THE USE OF THE MPEF QUALITY INDICATOR

Graeme Kelly, Michael Rohn,
European Centre for Medium Range Weather Forecasts
Shinfield Park, Reading, RG2 9AX, UK

ABSTRACT

Enhanced Meteosat wind data sets are provided every 90 minutes together with the Quality Indicator (QI) derived during the quality control of the Meteorological Product Extraction Facility (MPEF) at EUMETSAT. All three channel Cloud Motion Winds (CMW) and clear sky Water Vapour Motion Winds (WVMW) have been passively monitored by comparison to the ECMWF background field. The evaluation of the relationship between the MPEF QI and the background departures indicate possible benefits to be gained from the use of the QI within the observation screening of the assimilation system. The atmospheric motion winds (AMW) with 90 minute time sampling have been implemented into the ECMWF assimilation system. The MPEF quality indicator is used as a selection criterion within the screening. The applied thresholds are restricted in the Tropics compared to the extratropical regions where the threshold for high level winds has been relaxed below the Automatic Quality Control (AQC) at MPEF. The overall effect is an increase of active Meteosat winds by a factor of two.

1. Introduction

One step in the extraction of AMW observations is the quality control prior to the transmission of the data. Traditionally this includes a manual quality check based on a subjective comparison of the wind vector with the actual image triplet used in the retrieval. Following the increase in temporal and spatial resolution the task of a manual control became impossible. Therefore, the producers are working on the development of quality estimates for individual wind observations simultaneously to the attempts to increase the spatial and temporal coverage (Holmlund, 1998, Holmlund and Velden, 1998). The binary encoded experimental data stream from EUMETSAT contains all observations that pass a very weak quality threshold of QI>0.3 together with the final Quality Indicator (QI) assigned during the MPEF quality control.

2. Monitoring of the MPEF quality indicator

The MPEF QI value is traditionally used as a criterion by the Automatic Quality Control (AQC) to decide about the transmission of a particular datum. The current AQC set-up includes only observations which exceed a threshold of QI=0.8 in the 6 hourly CMW data set except for CMW observations from the visible imagery at high resolution (HRES VIS) where a threshold of QI=0.65 is applied. A concise description of the MPEF quality control scheme and the derivation of the QI value can be found in (Holmlund, 1998). The basic tests together with the currently used parameters are summarised in the appendix. The quality of the BUFR encoded MPEF winds have been routinely compared against the ECMWF background wind field. The background field is a 6 hour forecast of wind and pressure with 1.5° horizontal resolution at 50 vertical model levels. In particular the relation between the background departures and the assigned Quality Indicator (QI) have been monitored in order to assess the information content of the QI values towards a possible use within an assimilation system. Following the monitoring practice at MPEF the rms background departures versus assigned quality estimate are studied separately for different channels (IR, VIS low and high resolution, WV cloud and clear sky), in different geographical regions, and tropospheric layers. Due to the known problem of negative speed bias in high wind speed situations the mean wind speed and bias are included in this monitoring. The relation between QI value and background departures for high level (p < 400 hPa) IR winds is shown in Figure 1.

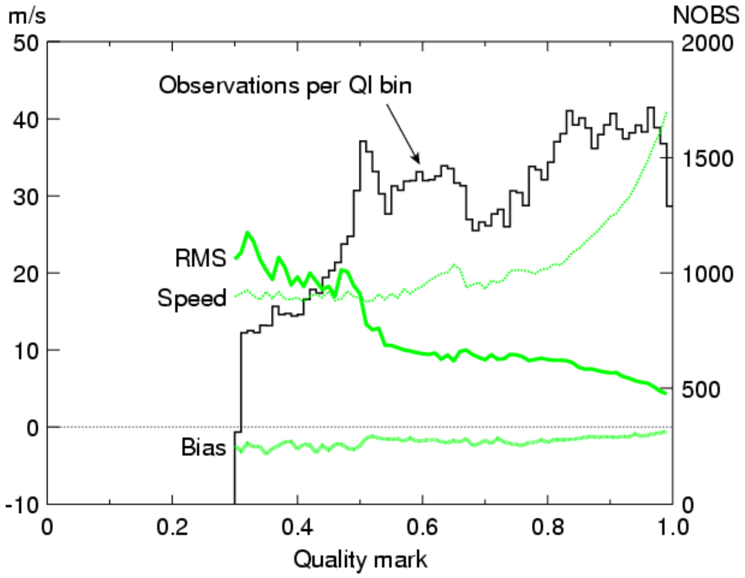

Figure 1. Monitoring of high level(p<400hPa) IR winds from Meteosat-7

Table 1. MPEF automatic quality control (AQC) thresholds.

channel	QI threshold
IR	QI>0.80
LRES VIS	
WVcloud	
HRES VIS	QI>0.65

The statistics have been computed for a period of one week from 1-7 February 1999. The departures are collected in QI bins of 0.01. The rms departures are shown by the solid line, the speed bias in dotted style, and the background wind speed as dashed line. The histogram shows the number of observations in each QI bin. All cloud tracked winds as well as the motion vectors from clear sky features within WV images have been assessed separately for the northern (lat > 20°) and southern (lat < -20°) extra tropical regions, and the Tropics (-20 °< lat < 20°). Additionally three tropospheric layers are distinguished (p > 700 hPa, 700 hPa > p > 400 hPa, 400 hPa > p). Generally, the background statistic shows decreasing rms departures and bias with an increasing quality estimate (QI). Furthermore, the mean wind speed in each quality interval is also increasing with the quality indicator. This is important in respect to the underestimation of high wind speeds by cloud tracked winds. Within the ECMWF assimilation system the so-called asymmetric check is applied as part of the first guess check of atmospheric motion vectors in order to prevent a slowing down of jet streams (Järvinen and Undén, 1997). The observed relation between quality indicator and background departures indicates the potential of the QI value as an additional parameter within the observation screening of an NWP assimilation system.

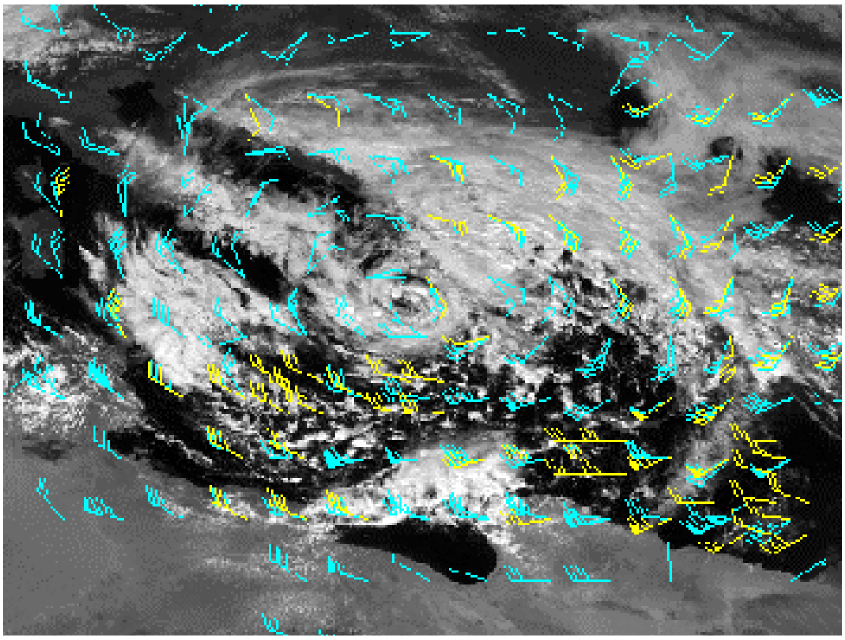

Figure 2. Atmospheric motion vector from Meteosat-7 on 19 March 1999

At 12 UTC.Observations at all levels are included.The observations which passed the automatic quality are marked in yellow. Remaining observations with QI values below the confidence threshold are plotted in blue.

3. Potential of enhanced Satellite Winds

The new data set generally provides more information due to increased spatial and temporal resolution as well as including the winds of poorer quality below the automatic quality control threshold. By the aid of a case study we illustrate the potential of the extended observation set. Figure 2 shows the visible image from Meteosat-7 on March 19, 1999 at 11:30 UTC. The vectors shown are observations between 9:00 and 15:00 UTC which passed the Automatic Quality Control (AQC) (yellow) together with the remaining observations with QI values below the AQC thresholds in Table 1. In case several observations from one imaging channel are derived within the six hour time window only one vector is plotted per channel. Multiple observations at some locations represent data from tracking of cloud features within different imaging channels. This is in contrast to the traditional wind product. It includes only one per wind per processing segment that is identified by the highest QI value. Therefore more than one observation can be provided within the same segment by tracking of clouds at different levels. Motion vectors derived in clear sky areas of WV imagery are not included in Figure 2 that illustrates only the potential of cloud tracked winds. The fleet of observations over North Africa where at first glance no clouds can be identified are results from the WV channel and indicate tracking of thin cirrus at upper level. There is a good indication that the quality control rejects many observations that appear to supplement information on the vector field in a consistent way. This is especially clear in the vicinity of the low-pressure system over the Mediterranean. A few obvious outliers are also apparent which is to be expected due to the missing quality control.

4. Use of QI for screening of atmospheric motion vectors

4.1 Blacklisting

Based on the monitoring described a set of QI thresholds is derived for blacklist decisions for the three channel cloud tracked winds. Unlike the MPEF quality control scheme, the cut-off parameters are chosen separately for channel, tropospheric layer, and geographical region. The selection that was used in the assimilation experiments described later are summarised in table 2. Generally, it led to a restriction in the use of low-level IR cloud tracked winds. At mid level IR winds were activated above QI > 0.90. These winds were not used within the operational system based on the observed background departures observed in the past (Rattenborg, 1998). The threshold for high level winds has been relaxed down to QI > 0.60 in the extra tropical region while the usage for tropical winds is restricted compared to the MPEF AQC. For VIS winds the AQC decision has been used. The VIS winds at high resolution are provided three hourly together with the low resolution VIS winds every 90 minutes. The time slots of low resolution VIS data which coincide with the high resolution VIS winds are blacklisted to avoid redundancy. These decisions are applied in conjunction with the transition to 90 minute time sampling.

Table 2. Data selection according to quality estimate QI

Area	Channel	Low 700<p<=1000	Medium 400<p<=700	High p<=400
NH	IR	QI>0.85	QI>0.90	QI>0.60
lat>20°	VIS	QI>0.65		
	WVcloud		not used	QI>0.60
TR	IR	QI>0.85	QI>0.90	QI>0.85
-20°<lat<20°	VIS	QI>0.65		
	WVcloud		not used	QI>0.85
SH	IR	QI>0.85	QI>0.90	QI>0.60
lat<-20°	VIS	QI>0.65		
	WVcloud		not used	QI>0.60

The overall effect can be expected to be a large increase in the number of satellite winds being presented to the analysis. The main reasons in order of decreasing importance are:
- 90 minute time sampling
- relaxed QI threshold at high level in the extra-tropical region
- multiple observations per processing segment from different channels at identical time slots
- introduction of IR winds at medium levels.

4.2 Selection in thinning

Besides the static QI thresholds the thinning step for atmospheric motion vectors has been extended using the MPEF QI value. The selection follows the thinning scheme applied to various observation types with high spatial coverage (Järvinen and Undén, 1997). Atmospheric motion vectors are collected in boxes of dimension as generally used for all CMW observations (Table 3). The quality estimate is included as selection criterion within each thinning box. In the presence of several observations within one thinning box the observation with highest quality estimate is retained as active in the assimilation.

Table 3. Specifications of SATOB thinning.

Parameter	value	comment
horizontal box dimension	1.25 °	
vertical extent	50, 70, 100, 150, 200, 250, 300, 400, 500, 700, 850, 925, 1000 [hPa]	varying according to nearest stand ard pressure level (50-175 hPa)
selection within a box	observation closest to analysis time preferred	

4.3 Assimilation and Forecast Experiments

The experiment hereafter referred to as ECQC-90 introduces the full 90 minute sampling using the QI thresholds based on the monitoring described in Section 2 (Table 2). Two experiments were performed using the ECMWF four-dimensional assimilation system (21 October - 10 November 1998 and 6-31 May 1999). Clear sky WV winds were not used in either the operational suite or the experiments.

Table 4. Experimental set-up for tuning of QI thresholds and transition to 90 minute winds.

experiment	Control	ECQC-90	
periods		21.10 - 10.11.1998	6.5 - 31.5.1999
time sampling	6 hour	1.5 hour	
IR/WVcloud	AQC	variable (see Table 3.), AQC passed	
low/high res. VIS	AQC		
WV clear	NO		
thinning	YES	YES including QI	

Both experiments are compared to the system which was operational during the relevant time period the main difference being the extension of the vertical resolution into the stratosphere (50 level compared to 31 level). This can be expected to be of minor importance in this context due to the similar vertical resolution between the surface and 50 hPa. The operational system (Control) uses only cloud tracked winds at the synoptic times (00, 06, 12, and 18 UTC) which passed the automatic quality control at MPEF (Table 1). The main differences in the data usage are therefore the increased time sampling, the revised blacklist decisions, and the introduction of the QI value as selection criterion as outlined above.

5. Analysis Impact

The background and analysis departures of the CMW observations used are discussed first for the experiment ECQC-90 during the autumn period. The statistics includes ten assimilation cycles at 12 UTC during the period 1 to 10 November 1998. The results are confined to the area covered by both Meteosat platforms (-55°<lat<55°, -55°<lon<118°). The number of active CMW winds in the analysis has been increased by a factor of two compared to the operational analysis(table 5).

Table 5. Number of active CMW observations during 1-10 November 1998, 12:00 UTC (55° South to 55° North, 55° West to 118° East

experiment	number of active CMW data
Control	57.263
ECQC-90	116.393

Differences in the number of active observations during the second experiment in spring are summarised in table 6 for all assimilation cycles during the 26 day period.

Table 6. Number of active CMW observations during 6-31 May 1999 00, 06, 12, and 18 UTC (55° South to 55° North, 55° West to 118° East)

experiment	number of active CMW data
Control	491.453
ECQC-90	1.089.368

The rms background and analyses departures of active CMW observations have been considerably decreased at all levels. A pronounced change of the zonal component bias occurs at mid tropospheric levels where no CMW winds from Meteosat were used in the operational analysis. The mid level observations used in the operational analysis are IR winds from GOES-8 which partly cover the Meteosat area between 55° and 15° West over the Atlantic. Since CMW observations are generally blacklisted over land below 500 hPa pressure height the differences must represent a different regime over the Indian Ocean. The fit of other observations to background and analysis within the area of influence of CMW data from Meteosat has hardly changed. Small differences in the fit of PILOT observations show decreased rms departures and bias especially at upper levels The fit of active radiosonde (TEMP) observations (remains mainly unchanged. A few additional radiosonde data are activated at low and upper tropospheric levels. Some rejections occur at medium levels and in the lower stratosphere. These changes of quality control decisions are very small (~ 0.01%) and due to changes in the background field. Minute differences in the background departures indicate an improved rms fit. The different signal in the fit of SATOB winds and other wind observations indicates that the observations are influencing different areas. This agrees with the geographical distribution of the mean rms increments discussed below.

Changes in the increments of the geopotential are further used in order to assess the quality of the modifications introduced into the analysis. The increment is defined as the difference between the analysis and the 6 hour forecast for the same time. The differences of rms increments are used in order to assess the impact over the entire experimentation period. In the following we discuss the difference field of rms increments between the experiment assimilating Meteosat winds with the ECQC-90 setup and the Control using the operational Meteosat winds with 6 hour time sampling provided by the MPEF quality control. The resulting fields for the geopotential at 250 hPa are presented in Figure 3.

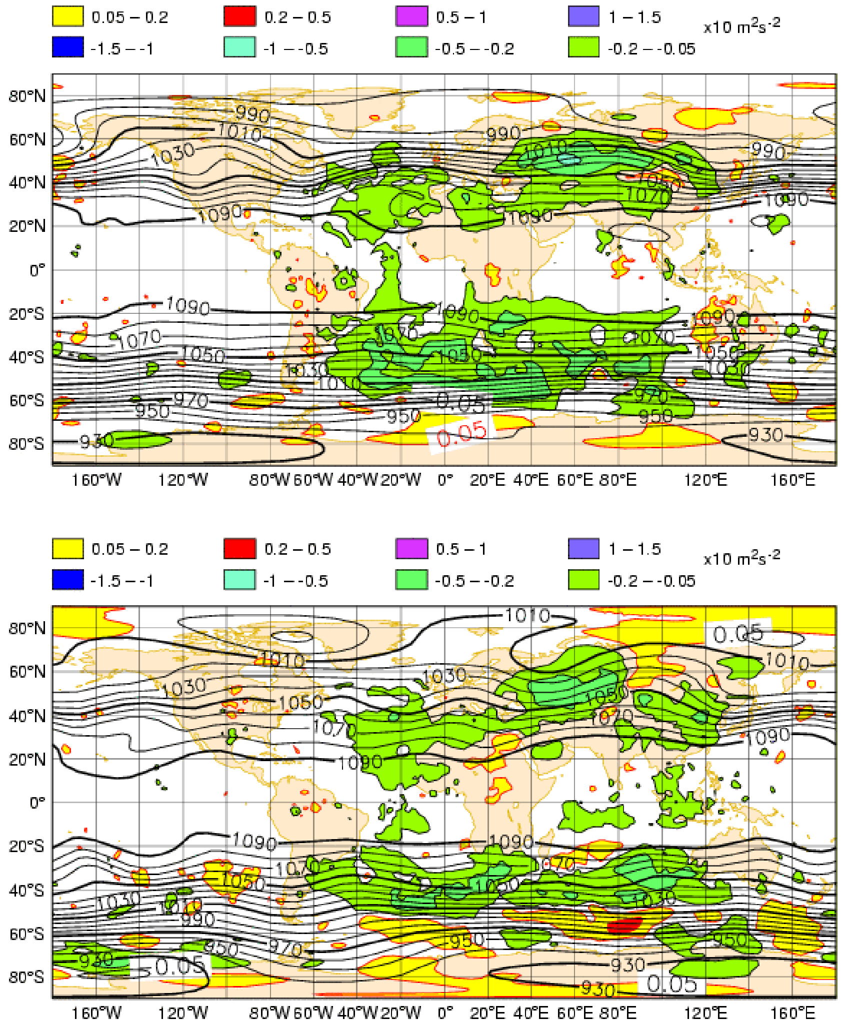

Figure 3. Differences in rms increments [x10 gpm] of geopotential at 250 hPa between experiment assimilating 90 minute winds and QI Negative values (marked in green) indicate reduced rms increment and yellow increased rms. The black contours are the mean analysed geopotential field. Top Spring experiment and bottom Winter experiment.

First of all the area of impact for Meteosat winds from both platforms is clearly visible. The observations are generally used only within a great circle of 55°. The rms increments are reduced within extended areas over the oceans especially in the Southern Hemisphere. The spring experiment (bottom panel) reveals increased rms increments right on and beyond the data boundary of 55° South. In the Northern hemisphere satellite winds are traditionally not used over land with the exception of North Africa (Tomassini *et al.*, 1997). This restriction has been relaxed with the introduction of observations from Meteosat-5 over the Indian Ocean beyond 30° East where AMW observations are active within the upper troposphere ($p < 500$ hPa). Consequently, the increment difference reveals no changes over Europe. In the area directly influenced by Meteosat winds the rms increments are reduced with a strong impact being centered over Kazakhstan. It is not intuitive that an increase in active observations by a factor two leads to reduced increments. This indicates that the changes in the observational system are consistent within itself, with the model background, and other observations within the same area (Erik Andersson, 1999, personal communication). Increased increments can indicate disagreement between satellite winds themselves, the background, or again other observations. TOVS radiances from tropospheric channels are not used over land in neither of both experiments. Remaining alternative information sources over Asia are therefore aircraft and sonde data. The strongest reduction of mean increments coincides with a data poor area over Kazakhstan. The differences in the rms increments at 850 hPa (not shown) reveal reductions only in the Southern Hemisphere coinciding with the impact on the 250 hPa field. The absence of significant impact in the Northern

Hemisphere is consistent with the fact that AMW data is generally not used over land below a pressure height of 500 hPa. The large areas of reduced increments indicate that the analysis has been improved towards a system that agrees with itself in respect to background and observational information. It should be noted that the relaxed QI threshold (QI > 0.6) for upper level observations (p < 400hPa) within the extratropical areas in the first place presents many observations with increased background departures to the analysis. The four dimensional assimilation appears to make good use of the 90 minute AMW data. An interaction between the first guess check, the variational quality control and the screening decisions dependent on the QI value also contributes to this positive result.

6. Forecast Impact

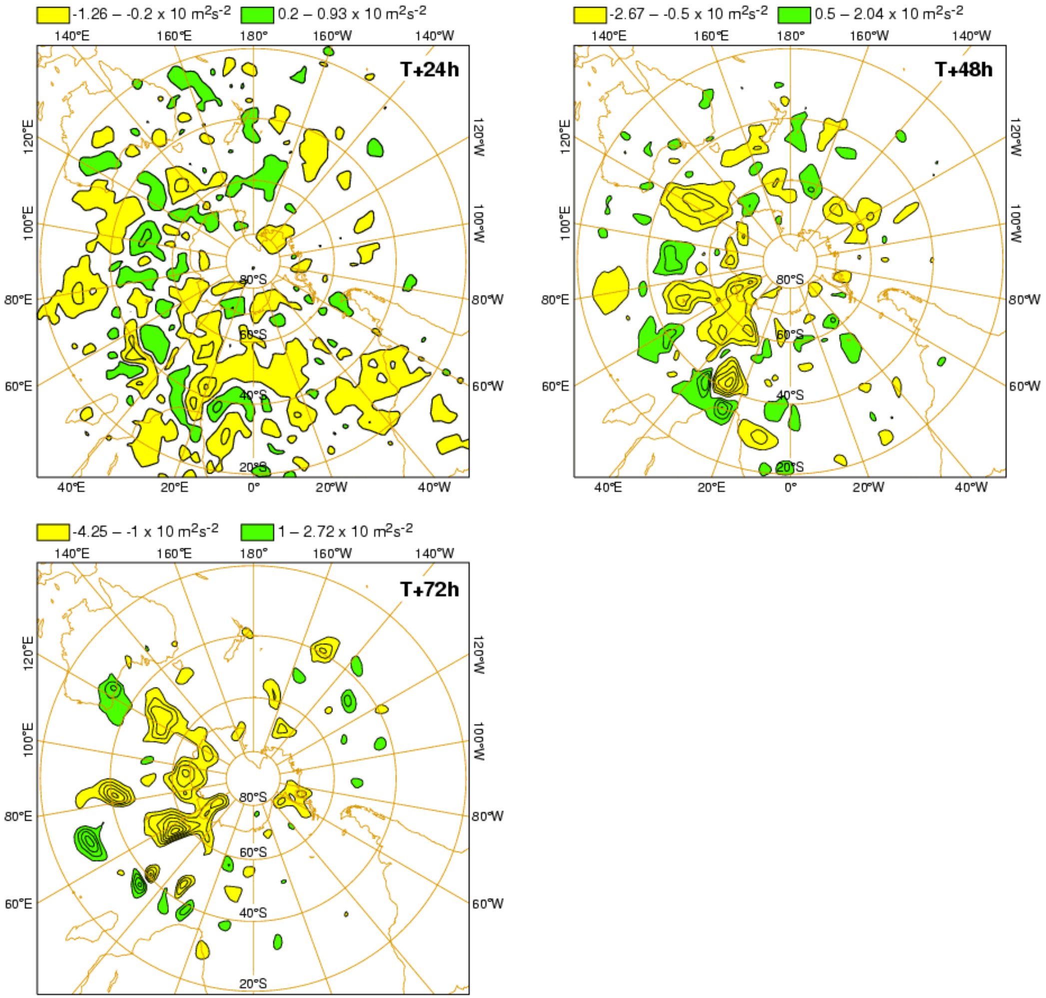

Figure 4 Differences in rms 250 hPa forecast error 21.10-7.11.1998,top left t+24h, top right t+48h and bottom t+73h. Yellow indicates decreased forecast error and green increased forecast error.

The assessment of the development of short term forecast errors between 24 and 72 hours shows the main signal in the Southern Hemisphere. Figure 4 contains the rms errors difference between the experiment (ECQC-90) during Autumn (21.10-10.11.1998) and the operational forecast of the 250 hPa geopotential. Yellow shading marks negative values and improved forecast. Green shading indicates increased rms forecast errors. The 24 hour forecast (top panel) reveals extended areas of reduced forecast errors. During the next two step (middle: 48 hour, bottom: 72 hour) the main contribution appears to concentrate in the South Indian Ocean. The Spring experiment shows similar patterns.

7. Summary

The BUFR encoded winds from both Meteosat platforms have been monitored including the MPEF QI quality estimates for use within a NWP system. The QI value appears to be capable of marking the quality regarding rms wind vector error, speed bias, and the observed wind speed. This provides good evidence to include the QI value as an additional criterion in the observation screening. A set of refined QI thresholds has been derived from the monitoring. The QI value of active observations is further used as a selection criterion within the thinning step for AMW data. This scheme is applied to Meteosat winds with 90 minute time sampling. The overall effect in the analysis is an increase in the number of active CMW data by a factor two. The two main reasons are the increased time sampling and a relaxed QI threshold at high level in the extra-tropical regions. Small contributions arise from multiple observations per processing segment from different channels at identical time slots and the less restrictive use of IR winds at medium levels. The fit of CMW data to background and analysis has been improved. The fit of other observations remains mainly unchanged. The rms increment for geopotential at 850 hPa and 250 hPa are generally reduced in extended areas over the oceans, North Africa and Asia. This indicates an improved analysis in terms of the consistency between the active Meteosat wind data, the background, and other available observations. The four dimensional variational assimilation system together with screening decisions depending on the MPEF Quality Indicator makes good use of the increased time sampling of AMW data.

ACKNOWLEDGEMENTS

This work was only possible through support from others in numerous technical and scientific issues. Thanks to all staff and consultants in both Operations and Research Departments at ECMWF. We would like to thank also Simon Elliott, Ken Holmlund, and Mikael Rattenborg at EUMETSAT for their strong support on the wind extraction side.

REFERENCES

Holmlund, K., 1998: The Utilization of Statistical Properties of Satellite-Derived Atmopheric Motion Vectors to Derive Quality Indicators, *Wea. Forecasting,* Vol. 13, No.4, 1093-1104.

Holmlund, K. and C. Velden, 1998: Objective Determination of the Reliability of Satellite- Derived Atmospheric Motion Vectors. *Proc. Fourth International Winds Workshop*, 20-23 October 1998, Saanenmoeser, Switzerland, publ. EUMETSAT, EUM P 24, 215-224.

Holmlund, K., C. Velden, and M. Rohn, 1999; Enhanced Automated Quality Control Applied to High-Density GOES Winds Derived During the North Pacific Experiment (NORPEX-98), *submitted to Monthly Weather Review*, October 1999.

Järvinen, H and P. Undén, 1997: Observation screening and back ground quality control in the ECMWF 3D-Var data assimilation system, ECMWF Technical Memorandum No. 236, 33 pp.

Rattenborg, M., 1998: Status and development of operational Meteosat wind products. *Proc. Fourth International Winds Workshop*, 20-23 October 1998, Saanenmoeser, Switzerland, publ. EUMETSAT, EUM P 24, 49-59.

Tomassini, M., G. Kelly, and R.W. Saunders, 1997: Use and impact of satellite atmospheric motion winds on ECMWF analyses and forecasts. EMWF, *EUMETSAT/ECMWF Fellowship Programme,* Research Report No. 6.