Improvements in ambiguity removal of scatterometer winds

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Numerical Weather Prediction

Introduction

Inversion of the Geophysical Model Function (GMF) generally yields more than one solution

ASCAT (triple fanbeam):

most 2 solutions (ambiguities); sometimes 4

SeaWinds, OSCAT, and HY-2A (rotating pencil-beam):

up to 4 ambiguities, but broad minima in nadir part of the swath

Ambiguity Removal (AR) to select the preferred solution from the ambiguities

Introduction

A number of AR schemes proposed, e.g.:

- 1^{st} rank (ambiguity closest to GMF)
- Median filter
- Closest-to-background (ambiguity closest to NWP forecast)
- DIRTH
- 2DVAR (closest-to-analysis); Multiple Solution Scheme (MSS) with 144 ambiguities (full directional probability) to handle broad minima in nadir swath of QuikSCAT and OSCAT

NWP SAF scatterometer processors use 2DVAR as default AR method

2DVAR

2DVAR consists of two steps:

1. Construct analysis from ambiguities and NWP model forecast from ECMWF
2. Select ambiguity closest to analysis (the easy step)

Step 1 requires:

1. Observation errors
2. Background errors and background error correlation matrix

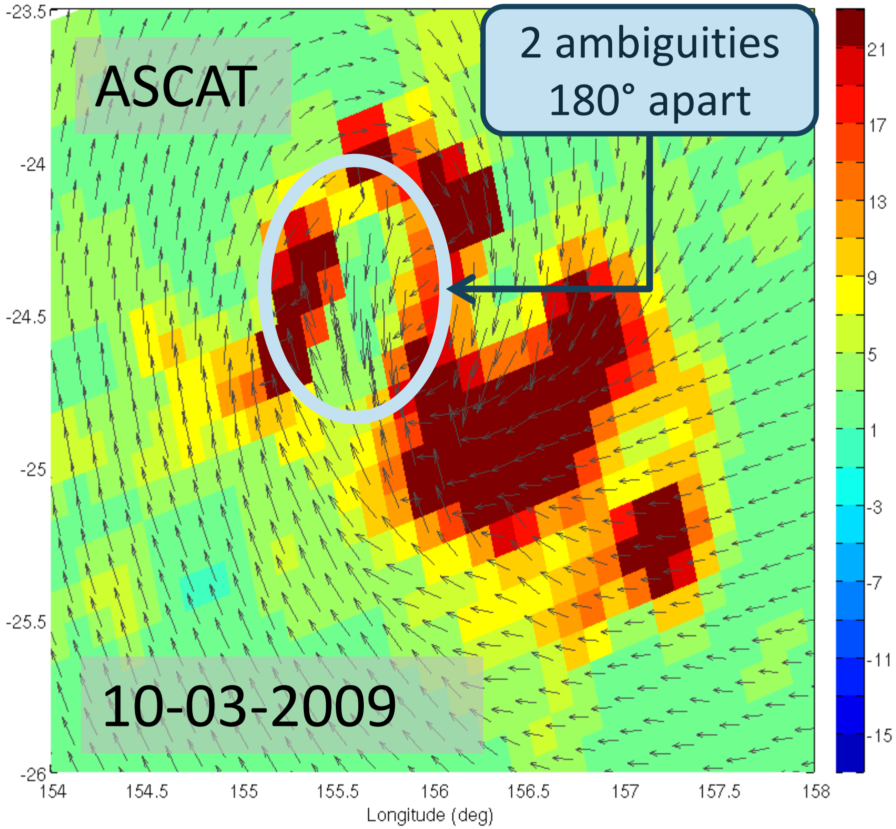
Present operational version of 2DVAR employs:

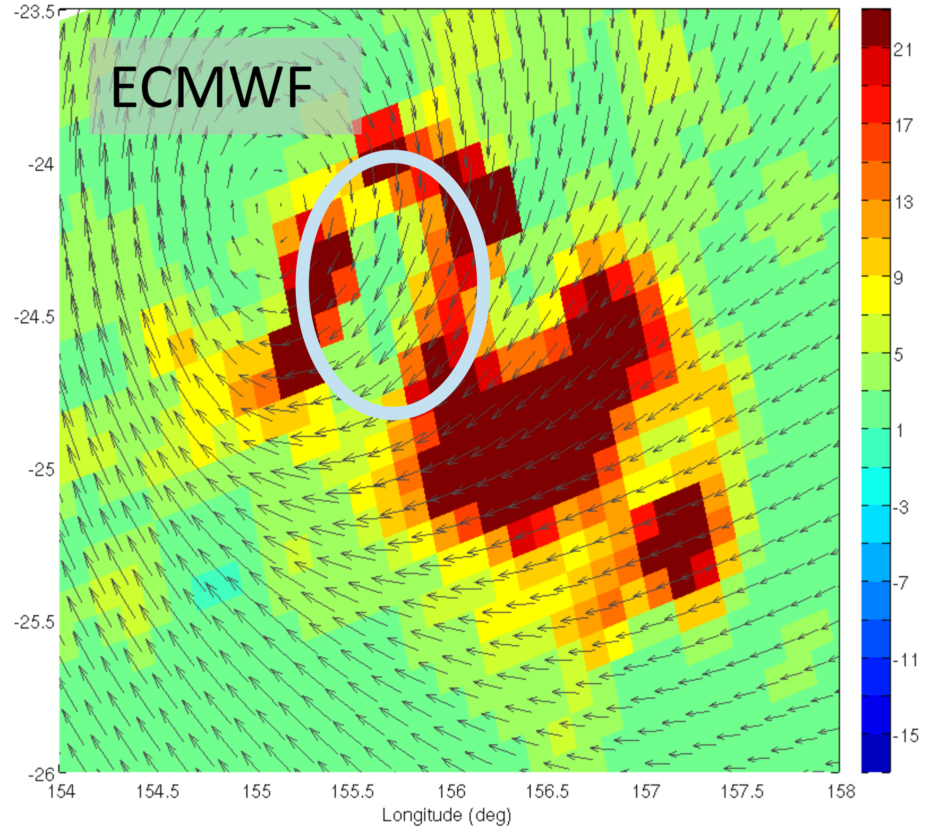
- constant observation errors (error variance 1.8 m^2/s^2 in *u* and *v*)
- constant background errors (error variance 2.0 m^2/s^2 in *u* and *v*)
- Gaussian background error correlation with correlation length

  600 km in the Tropics

  300 km outside Tropics

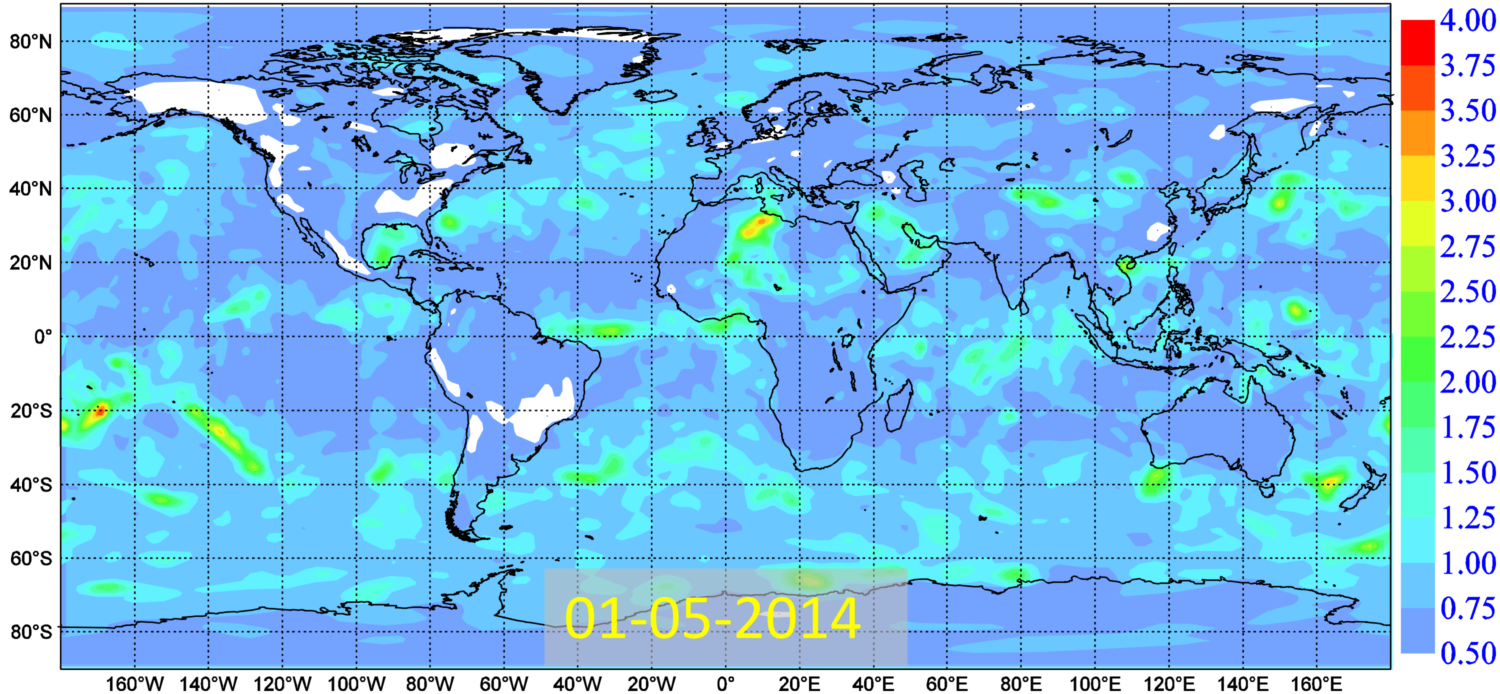
AR errors





AR errors caused by wrong background field
→ more information in 2DVAR needed

2DVAR improvement – EDA background errors



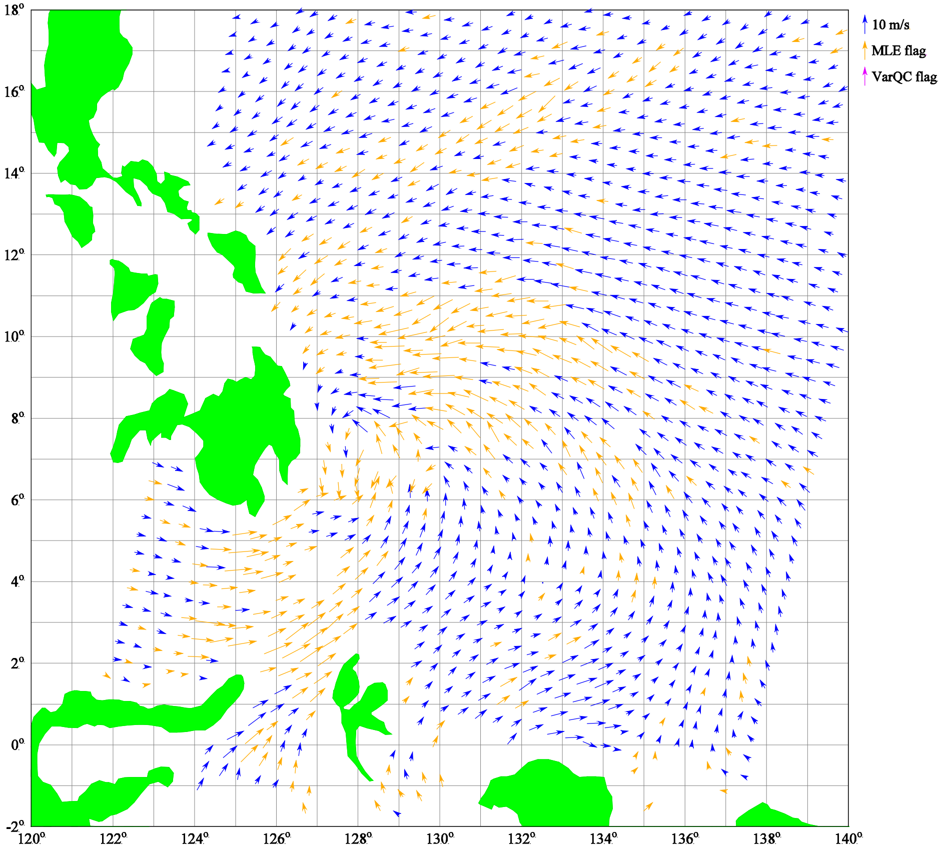
- EDA background error estimate twice a day (3 h and 15 h)
- Fits into current 2DVAR implementation
- With thanks to Massimo Bonavita (ECMWF)

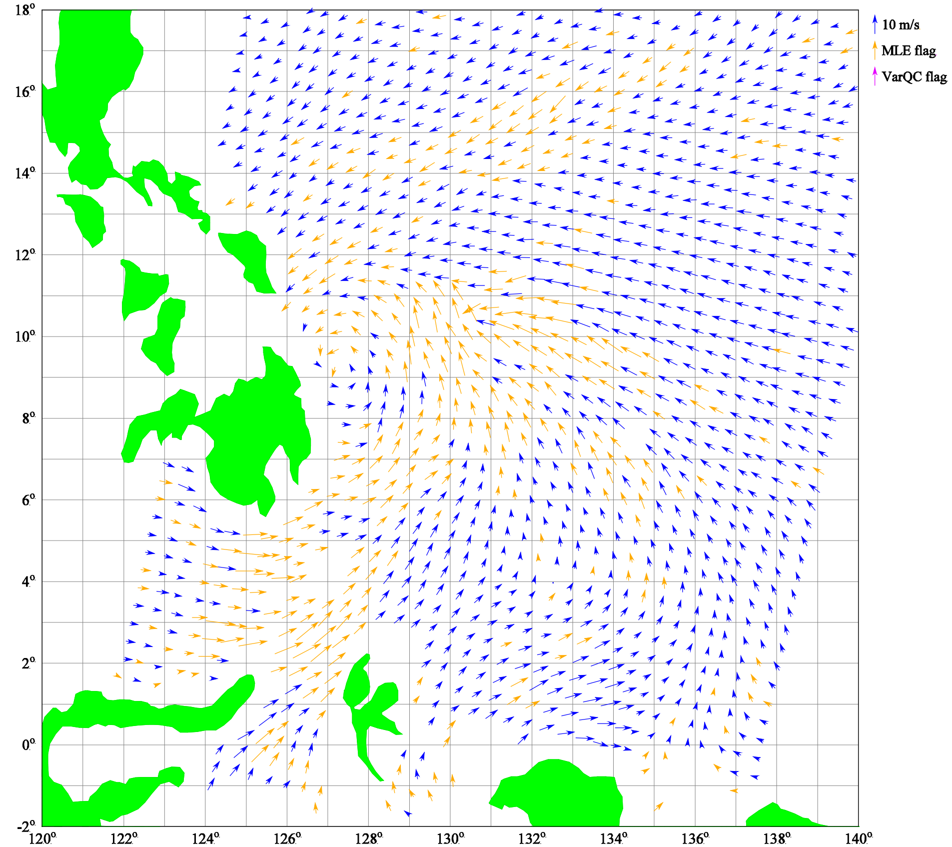
2DVAR with EDA background errors

- August 2013; comparison with buoy measurements
- Average EDA background error 1.2 m/s
- Reduced observation error to 0.7 m/s (triple collocation result)
- ASCAT-coastal and OSCAT-50
- Largest effect on OSCAT because of MSS
- NB: direction comparison only for wind speeds > 4 m/s (as in operational monitoring)

Wind product	**Buoy** σ_u **(m/s)**	**Buoy** σ_v **(m/s)**	**Buoy** σ_s **(m/s)**	**Buoy** σ_{dir} **(deg)**	**Background** σ_u **(m/s)**	**Background** σ_v **(m/s)**	**Background** σ_s **(m/s)**	**Background** σ_{dir} **(deg)**	N
ASCAT-coastal old	1.44	1.57	1.01	17.5	1.47	1.68	1.37	14.9	2724
ASCAT-coastal new	1.44	1.54	1.02	16.7	1.45	1.69	1.38	14.7	2729
OSCAT-50 old	1.53	1.48	1.06	15.2	1.17	1.13	1.18	9.3	3445
OSCAT-50 new	1.49	1.47	1.06	15.0	1.06	1.14	1.18	8.4	3445

OSCAT, 03-08-2013 ± 3:00 UT





Old 2DVAR, lots of AR errors near cyclone centre, but flagged by QC (orange)

New 2DVAR, less AR errors near centre, centre moved NW (further from ECMWF background centre at 7 °N 130 °E)

2DVAR with EDA background errors, effect of value of observation error

ASCAT-coastal

ε_o (m/s)	σ_{speed} (m/s)	σ_{dir} (deg)	σ_u (m/s)	σ_v (m/s)	N
0.5	1.01	16.9	1.46	1.53	2729
0.7	1.01	16.5	1.45	1.53	2729
1.0	1.01	16.5	1.43	1.53	2729
1.2	1.02	16.3	1.40	1.55	2729
1.5	1.02	16.3	1.40	1.56	2729
1.8	1.02	16.4	1.41	1.56	2729
control	1.02	16.7	1.43	1.54	2729

OSCAT-50

ε_o (m/s)	σ_{speed} (m/s)	σ_{dir} (deg)	σ_u (m/s)	σ_v (m/s)	N
0.5	1.06	15.2	1.48	1.51	3447
0.7	1.06	15.0	1.49	1.47	3451
1.0	1.06	15.0	1.49	1.47	3451
1.2	1.06	14.9	1.49	1.47	3447
1.5	1.06	14.9	1.49	1.47	3446
2.0	1.06	15.2	1.50	1.48	3439
control	1.06	15.9	1.58	1.53	3507

- Best agreement with buoys for observation error 1.2 m/s (same as average EDA background error)
- About the same optimum observation error for ASCAT-coastal and OSCAT-50, though ASCAT-coastal is much denser and therefore has more effect on the analysis

Varying observation errors

MLE-dependent observation error:

$$\varepsilon_o = \begin{cases} \varepsilon_o^{(0)} & MLE \leq 1 \\ \varepsilon_o^{(0)}\sqrt{MLE} & MLE > 1 \end{cases}$$

No effect for ASCAT-coastal, neutral effect for OSCAT-50 (no results shown)

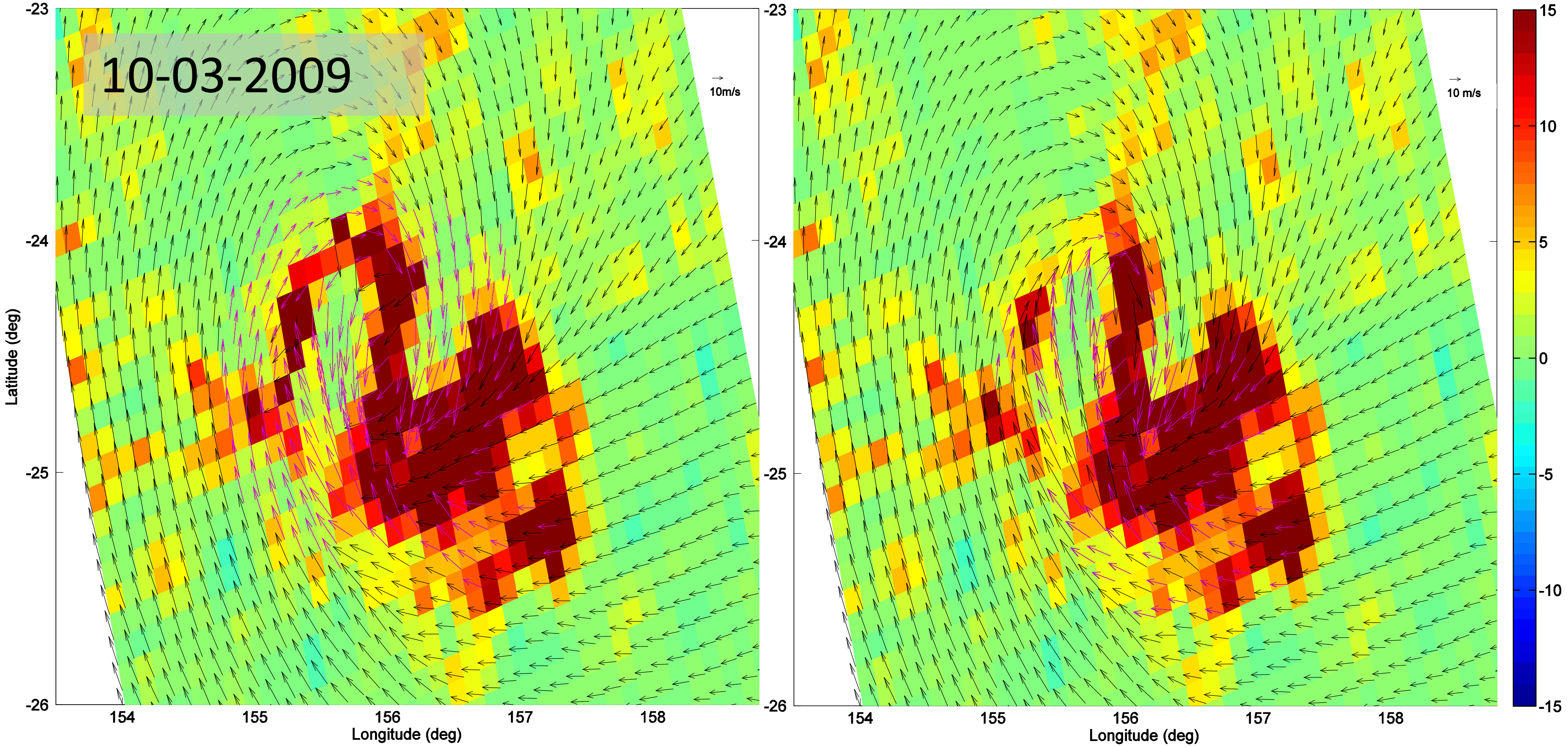
On the other hand, recent study indicates that high MLE is indicative for high wind variability. Also singularity analysis can be used (*Portabella et al*., Wednesday 14:15).

This is not well described by NWP background, so perhaps background errors rather than observation errors should be increased further in these situations

Numerical background error correlations

Standard 2DVAR

Numerical background error correlations



Conclusions

- EDA background errors have beneficial effect on 2DVAR for both ASCAT and OSCAT
- Ratio observation error – background error important
- Background error correlation important
- Weather dependency of errors exists in both o and b error variance and in b structure. EDA provides model-inferred b error and structure, but MLE may be helpful too to estimate these. If we find a relation between EDA parameters and MLE, we may be able to enhance our knowledge of b error and b structure beyond EDA inputs.

Outlook

Error model that accounts for meteorological situation, including expected variable background error correlation scales, from

- EDA
- MLE
- Singularity analysis
- Spatial statistics (structure functions, etc.)

Requires reformulation of 2DVAR implementation (besides a lot of study)