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Assimilation of reprocessed ERS scatterometer data into ECMWF weather analysis on the Mediterranean Sea

R. Crapolicchio[1], **P. Lecomte**[2], **and H. Hersbach**[3]

[1]Serco S.p.A., Via Sciadonna 24, 00044 Frascati (RM), Italy
[2]Directorate of Earth Observation – Earth Observation Ground Segment, Department ESA/ESRIN, Via G. Galilei, 00044 Frascati (RM), Italy
[3]ECMWF, Shinfield Park, Reading RG2 9AX, UK

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Abstract. Since the launch of ERS-1 in 1991 and ERS-2 in 1995, carrying a C-band Scatterometer, a data set of more than thirteen years of backscattered signal from the Earth surface is available for exploitation. With its global coverage, day or night and all-weather operation, ERS Scatterometer data offer unique opportunity for long-term studies and research. To fulfill the needs of the scientific community, the European Space Agency (ESA) has developed the project: Advanced Scatterometer Processing System (ASPS). Main scope of the project is to provide with state-of-the-art algorithm, high quality and homogenous Scatterometer measurements (sigma nought) of the Earth surface and high quality wind field over the Oceans by re-processing the entire ERS mission. Additional scope is to provide on experimental basis scientific products in high resolution tailored for the emerging Scatterometer application on Ice and Land. The ASPS project is now in a pre-operational phase and the scope of the paper is to give to the scientific community an overview of the ASPS data and show the assimilation of the data into the ECMWF weather analysis system. ASPS data hopefully will help the scientific community to better understand and monitor the Earth's climate changes and to protect our environment.

1 Introduction

The ERS Scatterometer mission initiated in 1991 with the launch of the first satellite (ERS-1) and continued in 1995 with the launch of a second satellite (ERS-2) is still into operation phase despite some harm occurred on the flight segment. Details regarding the last event happened throughout the mission lifetime are reported by Crapolicchio et al. (2004). The basic idea for the Advanced Scatterometer Processing System (ASPS) was born from the initial phase of the ESACA (ERS Scatterometer Attitude Corrected Algorithm) project at the end of 2001 (Lecomte, 2002). The redesign of the Scatterometer ground processor was a unique opportunity to have from one side a processor able to operate with the data acquired in Zero Gyro Mode (ZGM) in order to continue the Scatterometer mission and on the other side, to have the core element for a new state-of-the-art facility (Neyt et al., 2002) to re-process thirteen years of ERS Scatterometer data. Since December 2003 the ASPS system is in a pre-operational phase in ESRIN. Some beta products have been already generated and distributed to some European scientific groups like the ASCAT SAG for evaluation.

Correspondence to: R. Crapolicchio
(raffaele.crapolicchio@serco.it)

2 The ASPS goals

The first goal of the ASPS is the reprocessing of the entire ERS Scatterometer mission from 1991 to date.

This is an important achievement in particular for all applications that need a long and consistent data set of observations like oceanography and climatologic studies.

The second goal of the ASPS is to improve the quality of the Scatterometer data. Improvements are achieved for:

- the instrument measurements that is the Earth Surface backscattered energy
- the derived product that are the wind speed and direction over the Oceans.

The instrument measurements are improved by a more precise processing algorithm (Neyt et al., 2002) and the winds are derived with the last model developed by the ECMWF (Hersbach et al., 2004).

The third goal of the ASPS is to provide scientific products for emerging Scatterometer applications.

Beyond the original mission of the ERS Scatterometer, intended to provide measurements of the wind vector over the

Table 1. ASPS products overview.

Product Name	Description	Size [Mb]
ASPS Level 1.5	Engineering product for instrument and processing monitoring	0.5 MB
ASPS Level 2.0	– 3 beam sigma nought – Rank 1–4 Wind Vector (CMOD-5) – Ambiguity removed Wind Vector – Sea/Land Flag – Yaw angle flag – Sea Ice Percentage and flag – 19 nodes across track. The geometrical resolution of the node is about $50 \times 50\,km^2$ the distance between two adjacent nodes is constant and equal to about 25 km.	Full Orbit 2.7 MB
ASPS Level 2.0 Scientific	As the Level 2.0 but – 41 nodes across track, Node resolution about 25 km distance between two adjacent nodes about 12.5 km	Full Orbit 11.5 MB

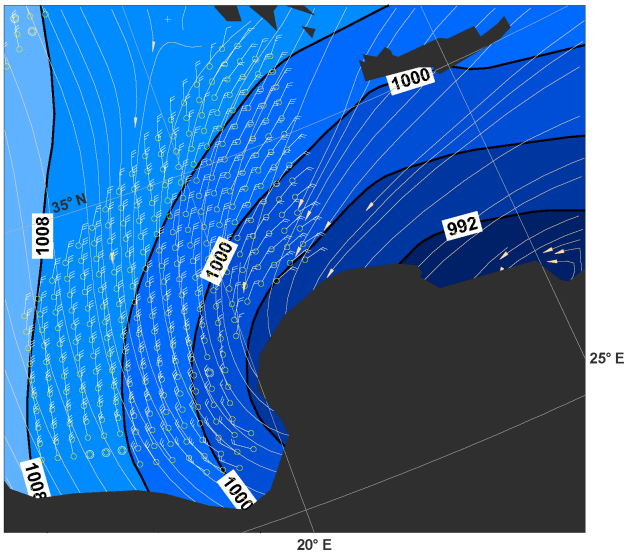

Fig. 1. ECMWF analysis for 15 March 1998, 12:00 UTC, of mean sea-level pressure (contours) and 10-m wind (streamlines), combined with ERS-2 Scatterometer reprocessed data (wind barbs).

Oceans, a large number of new unforeseen applications have emerged. Originally developed to measure winds over the ocean from space, Scatterometer data has proved to be very useful in a variety of studies. These new applications cover the wind, but also land, continental or sea ice, soil moisture, and vegetation and require high quality and long-term backscatter information. For these emerging applications the ASPS will provide instrument measurements with high resolution: 25 km instead of the nominal 50 km. ASPS will also provide additional information like the content of Sea Ice into the Oceans.

The fourth goal is the re-processing of the data acquired during the "Regional Mission" put in place since mid July 2003 to face out the on-board failure of booths tape recorders. In that scenario, the instrument data are acquired in the visibility of several ground stations. Here only a small data segment (ranging between 6 and 12 min depending on the station and on the relative orbit) is available in each station for the generation of the fast delivery data. Due to the ERS Scatterometer acquisition geometry a full set of sigma nought triplets are only available for a reduced segment with a drop of about 80 s at the beginning and end of the acquisition. The ASPS will ingest and re-process all those data segments, selecting the best quality raw data from the various ground stations in case of overlaps. The Quality of the winds improves when the processing is performed on a long data segment. The algorithm adopted in the ASPS takes care of the wind field coherence within a large area of the swath (about 3000 km along track or 7 min of wind data). That condition is not always guaranteed for the single passes currently generated in the ground station.

As last achievement, the ASPS shall be able to process ASCAT data (foreseen for launch on Metop on 2005 with 15 years of operations). In that way the ASPS products will cover a three decades of Scatterometer measurements.

3 The ASPS products

The Table 1 reports an overview of the products generated by ASPS. The standard ASPS product available for the users is named ASPS Level 2.0 and it is described in the second row of Table 1. The ASPS Level 2.0 scientific is the high resolution product and the main features are reported in the third line of Table 1. The User Wind (UWI) product that is the actual product delivered by the ERS ground segment to the users will be also generated to maintain that "historical" format. The ASPS Level 1.5 is an engineering product and is not available for the end users. A more detailed description of the Level 2.0 product is available on: http://earth.esa.int/pcs/ers/scatt/reports/articles/.

4 The ECMWF assimilation exercise

Since the beginning of the ERS-1 mission, ECMWF is involved in the global validation and long-term performance monitoring of the wind and wave Fast Delivery Products that are retrieved from the Radar Altimeter (RA), and from the Active Microwave Instrument (Scatterometer and SAR wave mode), on-board the ERS spacecrafts (Hersbach and Abdalla, 2004). Their geophysical content is compared with corresponding parameters from the ECMWF atmospheric and wave model as well as in-situ observations (when possible). In the framework of that cooperation an assimilation

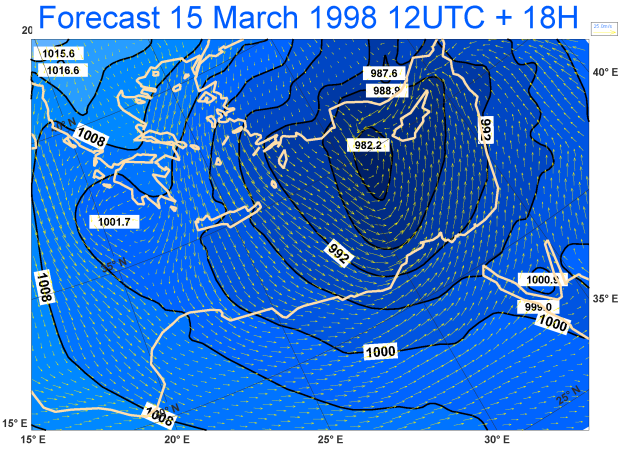

Fig. 2. ECMWF+18H forecast from 15 March 1998, 12:00 UTC analysis of mean sea-level pressure (contours) and 10-m wind (vectors).

exercise has been performed on the ASPS data. In the morning of 16 March 1998, a deep cyclone affected the South East of the Mediterranean, giving rise to snowfall in Israel. This event led to damages to agriculture, air traffic delays and road closures in Jerusalem (http://medex.inm.uib.es/). The day before this event, part of the structure of the developing cyclone was observed by the ERS-2 Scatterometer. ASPS reprocessed data from this pass was assimilated in the most recent version of the ECMWF system (Assimilation at T159 spectral resolution, forecast at T511). Its four-dimensional variational formulation is able to propagate the information provided by the Scatterometer surface winds to the entire troposphere. The Fig. 1 shows the resulting analysis for the surface wind field (streamlines) and mean-sea level pressure (contours), together with the ERS-2 Scatterometer data. The high-resolution Scatterometer winds have good quality and match well with the ECMWF analysis winds. In fact, the standard deviation of speed departures from the first-guess winds was reduced from 1.63 m/s (FGAT) to 1.05 m/s (analysis). In Fig. 2 the 18 H forecast from this analysis is displayed, indicating the strong wind condition in the area.

5 Conclusion

The purpose of this paper is to introduce the ASPS system to the scientific and application users and to show an example of ASPS data assimilation in meteorological model. The experiment shows that the quality of the ASPS winds is very high also in such kind of weather event.

The authors agree with the reviewers that the assimilation experiment have to be further analyzed. A preliminary investigation of the impact of the ASPS winds in the forecast shows a slight positive impact and more conclusive results will be reported in the future works.

A set of ASPS products covering a period of 35 Days in March–April 1999 is available from the authors for evaluation.

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References

Crapolicchio, R. and Lecomte, P.: The ERS-2 Scatterometer mission: events and long-loop instrument and data performances assessment, Proceeding of the Envisat & ERS symposium Salzburg (A), 6–10 September 2004, ESA-SP 572, 2004.

Hersbach, H. and Abdalla, S.: The global Validation of ERS Wind and Wave products at ECMWF, Proceeding of the Envisat & ERS Symposium Salzburg (A), 6–10 September 2004, ESA-SP 572, 2004.

Hersbach, H., Stoffelen, A., and de Haan, S.: The improved C-band geophysical model function CMOD5, Proceeding of the Envisat & ERS Symposium Salzburg (A), 6–10 September 2004.

Lecomte, P.: ERS-ASCAT The European Initiative on C-Band Scatterometry, Proceedings of PORSEC 2002, 482–485, 2002.

Neyt, X., Pettiaux, P., and Acheroy, M.: Scatterometer Ground Processing Review for Gyro-Less Operations, Proceeding of 9th International Symposium on Remote Sensing, Crete, Greece, 22–27 September 2002.