Operational wind products from new Meteosat Ground Segment

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Abstract

The new EUMETSAT Meteosat Transition Programme (MTP) ground segment took full control of all Meteosat satellites starting 15 November 1995. The MTP ground segment includes a Mission Control Centre (MCC) located in the new EUMETSAT headquarters building in Darmstadt, Germany.

The Meteorological Products Extraction Facility (MPEF) is a facility in the MCC. It is the function of the MPEF to produce a range of meteorological products for the end users. The main product is the Cloud Motion Wind product, extracted from all three Meteosat channels.

The MTP MPEF is the replacement of the MIEC run by ESOC as part of the Meteosat Operational Programme until November 1995. MTP MPEF features increased modularity and a number of improved processing and algorithms implementation. The algorithms are extensions of the MIEC algorithms and incorporate improvements in several areas. The new Automatic Quality Control provides a flexible means of controlling efficiently the quality of the generated product and will provide quality indicators to be used in advanced data assimilation schemes. The structure of the wind extraction and automatic quality control in MTP MPEF and some important differences with respect to MIEC are described in detail.

The planned extensions to the operational Meteosat wind product are described in summary form.

1 General Concept of the MPEF Design

The MTP MPEF is the successor to the Meteosat Information Extraction Centre (MIEC) for MOP. It features modular software design and incorporates a number of improvements in image data processing and product generation algorithm implementations. In addition the product algorithms are configured at run-time by a set of user-defined parameters whose values are under operator control. In this way the product generation processes may be tuned to produce optimum results. An example of these parameters are the thresholds used in the automatic quality control of the products.

The whole MTP ground segment is defined as a near real-time processing system in which the MPEF is embedded. The MPEF receives pre-processed (rectified) satellite image data from the Image Processing System normally on a line-by-line basis, and it processes these data to derive and distribute meteorological products. The near real-time derivation and distribution of the MPEF products minimises the delay for product distribution and reduces the overall processing load on the system. The system for instance extracts products from a half-hourly image slot for the southern hemisphere while Meteosat is still scanning the northern part of the earth disk.

2 MPEF Product Processing

2.1 General Description

The MPEF algorithms are extensions of the MIEC algorithms incorporating improvements in several areas. The products distribution is currently almost the same as the one used previously at MIEC:

MPEF Product	Distribution Times (UTC)
Cloud Motion Wind (CMW)	0000, 0006, 1200, 1800
Sea Surface Temperature (SST)	0000, 1200
Cloud Analysis (CLA)	0000, 0600, 1200, 1800
Upper Tropospheric Humidity (UTH)	0000, 0600, 1200, 1800
Cloud Top Height (CTH)	0300, 0900, 1500, 2100
Climate Data Set (CDS)	0000, 0100, 0200 .... 2200, 2300
Precipitation Index (PI)	Extracted at 0000, 0300, 0600 .. .. 1800, 2100 and accumulated for 5 days
ISCCP Data Set (IDS)	0000, 0300 .... 1800, 2100 (for Bl and B2 data sets) AC data set according to coordinated schedule

Table 1: List of MPEF products and their daily distribution times

The CMW, SST, CLA and UTH products are distributed to users via the GTS in WMO coded SATOB form, the CTH in pictorial form as part of the Meteosat Wefax dissemination mission and the CDS, PI and IDS products are archived in the Meteosat Archive and Retrieval Facility (MARF) from where they are retrieved by non-realtime users.

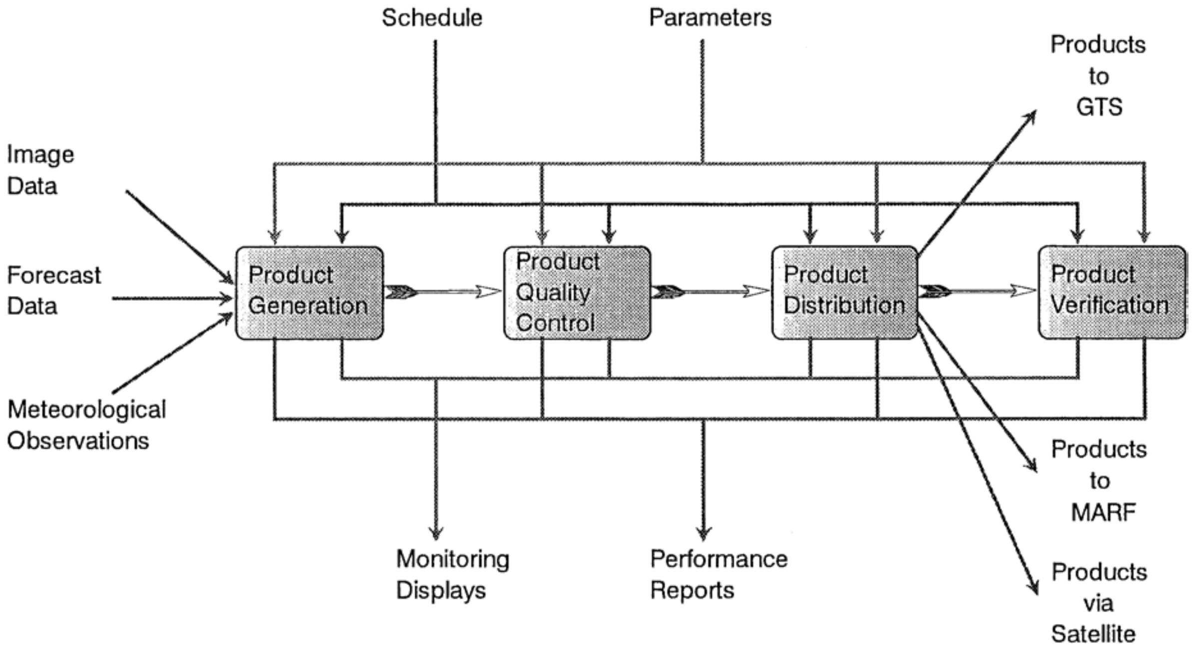

Figure 1: Overall structure of the MPEF products extraction process.

2.2 CMW Extraction

2.2.1 Overview

The Cloud Motion Wind (CMW) product is computed by identifying and localising the same cloud pattern ("tracer") in consecutive METEOSAT images (Buhler and Holmlund, 1993). This tracking is done in all 3 spectral channels independently. Using the knowledge of the tracer displacement, combined with the measurement of its temperature, the following values are extracted which constitute the CMW product : wind location, wind speed, wind direction, temperature and pressure level.

The first operation performed is the selection of the clouds that will be used as the tracers, based on the information provided by the Histogram Analysis. This tracer selection is done in a channel-specific way, including cluster merging or rejection when necessary. When a useful tracer has been identified, height assignment is performed and the corresponding wind component can be extracted. The wind-component extraction process comprises the definition of the Target and Search areas taken from the current and previous image, their enhancement, followed by their cross-correlation. The extracted wind components are thereafter subject to automatic quality control and combined to generate the intermediate CMW product, which potentially contains 3 winds per geographical location. Finally, the best wind per geographical location is selected from this intermediate product, presented to the operator for Manual Quality Control and if accepted, distributed in SATOB code. The original intermediate product is archived in the archive facility (MARF) and is available for retrievals from there.

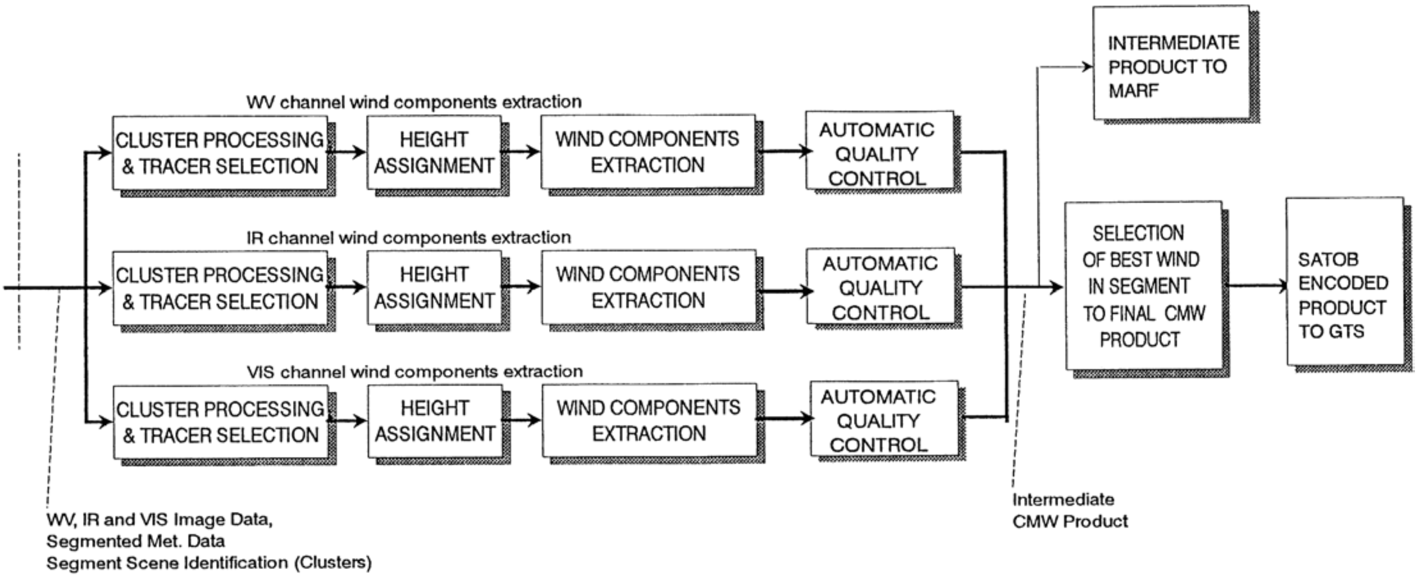

Figure 2: Overall internal structure of the CMW process.

2.2.1 Tracer selection

The main inputs to the tracer selection are the results from the histogram analysis, which provides information on the different scenes within a segment.

For IR the coldest cloud cluster in the segment is selected as the tracer. This is the same procedure as used in MIEC.

For VIS a tracer is selected only in segments where no high or medium cloud are present, and the low-level cloud cluster with the largest entropy in the segment is selected as the tracer. The entropy is calculated from the cluster VIS mean and VIS standard deviation. This differ significantly from MIEC, where the VIS tracers were identical to the IR low level tracers. For broken cloud situations where the low-level clouds are analysed as several clusters, the MPEF method generates lower level tracers, more or less corresponding to cloud base, because the clusters with the highest entropy are generally the lowest clusters. For compact clouds, where only one cluster is corresponding to the cloud top level, this method generates a higher tracer than the method previously used in MIEC.

For the WV the coldest cloud cluster is selected as tracer, but only if there is high or medium cloud present. The medium level winds are however filtered out in the automatic quality control, see below).

2.2.2 Height assignment

For IR (6 μm) the height is assigned using the measured 6 μm radiance of the coldest low level cloud, corrected for semi-transparency and atmospheric absorption (Schmetz et al, 1993), converted into temperature using a modified Planck function and into pressure using a forecast temperature profile. As opposed to MIEC, MPEF corrects the height for atmospheric absorption, which makes a significant difference for low level clouds. The differences for the final product are however not so pronounced as this effect was in the MIEC for low level clouds partially compensated by the cloud base height re-assignment. This process modifies the cloud radiance by using the calculated standard deviation of the cloud clusters to estimate the thickness of the cloud. MPEF also utilises cloud base height re-assignment for low level IR winds, but the correction is smaller and the overall effect, including atmospheric absorption, is on the average the same as in the MIEC scheme without atmospheric absorption correction.

For VIS (0.4µm - 1.1µm) the height assignment in MPEF is performed using the 6µ radiance of the low level cluster with the highest entropy.

In the MIEC also the WV height assignment was based on the IR cloud EBBT (Laurent, 1993). This was a good approach only in areas where high level clouds were identified. In other areas the WV height was corrected by an approximation of the moisture content above the highest identified scene. Even though these corrections provided a reasonable cloud height, they were still inferior to the IR EBBT in high cloud areas. In the MPEF the WV heights are based on the WV EBBT for the coldest scene. Semi-transparency correction, as applied for IR EBBT, is also utilised. This method provides for high clouds very similar heights as the IR EBBT, but a more stable height in areas where no high clouds are present.

2.2.3 Tracking

The actual tracking is in the two schemes based on cross correlation. The MIEC scheme was however utilising a first guess, provided by a numerical forecast, to reduce the amount of computations. This had a marginal impact on the quality and number of winds. The new scheme is completely independent of the forecast winds field for the tracking. It computes a larger correlation surface and is hence more reliable.

2.2.4 Automatic quality control

The largest difference occurs in the automatic quality control. The MIEC quality control was for the different channels non uniform. The VIS and IR winds used symmetry (consistency in time) checks for speed and direction as definite filters, i.e. no wind that failed to pass this test could be considered for dissemination. As a final check a comparison against the forecast was performed, which then was used to flag suspect winds. The final manual quality control could then either reinstate these winds or reject further poor vectors. The MIEC WV wind AQC was completely forecast independent. It utilised the a vector symmetry (consistency in time) check together with a local consistency check in order to filter out bad vectors. These winds were automatically disseminated, without manual intervention.

The MPEF quality control is uniform for all channels. Similar tests as those applied at MIEC were used to create a set of six tests (vector, speed and direction consistency in time, local consistency for vector and height difference and a forecast check). These tests are now continuous functions instead of definite filters and they all return a reliability assessment between 0 and 1. The final quality is a weighted mean of the individual qualities. The final quality is used to define the vectors with an acceptable quality for dissemination. For dissemination and manual quality control purposes the best wind, as defined by the final quality per segment, is selected. During manual quality control rejected winds can be reinstated and further winds deleted.

An example of the performance of the quality control is given in Fig. 3, which presents the relationship between MPEF quality mark for high level WV winds and an estimate of the real quality of the winds based on radiosonde statistics. The estimated quality is the vector RMS difference computed between collocated MPEF WV winds and radiosonde measurements normalised by the mean radiosonde observation speed. The good performance of the quality control is apparent. At the moment roughly 5% of the water vapour winds have a MPEF quality mark higher than .9, but the real quality as estimated by radiosonde statistics is higher than for the MIEC water vapour winds. 40% of the water vapour winds have a quality higher than .7 showing the high potential to increase the upper level coverage by the water vapour winds. On April 29 the quality threshold for WV winds was lowered from 0.85 to 0.7, dramatically increasing the yield of WV winds high level, without a decrease of quality, as is shown in the curve.

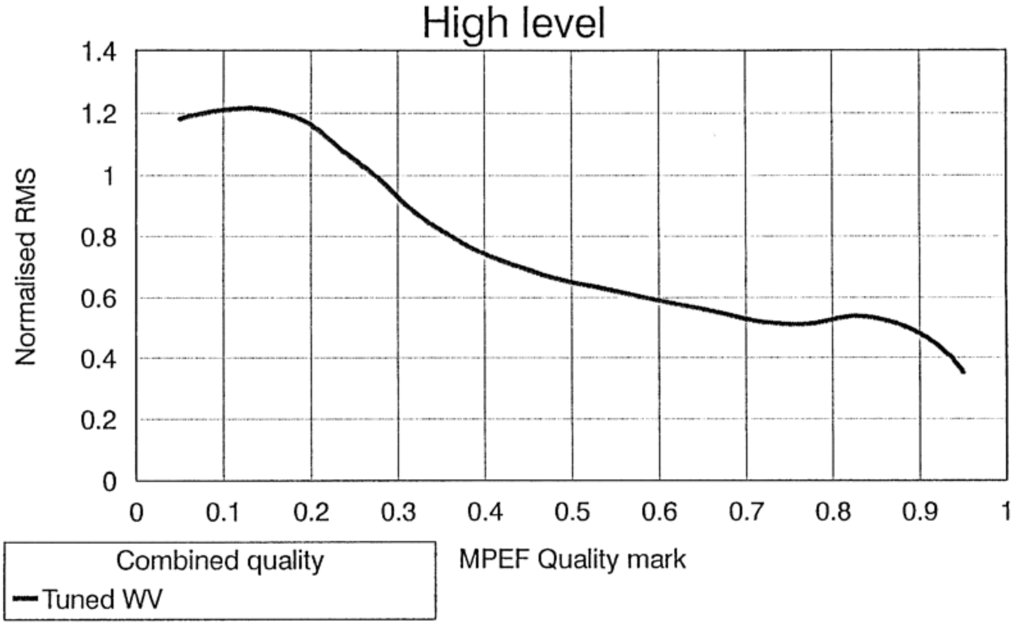

Figure 3: Performance of the MPEF Wind Quality.

2.3 Planned developments to the CMW product

2.3.1 High Resolution Visible Winds

These winds are derived from the high resolution VIS images, using the cluster information from the basic segment processing, but dividing the segment into 4 target areas and doing the correlations for each target area independently. This product was available from MIEC and will become available in BUFR format on the GTS starting August 1996.

2.3.2 BUFR version of the full CMW product

The full wind product from all 3 channels will be distributed starting in 1997 in BUFR form with quality indicators.

2.3.3 Improvements to the semi-transparency correction

The semi-transparency correction algorithm will be investigated for improvements, especially in the area of fitting the theoretical opaque curve to the observed background clusters. Improvements in this area are essential to improve the wind coverage over subtropical regions with hot surfaces and cirrus.

2.3.4 Clear-sky WV winds

The inclusion of clear-sky WV winds in the CMW BUFR product is being investigated. Methods for height assignment are being discussed. Our general approach is to avoid using statistical information or best level fitting for the height assignment, but for the clear-sky WV winds it is difficult to maintain this approach.

3 References

Buhler, Y., Holmlund, K.: The CMW Extraction Algorithm for MTP/MPEF, Proceedings of the Second International Winds Workshop, Tokyo, 13 - 15 Dec 1993. EUM P14, Published by EUMETSAT, D-64294 Darmstadt, 205-217

Laurent, H.: Wind Extraction from Meteosat Water Vapor Channel Image Data; J. Appl. Meteor., 32, 1124-1133

Schmetz, J., Holmlund, K., Hoffman, J., Strauss, B., Mason, B., Gärtner, V., Koch, A., van de Berg, L.: Operational Cloud-Motion Winds from METEOSAT infrared images; J. Appl. Meteor., 32, 1206-1225