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Ambiguity Removal using different background wind fields

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Introduction

In this report, we compare the OSI SAF SeaWinds 100-km wind products which are made using NCEP background winds, with those using ECMWF background winds. NWP winds are used in the ambiguity removal step of the wind processing, but the influence of the background wind field used should be small, i.e., the selected wind solutions should not depend too much on the quality of the used wind field. Hence, the purpose of this study is to show that the use of ECMWF winds has a small influence on the product quality. Moreover, when there is an influence, it should be an improvement.

The NCEP model winds, which are 1000 hPa winds rather than 10-m winds, are provided in the NOAA SeaWinds BUFR product. In the present pre-operational OSI SAF wind product, these are used in the ambiguity removal (as part of the production process). Moreover, the product monitoring is done with these winds as well (after finishing the product). This results in rather high biases and error standard deviations of the scatterometer wind fields as compared with the reference NWP winds. KNMI uses ECMWF 10-m winds for scatterometer wind product validation in several studies. ECMWF wind biases are below 0.5 m/s and wind component random errors about 1.0 m/s, albeit up to 1.5 m/s in the tropical region. Since we want to use NWP winds of better quality for the product monitoring and validation, collocation of the scatterometer winds with ECMWF winds is necessary. The ECMWF winds may also be used for the ambiguity removal provided that they are not detrimental to the product quality.

Ambiguity removal is the step in the wind production process after the retrieval of a set (typically 4) wind solutions from the radar backscatter data. From the available wind solutions in each Wind Vector Cell (WVC), the best one needs to be chosen in order to obtain a meteorologically consistent wind field. The NWP background wind field is used as input to this step. For the OSI SAF wind product, a 2DVAR ambiguity removal scheme is used. More information on this can be found in references [1], [2] and [3].

To investigate the influence of replacing the background winds, a set of scatterometer data, covering approximately 24 hours, was processed once using the NCEP data, and once using the ECMWF data.

KNMI receives NWP model data from ECMWF twice a day through the RMDCN. Wind forecasts (10-m winds) are available twice a day (00 and 12 GMT analysis time) with forecast time steps of +12h, +15h, …, +36h. The model wind data are interpolated with respect to time and location and put into the NOAA BUFR files. After that, the files are processed in the same way as the files with the NCEP model wind data.

SeaWinds data from 15 Aug 2006, 8:43 – 16 Aug 2006, 9:11 were processed twice (with NCEP and ECMWF background) and the resulting 100-km output products were compared. The number of times where the 1st rank, 2nd rank etc. wind solution was selected by the ambiguity removal was counted. A matrix was constructed to compare the selection frequencies of the different ranks in both cases. For example: in a certain WVC, the ambiguity removal may choose the 1st rank solution when NCEP background is used, but the 2nd rank solution when the ECMWF background is used. This WVC then contributes to the matrix element (NCEP rank 1, ECMWF rank 2). The total number of WVCs for which the same rank was chosen in both cases (i.e. the sum of the diagonal matrix elements) was also calculated.

One may expect the following outcomes from this comparison:

- In the majority of the WVCs, both products should have the same selected wind solution. If this is not the case, the ambiguity removal depends too much on the background field used.
- For higher wind speeds (above 4 m/s), the wind solutions from the inversion are more reliable and better defined. It can be expected that for these wind speeds the influence of the background in the ambiguity removal is smaller, i.e., an even higher fraction of the WVCs should yield identical wind solutions.
- Since the ECMWF winds are of better quality than the NCEP winds, it may be expected that the Variational Quality Control flag (VAR QC) will be raised in less WVCs in the products using ECMWF. The VAR QC flag is set in those cases where the contribution of a certain WVC to the cost function in the 2DVAR ambiguity removal scheme exceeds a certain threshold (see ref. [3]). The VAR

QC flag setting is an indication of spatial inconsistency in the wind field. When the NWP winds are closer to the scatterometer winds, this is expected to happen less often.

References

[1] J. de Vries, A. Stoffelen, 2D Variational Ambiguity Removal (2000), http://www.knmi.nl/scatterometer/publications/pdf/SAFOSI_W_2DVAR.pdf

[2] Ad Stoffelen, Siebren de Haan, Yves Quilfen, Harald Schyberg, ERS Scatterometer Ambiguity Removal Scheme Comparison, Ocean & Sea Ice SAF report (2000), http://www.knmi.nl/scatterometer/publications/pdf/SAFOSI_W_ARcomparison.pdf

[3] J. de Vries, A. Stoffelen, J. Beysens, Ambiguity Removal and Product Monitoring for SeaWinds, NWP SAF report NWPSAF_KN_TR_001, http://www.knmi.nl/scatterometer/publications/pdf/NWPSAF_TD_AR_1.2.pdf

Results

The tables below show the matrices for various selections of the collection of WVCs, as described in the Introduction. Table 1 shows that the same wind solution is selected in the majority of the cases: almost 96% of the cases. This number is even higher when the WVCs with low wind speeds (<4 m/s) are excluded: in about 97.5% of the cases the same solution is selected (table 2). This means that for lower wind speeds (< 4 m/s) only in 85.4% ((54693-48433)/(57117-49698)) of the cases the same wind solution is chosen. It is clear that wind direction information is less precise for such low winds and the 2D-VAR solution more arbitrary.

A second noticeable fact from the tables appears when comparing the bottom row with the rightmost column. 2D-VAR selects a higher number of the most likely high-rank solutions in case it is run with the ECMWF background, while it selects more of the relatively less likely low rank solutions with NCEP background. This indicates that the ECMWF-based 2D-VAR fields are more in line with the basic scatterometer data than the NCEP-based 2D-VAR fields, and therefore are presumably of better quality.

Comparing tables 3 and 4 shows that in the product using NCEP winds, the VAR QC flag is raised more than twice as many times (1195 vs. 492) as compared to the product using ECMWF winds, indeed indicating the better spatial consistency of the latter products.

Note that Table 4 shows an average higher rank selection for the NCEP-based fields than for the ECMWF-based fields in the few cases that the ECMWF-based 2D-VAR reports spatially inconsistent wind vector solutions. This indicates that, even if the ECMWF fields are better for 2D-VAR in general, in cases of noted inconsistency, improvements remain possible.

Table 1: all wind speeds

		ECMWF				
		1	2	3	4	NCEP totals
NCEP	1	49824	735	219	49	50827
	2	832	4490	105	30	5457
	3	225	86	329	18	658
	4	80	32	13	50	175
ECMWF totals		50961	5343	666	147	57117

Same selection in 54693 cases (95.8%)

Table 2: WVCs with 1st rank wind speed >= 4 m/s

		ECMWF 1	2	3	4	NCEP totals
NCEP	1	44636	422	121	29	45208
	2	403	3588	38	10	4039
	3	136	38	179	5	358
	4	41	16	6	30	93
ECMWF totals		45216	4064	344	74	49698

Same selection in 48433 cases (97.5%)

Table 3: WVCs with 1st rank wind speed >= 4 m/s and VAR QC flag set in products using NCEP background

		ECMWF 1	2	3	4	NCEP totals
NCEP	1	768	18	3	0	789
	2	73	178	5	2	258
	3	49	10	43	0	102
	4	18	8	2	18	46
ECMWF totals		908	214	53	20	1195

Same selection in 1007 cases (84.3%)

Table 4: WVCs with 1st rank wind speed >= 4 m/s and VAR QC flag set in products using ECMWF background

		ECMWF 1	2	3	4	NCEP totals
NCEP	1	188	47	34	12	281
	2	17	109	4	8	138
	3	4	6	38	2	50
	4	0	4	2	17	23
ECMWF totals		209	166	78	39	492

Same selection in 352 cases (71.5%)

Conclusions

The results indicate that the use of ECMWF model winds in the ambiguity removal of the OSI SAF 100-km wind product has a small but distinct positive impact on the product quality, especially in terms of the number of times when the VAR QC flag is set. Moreover, the ECMWF-based 2D-VAR provides slightly better ranking statistics. This provides sufficient justification to use the ECMWF model winds in the pre-operational OSI SAF products.