Evaluation of Ku and Ka-band sea state bias correction variability using Jason-3 and AltiKa data

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Motivations

- There is a need to characterize Ka-band (36 GHz) SSB in advance of the SWOT mission
  - How critical is wind speed for Ka-band SSB correction?
  - Will ancillary wave model data be useful?
  - Is the correction larger/smaller than at Ku-band?
- New near-final high quality AltiKa GDR-T data are now available to allow a global view of sea state impacts on range measurements by a Ka-band radar altimeter
- A robust on-orbit comparison of Ku vs. Ka SSB has not yet been made, nor compared to field data

Methods

1. While there is no dual frequency Ku/Ka altimeter, the approach taken here is to use the same empirical direct-method SSB model approach (Vandemark et al., 2002; Tran et al., 2010) to derive Ku- and Ka-band SSB training data and SSB models (2D and 3D) over the same two year time frame of 2017-2018.
2. We use global SARAL ALtiKa data after post-correction to limit the pointing angle to very near nadir and to post-correct for known antenna pattern issues. This provides wind speed, SWH, and range at near GDR-T quality.
3. We use global Ku-band Jason-3 GDR data for the same time period (C-band as well, not shown).

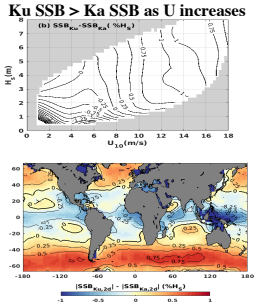
Main Findings

- SSB correction is smaller at Ka-band than at Ku-band excepting small (1 cm) differences at low wind speeds
- Ka-band SSB decreases measurably with respect to Ku-band as winds exceed 6-7 m/s, this is seen for any sea state (SWH)
- Ka-band SSB correction improves when adding wave period information from a model (Meteo-France WAM), the improvement gain is less than at Ku-band
- This is explained by weaker sensitivity to wave period variations at Ka-band, especially at higher wind speeds
- On-orbit and aircraft/tower data are in general agreement
- Physically, it appears that as winds increase, short-wave increases at Ka-band act to mask/attenuate long-wave EM bias impacts (Nonlinearity usually modeled using SWH, T_{02})

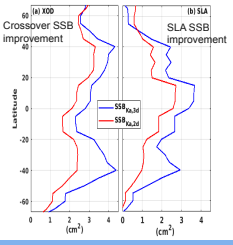
SSB data and models derived using global two year (2017-2018) J-3 and AltiKa datasets

Shown below - differences between J3 and AltiKa 2D SSB models at Ku and Ka-band in %SWH (significant wave height)

Ku SSB > Ka SSB as U increases

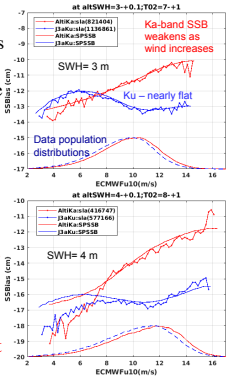


Shown below - ALtiKa range correction improvement beyond GDR versus latitude when using new UNH 2D model (red) new UNH 3D model (blue) -- **Blue curve shows adding wave model info. does help at Ka-band**



When winds increase, the Ka-band range bias decreases compared to Ku-band

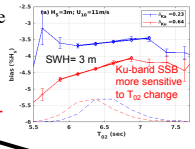
Ku and Ka-band SLA data (pts) and derived SSB models (solid curves) showing wind-dependence of absolute range change (cm).
Upper panel: SWH = 3 m; wave period = 7 sec.
Lower panel: SWH = 4 m; wave period = 8 sec.



- Ka-band SSB decreases as wind increases
- Difference with Ku is order 1% SWH consistent with 2D SSB results at left

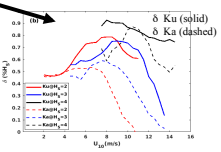
Wave period (T_{02}) impacts on SLA also weaken at Ka-band compared with Ku-band

Define SSB sensitivity to T_{02} change as $\delta = f(SWH, U_{10})$; calculated for various levels of SWH,U

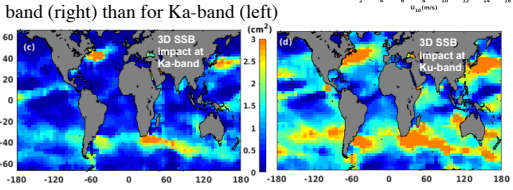


Marked difference in δ between Ku- and Ka-band as winds increase

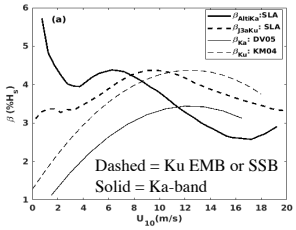
Maps below confirm Ku > Ka



Global maps of noise reduction due to SSB using 3D models is greater at Ku-band (right) than for Ka-band (left)



Results compared to previous aircraft/tower observations



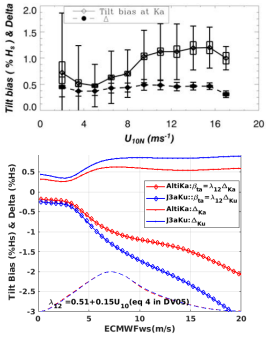
- Low wind speed ALtiKA SSB is quite high; an AltiKa tracker bias issue ??
- Above U=10 m/s, Field and Satellite data agree at both Ku and Ka; Ku > Ka by 0.5-1.0 %SWH

Upper right: V et al. (2005) long-wave 'tilt' EM bias at Ka-band from aircraft radar

Bottom right: Red is Ka-band derived tilt EM bias (symbols) inferred using AltiKa (see V et al. (2005))

Very similar 1% tilt bias is seen for Ka from space and from aircraft

Ku > Ka in derived tilt bias by 0.5-1%SWH



References and Acknowledgments

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