

# STATUS AND DEVELOPMENT OF SATELLITE WIND MONITORING BY THE NWP SAF

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## ABSTRACT

The Integrated Satellite Wind Monitoring Report was first established in 2000. Its purpose was to provide comparable satellite wind monitoring output from different NWP centres in order to help identify and distinguish error contributions from satellite winds and NWP models. The information is freely available on the internet at [http://www.metoffice.com/research/interproj/nwpsaf/satwind\\_report/](http://www.metoffice.com/research/interproj/nwpsaf/satwind_report/). It is hoped that the report will be of interest to the satellite wind community worldwide. The site is intended to stimulate thought and discussion and eventually to lead to improved production, as well as improvements in NWP models and assimilation procedures.

The aim of this paper is to provide an update on the status and developments of the satellite wind monitoring on the NWP SAF site. During its lifetime, the site has played an important role as a source of monitoring data for operational wind types, but it can also be used to assess the quality of new wind datasets, for example MSG and MODIS winds. Other recent or future developments to improve the usefulness of the site are highlighted and feedback is encouraged. Some possibilities include: an increase in the number of contributing NWP centres (currently the Met Office and ECMWF), the inclusion of new plots and more links to results of recent satellite wind impact experiments and case studies.

## 1. INTRODUCTION

The NWP SAF (Satellite Application Facility for Numerical Weather Prediction) is one of several EUMETSAT-sponsored SAFs. The purpose of the SAFs is to develop processing methods and software, and in some cases generate geophysical products, to enable satellite data to be exploited in various meteorological applications. Each SAF began with a 5-year research and development (R+D) collaboration of several National Meteorological Services or other institutes from within EUMETSAT Member States, with the likelihood of a subsequent operational phase to apply and extend the products of the R+D phase. More information about SAFs is available at the EUMETSAT web-site, <http://www.eumetsat.de>.

The NWP SAF has recently completed its five year research and development phase and entered its Initial Operational Phase. The SAF is led by the Met Office, with partners ECMWF, KNMI and Météo-France.

The objectives of the NWP SAF are as follows:

- to improve the benefits derived by European National Meteorological Services from NWP by developing techniques for more effective use of satellite data

- to prepare for effective exploitation within NWP of data and/or products from satellites in the EUMETSAT Polar System (EPS) and Meteosat Second Generation (MSG) Programmes and related programmes of other agencies.

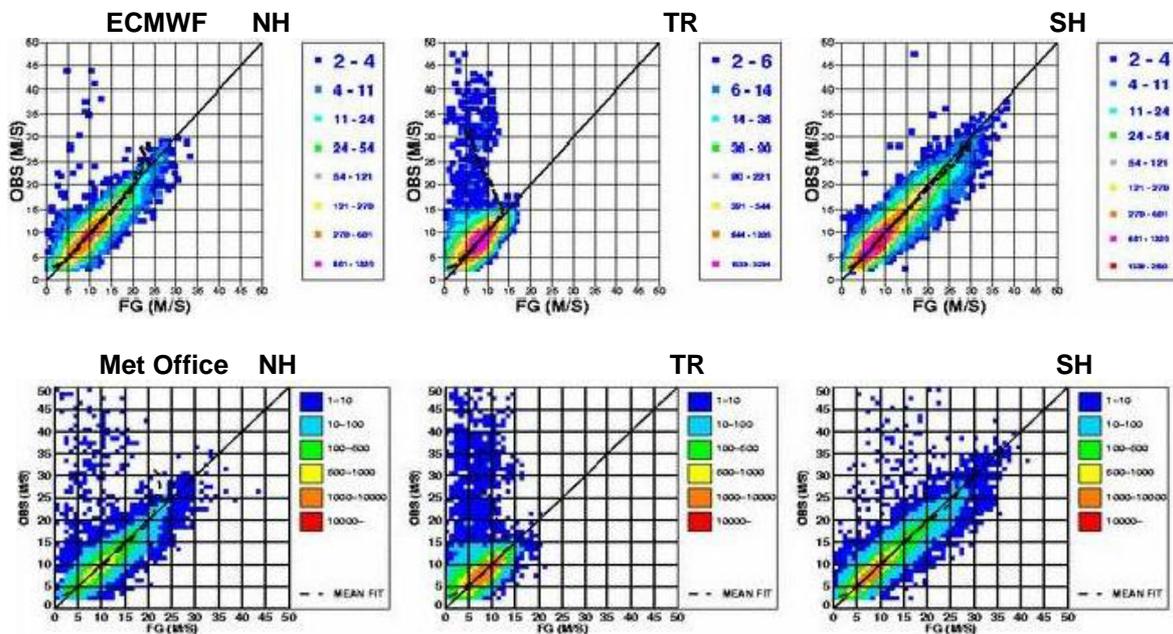
The Integrated Satellite Wind Monitoring Report was one of the first deliverables of the NWP SAF. It displays differences between satellite wind observations and NWP model backgrounds in order to try to separate the contributions from the two sources (observation and model). A better understanding of the errors should enable the improvement of both derived satellite winds and their treatment within NWP models. NWP centres contributing to the report are ECMWF and the Met Office.

In this paper, we provide examples of how the plots have already been used to highlight areas of concern. We outline the recent development work that has been carried out and ideas for future improvements to maximise the usefulness of the site. We welcome feedback on all of this.

## 2. THE EXISTING SITE AND HOW IT CAN BE USED

The plots on the Integrated Satellite Wind Monitoring Report show statistics of wind observations compared with 6 hour model forecasts valid at the observation time. Both the satellite wind observation and the model forecast contribute to the differences seen in the plots; neither can be assumed to be true. But by comparing plots of the same observations against different NWP backgrounds, it may be possible to separate error contributions from the observations and models. The aim of the Integrated Satellite Wind Monitoring Report is to provide easily comparable plots from different centres so that similarities and differences can be easily recognised.

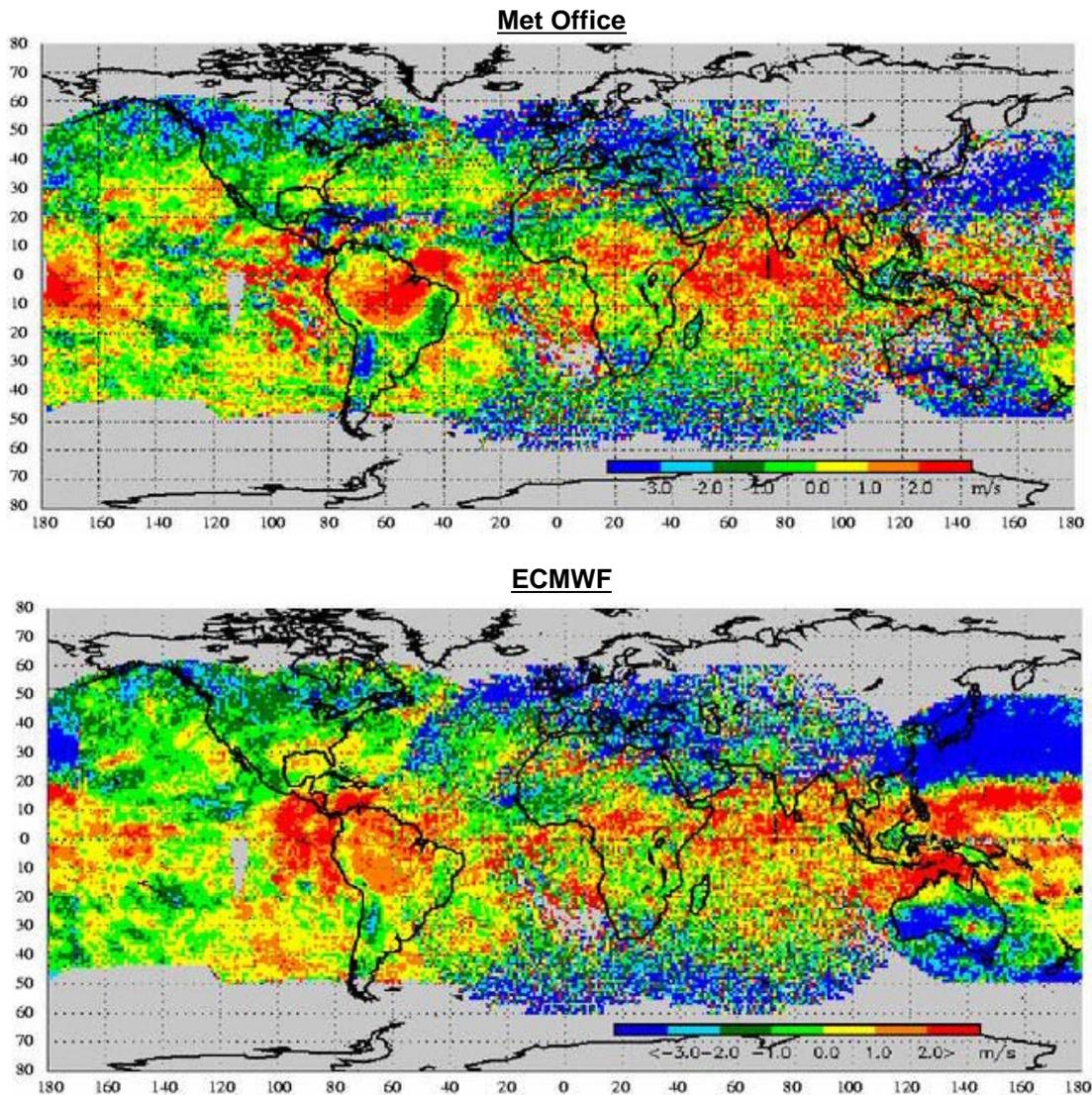
Currently there are two types of statistical quality plot. The first is a density map of observation wind speed against background wind speed for different satellite, channel, pressure level and latitude band combinations (e.g. Figure 1). The plots show average wind speed bias, and areas of significant departure from the 1:1 line. The second type is a global map of wind speed bias, standard deviation, mean vector difference (mvd), or normalised root mean square vector difference (nrmsvd) plotted for different wind types (infrared, water vapour, visible) and at different pressure levels (e.g. Figure 2). These plots can highlight geographical areas where there is significant mismatch between observations and model backgrounds.



**Figure 1: Wind speed density plots for Meteosat-7 infra-red winds at low levels (700-1000 hPa) for March 2004. Plots are shown for the northern hemisphere (NH), tropics (TR) and southern hemisphere (SH) for both ECMWF and the Met Office. Note the plume of winds in the tropics with observation speeds much greater than background speeds.**

Where areas of mismatch are similar for both centres, the problems are either due to the observations not reflecting the real winds, or they are model problems that are shared by the NWP models. Areas of mismatch between the two centres indicate regions where the models are treating the winds differently. This could be due to differences in the forecast models or due to differences in the quality control used to remove the poor quality winds.

Throughout the 4-year collection period, there has generally been good agreement between the plots from the two centres and large similarities from month to month and year to year. Some of the differences identified between the centres can be attributed to small differences in the winds included in the statistics. We are working to remove these discrepancies for future plots. Included below are a couple of examples of where the plots have highlighted problem areas. A more thorough summary of conclusions and an action list will be provided soon in the form of a second analysis report linked to the NWP SAF site.



**Figure 2: Observation minus background speed bias plots of infrared, high-level winds for January 2004. In general, the plots from the Met Office and ECMWF are very similar, although there are notable differences, particularly around Central America. Also noticeable is the differences in the data for GOES-9 (W. Pacific). ECMWF is displaying the BUFR winds, whereas the Met Office is displaying the SATOB winds. This difference will be resolved in the future. A final point to note is the change from GOES data to Meteosat data in the Atlantic. NESDIS implement a speed correction for high level winds in the extra-tropics, which alleviates the negative bias in this region.**

## 2.1 Meteosat low level winds in the tropics

Figure 1 compares the wind speed density plots for ECMWF and the Met Office for Meteosat-7 infrared low-level (700 - 1000 hPa) winds for March 2004. Note the plume of winds in the tropics, evident in the plots from both centres, where observation speeds are much greater than background speeds. This feature has been noted previously (Butterworth et al., 2000) and is a known problem at EUMETSAT. It is thought to be related to fast winds being assigned to too low a height where the actual wind speeds are lower. The problem is often that the wind-tracking algorithm is following semi-transparent cirrus clouds and assigning the motion to a lower height.

## 2.2 High level infrared speed bias

The second example (Figure 2) shows regions of similarity and difference between the two centres for high level infrared winds. In general the plots from ECMWF and the Met Office compare well, both showing negative speed bias in the extra-tropics for the Meteosat and GOES-9 winds produced by EUMETSAT and JMA respectively. The negative speed bias in the extra-tropics is a well recognised problem of the jet regions and is thought to result from a combination of factors including the tracer not representing the core of the high speed region, inaccurate height assignment and the vector being a spatial and temporal average (e.g. Holmlund & Schmetz, 1990). The negative speed bias is reduced for the GOES winds produced by NESDIS due to the implementation of a speed increase in the NESDIS wind processing, designed to target and alleviate the negative bias in the jets (Daniels, 2002). In the tropical region, the speed bias is very different. In general, the observations are faster than the background winds, possibly due to model errors, height assignment problems or tracking of convective cloud tracers, which may not reflect the broad scale motion.

Although the general appearance of the plots from the two centres is similar, there are some notable differences over the Caribbean and Central America. The Met Office plot shows some smaller areas of negative speed bias in some of these areas, which are not evident in the speed bias plot from ECMWF.

Some of the features identified in the plots require further investigation, for example comparisons with independent observations such as radiosondes or aircraft reports. It is also important to have a better knowledge of persistent biases inherent in each model and in the observations themselves. This would greatly benefit from increased communication between NWP centres and satellite wind producers. We should again stress that the point of the NWP SAF Integrated Satellite Wind Monitoring Report is to help to improve both the production and the use of satellite winds; deficiencies may be revealed in the satellite winds, the NWP models, or both.

## 3. RECENT DEVELOPMENTS

Several changes have recently been made to the Integrated Satellite Wind Monitoring Report and a new-look site is almost ready for launch. The main change has been to the site organisation. Until now, the plots from the Met Office and ECMWF have only been easy to compare for one month and one type at a time. The site has recently been updated to allow easier comparisons of all plots. It should now be simpler to track changes from month to month and year to year and to compare different types of plots to one another. It should also be easier to add plots from other NWP centres.

Other changes to the web pages have been made to include more links to other useful satellite wind monitoring sites, for example the new monitoring pages produced at ECMWF. Many of these pages are complementary to the NWP SAF plots, often providing more real-time statistical information.

Another area under development is the links to papers or summaries of recent satellite wind work including assimilation experiments. It should be noted that although much of the work currently included in this section has not been carried out under the remit of the NWP SAF, the site provides a useful point for the collection of experiences working with satellite winds.

The other major difference has been to include several new wind types including: the GOES BUFR winds, MODIS polar winds and Meteosat-8 winds (see Figure 3). The NWP SAF site is ideally set up to provide early feedback on new wind types and this role should be exploited more fully in the future.

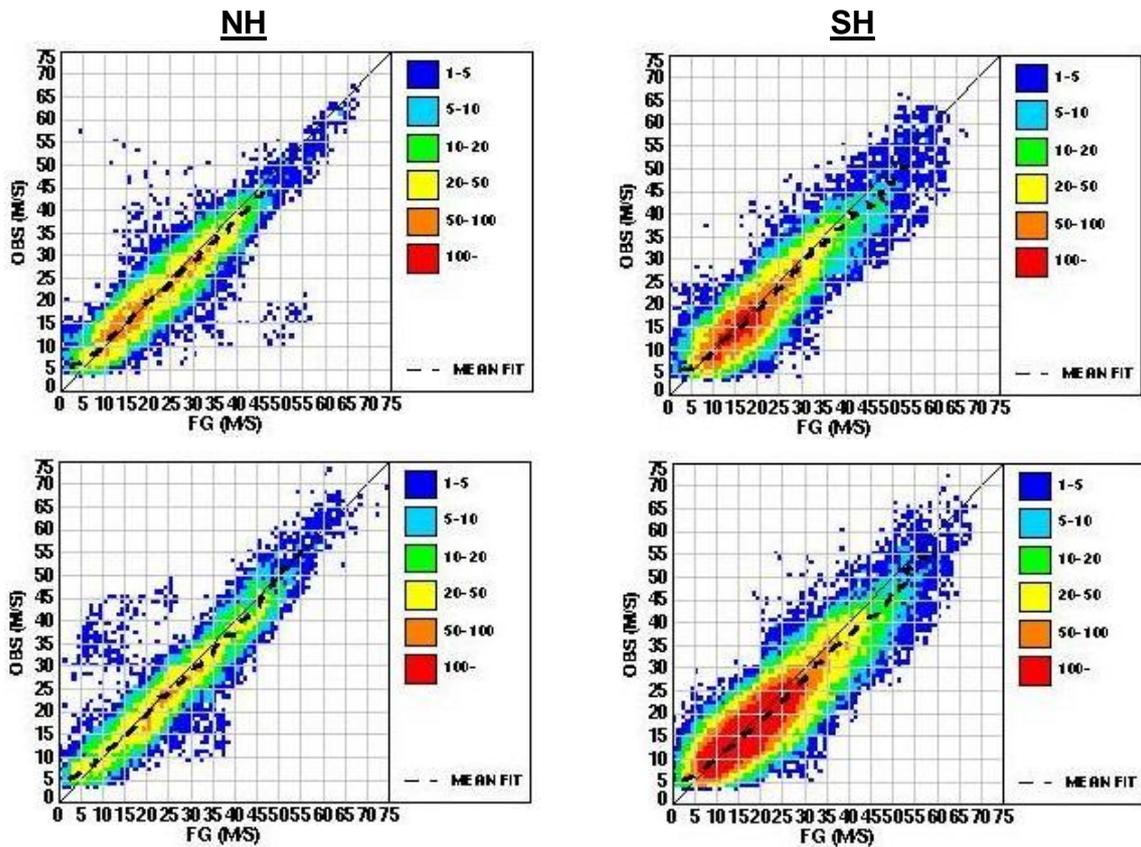


Figure 3: Speed bias density plots for the NESDIS MODIS winds for February 2004 using the Met Office model background. The top two plots are for the winds from Terra, and the bottom two for Aqua. Notice the similarities in the two sets of plots for the two polar satellites. Also notice the marked difference between the northern hemisphere (NH) and southern hemisphere (SH).

#### 4. FUTURE DEVELOPMENTS

Although significant work has already been undertaken to increase the usefulness of the site, there are further ideas and plans for the future. We are keen to see contributions from other NWP centres to help isolate likely model and observation errors. This invitation is not limited to centres within the NWP SAF or EUMETSAT Member States.

In addition, there are several more types of plot that may provide useful information. Examples of some current ideas are shown in Figures 4-7. There is also the possibility of providing more information on real-time monitoring, including time-series plots. We are very keen to receive feedback from users to further improve the usefulness of the site. A contact link is provided on the website.

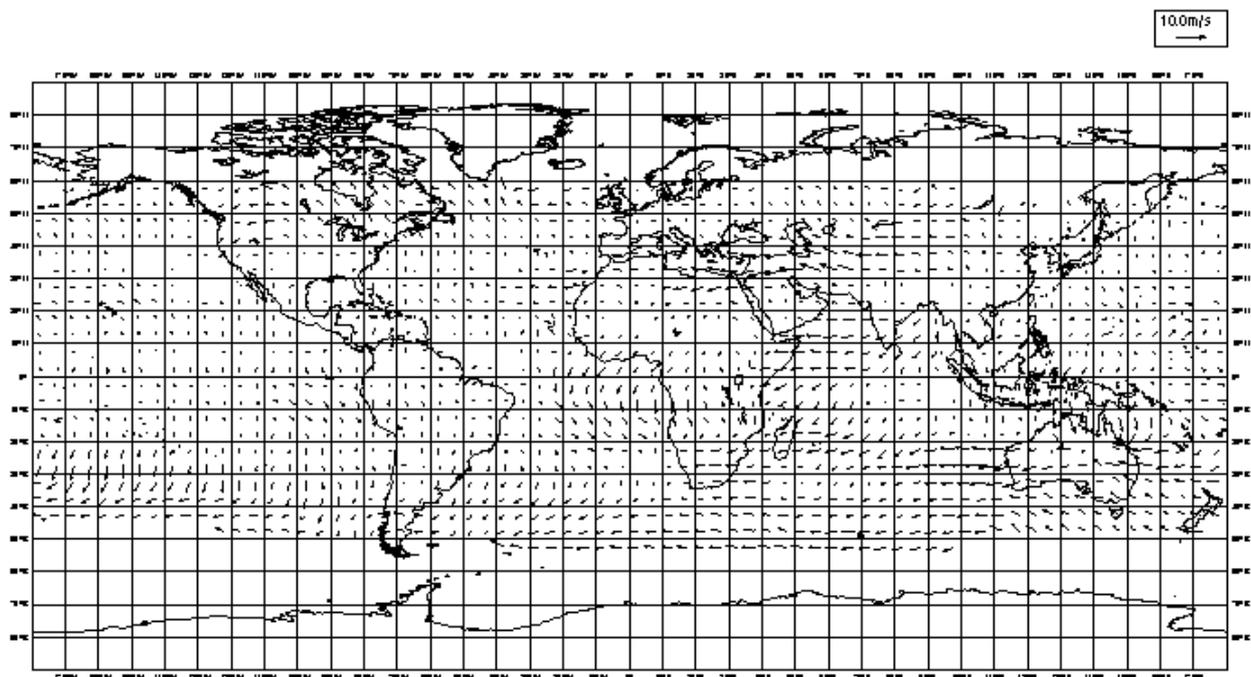


Figure 4: A map plot showing the mean vector differences between the satellite winds and ECMWFs model background during June-August 2002. The advantage of these plots is the directional bias information not available in the current map plots.

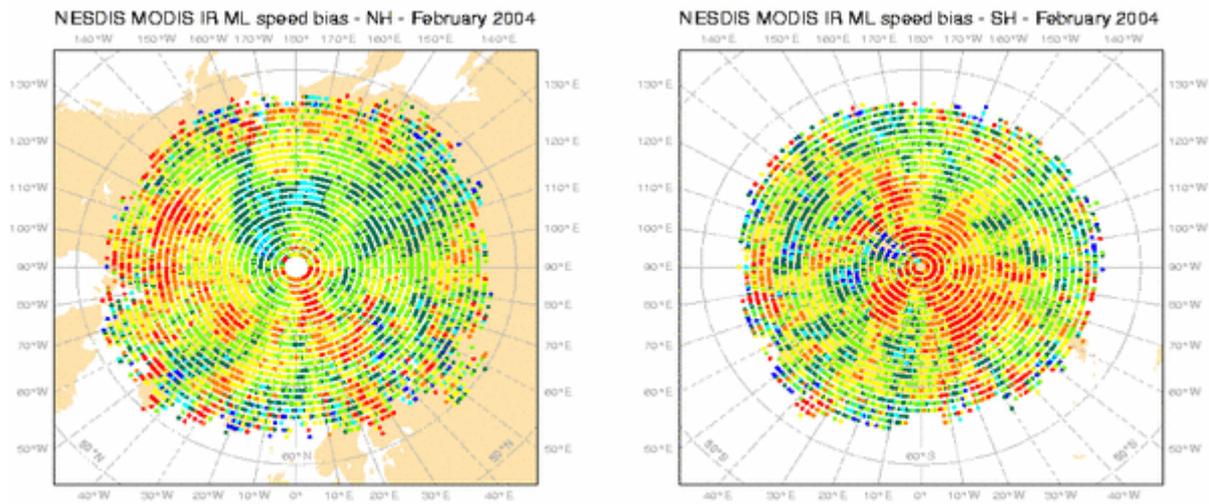


Figure 5: Polar map plots showing the mean O-B speed differences for the NESDIS MODIS IR medium level winds for February 2004. Polar projections are better for showing MODIS wind statistics than the cylindrical plots used for the geostationary winds.

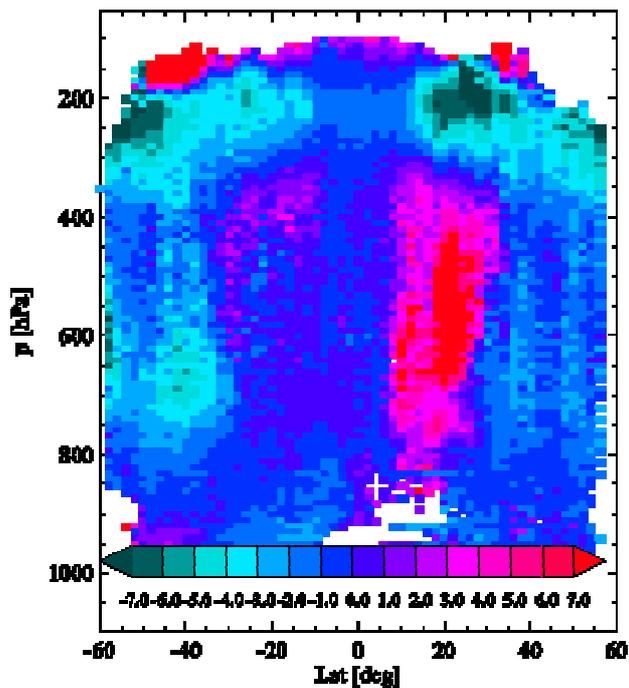


Figure 6: A plot showing speed bias as a function of pressure and latitude for Meteosat-8 IR 10.8 for 14<sup>th</sup>-27<sup>th</sup> April 2004. This is a useful plot that complements the existing map plots, but provides more information in the vertical. This Figure clearly shows two areas of negative bias at high levels at latitudes of the jet stream. An area of positive bias (in red) is also evident around 20°N at mid level. The location of this region of positive bias immediately below the probable Northern Hemisphere jet suggests a possible height assignment cause. It is possible that jet level winds with high wind speeds are being assigned too low in height. This picture is provided courtesy of Lüder von Bremen at ECMWF.

SATOB METEOSAT7\_IR  
 ABOVE 400 hPa  
 GLOBAL  
 JUN - AUG 2002

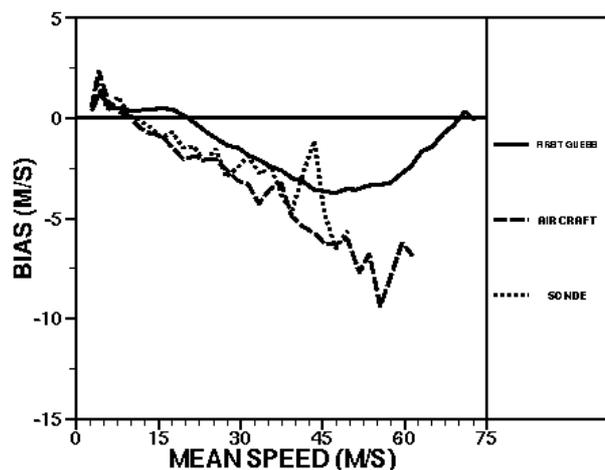


Figure 7: A bias plot of Meteosat-7 IR upper level winds compared to ECMWF's background, radiosondes and aircraft. Note the tendency for the speed bias to become more negative with increase in wind speed. The pattern is the same when compared to the model background, radiosondes or aircraft suggesting that the bias is due to the AMVs being too slow.

## 5. CONCLUSIONS

In this paper, we have provided a brief overview of the aims of the Integrated Satellite Wind Monitoring Report, some examples of results already obtained, summaries of the latest areas of development and possible plans for the future.

The Integrated Satellite Wind Monitoring Report provides an excellent opportunity for sharing results from different NWP centres both through plot comparisons and by links to summaries of work carried out. This collaboration and pooling of results may prove useful in improving our understanding of the errors in the satellite wind data, which are often biased, non-Gaussian and correlated both with each other and with the forecast-background used in the wind production. Improved knowledge of the errors may help to target areas of development in wind derivation, and should allow NWP centres to better exploit the information in this high density data type.

In addition to monitoring comparisons of existing winds, the Integrated Satellite Wind Monitoring Report has the potential to provide an important role in assessing new wind types, such as the MODIS and MSG winds. This potential of the site to provide feedback on new data types should be better exploited in the future.

## 6. REFERENCES

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