ABSTRACT

With the loss of the on-board ERS-2 tape recorders, ESA swiftly developed a new strategy for on-ground data acquisition. Rather than 14 ERS-2 data acquisitions per day, the acquisition rate has more than tripled, allowing data coverage in the North Atlantic and adjacent seas. Acquisition rate and coverage are still increasing. ESA processes all acquisitions independently, allowing user data access in typically 30 minutes. This is unprecedented for scatterometer winds and for the first time allows the use of the scatterometer winds for weather nowcasting. At KNMI, a procedure has been developed to provide on-the-fly unique scatterometer winds, i.e., swath overlaps are taken out, and incomplete Wind-Vector-Cells are combined for completion. As such, KNMI produces freely-available ERS-2 scatterometer wind products over the globe; see http://www.knmi.nl/scatterometer/ for further details.

1. INTRODUCTION

ERS scatterometer winds have proven to be very useful for the analysing and forecasting of dynamic weather [1]. Increased coverage, such as from tandem ERS-1 and ERS-2 measurements, clearly improves the usefulness in extreme events (e.g., [2]) in Numerical Weather Prediction (NWP). However, these NWP applications are useful for short- or medium-range weather forecasting, while shift meteorologists were not using the data for weather nowcasting, due to poor timeliness. The meteorological community recognises the timeliness problem associated with satellite data, e.g., EUMETSAT recently developed the Early Advanced Retransmission Service (EARS) for ATOVS and for ASCAT on METOP a similar service is being planned.

In anticipation of ASCAT on METOP, scatterometer research and development, and routine processing and monitoring are funded by EUMETSAT through the Satellite Application Facilities (SAFs [3]). More specifically, the Royal Netherlands Meteorological Institute (KNMI) participates in the Ocean and Sea Ice (OSI) SAF, the Climate Monitoring (CM) SAF, and the NWP SAF for these purposes.

In the context of these SAFs KNMI provides software and data with

- Tailor-made SeaWinds quality control (QC) in order to avoid unrepresentative wind data (e.g. rain contaminated or sea state, see [4]);
- Procedure to average backscatter measurements in a resolution cell of varying size, in order to provide spatially representative and accurate winds for NWP models;
- Generic scatterometer backscatter data inversion;
- Generic scatterometer cost function to cope with all kinds of scatterometer data;
- A 2D Variational Ambiguity Removal (2D-VAR) providing meteorologically consistent scatterometer wind fields;
- Routine processing and monitoring of wind and, in the near future, surface stress;
- Web-based product presentation, and distribution by FTP;
- Web-based monitoring reports.

SAF activity is currently mainly focused on SeaWinds, although much of the algorithms are generically applicable for the ERS scatterometer and ASCAT on METOP, to be launched in 2006. KNMI is seeking user participation in a Visiting Scientist programme or as beta user, aiding in the development of our software or data products.
Figure 1: http://www.knmi.nl.scatterometer/ers_prod/ display of Monday 6 September showing 22 hours worth of ERS-2 scatterometer winds. Colours indicate wind speed. The red arrow indicates land-fall of tropical cyclone Frances. A mouse-click anywhere on the coloured speeds provides a detailed wind vector plot.
Figure 2 Remnants of tropical cyclone Frances (see Fig. 1) in the Gulf of Mexico after landfall as observed by the ERS-2 scatterometer. The KNMI ERS-2 wind processor has been used. The background is a GOES IR cloud image.

Figure 3 Overview of on-the-fly ERS-2 scatterometer processing at KNMI. Horizontal axis is time of measurement, vertical axis time of receipt and processing at KNMI. Four batches of acquisition are shown with measurement data overlap. The number of backscatter measurements is indicated and green denotes wind processing for triple data. Red denotes triplet data, but already processed successfully in a previous batch; yellow denotes combination of incomplete batches resulting in complete triplets ready for successful wind processing.
With the loss of the on-board ERS-2 tape recorders, ESA swiftly developed a new strategy for on-ground data acquisition. Rather than 14 ERS-2 data acquisitions per day, the acquisition rate has more than tripled, allowing data coverage in the North Atlantic and adjacent seas (see Fig. 1). Acquisition rate and coverage are still increasing. ESA processes all acquisitions independently, allowing user data access in typically 30 minutes. This is unprecedented for scatterometer winds and for the first time allows the use of the scatterometer winds for weather nowcasting.

At KNMI, a procedure has been developed to provide on-the-fly unique scatterometer winds, i.e., swath overlaps are taken out, and incomplete Wind-Vector-Cells are combined for completion. This procedure is further explained below.

2. ON-THE-FLY AND UNIQUE ERS-2 SCATTEROMETER WINDS

In NWP data assimilation scatterometer data are processed and sorted in time batches. In this scheme redundant data in a batch can be identified at run-time and appropriate measures taken to complete WVCs or to reject redundant WVCs. Batch processing is not suitable for real-time use, due to its associated delay and poor timeliness. Rather, on-the-fly processing is required as depicted in Fig. 3.

In the on-the-fly processing, processed data exists that may be measured earlier or later than the data in a new batch. Moreover, the independent ground acquisitions cause measurement overlap and incomplete WVC. The latter is caused by the fact that the fore, mid, and aft measurements in a WVC are all measured at different times and therefore not always all available for downlinking.

The KNMI processor takes the most recent 2 hours of data, processed and unprocessed alike and sorts them by WVC measurement time. The processed data, however, are included for reference and not considered for processing; only the WVCs in the unprocessed batch are considered. First, the overlap of these unprocessed WVCs with the processed WVCs is determined. If a WVC was complete and processed before, then it is rejected in the current batch to avoid duplicates. If, on the other hand, a WVC was not complete, then information is transferred from the last processed batch to complete the current batch for processing. Only all completed WVCs are then processed, together with the non-overlapping WVCs, and the processing status (yes/no) written in the batch output. When a new batch comes in this procedure is repeated. Note that in this process no data redundancy remains in the output, nor is information lost. On the other hand, note that in the input batches overlap exists, as well as triplets divided over several batches.

3. PRODUCT QUALITY

The ERS-2 scatterometer data in gyroless mode have a quality similar to the ERS data before the gyro losses [5] [6]. ERS scatterometer data are quality controlled by a so-called distance-to-cone check. Since the cone represents the ocean wind regime, points away from the cone are likely affected by more complex geophysical phenomena [7].

The real-time Atlantic ERS data are useful for nowcasting, in particular of fast developing systems like in Fig. 4 or extreme cases as in Fig. 3. Both types of cases are sensitive to rain-contamination in case of Ku-band scatterometers, but not for C-band. Cases of rain contamination, due to splash effects, have been documented for small-footprint SAR, but not for the 50-km ERS scatterometer footprints. Fig. 5, however, shows a case of likely rain contamination due to splash.

Fig. 5 also shows some realistic-looking small wind cells, not at all present in the HiRLAM NWP winds plotted in the background; these latter winds are smoother, indicative of a more limited information content. For nowcasting, shift meteorologists use NWP model output and ancillary observations for verification. It may be clear that the complementary mesoscale detail as measured by the ERS-2 scatterometer in real time is of good value.

In Fig. 6, ERS and SeaWinds products are compared subjectively for meteorologically dynamic case. The ERS winds show the consistent flow around the low pressure system, besides a small area with ambiguity removal error to the northeast of the low. The 4 hours earlier SeaWinds product over this area shows rather erratic winds, most likely due to poor rain rejection. Moreover, the SeaWinds quality control algorithm tends to reject WVCs over more extensive areas due to rain contamination [8].
**Figure 4**: As Fig. 2, but for a fast developing low west of Scotland, blue arrows denote the HiRLAM model winds, that miss the sharp through line over the swath.

**Figure 5**: As Fig. 4, but on 12 July 2004, 1:30GMT. A likely case of rain contamination is present on the right, in an area with rather uniform wind flow.
Figure 6: Top, as Fig. 4, but on 4 July 2004, 1:30GMT. Bottom: SeaWinds at 100 km sampling for the same area, but previous day at 21:00 GMT. The bright cold clouds in the centre of this low, likely correspond to rain, as can be further inferred from the erratic QuikScat winds. ERS winds do not show any rain contamination.
4. OUTLOOK

KNMI developed a ERS-2 scatterometer real-time processing system that combines subsequent ground station acquisitions in order to make a unique and complete output product. The processor is very fast and does not add any significant delay to the timeliness of ERS-2 scatterometer winds. At the moment of writing, the processor also cures a land contamination problem present in the ESA processing.

Scatterometers provide accurate and spatially consistent near-surface wind information. Hardware permitting, there will be a continuous series of scatterometers with at times ideal coverage of the ocean surface wind for the coming two decades. EUMETSAT provides user services in collaboration with KNMI, where these are now being set up and freely available at http://www.knmi.nl/scatterometer for the SeaWindsI and ERS-II scatterometers. Near-real time FTP products or software can be obtained by sending a request to the author. Moreover, a visiting scientist scheme is funded in order to support the development programme and the use of the KNMI services. Again, the author will provide more information on request.

5. REFERENCES


5. Hans Hersbach et al., The Global Validation of ERS Wind and Wave Products at ECMWF, this issue, 3P10.

6. Raffaelle Crapolicchio et al., The Advanced Scatterometer Processing System for ERS data; Design, Products, and Performances, this issue, 3A5.

