Towards ocean eddy-scale wind forcing

Ad.Stoffelen@knmi.nl
L3 Wind product example

GLO-WIND_L3-OBS_METOP-A_ASCAT_25_ASC_20110910.nc

Ascending passes

GLO-WIND_L3-OBS_METOP-A_ASCAT_25_DES_20110910.nc

Descending passes
Timely sharing of data enables a significant reduction in revisit time

Liu et al. 2007, Int. J. of Remote Sensing
Scatterometers in operation

- 9:30 LST & 21:30 LST: Advanced Scatterometer ASCAT-A and ASCAT-B carried by the Metop-A and MetOp-B meteorological satellites operated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
- 12:00 LST & 0:00 LST: OSCAT from the Indian OceanSat-2 scatterometer
- 6:00 LST & 18:00 LST: HSCAT from the Chinese HY-2A scatterometer
- These have follow-on instruments

Diurnal cycle, mesoscale convective systems, eddy-scale

www.knmi.nl/scatterometer
scat@knmi.nl
ASCAT-A and ASCAT-B come together
ASCAT-B vs ECMWF

- Orbits 507 – 522
- Same day as A
- AWDP-A (no corrections)

- Very similar quality to ASCAT-A
- Within requirements!
The future: 6.25 km grid

- Left: coastal product at 12.5 km grid size, right: ultra high resolution product at 6.25 km grid size
- Product still looks consistent but data quality not yet assigned
Closer to the coast

- The ASCAT coastal product proves very useful

Verhoef et al., 2011
OSCAT OWDPv1.3 vs ECMWF

- SDs given
- All 50-km WVCs
- With $\sigma^0$ corrections
- Range correction
- NSCAT3
  - Better than without NSCAT3 and corrections
  - Some less extreme winds > 15 m/s
  - Direction error at 90 degrees decreased
  - Small speed bias (0.3 m/s)
- Development of 25 km product based on Level 1B from ISRO (cooperation with NOAA)
- Improvement of backscatter calibration (NOC) and quality control
- Improvement of ice screening model
- Coastal?
- Release of OWDP software in the NWP SAF
- Access to operational NRT wind is arranged on high level in a coordinated way (EUM, NOAA, NASA, ISRO, ...)

MyOcean Science Days, November 2012
Collocation 1H, 25km, Jan - Mar 2012

- STD collocation error ~
  STD observation error
- Bias; now corrected at KNMI

S. Guimbard et al, 2012

MyOcean Science Days, November 2012
HY-2A
KNMI L2B vs ECMWF

- OWDP as used for QSCAT and OSCAT
- -1.7 dB $\sigma^0$ corrections
- -0.0001 linear outer beam correction
- All WVCs
- SDs given

- No speed bias
- Rain issue reduced
- Scores similar to QScat and OSCAT

Marine Core Service
MyOcean Science Days, November 2012
NWP model comparison

Global NWP models

- Lack scales below 200 km
- Lack convection and associated wind downbursts
- Have a weak diurnal cycle
- Lack air-sea interaction
- Are rather neutral stability and show large direction errors
- Are rather inaccurate on the ocean eddy scale

> Can we use something better?
Spatial resolution

- Spectral analysis of collocated fields
- ASCAT near expectation ($k^{-5/3}$)
- NWP lacks resolution, both in analysis and forecast
- Verification of variances and resolution by averaging products (e.g., QSCAT 100km vs 25km, ASCAT 25km vs 12.5km) and triple collocation

See also Vogelzang et al., JGR, 2011

MyOcean Science Days, November 2012
**Triple collocation result**

<table>
<thead>
<tr>
<th></th>
<th>( u )</th>
<th>( v )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias ASCAT (m/s)</td>
<td>0.15</td>
<td>-0.02</td>
</tr>
<tr>
<td>Bias ECMWF (m/s)</td>
<td>0.28</td>
<td>0.08</td>
</tr>
<tr>
<td>Trend ASCAT</td>
<td>1.01</td>
<td>1.01</td>
</tr>
<tr>
<td>Trend ECMWF</td>
<td>1.03</td>
<td>1.04</td>
</tr>
<tr>
<td>( \sigma ) ASCAT (m/s)</td>
<td>0.69</td>
<td>0.81</td>
</tr>
<tr>
<td>( \sigma ) ECMWF (m/s)</td>
<td>1.50</td>
<td>1.52</td>
</tr>
<tr>
<td>Representation error *) (m/s)</td>
<td>0.79</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Representation error is part of ECMWF error

- OSI SAF NRT req. 2 m/s, WMO in speed/dir.

See also Vogelzang et al., JGR, 2011
Geographical dependence

- $k^{-5/3}$ and $k^{-2}$ spectra imply specified forms of spatial correlations
- Investigate correlations in different dynamical regimes
- ASCAT 12.5km shows most variation in variance of $k^{-5/3}$

Figure 6: Second-order structure functions for latitudes (-10, 10). Also shown are the structure functions for NWP background winds (dashed) for the same sampling. The thick solid lines are theoretical structure functions for $r^{2/3}$ and $r^2$ scaling.
Geographical statistics for QuikSCAT, July 2009

Average QuikSCAT wind speed (m/s) for all flows
2009070100 - 2009073018, EXPVER = 0001

Wind speed bias (m/s) of QuikSCAT vs ECMWF FGAT for all flows
Globe -0.15  N.Hem -0.21  Tropics -0.1  S.Hem -0.18  MIN -4.32  MAX 3.15
2009070100 - 2009073018, EXPVER = 0001

Wind speed stdv (m/s) of QuikSCAT vs ECMWF FGAT for all flows
Globe 1.2  N.Hem 1.16  Tropics 1.15  S.Hem 1.28  MIN 0.45  MAX 4.24
2009070100 - 2009073018, EXPVER = 0001
Geographical statistics for ASCAT, July 2009

Rain flag removes stronger winds for QuikSCAT
There are some regional differences
Tropical variability

- Dry areas reasonable
- NWP models lack air-sea interaction in rainy areas
- ASCAT scatterometer does a good job near rain
- QuikScat, OSCAT and radiometers are affected by rain droplets

Portabella et al, TGRS, 2012
Air-sea interaction
ECMWF too weak

Chelton et al., Science

QuikSCAT, January–February 2003
High Pass Filtered Curl and Crosswind $\nabla T$

MyOcean Science Days, November 2012
Lack of NWP cross-isobar flow

QuikSCAT vs model wind dir
Stratify w.r.t. Northerly, Southerly wind direction.
(Dec 2000 – Feb 2001)

- Large effect **warm** advection
- Small effect **cold** advection
- Similar results for other models

A. Brown et al., 2005

Hans Hersbach, ECMWF (2005)
How to exploit eddy-scale winds?

- MyOcean blended L4 product
- Globally, at increased resolution?
- Dynamical and nested PBL model (Harutyunyan et al.)
- Regional NWP model
Assimilation ASCAT winds ECMWF from 12/6/’07 Beneficial for U10N analysis Operational okt/nov 2007 (added to QuikScat&ERS)

*Hans Hersbach & Saleh Abdalla, ECMWF*
Example of Blended Surface Wind Fields
QuikSCAT / ASCAT / SSM/I / ECMWF

6-hourly global wind vector / and wind stress / 0.25°x0.25°
HARMONIE spectra

- EU GMES project
- Non-hydrostatic km-scale model, incl. North Sea
- Wave model SWAN, coupled hourly

MyOcean Science Days, November 2012
Conclusions

- Many scatterometers provide accurate global ocean surface winds at high spatial resolution which may be given more weight in NWP.

- Physical developments include:
  - Air-sea exchange aspects, ocean currents, mass density
  - Representation of convection and turbulence in NWP (artificial diffusion for dynamical closure)
  - PBL stratification
  - (Inter)calibration of scatterometers, extreme winds

- Regional NWP appears promising.

- What about km-scale global NWP, nesting and blending?

- [www.nwpsaf.org](http://www.nwpsaf.org), [www.osi-saf.org](http://www.osi-saf.org)
- [www.knmi.nl/scatterometer, scat@knmi.nl](http://www.knmi.nl/scatterometer, scat@knmi.nl)
GLOBAL SCATTEROMETER MISSIONS (CEOS VC)

Launch Date: 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22

C-band
- METOP-A Europe
- METOP-C Europe
- METOP-B Europe
- QuikSCAT USA
- Oceansat-2 India
- HY-2A China
- CFOSat China/France
- HY-2B China
- Meteor-M3 Russia
- GCOM-W2, -W3 with DFS Japan/USA
- FY-3E with 2FS China
- NASA ISS scatterometer
- OceanSat-3 India

Ku-band
- EPS SG Europe

Combined C- and Ku-band

- No NRT global availability
- Availability?

Operating: Design Life, Extended Life
Approved: Designed, Extended, Proposed

MyOcean Science Days, November 2012  sw 24feb11