

On Bayesian scatterometer wind inversion

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Abstract. For ERS scatterometer inversion, several studies reveal that the shape of the measurement space wind surface is more important than the measurement noise information. Such shape has to be locally symmetric as a function of wind direction in order to produce realistic and accurate wind direction distributions. A method, which looks for the measurement space transformation that produces such symmetric properties is presented. Although successful for ERS, the method is ineffective for SeaWinds due to limitations inherent in its measurement geometry.

1. Introduction

For ERS, Stoffelen and Anderson (1997) use the Bayesian approach to seek for the best point on the wind surface (σ_s^o) given a set of observations (σ_m^o):

$$P(\sigma_s^o | \sigma_m^o) = P(\sigma_m^o | \sigma_s^o) \cdot P(\sigma_s^o) \quad (1)$$

where $P(\sigma_m^o | \sigma_s^o)$ is referred to as the measurement noise term and $P(\sigma_s^o)$ as the surface shape term. For ERS, this surface has the shape of a double manifold cone in the 3D measurement space. Figure 1 shows the distribution of measurement triplets around a section of the cone, scaled by the noise. Figure 2 shows the artificial accumulations in the retrieved directions, denoting that certain directions are favoured in the inversion. Stoffelen and Anderson (1997) show that such accumulations can be avoided by making the cone sections circular rather than elliptic, i.e., when a constant $P(\sigma_s^o)$ is obtained.

2. Beam weighting method

For scatterometers, $P(\sigma_s^o)$ is constant when the distance traveled on the surface for a small change of wind direction (ϕ) is the same for all ϕ . This is equivalent to a constant total beam sensitivity to ϕ :

$$\left\| \frac{\partial \vec{\sigma}^o}{\partial \phi} \right\| = \sum_{i=1}^N \left(\frac{\partial \sigma_i^o}{\partial \phi} \right)^2 \quad (2)$$

Since Eq. 2 is not true for ERS when noise properties are used in the inversion (see Figure 1), we propose a method that looks for the σ^o space

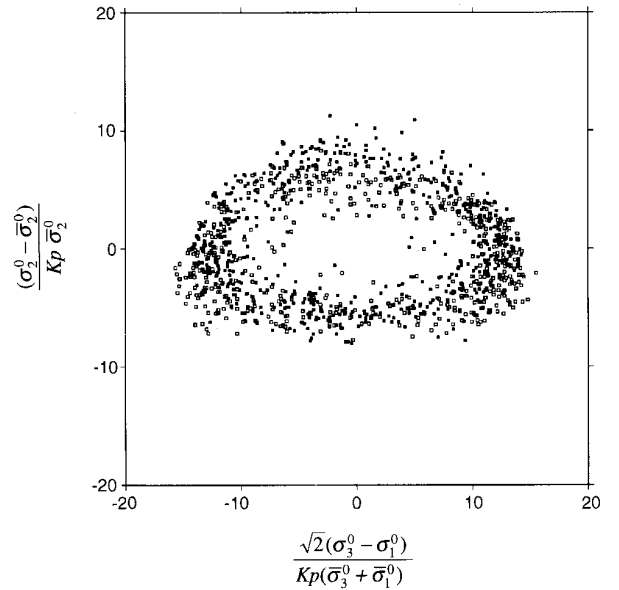


Figure 1. Section of the ERS cone at 8 m/s; the wind direction information lies on the ellipse.

transformation, by rescaling the axes, i.e., weighting the different beams ($\vec{\sigma}' = \vec{a} \cdot \vec{\sigma}^o$), which best meets Eq. 2. In line with Stoffelen and Anderson (1997), the beam weighting procedure is effective in making the ERS cone more circular and therefore reducing the problem of the artificial wind direction accumulations (see Figure 3 as compared to Figure 1). In other words, the shape of the surface is more important than the noise properties for ERS inversion. We now test the method for SeaWinds.

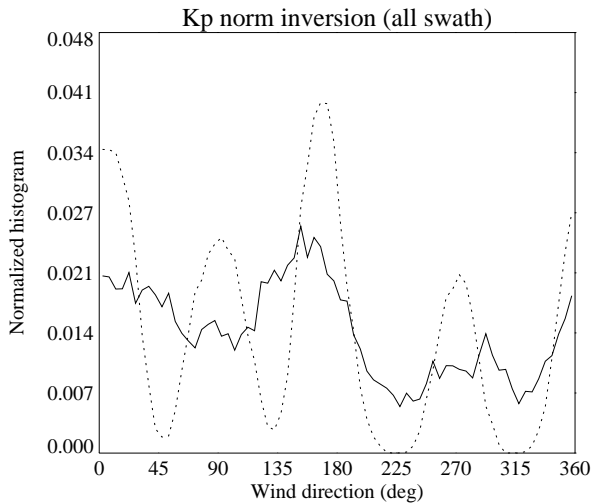


Figure 2. ERS retrieved (dotted) versus ECMWF (solid) wind direction distributions.

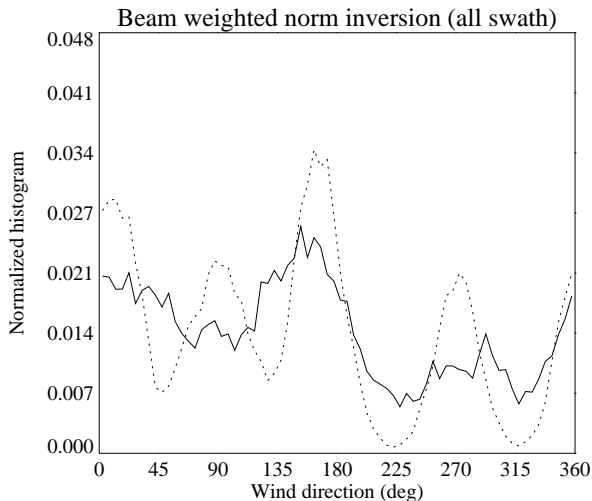


Figure 3. ERS beam weighted (dotted) versus ECMWF (solid) wind direction distributions.

3. SeaWinds geometry case

The problem of the retrieved artificial wind direction acumulations is also present in SeaWinds, as shown by Ebuchi (1999) (see Figure 4). As for ERS, Eq. 2 is not true for SeaWinds. The sensitivities of NSCAT-2 Geophysical Model Function (GMF) for the SeaWinds Wind Vector Cell (WVC) number 11 are shown in Figure 5. It is clear that the total sensitivity (solid) is not constant (flat) as a function of wind direction. Moreover, it has a large modulation, as indicated by the relatively very small sensitivities at certain wind directions (see deepest minima).

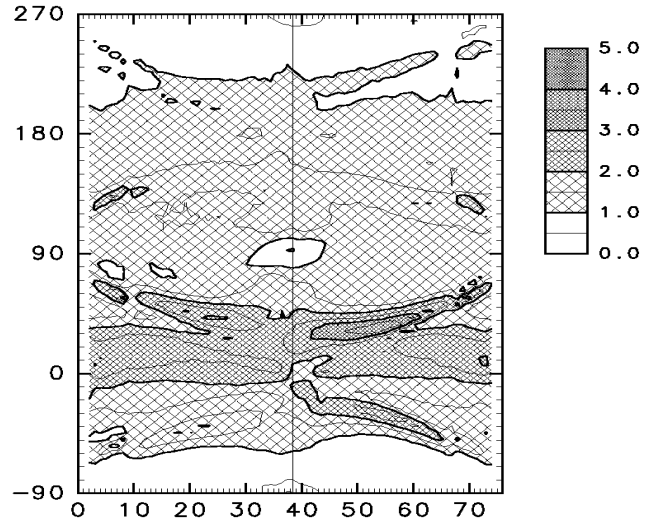


Figure 4. SeaWinds retrieved wind direction distributions as a function of wind direction (y axis) and WVC number (x axis) (kindly provided by Dr. Ebuchi).

In contrast with ERS, there is no transformation (i.e., $\vec{\sigma}'$) for SeaWinds that can produce a circular wind surface, i.e., flatten the solid curve. By looking at the individual beam sensitivities (non-solid curves) that contribute to the total sensitivity (solid curve) in Figure 5, one can easily understand that, because of the relative beam geometry, the beam weighting will not compensate for such insensitive areas. Figure 6 shows that this problem is present across the entire SeaWinds swath. The pattern of sensitivity peaks (white) and troughs (black) across the swath is directly related to the beam relative geometry. Note that a similar pattern is observed in the retrieved wind direction distribution of Figure 4, as such confirming the correlation between the sensitivity and the artificial accumulation of retrieved directions. For more details on this study, see Stoffelen and Portabella (2005).

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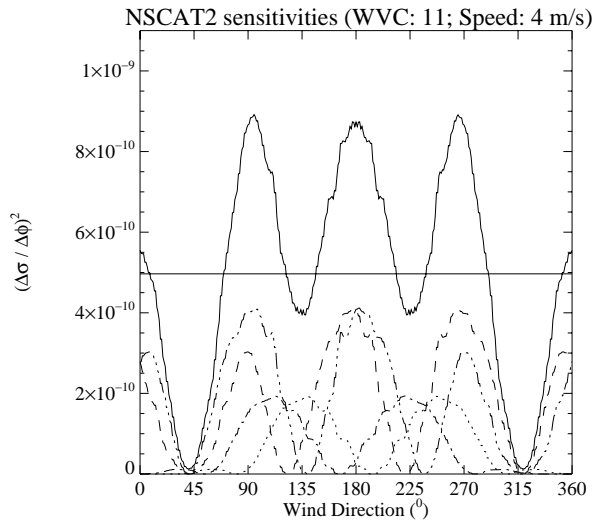


Figure 5. SeaWinds geometry with NSCAT-2 total sensitivity (solid curve) as a function of wind direction, before beam weighting, for WVC number 11 and 4 m/s. The dotted, dashed, dash-dotted, and dash-dot-dot-dotted curves represent the individual fore-inner, fore-outer, aft-inner, and aft-outer beam sensitivities, respectively. The straight line corresponds to the mean total sensitivity over all wind directions.

References

Ebuchi, N., "Statistical distribution of wind directions observed by QSCAT," *Proc. of first QuikSCAT Cal/Val Workshop*, Pasadena/Arcadia (USA), 1999.

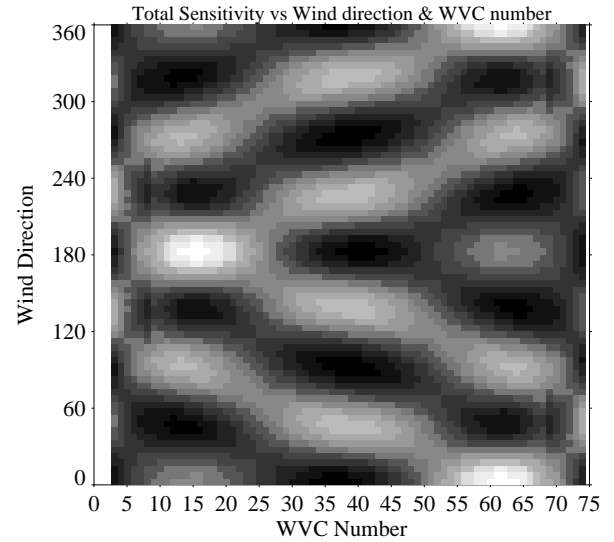


Figure 6. SeaWinds geometry with NSCAT-2 total sensitivity as a function of WVC number and wind direction for a wind speed of 8 m/s. The sensitivity values are plotted in grey scale, ranging from black (troughs) to white (peaks).

Stoffelen, A., and Portabella, M., "On Bayesian scatterometer wind inversion," *IEEE Trans. on Geoscience and Rem. Sens.*, in press, 2006.

Stoffelen, A., and Anderson, D., "Scatterometer data interpretation: measurement space and inversion," *J. Atmos. and Oceanic Technol.*, vol. 14(6), 1298-1313, 1997.