Absolute and relative calibration of HY-2B satellite altimeter using the permanent Cal/Val infrastructure in Crete

Mertikas, S.P.[1]; Mingsen Lin[2] ; Chaofei Ma[2]; Dimitrios Piretzidis[3]; Yongjun Jia[2], Lei Yang[4], Yufei Zhang[2], Xenophon Frantzis[1],
Constas Kokolakis[3], Achilles Tripolitsiotis[3]
[1]Technical University of Crete, Geodesy and Geomatics Engineering Lab, University Campus, GR-73100, Chania, Crete, Greece, mail:smertikas@tuc.gr;
[2]National Satellite Ocean Application Service, P.R. China; [3]Space Geomatica, Chania, Greece; [4]First Institute of Oceanography, P.R. China.

Abstract

The HaiYang-2B (HY-2B) altimeter satellite has been launched by the Chinese National Satellite Ocean Application Service (NSOAS) on 24 October 2018, to monitor the marine dynamic environment. In this work, HY-2B observations have been assessed by the Permanent Facility for Altimetry Calibration in Crete, Greece and in the context of the Dragon Research Initiative of ESA. This action supports Earth observation research activities between European and Chinese institutes. At first, a preliminary analysis of the HY-2B Geophysical Data Records revealed inconsistencies between the 1-Hz and 20-Hz products, and in the Net Instrument Correction and the Ku-band range. These have been reported to and immediately corrected by NSOAS, resulting in a consistent release of the HY-2B GDR data.

Two years of altimetric observations of HY-2B have been calibrated using sea-surface Cal/Val sites in China and Crete. In Crete results will be given for: the CRS1 site in the southwest tip of Crete, along its descending Pass D.66, and the RDK1 site in the central south Crete for the calibration of its ascending pass A.161. In China, calibration has been performed using the Altimetry Calibration Cooperation Plan of China, implemented through the Wanshan Cal/Val sites, close to Hong Kong. Results are provided for HY-2B and HY-2C from the Chinese side. In addition, relative calibration of HY-2B has also been carried out around Crete with reference to Jason-3, Sentinel-3A and Sentinel-3B. Finally, an assessment of the HY-2B's microwave radiometer has been performed by comparing radiometric tropospheric delays with tropospheric delays derived by the ECMWF model and the permanent GNSS stations in Crete.

1. What is Fiducial Reference Measurements for Altimetry?

Cal/Val results
Traceable to:
- SI Standards,
- With Metrology standards.
(i.e., light speed, atomic time)

Measurement Uncertainty Revisited
-Critically review current Cal/Val methodology;
-Identify each constituent of uncertainty ;
-Documented & unbroken chain of calibrations;
-Connect uncertainty to SI-traceable measurements.

Fiducial Reference Measurements
-Establish new procedures for Cal/Val uncertainty budget,
-Results well-characterized and reliable in the long-term,
-Comparable worldwide;
-Impervious to instrument, setting, location, conditions, …
-Standards, procedures, practices for FRM for altimetry.

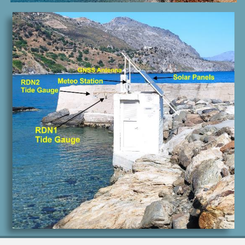
2. Why Need FRM for altimetry now?

- ✓ To build up **objective** & **reliable** record for Earth observation;
- ✓ **Trace observations** in the long term;
- ✓ **Compare measurements** world-wide;
- ✓ Connect to undisputed reference and measurement systems.

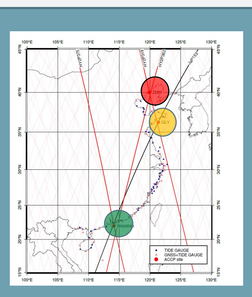
Accuracy	In scientific and monitoring data we produce and evaluate.	Science
Accuracy	Information presented to the Public for understanding effects of sea level rise to their lives.	People
Accuracy	In helping make the **right** Decisions, and put into action the **right** Policies.	Future

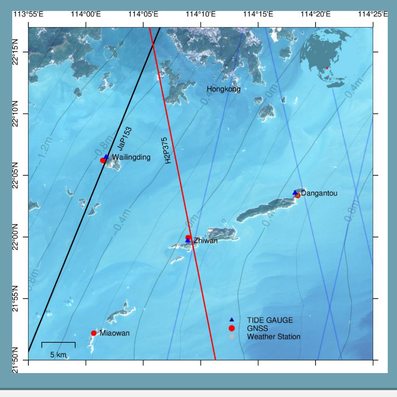
3. Permanent Satellite Altimetry Calibration Facilities in Europe and China

EUROPE

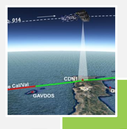


China





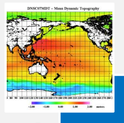
4. Constituents influencing Cal/Val Uncertainties



Site Selection
- Repeat Cycle
- Across-track distance
- Land contamination
- Water Depth
- Directional errors
- Multi-mission
- Reference surfaces
- Accessibility
- Security
- Ground stability
- Geodetic ties
- GNSS visibility
- Power supply & Communications

Absolute positioning
- Diverse GNSS satellites
- Diverse receivers & antennas
- Absolute GNSS antenna calibration
- 30s sampling rate
- 20 Hz high-rate
- Reference frames
- Relative & absolute positioning
- Height diffs <2mm
- Diverse positioning systems (i.e., GNSS, DORIS, SLR, etc.)
- UTC time for time tagging
- At least 2-3 years of continuous operation.

Atmospheric Delays
- GNSS-Derived ionospheric & zenith tropospheric delays at the time of satellite overpass
- Operation of meteo sensors
- Validation w.r.t. global/regional modeling
- Radiosondes, photometers, radiometers measurements
- OLCI observations.



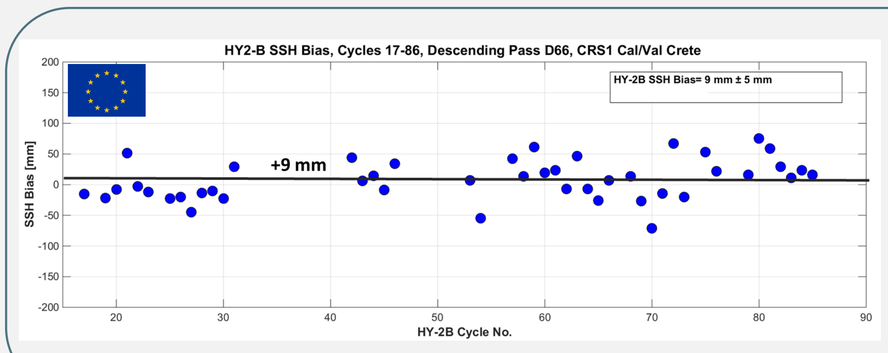
Geophysical effects
- Models for earth tides (solid earth, ocean tidal loading, pole tide) shall follow IERS conventions
- Establish reference geoid, MSS, MDT surfaces
- Validate reference surface with local/regional marine/aerial/terrestrial surveys

Water level determination
- Multiple (at least three) tide gauges of diverse measuring principle (radar, acoustic, pressure, floating).
- Geodetic ties between GNSS and tide gauge sensors via spirit leveling surveys with ± 1mm
- Calibration certificates from manufacturers for repeatability, reproducibility, hysteresis, drift, non-linearity, etc.
- Validation of instrument's performance, by the Cal/Val site operator, prior its permanent installation
- Field validation experiments to be conducted at least every 6 moths using a reference instrument
- Relative field calibration between operating tide gauges
- At least 1 hour of water level reading centered to the satellite overpass time of closest approach.

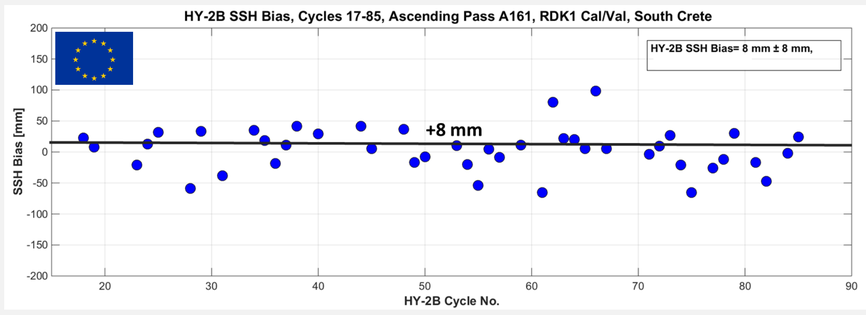
FRM Uncertainty Calculation

Description	CRS1	RDK1
Tide gauge Sensor	± 4 mm	± 6 mm
Repeatability	± 2.53 mm	± 2.53 mm
Zero-point reference	± 2.50 mm	± 2.50 mm
GNSS Receiver	± 3.46 mm	± 3.46 mm
GNSS Repeatability	± 0.08 mm	± 0.09 mm
GNSS ARP	± 4.04 mm	± 4.04 mm
GNSS Solution	± 0.08 mm	± 0.13 mm
GNSS Velocity	± 1.96 mm	± 4.55 mm
GNSS Integration	± 3.75 mm	± 3.75 mm
Control Ties	± 3.75 mm	± 3.75 mm
Reference Surfaces	± 42.00 mm	± 47.00 mm
Final Water Level	± 7.50 mm	± 7.50 mm
Geoid Slope	± 5.77 mm	± 5.77 mm
Processing	± 0.29 mm	± 0.29 mm
Unaccounted Effects	± 11.55 mm	± 11.55 mm
Uncertainty Budget	± 45.41 mm	± 50.44 mm

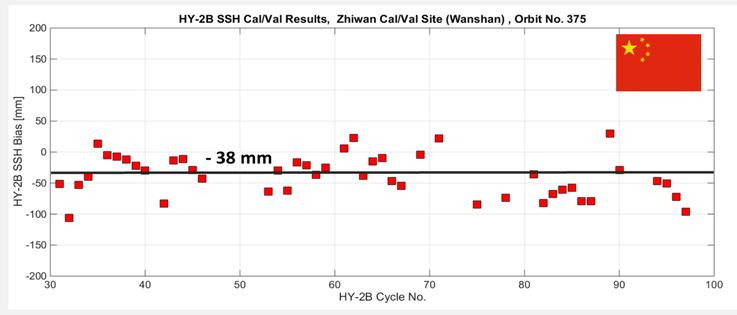
5. HY-2B Sea Surface Height Calibration Results



HY-2B SSH Bias: +9 mm ± 5 mm (FRM Uncertainty: ± 45 mm), CRS1

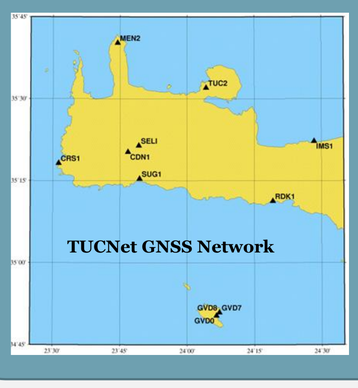


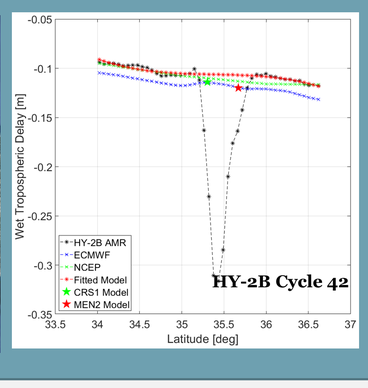
HY-2B SSH Bias: +8 mm ± 8 mm (FRM Uncertainty: ± 50 mm), RDK1



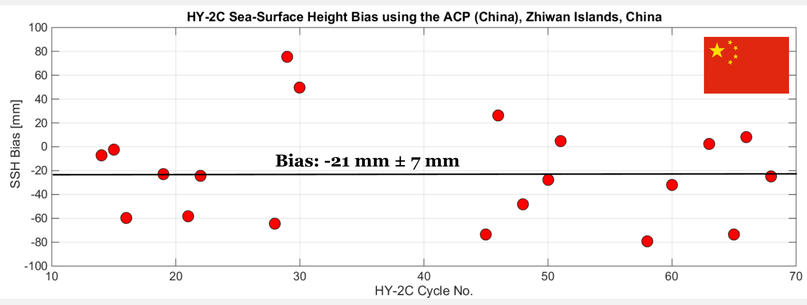
HY-2B SSH Bias: -38 mm ± 3 mm (FRM Uncertainty: ± 50 mm), Wanshan-Zhiwan

6. HY-2B Microwave Radiometer Calibration





Difference HY-2B – GNSS Delays	Average	STD
AMR – CRS1	-7 mm	± 27 mm
AMR – MEN1	+7 mm	± 30 mm
AMR – ECMWF	+3 mm	± 24 mm
AMR – NCEP	-13 mm	± 25 mm



7. Conclusions

- ➢ Joint effort to calibrate European & Chinese satellite altimeters;
- ➢ Analyze Fiducial Reference Measurements Uncertainty at Chinese Cal/Val;
- ➢ Extend Cal/Val to HY-2C, HY-2D, Sentinel-6 MF, etc.;
- ➢ Standardize the Cal/Val methodology;
- ➢ Cross-calibrate Diverse Missions;
- ➢ Joint Journal Publication.

Acknowledgments:
Part of this work has been produced with the financial assistance of the European Union and the European Space Agency (Contract No. 4000136863/21/I-NB). The views expressed herein can in no way be taken to reflect the official opinion of the European Union and/or European Space Agency.