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Tracer quality identifiers for accurate Cloud Motion Wind estimates

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The extraction of CMWs (Cloud Motion Winds) from METEOSAT infrared imagery has been operational at the European Space Operations Centre since the late seventies. The wind extraction scheme has now reached a stage where the small percentage of winds unrepresentative of the local wind field are not a result of the image preprocessing and filtering technique. These poor CMWs are related to situations where the tracked feature is not a passive tracer of the wind field. Therefore the present development work is concentrated on developing techniques to identify areas where the tracer is influenced by its surrounding. Results on using wind shear and variation of the radiative properties os tracer as quality indicators are presented as well as outlines for further investigations.

1. Introduction

The extraction of CMWs (Cloud Motion Winds) from METEOSAT infrared imagery has been operational at the European Space Operations Centre (ESOC) since the late seventies. The extraction technique has after several major improvements (Schmetz, 1991) now reached a stage where the main part of the produced vectors represents rather well the local wind field. Figure 1 shows improvements in terms of monthly mean speed bias, speed RMS and vector difference RMS for high level winds (above 400 hPa) for January 1987 - August 1991. The present operational scheme which was implemented in March 1990 is described in Schmetz et al. (1991). Figure 1 indicates that after the tuning phase during the first two months the monthly mean speed bias has on the average been - 1.4 m/s and the vector difference RMS 9.2 m/s.

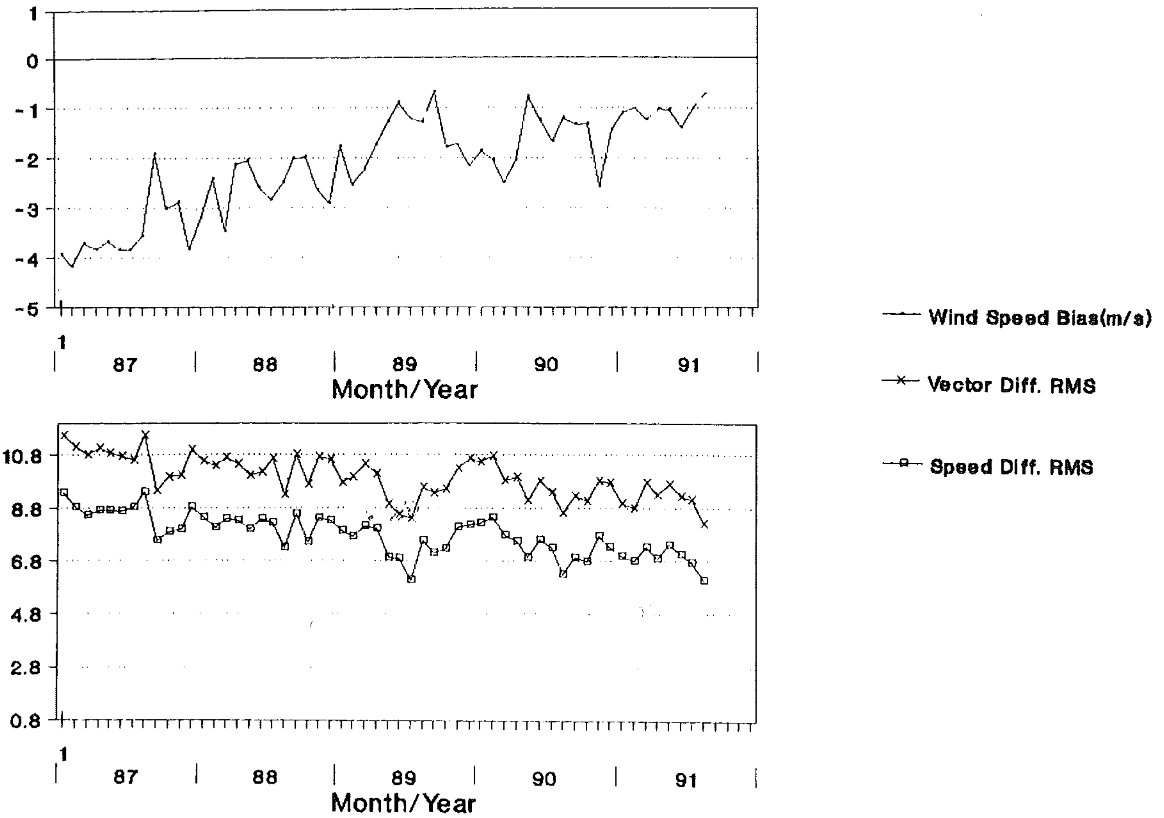

Figure 1. Speed bias, speed RMS and vector difference RMS for CMWs against radiosondes for January 1987 - August 1991.

The use of the CMWs in weather prediction is however complicated by the small number of vectors which represent other space and time scales than the traditional in situ measurements (e.g. radiosondes). The usefulness of the tracked cloud features (hereafter tracers) can be determined with the use of information based on the image processing, filtering and tracking as well as using auxiliary information about the atmospheric state (Holmlund and Schmetz, 1990). This paper will describe some parameters which have been derived from imagery processing and CMW derivation at ESOC and it will also outline possibilities for future studies. The potential of the parameters to improve the derived CMWs was evaluated by comparing speed bias and vector difference RMS for two cases (January 7th and August 1st, 1991). The comparison was made against the ECMWF 24 hour forecast. The limitations of this approach, especially in the tropical region, must be taken into account, when the results are assessed. Because of different image preprocessing, tracer selection and height assignment methods, the results can be satellite dependant. Therefore they might not be applicable to other satellites or CMW derivation techniques.

2. Present operational quality control

The automatic CMW scheme attempts to produce a vector for every segment which contains clouds. For these segment two vectors are derived from three half hourly images. The two vectors are then compared with each other and if they are consistent the final vector is derived as an average of the two half hourly vectors.

The present operational quality control is two phased. In the first, the so called automatic quality control (AQC) step, a check against the latest available forecast field is performed. If the speed difference between the CMW and the forecast field exceeds 55% of the forecast speed, the CMW is marked as suspicious. Also areas where the CMW speed is greater than 30 m/s and the forecast speed gradient is larger than 30 m/s over 150 km are marked. In the second step the CMWs are controlled by an experienced meteorologist who can either accept the AQC result or he can reinstate the wind. He has also the option to delete any other wind.

The shortcomings of the present scheme is that it doesn't provide the end user information about the reliability of the individual CMWs and it fails to identify some really bad vectors. The use of the CMWs could be improved if a appropriate set of tracer quality indicators could be derived.

3. Evaluation of tracer quality indicators

3.1 The derivation of tracers.

The operational production of CMWs at ESOC is based on image segments of the size of 32*32 pixels. The histogram analysis provides information about the radiative properties of the different scenes within the segment. This information is used in the CMW production for tracer selection, image filtering and height assignment. This stage already provides potential parameters for tracer quality assessment. The following parameters were tested: spatial tracer size and standard deviation of the tracer raw radiance. The amount of semi transparency correction will be discussed separately (see 3.4). Figure 2 shows the relationship between speed bias and vector difference RMS for tracers of different sizes.

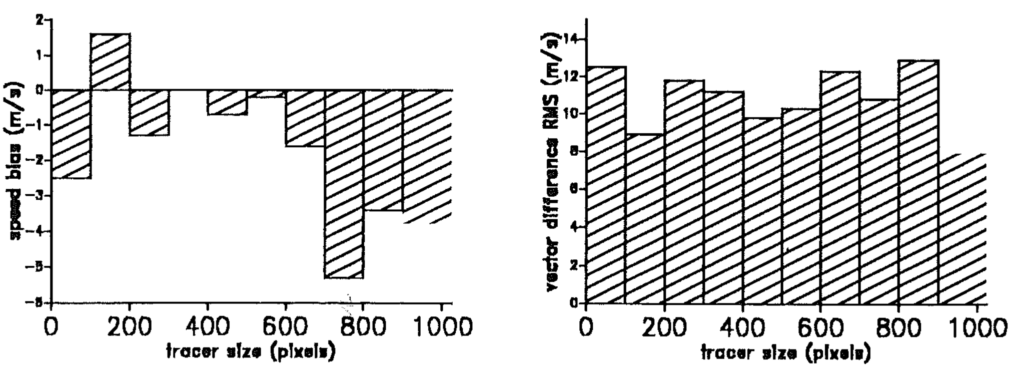

Figure 2. Speed bias and vector difference RMS for tracer of different sizes.

The smallest speed bias is achieved with tracers containing 300 to 600 pixels. The largest negative bias is for tracers with more than 700 pixels. These larger tracers are likely to be representative of larger scale motion or they may be convective systems, which would then explain the larger bias. The vector difference RMS doesn't show any conclusive dependance on the tracer size. The standard deviation of the coldest scene identified didn't contain any information vis avi speed bias and vector difference RMS. The image filtering changes however in some cases the predefined tracer sizes and this might blur out the signal. In the future the effects of the image filtering must be studied in detail. Parameters related to segment entropy, tracer entropy (i.e. number of tracer elements / tracer connectivity) and number of scenes should be evaluated.

3.2 The tracking

The immediate parameters which one can derive from the tracking are related to the produced correlation surfaces. Three parameters were evaluated. The first two were related to the correlation values derived for the two half hourly vectors.The first parameter studied was the maximum and the second the difference of the two available correlation surface maximum. The last parameter which was examined was the position of the two maxima in the correlation surface, i.e. the symmetry check, which was analysed with the speed and angle differences obtained for the produced vector pair. The results are presented in figure 3 and 4.

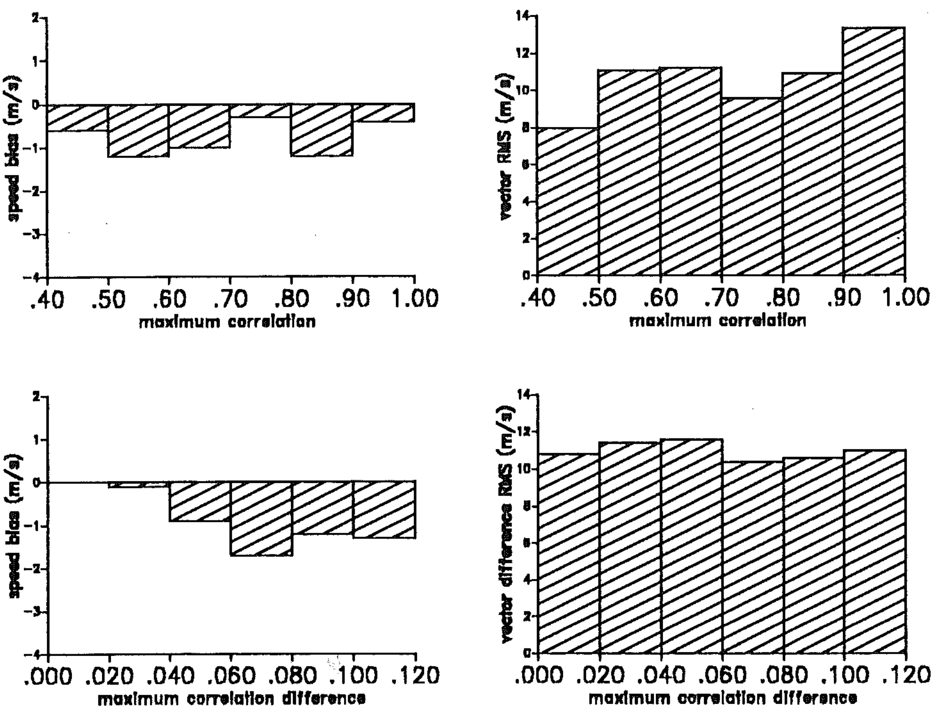

Figure 3. Speed bias and vector difference RMS for maximum correlation value obtained and for the difference between the maximum correlation for the two derived vectors.

The vector difference RMS for the maximum correlation value seem to indicate that tracers which produce low correlation values produce better winds than tracer for which the correlation maximum is high. This could be explained by the assumption that high correlation values are produced by convective cloud, which are not passive tracers, whereas the low correlation values are produced by thin cirrus which are following the flow in a more accurate manor. This conclusion should however be evaluated against long term statistics with consideration of possible seasonal variations. For the difference of the maximum correlation values, there is an indication of increased bias, when the difference becomes larger. The vector difference RMS seems unrelated to this difference.

The results for the symmetry check parameters are presented in figure 4..

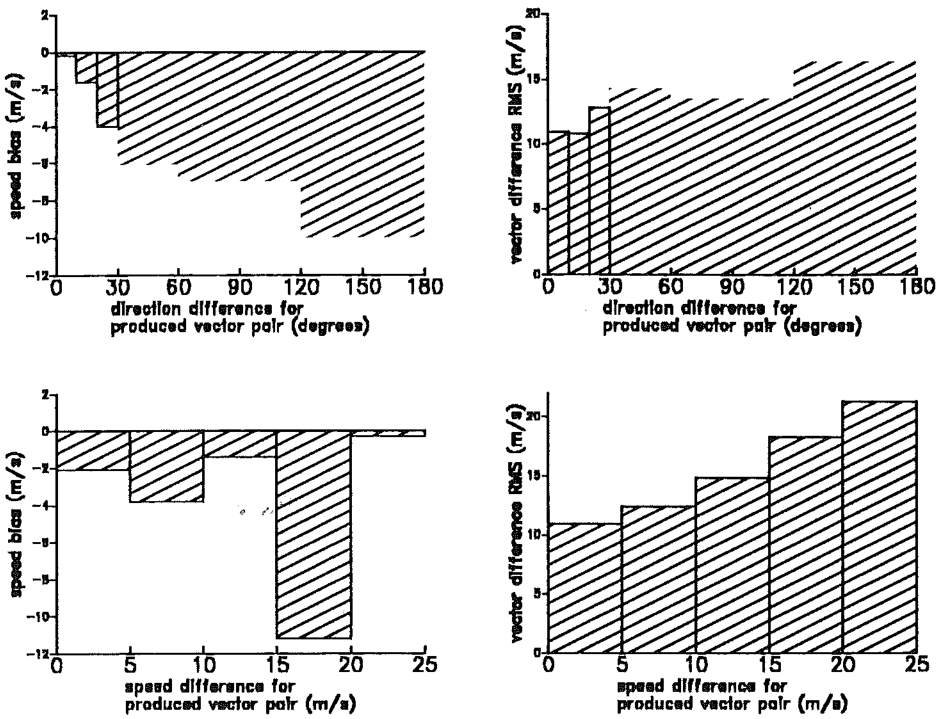

Figure 4. Speed bias and vector difference RMS for derived vector pairs, with various angle differences and speed differences.

The importance of a consistent symmetry check can be clearly seen in the results. The vector difference RMS is clearly related to changes in angle or speed difference. The speed bias seem also to be strongly related to angle differences but not so clearly to speed differences.

3.4 Height assignment

The applied correction method for the semi-transparent clouds is dependant on information about the cloud mean radiances in the WV and the IR channel as well as the mean background values and it can therefore only be applied when reliable background information is available. At this stage the only parameter evaluated was the amount of semi transparency correction. The results are presented in figure 5. The first correction class (shaded) is for tracer where no correction has been applied or the correction has failed.

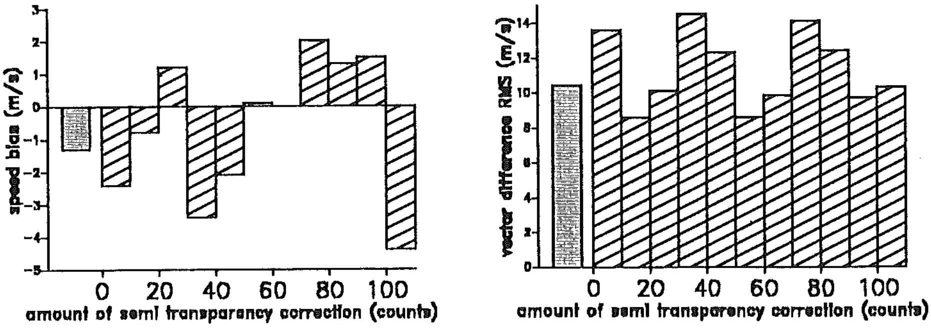

Figure 5. Speed bias and vector difference RMS for tracers with different amount of semi transparency correction. Results for tracers with for which no semi transparency correction has been done, are shaded.

The results doesn't show any relationship between the derived parameter and the speed bias nor the vector difference RMS. A better assessment of quality of the semi transparency correction could be done using information related to the tracer emissivity and the brokenness of cloud. This will be done in the near future. Another possibility is to study the consistency of the height assignment. This is discussed in the next chapter.

3.5 Local consistency

The failures of the semi transparency correction, i.e. no background information, can partly be resolved with studying height information derived in the neighbouring segments. Table 6 shows the speed bias and the vector difference RMS for CMWs for different pressure difference classes. The pressure difference classes are defined as the smallest difference between the CMW height and the height in one of the neighbouring segments. Pressure differences over 100 hPa were grouped together due to a very small number of occurrences (4% of all cases). The cases where the wind has been isolated are also in one separate group. The statistics on the two cases (figure 6) show a clear dependency between RMS and pressure difference.

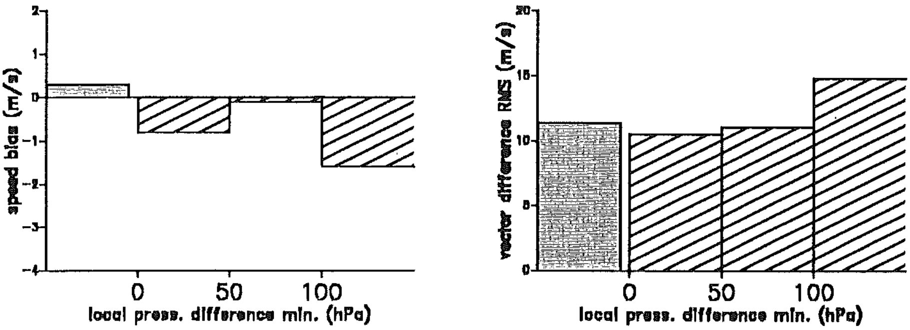

Figure 6. Speed bias and vector difference RMS for CMWs with various minimum pressure difference with neighbouring segments. Results for segments with isolated winds, i.e. no winds in the neighbouring segment, are shaded.

In order two resolve with higher accuracy the class with the smallest RMS, also the speed difference between the CMW and the CMW in the neighbouring segments was analysed. Figure 7 show a clear dependency between local speed difference and speed bias as well as for vector difference RMS.

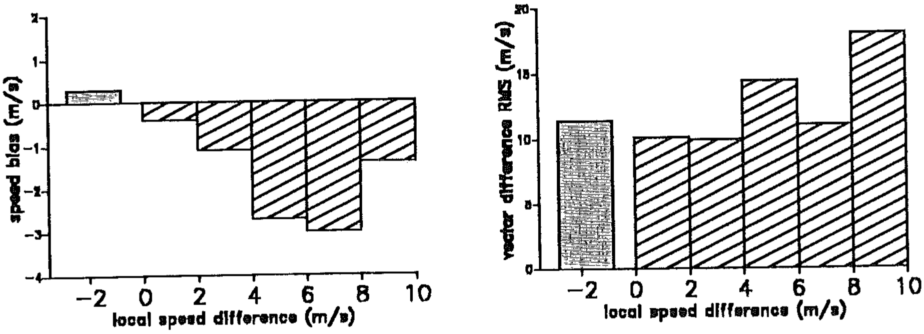

Figure 7. Speed bias and vector difference RMS for CMWs with various minimum speed differences to the neighbouring segments. Results for isolated CMWs are shaded.

4 Conclusions

The results obtained show that there are several parameters which potentially contain tracer quality information. Especially the height and speed consistency check have shown a clear relationship to wind quality. To obtain more reliable information about the usefulness of these parameters as quality indicators, a evaluation against a larger data set will be performed in the near future. This will give the opportunity to evaluate the impact of these parameters against radiosondes and not forecast fields. After a successful selection of such parameters, a semi operational tracer quality check is foreseen in the parallel mode of the operational scheme for further validation.

5 References

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