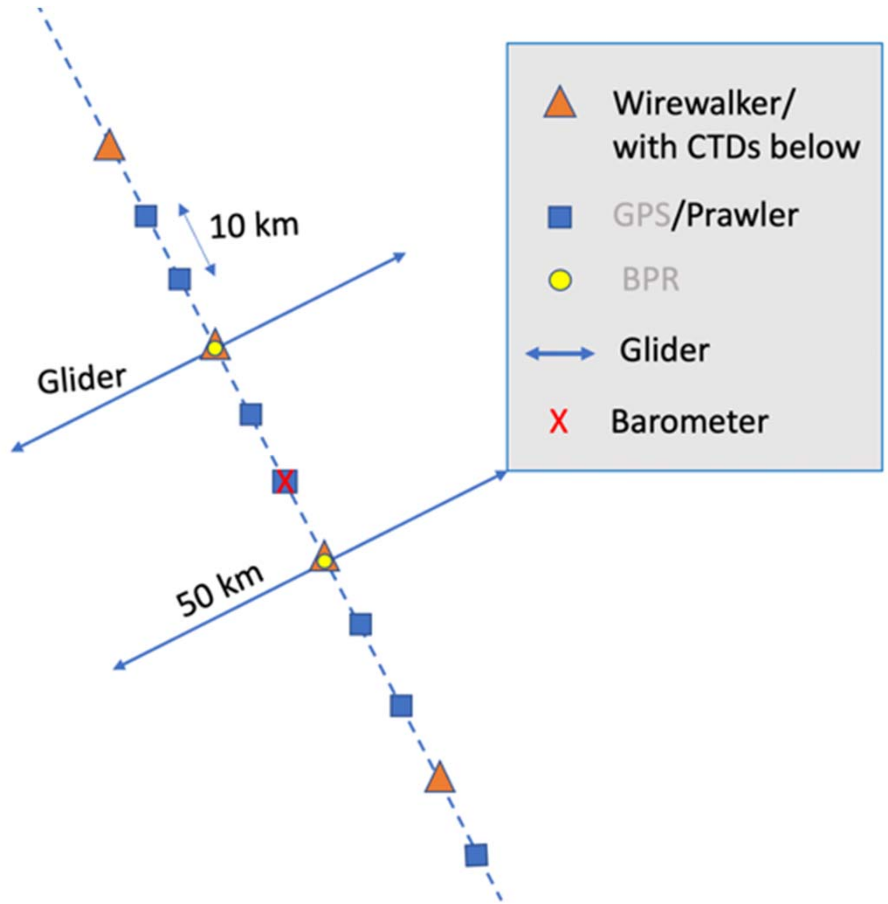




1. The upper 500 m (blue lines) is sufficient for sub-inertial, <100km motions.
2. Deeper ocean (z<-500m) (green lines) becomes more important at super-inertial frequencies, but mostly at tidal frequencies (e.g., M2), which are dominated by large scales (>30km).

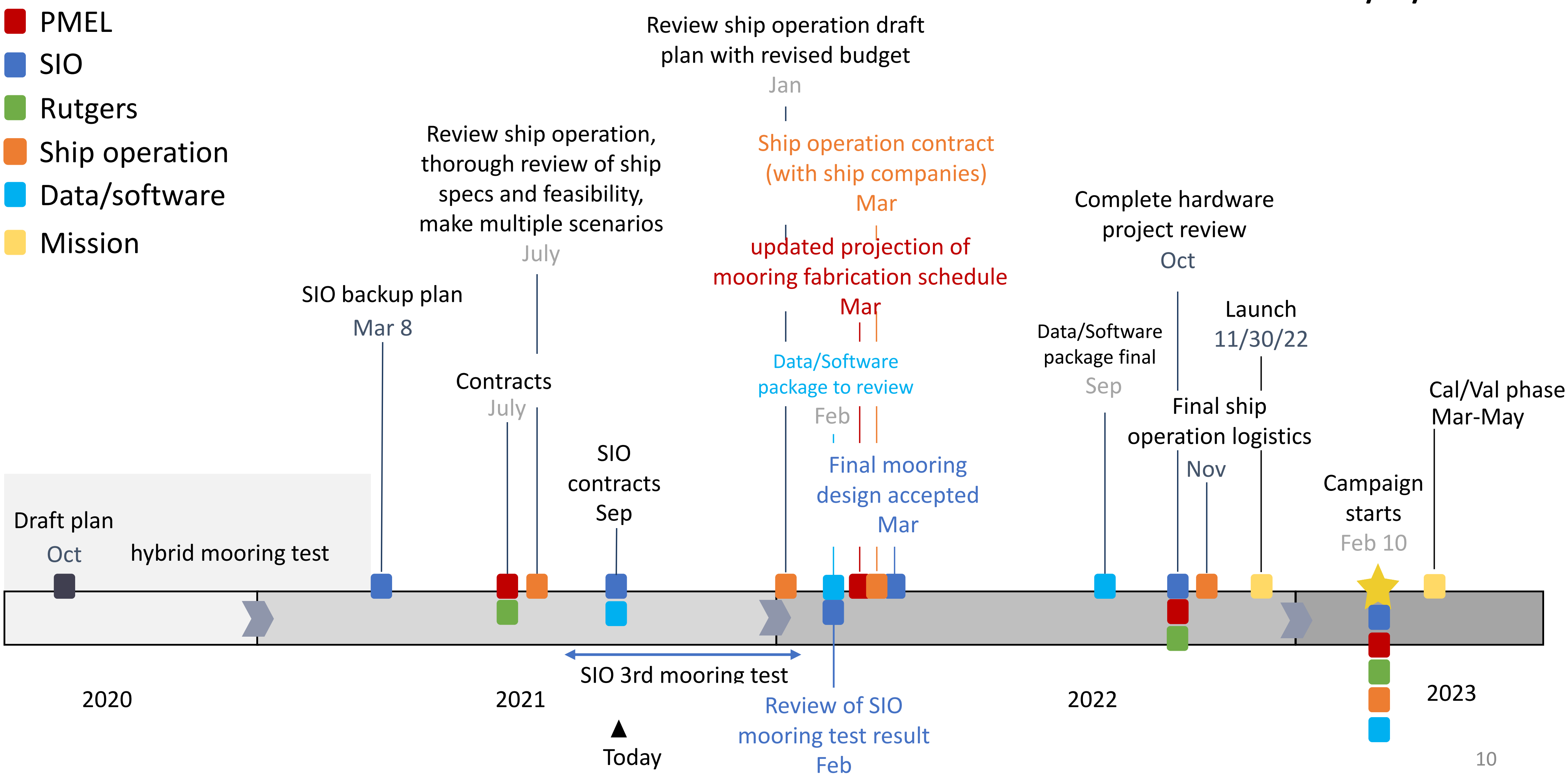
SWOT Post-launch Cal/Val campaign minimum baseline

- Four full-depth moorings with 30km separation
- Seven profiler moorings sampling the upper 500m
- Two gliders cross swath
- A barometer at the center of the array.
- The full-depth mooring will capture the large-scale, deep-reaching, high-frequency variabilities
- The gliders will sample the cross-swath direction to provide two-dimensional measurements, but also serve as a contingency for failed moorings.
- The barometer will provide high-frequency atmospheric pressure for IB corrections.
- GPS and BPR are not in the minimum baseline but considered as valuable upgrades.
- The array will be under a SWOT swath along a Sentinel 3A ground track as done in the 2019-20 prelaunch field campaign.



SWOT Post-launch oceanography Cal/Val Campaign teams and timeline

Revised 8/11/2021



Thank you

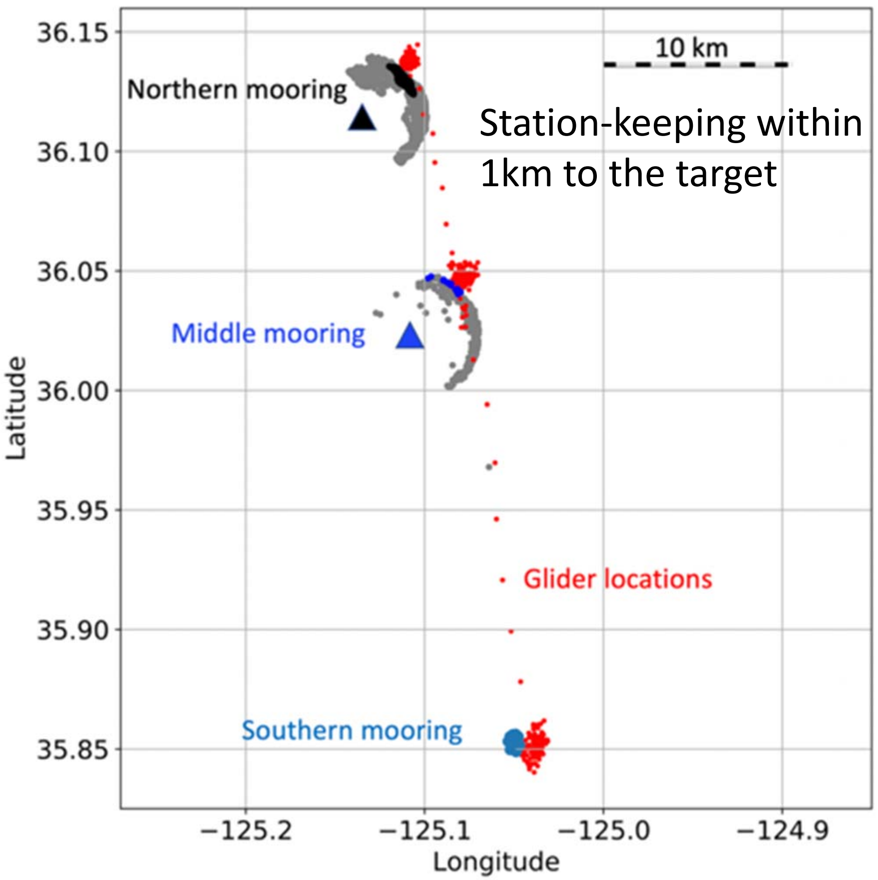
Mission Objectives and Requirements

- **The primary oceanographic objectives of the SWOT mission are to characterize the ocean mesoscale and submesoscale circulation determined from the ocean surface topography at spatial resolutions of 15 km (for 68% of the ocean).**

- **2.7.6 [Requirement] The SWOT ocean performance shall be verified by payload independent measurements or analysis during a post-launch calibration/validation period.**

- **2.7.2.a [Requirement] The sea surface height error spectrum (cross-track average of the along-track spectra computed at different cross-track locations over the swath) in the wavelength range smaller than 1,000 km shall not exceed the spectrum envelope given in Figure 1 and the formulas below. This requirement holds for significant wave heights (SWH) less than 2 meters.**

Station-keeping glider as a virtual mooring



The locations of the glider (red) and the northern (black), the middle (green, to add) and the southern mooring (blue) during the glider station-keeping phase 11/27/2019 - 12/17/2019.