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Triggering Effects for Deep Convection over Mountains

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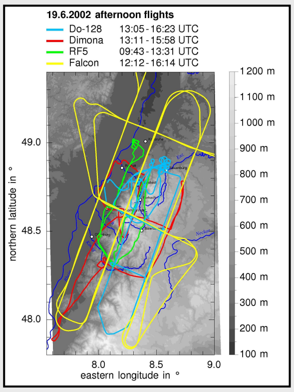
The Focus

The subproject TP 3 aims on the detection and understanding of the sequence of processes triggering deep convection over mountains. Extensive, multi-platform and multi-sensor experimental efforts are made to assess the 3-dimensional, time-dependent evolution of convection. The merged data sets are used for the evaluation and improvement of convection schemes in mesoscale models (LM, KAMM).

TP3 is linked to TP1, where surface processes (energy balance, soil moisture variation, vegetation cover, mesoscale circulations) are studied, to TP2, where the water balance of the developing convective clouds is investigated, and to TP 5 where LM simulations with changing model architecture are under focus. The case of June 19, 2002, comprises data from 4 aircraft operating over the northern Black Forest.

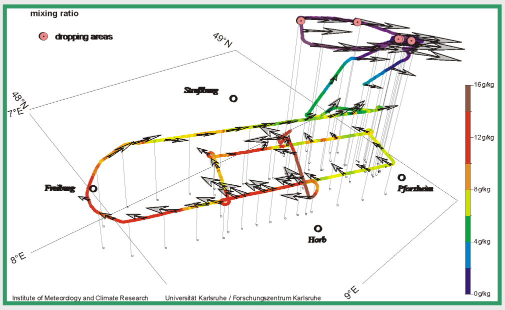


The Results

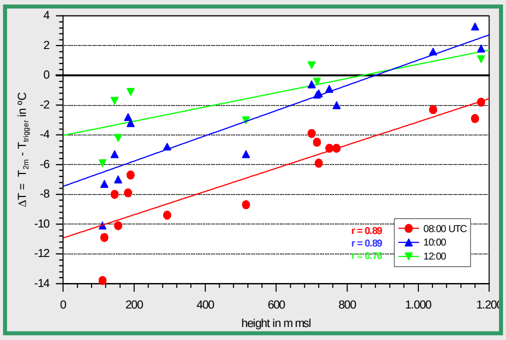
Moisture advection in the mountain range and moisture convergence above the ridges in co-action with surface processes (TP 1) triggers deep convection. In the pre cloud phase of convection the turbulent flux of latent heat is more than 6 times as high as the flux of sensible heat. The trigger temperature is exceeded in the high mountain range.

LM simulations (7 km) with convection parameterisation result in correct time and location of convection triggering but do not calculate terrain induced mass flux convergence, because the terrain structure of the model is not realistic. LM (2.8 km) without convection parameterisation simulates convection at the right place and time. The amount of precipitation generated by the model is half as much as in reality.

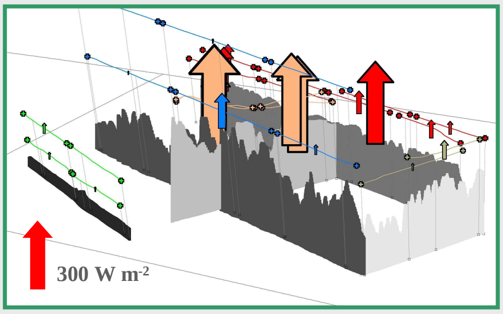
Experimental Findings



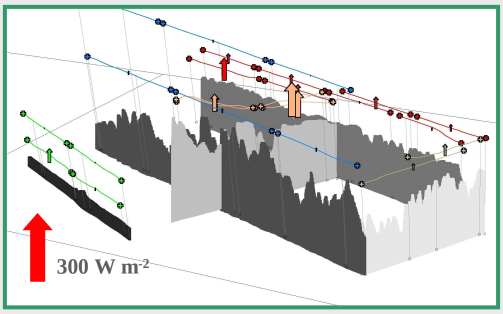
As airborne measurements show, at noon the PBL over the Black Forest is characterised by inflow of humid air from the east to the mountain range. In the Rhine valley and above wind from southwest prevails. Moisture advection and moisture convergence is detected.



Air temperature T_{2m} reaching the trigger temperature $T_{trigger}$ for convection is a function of time and terrain height. As calculated from surface data and temperature profiles convection is triggered in heights above 900 m msl after 10 UTC.



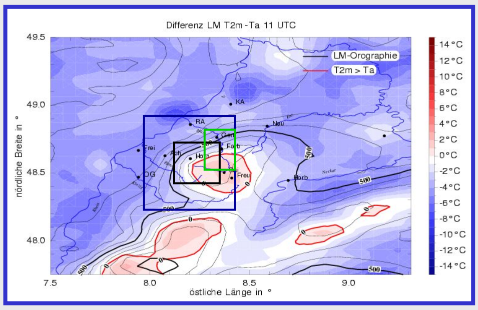
Turbulent fluxes of latent heat calculated from airborne measurements on low level flight legs above the northern Black Forest. View from SW. Heat fluxes up to 647 Wm^{-2} are detected over the steepest slopes.



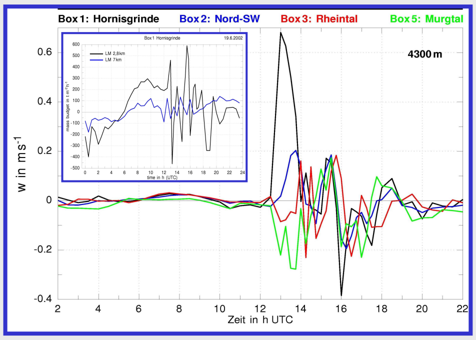
Turbulent fluxes of sensible heat deduced for the same flights as above. View from southwest. The maximum sensible heat is less than 100 Wm^{-2}. Moisture advection and moisture convergence governs the development of convection in this case.

Model Simulations

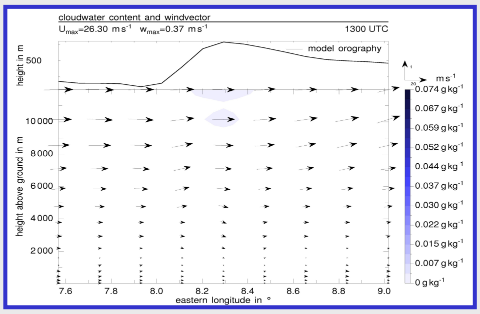
The LM operated with 7 km resolution and convection parameterisation: Convection is predicted over the entire northern Black Forest above 700 m, beginning at 11 UTC.



Vertical motion at 4300 m within 4 subdomains of the LM 2.8 km without convection parameterisation. Updrafts are simulated over the Hornisgrinde, compensating subsidence is found in the Murg-box (boxes see above). The LM (7 km) does not simulate the convergence necessary for convection



Cross section of vertical wind speed and cloud water content over the northern Black Forest at 13 UTC (LM 7 km, convection parameterisation). In spite of T_{2m} is exceeding $T_{trigger}$, no convective cells and no clouds are generated due to missing terrain forcing.



Same simulation as above but 2.8 km model resolution without convection parameterisation. Little east of the Hornisgrinde, a convective cell is generated at 13 UTC, forming a cloud with subsequent rainfall at the same position as the cell has been measured.