Satellite Altimetry Sea Surface Height Anomaly Processing at the Naval Oceanographic Office Altimetry Data Fusion Center

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Jason-2

SARAL /Altika

Cryosat-2

Abstract

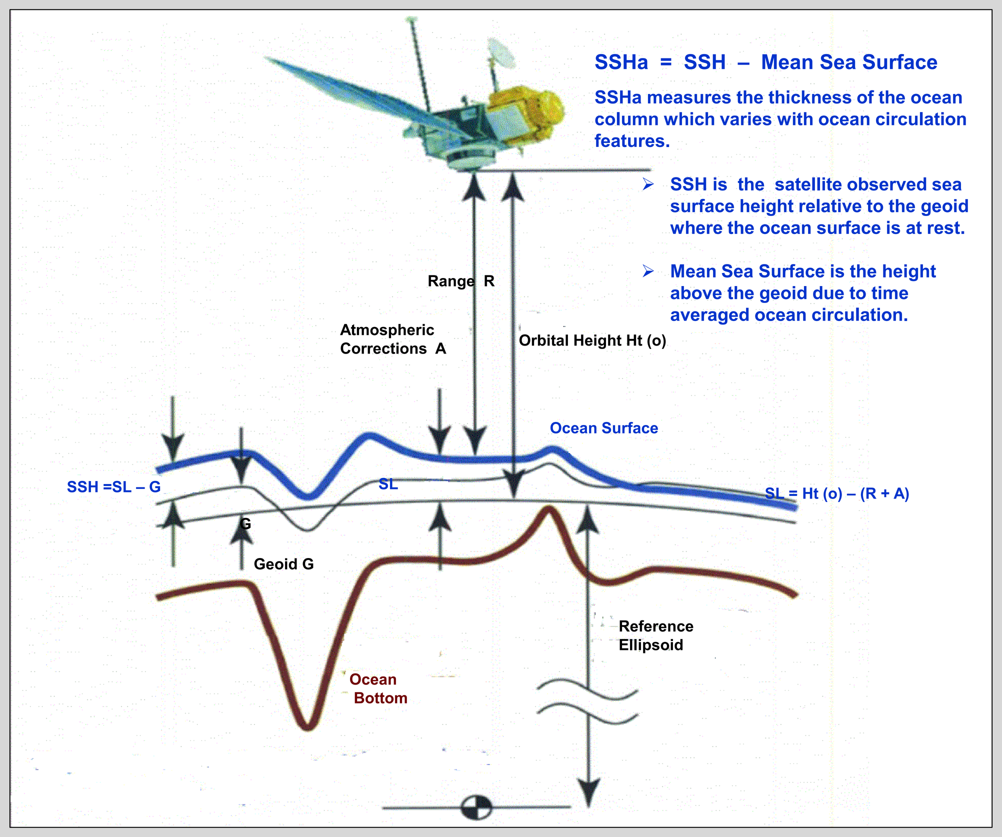
The Altimetry Data Fusion Center (ADFC) at the Naval Oceanographic Office processes, evaluates, produces, and disseminates near real-time altimetry-derived Sea Surface Height Anomaly (SSHa) products for assimilation into operational oceanographic models. The ADFC produces and distributes timely, accurate, and quality-controlled altimetry SSHa observations to agencies in the Department of Defense, the National Centers for Environmental Prediction, the National Aeronautics and Space Administration, and other civilian agencies. Current SSHa products provided by the ADFC utilize altimetry satellite data from the Jason-2, SARAL/Altika, and Cryosat-2 missions.

The ADFC produces ~ 50,000 SSHa observations per satellite per day. SSHa data latency is 24 to 48 hours from the satellite observation time. SSHa data are calculated by differencing along-track SSH observations (time and position) to a long term along-track reference mean. SSHa data are assimilated into ocean models that provide ocean circulation and acoustic predictions. SSHa observations measure the thickness of the ocean column, which varies with ocean mesoscale features, and are also the primary input into the upper ocean heat content analysis for the hurricane intensity models. These models are used to predict ocean energy potential for tropical storms.

Satellite data outputs are verified and compared with the other operational satellite outputs for the fraction/percent data used, orbit correction applied, and crossover RMS difference comparisons. Also, the ADFC is currently conducting a study, to be operationalized in the future, for satellite SSHa comparisons with in situ temperature-salinity profiles. This study compares satellite altimeter SSHa to steric height anomaly calculated from quality controlled temperature-salinity profiles. The two data sets are matched using a range of time and distance constraints, and the differences are examined. These comparisons can be used to identify future discrepancies or anomalies found in either data source. Ultimately these results can assist to identify sensor measurement constraints and improve satellite inputs to ocean forecast models.

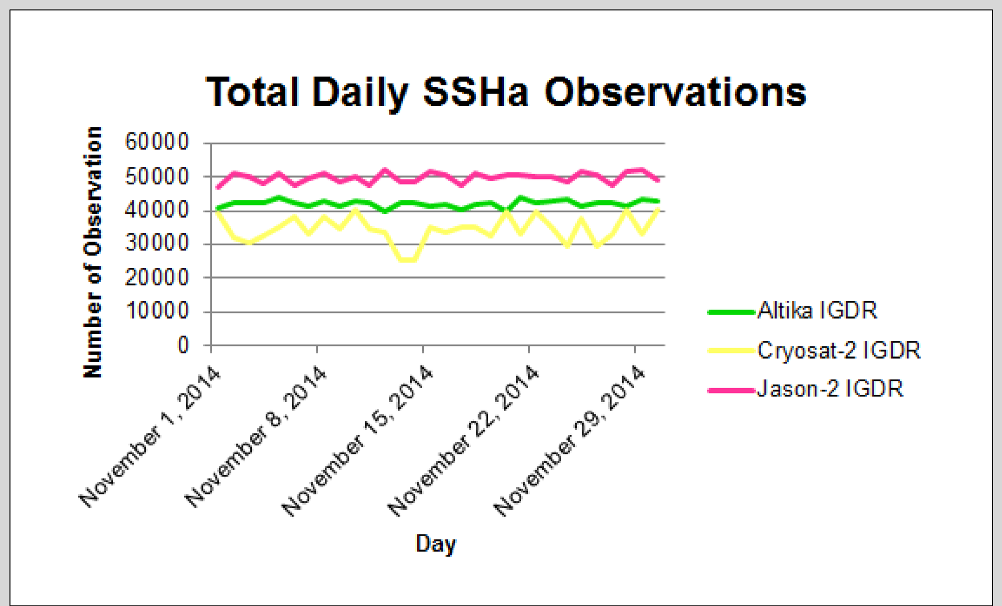
Sea Surface Height Anomaly (SSHa)

SSHa is measured as the difference between the satellite observed SSH and the mean sea surface. The mean sea surface is computed from altimetry data averaged over time (years). The SSHa is calculated by differencing along–track SSH observations (time & position) to a long term along-track reference mean. This methodology has been utilized in the ADFC since 1997. Data latency is 24 - 48 hours from the satellite observation time. SSHa files are produced once per day for each available Altimetry Satellite Geophysical Data Record type.



Number of SSHa Observations

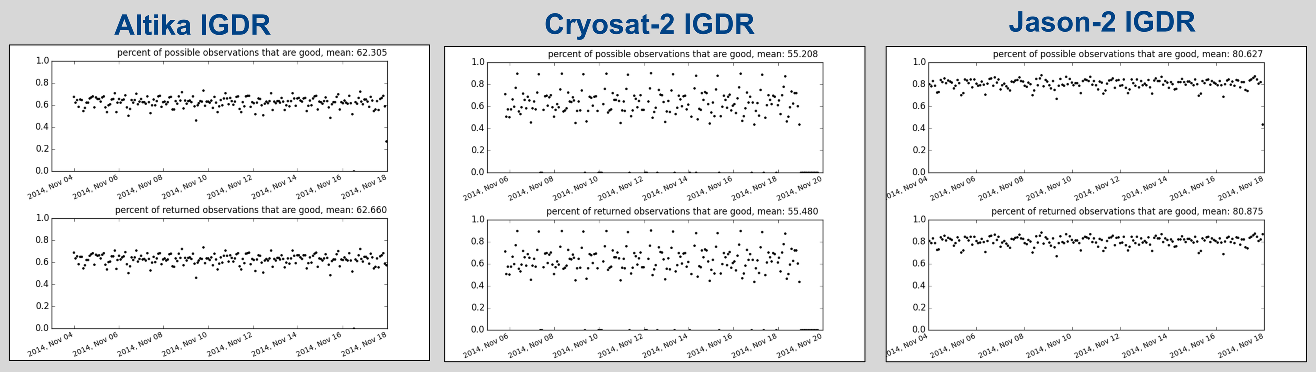
The number of Altika observations tend to be lower than Jason-2, because Altika passes over more ice covered areas. Altika observations are higher than Cryosat-2, because Cryosat-2 has no SSHa observations generated while in SAR mode.



Satellite Data Output Comparison

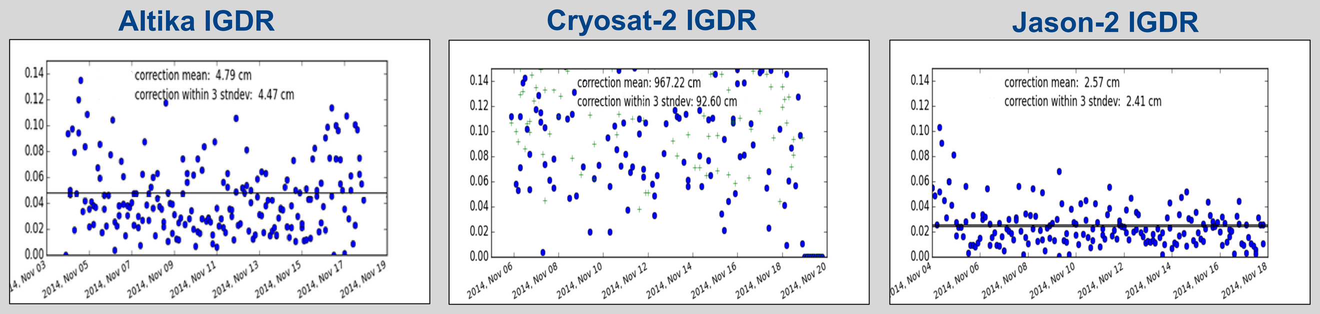
Fraction/Percent Data Used

Fraction of all data that is good (top). Fraction of all reference ground track points not flagged as suspect (bottom).

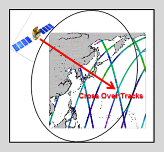


Orbital Corrections Applied

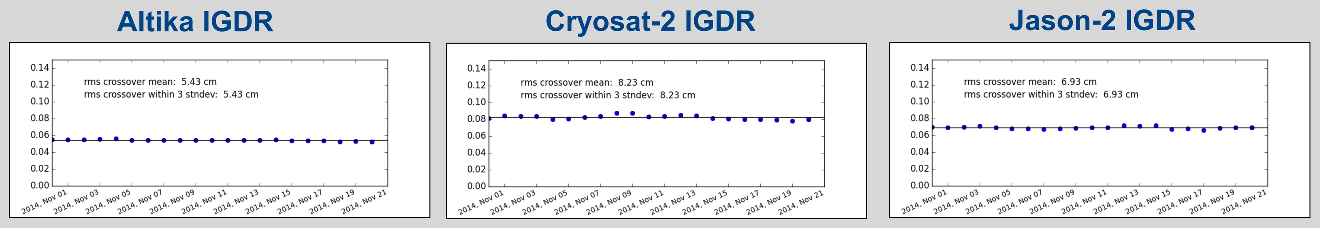
The estimated orbit error amplitude (m) applied for each satellite revolution. The average orbit error estimates for Altika and Cryosat-2 are higher than Jason-2. Jason-2 has a higher altitude than Altika and Cryosat-2, thus reducing the interactions with Earth's atmosphere and gravity making the orbit corrections more precise.



Satellite Crossover RMS Comparisons

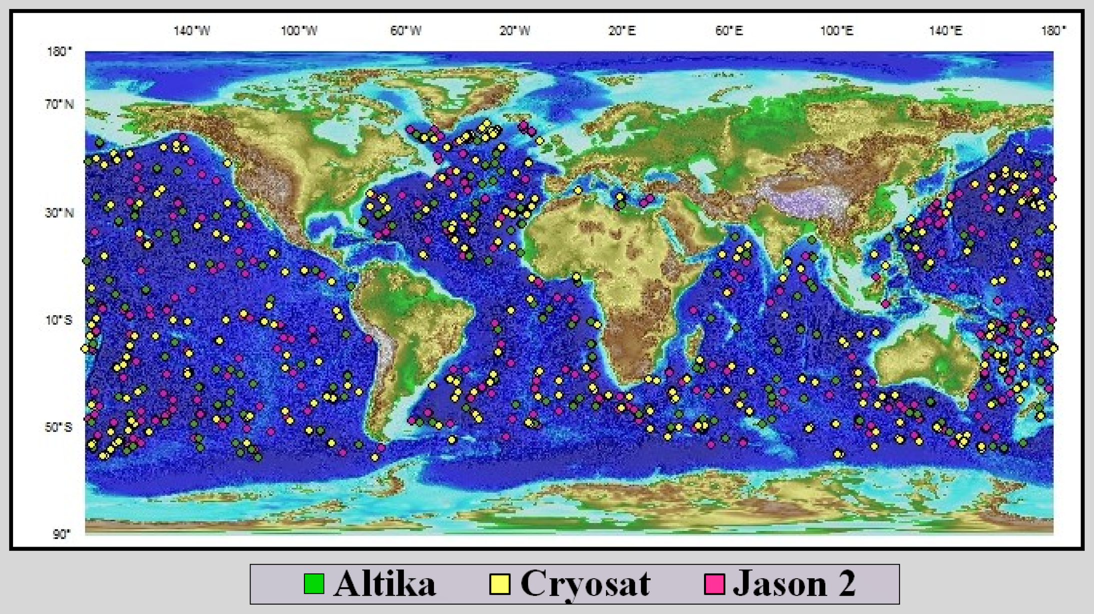


The RMS crossover difference comparisons are between the observations and a linear fit. Checks for outlier values. Allows monitoring of RMS crossover observations over time with RMS values on the scale of centimeters.

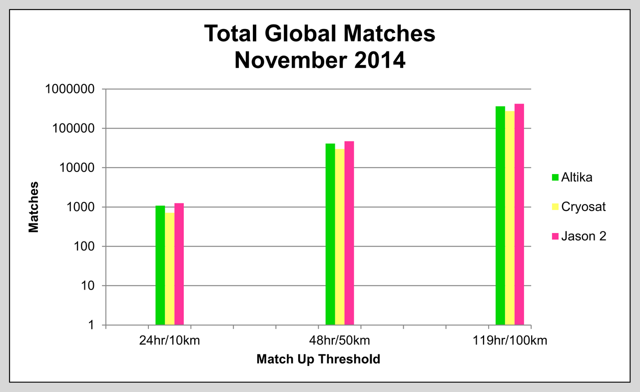


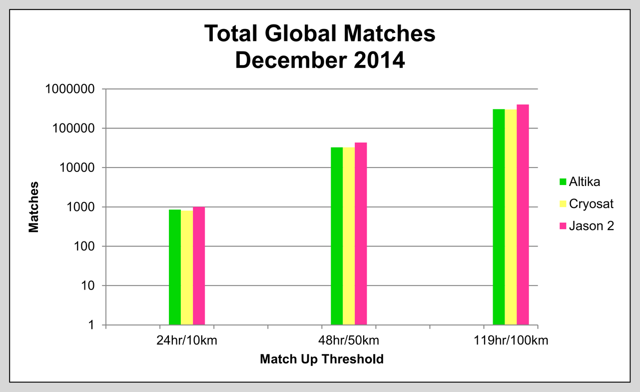
Satellite-Profile Difference Comparisons

Satellite-Profile Global Matches

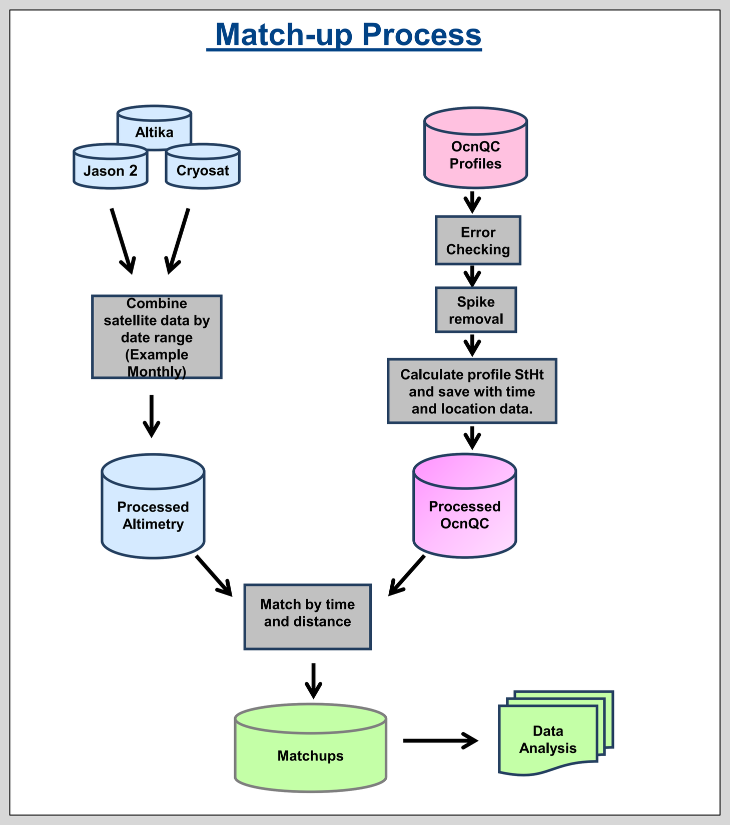


Example of satellite-profiles matches for 1 month. The constraint for the match-up data in this graphic is 24 hours and 10 kilometers.





Match-up Process



Steric Height Anomaly (SHa)

The Steric height anomaly is the difference between the height of a given water column and the height of an ideal 0°C, 35 salinity column, where the heights are integrated between specified pressure surfaces. Temperature, salinity, and depth control the density/pressure (thickness) of the water column. Changes in the Steric height are caused by changes in the density/pressure of the water column.

Steric Height anomaly calculation:

1) Profile is not used if the first level is below 20m.

2) Calculate the pressure at each depth.

3) Calculate specific volume anomaly (Svan) at each level. This is the difference in volume between water at (T,S,P) and water at (0,35,P).

$$\text{Svan} = \frac{1}{\text{Density (T,S,P)}} - \frac{1}{\text{Density (0,35,P)}}$$

4) Temperature/salinity profiles must go to 1000m depth (level of no motion).

5) Calculate steric height from surface to 1000m.

$$\text{SH} = [\text{ Depth (k+1)} - \text{Depth (k) }] \times [\text{ Svan (k+1)} + \text{Svan (k) }]$$

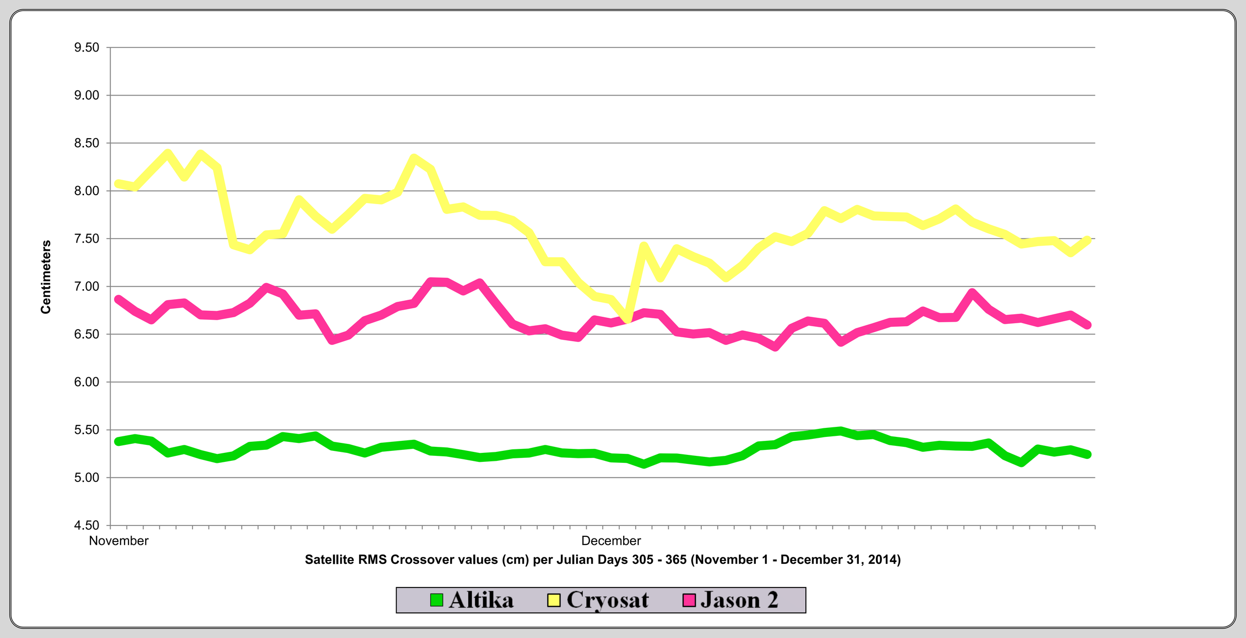
6) Sum all the levels from surface to 1000m to obtain steric height.

7) Subtract a Generalized Digital Environmental Model (GDEM) mean steric height from the total profile steric height to obtain steric height anomaly. GDEM is an annual mean valid for the profile's latitude and longitude location.

SSHa and SHa RMS Comparison Results

- Close correlation between satellite Sea Surface Height Anomaly crossover RMS and the satellite-profile Steric Height Anomaly RMS differences.
- RMS improves as time and distance constraints are tightened.
- These comparisons can be used to identify anomalies found in either data source.
- Once these results are operationalized, they can assist to identify sensor measurement constraints and improve satellite inputs to ocean forecast models in near real-time.

Satellite Crossover RMS Comparisons



Satellite – Profiles RMS Comparisons