Following selection for the SWOT Science Team 2020-2023, this document summarises our planned project activities for inclusion onto the SWOT science projects page:
https://swot.jpl.nasa.gov/science/science-team-projects/

Project Title:

An Australian contribution to SWOT validation from Bass Strait and surrounds

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1 Introduction

This project seeks to provide a contribution to the in situ calibration and validation of SWOT ocean observations from the Bass Strait altimeter validation facility (and surrounds) in Australia. This work extends and expands the longstanding validation of nadir altimetry over 26+ years at the Bass Strait facility that is located within the SWOT 1-day repeat validation orbit (Figure 1).

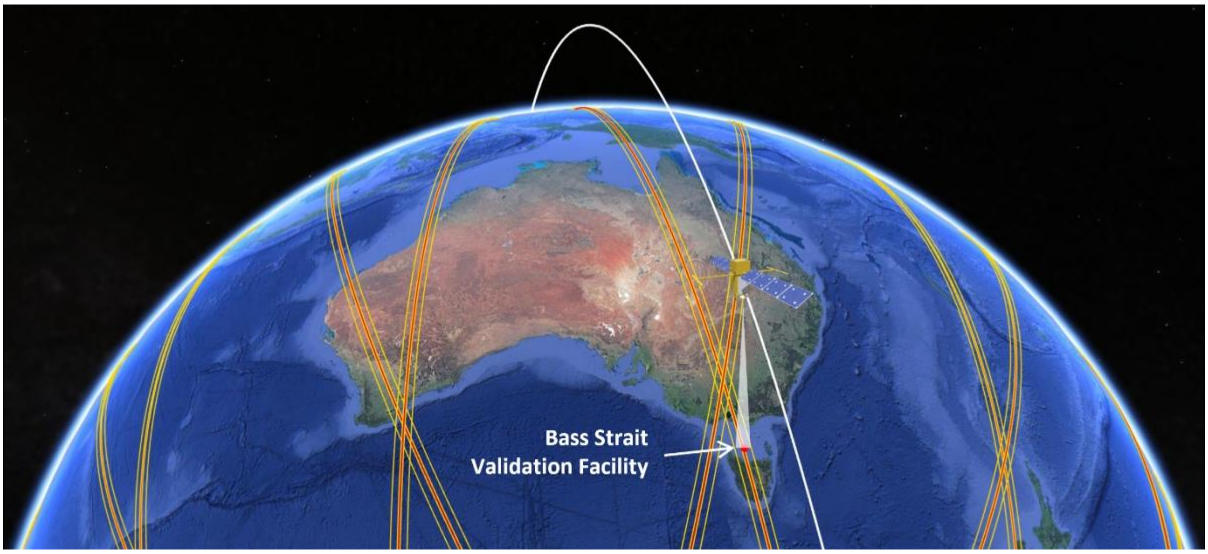

Figure 1. Location of the Bass Strait validation facility with respect to the SWOT fast-sampling orbit.

Bass strait provides a well understood and flexible ocean validation target in the coastal domain (30-80 m depth). The site offers comparably simplified logistics, significant yet predictable ocean tides, reasonably high spatial variability of sea state, yet relatively benign mesoscale ocean dynamics. These conditions combine to provide a well understood and highly complementary validation target to the primary SWOT validation sites off the Californian coast and in the Mediterranean Sea.

Our project focuses on the further development of a geometric geodetic approach that includes Global Navigation Satellite System (GNSS) / Inertial Navigation System (INS) equipped buoys, an array of coastal oceanographic moorings (pressure, temperature, salinity and 5-beam ADCPs / current, wave, pressure inverted echo sounders - CWPIES), and enhancements to regional high-resolution oceanographic modelling over the Bass Strait domain. The project includes preparatory studies with deployments along a Sentinel-3B track, followed by extended deployments along a Sentinel-6/Jason-CS track during its associated validation phase.

2 Objectives

The project seeks to contribute directly to the calibration and validation of SWOT sea surface height (SSH) using a geometric / geodetic approach. Our first two objectives are preparatory – we first seek to understand in situ observation of SSH via new GNSS equipped platforms (OBJ-1); second, we seek to complete development of a new current, wave, pressure inverted echo sounder instrument to derive accurate currents (U, V), 3D wave spectra and SSH (OBJ-2). Subsequently, we will use these understandings to achieve a cycle-by-cycle validation of SWOT SSH and ΔSSH (OBJ-3). Each objective is further outlined below.

OBJ-1 Fully understand systematic error contributions to GNSS equipped positioning in the marine domain. Components of this objective include:

a. Understanding potential biases in platform buoyancy location (antenna reference point to mean water level) as a function of current velocity and sea state.
b. Understanding biases between GNSS processing approaches (relative carrier phase-based v precise point positioning) over the frequency domain.

OBJ-2 Develop a current, wave, pressure inverted echo sounder (CWPIES) concept suitable for use in altimetry validation in shallow water environments. Components of this objective include:

a. Understanding systematic contributions from dynamic changes to sensor orientation.
b. Quantify performance over different frequencies against traditional bottom pressure sensors corrected for dynamic height using temperature and salinity observations.

OBJ-3 Undertake a geometric / geodetic validation of SWOT SSH using lessons learnt from Objectives 1 and 2. Components of this objective include:

a. Validations of SWOT SSH and ΔSSH across the left swath in Bass Strait, Australia.
b. Assessment of SSH, wave and tropospheric variability within the SWOT smoothing wavelength of 15 km.
c. Secondary point-based validation of SWOT SSH at locations in the Southern Ocean (SOFS) and Yongala (both located on the same 1-day repeat SWOT track).

A detailed view of the Bass Strait validation facility is shown in **Error! Reference source not found.**.

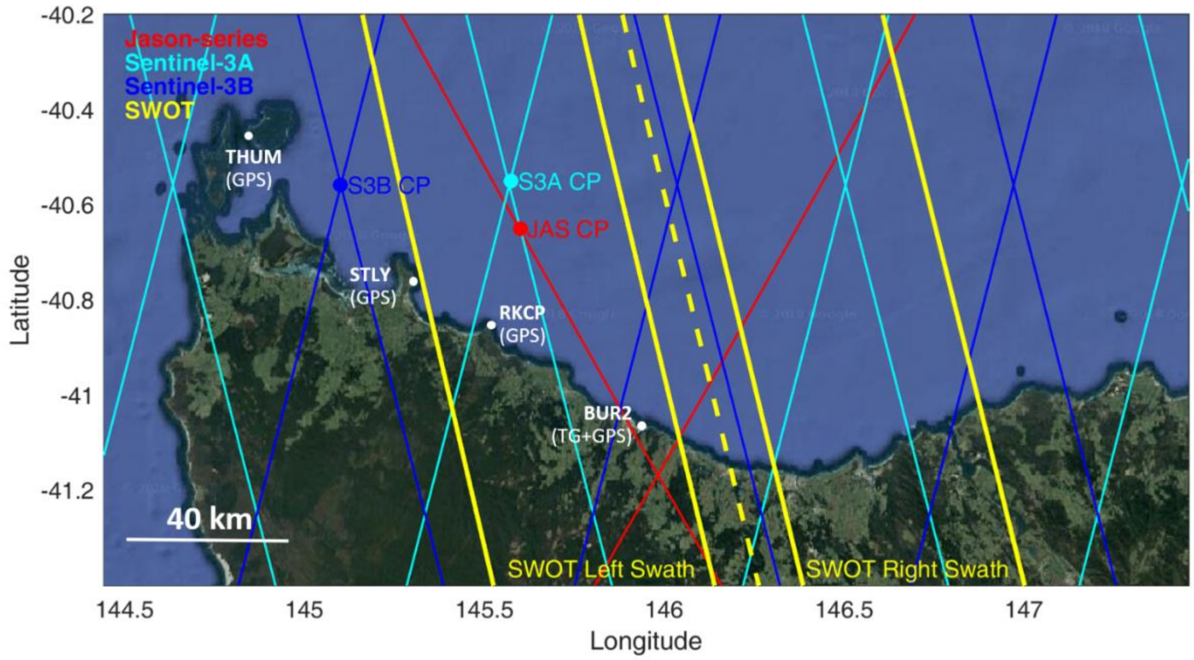

Figure 2. Detailed view of the Bass Strait altimeter validation facility. Existing comparison points (CPs) for the Jason series, Sentinel-3A and Sentinel-3B missions are shown as coloured dots. Mission ground tracks shown as coloured lines. The SWOT 1-day repeat fast sampling orbit is shown in yellow (swath limits shown as solid lines, centre nadir altimeter shown as a dashed line). The proposed activities focus on the left (western) swath. Note the red line indicates the Jason-series ground track also to be used for Sentinel-6/Jason-CS.

3 Overarching approach

To address the three stated objectives, five key activities have been identified:

1. Sensor developments:
    - Further develop new IMOS/UTas 'Mk-V'GNSS buoys.
    - Refine 5-beam ADCP / CWPIES sensor and associated workflow.
    - Operationalise high resolution ocean modelling (CSIRO SHOC model) over the Bass Strait domain.
2. Pilot deployments:
    - First extended deployments of new GNSS buoys and 5-beam ADCP / CWPIES moorings along a Sentinel-3B track at the Bass Strait validation site.
    - Second extended deployments for Sentinel-6/Jason-CS validation. Note these deployments will be in the same region as proposed for SWOT validation.
3. Core Bass Strait SWOT validation experiment (3 months):
    - Deploy the complete IMOS/UTas GNSS buoy array and 3 core moorings over the duration of the SWOT validation phase.
    - Retain flexibility to reconfigure the surface array to address different objectives.
4. Secondary opportunities:
    - Augment existing SOFS and Yongala moorings with GNSS and CWPIES for Yongala.
5. Sustained monitoring:
    - Ongoing point-wise monitoring of SWOT at the historical Jason-series comparison point in Bass Strait.

4 Sensor developments

A key component of our validation approach is the development of GNSS equipped buoys and a current, wave, pressure inverted echo sounder concept. Development of the GNSS equipped buoys (Figure 3) involve a focus on understanding the systematic errors associated with buoyancy position as a function of sea state and orientation of the buoy.

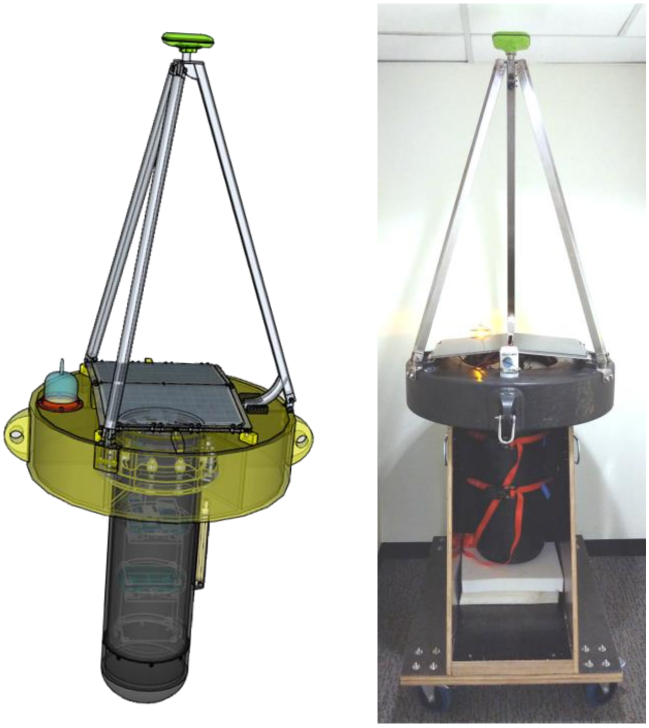

Figure 3. IMOS / UTas 'Mk-V' GNSS buoy. Initial CAD model shown (left) and one of two prototypes completed (right). Payload includes geodetic GNSS receiver, inertial navigation sensor, SBE56 SST sensor, solar power, iridium tracker and cellular telemetry systems.

The development of the CWPIES approach has required a focus on refining a gimbal mount to ensure vertical pointing of the ADCP (Figure 4).

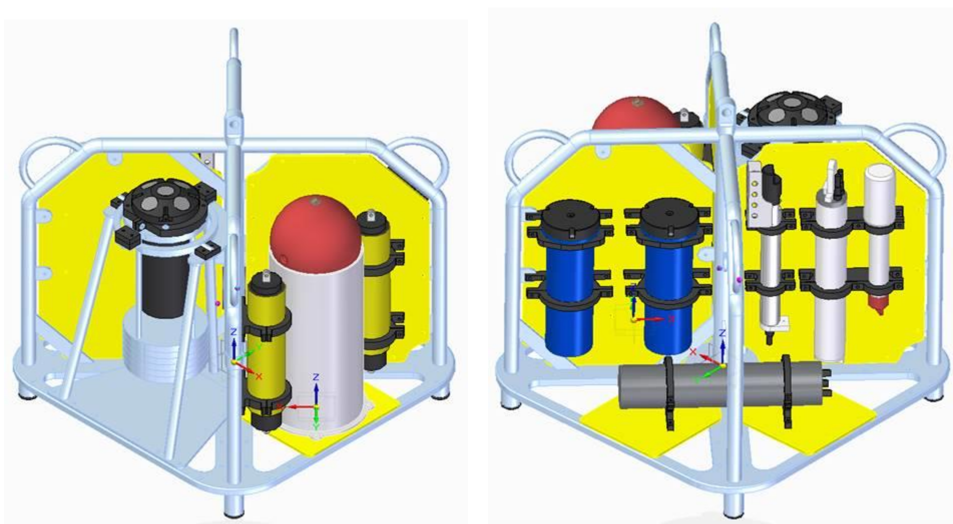

Figure 4. Forward (left) and reverse (right) view of 5-beam ADCP / CWPIES, bottom pressure, temperature and salinity mooring lander and sensors currently in use at the S3B site. Note the gimbal mount for ADCP sensor on left panel.

5 Deployment plans for SWOT validation

We are planning an extended 3-month deployment of 6 GNSS equipped buoys, 5-beam ADCP / CWPIES moorings and opportunistic instruments spanning the 1-day repeat fast sampling Cal/Val phase of the SWOT mission in Bass Strait. A series of deployment configurations are under consideration – we retain flexibility to shift between deployment configurations during the validation phase. These deployment configurations have the advantage of connecting SWOT validation to the heritage of the Bass Strait site given simultaneous sampling of the long-standing JAS comparison point. One example deployment configuration is shown in Figure 5.

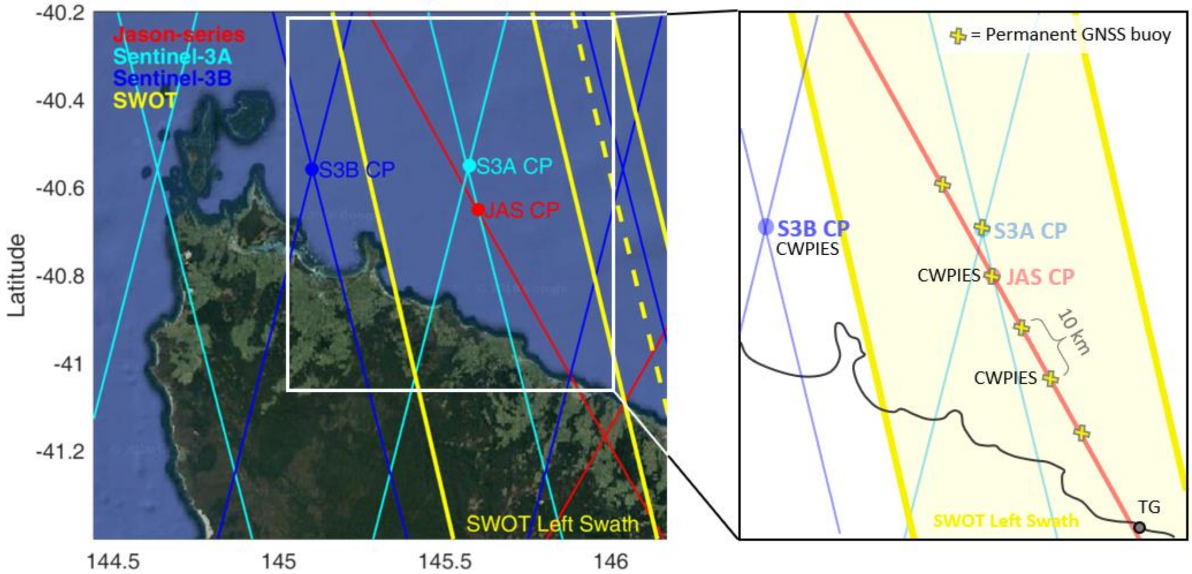

Figure 5. Example deployment configuration sampling along a Sentinel-6/Jason-CS track that is approximately aligned with the centre of the left SWAT swath. The deployments include 6 GNSS equipped buoys and 2 CWPIES. GNSS buoys are spaced at ~10 km along track, with the nearshore buoy site ~7 km from land.

Additional secondary targets that will contribute pointwise validation include enhancements (by way of inclusion of GNSS sensors) to the SOFS mooring in the sub-Antarctic (-46.6° S) and the Yongala mooring adjacent to the Australian Great Barrier reef (both located on the same 1-day fast sampling SWOT track as the Bass Strait validation facility).

6 Anticipated Results

As a primary output, we will produce observed SSH, current (U, V) and 3D wave spectra time series from numerous point locations in Bass Strait, combined with outputs from a high-resolution regional ocean model. Our flexible deployment approach enables specific questions to be addressed under the umbrella objective of cycle-by-cycle validation of SWOT SSH measurements. The desired outcome is a contribution to achieving a robust understanding of SWOT measurements and the data products that will follow.

Secondary results will include single point validation of SWOT SSH over the validation phase in the energic sub-Antarctic region of the Southern Ocean (SOFS mooring) and near the Australian Great Barrier Reef (Yongala mooring). Whilst of less significance than results from the dense array in Bass strait, these sites are located ~3000 km apart along the same 1-day repeat SWOT track.