NOAA ASCAT NEAR REAL-TIME COASTAL WINDS

Seubson Soisuvarn[1, 2], Zorana Jelenak[1, 2], Paul S. Chang[1] AND Qi Zhu[1, 3]

[1]NOAA/NESDIS/Center for Satellite Applications and Research, [2]UCAR, [3]Global Science & Technology Inc.

Abstract

The Advanced SCATterometer (ASCAT) is a vertically polarized C-band ocean wind radar sensor carried on the Metop series of three polar-orbiting satellites launched between October 2006 and November 2018. The NOAA produces two global ocean wind products with the resolution of 12.5 km and 25.0 km up to 15 km of the coast for its operational users. While the ASCATs provide invaluable data in the open ocean, due to land contamination of the signal, most inner coastal zones are left void of the data. Most coastal marine activity occurs within a few kilometers of the coast, coastal observations are also needed for ocean forcing for upwelling affected areas. In order to retrieve winds closer to the coast, a coastal wind retrieval algorithm that utilizes enhancement resolution technique and the land contamination removal was developed and applied to the ASCAT measurements. This allowed us to retrieve winds within 20 km inner coastal zone.

The enhanced resolution can be achieved by utilizing overlapping measurements of the ASCAT antenna gain. For each near coastal measurement amount of the land signal contamination is determined by computing land contamination ratio (LCR). The normalized radar cross section (NRCS) measurements over near by land mass are used to calculate a mean and a standard deviation of the land brightness for each coastal observation. By using the LCR and the mean and the standard deviation of the land brightness we have developed the land contamination correction for each coastal NRCS slice is determined within a few iterations. However in the vicinity of strong land brightness, the proposed NRCS corrections alone cannot completely remove land contamination. A post wind retrieval processing is developed and applied before final coastal wind product is produced. This post wind retrieval processing involves processing of the corrected NRCS using varying LCR threshold.

The first version of the coastal wind and ice ASCAT product is being produced in NRT for operational validation. New products will be presented and discussed.

ASCAT Coastal Winds Near Real-Time Processor

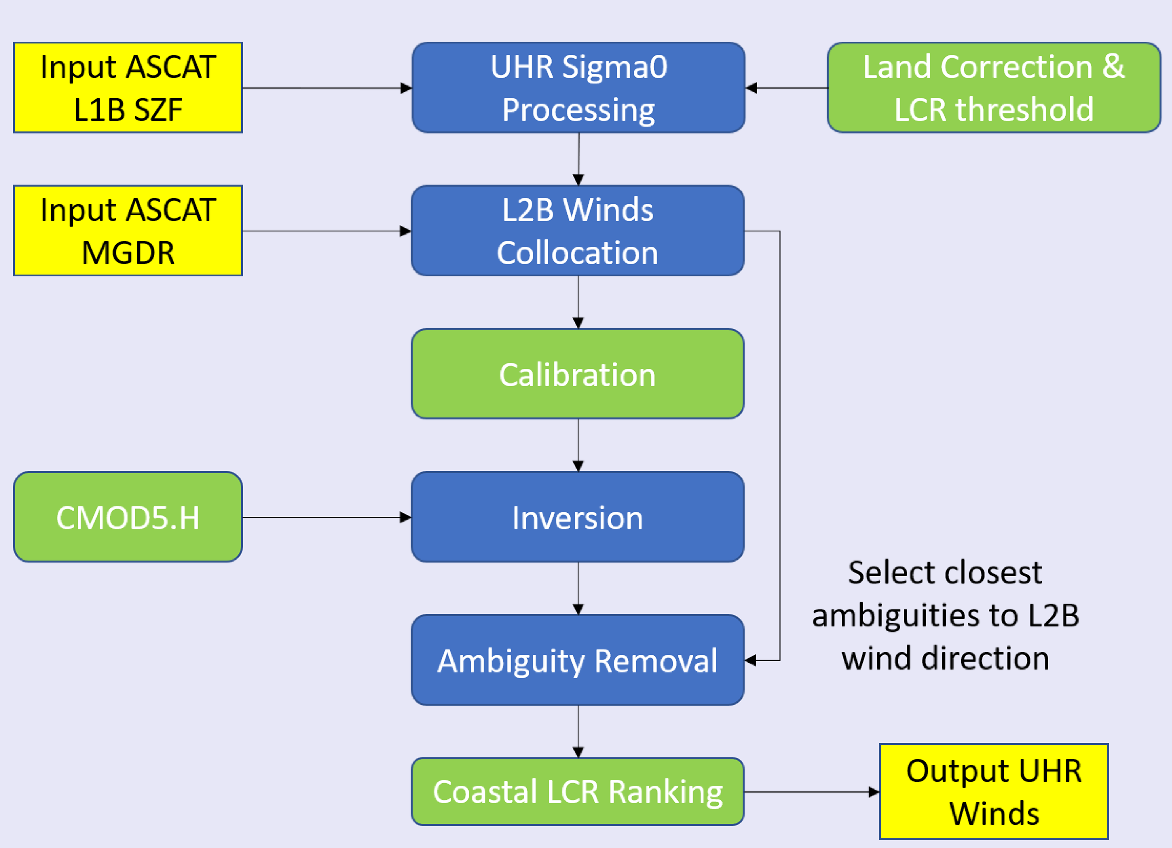

Fig.1. NOAA Near Real-Time ASCAT Coastal Wind Schematic.

- The NOAA near real-time ASCAT coastal winds processor is shown in Fig. 1. The input data are ASCAT full resolution L1B SZF and the near real-time ASCAT 12.5 km winds. The blue boxes represent the previous work developed by [1, 2] and the green boxes represent the new improvements.
- Land contamination correction is implemented to reduce a land contamination of the sigma0 near the coast so that an aggressive land contribution ratio (LCR) threshold can be applied.
- The enhanced resolution sigma0 is calculated by using the weighted average of the sigma0 and its Spatial Response Function (SRF) and reject any sigma0 slices in which its LCR is exceeding a threshold [1, 2].
- Calibration is implemented to remove a residual error between ASCAT measurements and the modeled sigma0 using the CMOD5.H Geophysical Model Function (GMF) [5].
- Wind inversion step is used to convert the sigma0 into wind vector ambiguities using the Maximum Likelihood Estimator (MLE) approach.
- In an ambiguity removal step, a unique wind vector solution is found by selecting the ambiguity that is closest to the 12.5 km wind direction.
- The coastal wind retrievals is done on a different LCR threshold ranked according to the LCR value where the lowest value has the highest rank and the highest value has the lowest rank.

NOAA ASCAT Coastal Winds

- NOAA ASCAT coastal wind build upon the BYU's previous work on the Ultra High Resolution (UHR) coastal wind retrievals [1-3] utilized an enhanced resolution normalized radar backscattered cross section (sigma0) processing technique and land contribution ratio (LCR).
- The improvement of the land contamination is done by dynamically correcting for the land contamination using the mean and standard deviation of the land sigma0 from each measurement. This technique was first demonstrated in [4].
- The land sigma0 correction allow for the use of aggressive LCR threshold up to 50%; thus, wind retrieval can get much closer to the coast.
- The NOAA CMOD5.H high wind GMF [5] is used in the wind retrieval and the ocean calibration.
- Post processing best wind ranking is used to further remove the land contamination.
- The first version of the UHR ASCAT coastal wind and ice product is being produced in near real-time for operation validation.

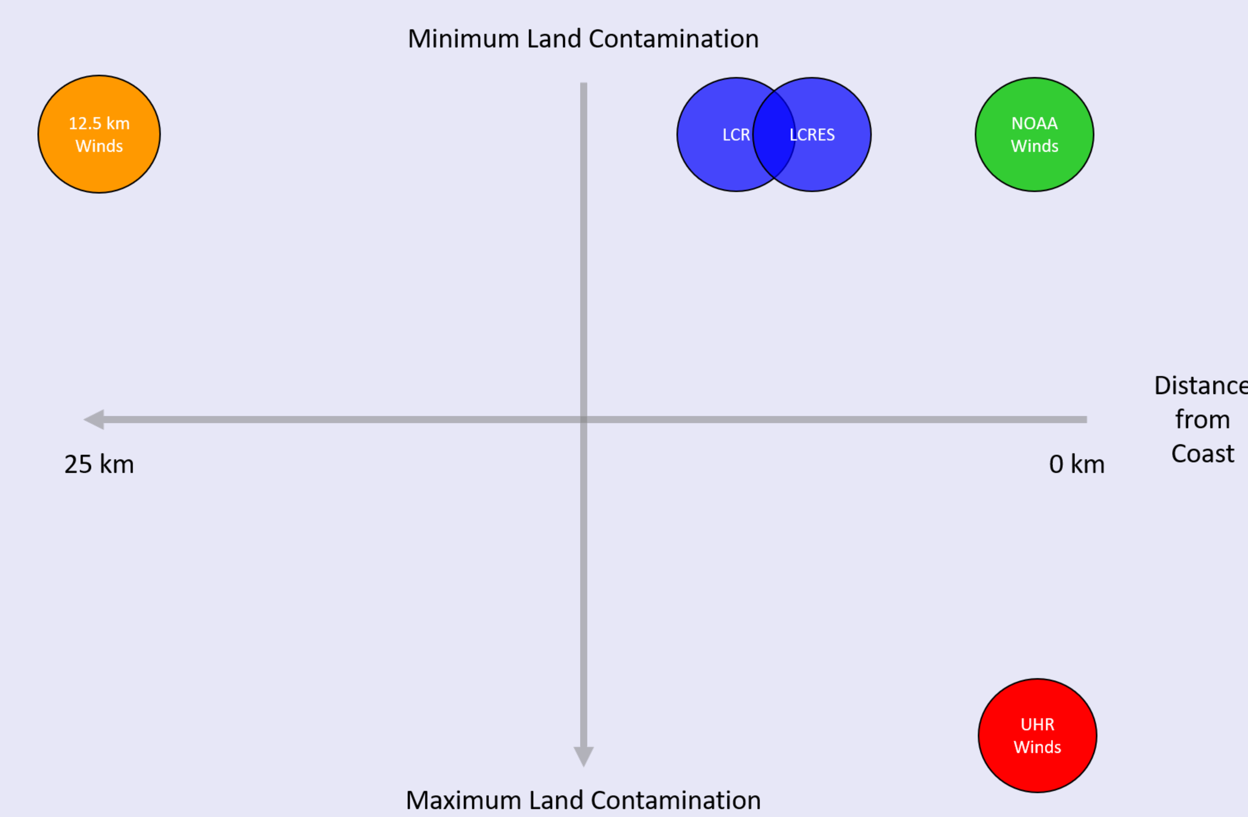

Fig.2. Land Contamination and Coastal Wind Distance Relationship

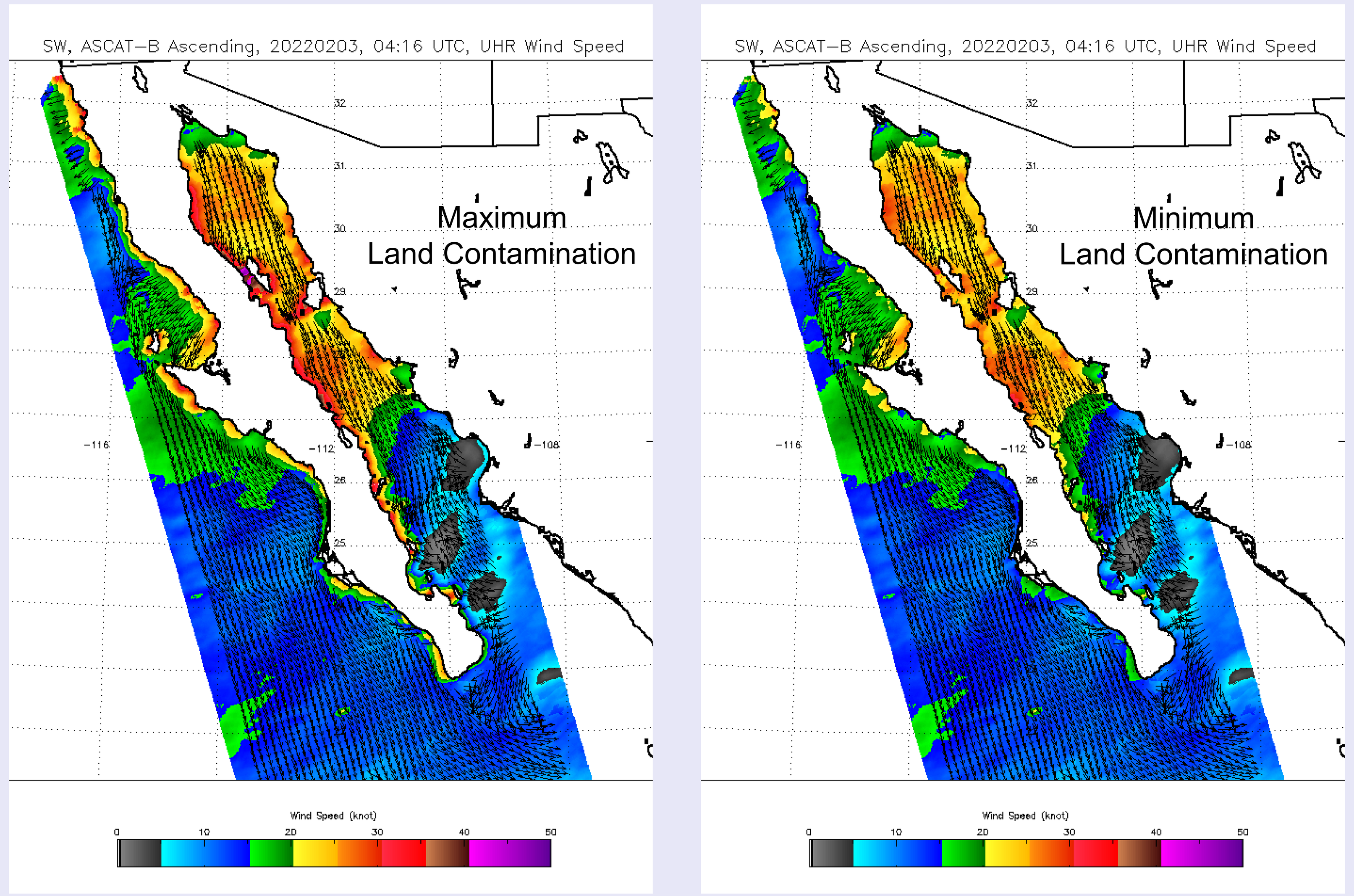

Fig.3. NOAA ASCAT Coastal Wind Without (left) and With (right) Land Contamination Correction

- UHR winds processing with high resolution land mask can retrieve wind in the coastal zone but suffer large land contamination.
- Previous works by other investigators:
  - Empirical Land Mask (Vanhoff 2013)
  - Land Contribution Ratio (LCR) (Owen 2009, Lindsley 2016)
  - LCR Expected Sigma0 (LCRES) (Stiles 2014)

Land Contamination Correction

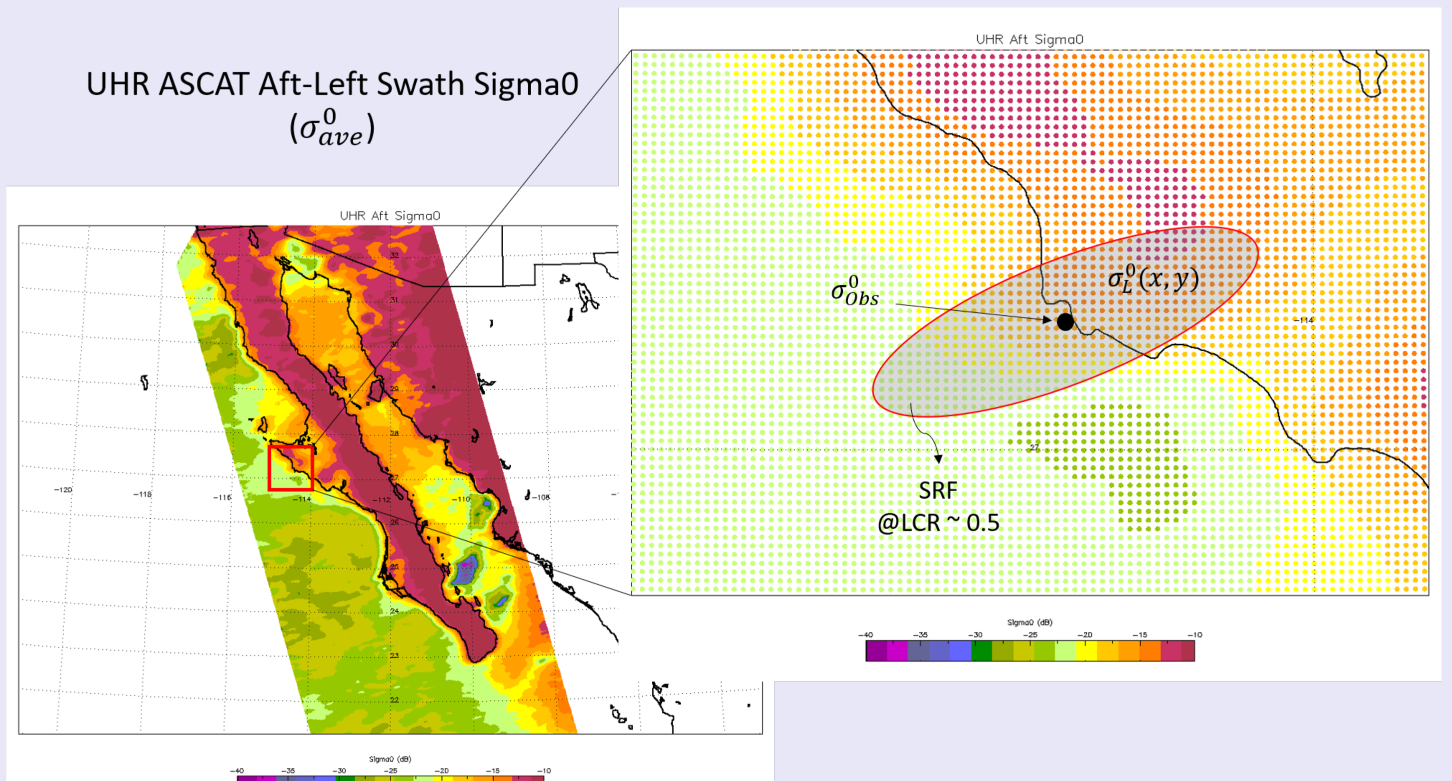

Fig.4. UHR ASCAT Sigma0 from the Aft-Left Swath. The Enlarged Area Show the SRF with LCR ~ 50%.

- For each of the sigma0 measurement near the coast, the sigma0 can be written in a term of land-only and ocean-only sigma0 as in (1) and in discrete form as in (2)

$$\sigma^0_{Obs} = \sigma^0_{Land} + \sigma^0_{Ocean} = \frac{\iint \sigma^0(x,y)h(x,y)dxdy}{\iint h(x,y)} \quad (1)$$

$$\sigma^0_{Obs} = \frac{\sum \sigma^0_L(x,y)\cdot G_L(x,y)}{\sum G_L(x,y)} \cdot \frac{\sum G_L(x,y)}{\sum G_{Total}(x,y)} + \frac{\sigma^0_O \cdot (\sum G_{Total} - \sum \cdot G_L(x,y))}{\sum G_{Total}(x,y)}$$

$$\sigma^0_{Obs} = \sigma^0_{L,ave} \cdot LCR + \sigma^0_O \cdot (1 - LCR) \quad (2)$$

- The terms $\sigma^0_L(x,y)$ and $G_L(x,y)$ are the surface land-only sigma0 and land-only gain response respectively.
- The mean and the standard deviation of the land-only sigma0 for each measurement are:

$$\sigma^0_{L,ave} = \frac{\sum \sigma^0_L(x,y) \cdot G_L(x,y)}{\sum G_L(x,y)} \quad (3)$$

$$\sigma^0_{L,std} = \left(\frac{\sum\left[\left(\sigma^0_L(x,y) - \sigma^0_{L,ave}\right)\cdot G_L(x,y)\right]^2}{\sum G_L(x,y)}\right)^{0.5} \quad (4)$$

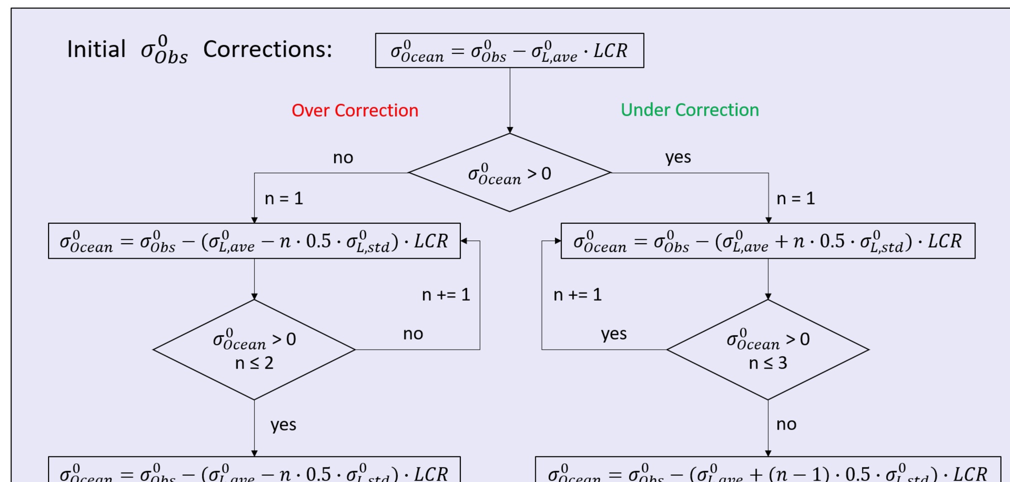

Fig.5. Sigma0 Correction Procedure

- The initial ocean-only sigma0 can be solved using (1).
- Since $\sigma^0_{L,ave}$ can vary greatly depending on the geographical features and observation orientation, (1) is modified to include the land stand deviations $\sigma^0_{L,stdv}$. The iteration process is carried out until the correction produces a non-negative sigma0 or until it reaches a maximum of n = 3.

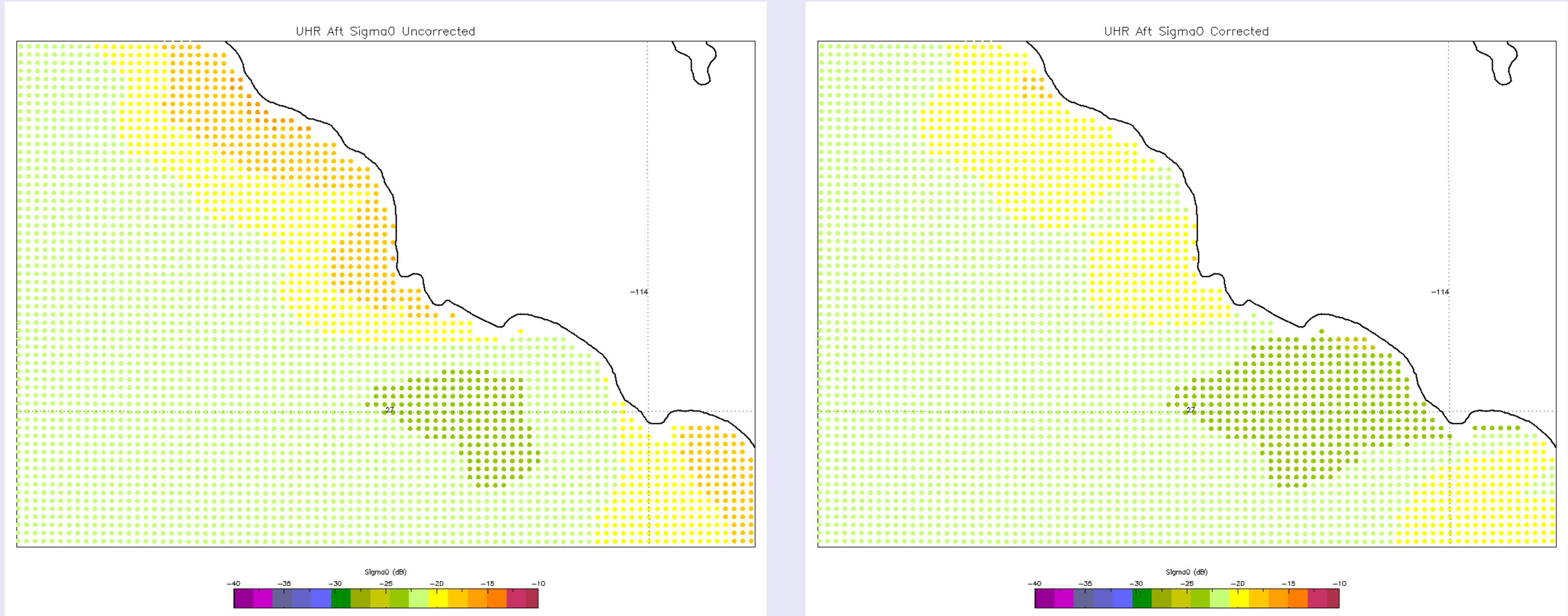

Fig.6. The UHR ASCAT Sigma0 Before (left) and After (right) Land Contamination Correction using 50% LCR Threshold.

References

1. R. D. Lindsley and D. G. Long, "Enhanced-Resolution Reconstruction of ASCAT Backscatter Measurements," IEEE Transactions on Geoscience and Remote Sensing, Vol. 54, No. 5, pp. 2589-2601, doi:10.1109/TGRS.2015.2503762, 2016.
2. R. D. Lindsley, J. R. Blodgett, and D. G. Long, "Analysis and Validation of High-Resolution Wind from ASCAT," IEEE Transactions on Geoscience and Remote Sensing, Vol. 54, No. 10, pp. 5699-5711, doi:10.1109/TGRS.2016.2570245, 2016.
3. M. P. Owen and D. G. Long, "Land Contamination Compensation for QuikSCAT Near-Coastal Wind Retrieval," IEEE Transactions on Geoscience and Remote Sensing, doi:10.1109/TGRS.2008.2005633, Vol. 47, No 3, pp. 839-850, 2009.
4. S. Soisuvarn, Z. Jelenak, P. S. Chang and Q. Zhu, "Coastal Winds from NOAA Near Real-Time SCATSAT-1 Scatterometer Processor," OCEANS 2021 – MTS/IEEE San Diego-Porto, Sep. 20-23, 2021.
5. S. Soisuvarn, Z. Jelenak, P. S. Chang, S. O. Alsweiss and Q. Zhu, "CMOD5.H—A High Wind Geophysical Model Function for C-Band Vertically Polarized Satellite Scatterometer Measurements," IEEE Transactions on Geoscience and Remote Sensing, vol. 51, no. 6, pp. 3744-3760, 2013.

2022 International Ocean Vector Winds Science Team Meeting, 19 April 2022, Virtual Meeting.