# JP1.1 ON THE SMALL SCALE STRUCTURE OF CONVECTIVE PRECIPITATION

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## 1. OBJECTIVES

The spatial structure of precipitating clouds as seen by conventional C-band weather radars in the air mass behind cold fronts were investigated. These cloud fields reveal an unique structure with e.g. isolated clouds, cloud clusters, rolls, open and closed cells which make them clearly identifiable by radar and also satellites. The objective of the study is to adequately describe the cloud field structure, to understand its formation and its temporal development. Here we present two first results.

## 2. METHOD

We have used weather radar data from the German Weather Service radar network. Data was available for the time periods between 01 May 1997 to 06 September 1997 and 01 June 1998 to 31 August 1998, respectively the summer months. The national radar composite product comprises the spatial distribution of the near-surface radar reflectivity as a logarithmic, six-step color scale (dBZ values) with a lower cut-off of 7 dBZ. Each of the 15 local radars contributes the lowest elevation PPI (plane position indicator) which is not obscured by the surrounding terrain. The radar composite covers most of Germany and also parts of neighbouring countries and extends over an area of 920 km x 920 km. The spatial resolution is 2 km x 2 km per pixel. Every 15 minutes a new radar composite is available. Data in this study was clutter filtered by the routinely applied filters. Based on satellite images and conventional weather maps we have selected 39 days where cold fronts passed over Germany. From altogether 3258 radar scans we identified the cloud fields and the convective clouds contained herein. For the extracted approximate 140000 precipitating clouds we determined (i) the number of clouds in the respective cloud field, (ii) the area coverage, (iii) a length scale D of a cloud, (iv) the perimeter U, and (v) the area F, given by the lowest reflectivity value of 7dBz. For each of these quantities we determined the diurnal cycle, the frequency distributions and functional relationships between them.

## 3. RESULTS

In the present analysis we distinguished isolated clouds with only one radar reflectivity maximum from clusters with more than one.

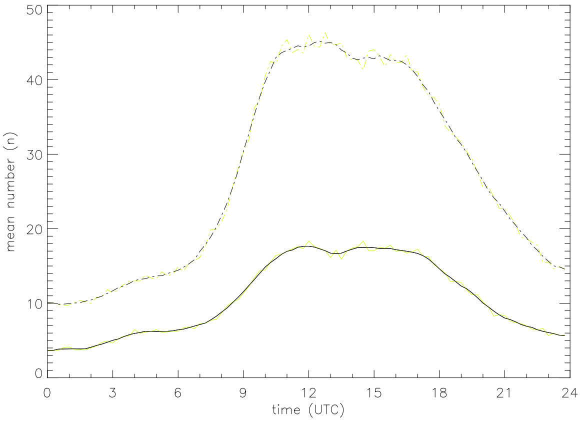

Figure 1. Diurnal cycle of number of isolated cells (dashed) and clusters (solid).

From the diurnal cycle of number of isolated cells and clusters in Fig.1 we first note that there is a certain number of ~ 20 cells even during the night. As the 39 analysed days are not consecutive ones, the mean diurnal cycle is not necessarily periodic. The number of cells increases strongly between 7 and 11 UTC. After local noon at about 11:15 UTC it remains more or less constant for six hours. After 16 UTC the number of cells decreases at a rate of approximately eight per hour. The average maximum number of cells is about 60. There are far more individual cells than clusters. On average the maximum number of individual cells reaches 45. But at the same time only eighteen clusters are present. Surprisingly, the ratio between the number of individual cells and clusters remains almost constant during the day. On average 28 % of the cells are

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clusters and 72 % single cells with only a slight variation of ± 3 %. As cloud clusters are formed by merging of individual cells, the constant ratio points towards a equilibrium state of this process, irrespectively of the number of cells present. Individual cell area is approximately 240 km$^2$, cluster area varies between 2500 km$^2$ at night and 4500 km$^2$ at about noon. As the number of cells which make up a cluster is known, their average size can be calculated as well. The result shows that cells within a cluster are about 2.5 times larger than individual cells. Their area ranges between 520 and 700 km$^2$ during the day. The reason for this size difference is not understood yet but may be attributed to the fact that the merging process of individual cells is more likely for large cells, which after the merging maintain their size or become even larger. This significant difference in area size per cell, isolated or as part of a cluster, emphasizes the importance of cloud cluster.

A second result concerns the relation between the perimeter U and the area F. Lovejoy (1982) in his analysis of area-perimeter relation for rain and cloud areas found

(1) $U^2 \sim F^D$ with D=1.35.

The number *D* is referred to as fractal dimension of cloud and rain areas in reference to Mandelbrot's (1977) theory of fractals.
The scatter plot of $U^2$ vs. F in Fig. 2 ranges over four orders of magnitude in $U^2$. To the first order a straight line is found in the log-log presentation implying again a relationship of the form

(2) $U^2 \sim F^D$

with D = 1.359. This value is nearly identical with the one found by Lovejoy and confirms the consistency of both studies. A closer look, however, reveals a slight curvature of the data which points to the existence of at least two values for b. Trying to find the best choice for a two-line fit, we distinguished between cells which consist of no more than 3 single cells and larger cells. For the former a value of D ~ 1.25 is found while for the latter D ~ 1.54. The scatter could be reduced by this in comparison with the one-line fit. This is clearly a modification of Lovejoy's result who derived a universal fractal dimension for the clouds he investigated. It should be noted that his analysis was based on radar and satellite data, while in this study only radar data was used. Following his arguments, we conclude that the structure of individuals cells and cluster and the processes involved in their formation differ significantly. The larger area value of cells contained in a cluster which was mentioned above, is in line with this result.

## 4. SUMMARY

This first analysis of precipitating cloud fields in the postfrontal cold air mass yields interesting results. Despite of the huge variability of individual cloud forms and shapes some characteristics seem to follow universal laws. Two were emphasized: (i) the constant ratio of clusters and individual cells in the mean diurnal cycle, and (ii) the perimeter-area relationship (2). The latter on the one side shows similarity between small clouds and large clouds, respectively clusters over four orders of magnitude. On the other side differences also become visible.
Further results not discussed here concern the third structure parameter D, the distribution function for the structure parameters and the regional distribution within Germany. Results will be published elsewhere.

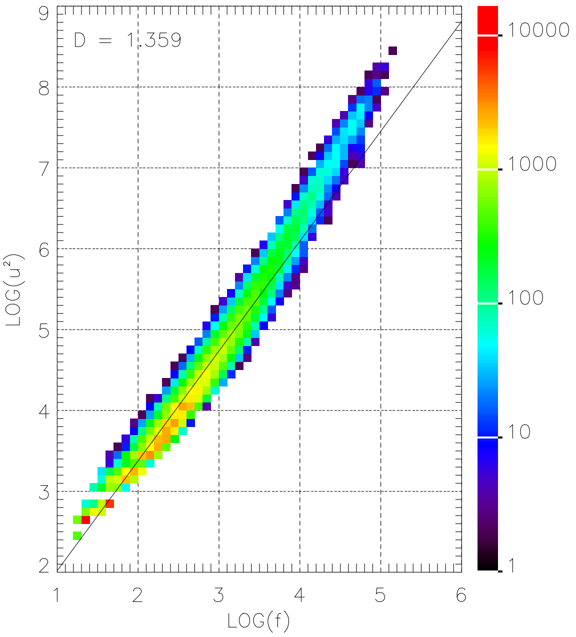

Figure 2. Area-perimeter distribution. Color code gives the number of clouds involved.

Lovejoy, S.: Area-perimeter relation for rain and cloud areas. *Science*, 216, 185 – 187, 1982.

Mandelbrot, B.: *Fractals*, Freeman San Francisco, 1977.