Orographic Influence on the Life Cycle of Convection – Observations during the COPS Field Campaign

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1. Introduction

COPS (Convective and Orographically-induced Precipitation Study, Wulfmeyer et al., 2008) was an international field campaign. That took place in the Upper Rhine Valley, the Black Forest and the Vosges Mountains during summer 2007. The aim of COPS was to study the orographic influence on the initiation and life cycle of convection, mainly by investigating the humidity structure. Observations with advanced instruments should help to improve the forecast skill of mesoscale numerical models, especially precipitation forecasts. Among the large number of observed convective systems we will concentrate on the observations of isolated small convective rain showers which developed in the Vosges Mountains on two consecutive days. While on one day the cells were initiated at the crest line of the mountain range, on the second day the cells developed on the lee side of the Vosges Mountains in the Rhine Valley.

2. The COPS field campaign

For the COPS field campaign the polarimetric C-band Doppler radar POLDIRAD (Schroth et al., 1988) was deployed for 3 month in the foothills of the Vosges Mountains about 20 north-west of Strasbourg (Fig. 1) and about 100 m above the floor of the Rhine Valley. Volume scans were performed up to 120 km range every 10 minutes. A large set of instruments were set up at the super sites Aachern, Hornisgrinde, Deckenpfronn, and Bischenberg/ Meistratzheim. Additionally the ARM mobile facility was installed in the Murg Valley. At the French super site Bischenberg a high resolution (temporal 30 sec., radial 60 m) scanning X-band radar was installed. The maximum range was 20 km.

In addition to the observations several meso-scale numerical models were used to provide forecasts for the field campaign and to perform studies with different microphysics schemes. For the present study we used the simulations with the French MesoNH model. The model was run nested with three levels, the inner nest was centered around the COPS region covering a domain of 400x400 km^2 using a horizontal resolution of 2x2 km^2.

3. Observations of isolated cells

In addition to stratification and the moisture field, topographic features have a strong influence on the initiation and development of convection. Mountains

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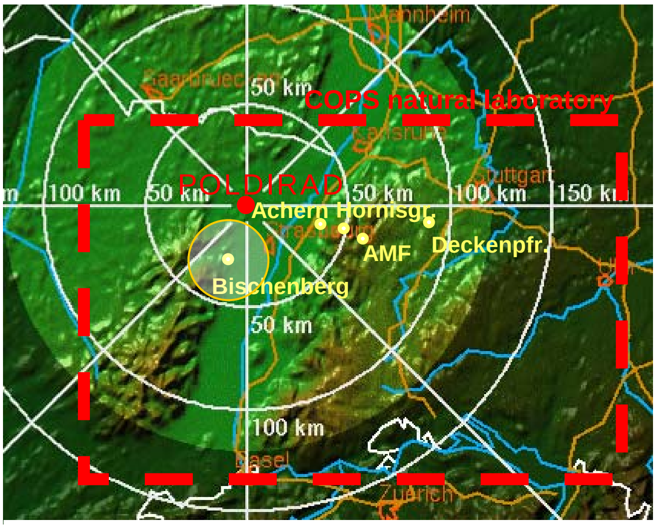

Fig. 1 The COPS region in South-Western Germany and North-Eastern France. Range rings are from POLDIRAD, yellow dots show locations of super sites. The highlighted circle around Bischenberg indicates the 20 km range of the X-band radar.

provide elevated heat surfaces which can destabilize the stratification in the boundary layer. Also, mountains can initiate flow convergence along the crest line providing a source for convection initiation. On a larger scale mountains can distort the flow generating convergence in relation the orography.

During COPS on several days only small isolated shower or thunderstorm cells developed in the COPS region. A distinct situation was observed on August 12 and 13, 2007. On both days isolated cells developed in relation to the Voges Mountains. On August 12th the cells were initiated along the crest line, whereas on August 13th the cells were initiated in the lee of the mountains.

Fig. 2 shows two sample PPI images of reflectivity for

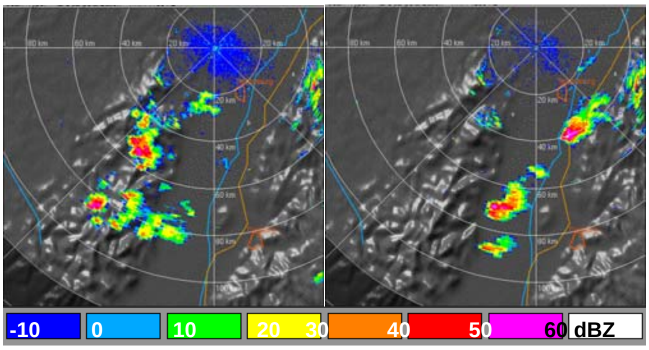

Fig. 2 PPI of reflectivity on 12 Aug. 2007 1440 UTC (left) and 13 Aug. 2007 1120 UTC (right).

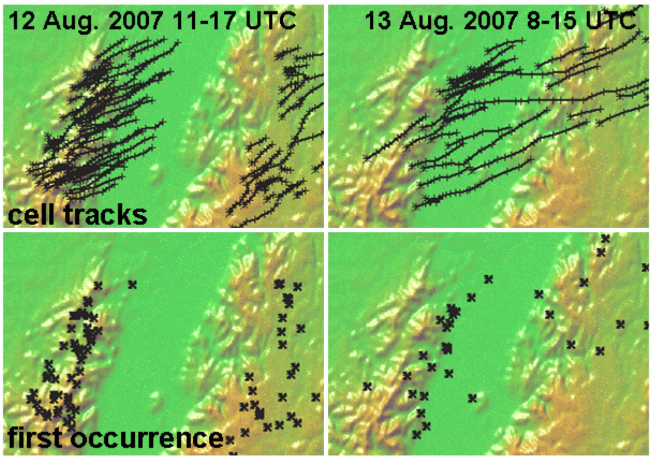

Fig. 3 Tracks of cells (top row) and location of first occurrence (bottom row) for 12 August and 13 August 2007.

the two days. On 12 August cells developed over the Vosges and travelled afterwards with the mean south-westerly flow into the Rhine Valley while decaying there. On 13 August the cells developed in the lee of the Vosges, traveling across the Rhine Valley and some of them where enhanced again at the windward slopes of the Black Forest.

Fig. 3 shows the cell tracks and location of first radar echo for the two days. In total 80 and 38 cells were tracked on 12 and 13 August, respectively. 51(22) of them have been initiated in relation to the Vosges Mountains. The life time of the cells is shown in Fig. 4. On both days the life time was in the order of 0.5 to 2 hours, with some cells being active for even a longer time. This is mainly for 13 Aug. where some cells were able to cross the Rhine Valley and were intensified at the windward slopes of the Black Forest.

The X-band radar at Bischenberg allows for observations with high temporal resolution. In Fig. 5 the evolution of a cell within 14 minutes is shown. This cell decayed later south of POLDIRAD (see Fig. 2 left, 1440 UTC). These observations show that the cell is fed by a convective source until about 1308; afterwards it is advected with the mean south-westerly winds.

Simulations with the mesoscale model MesoNH have been able to reproduce the diverse life cycle of the cells. The quite realistic simulations are also of great value to

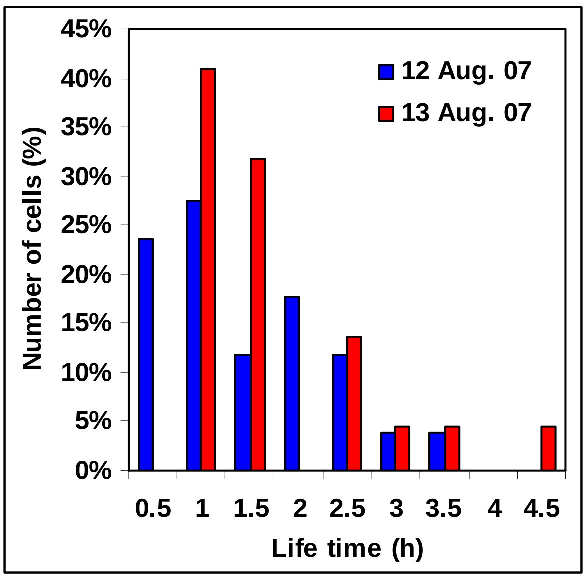

Fig. 4 Life time of the cells initiated in relation to the Vosges Mountains.

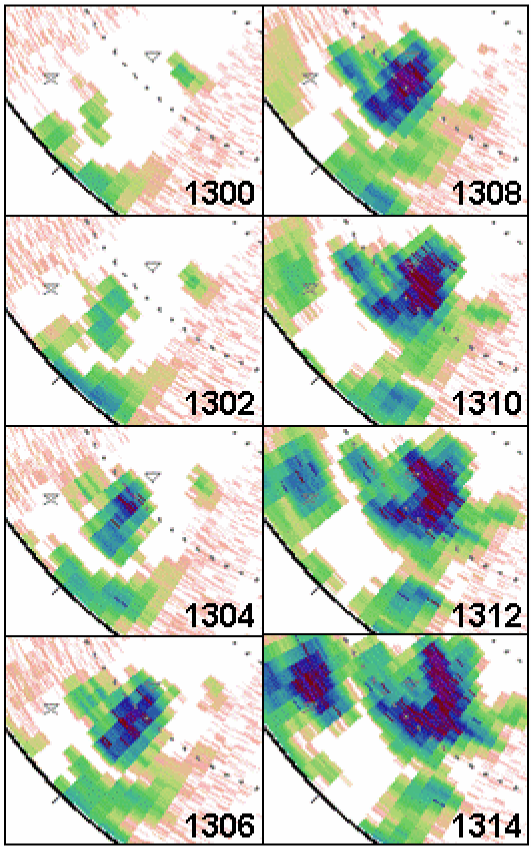

Fig. 5 X-band radar observation of a cell development south-west of the radar, 12 Aug. 2008, 1300 - 1314 UTC. Range rings are at 10, 15, and 20 km.

access atmospheric parameters which have not been observed in 3 dimensions, like the moisture structure and the wind field. Wind observations like wind profiles are available from super sites, or from VAD profiles analysed from POLDIRAD measurements. However, the wind profiler at the French super site close to Bischenberg was no longer available in August, and in any case these instruments can not reveal the horizontal variability.

The wind field close to the surface and simulated radar reflectivity is shown in Fig. 6. While on 12 Aug. weak south-westerly winds are prevailing, strong westerly winds are simulated and observed on 13 Aug. The simulated cells correspond to the observed ones, not exactly in time and

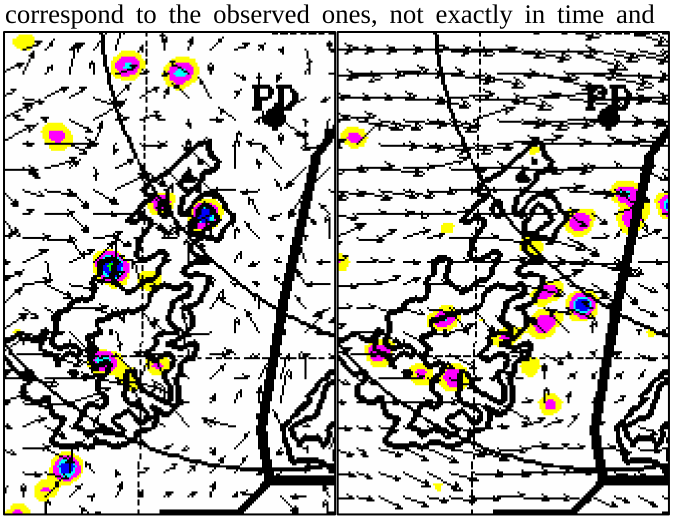

Fig. 6 MesoNH simulations showing surface winds and simulated radar reflectivity for 12 Aug. 07, 15 UTC (left) and 13 Aug. 07, 11 UTC (right). PD indicates POLDIRAD.

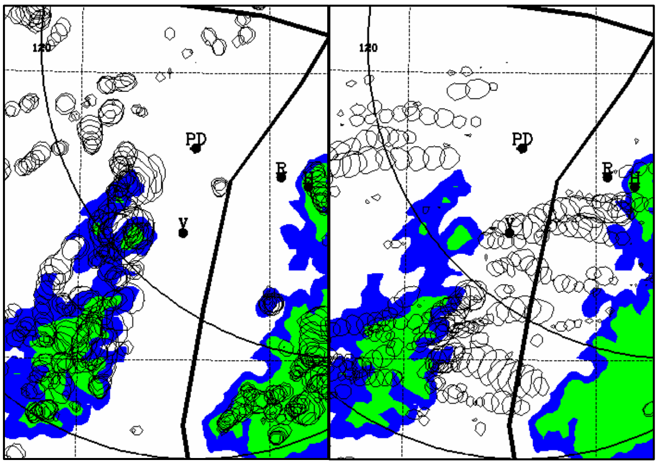

Fig. 7 Traces of cells derived from simulated reflectivities for 12 Aug. 11-17 UTC (left), and 13 Aug. 8-15 UTC (right).Colors indicate height of terrain, blue > 500 m, green > 750 m MSL.

location, but with similar life time and cell initiation (cf. also Fig. 7). Some discrepancies between observations and simulations occur on 12 Aug. when the cells did not propagate into the Rhine Valley, and on 13 Aug. when there are some simulated cells over the Vosges Mountains. In the observations cells develop over the Vosges Mountains about 2 hours later in relation to an approaching trough.

4. Conclusion and outlook

Observations with radar during the COPS field campaign in Central Europe of isolated shower cells show a strong dependence on the orography and the prevailing wind field. The wind field is different on both days. On 12 Aug. weak winds prevail and convergence over the mountains initiate convection above the Vosges. On 13 Aug. strong westerly winds prevail, the simulations show a channelling of the flow in the Rhine Valley and backing winds towards the Vosges. The convergence occurs in the lee of the Vosges and cells develop along the eastern slopes. Fig. 8 tries to sketch the processes on the two days.

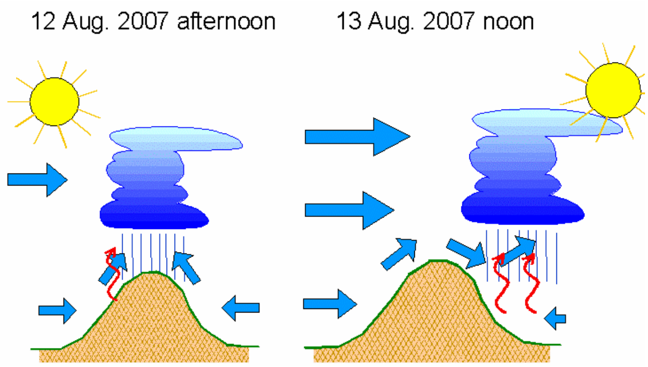

Fig. 8 Sketch of the development of cells in relation to the Vosges Mountains on 12 and 13 August 2007.

The simulations with MesoNH were able to reproduce the observations in a quite realistic manner. Certainly some details can not be reproduced like the exact timing of the development. However, there are some similarities regarding “hot spots” of cell initiation in relation to orography. One “hot spot” is evident on 13 Aug. in the northern part of the Vosges close to the French super site (indicated as **V** in Fig. 7).

Further data evaluation will concentrate on clear-air Doppler measurements with POLDIRAD and a mobile Doppler radar (DOW) located east of the river Rhine close to Strasbourg.

References

Schroth, A.C., M.S. Chandra, and P. Meischner, 1988: A C-Band coherent polarimetric radar for propagation and cloud physics research. *J. Atmos. Ocean. Technol.*, **5**, 803-822.

Wulfmeyer, V., et al., 2008: The Convective and Orographically-induced Precipitation Study. *Bull. Amer. Meteor. Soc.*, in press.