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STUDYING THE LIFE CYCLES OF CONVECTIVE CELLS IN THE UPPER RHINE VALLEY

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1 INTRODUCTION

It is a reasonable suggestion that the formation and life cycles of convective cells can be triggered by orography. The revelation of such an assumption is possible if the following items are met: a pronounced orography as well as an instrument which detects and tracks convective cells. This is the case in the Upper Rhine valley where a radar is operated.

As can be seen from fig. 1 the Upper Rhine valley is surrounded by the Vosges and the Black Forest in the south as well as the Palatinatian Mountains and the Odenwald in the north. This situation shows, e.g., a remarkable channeling of surface winds (Fiedler, 1983). On the other hand, a C-band Doppler radar is available the data of which have been analyzed by a newly developed tracking algorithm TRACE3D allowing for identifying and tracking of appropriately defined radar reflectivity cores (= convective cells) Handwerker (1999). This study presents some characteristics of convective cells as its appearance due to season, daytime and wind direction in the Upper Rhine valley.

The only data used by TRACE3D are the polar reflectivity data as measured by the radar and, if available, the wind data from the VVP algorithm (Waldteufel and Corbin, 1979). The input data are measured with a time resolution of 5 min. Each radar data set consists of 14 elevations (from 0.4° to 30°) with 1° angular resolution. The range is 120 km, consisting of 240 range bins à 500 m length. The data used cover the whole year 2000.

2 STATISTICAL DESCRIPTION

Within the year 2000, more than 16 000 tracks of thunderstorms were analyzed. 82% of them are free of any splitting or merging event. For 14% of the tracks there is at least one radar image, where two convective cells belong to this single track, i.e. a splitting and/or merging took place. Only in 4% of all tracks there are radar

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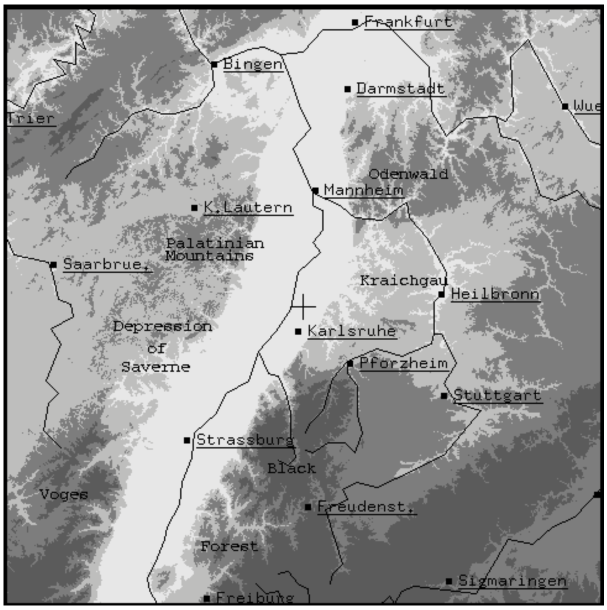

Figure 1: The orography around the radar, which is sited 10 km north of Karlsruhe (+). The grey scale denotes heights of < 200 m, 200 m to 350 m, 350 m to 600 m and > 600 m a.s.l.

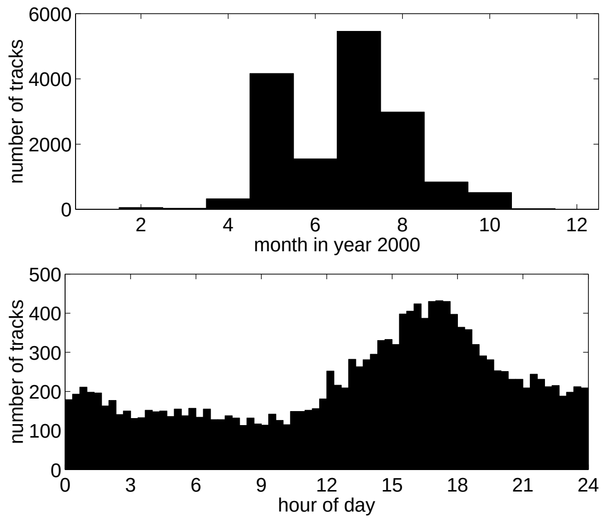

Figure 2: Distribution of cell tracks as function of time.

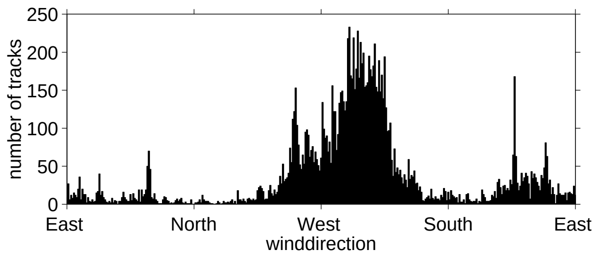

Figure 3: Distribution of the thunderstorms as function of wind direction.

images with more than 2 cells belonging to the same track.

The distribution of thunderstorm tracks as a function of the season and daytime is shown in fig. 2. Besides the fact that there is an significant lack of convective events within june 2000, the figure meets expectation: There is a prominent maximum of convective activity in the late afternoon (1700 LT) and there are secondary maxima around 2200 LT and 0100 LT.

The distribution of thunderstorms with respect to winddirection, calculated as average of the VVP velocities between 2000 m and 4000 m above radar, shows a strong preference of thunderstorms to occur during periods with westerly and southwesterly wind (fig. 3). 72% of the thunderstorms are observed for winds from 245°± 45°, additional 15% when wind came from easterly directions (110°± 45°).

The average life time of a thunderstorm as it is calculated by TRACE3D is roughly 18 min. Nearly 6000 cells (roughly 35%) were observed for as short as 5 min. (fig. 4). If these very short living thunderstorms are left out, the average life cycle is 25 min. Note that these times depend strongly on the criteria by which a convective cell is defined. It is seen that the number of thunderstorms decays nearly exponential as a function tims. The average duration shows neither a significant dependency on winddirection nor on season.

On the basis of a temporal resolution of 5 min. the number of observations of a certain thunderstorm is equivalent to its life cycle. Fig. 5 shows, that the life

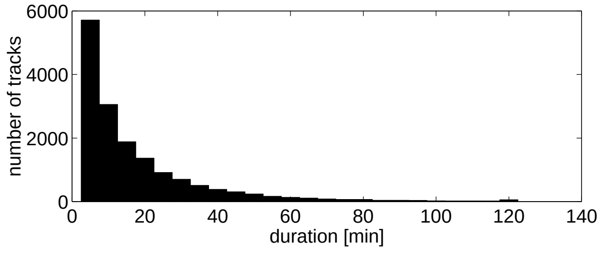

Figure 4: Distribution of life cycle of storms.

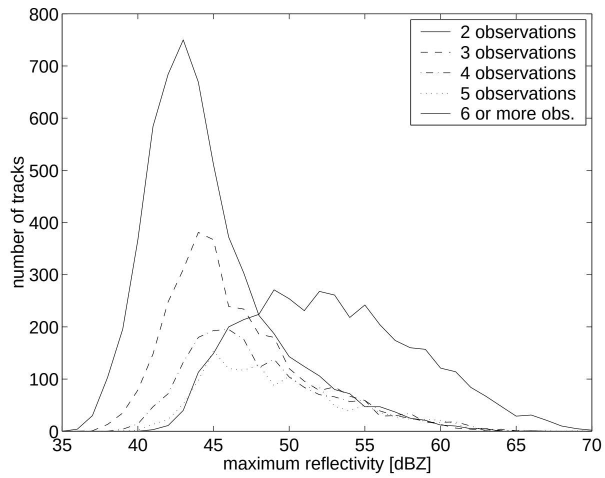

Figure 5: Distribution of the maximum reflectivity. The number of observations is equivalent to the life cycle of the storm. The time step is 5 min.

cycle of a thunderstorm and the maximum reflectivity value reached by this storm during its life cycle are correlated. The maximum reflectivity value of those thunderstorms, that were observed in 2 radar images corresponding to a 5 min. life cycle is 44.6 dB_Z. The storms that are observed in 3 (4, 5) images have a maximum reflectivity of 46.4 dB_Z (48.1 dB_Z, 49.2 dB_Z) and the storms that reach a longer life cycle attain maximum reflectivities of 52.9 dB_Z on the average.

This correlation does not necessarily mean that thunderstorms showing large reflectivity values tend to live for a longer time span. Whether this thesis holds or longer living cells just have statistically more chances to reach higher reflectivity values is not clarified yet.

No obvious dependency of the maximum reflectivity on season is found.

3 OROGRAPHY AND CONVECTION

How orography influences convection should depend on the synoptical situation. Besides the vertical wind structure especially the temperature and humidity profiles influence the way how thunderstorms react on obstacles. These data are not actually at hand for 2000. Instead all tracks found in 2000 were classified with respect to the winddirection derived from the VVP algorithm within 2000 m and 4000 m during their life cycle. There are some tracks where no VVP velocity is available because there was not sufficient precipitation around the radar site. These tracks were left out for this analysis. The remaining tracks are grouped to 36 equally populated groups of corresponding wind direction. The first group consists of those tracks with winddirection between 56° and 90°, the second between 29° and 56° and so on. Each group consists of 375 tracks.

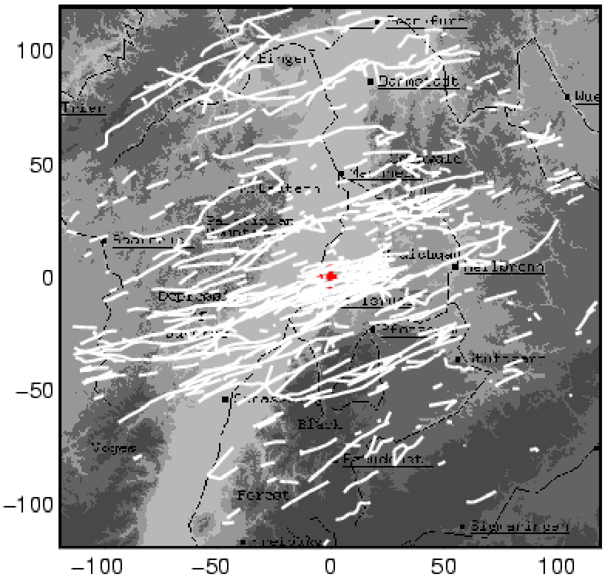

Figure 6: All tracks of thunderstorms observed in 2000 during periods with winddirection between 250° and 252°.

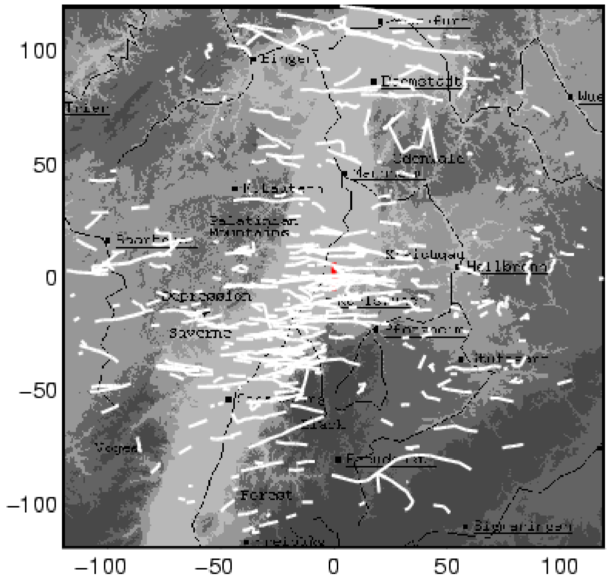

Figure 7: Same as fig. 6 but for winddirections between 265° and 269°.

These tracks are then plotted into the orography map (fig. 1), producing 36 images of thunderstorm tracks. Two of them are exemplarily presented here.

Fig. 6 shows all tracks which were observed during periods with a winddirection between 250° and 252°. Although most of the tracks are observed in the Upper Rhine valley, the depression of Saverne and the Kraichgau there are some tracks crossing the Black Forest. There is a cumulation of tracks starting at locations between the northern part of the Voges and the depression of Saverne and heading towards the radar and beyond. The tracks in this figure belong to 39 different days.

The comparison with fig. 7 shows a significant different situation: The wind direction varied between 265° and 269° when these tracks were observed, i.e. there is a difference of only 16°. These tracks stem from 29 days during year 2000. Their average track length is a lot shorter, they cross the upper Rhine Valley from west to east and there is a gap on the rear side of the Palatinatian mountains as well as the Black Forest. Considering the only small difference in wind directions between figs. 6 and 7, this is a remarkable result. There is no such preferred concentration of tracks as in fig. 6, although there are still more thunderstorms observed in the vicinity of the radar than in larger distances.

Note that this is only a first glance on the data. Further investigations will have to prove significance of these results. Is the difference between the two groups of tracks shown here caused by meteorological phenomena or is it due to the limitations of the radar (e.g. attenuation or visibility) or is it just random? Does the difference hold for other years? These questions need a deeper investigation, and are left to future.

4 OUTLOOK

The thunderstorms observed in the year 2000 by the Karlsruhe Doppler Radar were tracked using the algorithm TRACE3D. More than 16000 tracks were identified and described statistically by some properties, relying on certain specifications of TRACE3D.

Sorting the tracks just by the prevailing winddirection shows a distinct dependency of the spatial distribution of the tracks on this parameter. At the moment we can not give a detailed explaination for this difference. Additional data on the meteorology of all situations with convective cells might reveal certain conditions on the growth and decay of convective cells developing over a pronounced orography.

References

Fiedler, F., Einige Charakteristika der Strömung im Oberrheingraben. Wiss. Ber. des Meteorologischen Instituts der Universität Karlsruhe, (1983).

Handwerker, J., First results of TRACE3D – a new tracking algorithm for convective cells. In: 29th International Conference of Radar Meteorology, AMS, Montreal (1999).

Waldteufel, P. and Corbin, H., On the analysis of single doppler data. J. Appl. Meteor., 18 (1979) 532–542.