Operational production of Cloud Motion Winds (CMW) at the European Space Operations Centre (ESOC)

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1. Introduction

At the European Space Operations Centre (ESOC) in Darmstadt the Meteosat Operational Programme (MOP) is conducted. One important aspect of this programme is the derivation of operational meteorological products from Meteosat image data in the Meteorological Information Extraction Centre (MIEC). The products are:

Sea Surface Temperatures
Cloud Analysis
Cloud Top Height Maps
Cloud Motion Winds
Upper Troposheric Humidities

Beside the metorological products there are also three sets of climatological data produced operationally:

Climate Data Set
Precipitation Index
ISCCP Data

All these data sets are stored on tape and will be available to interested users on request. The climate data set is a summary of the contents of an image, the precipitation index is based on the cloud top temperatures and allows an estimation of precipitation from convective clouds in the tropics. The ISCCP data is a set of reduced image data which is being supplied to the International Satellite Cloud Climatology Project in the framework of the World Climate Research Programme.

Among these products the Cloud Motion Winds (CMW) are most important. They are used on a routine basis in the data assimilation process of numerical forecast models. The CMW product is at present derived three times a day close to the synoptic hours of 00, 06 and 12 Z. The basic information for deriving the Cloud Motion Winds is a triplet of three consecutive Meteosat images taken in the spectral range of the so called 'atmospheric window region' in the infrared (IR) part of the electromagnetic spectrum (10.5 µm - 12.5 µm). As the Meteosat images are taken every half hour the wind information is based on an one hour time interval.

2. Automatic derivation of Cloud Motion Winds

For objective processing purposes the Meteosat images are devided into segments which consist of 32 by 32 infrared pixels. Where an image pixel is of about 5 x 5 km^2 in the surrounding of the subsatellite point. A whole Meteosat image is covered by 80 by 80 segments while in practice the processing for product derivation is limited to approximately 3500 segments within the 55 degree great circle arc of the subsatellite point. A more detailed description of the MIEC processing can be found in MEP (1987).

The IR segments of the three consecutive images are used to determine the wind vectors by an automatic correlation process. The central image segments are used as targets and the cross-correlation algorithm searches for similar patterns in each of the two adjacent images in turn. At present for each segment only one CMW is produced. The height assignment for the CMW is based on the cloud pattern contributing most to the total correlation and a forecast ECMWF temperature - height profile. The number of segments with suitable target tracers in it is usually of the order of 50 % of all segments within the processing area. Out of these suitable segments the automatic processing then derives about 1000 CMW's This is due to the fact that the two cloud motion wind vectors which are derived from two adjacent images for the first and second half hour interval are used to perform a symmetry check on them. By the symmetry check thereby a considerable number of possible wind vectors is excluded Depending on the number of available tracers the number of produced wind vectors varies from about 750 up to about 1300 per run.

A major shortcoming of the automatic technique described so far is its inability to discriminate unambiguously between cloud motions when more than one cloud layer is present in the same segment. The use of the full radiometric information in an image implies that the peak in the correlation surface can be the result of the superposition of the displacement of different layers. It is also possible that the seperate height attribution assigns a CMW to a wrong altitude level. As high clouds usually have the highest speed it is likely that those exhibit the the largest bias due to the above errors. This is demontrated in Figure 1. However, it is worth mentioning that there are other reasonsfor a speed bias between radiosondes and CMWs. For instance, clouds do not necessarily drift with the wind, or, high level jet stream clouds preferably occur in areas away from the high speed jet core (e. g. England and Ulbricht, 1980).

While the latter is a pertinent feature of CMWs which is not so obvious to circumvent, the superposition problem can be tackled by windowing the radiances and thereby, tracking only clouds related to certain levels. In February 1987 this technique has been introduced operationally for the high level winds, and thereby the bias between radiosondes and Meteosat winds for high level winds has been reduced by about 0.5 m/s.

The windowing is sketched in Figure 2: The IR radiance of all scenes in a segment apart from the high level cloud is screened out and set to a constant value. The remainder forms the data to which the cross correlation is applied. That way the superposition problem is overcome and it furthermore no longer necessary to perform an extra height attribution test. At presence the windowing technique is only applied to high level cloud motion winds, but the extention to all levels is under development. A more detailed decription of the automatic cloud tracking method using the windowing technique is given by Schmetz/Nuret (1988).

3. Automatic quality control

All produced cloud motion winds are objectively screened prior to the manual quality control and dissemination. Each wind is compared with a wind forecast, received from ECMWF, interpolated horizontally to the segment position and vertically to the pressure level of the wind vector The control is performed by calculating the vector difference between the cloud motion wind and the interpolated forecast. If the norm of the vector difference is more than a certain percentage of the norm of the forecast wind, the cloud motion vector is flagged as being suspect. This information is then passed to the meteorologist who is performing manual quality control.

4. Manual quality control

The results of the automatic processing are overlayed on a video display unit (VDU) over an animation loop of the image triplet from which the results were derived. The display shows the wind vectors and also displays for every wind the speed in m/sec and the assigned pressurelevel. Furthermore all those wind vectors which have been flagged in the automatic quality control step are marked. The task of the meteorologist is then to carefully inspect all displayed results by comparing the underlaying cloud motions with the the results of the automatic processing. If the meteorologist finds a suspect wind this result is flagged, and on the other hand the meteorologist can also reinstate winds which had already been flagged by the automatic quality control.

As timely dissemination of Meteosat wind data, like other Meteorological observational data, is essential the manual quality control is allowed to take only 75 to 90 minutes. The average number of manual deletions/ reinstations is about 150 but with a considerable variation.

After the wind product as every other meteorological product has been quality controlled the results are coded according to the SATOB code of the World Meteorological Organisation (WMO). Finally the coded results are feeded as bulletins into the Global Telecommunication System (GTS) of the WMO.

5. References

England, J., H. Ulbricht, 1980 , Flugmeteorologie , Transpress VEB Verlag , Berlin , 403 pp.

MEP(Meteosat Exploitation Project), 1987: MIEC processing, ESA-STR No. 224

Schmetz, J., M. Nuret, 1988 , Automatic Tracking of High Level Clouds in Meteosat IR Images with a Radiance Windowing Technique, To appear in ESA Journal

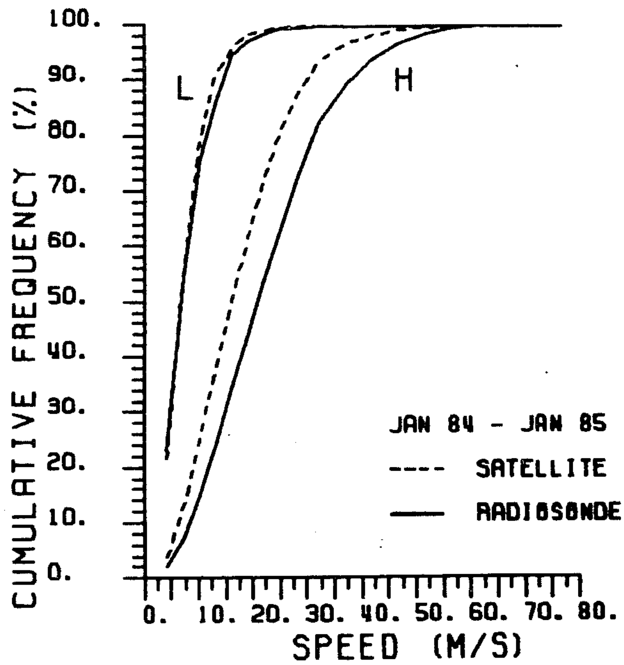

Figure 1: Cumulative frequency of cloud motion winds (----) and radiosonde winds (----) as a function of wind speed for low level (L) and high level (H).

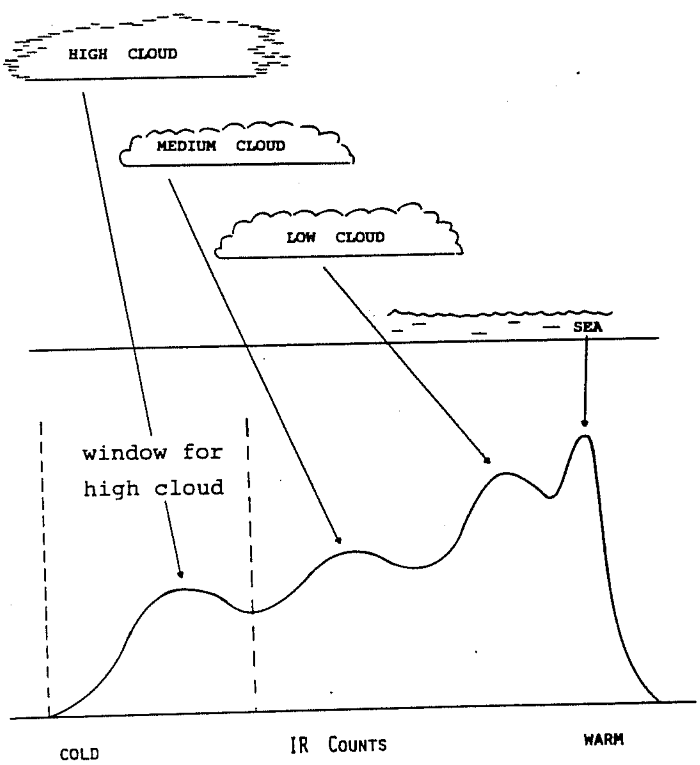

Figure 2: Sketch illustrating the windowing of radiances in the IR image. The cloud tracking then is performed for count values (or radiances) inside the window.