The SWOT Mission: SSH at small scales validation and understanding

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Vertical 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
SSH wavenumber spectra

SWOT noise spectrum

Altimeter noise

SWOT resolution

$\kappa^{-4}$

$\kappa^{-2}$

$\text{cm}^2/\text{cycles/km}$

$\text{cycles/km}$
SWOT measurement system

Interferometric Altimetry Measurement

Interferometer Antenna 1
Interferometer Antenna 2

10 m Baseline

Nadir Altimeter

Interferometer Left Swath
Interferometer Right Swath

Ocean Topography
Surface Water Topography

H-Pol Interferometer Swath 10 - 60 km
Nadir Altimeter Path
V-Pol Interferometer Swath 10 - 60 km
Cross-track Resolution from 70m to 10m
Sea Surface Height Requirement

Based on historical altimetry data with power-law extrapolation at wavelengths shorter than 70 km.
Challenges:
Reconstruction of ocean state from irregular sampling
Challenges: Dealing with Internal tides and internal waves

From T. Farrar
Wavenumber spectrum of internal waves

At 20S, 85W from a mooring
Challenges: Reconstruction of ocean state from irregular sampling

A software tool available for simulating SWOT-like observations for studying reconstruction methodology
Surface Vorticity and Vertical Velocity
A Grand Challenge for Ocean Remote Sensing

(Qiu et al, 2018)
One-day repeat phase for initial Cal/Val
SWOT ocean calval objectives

- Geodetic validation - validate the measurement of SSH to meet the wavenumber spectrum requirement
  - GPS buoys and airborne lidar

- Oceanographic validation – validate the utility of the SSH measurement to meet the science objectives
  - Moorings of temperature and salinity sensors
  - Station-keeping gliders
  - Upper ocean profilers (Prawler, wire-walker)
Meeting the challenge of CalVal with an in-situ observing system

A strawman design:

An along-track array of GPS buoys for SSH validation

A two-dimensional array of hydrographic sensors (gliders, prawlers, possibly some deep CTDs, or combination of them) for the oceanographic understanding. Such deployment will link the mission’s calval plan to the development of the post-launch science campaign.

The minimum length of the GPS array needs to be ~110 km, according to a modeling study of the long-wavelength calval by the SWOT nadir altimeter.
Objectives of the Oceanographic Validation

• Vorticity dynamics and vertical velocity/transport

• Modeling/data assimilation is a tool to address the objectives.
  • Before launch: design an in-situ observing system to provide estimate of vorticity and vertical velocity
  • After launch: test the performance of SWOT for vorticity and vertical velocity
Back-Up
Mission Phases/Timeline

<table>
<thead>
<tr>
<th>Mission Phases</th>
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<tbody>
<tr>
<td>LEOP 7 days (Includes DAA deployment)</td>
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<tr>
<td>Checkout/Commissioning Phase (83 days)</td>
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<tr>
<td>Calibration Phase (90 days)</td>
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<td>SWOT Validation meeting</td>
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<tr>
<td>Measurement Validation: 8 months, nominal science orbit</td>
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<tr>
<td>Science Phase (21-day Repeat) (36 mos)</td>
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<tr>
<td>SC Decommissioning (1 mos.)</td>
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<tr>
<td>Science Data Product Generation Closeout (4 mos.)</td>
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<td>Fast Repeat (1 day repeat, 77.6 deg, 857 km)</td>
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<tr>
<td>Transition to Science Repeat Orbit (~1 wk)</td>
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<tr>
<td>Science Orbit: 21-day repeat, 77.6 deg, 891 km (36 mos.)</td>
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Calendar Years

- 2021
- 2022
- 2023
- 2024
- 2025
Sampling pattern of the 21-day orbit for the Science Phase
Pre-launch ocean in-situ calval experiment
Targeting the dynamics of the smallest scales of ocean currents

Sea surface elevation is needed for dynamics.
SWOT SSH resolution in the global ocean

Fu and Ubelmann (2013)

SWH = 2m