# OSI SAF SCATTEROMETER WIND PRODUCTS

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## ABSTRACT

In Europe, scatterometer product development is organised through the EUMETSAT Satellite Application Facilities. SeaWinds developments are focussed on using the data for Numerical Weather Prediction and short-range weather forecasting. The former is well suited by the products as currently produced at KNMI at 100-km resolution (see http://www.knmi.nl/scatterometer/qscat_prod). For short-range forecasting or in semi-enclosed sea areas such as the Mediteranean, however, higher resolution is desirable. KNMI attempts to improve the spatial filtering properties of the wind retrieval by using prior information on the expected meteorological balance, e.g., favouring rotational structures in high-latitude regions. Moreover, we use solutions in all wind directions, but weighted by their inherent probability. Our 2D Variational Ambiguity Removal, 2D-VAR, is capable of exploiting such probability information.

We anticipate that the 2D-VAR method has the advanced filtering properties for maintaining small-scale meteorological information in SeaWinds, while reducing noise. This is tested by comparing the spatial covariance structures of the KNMI products, with those of the NOAA SeaWinds product, and, for reference, those of the ECMWF model. The methodology leads towards a high-resolution scatterometer wind product for SeaWinds, but is also envisaged for ASCAT on METOP.

## 1. INTRODUCTION

The all-weather capability of a scatterometer provides unique wind field products of the most intense and often cloud-covered wind phenomena, such as tropical cyclones (for example, see figure 1). As such, it has been demonstrated that scatterometer winds are useful in the prediction of tropical cyclones, e.g., Isaksen and Stoffelen (2000), and extra-tropical cyclones (Stoffelen and Beukering, 1997). At the moment the ESA ERS-2 and the NASA SeaWinds scatterometer on QuikScat provide respectively a regional real-time and a global near-real time data stream. In 2005 EUMETSAT will continue the global scatterometer mission with the ASCAT scatterometer on EPS/METOP, and will start a regional real-time ASCAT dissemination. As such, continuity of both services is likely provided to the operational meteorological community for another period of 15 years.

EUMETSAT set up Satellite Application Facilities (SAF) providing software and data products and services. KNMI is involved in the scatterometer activities of the following SAFs in preparation for ASCAT:

- Numerical Weather Prediction SAF for scatterometer software products;
- Ocean and Sea Ice SAF for scatterometer wind products; and
- Climate SAF for Scatterometer Ocean Stress (SOS) products.

Scatterometer sea surface wind research and development lies at the basis of these products:

- Input product consistency checks, quality control, rain (for SeaWinds) and ice (for ERS) screening;

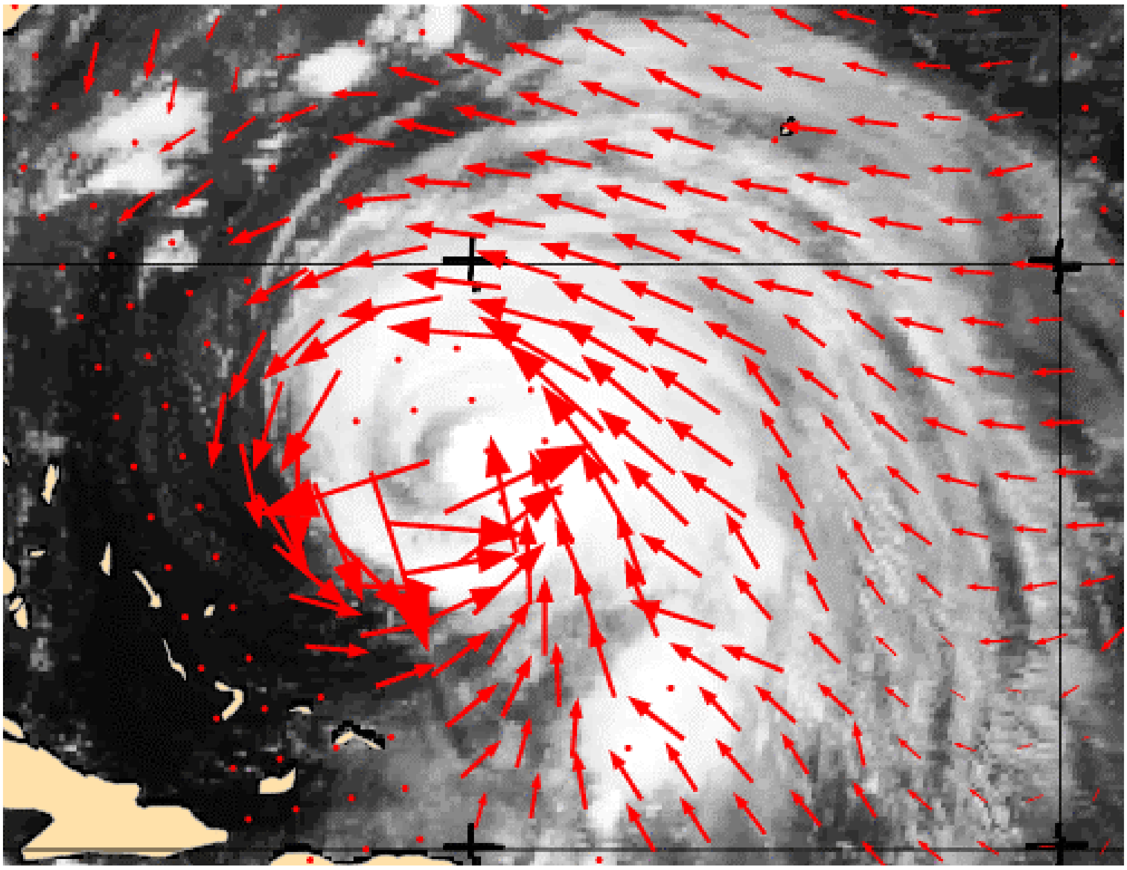

***Figure 1.*** *QuikScat SeaWinds 100-km wind product generated at KNMI for tropical cyclone Isabel (2003), raging in the Caribbean. GOES IR cloud imagery is provided underneath for reference.*

- Simultaneous processing of multiple ERS-2 ground station acquisitions in order to
  - provide unique processing at all wind vector cells (WVC), i.e., avoid duplicates;
  - complete backscatter triplets by combining acquisitions of all available ground stations at each WVC;
- Spatial averaging methodologies to reduce noise and enhance quality of SeaWinds products;Inversion: computation of optimal wind solutions and associated probabilities from measurement information;
- Determination of information content; definition of observation operator; ambiguity removal (spatial filter to determine a unique wind vector field);
- Processors for real-time and archive scatterometer wind and stress products;
- Active monitoring and quality assurance methodologies (of instrument and processing); and
- Web site (visualisation) and product distribution;

Product enhancement and the preparation of wind production and user services for ASCAT on METOP are the main goals of this R&D. KNMI currently processes a global QuikScat 100-km product and a North- Atlantic ERS-2 25-km product, and distributes it to the international meteorological community. Moreover, at http://www.knmi.nl/scatterometer links to the visual presentation of these products are provided. Global maps of wind speed are provided over the last 22 hours (as in Figure 2), segregated in ascending and descending orbit tracks. By mouse clicks on these maps more detailed regional plots become available (as in figure 1). The link also provides documentation, papers, and software products.

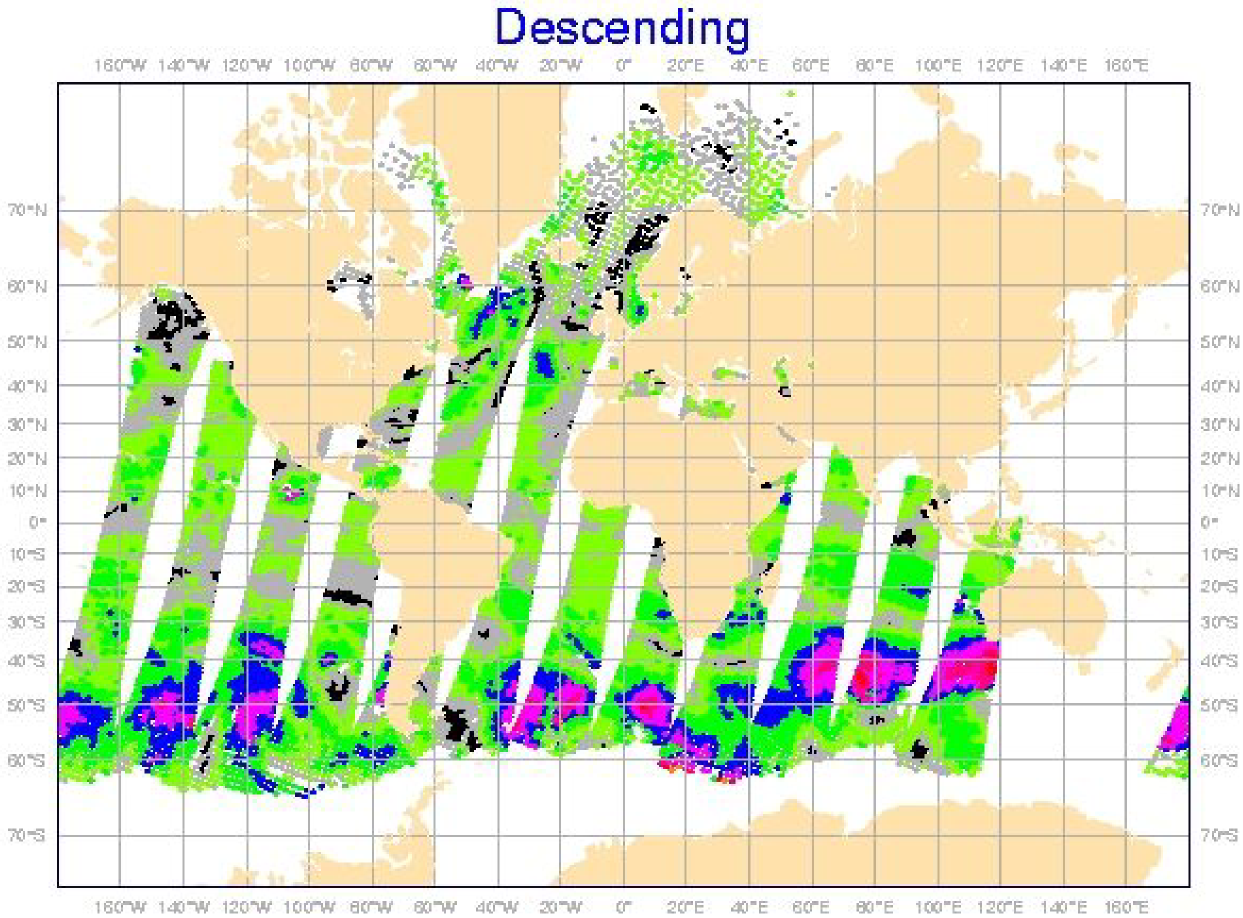


***Figure 2.*** *Overview of QuikScat SeaWinds 100-km wind speeds (coloured) as generated at KNMI.*

## 2. QUIKSCAT 100-KM PRODUCT

The standard KNMI 100-km QuikScat product has been developed for NWP assimilation. A validation is given in table 1. KNMI speeds compare better with ECMWF than NOAA speeds, whereas the wind direction verification is more similar. The noisy wind speeds of NOAA also affect both wind component verifications. Most likely the Direction Interval Retrieval and Threshold Nudging method applied by NASA causes the wind speed noise (Portabella, 2002). Moreover, this scheme results in rather smooth wind direction fields, thus providing a wind direction verification similar to the KNMI 100-km product. The use of the KNMI 100-km product in NWP provides positive or neutral impact, depending on the study period. Further noise reduction and QC is believed to be beneficial for NWP impact and further progress is being made. The former may be achieved by less arbitrary wind vector solution selection after the inversion step.

| SD | KNMI | NOAA |
|---|---|---|
| Speed | 1.31 | 1.64 |
| Direction | 13.58 | 14.58 |
| U | 1.60 | 1.96 |
| V | 1.58 | 1.80 |

***Table 1.*** *KNMI QuikScat 100-km wind product and collocated NOAA 25-km product as verified with independent ECMWF first-guess winds at 10m. The standard deviation (SD) of difference for both products is given (both have small mean bias).*

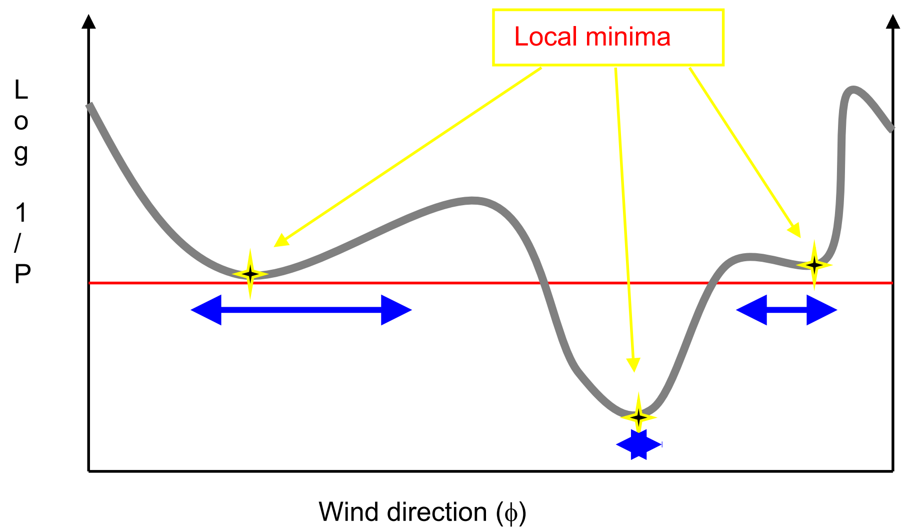


***Figure 3.*** *Schematic of wind direction probability (logarithm 1/P) in a scatterometer Wind Vector Cell (WVC). Occasionally broad solution wind direction minima exist not well represented by the local minimum. In wind speed minima are generally sharp.*

| Swath region | Standard procedure | MSS | NCEP |
|---|---|---|---|
| Sweet | 2.48 | 2.23 | 2.85 |
| Nadir | 2.98 | 2.45 | 2.96 |

***Table 2.*** *Standard QuikScat SeaWinds 100-km wind product and collocated MSS 100-km product as verified with independent ECMWF first-guess winds at 10m. The wind vector RMS of difference for both products is given.*

## 3. MULTIPLE SOLUTION SCHEME

Portabella and Stoffelen (2003) have shown that the KNMI 100-km product can be improved by more fully exploiting the probability information (see table 2), which is implicitly provided by the wind inversion procedure (see figure 3). They represented broad wind solution minima by multiple solutions, denoted multiple solution scheme (MSS).

The table shows the beneficial working of MSS, in particular in the nadir swath, but also elsewhere. Note that Table 2 is produced over a different time period than Table 1 and by keeping some more winds in meteorologically relevant dynamical situations (Portabella and Stoffelen, 2002). The NCEP 1000-mb wind background used for ambiguity removal does not play an important role in the verification, but the improvement is brought by using probability information in combination with the 2D-VAR background constraints on rotation and divergence (Portabella and Stoffelen, 2003). We further note that the improved verification of MSS is mainly due to the reduction of occasional erratic noise; coherent mesoscale structures remain present and become more visible due to the noise reduction.

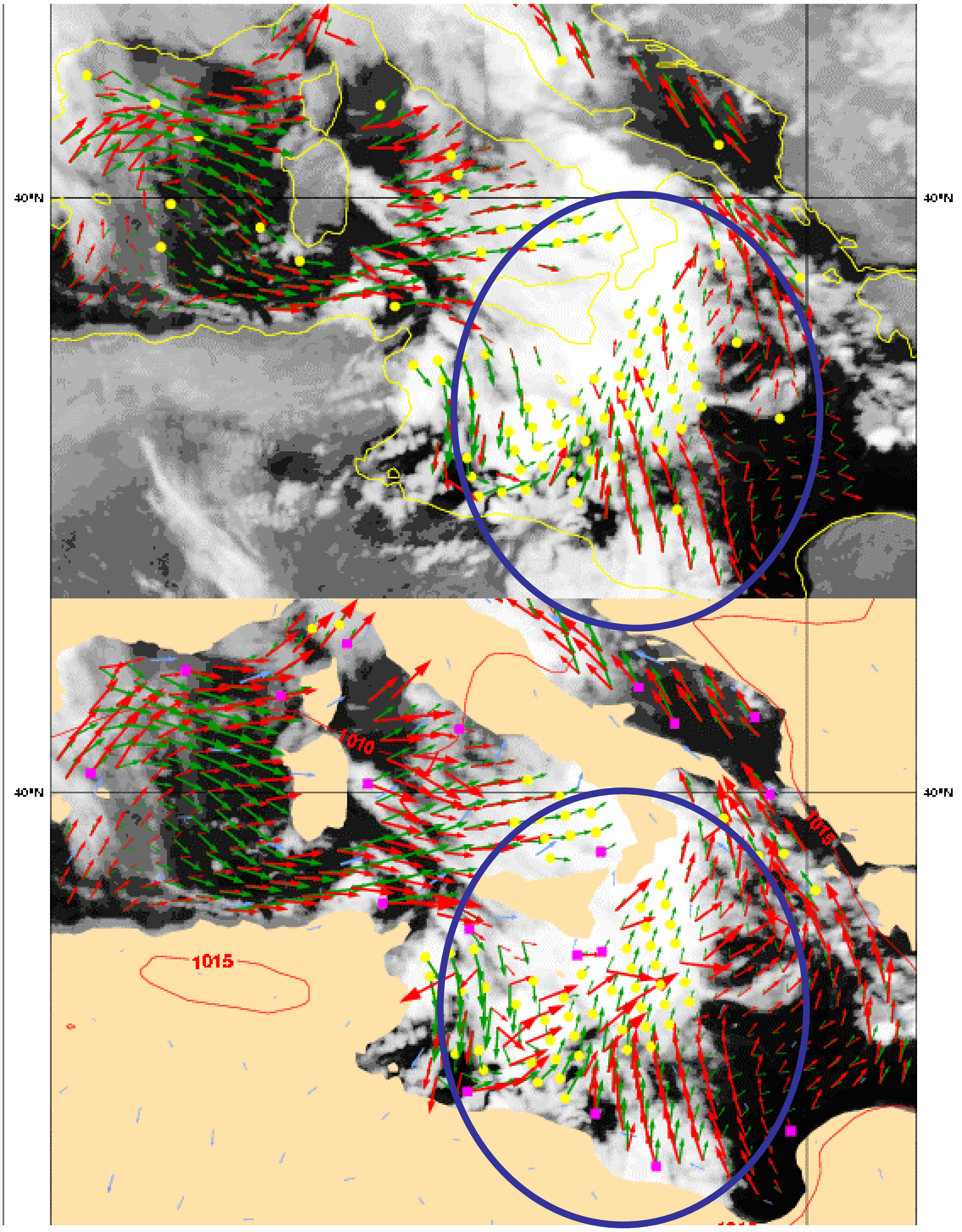


***Figure 4*** *Top: Typical KNMI 25-km MSS SeaWinds product in the Mediteranean (red) and corresponding NWP model winds (green) on top of a MeteoSat IR cloud image showing a convective system. The circle contains an area with moist inflow to the convective system at the surface. Arrows are plotted at 50-km resolution.*

*Bottom: Same as at the top, but NOAA DIRTH SeaWinds product, which shows a somewhat more erratic wind direction field than KNMI. Note, e.g., now the winds in the circle do not show the same moist inflow as in the upper plot, but the 25-km NOAA product shows erratic rain contaminated winds..*

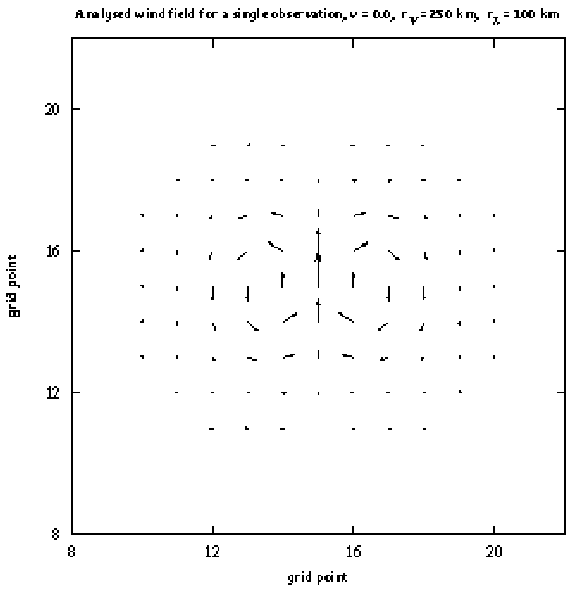


***Figure 5.*** *Meteorological spatial balance as implied by 2D-VAR for southerly analysis increment as shown in the centre of the plot in the Northern Hemisphere extratropics.*

## 4. HIGHER SPATIAL RESOLUTION

Figure 4 shows an example of a Mediteranean wind field as depicted by the NCEP 1000-mb winds (green), the 100-km KNMI SeaWinds product (top;red), and the NOAA DIRTH product (bottom;red). It illustrates the smooth wind direction field of the latter and some wind direction ambiguity removal problem in the outer swath at the left. On the other hand the NOAA product shows more coastal winds due to its processing at 25 km.

For many applications in the Mediteranean both coastal winds and high-resolution winds would be particularly useful. However, many researchers documented the non-uniform noise properties of SeaWinds (e.g. *COAPS, 2004*). To obtain more uniform noise properties spatial filtering of SeaWinds data is required. Moreover, from the comparison above it may be clear that coastal winds may be obtained by using a 25-km grid. Rather than statistically filtering median wind direction intervals, such as in DIRTH, a more meteorologically balanced way of spatial filtering is sought at KNMI in our 2D Variational Ambiguity Removal, 2D-VAR (see figure 5).

## 5. OUTLOOK

The meteorologically balanced 2D-VAR spatial filtering method can fully exploit the wind vector information obtained by scatterometer wind retrieval (Portabella and Stoffelen, 2003) in a mode, called MSS. Given the beneficial working of MSS, an increase in the resolution of the QuikScat wind retrieval may be feasible. For this purpose, the scatterometer wind retrieval software has been adapted, and the occurrence of systematic effects in the wind retrieval investigated. MSS is expected to work better than a statistical (median) filter such as DIRTH (see figure 4). The KNMI 25-km version of MSS will become available in mid 2005 for the user community. It will be verified spatially by correlation analyses and against in situ observations. KNMI welcomes potential users and testers of this product, whom should contact the author.

Scatterometers provide accurate and spatially consistent near-surface wind information, useful for weather and climate (see, e.g., Massimo et al, Cress et al, this issue). Hardware permitting, there will be a continuous series of scatterometers with at times ideal coverage of the ocean surface wind for the first two decades of this century. 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 QuikScat and ERS-2 scatterometers. Near-real time and quasi real-time FTP products or software can be obtained after registration.

These services are being extended to prepare for ASCAT on METOP. We are working on an
- ✓ ASCAT wind Cal/Val preparations;
- ✓ ASCAT sea ice screening (see also Verspeek et al in this issue);
- ✓ ASCAT 12.5-km resolution (see also Verhoef et al in this issue);
- ✓ ASCAT wind stress product; and
- ✓ ASCAT coastal wind product.

Moreover, a visiting scientist scheme is funded in order to support the development programme and the use of the KNMI services by visiting or associated scientists. Again, the authors will provide more information on request.

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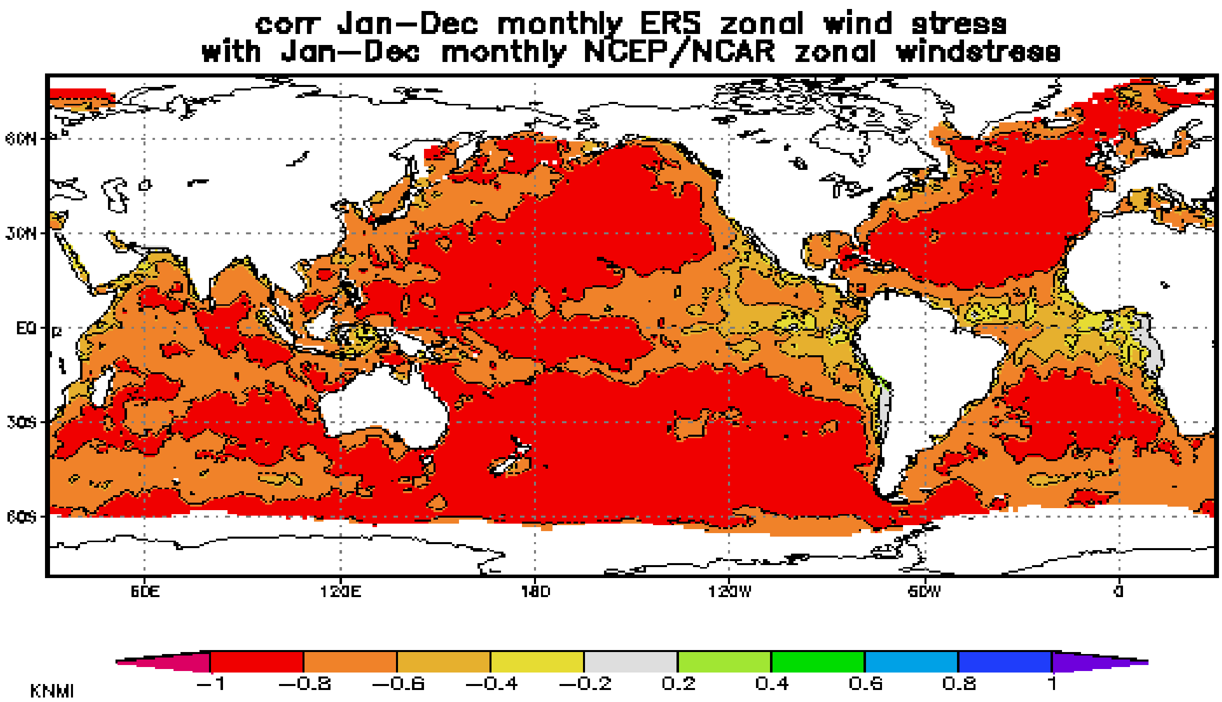


***Figure 6.*** *Example plot from the on-line KNMI Climate Explorer, denoting the correlation of the monthly ERS scatterometer wind stress with the NCEP monthly wind stress , averaged over a full year (1999). Large discrepancies are manifest in the tropical region.*


ECMWF (2004) European Centre for Medium-range Weather Forecast, http://www.ecmwf.int

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