A statistical approach for SeaWinds data assimilation

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Abstract. Scatterometer measurement potentially contain relevant information on the mesoscales. However, as the resolution increases both the noise and the ambiguity in retrieved winds increases, leading to arbitrary local minima wind solutions. Exploiting the full wind vector probability density function of the wind retrieval, and adopting spatial meteorological balance constraints in a 2D-Var alleviates the problem of arbitrary minima and noise and provides a spatially consistent scatterometer wind field. The method can de adopted in the context of 3D- or 4D-Var data assimilation systems.

1. Introduction

In scatterometry, the wind vector retrieval problem is ambiguous, i.e., the inversion procedure does not result in a unique wind solution. To remove such ambiguity, a spatial filter is applied over the ambiguous wind field (e.g., Stoffelen and Anderson, 1997; JPL, 2001).

Figure 1 shows the wind solutions derived from the scatterometer inversion (the ambiguity is most relevant in the wind direction domain). The blue curve local minima represent wind solutions with (local) maximum probability of being the true wind. The standard procedure uses such minima as the "candidate" (ambiguous) solutions before ambiguity removal (AR). This is a valid procedure when the local minima are well defined. However, when the minima become broad, the standard procedure may not be appropriate since many wind solutions with comparable probability are not taken into account for AR. Figure 2 shows that the number of wind solutions with comparable probability (solution bands) increase when approaching the SeaWinds nadir (centre) region, due to measurement geometry.

2. Multiple Solution Scheme (MSS)

In contrast with the standard procedure (SP), the MSS uses all wind solutions with significant probability (see Figure 2) as ambiguities. Both
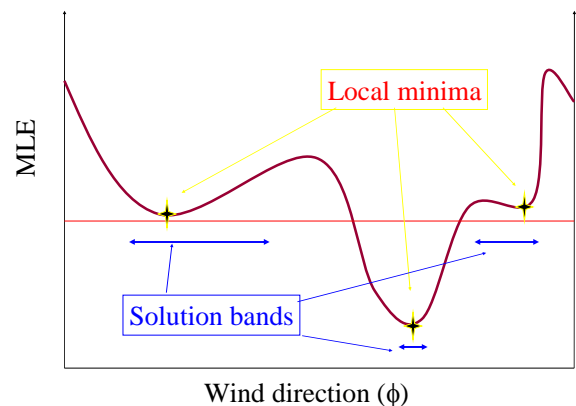

Figure 1. *Schematic representation of the scatterometer inversion output in terms of solution probability.*

procedures use a variational analysis scheme, i.e., 2D-Var, for AR. Such scheme combines a background field (e.g., the National Centre for Atmospheric Prediction or NCEP winds) with the observations (ambiguous solutions), assuming that both sources contain errors and these are well characterized, to get an analysis field, which is spatially consistent and meteorologically balance. The closest-to-analysis ambiguous solution is then selected. In 2D-Var, the solution probability is explicitly used, such that solutions with higher probability will have a greater chance of being selected.

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The MSS has been successfully tested at 100 km resolution. Figure 3 (bad rainy case) shows a more consistent wind field when using MSS, as compared to SP, especially at nadir. Table 1 shows higher wind retrieval quality (against the European Centre for Medium-range Weather Forecasts or ECMWF winds) for MSS than for SP. The worst scores are for NCEP, indicating that 2D-Var is successfully exploiting the observations rather than the background. As such, the quality of the background does not significantly affect the quality of the retrieval.
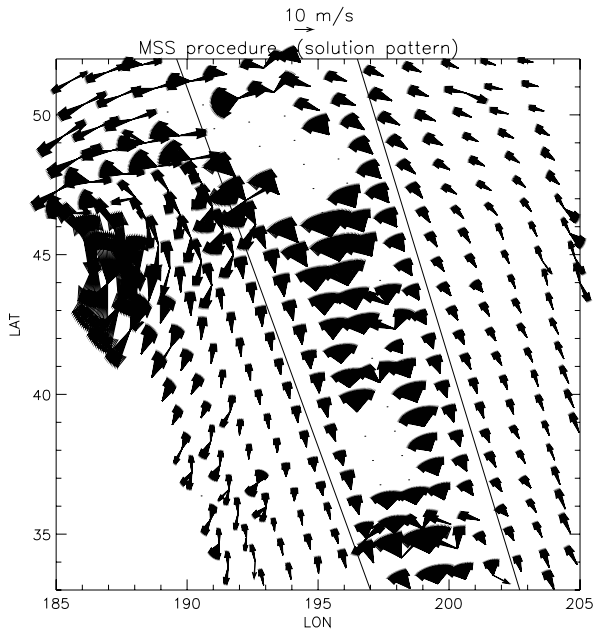

Figure 2. *Example of SeaWinds inverted solutions with probability larger than 2x10-7.*

Table 1. *RMS of the wind vector difference between ECMWF and the different wind sources for the sweet and nadir swath regions.*

Swath region	Sweet	Nadir
Standard	2.48	2.98
MSS	2.23	2.45
NCEP background	2.85	2.96

3. MSS versus NOAA DIRTH at 25 km

The SeaWinds DIRTH product distributed by the National Oceanographic and Atmospheric Administration (NOAA) uses the concept of multiple solutions together with a median filter AR (Stiles et al., 2002). In contrast with MSS, DIRTH does not use the solution probability information explicitly nor meteorological (but rather direction continuity) constraints. Figure 4 shows a case where MSS (b) realistically depicts the cold front air flow, whereas DIRTH (a), because of the

direction continuity constraints, selects the wrong field (see white ellipses). Note also the better performance of MSS around rainy areas (see yellow squares).
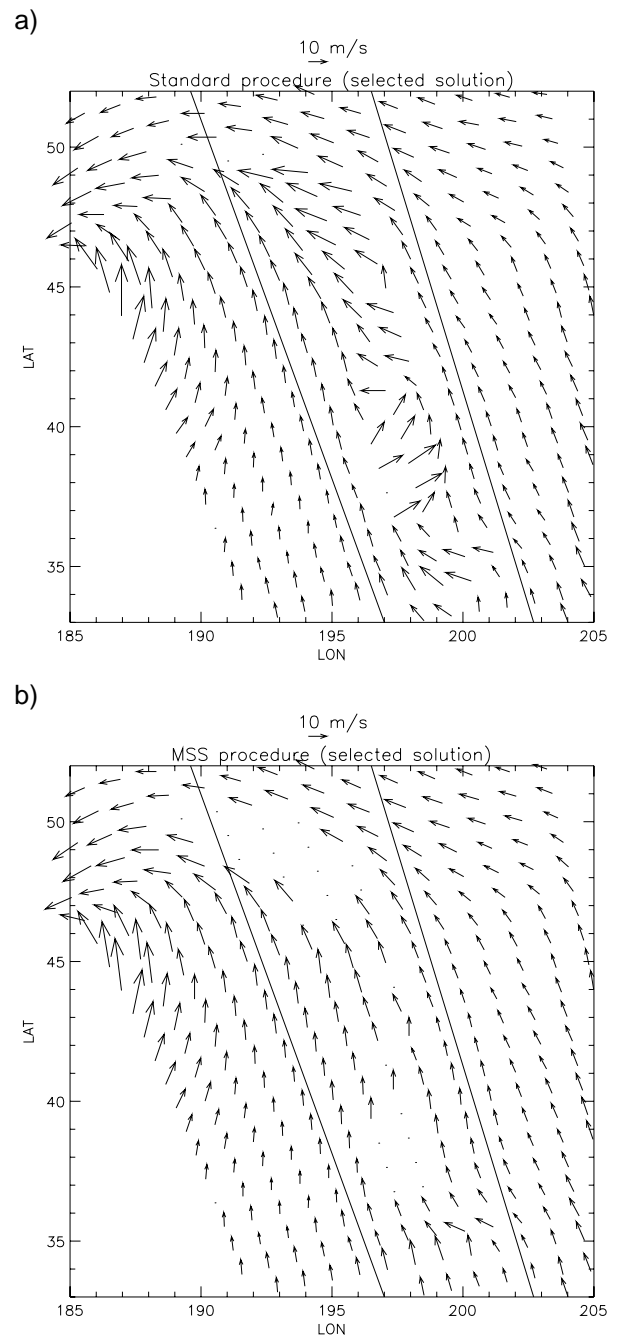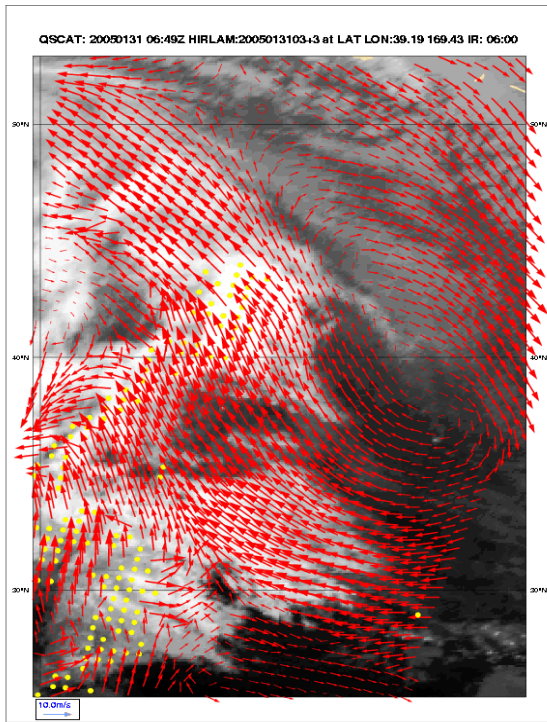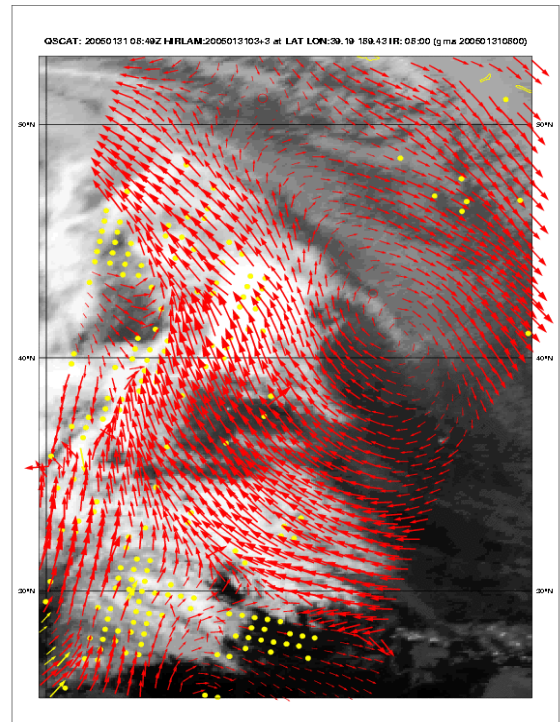
a)

b)

Figure 3. *Same example as Figure 2 but showing the selected wind solutions using (a) the standard procedure and (b) the MSS.*

Future plans include a thorough comparison between MSS and DIRTH. For more details on MSS see Portabella and Stoffelen (2004). See KNMI scatterometer wind products at *http://www.knmi.nl/scatterometer*.

a)

b)

Figure 4. *Example of (a) NOAA DIRTH and (b) KNMI MSS wind fields at 25-km resolution. The yellow dots correspond to quality-controlled points*

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