Revised sea state bias models for retracked TOPEX altimeter data

Hui Feng[1], Doug Vandemark[1], and Phil Callahan[2]

University of New Hampshire [1]Ocean Process Analysis Lab ,University of New Hampshire, Durham, NH, USA

[2]JPL, Pasadena, CA, USA

Objectives

- Understand details within the TOPEX retracking data (RGDR) released by JPL in early 2015 including the proposed range corrections
- Develop TOPEX Ku-band 2D and 3D Sea State Bias (SSB) correction models for both RGDR and MGDR data
- Provide a comprehensive data evaluation
- Recommend optimal and sufficient SSB models for climate record TOPEX data applications
- Release new SSB models for community evaluation

Methodology

- SSHA (sea surface height anomaly) is calculated in terms of the latest geophysical corrections, including the new GSFC std1410 orbit
- SSB models based on SPline(SP) nonparametric estimator (Feng et al., 2010) using direct SSHA data (Vandemark et al, 2002)
- SSB correction look-up tables were derived as follows for both Side A and Side B data:
  - Produce yearly SPSSB models in 2D (swh, altU10) and 3D SSB(swh, altU10, Tm_{02}) where Tm_{02} is the mean wave period from the Wavewatch 3 model (ver CFSR from IFREMER)
  - Final results are multi-year ensemble solutions for MGDR & RGDR (skewness= 0,0.1, derived (fit))

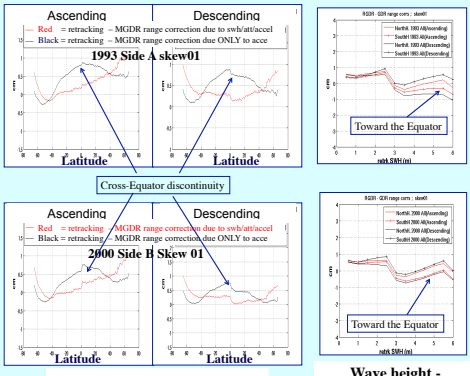
  Side A: **1993-1998 (cycles 21-232);** Side B: **1999-2002 (cycles 240-350)**

Result: Data Evaluation

- **PART 1:** Residual range correction differences observed between retracked RGDR and MGDR data (swh/att/accel) following Rodriguez and Martin (1994)
- **PART2:** SSB Model comparisons – RGDR compared to 'standard' MGDR CLS SSB2d developed with Linear Kernel Smoothing on collinear data (Tran et al. 2010)
- **PART3:** J1/Tx assessed for cal/val phase (J1 cycles 1-21; Tx 344-364) in terms of SSHA without SSB & SSHA with SSB corrections
- **PART 4:** Variance reduction (new SSB3d or SSB2d vs. CLS SSB2d) in MGDR and RGDR applications

Result PART 1: Resual range correction difference

between Tx RGDR(skew=0.1) and MGDR(swh/att/accl)



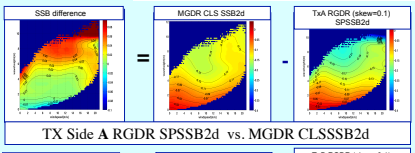
Latitude-dependency

Wave height - dependency

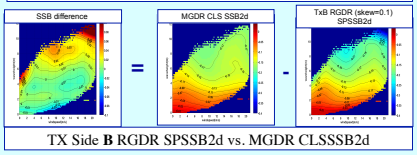
PART 1: Summary

- The residual range correction between RGDR(skew=0.1) and MGDR is higher than those reported by Rodriguez and Martin (1994) – reasons TBD.
- The residual range correction in skew=0.1 case is much lower than for the RGDR skew=fit case (not shown) - consistent with the MGDR swh/att/accel imposition of skew=0.1 (Hayne et al., 1994).
- Cross-equator range discontinuity is still seen due to sign change in range (i.e. height) rate, depending on whether a pass is descending or ascending.
- Some level of SWH-dependent residual range correction still associated with range rate, toward or departing from the equator.

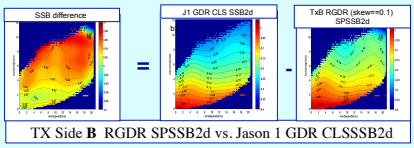
Result PART 2: 2D SSB model comparison



TX Side **A** RGDR SPSSB2d vs. MGDR CLSSSB2d



TX Side **B** RGDR SPSSB2d vs. MGDR CLSSSB2d



TX Side **B** RGDR SPSSB2d vs. Jason 1 GDR CLSSSB2d

PART 2: Summary

- TxA and TxB RGDR (skew=0.1) 2DSPSSB do show some significant difference, compared to the MGDR CLS SSB2d:

  1) in the domain SWH>4-5m & U10 >7-12m/s, the MGDR CLS 2DSSB(Hs, U10) has less structure with SWH, but RGDR 2DSSBs display richer structure

  2) at the lower U10 <2m/s, the RGDR 2DSSB displays more wind speed dependent feature than the MGDR CLS 2DSSB
- New TxB RGDR 2D SSB model is closer to Jason-1 GDR 2d SSB in terms of SWH sensitivity

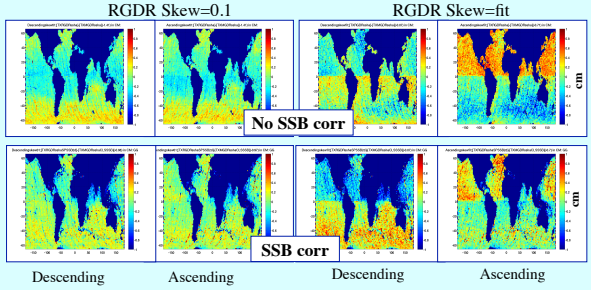
Result PART 3:

J1/Tx tandem cal/val phase evaluation (J1: cycles 1-21: Tx sideB: cycles 344-364)

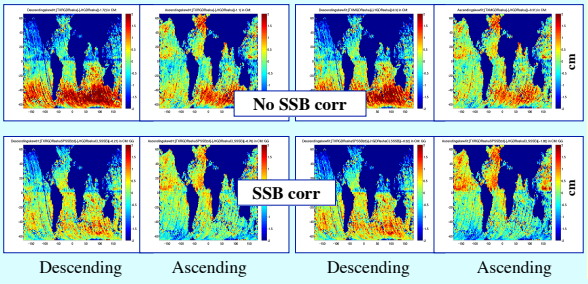
SSHA data used
- TX RGDR SSHA: the orbit: gsfc/std1410 GOT4.10tide
- TX MGDR SSHA: the orbit: gsfc/std1410 GOT4.10tide
- J1 GDR SSHA : the orbit: gsfc/std1204 GOT4.08tide

SSB corr. models applied
- TX RGDR: SPSSB2d
- TX MGDR: CLS SSB2d(Tran et al. 2010)
- J1 GDR CLS SSB2d (Tran et al. 2010)

Difference between Tx RGDR and Tx MGDR SSHA without/with SSB



Difference between Tx RGDR and J1 GDR SSHA without/with SSB

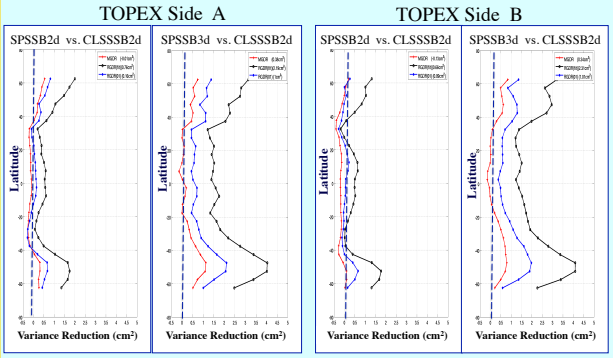


PART3 Summary

- TX RGDR (skew=fit) not a recommended option for application (excessive quadrant offsets)
- Compared to TX MGDR, RGDR (skew=0.1) SSHA with SSB correction applied has reduced quadrant offset
- TX RGDR (skew=0.1) after SSB correction looks fairly consistent with the J1 GDR

Result PART 4:

Latitude-dependent variance reduction on collinear SSHA difference



PART 4 : Summary

Briefly, one can expect modest improvement, mostly at high latitudes using the 2D RGDR (skew =0.1) SSB models versus the standard MGDR 2D SSB model when working with the RGDR data. Otherwise, the 3D SSB model improvement is more obvious and in line with gains seen for the Jason satellites when working with either the MGDR or RGDR datasets. Clearly one also needs the new SSB model in using RGDR (skew=fit) data.

References
- Feng et al., 2010. Splin based nonparametric estimation of the altimeter sea state bias correction, IEEE Geoscience and Remote Sensing Letters, vol. 7, issue 3, pp. 577-581.
- Tran et al., 2010. Overview andUpdate of the Sea State Bias Corrections for the Jason-2, Jason-1 and TOPEX Missions, Marine Geodesy, 33:S1, 348-362.
- Rascle and Ardhuin, 2013, global wave parameter database for geophysical applications. Part 2: Model validation with improved source term parameterization. Ocean Modelling, 70, 174–188.
- Rodriguez and Martin, 1994, Assessment of the TOPEX altimeter performance using waveform retracking, JGR,
- Hayne et al., 1994, The corrections for significant wave height and attitude effects in the TOPEX radar altimeter, , JGR.
- Vandemark et al., 2002, Direct estimation of sea state impacts on radar altimeter sea level mea- surements, Geophys. Res. Lett., 29(24), 2148, doi:10.1029/ 2002GL015776

Acknowledgements : JPL and NASA's Science Directorate Physical Oceanography Program