Sentinel-1 Level-2 Ocean Products Performance Monitoring

Current status and evolutions

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May 23rd 2022
ESA Living Planet Symposium, Bonn

(1) Brest, FRANCE
(2) Frascati, ITALY
(3) Brest, FRANCE
(4) Bergen, NORWAY
(5) Brest, FRANCE

Outline

1. Introduction
2. Ocean Surface Waves spectra
3. Ocean surface WInd
4. Radial VeLocity

Ocean surface Waves spectra

Ocean SWell products (OSW)

Main improvements regarding Swell and Wave Mode products since beginning of S1 mission

<u>June 2019:</u>

- ***quality flag*** *added to the delineated swell partitions*
- ***low frequencies filter*** *added to the wave cross spectrum + add of optimized resampling of image cartesian cross-spectra in WV products*

<u>May 2020:</u> *Tuning of the geophysical* ***calibration gains***

→ ***better wind speed***

<u>June 2020:</u> *activation of owi and rvl grids for WV products + revisit of the MTF to fix issues*

→ ***higher resolution*** *OWI and RVL parameters*

→ *Swell energy:* ***Better wind speed dependence***

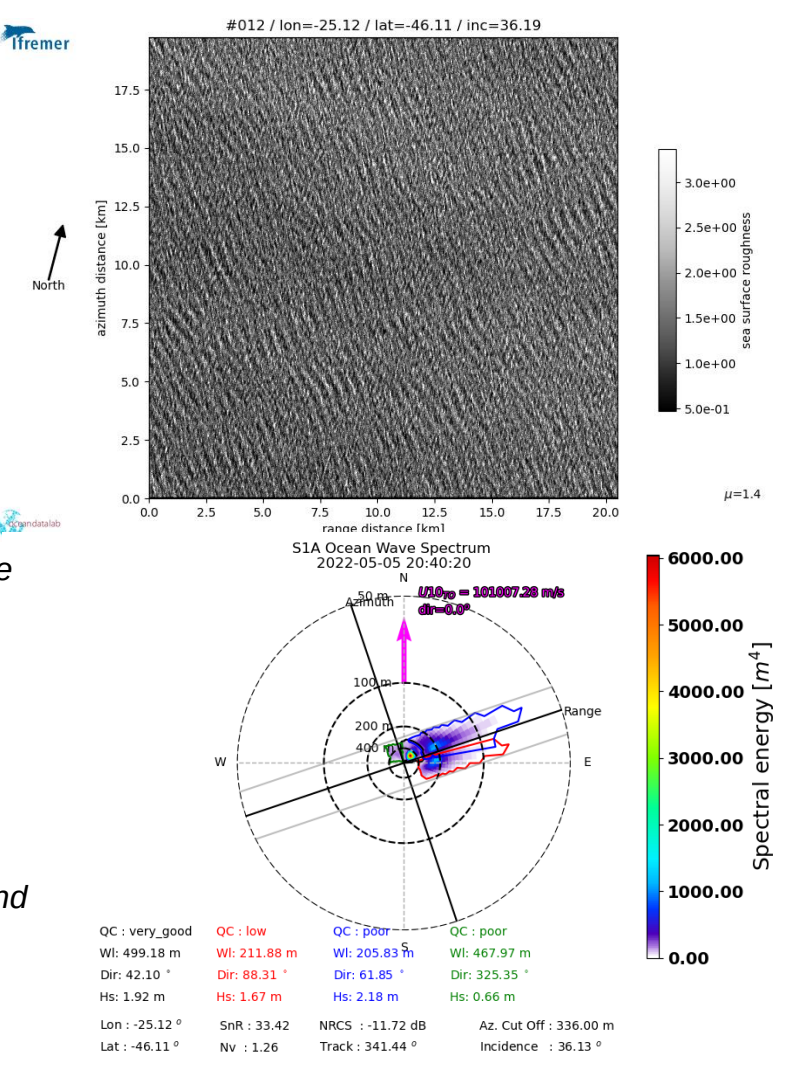
<u>June 2021:</u> *update of WV2 elevation antenna pattern to get better SnR*

→ *Removal of the 10 cm bias for Partition Hs on WV2*

<u>March 2022:</u>

- ***Alignment*** *of the NRCS values given in the 3 components OSW RVL and OWI*
- *Review of the quality flag computation using ML approach*

→ ***Better differentiation*** *btw good / bad measured partitions.*



Ocean SWell products (OSW)

To come:

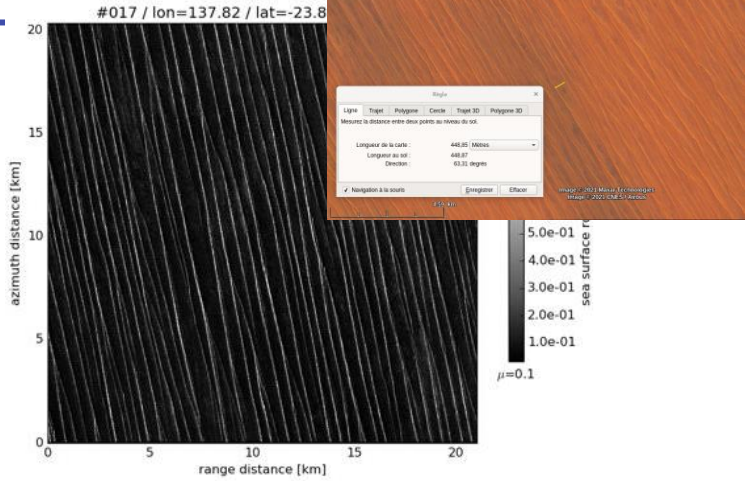
- *Understanding of* ***revert swell direction propagation****:*
→ *Uncompensated changing viewing angle between two looks*

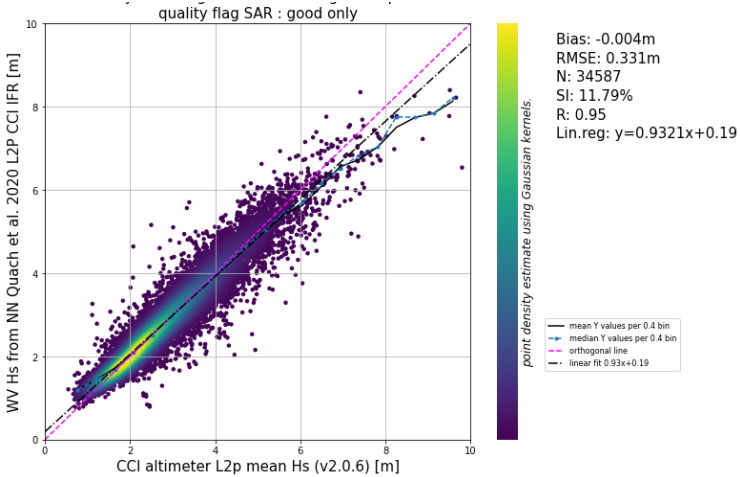
- New algorithm for « TotalHs » computation: [*Mouche and Stopa 2017,* Quach et al 202*]:*
→ *N*ew algorithm to compute « altimeter-like » significant wave height from SAR image.
→ **Still not activated**

- More in-situ validation (in-situ : buoys, drifters…, satellite : CFOSAT, S2, S6...)

- Investigations on remaning MTF bias (e.g. at high winds)

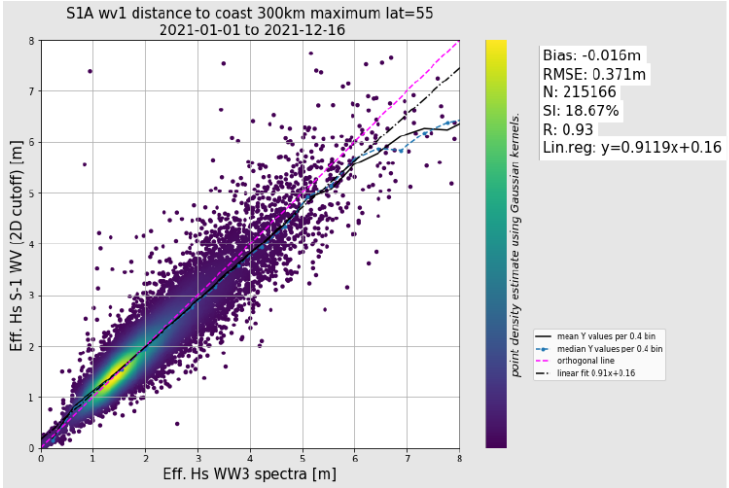
- Investigate X-spectra in TOPS data

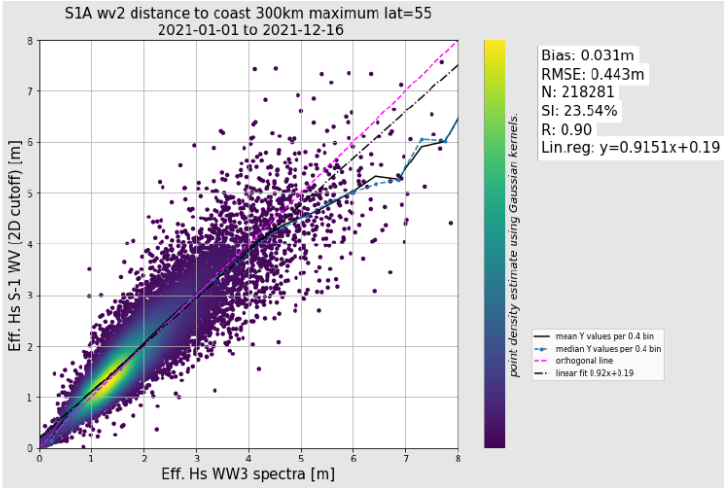




Visualization tools: https://cyclobs.ifremer.fr/ - https://xwaves.ifremer.fr/
Automated monthly reports: https://oceanwavesremotesensing.ifremer.fr/

Performances of WV: comparison to WW3 numerical model - « Effective Hs »





Scatter plot of effective significant wave height computed on the whole spectra S-1 WV OCN and associated WW3 spectra. Top left: S-1A WV1, top right: S-1A WV2

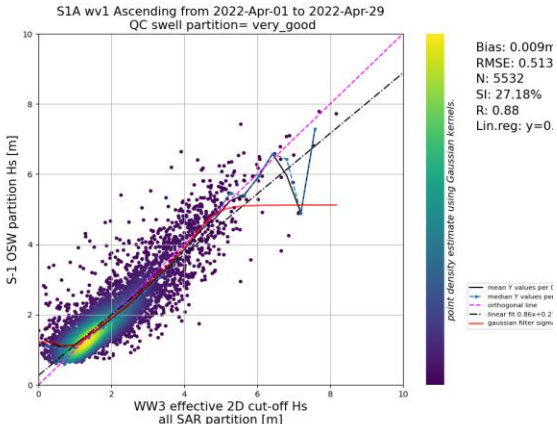
The directional wave spectrum energy « Effective Hs »

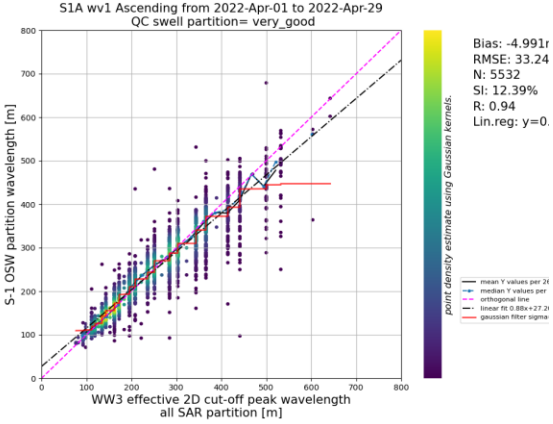
- Very close performance between S-1A and S-1B is observed. For both sensors, the WV2 effective Hs overestimation has been fixed thanks to ***new WV2 EAP and MTF review*** *update in June 2021.*

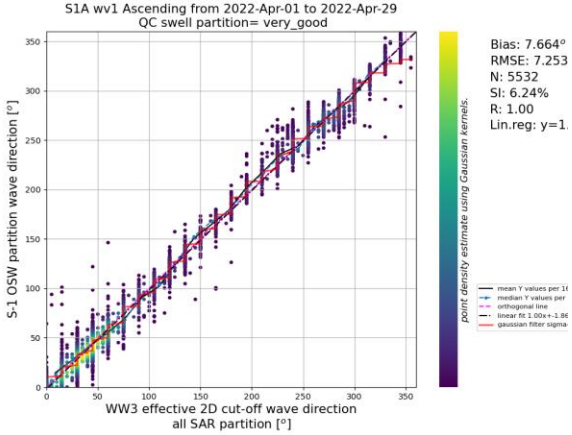
- Performances with respect to specifications: The RMSE and the bias are ***within the specifications*** *(0.5 m resp. 0.1 m) for S-1A&B and WV1/WV2.*

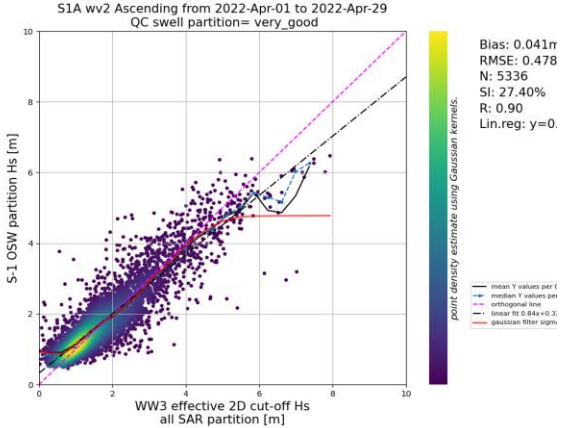
Performances of WV: comparison to WW3 numerical model – wave partitions

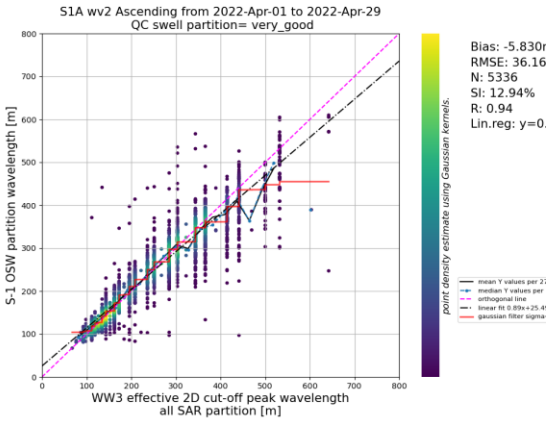
QF = Very Good

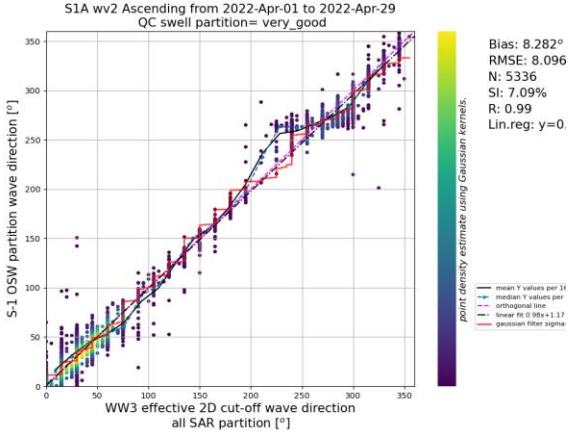






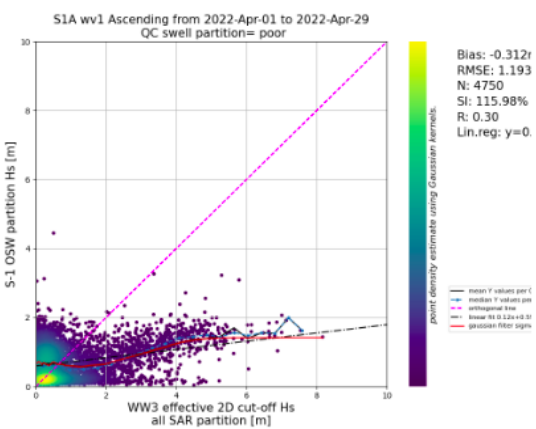


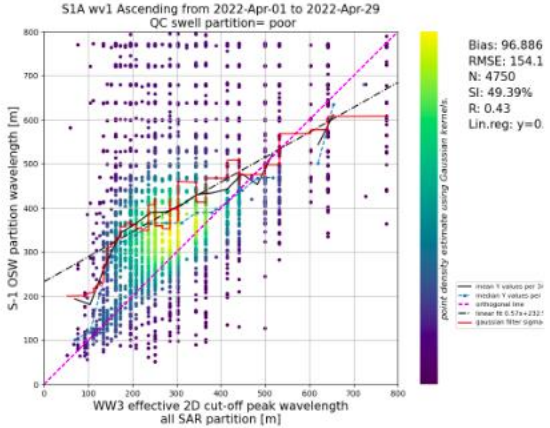


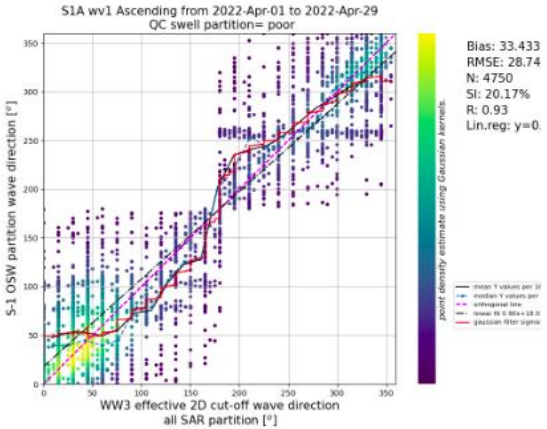


Performances of WV: comparison to WW3 numerical model – wave partitions

QF = Poor







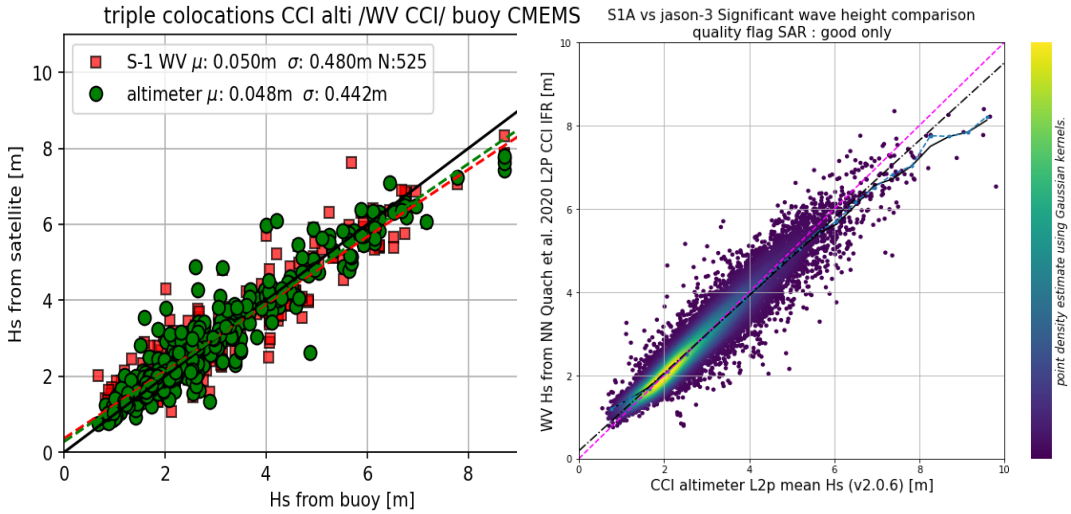
The directional wave spectrum partitions – Hs, peak Wl, peak Dir and quality flags

- « Very good » and « good » partitions are within specs. for Hs (more than 46 % WV1) (only « very good » for WV2) - Bias: 0.1 m, RMSE: 0.5 m

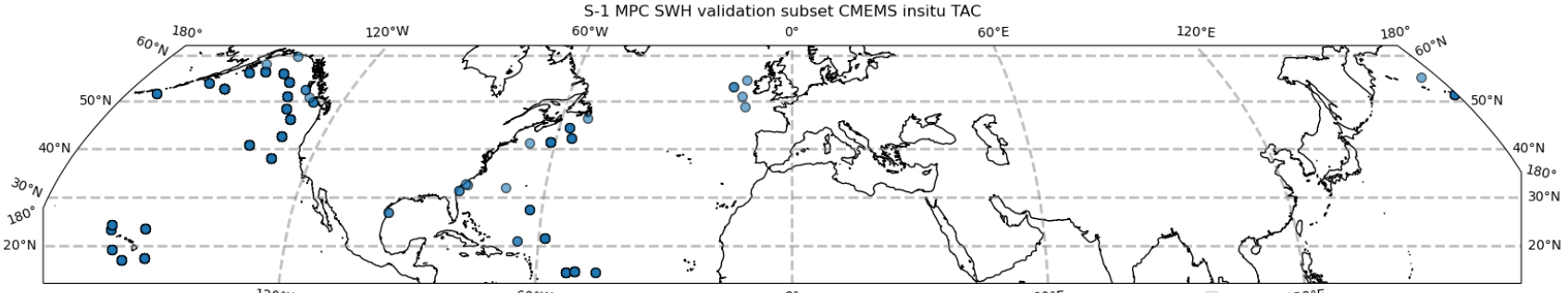
- « Very good » and « good » partitions are within specs. for peak Wl and Dir (more than 45 % WV1 and 30 % WV2) - Bias: 10 m, RMSE: 50 m - Bias 10° and RMSE 40°

- S1-A/S1-B close performances

Performances of WV « Total Hs »: comparison to Altimeters (CCI sea state)



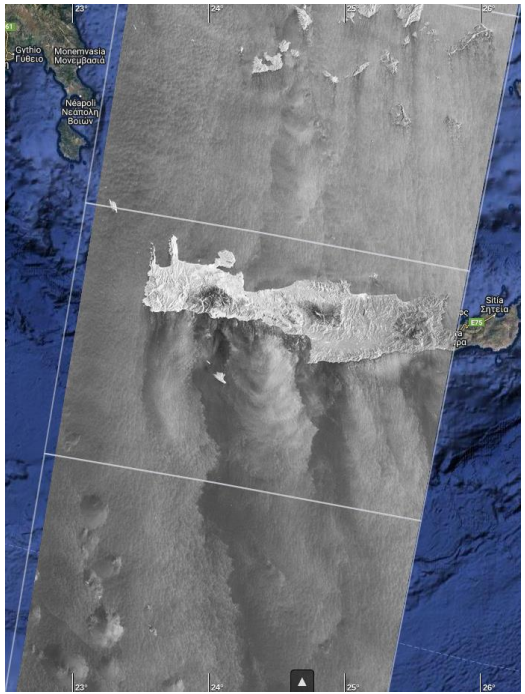
- *Good comparison to Altimeters (J3, J2, Saral)*
- *Quite good results of S-1 WV compare to moored buoys*
- *Buoys networks contains data with different level of quality.*
- *Numerical models are giving comparable results in average but fail to forecast extreme events.*

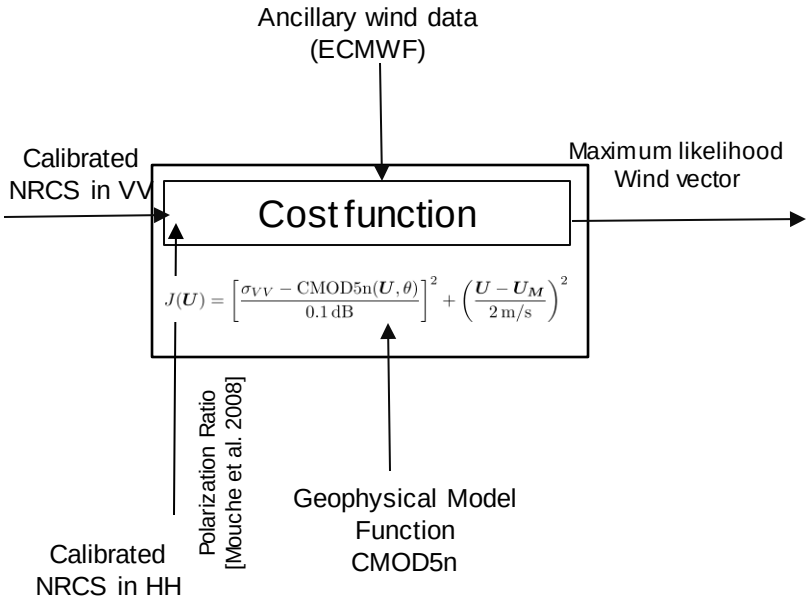


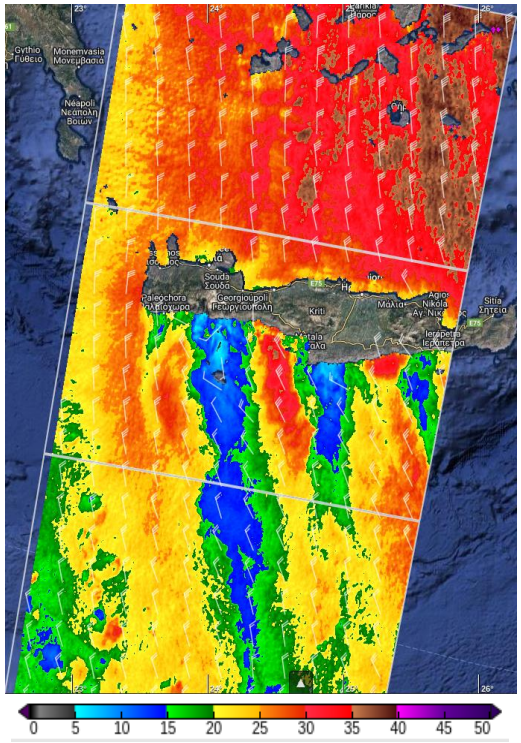
Ocean surface Wind

Algorithm status

Example on strong Northern winds over Crete (Feb. 9th 2022)





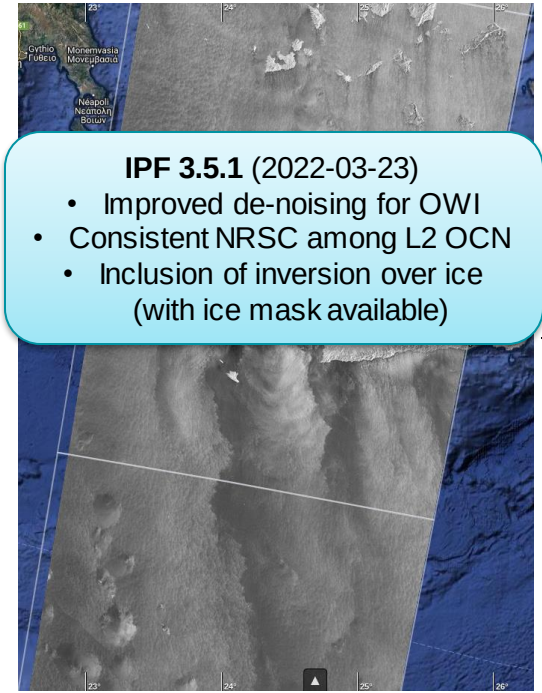


SAR surface roughness (from NRCS)

Inverted SAR wind (in knots)

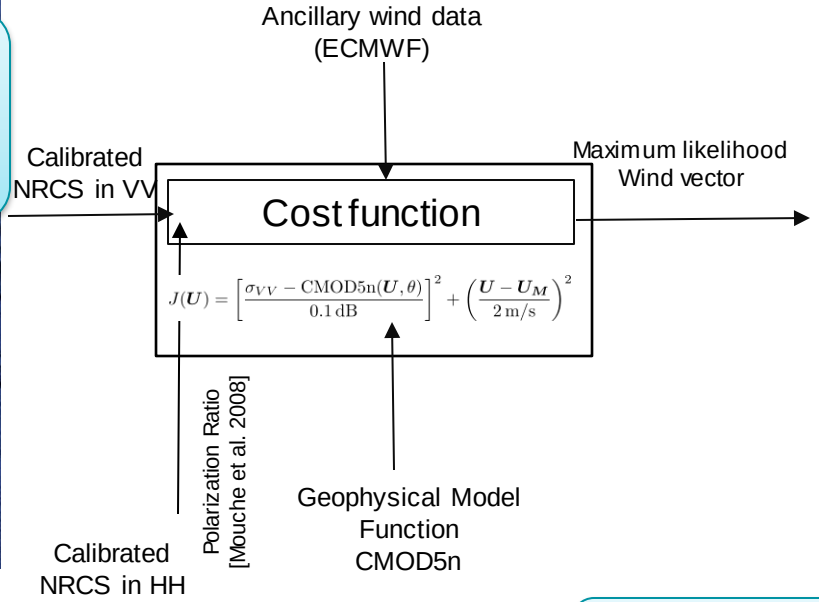
Algorithm status

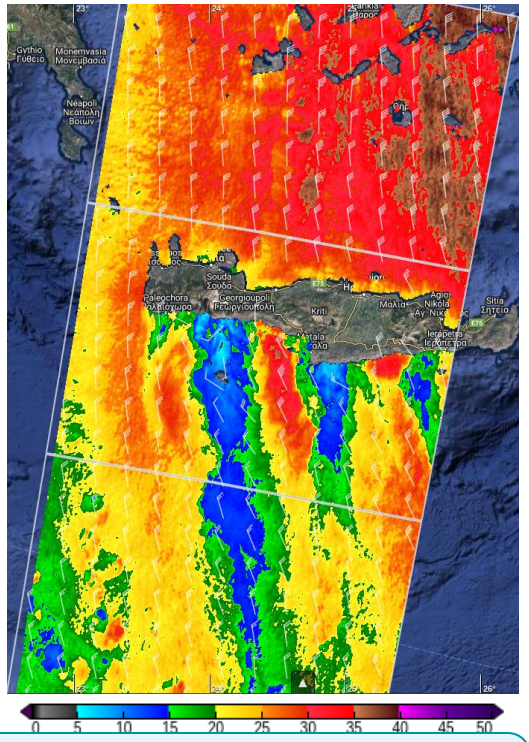
Example on strong Northern winds over Crete (Feb. 9th 2022)



IPF 3.5.1 (2022-03-23)
- Improved de-noising for OWI
- Consistent NRSC among L2 OCN
- Inclusion of inversion over ice (with ice mask available)

Since switch to ADGS in May
Improved step (from 3h to 1h), potential benefit for fast moving phenomena (e.g. Atm. fronts)

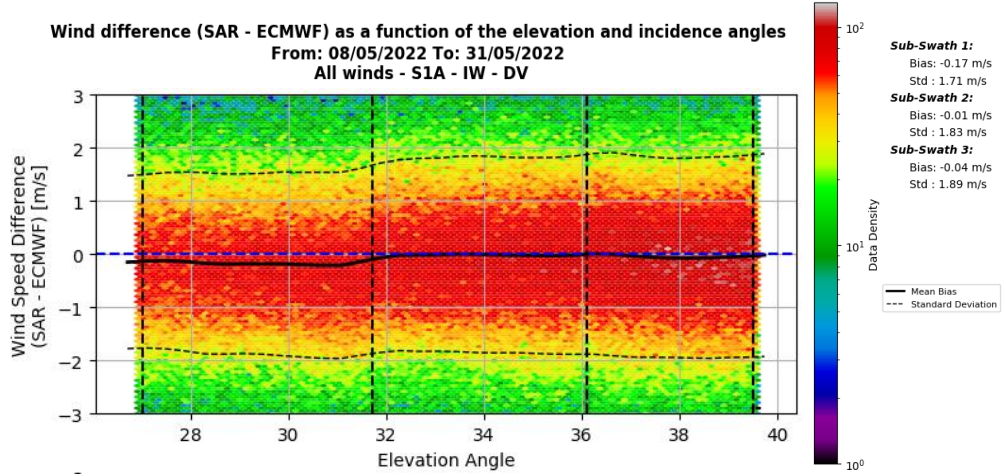


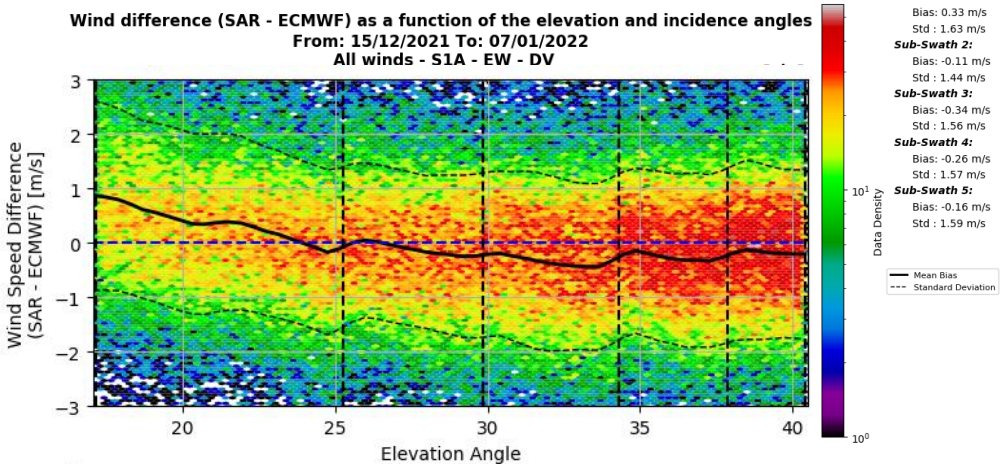


SAR surface roughness (from NRCS)

ESL activities
- Validation of wind speed against model showing good agreement (bias < 0.5 m/s, std < 2 m/s)

Latest performances

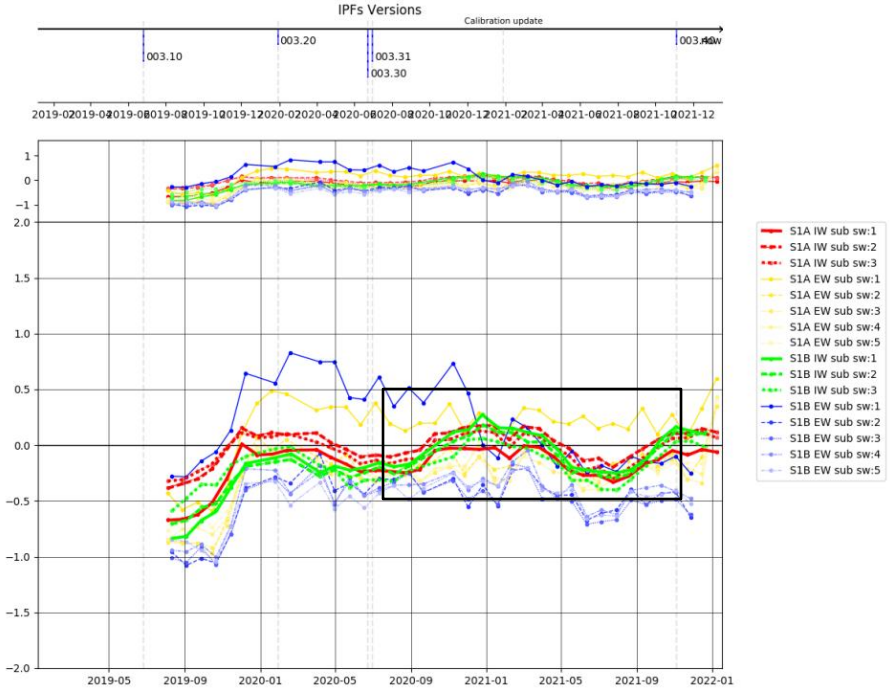


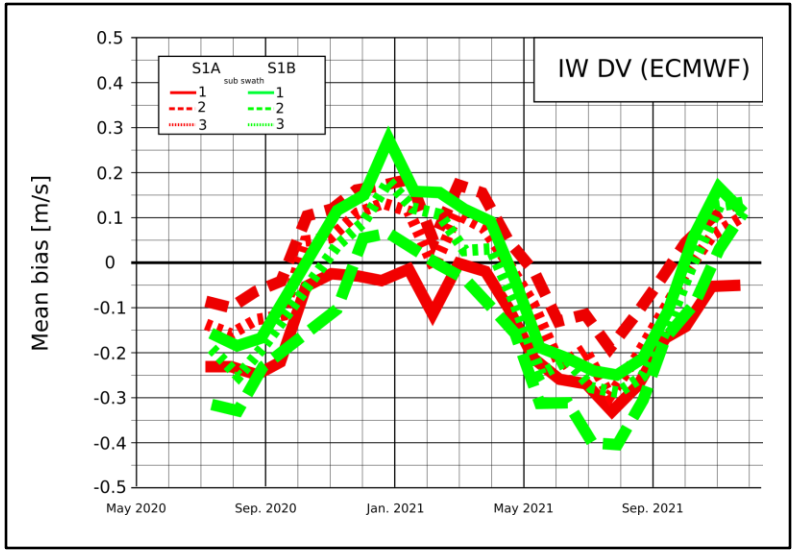


ESL activities

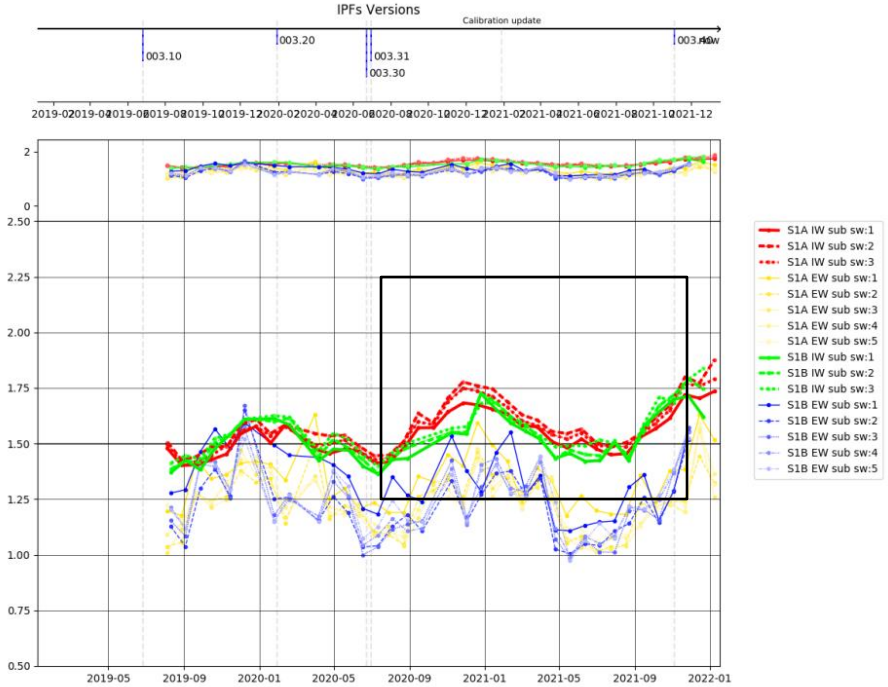
- Validation of wind speed against model showing good agreement (bias < 0.5 m/s, std < 2 m/s)

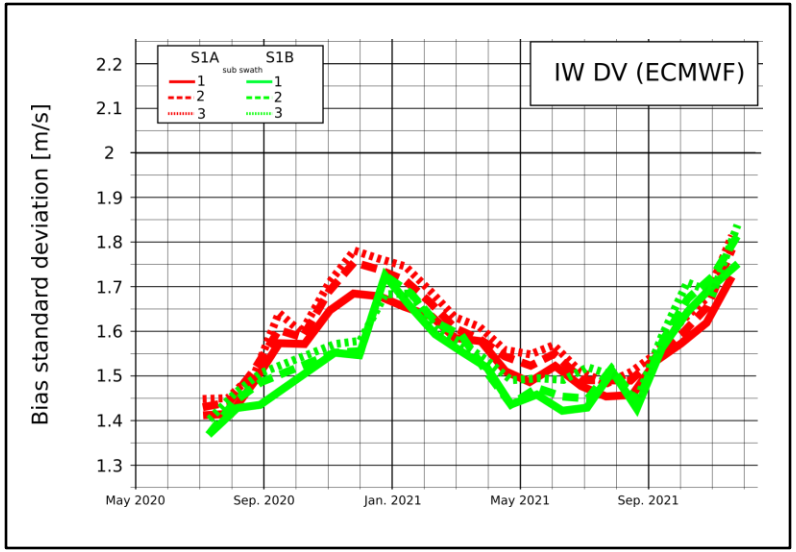
Yearly performances - IW DV bias SAR - ECMWF





Yearly performances - IW DV RMSE vs ECMWF





Wind and Roughness visualization platform: https://ovl.oceandatalab.com/
Automated wind monitoring: https://mpc-calval-wind.svc.groupcls.com/

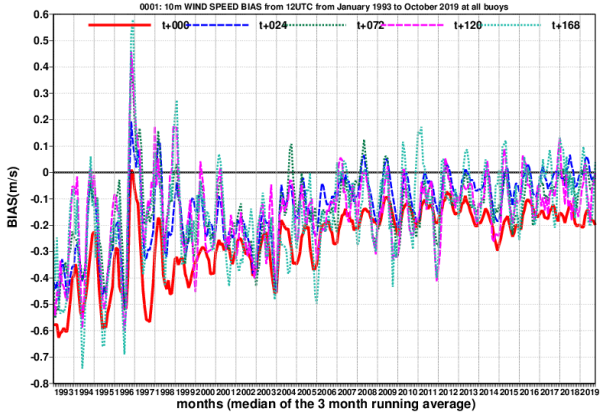
Yearly performances – IW DV

Seasonal variability to be more accurately quantified

but yet, on S1 IW DV (main messages)

- Performances stable in 2021
- Yearly average: S1A ≈ S1B<0 m/s (order -0.1 m/s)
- Seasonal variability on bias and RMSE

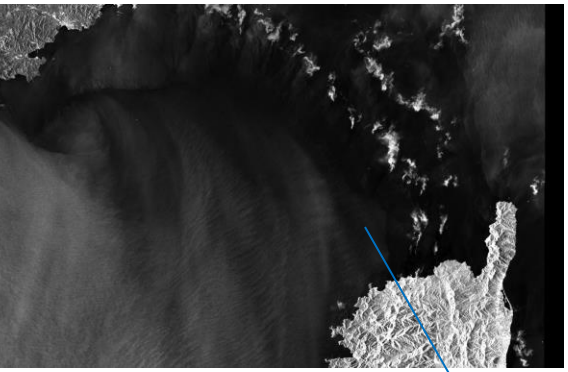
Origins (to be investigated later): roadmap



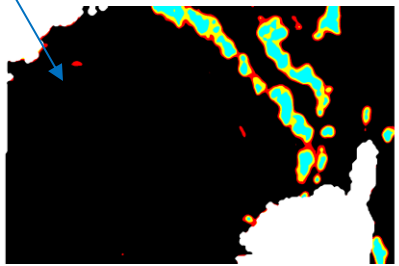
ECMWF forecast surface wind speed mean bias against weather buoys along time (taken from link on Dec. 13th 2021)

Evolutions

Rain filter

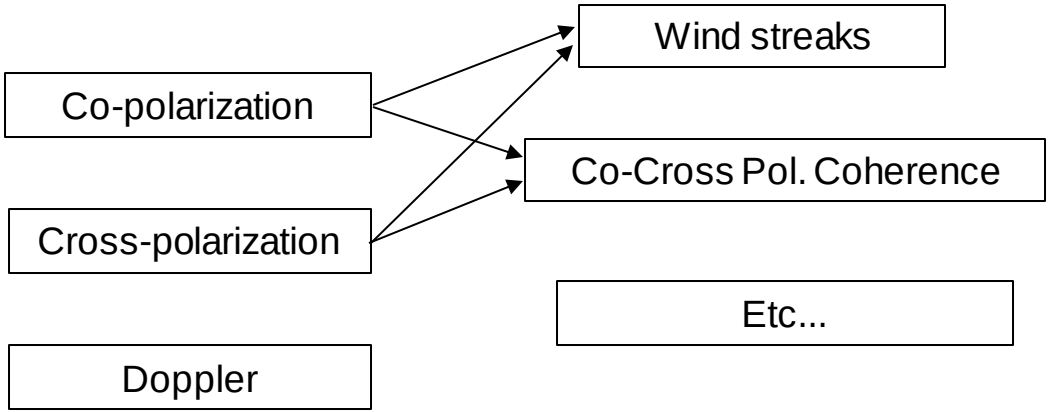


Colin et al. 2022



]1, 3] mm/h]3, 10] mm/h > 10 mm/h

Algorithmic improvements



- Cross-pol : EVO5, Mouche et al. 2017
- Doppler : ESL RadCal, Mouche et al. 2012
- CCPC : Longépé et al. 2021
- Wind streaks : Husson et al. 2021

Radial VeLocity

Sentinel-1
Radial Velocity

Team: G. Guitton (ODL), F. Collard (ODL), A. Recchia (Aresys), A. Cotrufo (Aresys), S. Bras (ESA), N. Miranda (ESA), M. Pinheiro (ESA), G. Engen (Norce), H. Johnsen (Norce)

Main issues with S1 OCN RVL products

- The estimated Doppler Centroïd (DC) frequency is coloured by attitude DC.
  - The attitude DC shows a variation of around 20 Hz around the orbit
  - The attitude DC is currently not available for the operational Level-2 processor.

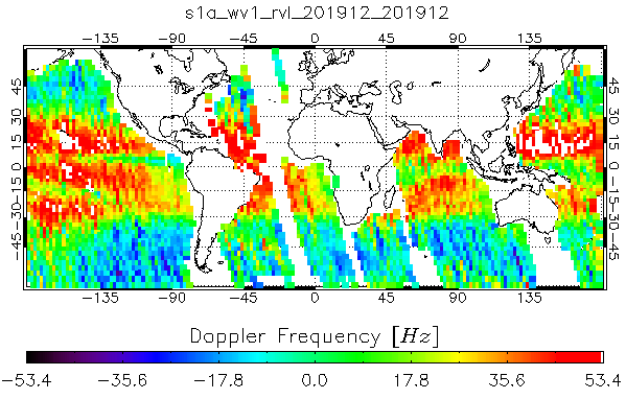
- The estimated DC frequency is affected by temperature compensation applied to antenna
  - Currently there is no means of correcting these sudden jumps in DC

- Antenna electronic mis-pointing over the sub-swaths.
  - Pre-computed mean DC (land) profiles over sub-swaths are currently not available to the Level-2 processor.

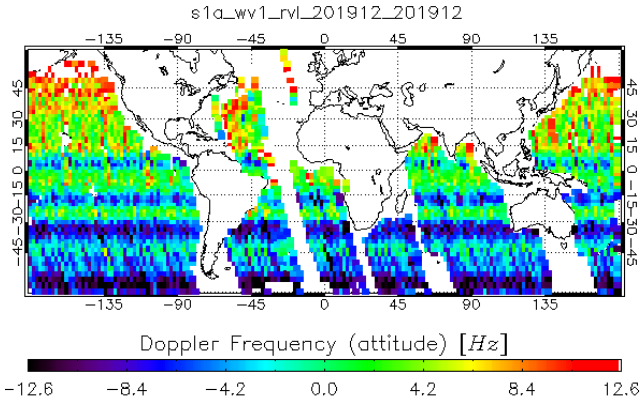
- However, careful combination of S1 gyro and SAR data has provided means to estimate restituted attitude DC and mean DC profiles (OceanDataLab, 2019). See next slide.
  - Whether or not the methodology will be implemented into the operational processor remains to be seen

Restituted Attitude DC

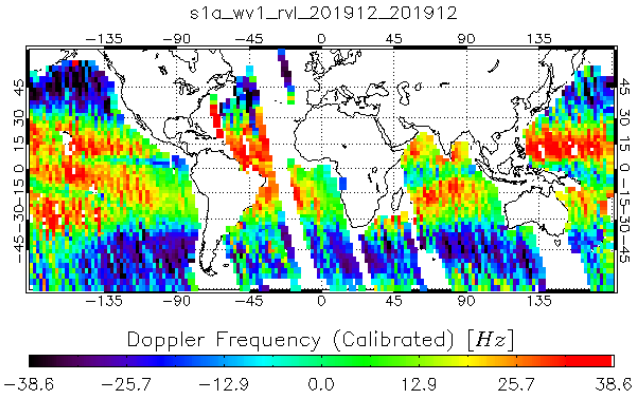
✓ The attitude DC can be estimated from combining S1 SAR observations and S1 gyro rate data. Example shown below. (OceanDataLab 2019)



DC observed



DC attitude



DC anomaly

Figure: S1-A WV DC observed (left), DC attitude (middle) and DC anomaly (right).

Restituted Attitude DC

✓ The DC anomaly is then well correlated to the range winds, given by a co-located model.

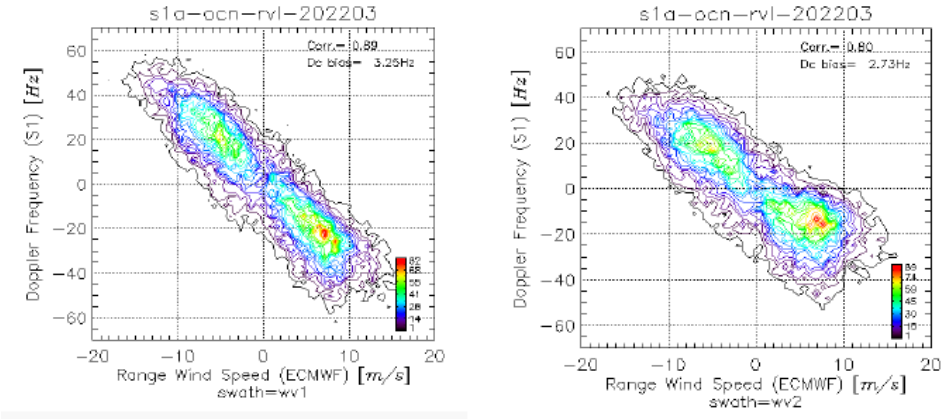


Figure: S1-A WV DC anomaly for WV1 (left), WV2 (right) wrt. range wind speed from ECMWF

DC jumps caused by temperature compensation

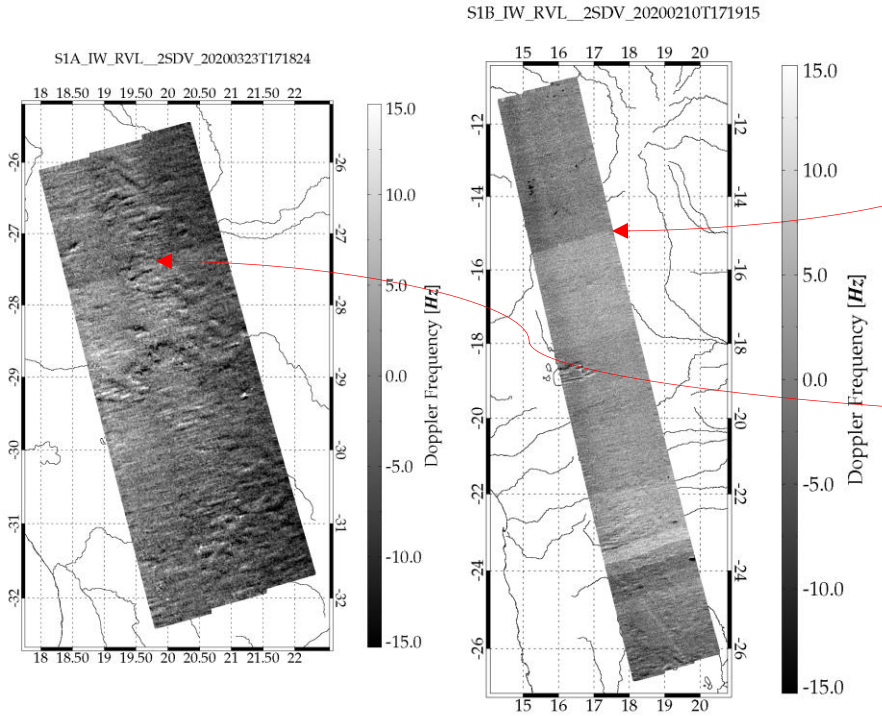


Figure: S-1A (left) and -B (right) IW DC frequency acquired over Africa showing sudden jumps in the frequency.

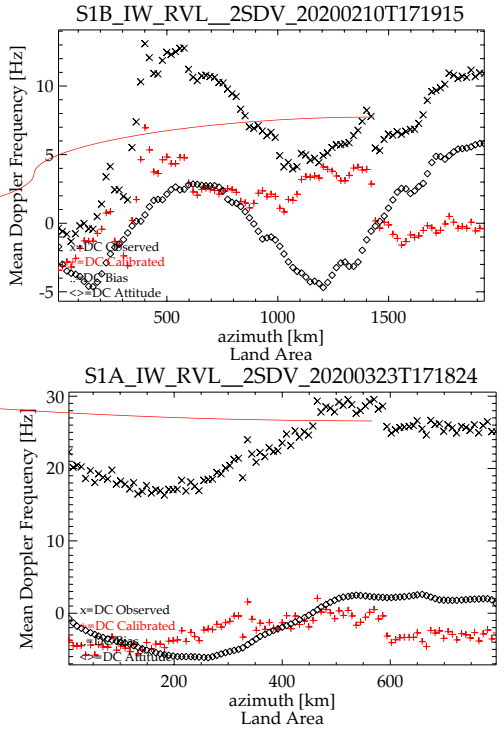
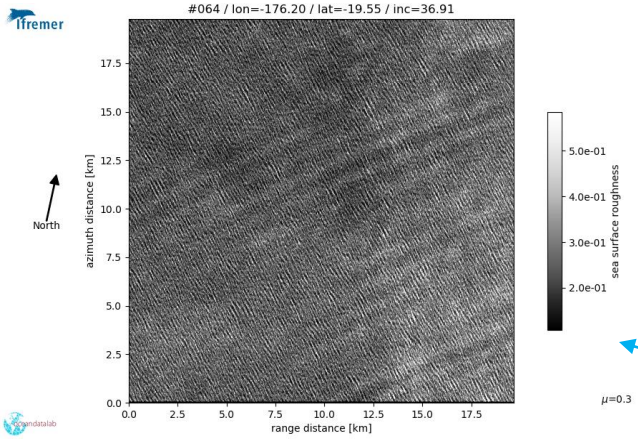
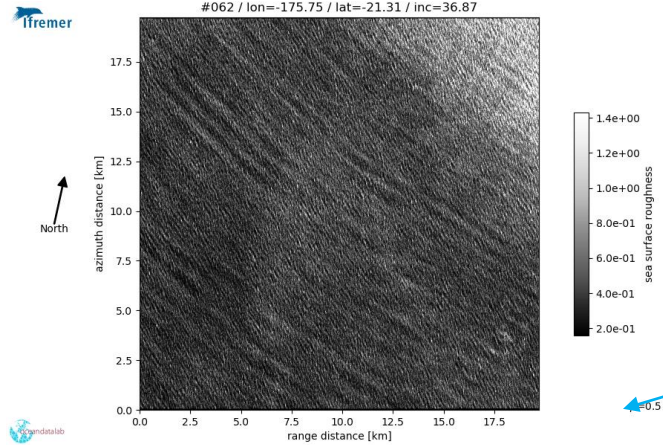


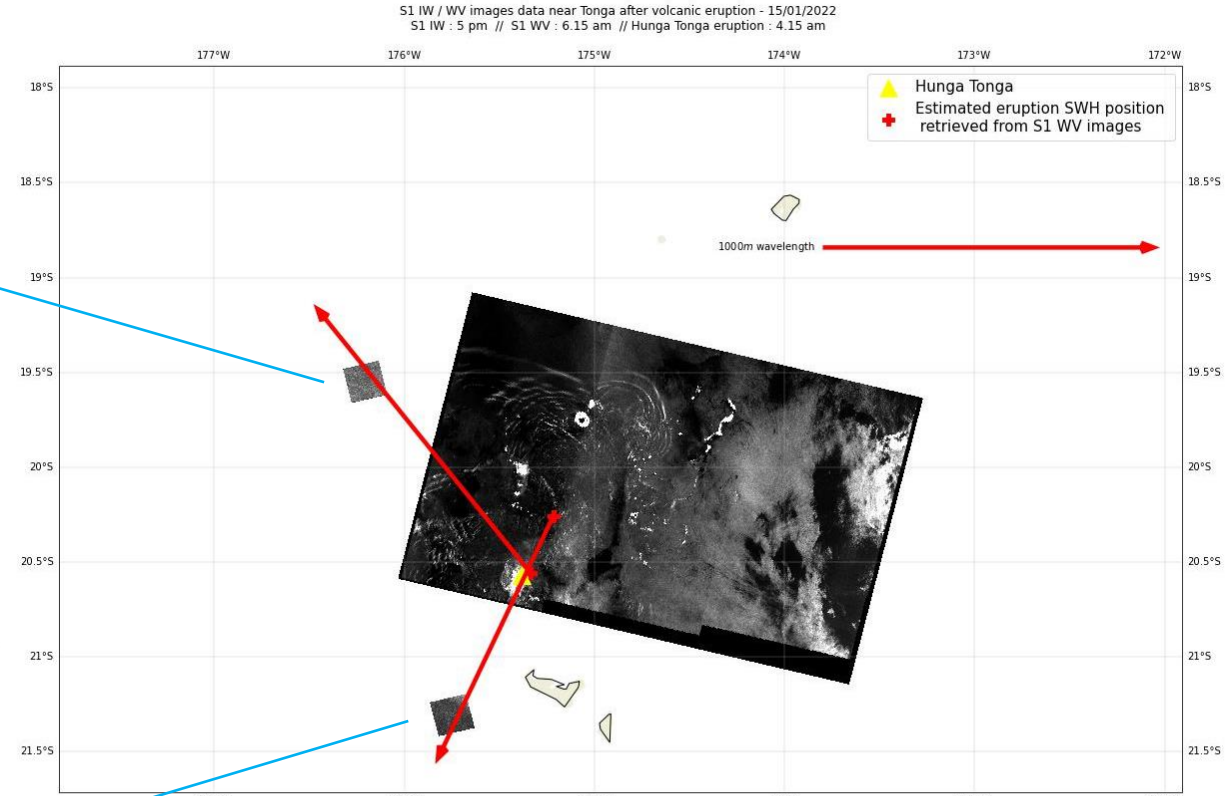
Figure: Mean DC profiles along-track: +DC Obs, +DC ObsCal, ◇DC Att) .

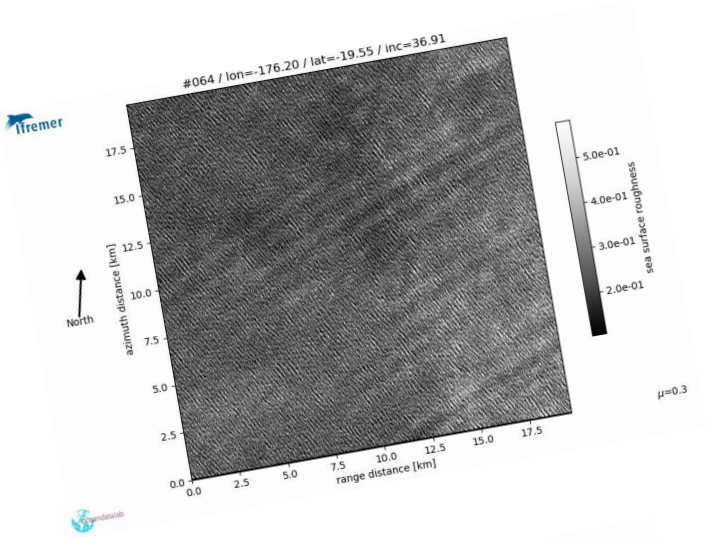
Thanks for your attention

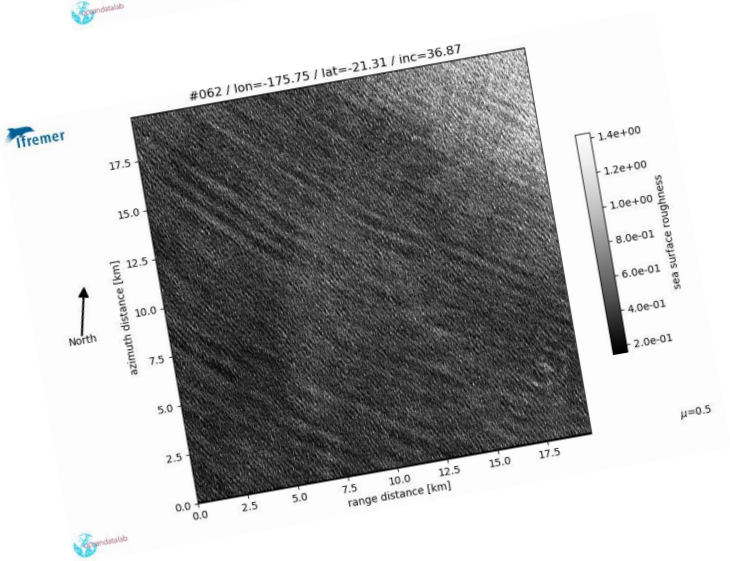
- The wave front curvature is visible in the sea surface roughness and indicates the direction of propagation of the long swell











- The wavelength for #64 is too long and filtered out from default ESA processing.

  A new processing was performed not to exclude this wave partition.

  It indicates:
  - partition peak wavelengths of 1029m(#64) and 815 m (#62),
  - partition Hs of 0.53m (#64) and 1.4m (#62).

  Using peak direction and peak wl, their position can be back-traced and estimated at the exact eruption time. Estimated locations are very within a few kilometers from the actual eruption location.