CONSTRUCTION OF CLOUD TRAJECTORIES : A WAY TO CHECK CLOUD WIND QUALITY

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ABSTRACT

Trajectories of clouds and other atmospheric structures are computed from series of up to 47 consecutive Meteosat IR or WV images, with an usual "euclidean distance" technique. When a selection of the coldest pixels of the template is used for the tracking of high level clouds, trajectories (which present more inconsistent cloud motion vectors) show significant differences from those computed without selection in the same areas, even though individual winds are not so much different.

Starting from the same initial gridding of the images, the trajectories without selection show regular patterns depicting for example the divergence of high level motions around a frontal system, while "selected cold cloud" trajectories have a tendency to converge on a limited number of cloud clusters whose motions seem more representative of the meso- or synoptic scale systems displacements than of local winds.

From well defined sets of trajectories of the two kinds (unselected and selected cold pixels), the motion and evolution of the structures tracked has been studied. Several causes for inconsistent cloud motion vectors appearing on some trajectories have been identified with the help of computer animations. Relations between the type of mesoscale atmospheric structure and the quality of cloud motion vectors are shown for different synoptic situations.

1. INTRODUCTION

Cloud motion winds are usually calculated on regular grids in longitude and latitude from pairs of images. Our method is a lagrangian approach of the motion of clouds: it consists in tracking clouds or atmospheric structures on a series of consecutive images from geostationary satellites. It was primarily developed to study the evolution of clouds. For this purpose, some improvements have still to be made on this method. Nevertheless this study gave us a better knowledge of the behaviour of the cloud motion vector algorithm.

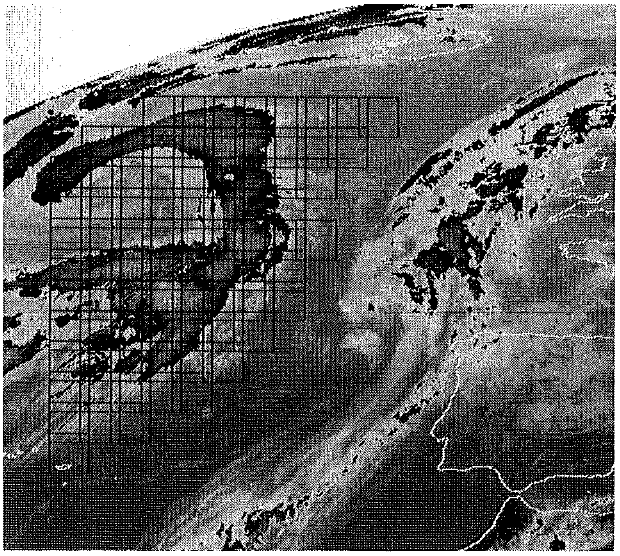

Fig. 1a : initial grid for trajectories (13:00)

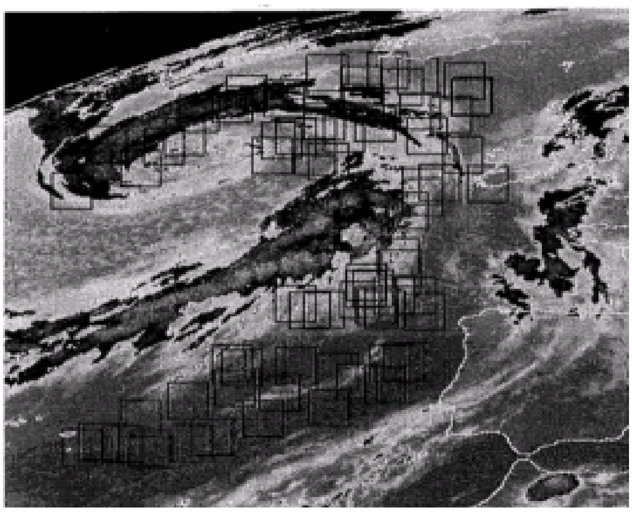

Fig. 1b : end of trajectories without cold pixel selection (22:30)

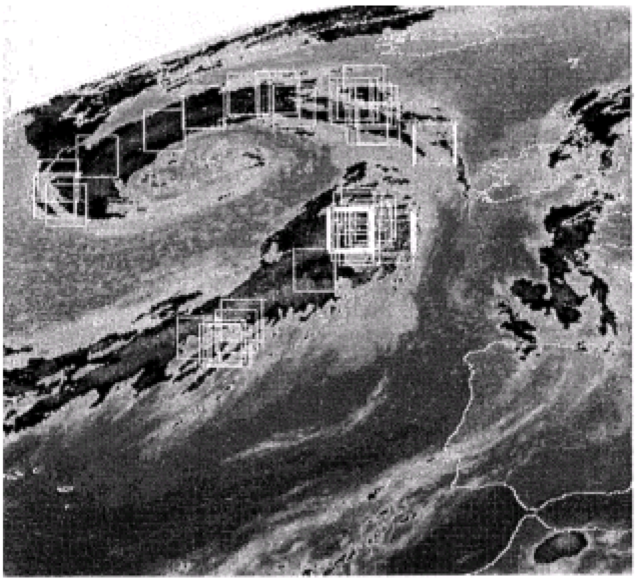

Fig. 1c : End of trajectories with cold pixel selection (22:30)

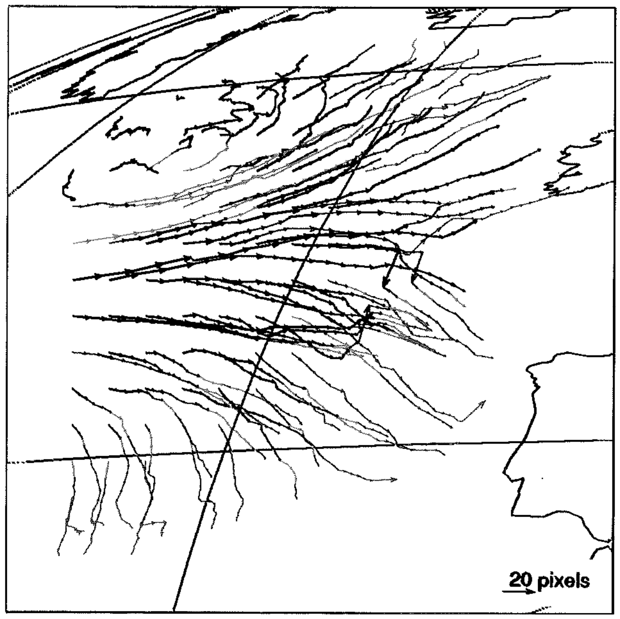

Fig. 1d: trajectories without cold pixel selection (13:00 - 23:00)

Color code for the brightness temperature of the coldest pixels of the template : T<228 K: black, 228-238 K : blue, 238-248 K : light blue, 248-258 K : green, 258-273 K : red, T>273 K : pink

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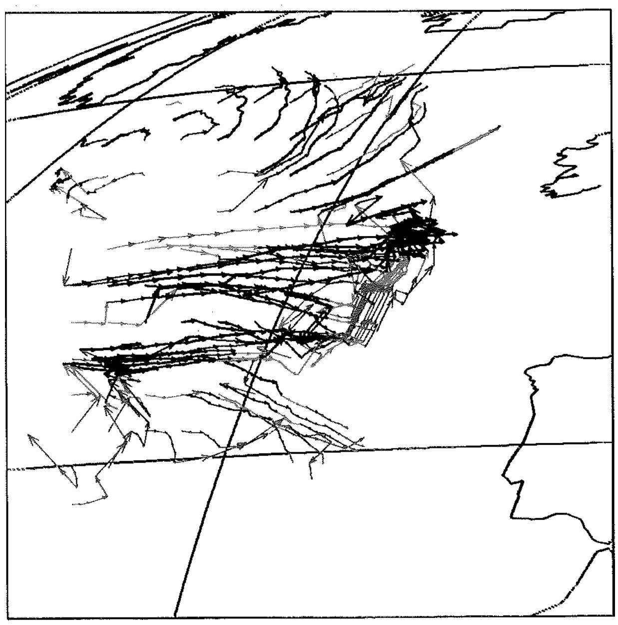

Fig. 1e : Trajectories with cold pixel selection

Color of vectors : percentage of pixels below -30° C inside the template : 0-6 % : pink, 6-12.5 % : red, 12.5-25 % : green, 25-50 % : light blue, 50-75 % : blue, 75-100 % : black

2. METHOD

In the main part of this study, a series of 21 images, one every 1/2 hour, is used to obtain sets of trajectories. The examples shown were computed from the infrared channel, but the method has also been tested with water vapour images.

2.1) Calculation of cloud motion vectors:

The euclidean distance (or norm 2) method (Sitbon et al., 1974) has been chosen to minimize the computation time of cloud motion vectors (referred to as CMV hereafter). Calculation of euclidean distances are executed with a 32x32 pixels template over a search window of 80x80 pixels. In the first phase, all the pixels of the template are used for the computation.

2.2) Trajectories:

The first trajectory charts were computed over a large region covering Europe and the north Atlantic on longitude and latitude grids (Szantai and Desbois, 1994). In the following examples, the first CMVs are computed on a regular grid in lines and points. The borders of this grid were determined visually on the first images of the water vapor channel to select mesoscale features.

The first vectors of the trajectories are computed between the first and second image, as done in (eulerian) CMV calculations. But for the next step, the positions reached by the "clouds" at the end of the first step are used to compute the second elements of the trajectories between the second and third image. This process is carried on up to the last vectors obtained from the last two images. No quality control is performed on the CMVs.

3. EXAMPLES

3.1) Cyclonic system:

The first example shows the evolution of a cyclonic system over the north Atlantic on 18 Oct. 1989. Trajectories start at 13 h and finish at 23 h (fig. la and lb). Templates corresponding to the starting grid have a partial overlap with their neighbours. Visually, a large number of trajectories have a regular aspect (fig. Id), and the number of inconsistent vectors (with a very large intensity or an abrupt change in direction) is proportionally small. Trajectories reflect the spreading of clouds with a low brightness temperature, apparently associated to the divergent motion of air masses at high levels around a cyclonic system. The warming up and dissipation of some of these clouds can also be observed, especially in the south eastern part of the depression.

3.2) Cirrus band :

This example shows a different type of evolution. The region studied is a band of thick cirrus squeezed between two conflicting air masses (coming from the north-west and south-east directions) and associated to a cold front. Trajectories start at 1 h on 13 Oct. 1989 (fig. 2a) and end at 11 h ; one image (at 7h 30) is missing. The trajectory chart reveals three main regions of evolution (fig. 2b). The north-eastern part of the cloud structure moves eastwards along rather regular trajectories, possibly in relation with a jet stream. The southern part moves south-eastwards and is warming up and dissipating. The central part does not show a privileged direction of motion ; the high proportion of inconsistent CMV seems to be correlated to the dissipation of high level clouds in this area.

The proportion of inconsistent CMV is more important in this case than in the first one. This indicates that the quality of trajectories can depend on the meteorological situation.

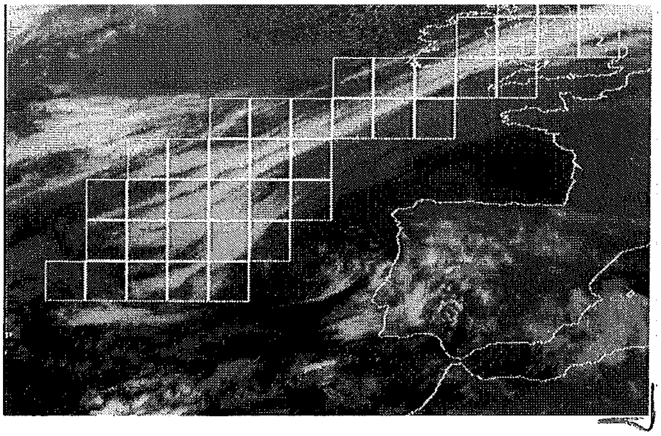

Fig. 2a : initial grid for trajectories (at 1:00)

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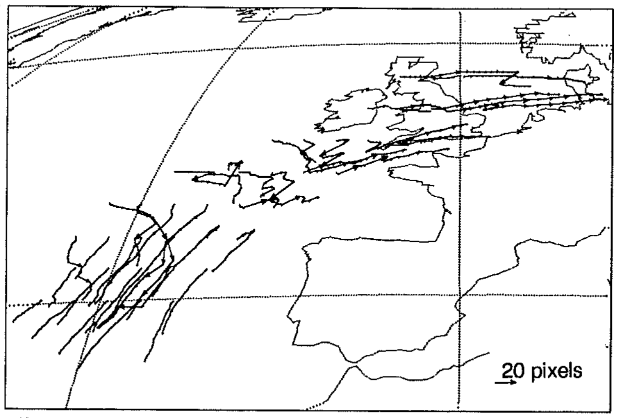

Fig. 2b : trajectories (1:00 - 11:00)

4. TRAJECTORIES WITH COLD PIXEL SELECTION

The aim of a selection of the coldest pixels was to improve the tracking of high level clouds. The method used consists in selecting the pixels inside the template with a brightness temperature below a chosen threshold for the calculation of the CMV. It is a simplified version of a radiance windowing technique proposed by Schmetz and Nuret (1987).

The example shown is again the depression of 18 Oct. 1989, starting on the same grid. The number of trajectories is smaller because some of the templates of the initial grid do not have any cold pixels. The brightness temperature threshold used is -30° C (fig. la, b and c, cold clouds in blue or white). No quality test is made on vectors.

Trajectories appear to have more inconsistent CMVs than without cold pixel selection (fig.le), in some cases because of the very small number of cold pixels inside the template. Due to these vectors, trajectories tend to converge on active cold systems, where clouds are formed or remain stable (fig. lc).

In this form, this method is too inefficient to track a large number of high clouds. Nevertheless one of its biases, the tendency to find the coldest cloud or structure in the vicinity, can be used to track or at least point out cold active areas of cloud systems.

5. CAUSES OF INCONSISTENT CLOUD MOTION VECTORS

Several trajectories with an inconsistent CMV were selected on a chart computed from a complete series of 47 infrared images from 18 Oct. 1989. The content of the template is observed along each trajectory on a computer animation of the corresponding images. The causes for some of the inconsistent vectors were clearly identified :

- the dissipation of clouds,
- the tracking of a similar structure in the vicinity (fig. 3)
- the tracking of a cloudless region (in this case, the trajectory avoids surrounding clouds),
- orographic effects (the presence of mountains can modify the direction or slow down trajectories).

A qualitative and approximative way to correct a trajectory consists in replacing the inconsistent CMV by a duplicate of the previous vector : its end becomes the start of the "corrected" trajectory. This procedure results often in trajectory extensions in good continuity with the initial (apparently correct) part of the original trajectory.

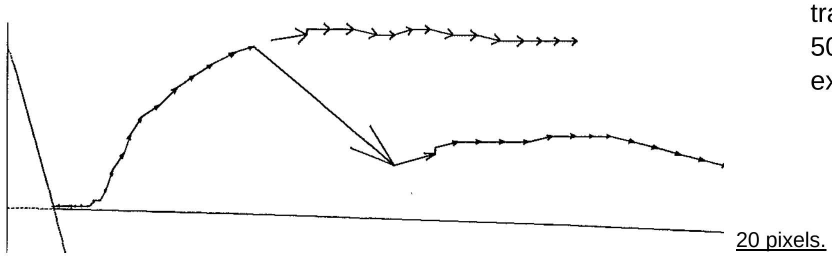

Fig. 3: example of a trajectory (starting at 50°N, 10° W) with its extension

6. CONCLUSIONS AND SUGGESTIONS

Calculation of trajectories with whole template are efficient to track independant cloud elements, and can give indications about divergence in mesoscale structures. At the opposite, trajectories with cold pixel selection tend to converge on active systems, where clouds are generated or remain stable.

Several causes of inconsistent cloud motion vectors were identified. We suggest to use trajectories as quality indicators for cloud motion vectors : checking the consistency of several vectors and related parameters (like the average brightness temperature of the coldest clouds) seem to be a more reliable test than the usual consistency check between two (or three) vectors.

The dependence of the quality of cloud motion vectors with the spatial scale of the structures and clouds inside the templates should be investigated.

Comparisons with interpolated trajectories from other sources, especially ECMWF analyses, will be performed in the near future to validate our method.

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