P5.13 TRACKING AND NOWCASTING OF CONVECTIVE CELLS USING REMOTE SENSING DATA FROM RADAR AND SATELLITE

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1. INTRODUCTION

Rad-TRAM, a new tracking and nowcasting algorithm based on radar data, has been developed at Institute for Atmospheric Physics of the German Aerospace Center (DLR) recently. Rad-TRAM uses a pyramidal image matcher taking into account the spatial scale of detected cells, an algorithm already used in the existing cloud tracker Cb-TRAM (Cumulonimbus Tracking and Monitoring; Zinner et al. (2006)). Using the European radar composite of the German Weather Service (DWD) cells of high reflectivity representing regions with heavy precipitation and hail are identified via a threshold criterion. In order to achieve a more comprehensive picture of the heavy precipitation cells and to evaluate its performance a visual and a statistical analysis has been carried out where the cloud cells detected by the cloud tracker Cb-TRAM and the precipitation cells detected by Rad-TRAM are investigated in parallel. Furthermore the quality of short range forecasts of heavy precipitation cells up to one hour provided by Rad-TRAM has been analysed via typical quality measures.

2. RADAR TRACKER RAD-TRAM

Rad-TRAM (Radar Tracking and Monitoring) is a fully automated tracking and nowcasting algorithm based on the European radar composite by the German Weather Service (DWD). Cells exceeding the threshold of 37 dBZ are identified as areas representing heavy precipitation with the possible occurrence of graupel or hail. They are tracked using the method of maximum overlap and extrapolated for the next 4 timesteps (one timestep is equivalent to 15 minutes) in order to get a one hour forecast. To check if the tracking algorithm works reliably even over many timesteps it was tested over 12 hours for different synoptic situations: a single thunderstorm cell over southern Germany (08.07.2004), a significant cold front passage over Central Europe (12.08.2004) (Fig. 1) and several local thunderstorms caused by heating in the Alps (24.06.2005).

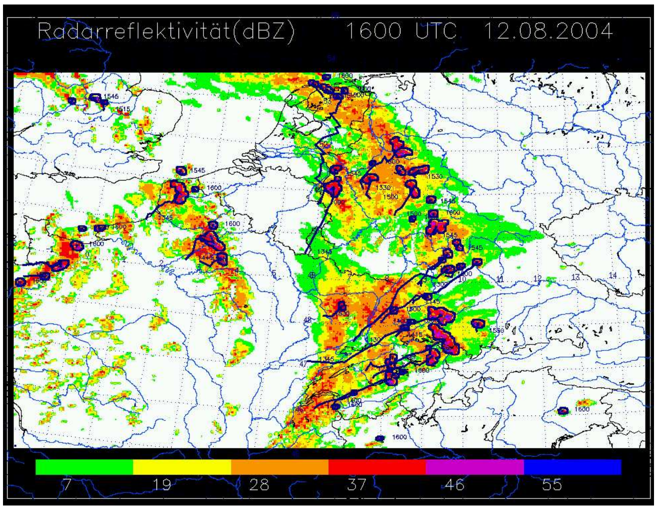

Figure 1: Radar Tracker Rad-TRAM, 12.08.2004, 16 UTC.

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The results show for all days that Rad-TRAM is able to identify and track quite reliably and physically sensible the different cells at the consecuting timesteps as is evident from a subjective visual analysis. Especially when developments are connected to synoptic disturbances long-living cells exhibiting long tracks are found (Fig. 1). Even splitters and mergers can be handled reasonably well due to the applied maximum overlap technique. However, splitting sometimes shows up as sudden kinks in the tracks due to the then sudden displacement of the centre of the cell which is calculated as an intensity weighted average over the cell's area.

3. COMPARISON OF RAD-TRAM AND CB-TRAM

Fig. 2 shows METEOSAT-8 SEVIRI data from broad band high resolution visible channel (HRV) and the cells detected by both trackers at 12th August 2004. Cb-TRAM distinguishes three warninglevels according to the different stages of the life cycle of a thunderstorm cell. Warninglevel 1 (WL 1) represents convection initiation (yellow), Warninglevel 2 (WL 2) rapid vertical development (orange) and Warninglevel 3 (WL 3) mature thunderstorm cells (red). The precipitation cells detected by Rad-TRAM are marked in blue. The relative positions of the cells detected by the both trackers have been investigated for the three synoptic situations mentioned before. A visual inspection exhibited that quite frequently precipitation cells are found within cloud cells or at least overlap in part with those cells. However, at some instances precipitation cells appear without an identified convective cloud. This happens primarily in places where heavy precipitation occurs along the cold front obviously not enforced by convective processes. On the contrary, cloud cells appear without underlying precipitation cells during the initial phase of convection where precipitation has not yet grown above the threshold of 37 dBZ or, conversely, during the decaying phase of the thunderstorm where heavy precipitation has ceized. Of course, most frequently cloud cells representing mature thunderstorms (red contours in Fig. 1) overlap with precipitation cells because in this development stage the highest radar reflectivities are observed. In the case of propagating thunderstorms, as found e.g. in the example from 12 August 2004, long living cells are found in both Cb-TRAM and Rad-TRAM which in cases can be traced in almost parallel tracks for several hours.

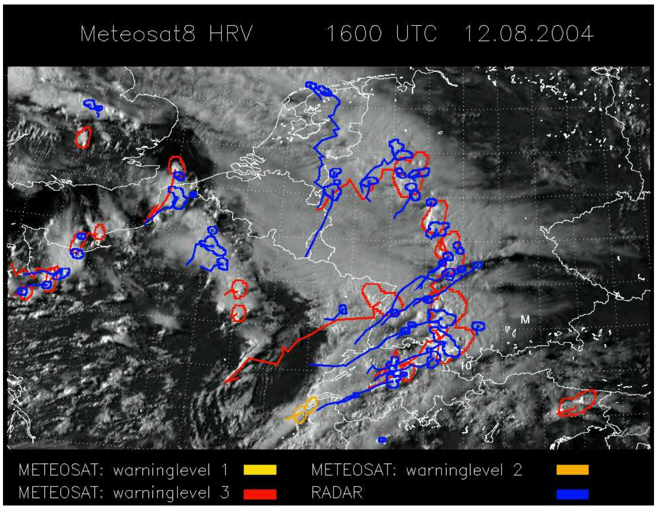

Figure 2: Comparison of Cb-TRAM and Rad-TRAM, 12.08.2004, 16 UTC.

In order to yield a more objective estimation on how often cloud and precipitation are found in same place, a statistical analysis has been carried out. Two different conditions have been applied: firstly the centre of gravity of the precipitation cell has to be within the cloud cell (Tab. 1) and secondly, there has to be some overlap, chosen to be at least one pixel, between both cell structures (Tab. 2). The columns in the tables indicate the date and the relative frequency of occurrence of cell combinations, as given for all cells (RAD/SAT) and also differentiated according to the warning level of the cloud cells. As expected, all values calculated via the first criterion are lower than those with the overlap criterion. In accord with the visual analysis the percentage of cells representing convection initiation (warninglevel 1) is for both criteria the smallest and cells representing warninglevel 3 the highest. All in all, the relative frequencies for both criteria are, and especially for warninglevel 3, lower than could be expected. There are different reasons possible. First of all, even deep convective clouds do not produce precipitation rates detectable as radar signals above 37 dBZ during their whole life time. Furthermore convective clouds are well identified in satellite imagery but corresponding precipitation regions may not be seen by radar due to radar coverage limitations, beam blocking or attenuation. Finally, radar reflectivity might reach a value just below the prescribed threshold or the detected volume might not see the strongest echo cores due to the selected scanning mode.

Table 1: Centre of gravity criterion. (RAD/SAT: Cb-TRAM clouds with Rad-TRAM cells; WL = warning level)

date	Rad/SAT	WL 1	WL 2	WL 3
08.07.2004	9.1 %	1.7 %	4.9 %	38.3 %
12.08.2004	13.0 %	4.0 %	3.6 %	36.8 %
24.06.2005	14.0 %	0.9 %	8.1 %	44.5 %

Table 2: Overlapping criterion. (RAD/SAT: Cb-TRAM clouds with Rad-TRAM cells; WL = warning level)

date	Rad/SAT	WL 1	WL 2	WL 3
08.07.2004	13.7 %	3.4 %	7.9 %	54.3 %
12.08.2004	18.7 %	6.0 %	8.2 %	46.0 %
24.06.2005	18.5 %	0.9 %	12.7 %	53.6 %

4. NOWCASTING - TECHNIQUE AND QUALITY

Rad-TRAM nowcasts precipitation cells based on extrapolation by applying the displacement vector field calculated by the pyramidal image matcher to each detected cell. As the vector field is defined on pixel basis, changes in location, area and shape of the cells are taken into account. Forecasts for 4 timesteps (i.e. one hour) are provided. In order to perform a first check of the quality of the forecasts provided by Rad-TRAM, these are compared with forecasts produced under a persistence assumption. That means the precipitation patterns are displaced without changes in size and shape. These two different types of forecasts are overlaid with the actual observed pattern at the forecasted timestep. For every pattern the nowcasting quality measures 'False Alarm Rate' (FAR), 'Propability of Detection' (POD) and 'Critical Success Index' (CSI) are calculated for the three investigated cases (Fig. 3, 4 and 5). Here it has to be kept in mind that all cells for which a verification was possible were used and no restriction as regards to cell size are made. The POD and FAR consistently show a decrease in forecast quality with increasing forecasting period for all days. The forecasts provided by Rad-TRAM continuously show better results for both measures. But after one hour it can be seen that there are nearly no differences between the forecasts. This shows that limiting the forecast horizon to one hour is reasonable (Mueller et al. 2003). Overall forecasts provided by Rad-TRAM show better skills than those based on persistence. This is, of course, not a surprising result, but at least a first step towards more demanding tests to be performed within the near future.

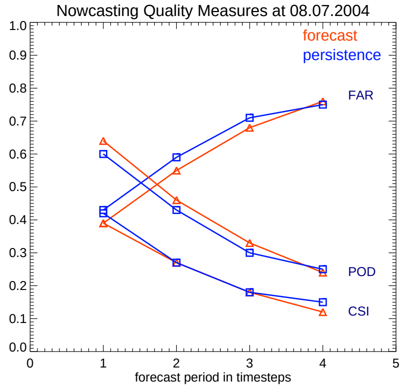

Figure 3: Nowcasting Quality, 08.07.2004.

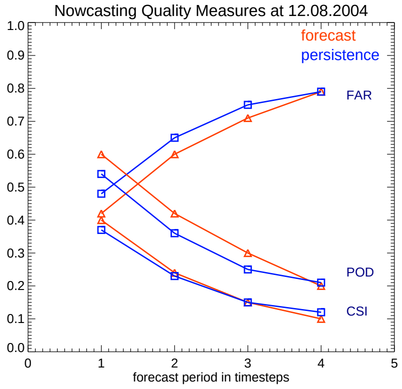

Figure 4: Nowcasting Quality, 12.08.2004.

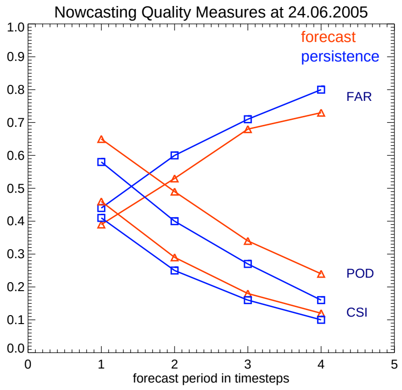

Figure 5: Nowcasting Quality, 24.06.2005.

5. CONCLUSIONS

The results from this study suggest that the new radar tracker Rad-TRAM has the potential for further development. Precipitation cells could be tracked realistically and during surprisingly long time intervals. Comparisons to convective clouds identified and tracked by the satellite tracker Cb-TRAM show agreement and overlaps in many cases, especially when clouds have reached a mature thunderstorm state. The appearance of one sort of cells without the other is attributable to the life cycle of thunderstorms and to deficiencies in radar coverage and difficulties in detection. Based on this first experience it is planned to use the radar and satellite trackers in combination which should allow a more complete description of the storm at hand, especially as regards to life cycle and near future development.

References

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