Coherent structure patterns affect energy balance closure: evidence from virtual measurements for a field campaign

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Introduction

In this study, a large-eddy simulation model with synoptic scale forcing is used to investigate the influence of the large - scale organized turbulent transport on the surface energy imbalance.
Two days with different energy balance closure(EBC) were studied and simulated, in order to:

1. Characterize the influence of the large-scale organized turbulent transport on the surface energy imbalance
2. Assess the partitioning between sensible and latent heat flux of the energy balance residual

Measurements

The data used in this study was collected from the field campaign “High definition clouds and precipitation for advancing climate prediction” (HD(CP)²), which was conducted near Jülich, Germany.

Time period	April and May, 2013
EC sites	Merzenhausen (50.87°N, 6.45°E) Selhausen (50.93°N,6.30°E) Surface heat fluxes
Doppler wind lidar	Vertical and horizontal wind
Radiosondes…etc	Temperature, Relative Humidity…etc

Table 1. *Descriptions of the measurements from the campaign*

On April 7, the day with cell-like pattern had a lower energy balance ratio (R), whereas the day with roll-like pattern, April 16 presented a better energy balance closure.

	April 7	April 16
Surface wind speed(m/s)	0~2	2~4
$R_{Selhausen}$	0.79	0.97
$R_{Merzenhausen}$	0.70	0.85

Table 2. *The energy balance ratios R at Merzenhausen and Selhausen*

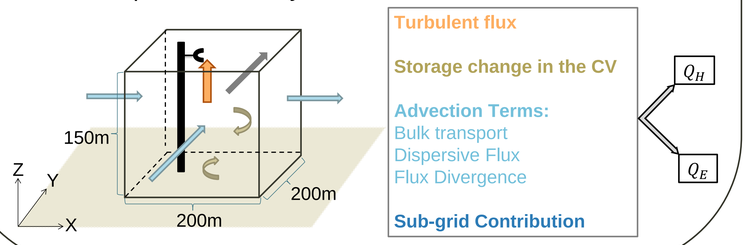
Model setup

PALM, a PArallelized Large-Eddy Simulation Model, is used to simulate the selected two days of interest.

Domain size	12km×12km×16.75km (streched)
Grid points	960× 960×400 (12.5m resolution)
Large-scale forcing	COSMO_DE analysis data (2°x 2°) Horizontal and vertical advection Geostrophic wind
Nudging	τ = 3 h
Simulating time	15h (06:00 – 21:00)

Eddy-covariance control volume method

An approach to determine EBC instead of spatial averaging was applied in the simulation. Within a control volume, the prescribed surface heat flux is decomposed into several terms by the budget equation. Moreover, the calculation was conducted for sensible or latent heat part individually.



Results

April 07th, R_{model}= 0.65 | **April 16th, R_{model} = 0.85**

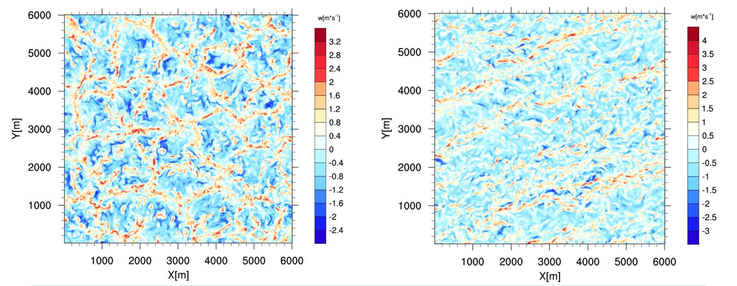


Fig.1. *X-Y cross section of vertical velocity at the height of 100m*
Model outputs showed different coherent structures: on April 07, the spoke-like patterns appeared during the daytime. By contrast, it presented streaky patterns on April 16.

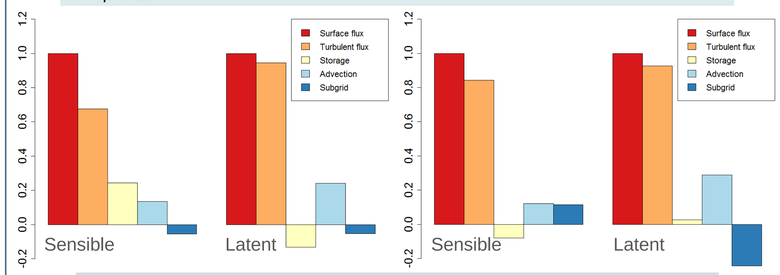


Fig.2. *Daily-averaged contributions of control volume terms for the surface heat budget*
The main factors that affected the control volume energy imbalance are the advection and storage terms. Furthermore, eddy-covariance method did not underestimate sensible and latent heat fluxes in the same proportion and a larger part of the “missing” energy was related to the sensible heat flux.

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Conclusions

In this study, we have employed PALM as a virtual measurement tool to investigate the energy balance closure. On the day with poor energy balance closure, advection and storage terms play an important role in the transportation of surface heat. Furthermore, by comparing the control volume results for sensible and latent heat budget, we draw the conclusion that the lack of EBC originates mainly from an underestimation of the sensible heat. Latent heat is also underestimated, but to a lesser extent.