The Usage of Scatterometer Data at ECMWF

Hans Hersbach, ECMWF

Overview
- Assessment of the EARS ASCAT service
- Re-calibration of ERS-1 and ERS-2
- Usage/inter-comparison of scatterometer data in the ECMWF interim reanalysis
- Concluding remarks
Assessment of EARS ASCAT data

- EUMETSAT Global ASCAT data service (GDS)
  - Since February 2007,
  - timeliness of about 2 hours,
  - used at ECMWF since 12 June 2007.

- EUMETSAT Advanced Retransmission Service (EARS)
  - Available in pilot phase since September 2008,
  - Timeliness of 15 to 45 minutes.

- Collocation study

- Impact study
  - Duplicate data to be automatically removed by generic thinning algorithm
Collocation between EARS and GDS ASCAT

Average (km) EARS (Collocation distance up to 12 km)
Globe 5.8  N.Hem 5.7  Tropics 5.9  MIN 0  MAX 11.9
2008091500 - 2008093018, EXPVER = T1X12
EARS + GDS ASCAT Impact study
Data count

Delayed cut off
(12-hour window + 4h45m cut off)

Early delivery
(6-hour window + 1h cut off)
Re-calibration of the ERS archive

ESA report, Abdalla and Hersbach 2007, www.ecmwf.int/publications

- ERS-1&2 have known periods of $\sigma_0$ calibration.
- Triple collocation:
  - ERS, buoy, ERA-40 (all as non-neutral 10m wind)
  - 18 Buoys: far enough from coast, stable, available for long period
  - ERS based on CMOD5

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Table 1: Five-digit WMO identifiers of buoys that were taken in consideration for the collocation with ERS winds, grouped into originating data provider.

Figure 36: Number of collocations accumulated over the indicated period (and mapped on a N80 reduced Gaussian grid) for which buoy and ERS-1 (left) respectively ERS-2 (right) are positioned within 39 minutes and 50 km. Adjacent non-empty grid boxes expose buoy displacements.
Re-calibration of the ERS archive

- For ERS-2, CMOD5 ~ 0.5 m/s biased low → CMOD5.4
- Relative bias between ERS-1 and ERS-2
- @ buoy location, ERA-40 is biased low as:

\[
S_{\text{unbiased}} = \begin{cases} 
  s & s \leq 3.5 \text{ms}^{-1} \\
  1.08s - 0.28\text{ms}^{-1} & s > 3.5 \text{ms}^{-1}
\end{cases}
\]
Re-calibration of the ERS archive

- Extend ERA-40 bias correction @ buoy location for:
  - entire globe
  - from ~1991-2000

- Perform ocean calibration:
  \[ \text{ERS bias} = \sigma_0 - \text{CMOD5.4}(\text{ERA-40}_{\text{corrected}}) \]

- Correct for this bias
- Automatically identify specific periods

- Correct for bias in \( \sigma_0 \), then apply CMOD5.4
- Re-make scatter plots
  - Residual small wind-speed and WVC dependent speed correction
ERA-Interim reanalysis at ECMWF

ERA-40

Aircraft data
1973

TOMS/ SBUV O3
1979
1982
1988

METEOSAT reprocessed cloud motion winds

HIRS/ MSU/ SSU
Cloud motion winds
1987

SSM/I

Conventional surface and upper-air observations:
NCAR/NCEP, ECMWF, JMA, US Navy, Twerle, GATE, FGGE, TOGA, TAO, COADS, ...

1973 VTPR
1979

ERS

ERS-1
1991
1995

ERS-2

1996 GOME O3 2003

1998 AMSU-A

2000 AMSU-B
QUIKSCAT

2001 GPSRO
GEOSTATIONARY IR

2003 AIRS
SCIAMACHY O3

ERA-interim compared to ERA-40:
- Higher resolution: T255 versus T159
- 4D-Var, versus 3D-Var
- Variational bias correction
- Few months lag to real time.

OVWST meeting, Boulder (CA), 18-20 May 2009 Slide 8
Operational Model Forecast Performance

Anomaly Correlation (%) for the 500 hPa Geopotential Height

100% = perfect forecast
60% = limit of use

Operations

Northern hemisphere
Southern hemisphere

3-day forecast
5-day forecast
7-day forecast

Reanalyses Forecast Performance

Anomaly Correlation (%) for the 500 hPa Geopotential Height

100% = perfect forecast
60% = limit of use

ERA-Interim
ERA-40

3-day forecast
5-day forecast
7-day forecast
The usage of Scatterometer data in the ECMWF interim reanalysis

- **ERS1**: 15 Apr 1992, recalibrated
- **ERS2**: 22 Nov 1995, recalibrated
- **QSCAT**: 23 Feb 2000, non-neutral (-4%), v>17 m/s
- **ASCAT**: None

Differences ERS/QSCAT: Sampling, QC, tuning
Slightly increasing wind speed 1998?

ERA-interim biased low ~0.2 m/s
Gradually improves since 2003

SCAT-U10m_V10m_GLOBE_o-a
Concluding remarks

Scatterometer data from ERS-2, QuikSCAT and ASCAT are routinely assimilated:

- Operational model
- Interim reanalysis (ERS, QuikSCAT)
- ERS/ASCAT well inter-calibrated
- ESA ERS reprocessing underway
- ERS/QuikSCAT inter-calibration to be revisited

Pending operational changes
- ASCAT EARS has been assessed

Ongoing research
- Include option for ocean currents and neutral winds in SCAT observation operator (switch in current model cycle)
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ERS and ASCAT together fill in data gaps
Re-calibration of the ERS archive

Figure 39: Biases observed in backscatter levels, based on ocean calibration for ERS-1 (top panels), respectively ERS-2 (lower panels) for the indicated periods, and relative to the nominal period for ERS-2 (lower right-hand panel). The vertical scale varies between the plots.
Usage of ocean current/neutral wind in the ECMWF assimilation system

Adaptation of the scatterometer cost function:

\[ J_o^{\text{scatt}}(\tilde{u}^{\text{mod}}, \tilde{u}^{\text{scatt}}) = \frac{|\tilde{u}^{\text{mod}} - \tilde{u}^{\text{scatt}}|^2}{\sigma_0^2} \]

Here, \( \tilde{u}^{\text{mod}} \) is the scatterometer observation operator.

It is determined from the wind \( \tilde{u}_L \) at lowest model level \( z_L \) (Geleyn 1988):

\[ \tilde{u}_{\text{rel}}(z_{\text{obs}}) = R \tilde{u}_{\text{rel}}(z_L), \]

where

\[ R = R(z_{\text{obs}}/z_L, z_0, \text{stability}), \quad R = 1, \text{ for } z_{\text{obs}} = z_L. \]

Since now \( \tilde{u}_L = \tilde{u}_{\text{abs}}(z_L) \), rather than \( \tilde{u}_{\text{rel}}(z_L) \)

**scatterometer**:

\[ \tilde{u}^{\text{mod}} = \tilde{u}_{\text{rel}}(z_{\text{obs}}) = R \left( \tilde{u}_L - \tilde{u}_{\text{oc}} \right) \]

**buoy/ship**:

\[ \tilde{u}^{\text{mod}} = \tilde{u}_{\text{abs}}(z_{\text{obs}}) = R \tilde{u}_L + (1 - R) \tilde{u}_{\text{oc}} \]
The usage of ASCAT data at ECMWF

Hans Hersbach
Impact of ASCAT and IASI on the ECMWF analysis system

Vector wind from ASCAT and radiances from IASI were introduced on 12 June 2007.

A positive effect on the quality of ECMWF winds emerged from a comparison with (already active) QuikSCAT data.
Collocation of ERS-2 and ASCAT
(for one year, $\Delta t < 60$ min, $\Delta x < 25$ km)

- Both ASCAT and ERS-2 data are bias-corrected at ECMWF
- Both inter-compare very well: no bias, very low scatter