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

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Abstract

This research and collaboration work aims at the calibration and validation (Cal/Val) of the Chinese HY-2B satellite altimeter based upon two permanent Cal/Val facilities: (1) the China Altimetry Calibration Cooperation Plan in Qingdao, Bohai Sea and the Wanshan islands, China and (2) the Permanent Facility for Altimetry Calibration established by the European Space Agency in Crete, Greece. The HY-2B altimeter and its radiometer have been calibrated and monitored using uniform, standardized procedures, protocols and best practices and also built upon trusted and indisputable reference standards at both Cal/Val infrastructures in Europe and China. The HY-2B altimeter is thus monitored in a coordinated, absolute, homogeneous, long-term and worldwide manner. Calibration of altimeters is accomplished by examining satellite observations in open seas against reference measurements. Comparisons are established through precise satellite positioning, water level observations, GPS buoys and reference models (geoid, mean dynamic topography, earth tides, troposphere and ionosphere) all defined at the Cal/Val sites. In this work, the final uncertainty for altimeter bias will be attributed to several individual sources of uncertainty, coming from observations in water level, atmosphere, absolute positioning, reference surface models, transfer of heights from Cal/Val sites to satellite observations, etc. Through this project, the procedures, protocols and best practices, originally developed in the course of the ESA FRM4ALT project are updated, upgraded and followed at both Cal/Val facilities in Europe and China. All in all, the HY-2B satellite altimeter observes sea level quite well and within its specifications.

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.

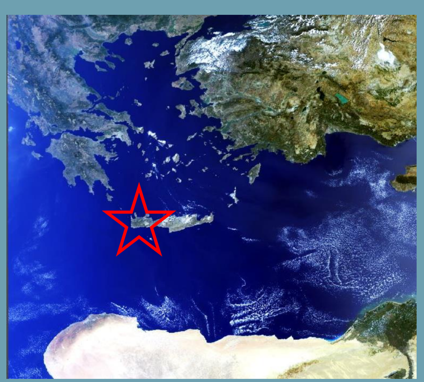
2. Why Need FRM for altimetry now?

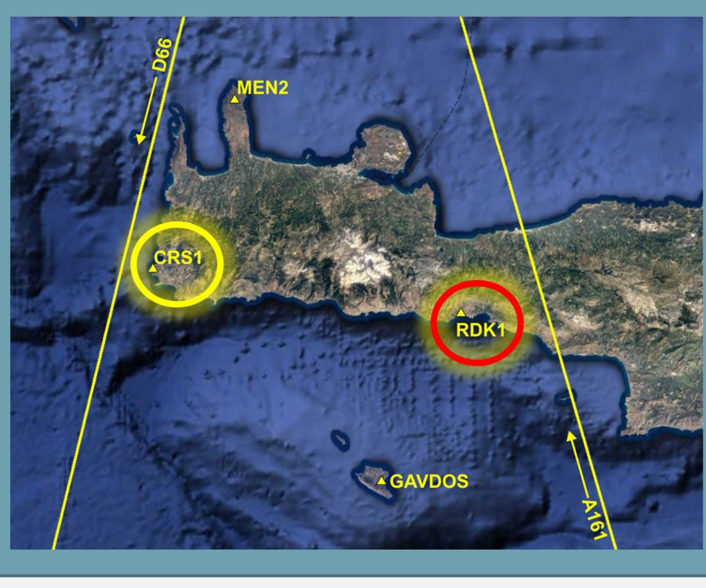
- ✓ To build up **objective** & **reliable** record for Earth observation;
- ✓ **Trace observations** in the long term;
- ✓ **Compare measurements** world-wide;
- ✓ Connect to undisputed reference and measurement systems.

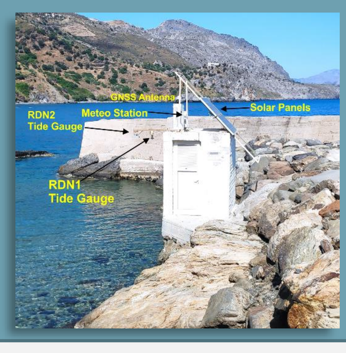
Accuracy	In scientific and monitoring data we produce and evaluate.	Science
Accuracy	Information presented to the Public for understanding effects of sea level rise to their lives.	People
Accuracy	In helping make the **right** Decisions, and put into action the **right** Policies.	Future

3. Permanent Satellite Altimetry Calibration Facilities in Europe and China

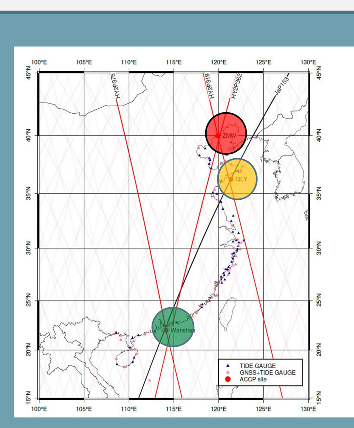
EUROPE

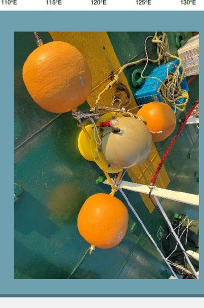


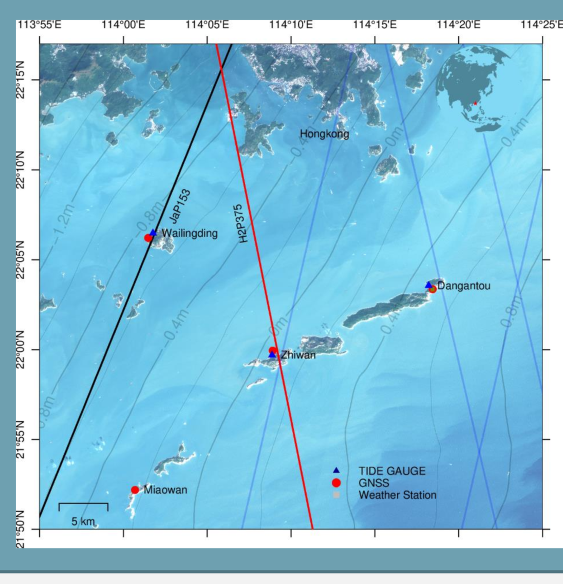


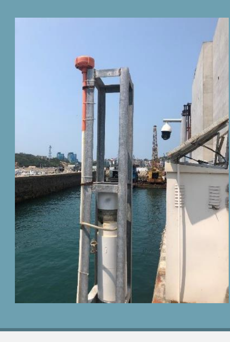


China



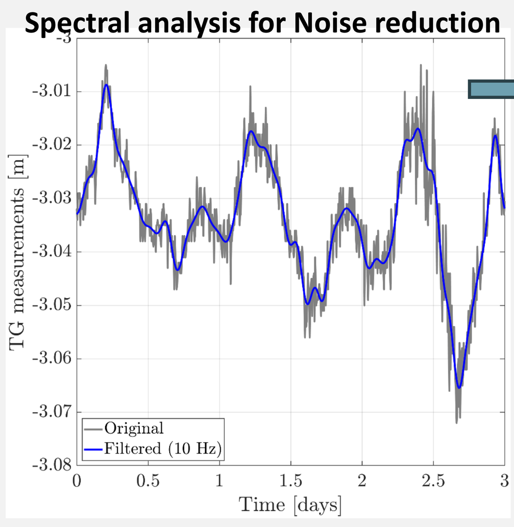


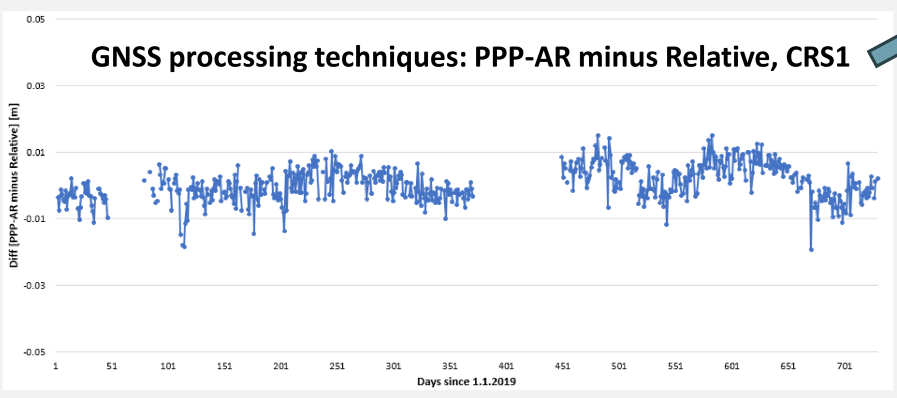




4. FRM Uncertainty Calculation

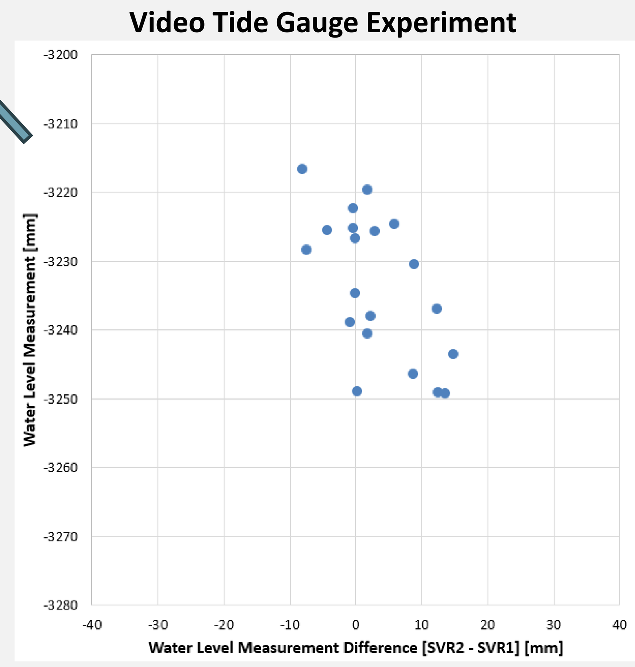
Spectral analysis for Noise reduction

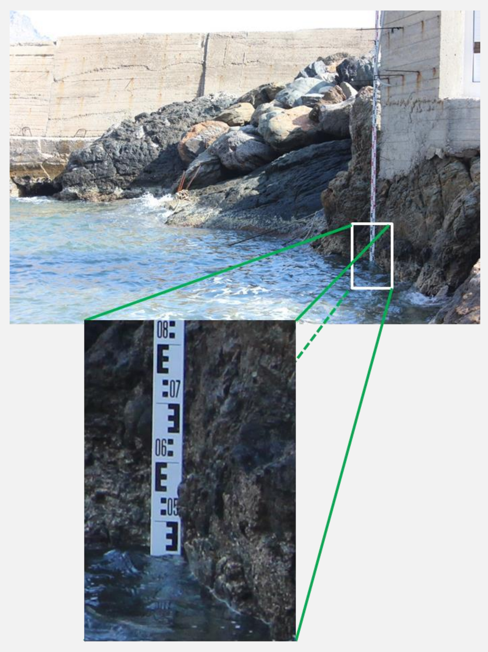




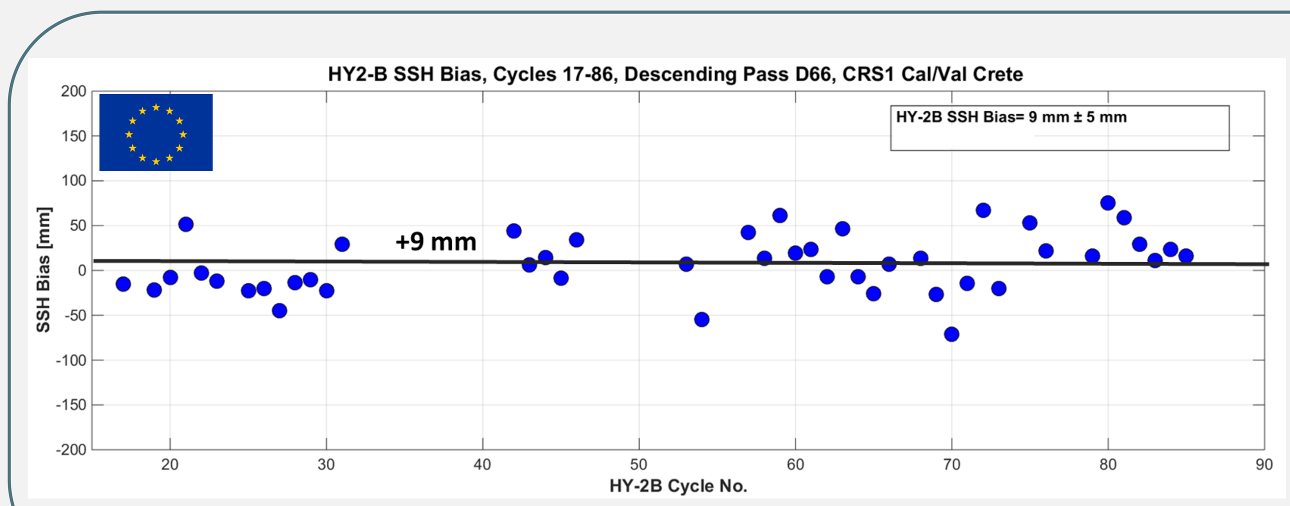
Description	CRS1	RDK1	Wanshan
Tide-gauge sensor	±4.00 mm	±6.00 mm	±1.00 mm
Repeatability	±2.53 mm	±2.53 mm	±2.53 mm
Zero-point reference	±2.50 mm	±2.50 mm	±2.50 mm
GNSS receiver	±3.46 mm	±3.46 mm	±3.50 mm
GNSS repeatability	±0.08 mm	±0.09 mm	±0.10 mm
GNSS ARP	±4.04 mm	±4.04 mm	±5.00 mm
GNSS solution	±0.08 mm	±0.13 mm	±0.10 mm
GNSS velocity	±1.96 mm	±4.55 mm	±2.50 mm
GNSS integration	±3.75 mm	±3.75 mm	±3.75 mm
Control Ties	±0.09 mm	±0.10 mm	±0.28 mm
Reference Surfaces	±42.00 mm	±47.00 mm	±50.00 mm
Final Water Level	±7.50 mm	±7.50 mm	±7.50 mm
Geoid slope	±5.77 mm	±5.77 mm	±3.50 mm
Processing	±0.29 mm	±0.29 mm	±0.29 mm
Unaccounted effects	±11.55 mm	±11.55 mm	±11.55 mm
Uncertainty Budget	±45.41 mm	±50.44 mm	±52.66 mm

Video Tide Gauge Experiment

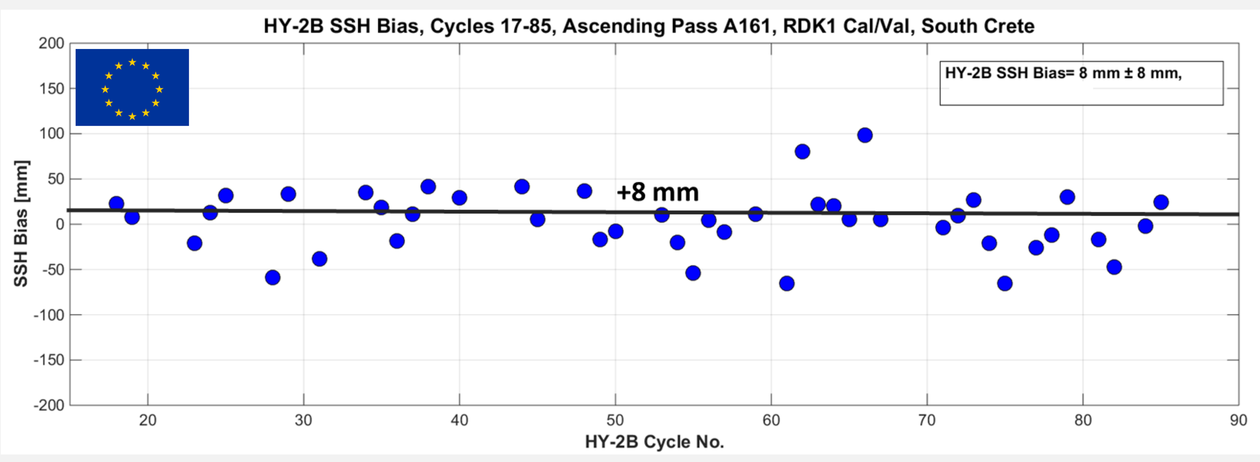




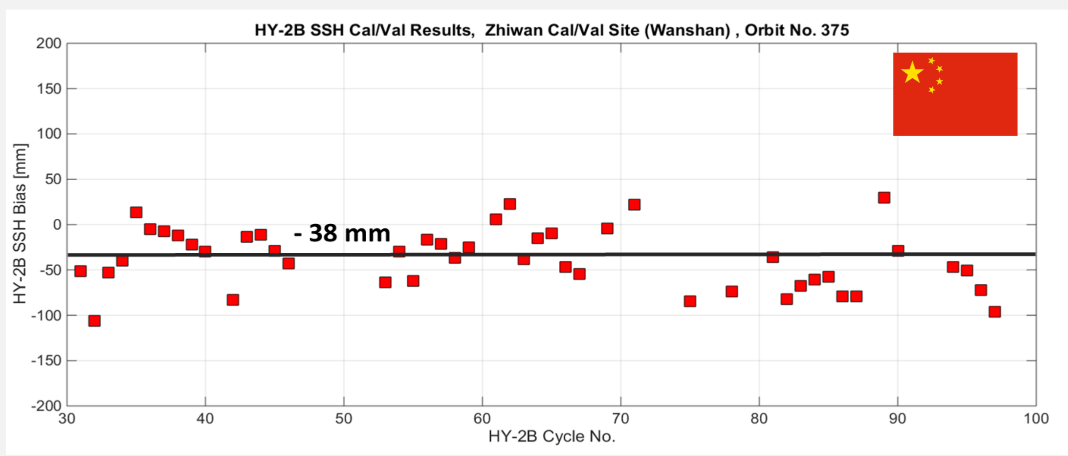
5. HY-2B Sea Surface Height Calibration Results



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

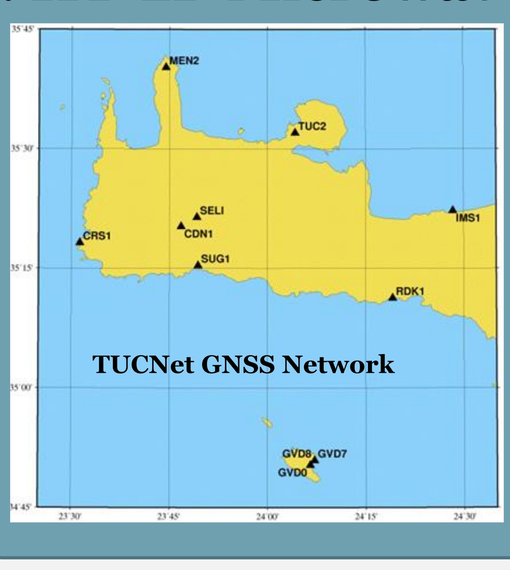


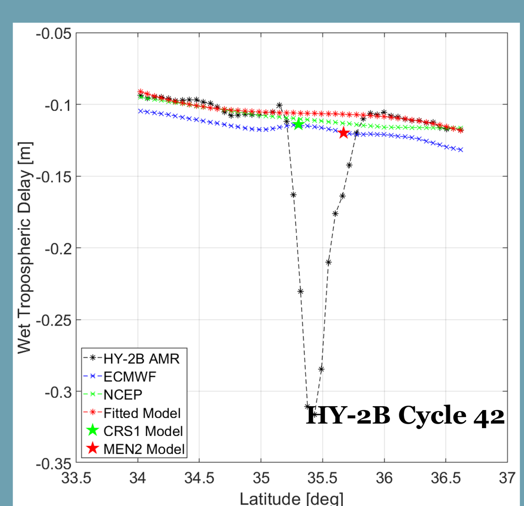
HY-2B SSH Bias: +8 mm ± 8 mm (FRM Uncertainty: ± 50 mm), RDK1



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

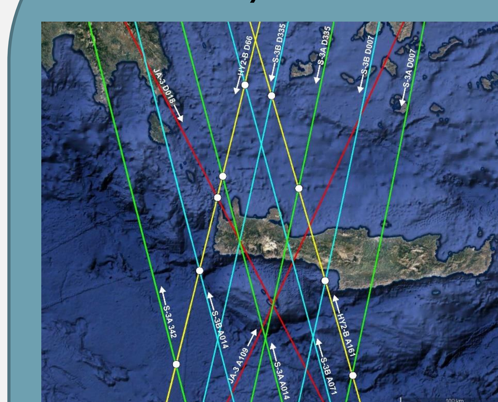
6. HY-2B Microwave Radiometer Calibration





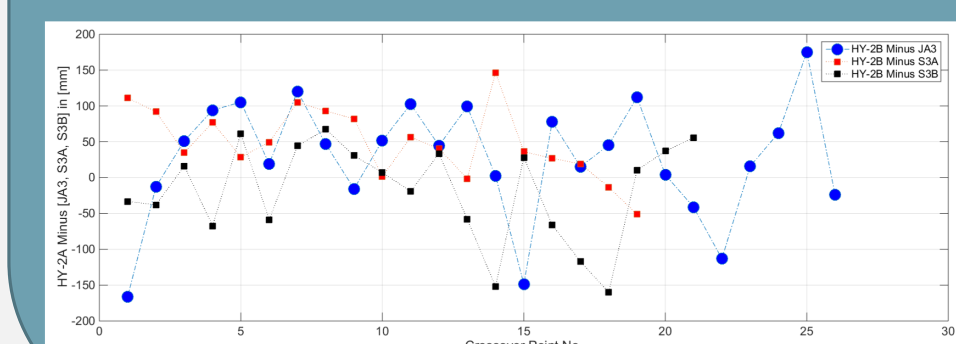
Difference HY-2B – GNSS Delays	Average	STD
AMR – CRS1	-7 mm	± 27 mm
AMR – MEN1	+7 mm	± 30 mm
AMR – ECMWF	+3 mm	± 24 mm
AMR – NCEP	-13 mm	± 25 mm

7. Crossover Analysis



- ➢ Temporal distance <2 days
- ➢ Period: Jan.2019 – Dec. 2021
- ➢ Few samples→ Statistically unreliable

SSH Diff.	Average	N(samples)
HY2B – Jason-3	+33 ± 18mm	11
HY2B – S3A	+46 ± 11mm	14
HY2B – S3B	-5 ± 15mm	11



8. 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
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GeoMatLab

NSOAS National Satellite Ocean Application Service

FIO

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