Understanding the Level of Error within Sea State Bias Models

Alexa A. Putnam[1]; R. Steven Nerem[1]; Shailen Desai[2]
[1]University of Colorado Boulder, [2]Jet Propulsion Laboratory | alexa.putnam@colorado.edu | OSTST 2019

Abstract

The sea state bias remains the largest error for estimating sea level using satellite radar altimetry. Empirical approaches using in-flight observations of sea surface height are typically used to determine models for the sea state bias (SSB). These observations contain signals such as dynamic ocean topography, orbit errors, as well as ionosphere, troposphere, tide and mean sea surface modeling errors, which all contribute to errors in the SSB estimates. We investigate the relative contribution of these error sources to provide an error assessment of the SSB models.

In an effort to evaluate errors in the SSB estimates, we have examined the correlation between components within sea level anomaly measurements and the model variables, model estimate variation, and the dependency on the span of data used for estimation.

Mapping Technique

We employ a non-parametric approach that implements inverse bilinear interpolation of significant wave height (SWH) and wind speed (WS) to solve for the unknown sea state bias model using least squares (referred to as *ibiSSB*). The observable consists of sea level anomaly measurements uncorrected for the SSB. The SSB is estimated at discrete nodes of SWH and WS without any constraints, using bilinear interpolation of the observed SWH and WS

Table 1. Modeling methods

	Model	Description
1	**Direct**	Determined using along-track data
2	**Combined -dynamic**	Determined from along-track data together with cycle-averaged mean global SSH in 3-degree equal-area grids.
3	**Collinear**	Determined using collinear data ($\Delta t \approx 10$ days)
4	**Crossover**	Determined using crossover data ($\Delta t \leq 5$ days)

The ibiSSB mapping technique was applied to along-track (direct), collinear and crossover measurements(1). Another modeling technique (combined-dynamic) was developed in an attempt to remove aliasing effects. It is the combined solution of the ibiSSB technique using along-track data modeled with temporal and spatial variations of sea surface height (SSH).

References

(1) Scharroo, R. Radar System Database (RADS). Version 4.3.6. [Software] .
(2) Tran N., Phillips S., Poisson J-C., Urien S., Bronner E. Picot N. Impact of GDR_D Standards on SSB Corrections. Poster presented at: OSTST Meeting; 2012; Venice.

Aliasing Effects

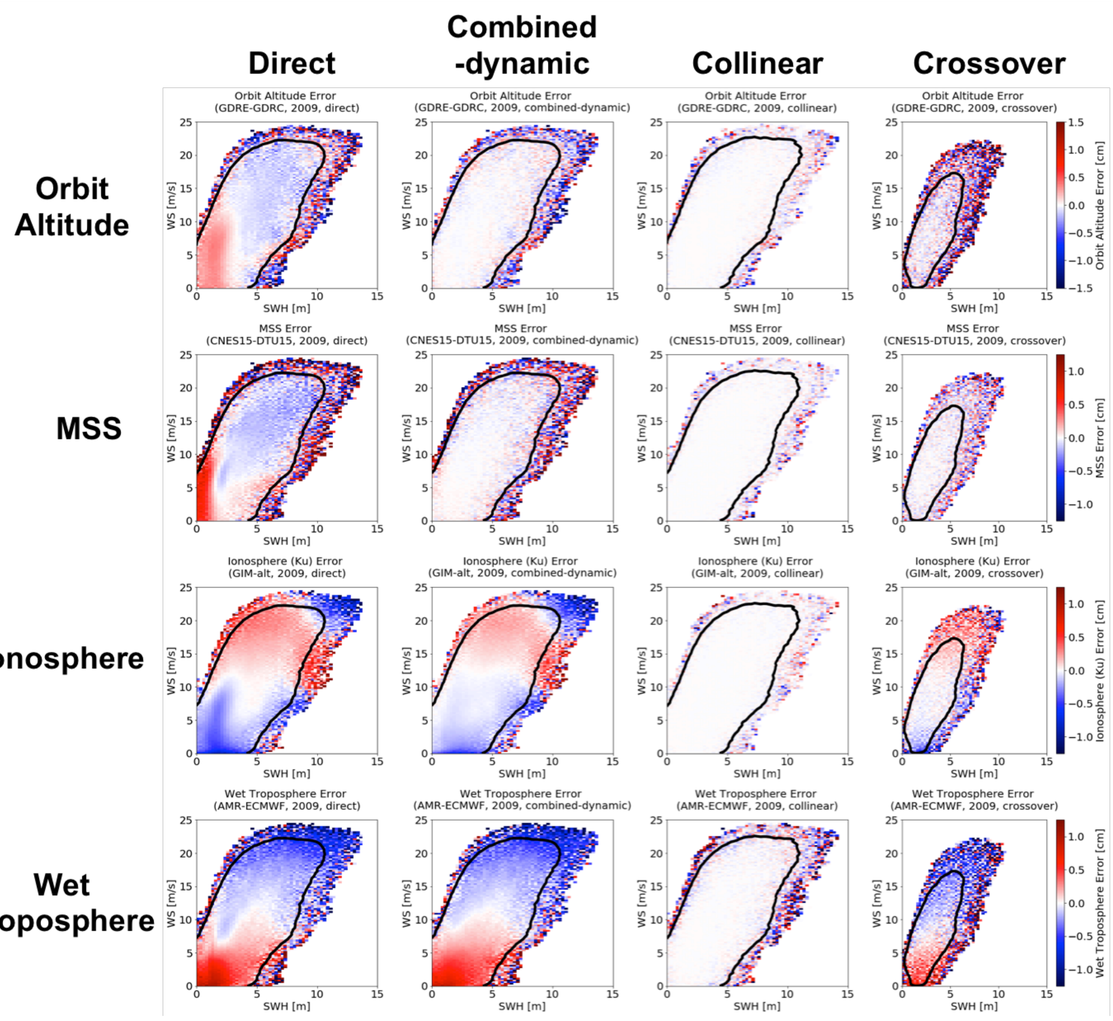

Figure 1. Aliasing effects caused by errors within sea level corrections as a function of significant wave height and wind speed using ibiSSB for 2009 Jason-2 data. The black line outlines the bins that have at least 250 observations to estimate the node value.

Sensitivity to Noise in the Independent Variables

Table 2. Root mean square error of the difference between an SSB model that has been mapped using measurements of SWH and WS from the product output and an SSB model that has been mapped with added random noise derived from the RMS of SWH and WS, also provided by the product.

Jason-2	Direct	Combined-dynamic	Collinear	Crossover
2009 Model	2.03 cm	3.48 cm	1.68 cm	3.73 cm
2-year Model	2.09 cm	3.72 cm	1.70 cm	3.94 cm
3-year Model	2.09 cm	3.71 cm	1.64 cm	3.72 cm

Crossvalidation

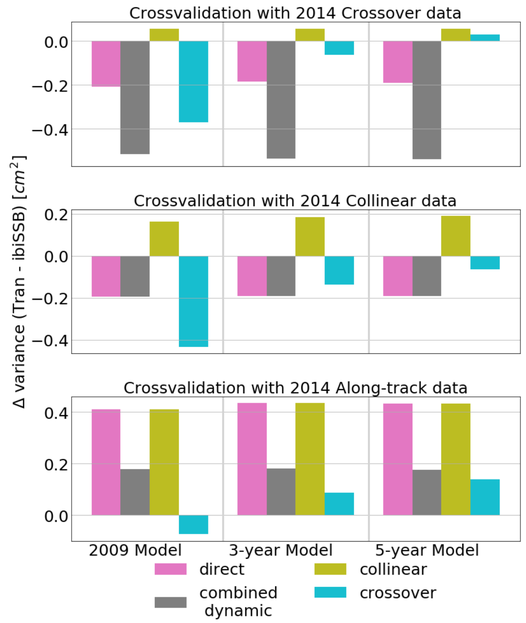

Figure 2. Mean of the difference in variance of the residuals for SSB models evaluated at SWH and WS measurements from Jason-2 2014 data. Differences are found by subtracting residuals of the four ibiSSB models from residuals using 'SSB_J2_New'(2).

Conclusions

We developed an SSB mapping technique to evaluate errors in SSB estimates.

Results:
- The collinear approach is the least sensitive to aliasing errors and noise in the variables.
- The combined-dynamic approach outperforms the direct approach with respect to removing spatially-correlated errors.
- The benefits of differencing sea level anomaly measurements using the crossover approach are first realized with more than one year of data used for SSB estimation.

Further Questions:
- What is the correlation between temporal resolution and the number of observations per bin for crossover models?
- Does the combined-dynamic approach remove important sea state information required to produce an accurate SSB model?
- Can the ibiSSB mapping technique be improved to provide better resolution to peripheral bins?