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TAKING THE PULSE OF OUR PLANET FROM SPACE

Estimating Sea Surface Local Wind Variability from ASCAT-derived information

Wenming Lin [1], Marcos Portabella [2,3]

(1) 南京信息工程大學 Nanjing University of Information Science & Technology

(2) Institut de Ciències del Mar

(3) BEC Barcelona Expert Center

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1.Motivation

2.Data and method

3.Results

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ASCAT Quality Control

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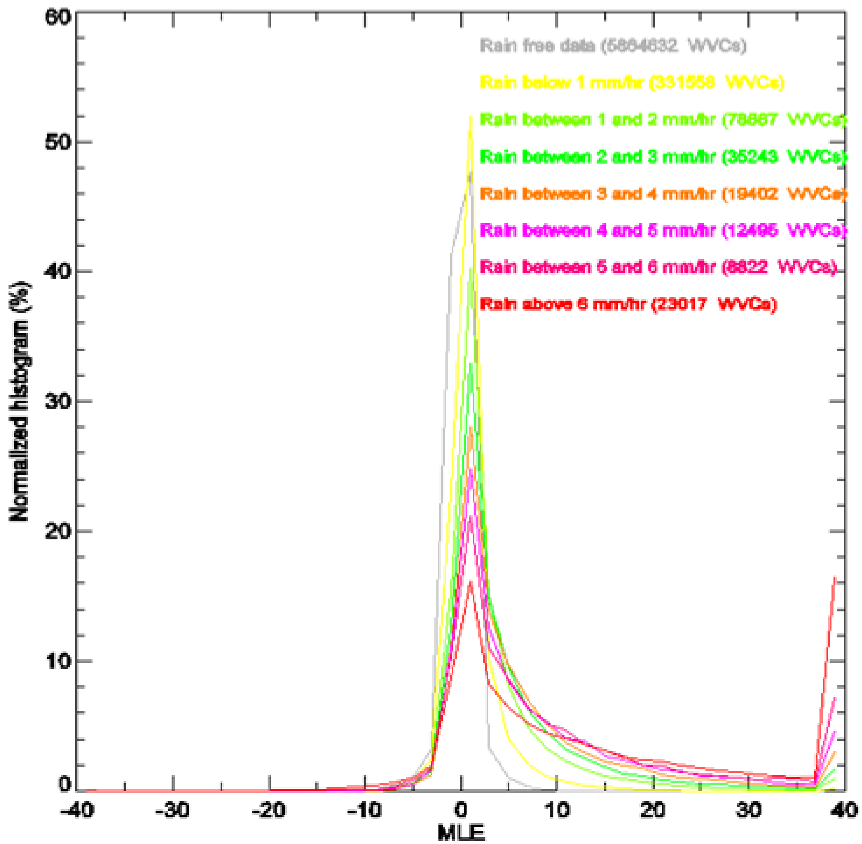
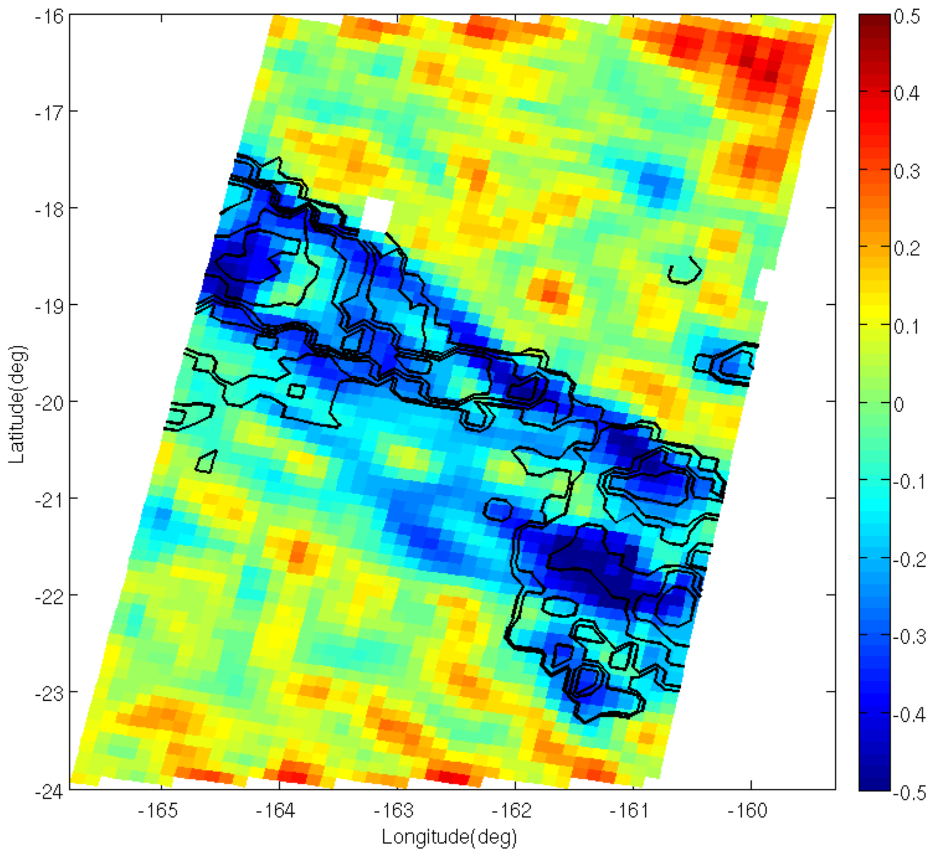


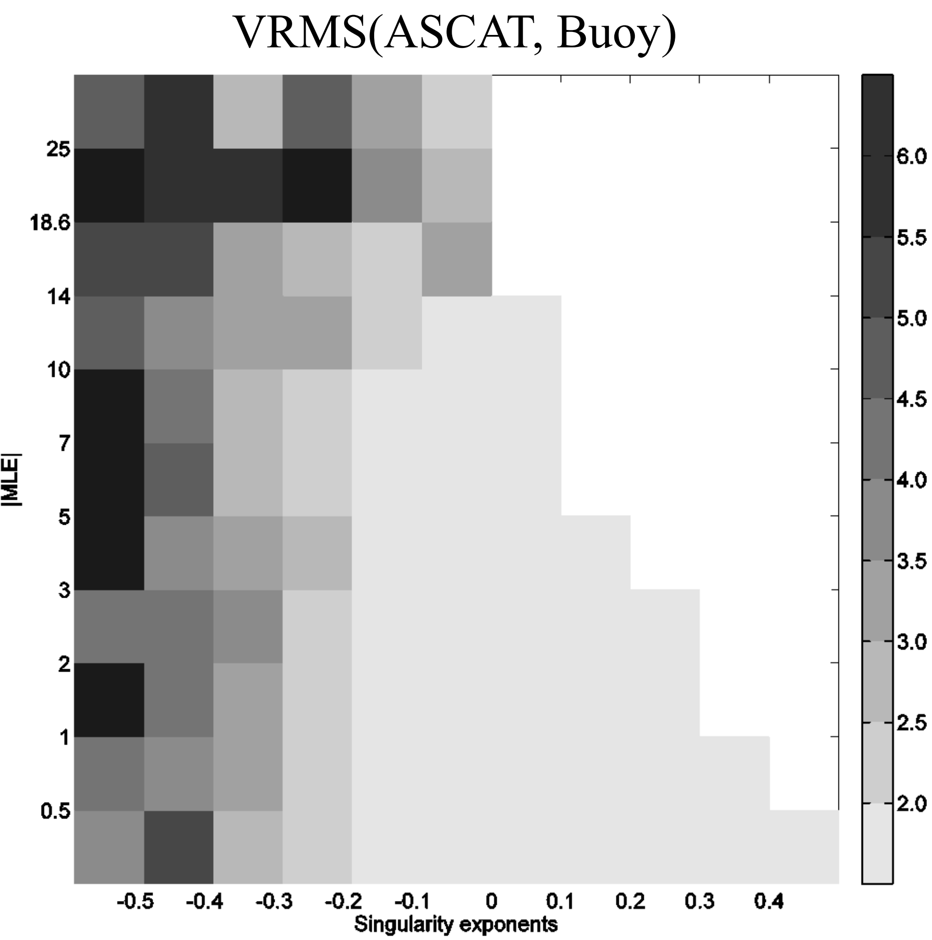
ASCAT inversion residual distributions w.r.t. TMI RR data



Singularity map of the ASCAT-retrieved wind field. TMI RR data shown as contour lines

- **Good correspondance between TMI RR and positive (negative) MLE (SE) values**

ASCAT Quality Control

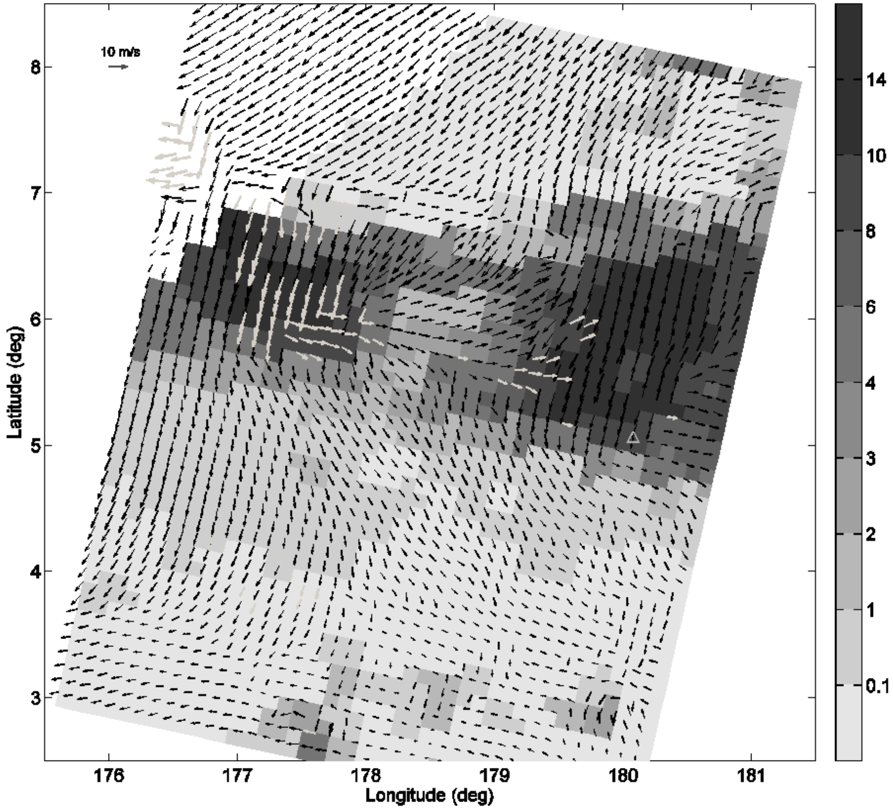


VRMS difference between buoy and ASCAT winds, as a function SE and MLE

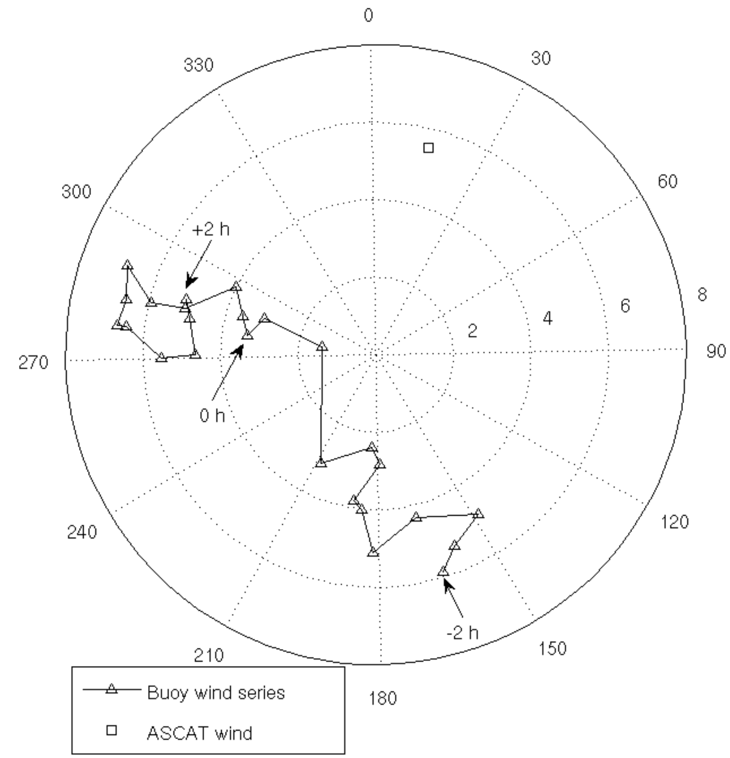
- The correspondence of buoy and ASCAT winds reduces as SE decreases and MLE increases

- SE and MLE parameters are complementary in terms of quality classification

Rain contamination or increased wind variability effects?



(*a*)



(*b*)

Fig.2 (*a*) ASCAT wind observed on December 15, 2009, at 21:17 UTC, with collocated TMI RR superimposed (see the legend). The black arrows correspond to QC-accepted WVCs, and the gray ones correspond to QC-rejected WVCs. The buoy measurements (denoted by the triangle) were acquired at 21:20±2 hours UTC, as shown in the polar coordinate plot (*b*).

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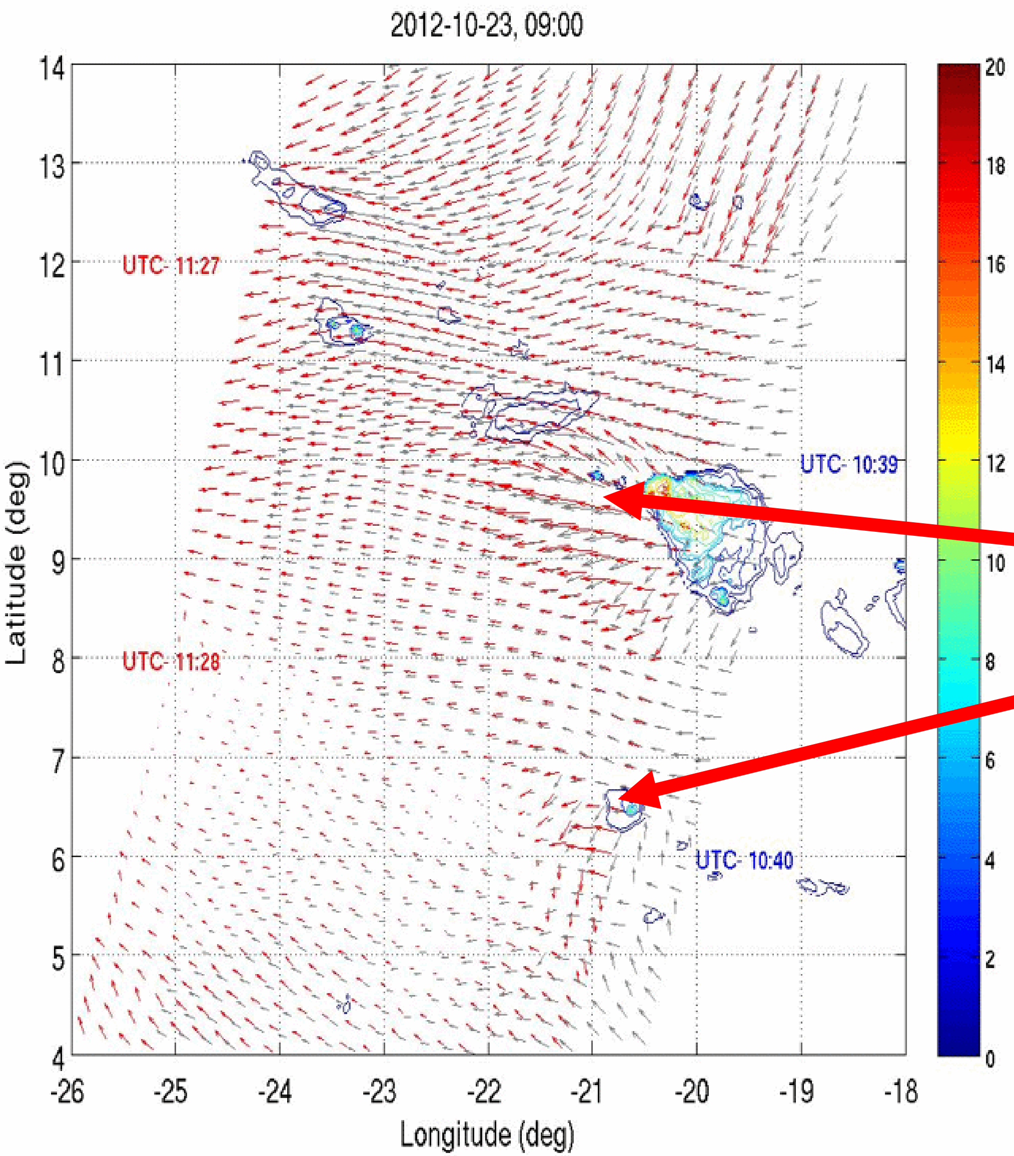
ASCAT winds show rain-induced dynamics!



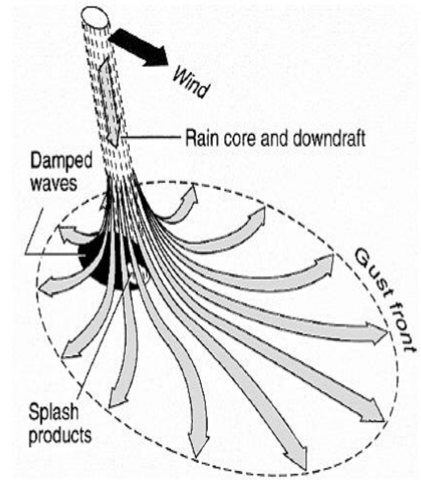


Figure 17.1. Schematic sketch of the downdraft associated with a rain cell. The downdraft spreads over the sea surface, causing and enhanced roughening of the sea surface and, thus, an increase in the backscattered radar power [After *Atlas*, 1994b].

Convective downbursts

ASCAT-A and ASCAT-B come together.

Red arrows: ASCAT-A;
Blue arrows: ASCAT-B;
Contours: MSG RR.

1. Motivation

- Local variability of sea surface wind has a significant impact on the mesoscale air-sea interactions and wind-induced oceanic response.

- *Lin et al.* (TGRS, 2015) show that the ASCAT wind quality seems to be mainly associated with large (sub-WVC) wind variability, i.e., wind variability within a wind vector cell (WVC) may be characterized using the quality indicators of ASCAT, such as the inversion residual (MLE) and the singularity exponent (SE).

- Once the above inference is validated, one can develop a new useful NRT variable – wind variability, using the ASCAT wind data.

2. Data and Method

1) "True" local wind variability is estimated from the 10-min buoy wind series within a certain temporal window, following the Taylor Hypothesis [*Lin et al., 2015*]

$$SD = \sqrt{\frac{1}{M-1}\sum_{i=1}^{M}(x_i - \bar{x})^2} \qquad SD_{\text{vector}} = \sqrt{SD_u^2 + SD_v^2}$$

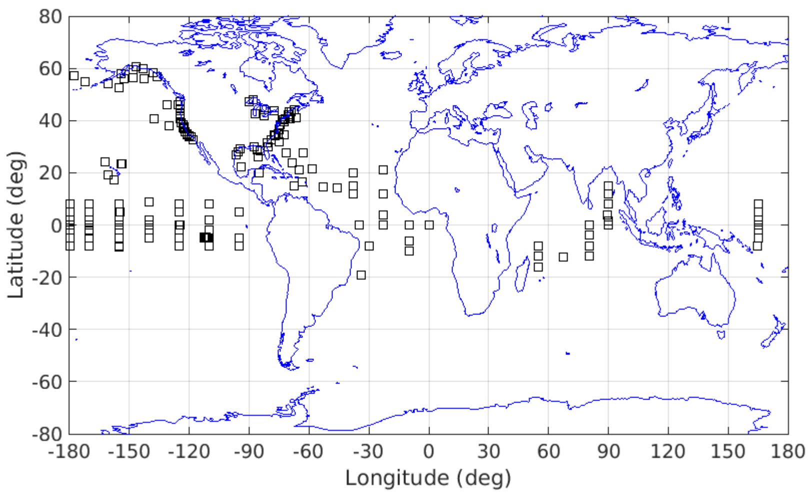
2) The wind variability as a function of wind speed is studied under different rain conditions, based on the collocated buoy-GMI rain data.

3) The correlation between wind variability and ASCAT quality indicators (MLE & SE) is evaluated using the collocated buoy-ASCAT data.

$$\text{MLE} = \frac{1}{3}\sum_{i=1}^{3}(z_{mi} - z_{si})^2 \qquad \text{SE(x)} \sim \frac{\log|\nabla s|\,(\text{x})}{\log r}$$

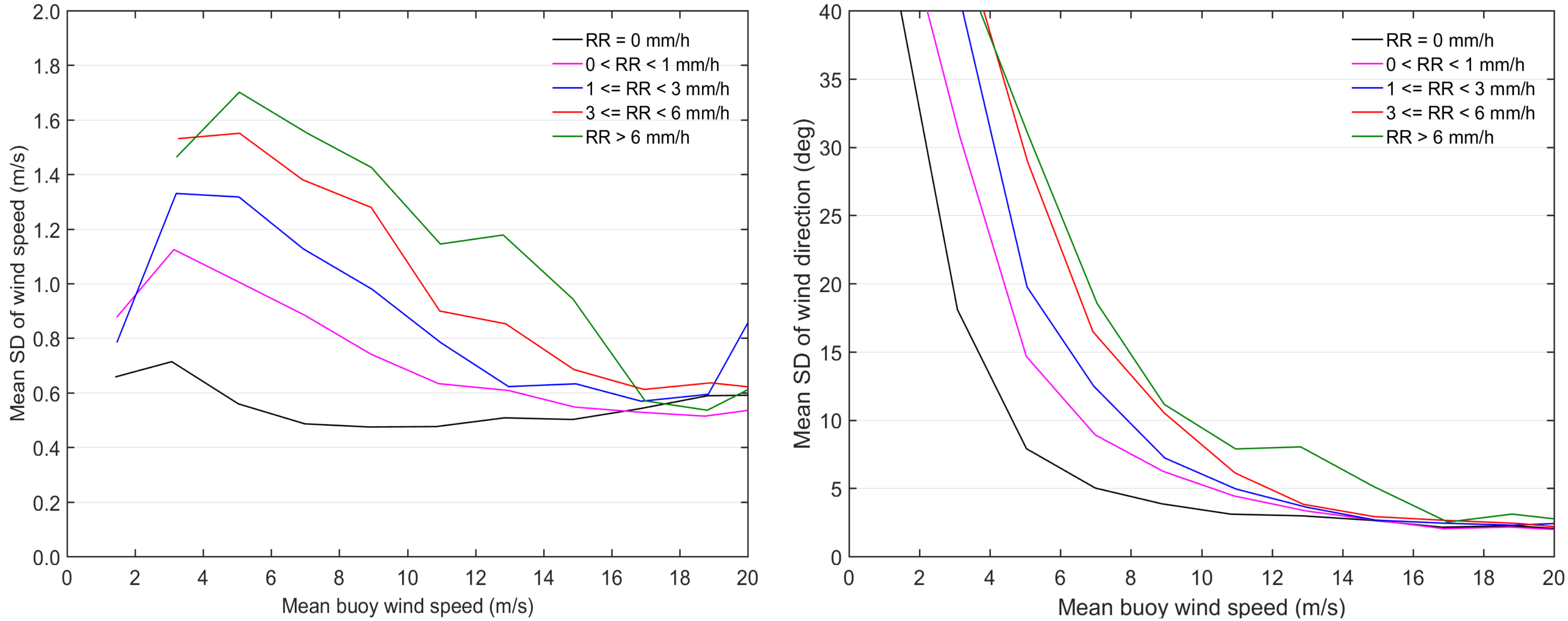
2. Data and Method

- OSI SAF 12.5-km ASCAT-A winds in the period 2010-2019
- Moored buoy data arrays (TAO, TRITON, PIRATA, RAMA, NDBC)



- ASCAT – Buoy collocation sets
  - Training set (2012-2019) ~ 218k collocations
  - Test set (2010-2011) ~ 60k collocations

3. Results

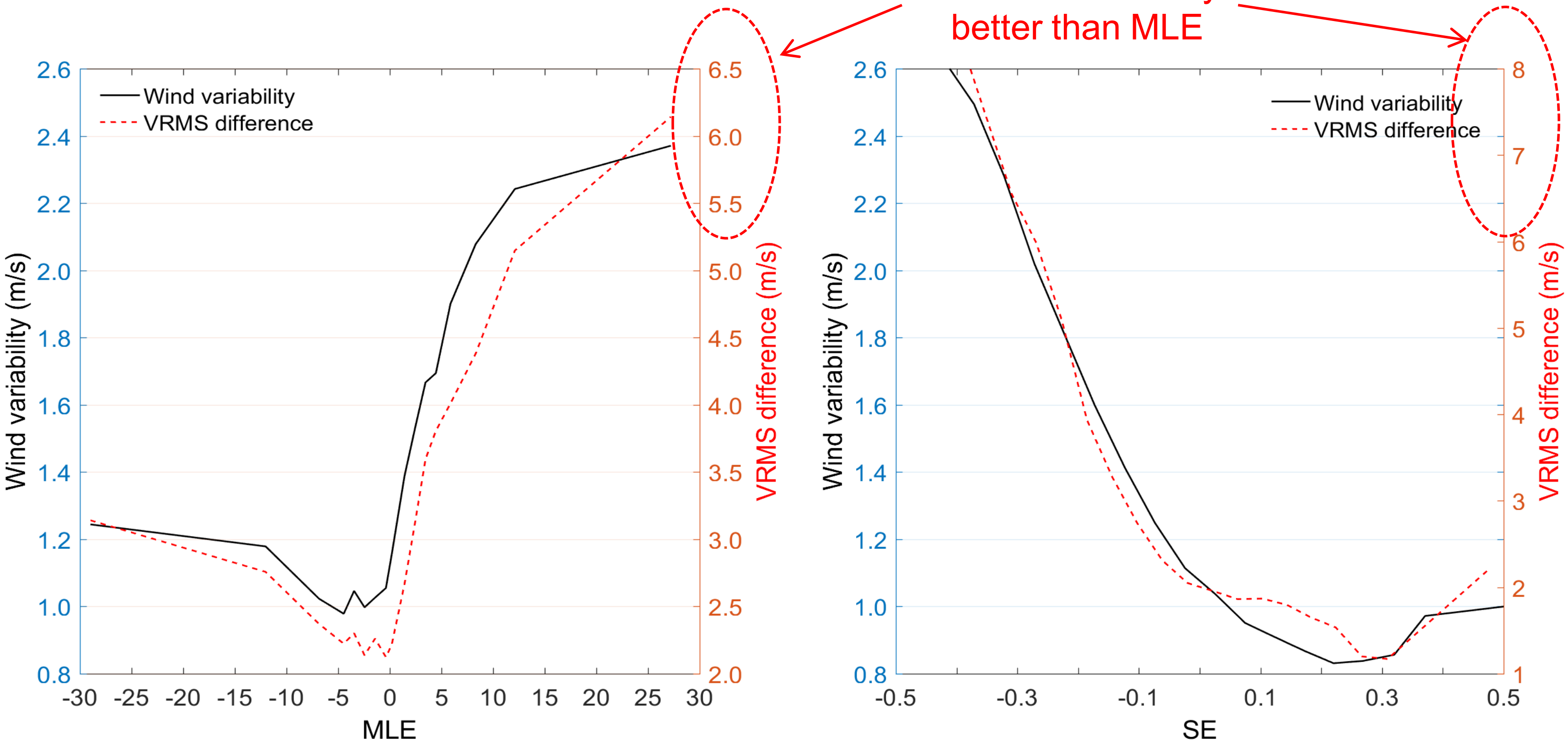


The mean wind speed (left) and direction (right) variability as a function of wind speed under different rain conditions (see the legends)

Rain increases sea surface wind variability!

3. Results

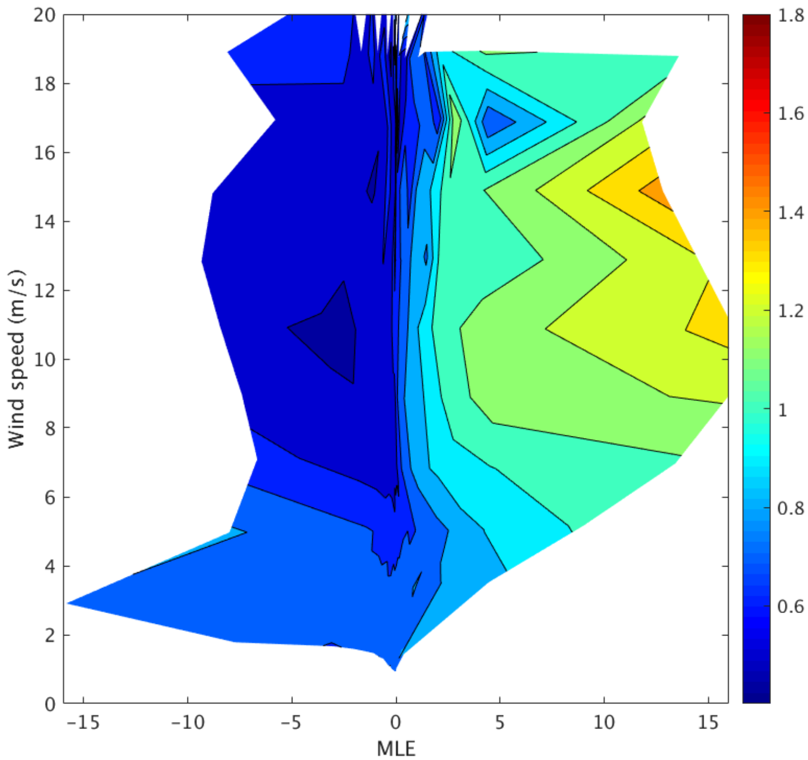
SE describes wind variability better than MLE



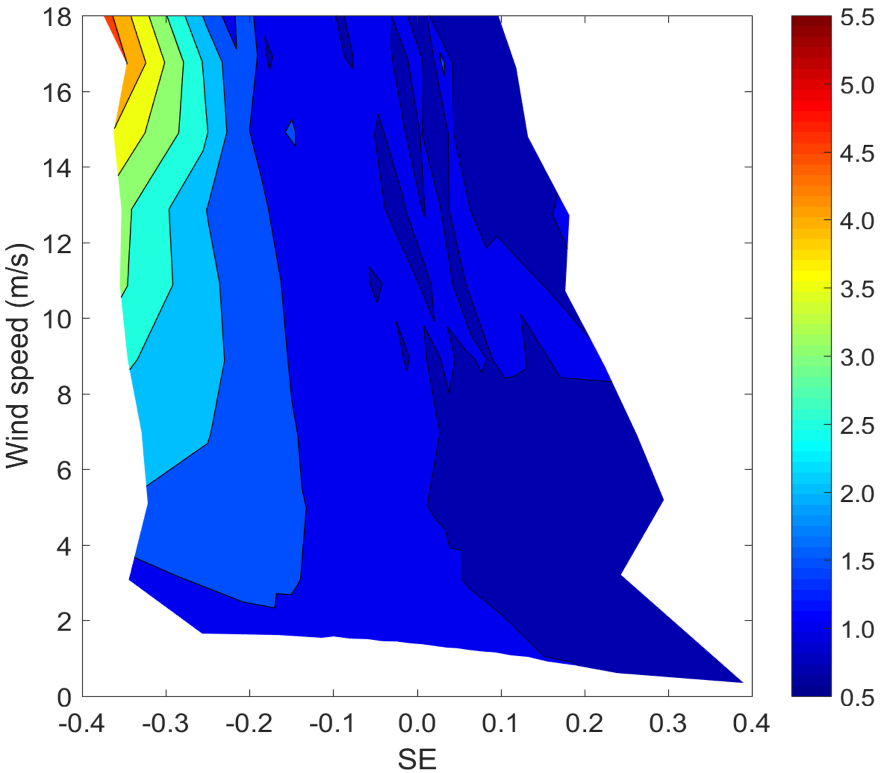
The vector variability (black curves) and VRMS difference between ASCAT and Buoy winds (red curves) as a function of MLE (left) and SE (right)

- **Sea surface wind variability degrades the statistical scores w.r.t. buoy**
- **Sea surface wind variability is captured by ASCAT wind quality indicators**

3. Results

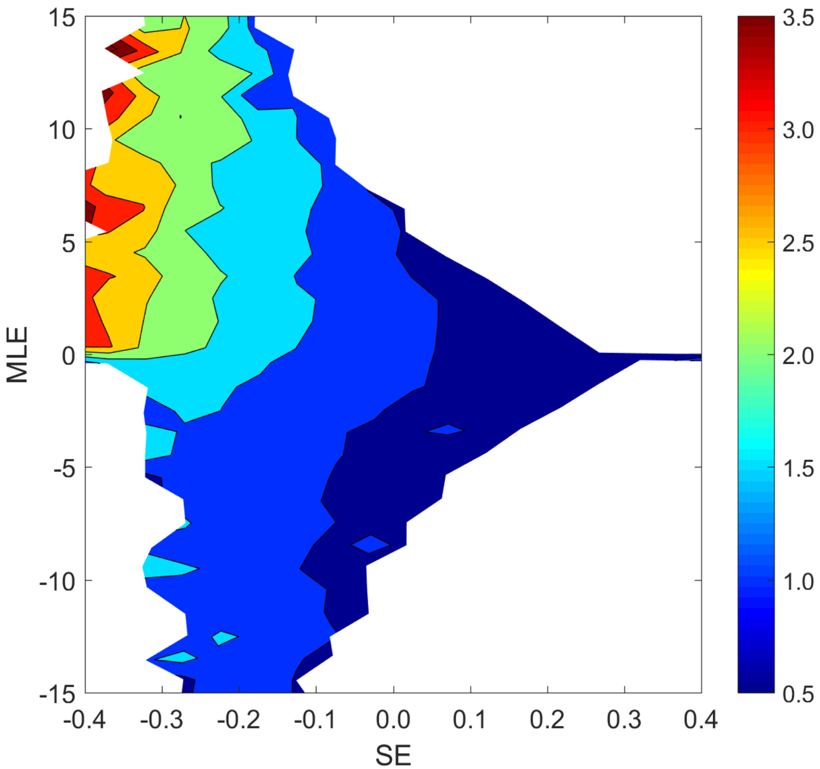


The vector variability (colorbar) versus ASCAT wind speed and MLE. Blank area is due to the lack of data.

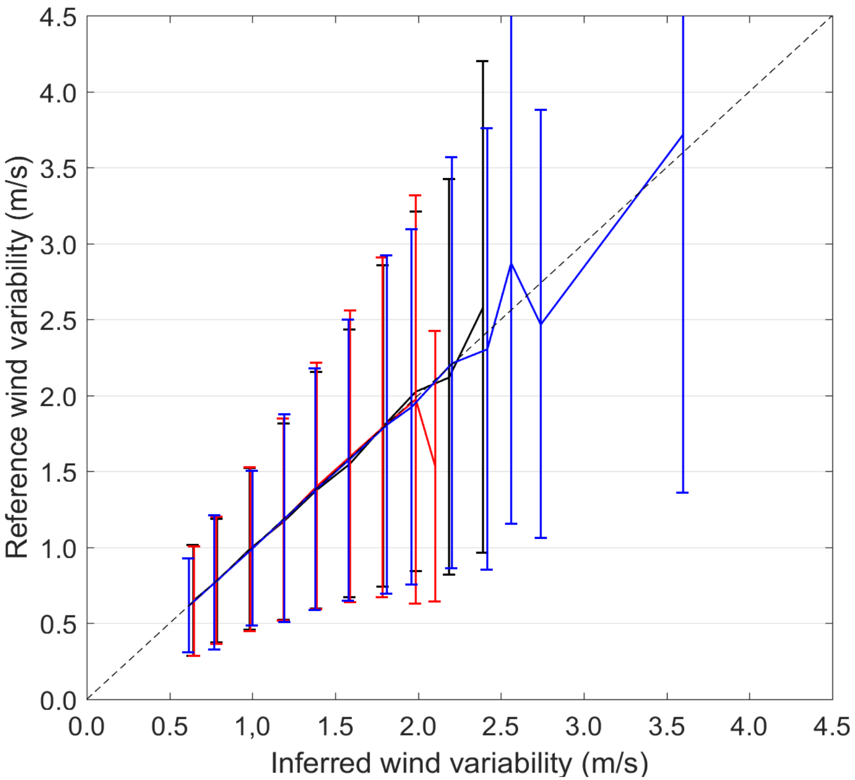


The vector variability (colorbar) versus ASCAT wind speed and SE. Blank area is due to the lack of data.

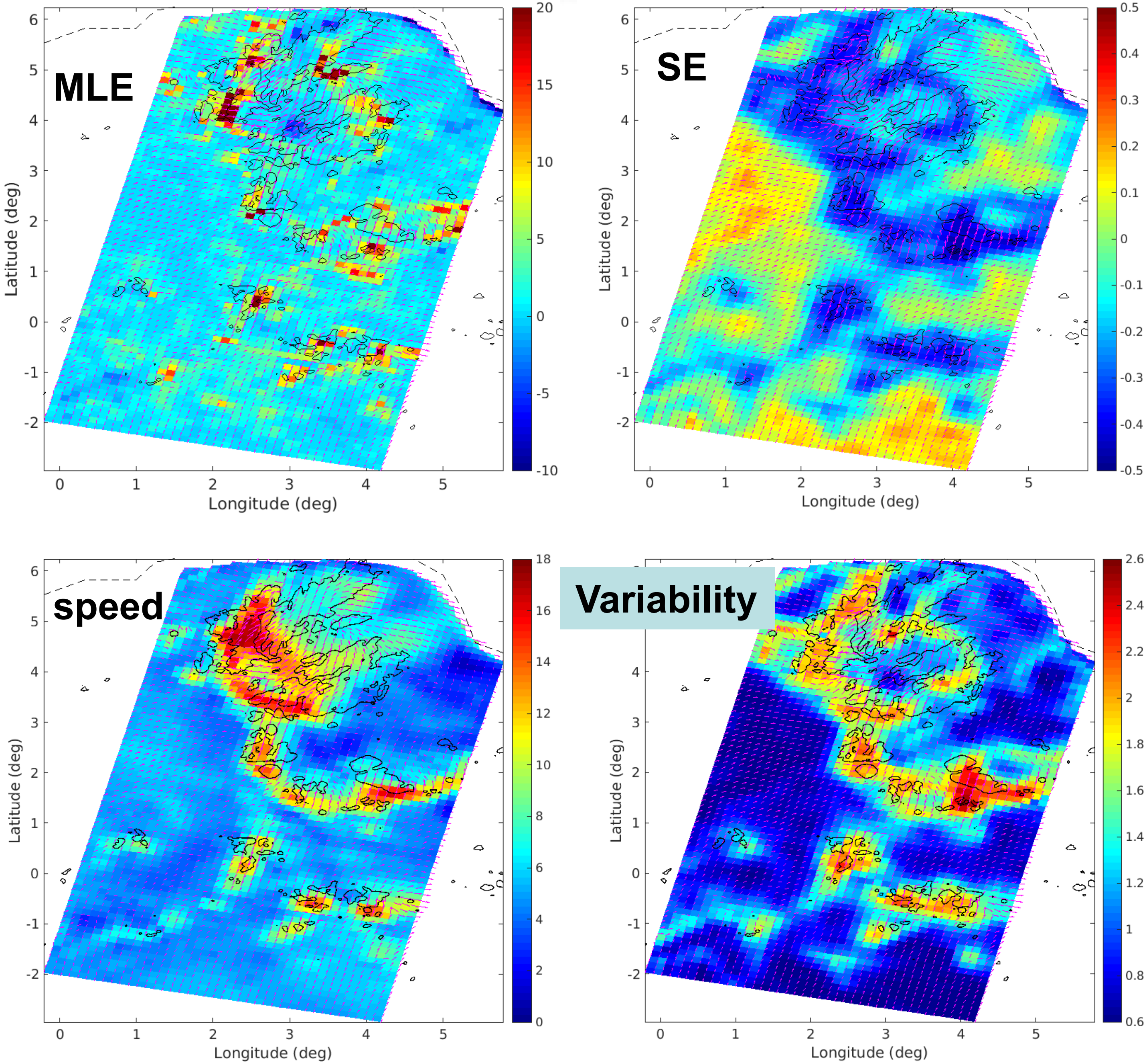
3. Results



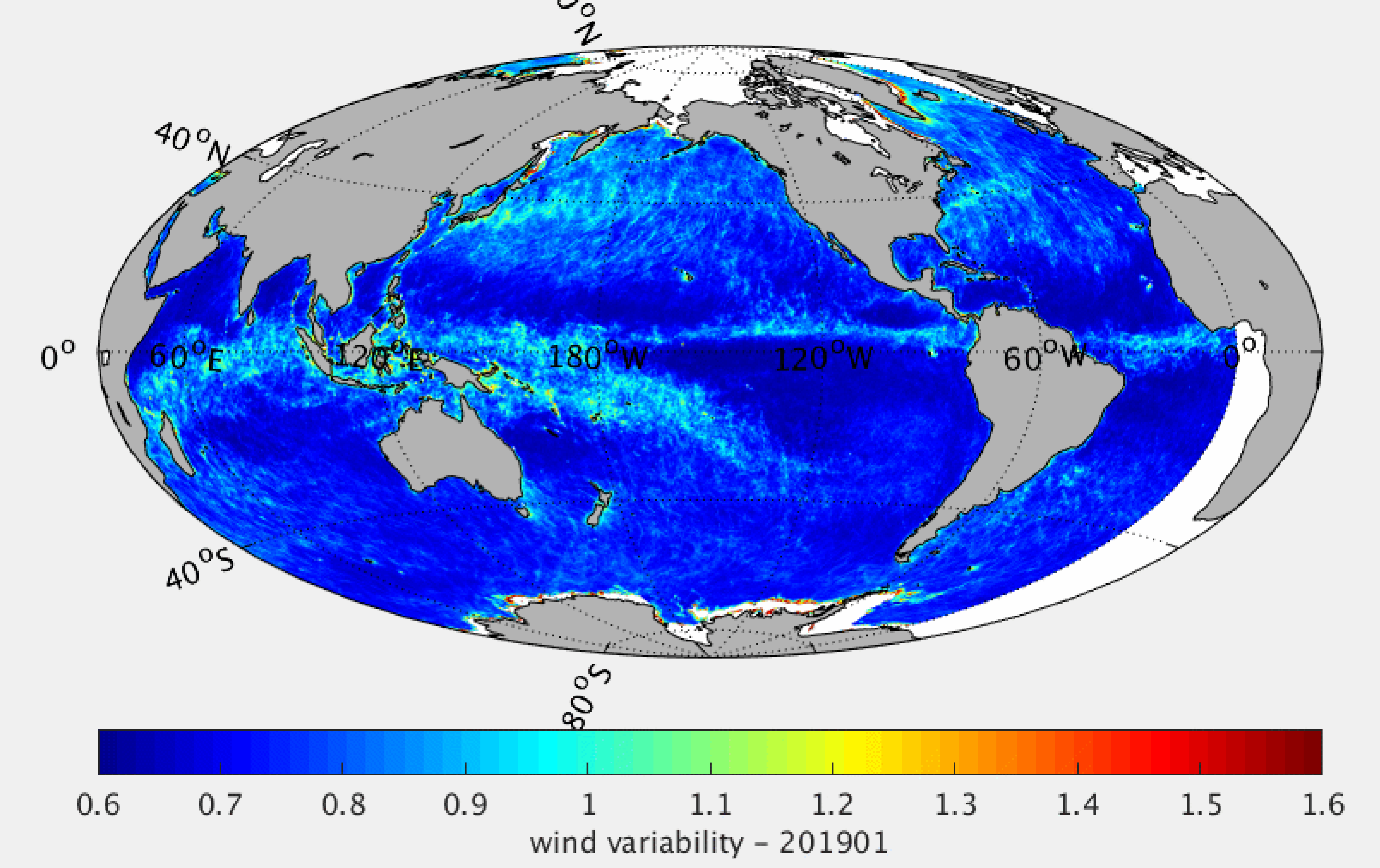
The vector variability (colorbar) versus ASCAT MLE and SE. Blank area is due to the lack of data.



1. Estimate the wind variability a function of SE/MLE (2012-2019)
2. Define the wind variability using SE/MLE; (2010-2011)
3. Evaluate the wind variability from the collocated buoy winds; (2010-2011)
4. Compare 2 and 3.



Black contours indicate rain above 1 mm/h



Monthly variability derived from ASCAT (Year 2019, Movie)

4. Conclusions

- ASCAT MLE and SE are indeed good & complementary indicators of wind variability
- Although the ASCAT wind quality is strongly correlated with sub-cell wind variability, note that ASCAT winds are proven to be of fair quality at high wind variability conditions
- A new sub-cell wind variability parameter can be easily incorporated in the ASCAT wind product
- This parameter is particularly relevant for, e.g., nowcasting purposes, since it clearly depicts areas of wind disturbances
- It can also be used to filter out small-scale wind information which is potentially detrimental in global NWP data assimilation
- We plan to serve the combined ASCAT wind + sub-cell variability product in Fall 2022 from **bec.icm.csic.es**

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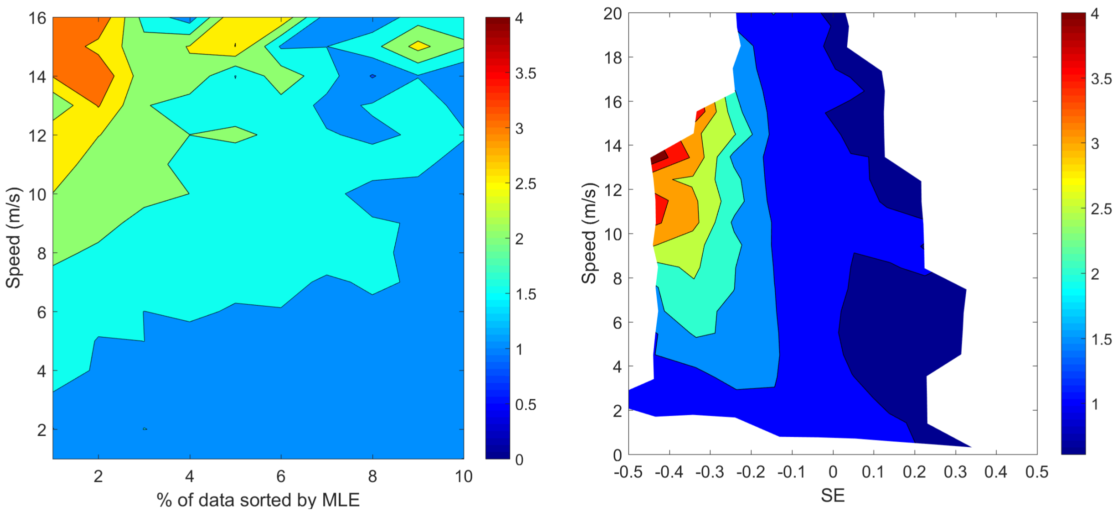
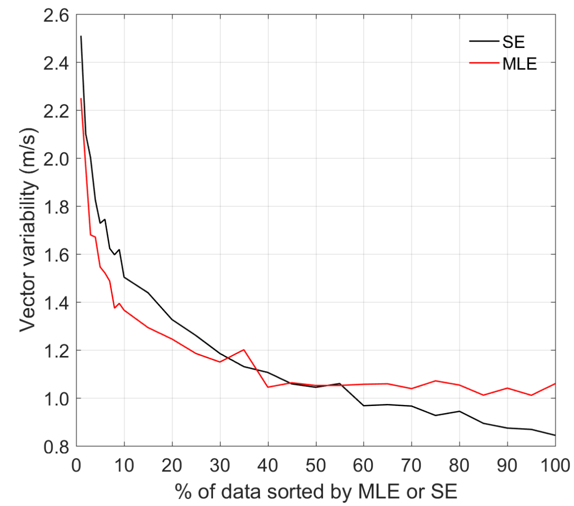
3. Results



The vector variability (colorbar) versus ASCAT wind speed and percentiles of data sorted by MLE (left) or SE (right).



The vector variability versus percentiles of data sorted by MLE (red) or SE (black).

Quality verification

- Mean buoy winds (25-km-equivalent)

$$\overline{\varphi} = \arctan\left(\frac{-\overline{u}}{-\overline{v}}\right)$$

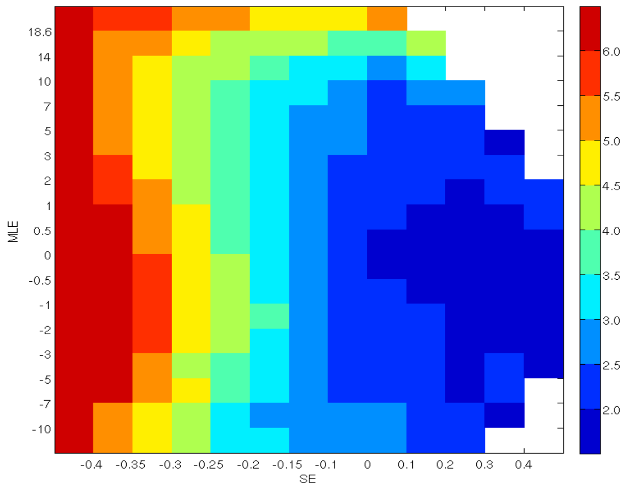
$$\overline{w} = \frac{1}{M}\sum_{i=1}^{M} w_i$$

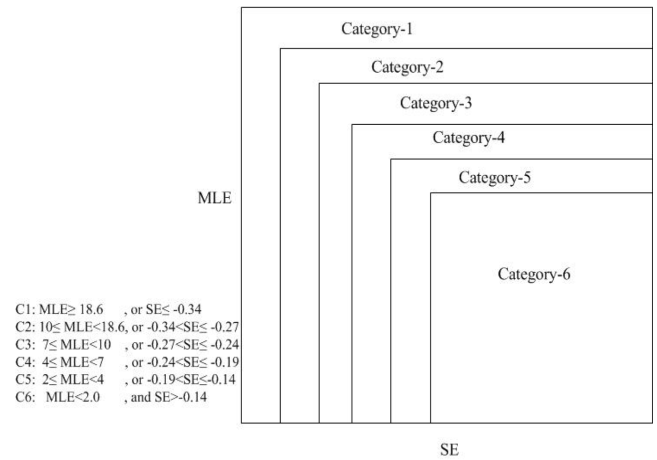
where
$$\begin{cases} \overline{u} = \frac{1}{M}\sum_{i=1}^{M} -w_i \sin(\varphi_i) \\ \overline{v} = \frac{1}{M}\sum_{i=1}^{M} -w_i \cos(\varphi_i) \end{cases}$$

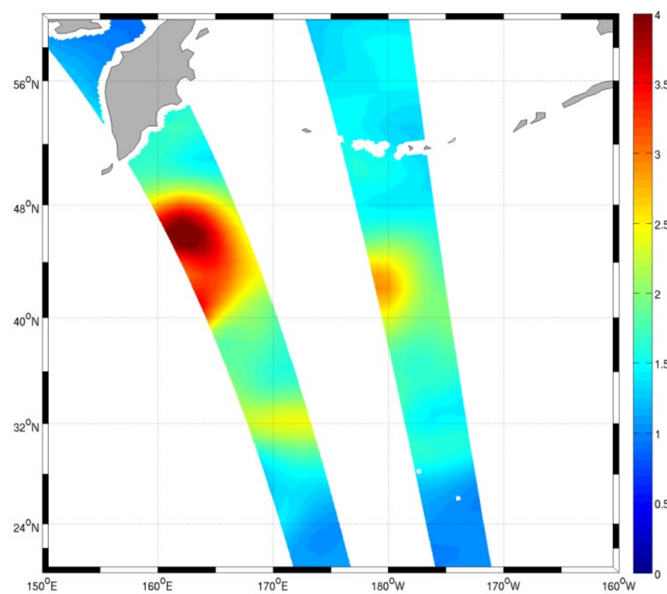
V≥4 m/s	VRMS (Rejected WVC)			VRMS (Accepted WVC)			QC-ed ratio (%)		
	MLE	MLE/SE	MUDH	MLE	MLE/SE	MUDH	MLE	MLE/SE	MUDH
10-min buoy wind	5.04	5.28	5.21	1.63	1.62	1.61	0.32	0.65	1.04
Mean buoy wind	4.25	4.41	4.45	1.29	1.28	1.27	-	-	-

- By using mean buoy winds, the variance reduction is about 30-40% in both accepted and rejected categories
- Sub-WVC wind variability is therefore the dominant factor for quality degradation (in both wind sources!)

Situation-dependent O/B errors







ECMWF Ensemble Data Assimilation
(EDA background error)