PRESENT DAY STATUS AND ONGOING DEVELOPMENTS OF TWO METEOROLOGICAL PRODUCTS AT ESOC

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1. INTRODUCTION

The geostationary Meteosat satellite observes the Earth with an imaging radiometer in three channels: in the solar spectrum (VIS) between 0.4 and 1.1 μm, in the infrared window region (IR) between 10.5 and 12.5 μm and in the water vapour absorption band (WV) between 5.7 and 7.1 μm. From Meteosat image data seven operational products are derived in near-real time: cloud motion winds, upper tropospheric humidity, cloud analysis, cloud-top height distribution, sea-surface temperatures, a precipitation index and a climatological data set. The status and some new developments of cloud motion winds (CMWs) and upper tropospheric humidity (UTH) will be discussed. Both products (can) play an important role for climatological studies and operational meteorology.

2. CLOUD MOTION WINDS

2.1 Present retrieval

Cloud motion winds are retrieved from three successive IR images using a cross correlation technique for Meteosat segments of 32×32 IR pixels. The average segment size is about $200 \times 200\ km^2$. In about 2000 segments cloud tracers are identified by a multispectral histogram analysis. Correlation surfaces are computed for two pairs of half-hourly images and a maximum in each of the two correlation surfaces is determined using a specific search strategy. For low-level ($p > 700\ hPa$) and medium-level $(700 < p < 400\ hPa)$ clouds the search strategy has not been changed in recent years: it starts at the centre of the correlation surface of one pair of images and searches along the steepest ascent until the first maximum in the correlation surface is found. This procedure is repeated for the other pair of images starting now at the symmetry point of the maximum correlation point with respect to the zero displacement point. Hence two vectors are found which form a CMW by taking their average. For high-level $(p < 400\ hPa)$ a starting point for the computation of the correlation coefficients is found by using the ECMWF wind forecast (Nuret, 1989). A windowing technique is applied, which means that only radiances emanating from high-level clouds are kept (Schmetz and Nuret, 1987). This excludes the problem of different cloud layers moving with different velocities. All correlation coefficients on a square of 35×35 pixels, centred around the starting point, are now computed to find the absolute maximum (hence the first vector). Then for the second vector all correlation coefficients of an area of 19×19 pixels centred around the symmetry point of the first vector are computed. From these two vectors a CMW is computed.

2.2 Results

The present scheme for deriving high-level CMWs was introduced on the 7th March 1989. For a test period of four weeks in February 1989, Nuret (1989) reported that significantly more high-level winds (about 10 %) were produced using the new scheme with about the same quality. This is confirmed by the average number of disseminated winds after the 7th March 1989. The bias of the high-level CMWs with respect to radiosonde measurements also decreased (see figure 1). However, the time series after taking the scheme in to operational use are too short for a firm statement.

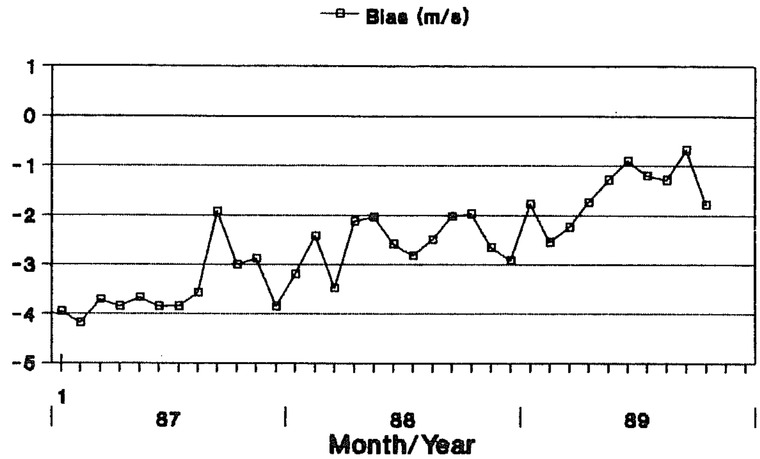


Fig. 1: Bias of high-level CMWs with respect to radiosonde winds.

2.3 New developments

The principal technique of a new scheme for the derivation of the peak in the correlation surfaces, has already been presented by J. Hoffman (1988). The method uses additional image information: of each pixel the local mean count and its standard deviation in an 3 × 3 pixel area, are determined. For each segment a bidimensional histogram of the mean count and the standard deviation is constructed. It will have the form of one or more arches (see figure 2 for the case with two reflectors). The foots of the arch represent pixels with radiances emanating from only one reflector.

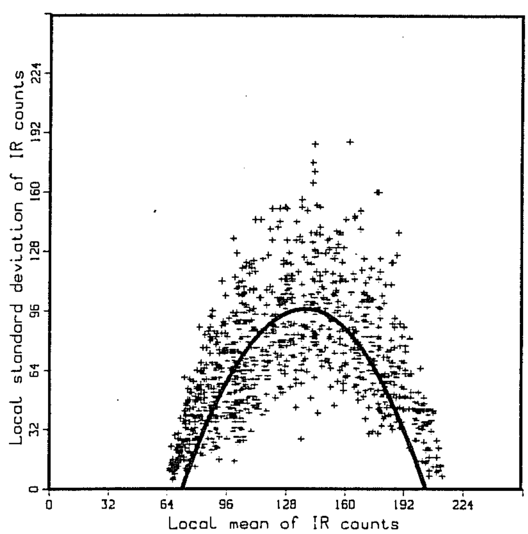


Fig. 2: A bidimensional histogram of a segment using a spatial coherence method.

Masks can now be constructed which take into account the mean radiance of a reflector as well as the minimum and maximum. It replaces the windowing technique by a more elaborate way of masking and smoothing the irrelevant information in an image. For the highest reflector level, which is not necessarily always a high-level cloud, a CMW is derived (if possible) using the

ECMWF wind forecast to determine a centre point of the cross correlation area. First results of a test period starting at the 19th September 1989 indicate an increase of the quantity of CMWs with about 18 %, while the quality remains nearly unchanged (see table 1). A second step can be performed: when there are two cloud layers, it can be tried to derive also a CMW for the lower cloud layer (Hoffman, 1989).

	Operational			Test (1st step)			Test (2nd step)		
	CMWs before	CMWs after	%	CMWs before	CMWs after	%	CMWs before	CMWs after	%
all	1051	639	61	1250	789	63	182	72	40
high	396	252	64	461	305	66	0	0	0
medium	302	157	52	418	222	53	89	30	33
low	353	230	65	371	262	71	93	42	46

Table 1: Number of CMWs before and after automatic quality control against the ECMWF-forecast of the operational wind scheme and the test scheme (first and second step).

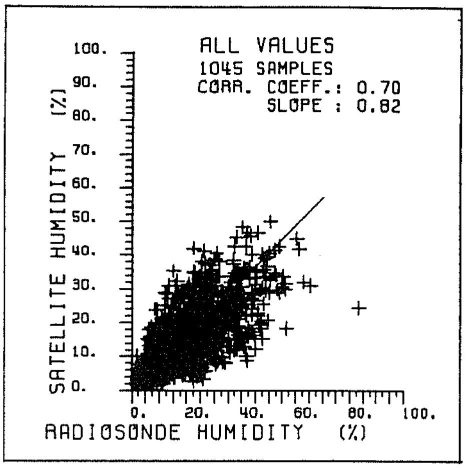
3. UPPER TROPOSPHERIC HUMIDITY

3.1 Retrieval

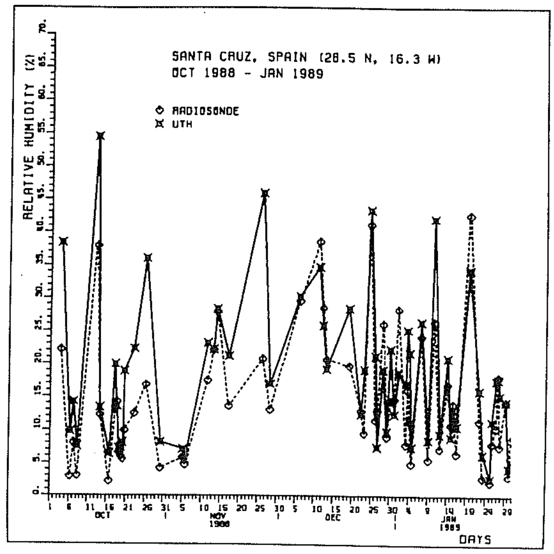
The UTH product is based on image data from the water vapour channel. With the aid of a efficient radiative transfer model (Schmetz, 1986), the radiances at the top of the atmosphere are determined as a function of the upper tropospheric temperature and humidity. Tables that relate IR and WV radiances on one hand with UTH-values on the other hand, form the basis of the retrieval. For the computation of these radiances some additional data are required: vertical profiles of the ECMWF temperature and humidity (for altitudes below the 600 hPa layer) forecasts (Schmetz and Turpeinen, 1988). The retrieved UTH value is a mean value for the layer between 600 hPa and 300 hPa. For this layer the relative humidity is varied, while the relative humidity decreases linearly with height to 0 % at 100 hPa at higher altitudes. Once these tables have been constructed, the actual retrieval is quite simple: it consists of a linear interpolation of the measured IR and WV radiances, giving a UTH value representative for a segment. Generally layers below and above contribute little to the outgoing radiation at the top of the atmosphere.

3.2 Validation

A validation study of the UTH product against radiosonde measurements has been presented by Turpeinen and Schmetz (1988). A comparison of a large sample of collocations is presented in figure 3.a. The correlation coefficient for this sample is 0.70, while the bias is 4 % (radiosonde - UTH). Though these results show already the good quality of the UTH product, it does not show clearly that the UTH product can track tendencies in the upper tropospheric humidity field. Therefore we compared the relative humidity, derived from single radiosonde stations, with UTH values for the collocated segment as a function of time. Figure 3.b shows a four month time series for the Spanish station Santa Cruz. The correlation coefficient of these data sets is 0.83. Several other comparisons have been made with the same result: all show that the UTH product does indeed follow tendencies quite well. We will prolong this study in a semi-operational way to make comparisons on a even longer time scale (e.g. one year).



a



b

Fig. 3 a: Comparison of radiosonde relative humidity and UTH.
b: Time series of radiosonde relative humidity (dashed line) against UTH (solid line) for radiosonde station Santa Cruz. The correlation coefficient is 0.83.

3.3 New developments

The largest disadvantage of the UTH product is that a value is only retrieved for segments without medium- or high-level clouds. A UTH value for the cloud free part of the segment can be derived, but it's not a representative value for the whole segment. However, it could be possible to extend the UTH product with a so called "Bogus" humidity product for the cloudy areas. It would be a combination of the UTH product and the cloud analysis product. If a cloud represents a certain relative humidity (RHCL) over ice or water, then a relation for a relative humidity (RH) at cloud-top level could read as:

$$RH = RHCL \times N + UTH \times (1 - N) \quad [1]$$

So the relative humidity would depend on the cloud cover (N) and the UTH value of the cloud-free part of the segment.

4. REFERENCES

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