USE, QUALITY CONTROL AND MONITORING OF SATELLITE WINDS AT UKMO

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ABSTRACT

Satellite wind fields derived from geostationary imagery have been assimilated into the UKMO global NWP model since 1989. During this time, satellite winds have been refined and generally improved with "new" types of satellite winds from different channels having been introduced. This requires continual monitoring and updating of the NWP observation processing system in order to use the wind products to their best advantage. This paper outlines the current use of satellite winds at UKMO, and includes a brief description of the automatic quality control system that processes observations for assimilation into the model. Some observation-background monitoring statistics are shown to illustrate the ways that the different wind types compare against the background field (the T+6 forecast field valid at the observation time).

1. INTRODUCTION

Satellite winds, or atmospheric motion vectors (AMVs), are currently transmitted operationally on the global telecommunication system (GTS) by four geostationary satellite operators. NOAA/NESDIS retrieves satellite winds from data from GOES-8(-E) and GOES-10(-W), operational at 75 and 135°W, respectively. The Indian Meteorological Department sends out vectors from INSAT (74°E), the GMS satellite at 140°E is operated by the JMA, and EUMETSAT currently controls two operational satellites: Meteosat-7 at 0° and Meteosat-5 at 63°E in support of the INDOEX mission over the Indian Ocean.

In recent years there have been many refinements to the processing of satellite winds, and also innovations with regard to the channels used to derive vectors. Their resolution, both spatial and temporal, has also generally been increased. The proceedings of previous winds workshops outline the methods used at each of the operating centres, and this volume should update this knowledge. Information can be gained from the following papers: Schmetz *et al.,* 1993; EUMETSAT, 1996; Nieman *et al.,* 1997; Velden *et al.,* 1997; Gopala Rao, 1991; Kelkar *et al.,* 1993; Bhatia *et al., 1997;* Takata, 1993; Tokuno, 1997.

One of the main uses of AMVs derived from geostationary satellite imagery is as input into numerical weather prediction (NWP) models in order to initialise the model field before running the forecast. Many NWP centres running global models assimilate AMVs in order to derive a better initial model state. However, care must be taken in what observations are assimilated, and as such each NWP centre uses and quality controls the AMVs in different ways, tailored to each model. Results from impact tests, where the assimilation and subsequent forecast fields are run in non-operational mode and then compared with the operational system forecasts, are also used to quantify the benefit that could be gained from the assimilation of selected observations.

2. USE OF SATELLITE WINDS

The current operational use (at October 1998) of satellite winds at UKMO is outlined as follows:

Meteosat-7 (prime mission)
IR winds used except low-level northern hemisphere (NH) over land
All WV winds used
VIS winds used except low-level NH over land
GOES-8,10
IR winds used except at low-levels, thinning applied
No WV winds used
GMS-5
IR winds used except low-level NH over land
No WV winds used
VIS winds used except low-level NH over land
Meteosat-5 (INDOEX)
No winds used
INSAT
No winds used

In an ongoing effort to try and make use of more different types of wind and those from different satellites, the UKMO has set up a programme of impact testing. An impact test on the assimilation of Meteosat-5 winds, in the same operational configuration as Meteosat-7, has just been completed. Forthcoming impact tests will be run using Meteosat-7 high-resolution visible winds, GMS WV winds and GOES WV winds, amongst others.

3. QUALITY CONTROL

The very first stage of quality control (QC) is to reject from assimilation all those observations that will not be assimilated regardless of their quality (see Section 2). These observations still go through some QC in order that observation - background (O-B) statistics can be compiled for observation monitoring.

The automatic QC system is based on Bayesian probability theory: it combines the results of different tests and makes an accept/reject decision when all checks have been performed (Ingleby and Parrett, 1996). An initial probability of gross error (PGE) is updated by internal consistency checks and followed by checks against the model background field (a short-term model forecast, generally T+6, valid at the observation time) and other nearby observations (buddy checks). Peculiar to satellite winds is an asymmetry (speed bias) check, i.e. satellite winds which are weaker (but not stronger) than background have their PGEs increased by a set amount dependent upon the difference between background and observation. Only after all stages have been completed is a decision taken on whether to use the element or not, with observations having a PGE greater than a certain threshold being rejected.

Since the advent of high-density wind datasets from the GOES satellites, an additional QC check has been installed in order to thin the observations being presented to the automatic QC system.

This was in response to poor impact test results found by ECMWF when assimilating the full wind dataset (M. Rohn, personal communication). Currently, only one observation in a box volume of 2 x 2°, 200 hPa is allowed into QC for consideration. This results in approximately 70% of GOES high-density winds being prior rejected.

At present, the analysis correction (AC) assimilation scheme is in use at the UKMO (Lorenc *et al*., 1991). This scheme adjusts the model state towards observations, providing initial fields for forecasts; observational data are assimilated by an iterative or ‘nudging’ procedure which is carried out at each time step of a separate model integration before and after the nominal analysis time. Detailed explanation is given in Bell *et al*. (1996). A three-dimensional variational assimilation scheme is due to become operational, replacing the AC scheme, early in 1999.

4. MONITORING

Routine observation monitoring takes place on a daily, weekly and monthly basis. O-B differences for the four main global model runs per day can also be assessed. This information is used to monitor internally the number and the quality of observations being assimilated into the model, and as an alert system should no observations be assimilated for any particular run. Monthly O-B statistics calculated in accordance with the Report from the Working Group on Verification Statistics from the 3rd International Winds Workshop are sent to the satellite wind producers as feedback.

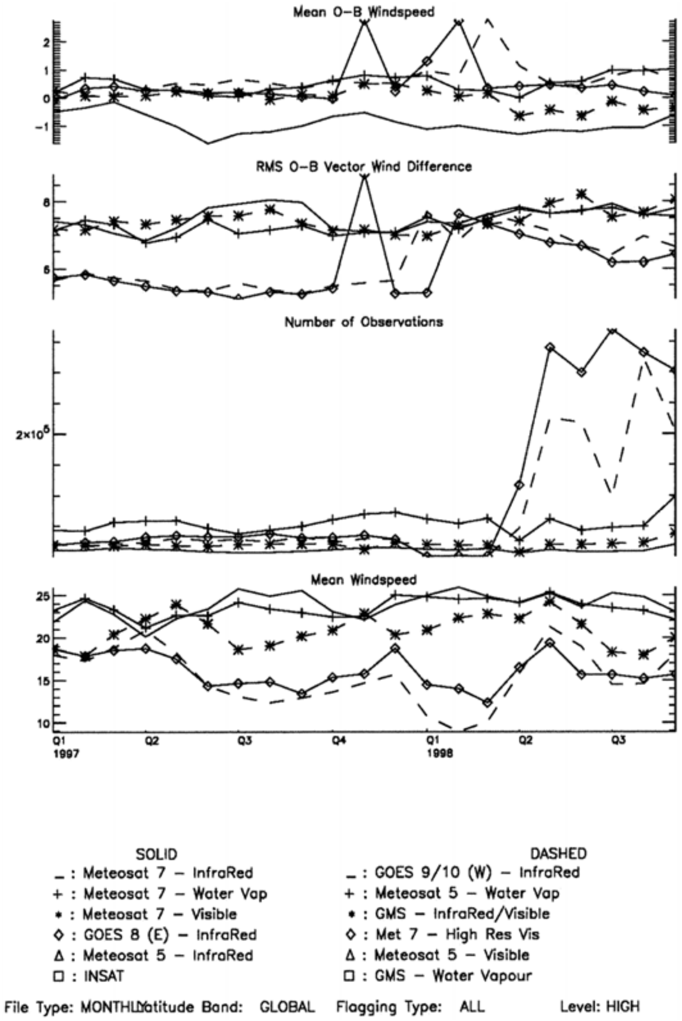

Fig. 1. Monthly observation-background monitoring statistics showing high-level winds.

Figure 1 shows a series of O-B monthly statistics, for high-level winds averaged over all latitudes. The traces shown are for all winds received, not just those that are assimilated.

Monitoring traces can also be used to observe step changes in quality of particular wind types after a processing change has been made. For example, Fig. 2 shows a substantial increase in O-B wind speed bias for GOES high-density winds when compared with the bias of low-density winds. Subsequently, the assimilation of GOES high-density winds was switched off at low levels due to concern about the high bias. The trace for Meteosat-7 is shown for comparison.

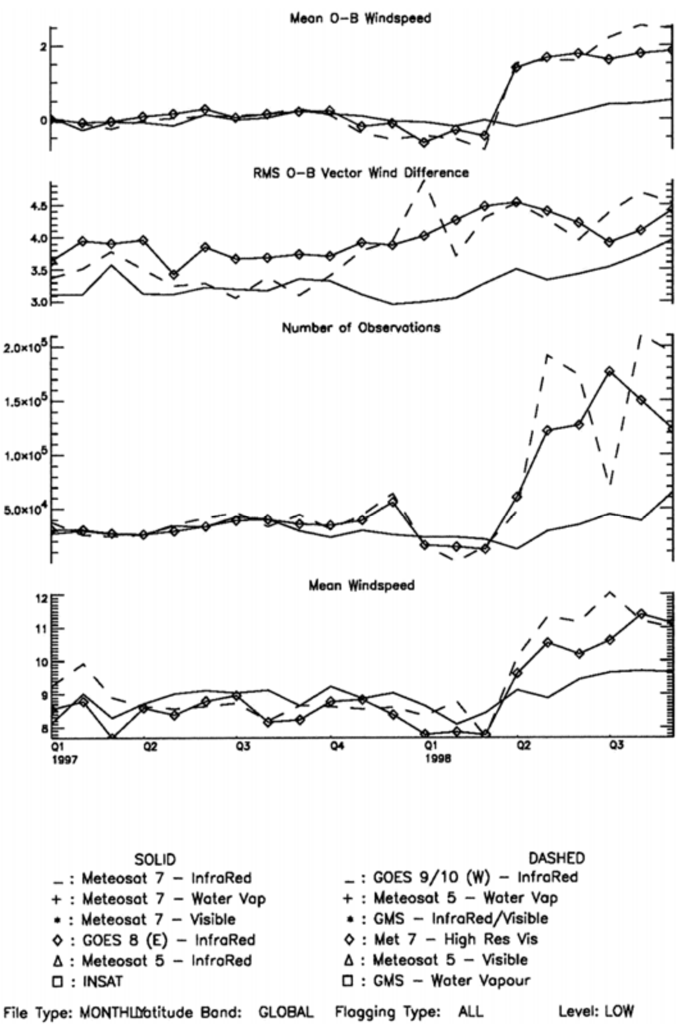

Fig. 2. Monthly observation-background monitoring statistics showing low-level IR traces for the two GOES satellites and Meteosat-7.

A global pattern of biases can be easily seen from colour plots. Figure 3 shows O-B wind speed biases for IR satellite winds at low levels (below 700 hPa) averaged for September 1998. Areas of blue show where satellite winds are reporting lower wind speeds than the model, areas of red show where the model is reporting lower wind speeds than the observations. The plot clearly defines the area of oceanic upwelling off the coast of western Africa, indicating problems with wind retrieval or model winds in this region. The high biases of GOES camouflage this signal in the Pacific, yet it was seen in the bias plots of July 1997.

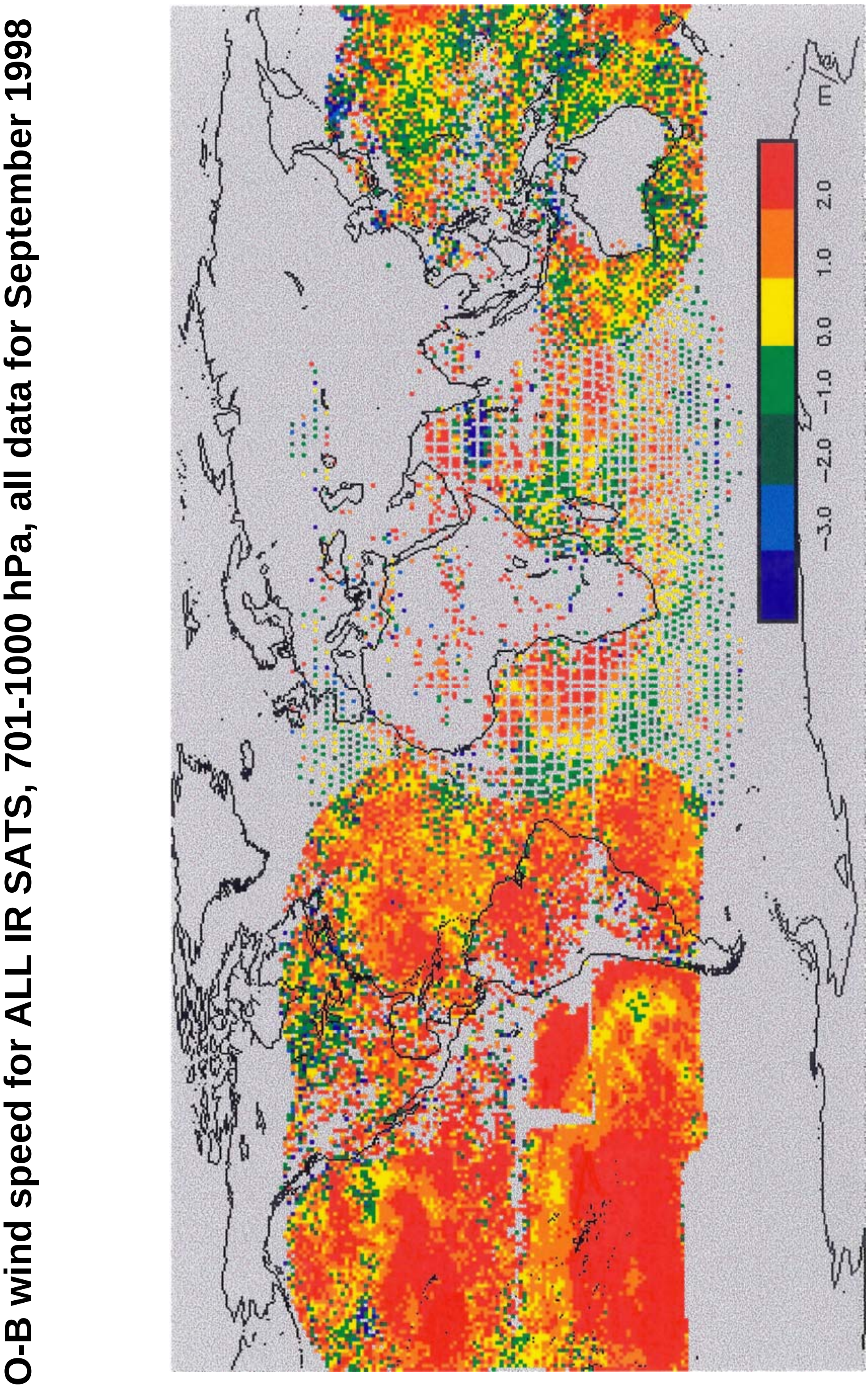

Fig. 3. Global observation-background wind speed biases for low-level IR winds.

5. SUMMARY

In order to make the best use of these observations within NWP models, the NWP users must be aware of any changes in processing methods, particularly the use of other NWP fields in deriving the satellite winds. This is necessary in order to adjust the quality control procedures within the model and assimilate the observations to their best advantage. However, so that this procedure can be followed, the satellite wind producers must make the effort to notify NWP users of changes in processing methods, try to limit the use of NWP fields in deriving winds (an undertaking which some producers are working towards) and to be aware of the realities of operational forecasting and thus avoid making too many changes in the operational transmission of winds. Also, if there is to be a substantial change in wind processing, then an extended period of parallel transmission should be guaranteed in order to help the NWP user adjust to the new data. In return, the NWP user is able to provide valuable feedback in the form of monitoring statistics so that the satellite winds and subsequently the NWP models continuously improve.

REFERENCES

Bell RS, AC Lorenc, B Macpherson, R Swinbank and P Andrews (1996) The analysis correction data assimilation scheme. UMDP 30, UKMO, Bracknell.

Bhatia RC, PN Kanna and S Prasad (1997) Improvements in automated cloud motion vectors (CMVs) derivation scheme using INSAT VHRR data. *Proc. 3rd Int. Winds Workshop,* Ascona, Switzerland, 10-12 June l996. EUMETSAT, Darmstadt.

EUMETSAT (1996) The operational cloud motion winds from the Meteorological Products Extraction Facility (MPEF) in the new EUMETSAT MTP ground segment. CGMS-XXIV, EUM-WP-26, EUMETSAT, Darmstadt.

Gopala Rao UV (1991) Operational derivation of INSAT winds: present status and future plans. *Proc. Workshop on Wind Extraction from Operational Meteorological Satellite Data,* Washington, DC, 17-19 September 1991. EUMETSAT, Darmstadt.

Ingleby NB and CA Parrett (1996) Quality control of atmospheric data. UMDP 32, UK Met. Office, Bracknell.

Kelkar RR, AVRK Rao and RC Bhatia (1993) Recent improvements in cloud motion vector derivation from INSAT. *Proc. 2nd Int. Wind Workshop,* Tokyo, 13-15 December 1993, pp. 65-70. EUMETSAT, Darmstadt.

Lorenc AC, RS Bell and B Macpherson (1991) The Meteorological Office 'Analysis Correction' data assimilation scheme. *Q. Jl R. Met. Soc.* **117,** 59-89.

Nieman S, J Daniels, D Gray, S Wanzong, CS Velden and WP Menzel (1997) Recent performance and upgrades to the GOES-8/9 operational cloud motion vectors. *Proc. 3rd Int. Winds Workshop,* Ascona, Switzerland, 10-12 June 1996. EUMETSAT, Darmstadt.

Schmetz J, K Holmlund, J Hoffman, B Strauss, B Mason, V Gaertner, A Koch and L van de Berg (1993) Operational cloud-motion winds from Meteosat infrared images. *J. Appl. Met.* **32,** 1206-1225.

Takata S (1993) Current status of GMS wind and operational low-level wind derivation in a typhoon vicinity from short-time interval images. *Proc. 2nd Int. Wind Workshop,* Tokyo, 13-15 December 1993.

Tokuno, M (1997) Operational system for extracting cloud motion and water vapor motion winds from GMS-5 image data. *Proc. 3rd Int. Winds Workshop,* Ascona, Switzerland, 10-12 June 1996. EUMETSAT, Darmstadt.

Velden CS, CM Hayden, SJ Nieman, WP Menzel, S Wanzong and JS Goerss (1997) Upper-tropospheric winds derived from geostationary satellite water vapour observations. *Bull. Am. Met. Soc.* **60,** 173-195.