Perspectives on combining SAR Sentinel-1 Ocean Wave parameters with Jason-3 and Sentinel-3 estimations for SSB models

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Introduction: SSB parametrization

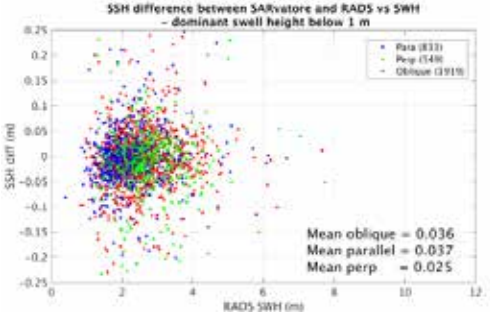
- The usual SSB estimations are obtained from empirical methods
- Parametric or non-parametric techniques using (1) collinear differences, (2) crossover differences, (3) direct approach from residuals of SSH-MSS
  [Chelton, 1994; Gaspar et al., 1994; Labroue et al., 2004; Vandemark et al., 2002]
- 2D SSB combining altimetric information: (H_s, U_{10}) or (H_s, σ_0).
  [Scharroo & Lillibridge, 2004]
- 3D SSB adding information from numerical wave models: (T_m) from WW3 or WAM.
  [Tran et al., 2010; Jiang et al., 2016]
- 3D SSB adding information exclusively derived from altimeter data.
  [Pires et al., 2016; Pires et al., 2018]

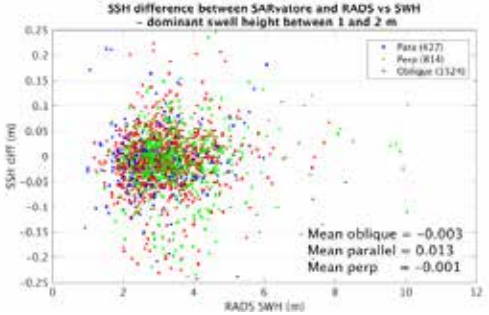
Introduction: UPORTO SSB model

- Nonparametric regression techniques based on penalized smoothing splines and GAMs
- 3 predictors: H_s, U_{10} and a mediator predictor provided by the mean wave period (T_z) derived from radar altimetry
- Designed for all reference missions (TOPEX, Jason-1, -2 and -3)
- Computationally efficient and capable of generating a stable model using small training datasets
- Good performances for a wide range of ocean conditions
- Pires, N.; Fernandes, M.J.; Gommenginger, C.; Scharroo, R. Improved Sea State Bias Estimation for Altimeter Reference Missions With Altimeter-Only Three-Parameter Models. IEEE TGRS. 2018. DOI: 10.1109/TGRS.2018.2866773

Introduction: Previous studies

- Bellingham et.al. 2016: Jason-CS SAR Mode Sea State Bias Study
- Collocation between Cryosat-2 and Envisat ASAR Globwave products
- No evidence of swell effects on Level 2 SAR altimeter SSH



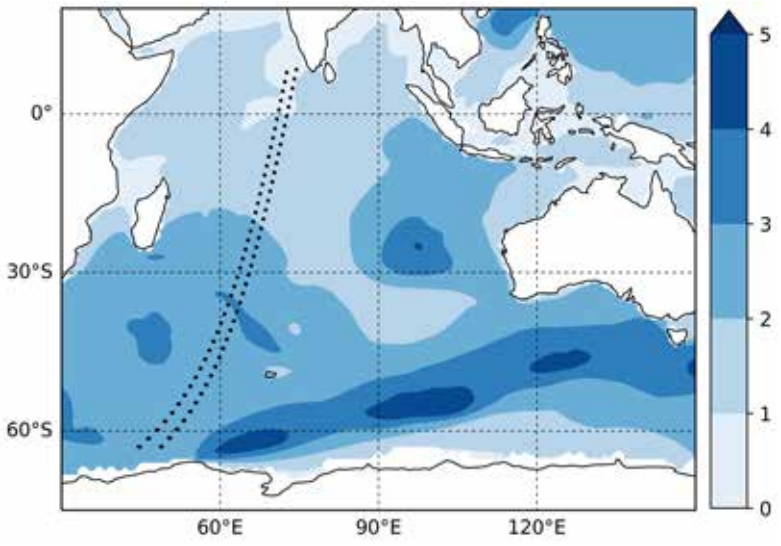


Sentinel-1 Level-2 Ocean (OCN) products

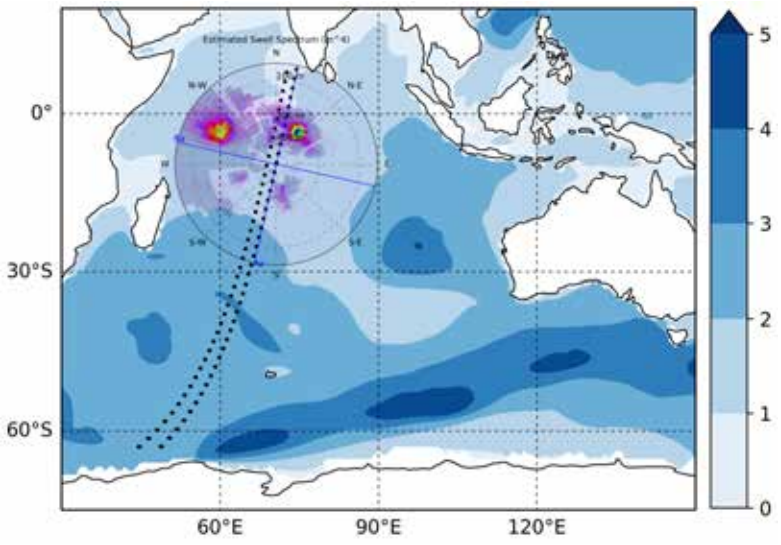
- 3 components: Ocean Wind field (OWI), Ocean Swell spectra (OSW) and Surface Radial Velocity (RVL)
- OSW component is a two-dimensional ocean surface swell spectrum with estimations of wind speed and direction per spectrum
- For Wave mode, one spectrum per imagette (20 x 20 km) with derived integrated parameters

• Imagette ID	• Platform heading	• Wavelength (pp)
• Centroid lat	• Backscatter	• Wave direction (pp)
• Centroid lon	• Wind sea H_s	• Image intensity
• Polarization	• H_s (per partition)	• Image skewness
• Wind speed	• Azimuth cut-off wl	• Wind speed (ECMWF)
• Wind direction	• Range cut-off wl	• % of land coverage
• Incidence angle	• Inverse wave age	• Water depth

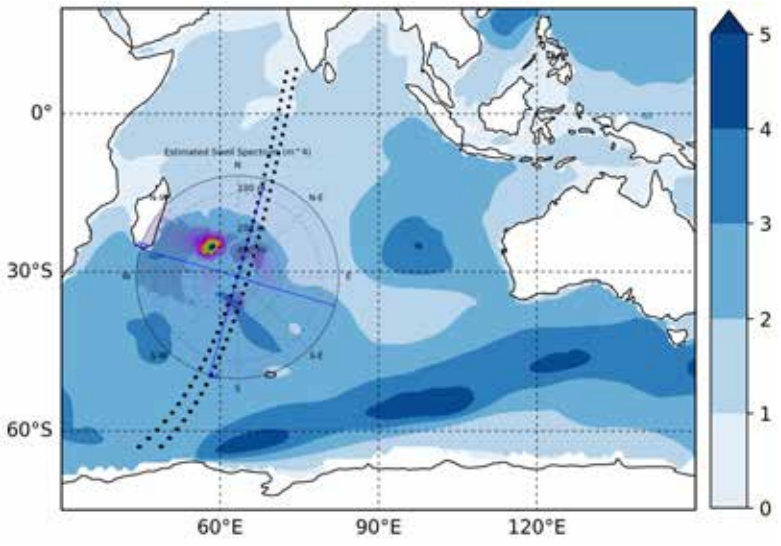
Sentinel-1 Level-2 Ocean (OCN) products



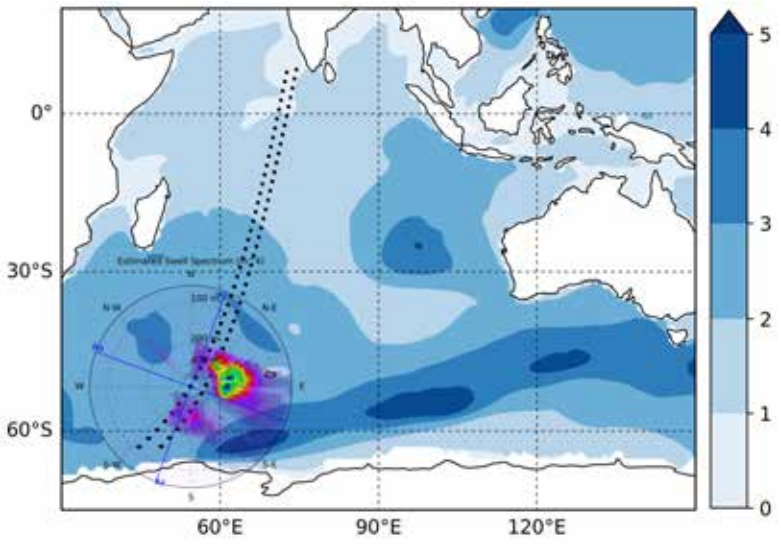
Sentinel-1 Level-2 Ocean (OCN) products



Sentinel-1 Level-2 Ocean (OCN) products



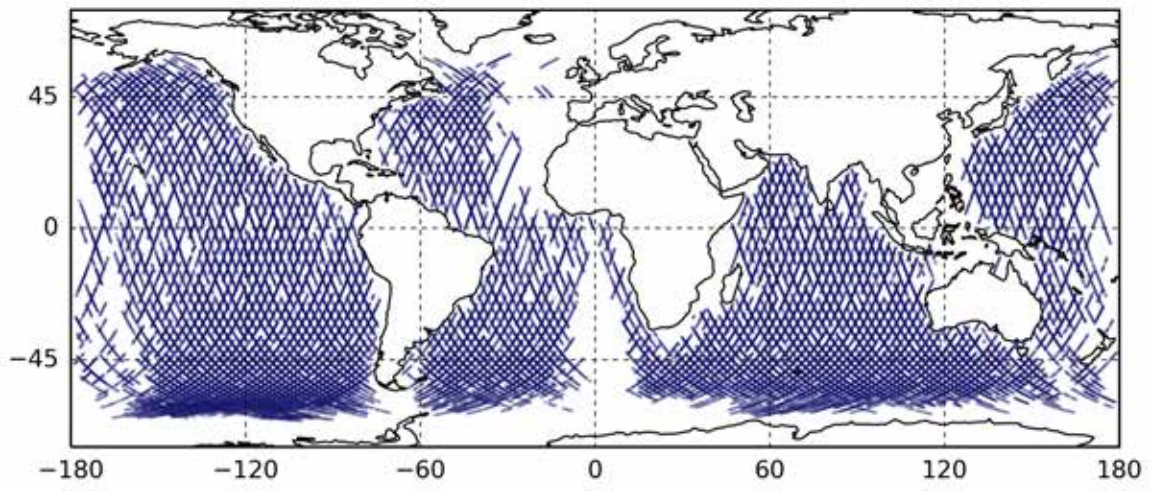
Sentinel-1 Level-2 Ocean (OCN) products



Data availability and collocation procedure

- The collocation procedure was performed for the year 2017
- 23349 Sentinel-1 OCN products available $\rightarrow$ 1242556 imagettes
- Temporal separation: $\leq$ 100 min (Jason-3); $\leq$ 300 min (Sentinel-3)
  (S-1 and S-3 sun-synchronous with 4h time difference; J-3 non sun-synchronous)
- Spatial separation between altimeter point and imagette centroid:
  $\leq$ 100 km (Jason-3); $\leq$ 200 km (Sentinel-3)
- Collocated measurements: 628827 (Jason-3); 4674652 (Sentinel-3)
- Despite the greater number, Sentinel-3 is less correlative

Data availability and collocation procedure (Jason-3)



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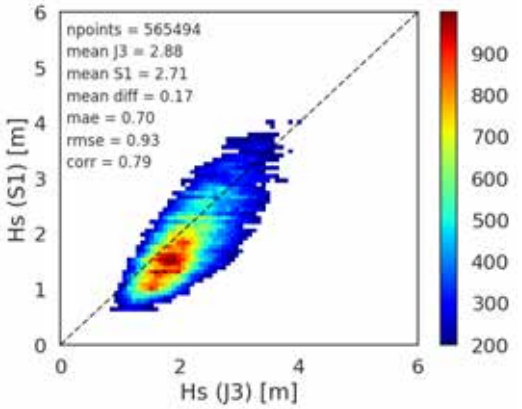
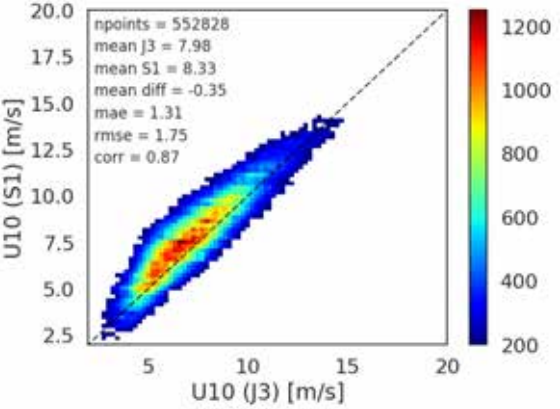
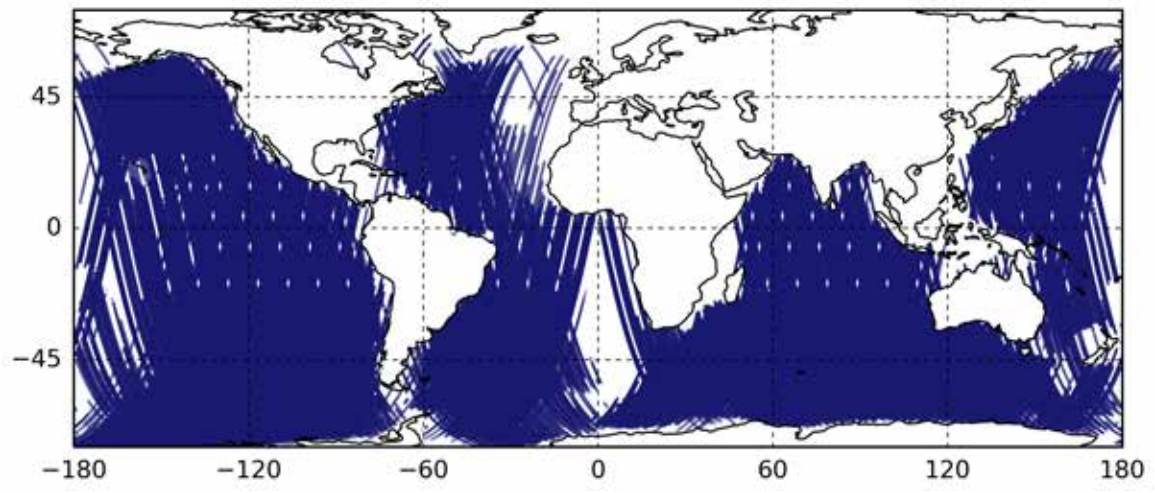
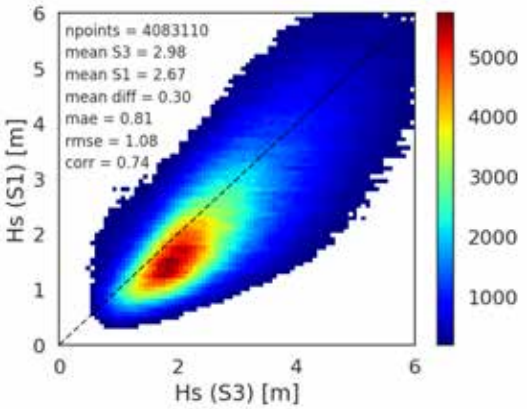


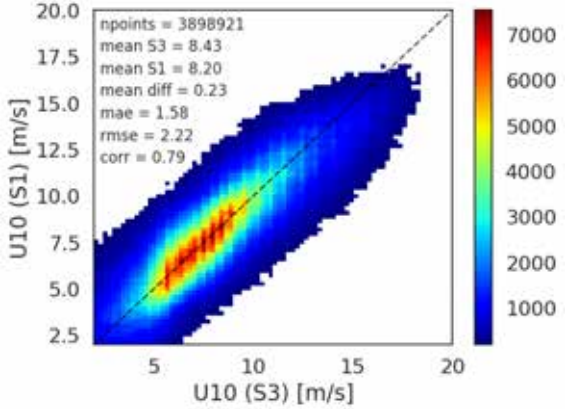


Data availability and collocation procedure (Sentinel-3)

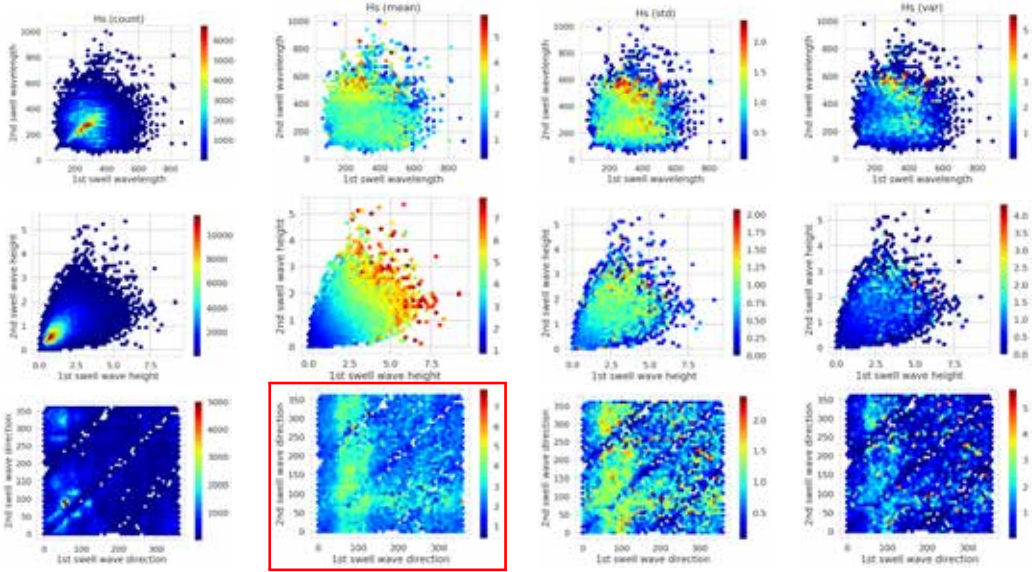


Data availability and collocation procedure (Sentinel-3)





Results: Jason-3 H_s / Sentinel-1 swell (length, height and direction)



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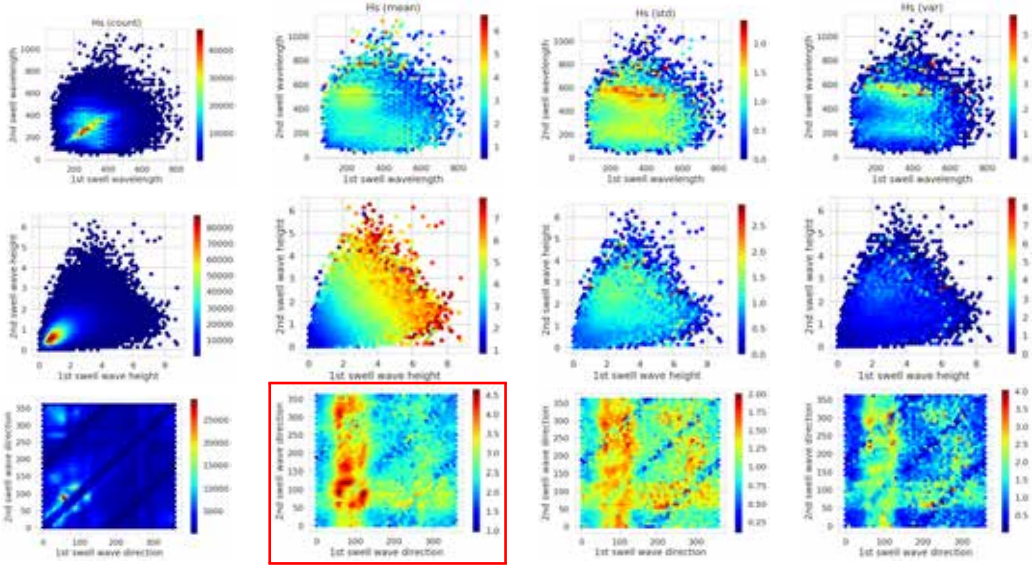
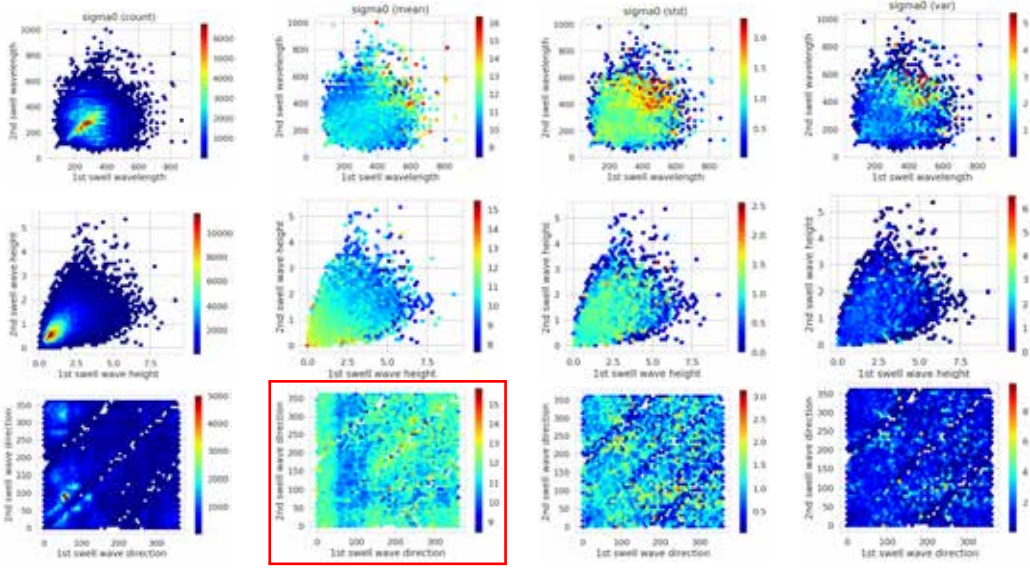
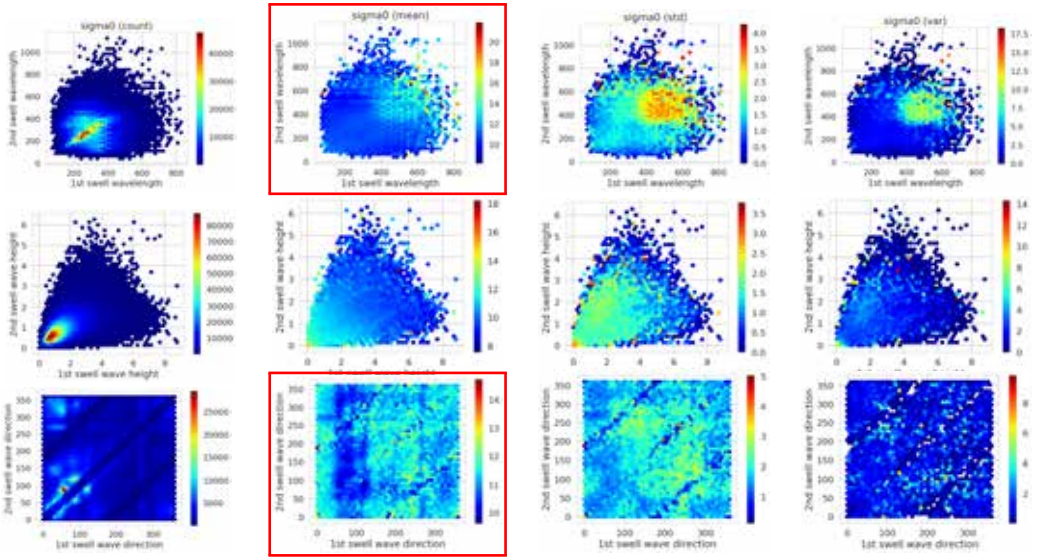


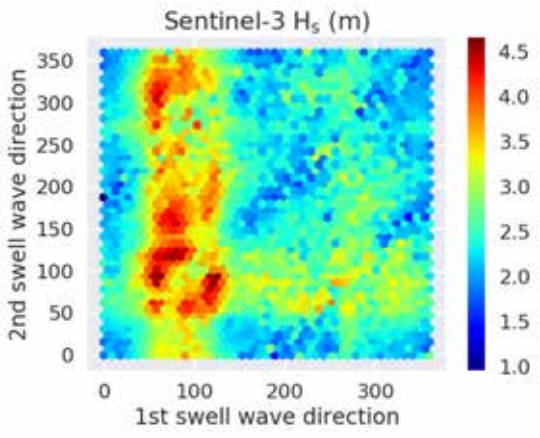
Results: Jason-3 σ_0 / Sentinel-1 swell (length, height and direction)

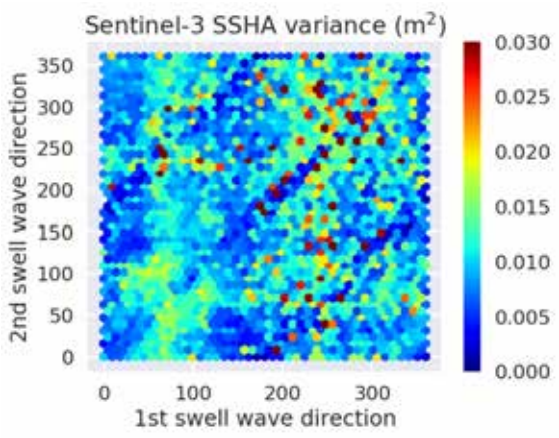


Results: Sentinel-3 σ_0 / Sentinel-1 swell (length, height and direction)

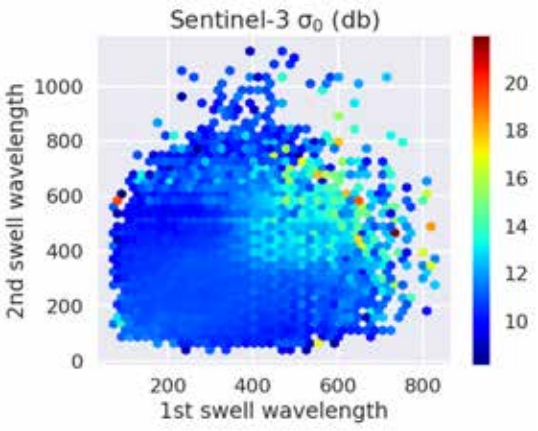


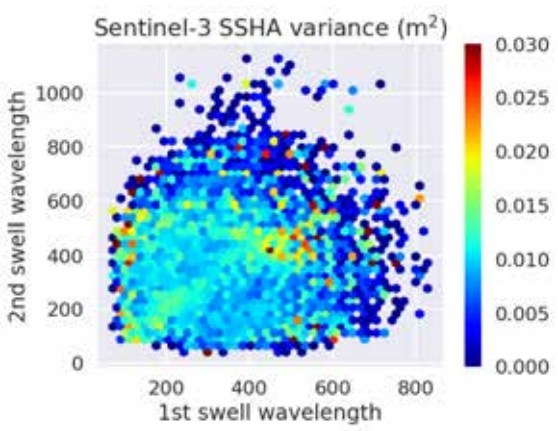
Results: Sentinel-3 H_s swell wave direction / SSHA



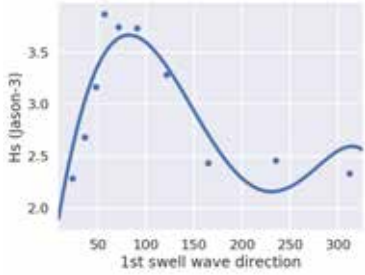


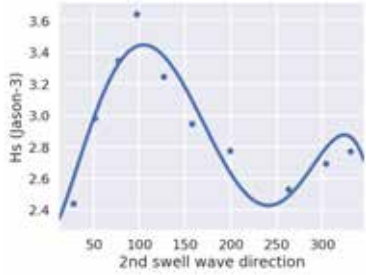
Results: Sentinel-3 σ_0 swell wavelength / SSHA

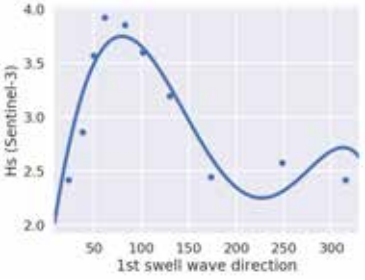


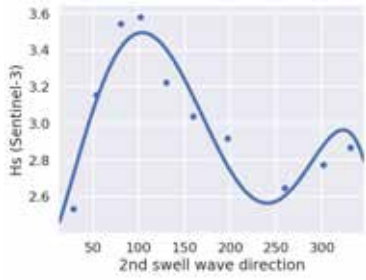


Results: H_s / swell wave direction

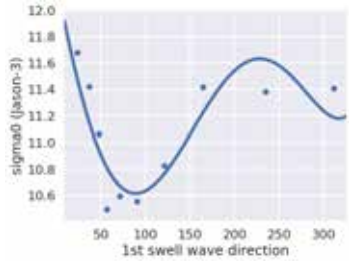


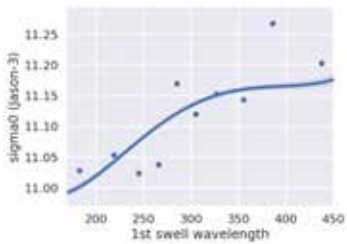


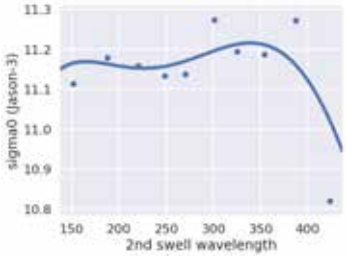


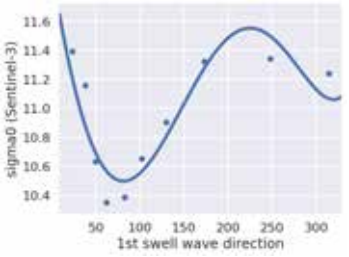


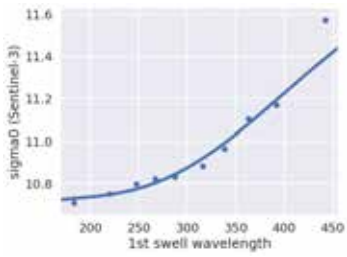
Results: σ_0 / swell wave direction and length

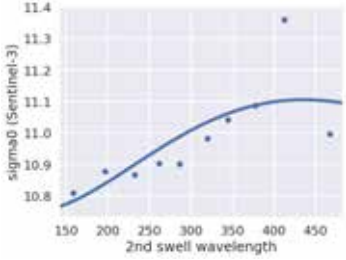




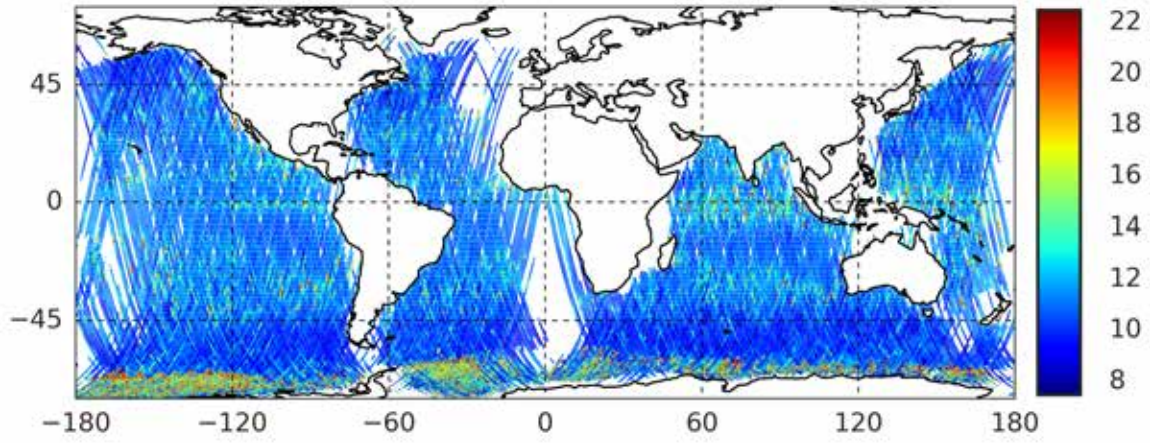




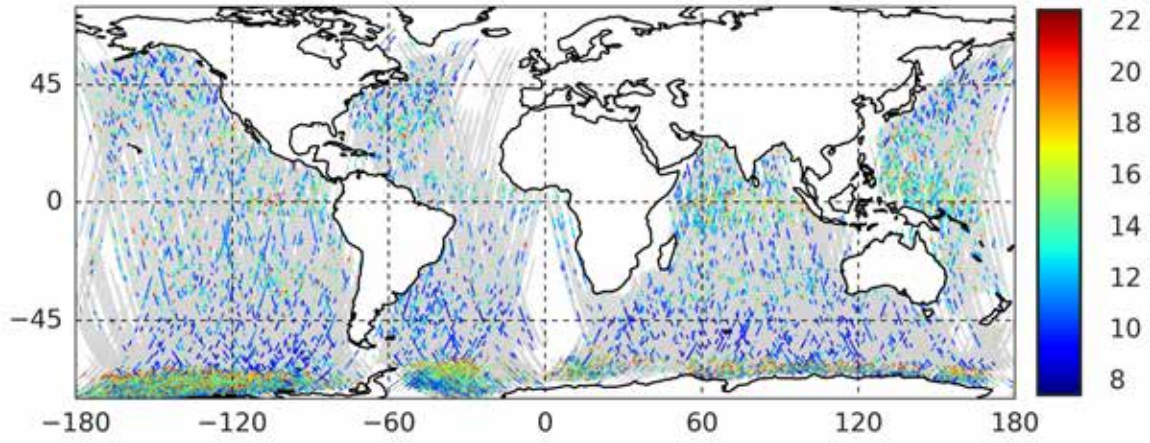




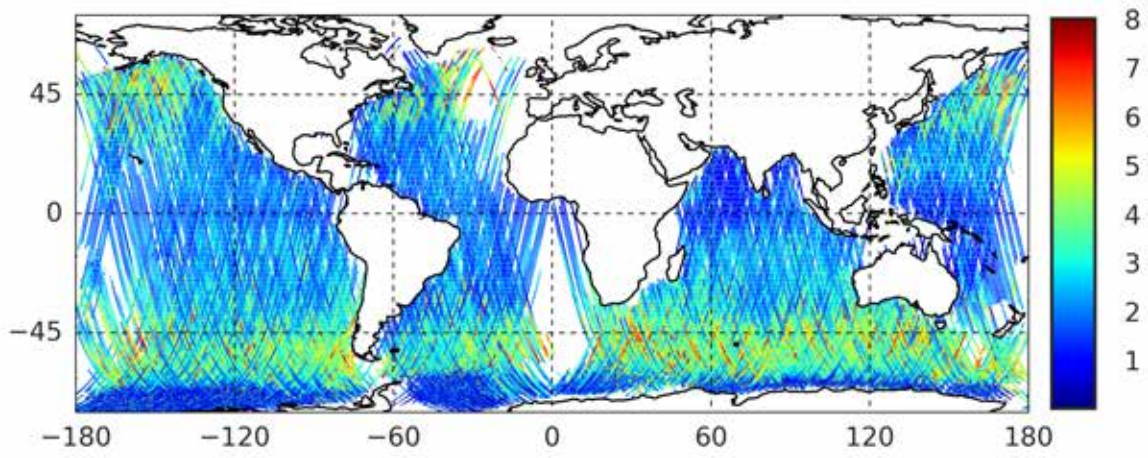
Results: Sentinel-3 σ_0 (entire dataset)



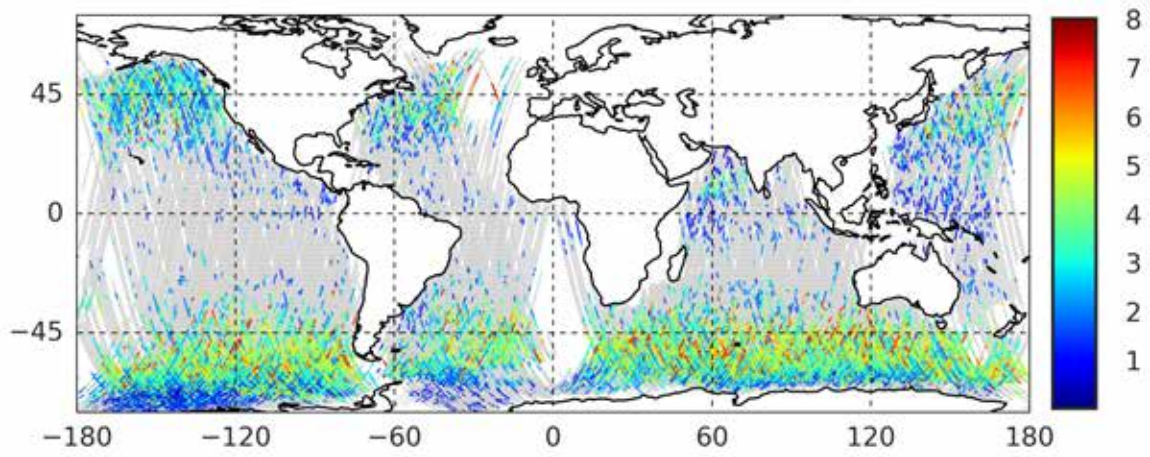
Results: Sentinel-3 σ_0 (400 m $\leqslant$ swell wavelength $\leqslant$ max)



Results: Sentinel-3 H_s (entire dataset)



Results: Sentinel-3 H_s ($80^\circ \leqslant$ swell wave direction $\leqslant 110^\circ$)



Summary

- Sentinel-1 Level-2 Ocean (OCN) products deliver a valuable source of information.
- No significant differences between Jason-3 and Sentinel-3, the swell produce similar impacts on both altimeter retrievals.
- Swell wave direction seems to affect the altimeter H_s (and also σ_0).
- Swell wavelength have repercussions on altimeter σ_0.
- H_s and σ_0 dependency on wave direction and length appears to be leaking on SSHA.
- This is a study in progress: since H_s and σ_0 are crucial for SSB empirical estimations.