Sea state bias (SSB) in radar altimeter measurements is one of the most complex sources of the ranging errors. Being of the order of a few percent of significant wave height it is the largest remaining error in mean sea level estimates (Gommenginger et al., 2018). Three main effects are assumed to be responsible for SSB:  

1. Electromagnetic bias (EB): Different reflectivity of wave crests and troughs -> mean scattering level is shifted towards the wave troughs  
2. Skewness bias (SB): The inherently nonlinear dynamics, asymmetric profiles with flat troughs and sharp crests leads to the SSB overestimation.  
3. Tracker bias (TB): Numerous instrumental and retracking effects. 

SSB is usually parameterized as a function of the altimeter-derived dimensional variables: wave height ($H_w$) and wind speed ($U_10$). We propose to solve the problem in terms of dimensionless altimeter derived quantities: pseudo-wave age $\xi = \frac{gH_w}{U_10 \lambda}$ and wave steepness $\mu = \frac{\lambda^2}{\sigma^2 \lambda^2}$. Wave steepness is estimated from along-track measurements as 

$$ \mu = 0.598 \left( \frac{dh}{dS} \right)^{1/3}. \quad (1) $$

Similarity approach allows for developing a physical model and discriminating distributions of different physical effects into SSB. The model of a random weakly nonlinear sea surface (Srokosz, 1986) predicts

$$ SSB = \frac{1}{\alpha} \left( \frac{\lambda}{\xi} \right)^{1/2} H_w $$

and, after additional assumptions,

$$ SSB = C(\mu) \Delta H $$

as the skewness bias fraction of SSB.

- Can we find the complete (the 2nd type) self-similarity in altimetry data?  
- Does the new model reflect physical effects (1), (2), (3)?  
- Is it able to provide relevant quantitative modeling of the SSB in altimetry within the approach?

2. FEATURES OF ($\xi$, $\mu$) and SSB

Our dimensionless variables are mission- (mostly $\xi$) and orbit-dependent (mostly $\mu$, see eq.1 because of track and wave directions mismatch).

PPDs of $\xi$ for J3 and SA are quite close (Fig.1a,b) while their counterparts for $\mu$ are different in magnitudes and locations of peaks (Fig.1c,d). Simple transformation $\mu_{sa} = 1.159 \mu_{j3}$ (3) makes the distributions almost identical (Fig.1e,f). Thus, the pair ($\xi, \mu_{sa}$) looks closer to the problem discussed with $\mu$ corrected.

PPDs of the SSB for two missions shows possible flaws of SSB parameterizations (Fig.1g,h).

3. RE-MAPPING SSB DATA ONTO ($\xi, \mu$)

The data used here has been retrieved from Sensor Geophysical Data Records (SGDR, L2 product) with 1-Hz sampling from (https://www.aviso.altimetry.fr). It should be stressed, that the SSB series cannot be considered as ‘an ultimate truth’. The corresponding parametric models provide the best fit in space of dimensional $H_w$ and $U_{10}$ but, in general case, do not guarantee a reasonable result in space of dimensionless pair ($\xi, \mu$).

![Fig. 3: a, b, c, d) - isolines for the global SSB (m) from bin-averaging into boxes 0.25 m/s by 0.25 m over the $(H_w, U_{10})$ domain. a) J3 cycles 70-105, b) - J2, cycles 18-55 c) - J1, cycles 257-294; d) - SA cycles 116-124 (cf. Vandemark et al., 2002, Fig.1); e, f, g, h) - isolines for normalized value $SSB/H_w$ (in percents) over the $(H_w, U_{10})$ domain for the same data.](Image 1240x1430 to 2318x1651)

![Fig.4: Isolines for the global normalized value $SSB/H_w$ (in percents) obtained from bin-averaging into boxes $J_{1}=1.1$ by $J_{3}=0.002$. a) - J3, cycles 70-105, b) - J2, cycles 18-55, c) - J1, cycles 257-294; d) - SA, cycles 116-124.](Image 1511x1757 to 1779x1976)

4. CONCLUSIONS

1. The similarity approach is applied to the problem of sea state bias (SSB) in altimetry measurements;  
2. A comprehensive analysis of SSB data is performed within dimensionless wave characteristics (wave steepness and pseudo-age)  
3. Similarity of global distributions of SSB within the new approach is demonstrated for altimeters with different operational bands of Jasons’ and SARAL/Altika missions.

SSB should be re-tracked for employing the new approach in altimetry

References;


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