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METEOROLOGY

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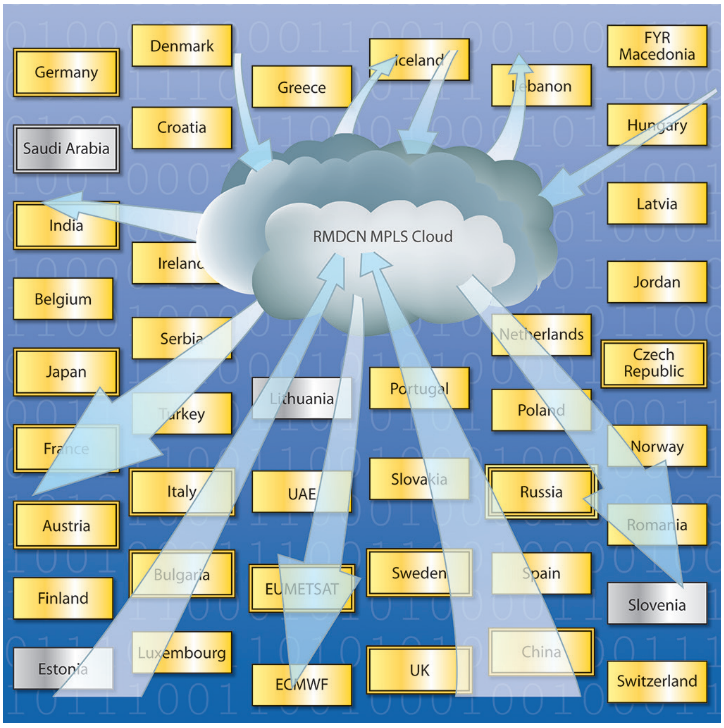

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Operational assimilation of surface wind data from the MetOp ASCAT scatterometer at ECMWF

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ASCAT (Advanced Scatterometer) is a new-generation C-band instrument on-board EUMETSAT's MetOp satellite (launched on 19 October 2006). It is based on the successful AMI scatterometers on-board the ERS missions. Use is made of triplets of radar backscatter to estimate surface vector winds over the global oceans, soil moisture over land, and properties of sea ice in polar regions. Both AMI and ASCAT operate at C-band (5.3 GHz) and share antenna geometry. Two main differences are a different range of incidence angle (optimized for ASCAT to enhance performance in wind direction) and the fact that ASCAT carries two sets of antennas, providing two swaths of 550 km each. This doubles the coverage compared to the ERS-1 and ERS-2 scatterometers. For more details about geometry and design see *Figa-Saldaña et al.* (2002, *Can. J. Remote Sensing,* **28**, 404–412).

Data from ASCAT has been monitored at ECMWF since the start of dissemination via the EUMETCast system on 31 January 2007. Surface winds are inverted in-house from available (level 1B) backscatter triplets on the basis of a modified version of the geophysical model function CMOD5 (see *Hersbach et al.,* 2007, *J. Geophys. Res.,* **112**, C03006, doi: 10.1029/2006JC003743) and compared to collocated ECMWF short-range forecast winds. This monitoring confirmed that the ASCAT instrument is working well. Due to the unavailability of two out of three in situ transponders, the absolute calibration performed at EUMETSAT has not been finalized. However, stable average levels have been observed from the start. After appropriate corrections in backscatter space prior to wind inversion, a homogeneous and stable wind product of high quality has been obtained at ECMWF throughout.

By using a similar set-up as for ERS-2 winds, assimilation experiments including ASCAT surface vector winds in the ECMWF analysis and forecast system at full model resolution (T799) showed a positive effect on forecast skill over the southern hemisphere. For ocean waves, in addition, significant positive impact was observed in the tropics. The excellence of ASCAT data is illustrated in Table 1; this summarizes global statistics for actively assimilated ASCAT and QuikSCAT data accumulated over the period covered by the ASCAT experiment.

	Wind speed (m s^{-1})		Wind direction (degrees)	
	Bias	**Standard Deviation**	**Bias**	**Standard Deviation**
ASCAT	(2 ambiguities)			
First guess	0.00	1.29	0.8	14.6
Analysis	0.06	0.97	0.4	10.1
QuikSCAT	(2 ambiguities / 4 ambiguities)			
First guess	-0.09/-0.12	1.33/1.30	0.7/0.8	18.5/14.3
Analysis	0.06/0.04	1.11/1.08	0.6/0.7	15.6/11.1

Table 1 Average bias and standard deviation of scatterometer data as assimilated compared to ECMWF first-guess at appropriate time and the associated analysis for wind speed and direction for the ASCAT assimilation experiment. At assimilation, neutral QuikSCAT winds are lowered by 4% to incorporate average stability effects, and two out of four possible wind ambiguities are used.

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Following the promising results, surface winds from ASCAT were introduced into the operational suite on 12 June 2007 by a blacklist change, one week after the introduction of model cycle Cy32r2. Since this change, data from three scatterometers is assimilated simultaneously: ERS-2, QuikSCAT and now also ASCAT. ECMWF is the first operational institute to actively assimilate wind data from ASCAT. Since ascending nodes for ASCAT, QuikSCAT and ERS-2 are all different, large portions of the globe are now covered during a six-hour period. Figure 1 shows a typical coverage plot. This coverage should allow to some extent a diurnal cycle in surface winds to be represented.

At EUMETSAT data is processed at 50 km and 25 km horizontal resolutions on grids of 25 km and 12.5 km. At ECMWF only the product at lower resolution is currently presented to the assimilation system. Like scatterometer wind from ERS, data is thinned to 100 km and use is made of the standard scatterometer observation operator (model vector wind at 10-metre height), 4D-Var cost function and variational quality control. The only difference is that ASCAT data is given a larger weight than that for ERS and QuikSCAT data (an observation error of 1.5 $m s^{-1}$ is assumed instead of 2 $m s^{-1}$). This reflects the higher accuracy in wind direction for ASCAT data, and appears to result in a comparable contribution per datum to the 4D-Var cost function.

Since ASCAT operates at C-band, the data is hardly affected by rain; therefore it provides accurate winds in all weather conditions. An example of a system of two extreme storms in the North Atlantic is displayed in Figure 2. ASCAT winds up to 65 knots are observed, and show the full structure of the two weather systems. Assimilation of ASCAT winds resulted in small adjustments in position and intensity for both systems.

After the operational implementation of the ASCAT data an improved accuracy of the first-guess and analysis surface wind was revealed. This is illustrated by a comparison with ENVISAT altimeter wind data as given in Figure 3.

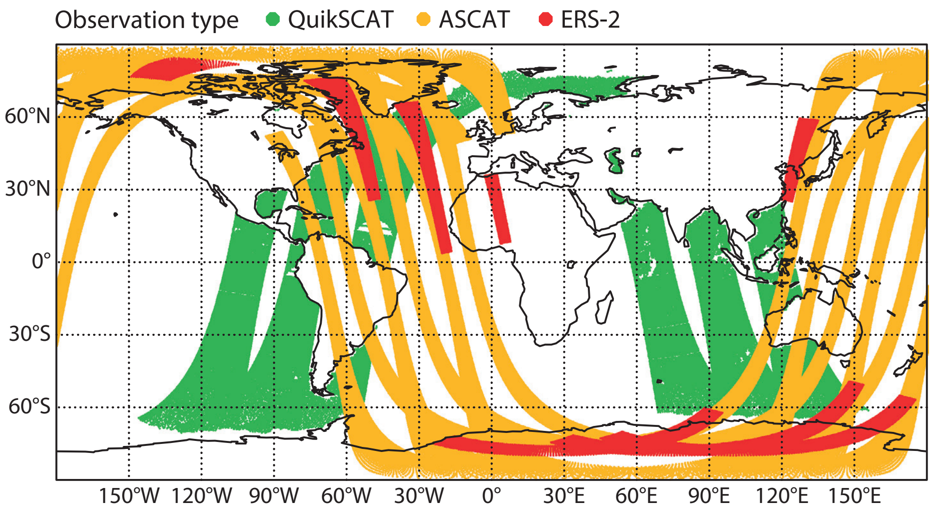

Figure 1 Coverage of received scatterometer data for the six-hourly cycle starting at 00 UTC on 6 June 2007. The total number of observations is 279,253.

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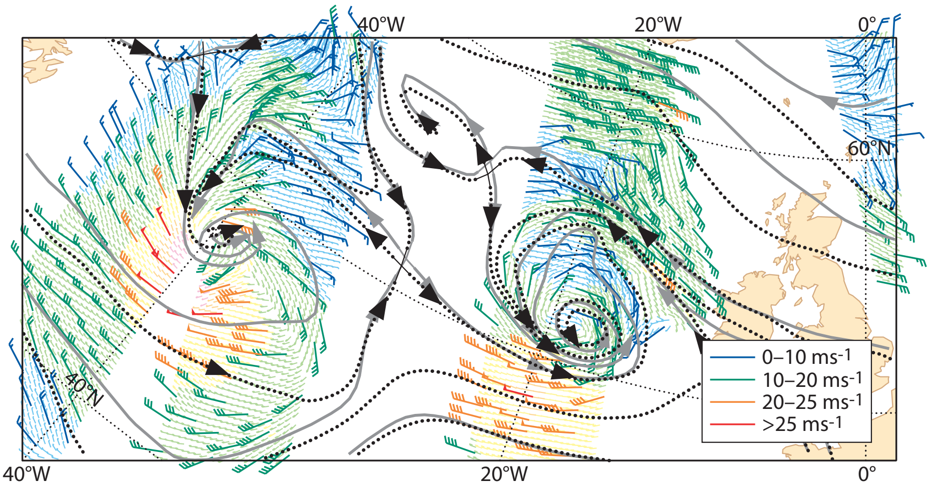

Figure 2 ASCAT wind field at 00 UTC on 20 February 2007 in the North Atlantic. Large barbs indicate actively assimilated winds and small barbs indicate rejected (mostly thinned) winds within the ASCAT assimilation experiment. Black and grey lines represent streamlines for the ECMWF analysis and first-guess surface winds.

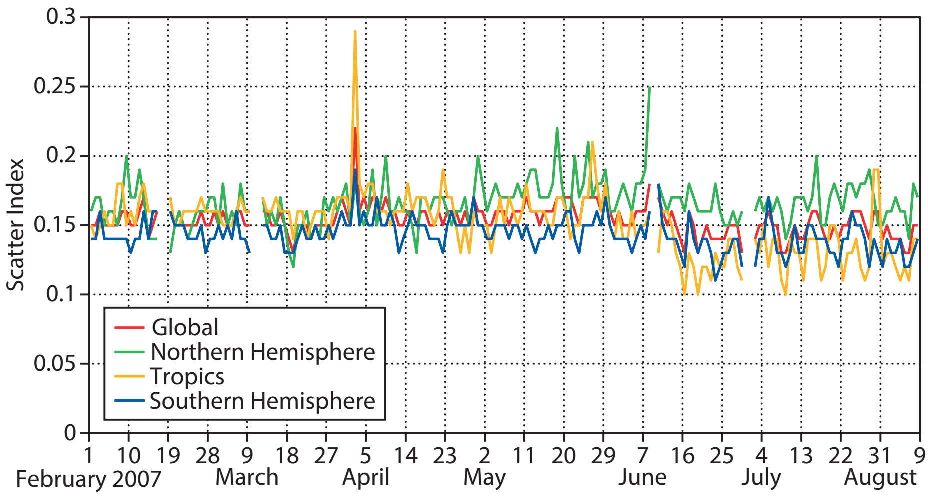

Figure 3 Time series of the Scatter Index for ENVISAT Radar Altimeter wind speed versus ECMWF analysis surface wind speed for the globe, northern hemisphere, tropics and southern hemisphere.

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