Impact of the structure function definition on ASCAT variational ambiguity removal

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1. Introduction

The two-dimensional variational ambiguity removal scheme (2DVAR) provides a spatial analysis of the sampled ocean vector winds to resolve the local Advanced Scatterometers (ASCATs) dual wind vector ambiguity. 2DVAR is in general effective, but it may select the wrong ambiguity under certain conditions, e.g., when the background mismatches frontal (convergence) areas or low-pressure centers, or when it misses convective systems. The background in 2DVAR consists of forecasts from the European Centre for Medium-range Weather Forecasts (ECMWF).

The relative influence of the background and the ASCAT wind fields in the resulting 2DVAR analysis field can be controlled by adjusting the background error spatial correlation structure, and the background and/or observation error variances. In this study, an adaptive 2DVAR approach is proposed to improve ASCAT ambiguity removal:

- using background error spatial correlations estimated from the autocorrelation of observed scatterometer wind components minus ECMWF forecasts (i.e., numerical structure function, NSF);
- using background and observation errors estimated from triple collocation (TC) analysis on collocated buoy, ASCAT, and ECMWF data.

2. Methodologies

The ASCAT inversion residual or Maximum Likelihood Estimator (MLE) contains valuable information on the wind vector (WVC) variability, which is generally associated with wind convergence (fronts) and divergence (e.g., downdrafts) conditions [1]. Moreover, Lin et al. show that an image processing technique called singularity analysis (SA) can be used to detect subtle disturbances in the ASCAT-derived wind field ambiguities which may be associated with wind fronts. A thorough characterization of the MLE and SA-based (i.e., the singularity exponents or SE) parameters derived from ASCAT product is carried out.

3. Results

![Fig 6](image)

Fig. 6 (a) ECMWF forecast surface winds collocated with the ASCAT observation on July 3rd, 2015, around 11:45 UTC. (b) ASCAT-derived wind ambiguities; the lower-left reference scale indicates two opposite ambiguities with the same speed of 10 m/s.

![Fig 7](image)

Fig. 7 2DVAR analysis wind field derived from: (a) Test 1, GSF + Fixed O/B errors, AWDP default setting; (b) Test 2, GSF and situation-dependent O/B errors; (c) Test 3, NSF and AWDP default O/B errors; (d) Test 4, NSF and situation-dependent O/B errors. The reference scale in the left-lower corner of (a) applies to all the panels.

![Fig 8](image)

Fig. 8 ASCAT selected wind field superimposed with MLE values (see the color bars) for the four different tests in Fig. 7. The grey arrows in (b)-(d) indicate which selected wind vector ambiguities are different from those in (a).

Conclusions

Even though the combination of GSF and flexible O/B errors shows some improvement in the cyclone case, it generally does not produce better wind selection than the default setting. In fact, the ratio of observation and background error is, on the ECMWF scale, generally close to the default setting and not very weather dependent.

In contrast, by adopting NSF in 2DVAR, about 2% of the wind selections are modified w.r.t. the default 2DVAR scheme, since the much broader structure function effectively decreases the background weight.

Furthermore, the 2DVAR analysis becomes much closer to the selected ASCAT winds. The combination of NSF and flexible O/B errors slightly further improves the ASCAT wind quality, when compared against continuous buoy winds and mean buoy winds [4].

![Fig 9](image)

Fig. 9 The vector Root Mean Square (RMS) error (the average of the random errors associated with wind components, i.e. ) on the ECMWF scale for ASCAT and ECMWF winds.

![Fig 10](image)

Fig. 10 RMS error ratio between ECMWF and ASCAT winds on the ECMWF scale.

![Fig 11](image)

Fig. 11 The structure functions (Stream function, dashed curve; Velocity potential, solid curve) estimated from ASCAT-12 km product and 25-km (blue) wind data [3]. The default Gaussian structure functions (GSFs), currently used in the operational 2DVAR scheme with different length scales for the Tropics (black dashed curve) and mid-latitudes (red solid curve), are presented as a reference. The numerical structure functions (NSFs) are much broader than the Gaussian structure functions. Since the spatial structure functions act as spatial filtering functions in meteorological analysis, one may expect that smoother analyses result from broader background error structure functions. Moreover, in case of dense observation coverage at high weight, such as from ASCAT, broad structure functions may cause overfitting.

References


