A strategy to study effects of soil moisture, evapotranspiration and water vapour in the PBL on QPF on the COPS scale

C. Hauck, N. Kalthoff, U. Corsmeier, L. Gantner, M. Kohler, F. Königer, C. Meissner, G. Schädler, C. Kottmeier

Institute for Meteorology and Climate Research, University of Karlsruhe/Forschungszentrum Karlsruhe

Motivation

- water budget in the PBL:
  - moisture content = source of precipitation
  - local vs regional effects:
    - advection of moisture, wind field
    - initiation of convection, turbulent fluxes, surface characteristics, soil moisture
    - orography
- problem:
  - convective precipitation ➔ small-scale effects have to be resolved & large-scale wind, temperature and moisture fields have to be measured as well
  - atmospheric part (smaller variability) of the water budget easier to measure than the subsurface part:
    ➔ **no soil moisture data on a larger grid**!
  - representativeness of single point measurements ?
  - variable land use & surface characteristics

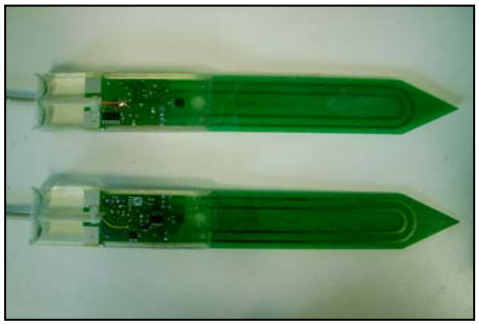
Goal & Strategy

- ***ultimate goal***: improve convective precipitation forecast through realistic representation of water budget in the subsurface and the PBL

Strategy

- Quantification of the effects of soil moisture, evapotranspiration and water vapour in the PBL on QPF
  - identification of the dominant scales and sensitive regions !
- Measurement of all components of the water budget ➔ evolution of the moisture fields on small scales
- Initiation of shallow (<50cm) soil moisture monitoring network & regionalisation
  - Analysis of the representativeness of single point soil moisture measurements through new 2-dimensional approaches
- Model studies on the effects of an improved soil moisture initialisation and representation in the LM on QPF

Water budget measurements



low cost soil moisture sensor SISOMOP

energy balance

radiosonde

turbulence

tethersonde

IMK/Karlsruhe:

• LIDAR	wind
• SODAR 2	
• profiler	wind/temp.
• energy balance	2
• turbulent fluxes	7
• radiosonde	2
• tethersonde	2
• aircraft	DO 128 (Braunschw.)
• soil moisture	single point & 2-D

Measurement strategy (to be discussed !)

local moisture change = advection + divergence of turbulent fluxes

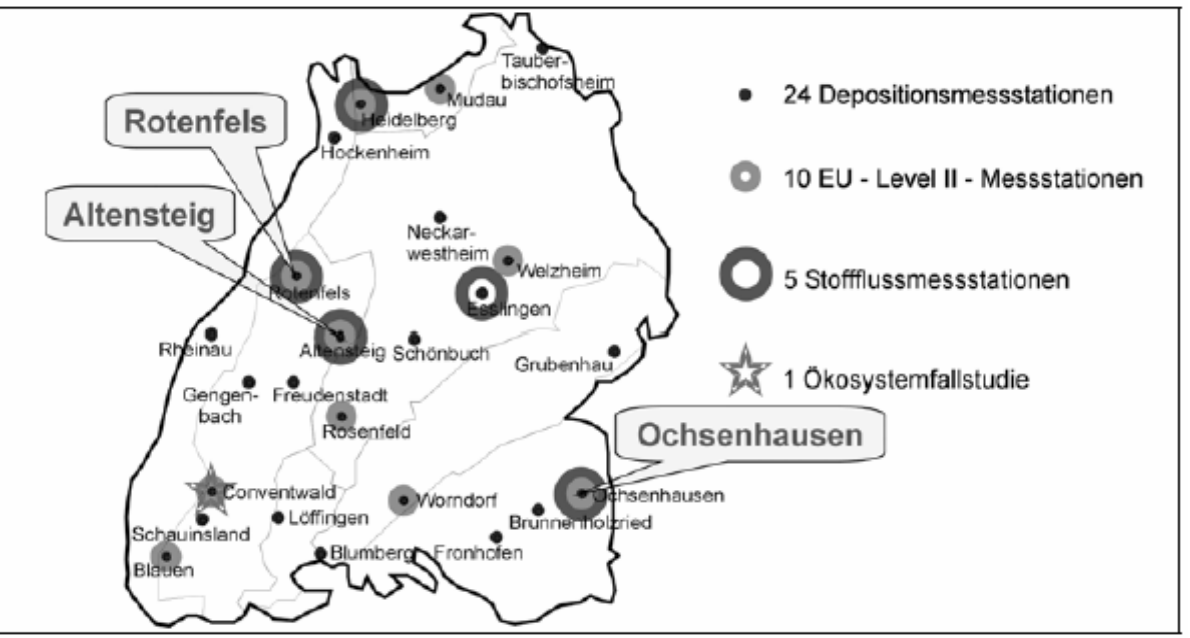
Radiosonde Tethersonde GPS Microwave profiler Aircraft (drop sonde) SODAR	Synoptic scale	Evapotranspiration Soil moisture Flux profiles LIDAR (high resolution moisture/wind) Aircraft

in principle: over whole investigation area ➔ not possible!

➔ clustering: high resolution (e.g. turbulent fluxes) measurements in a few sensitive regions
➔ representative & integral measurements of most variables over spatially larger domain (aircraft, satellite information, spatial extrapolation)
➔ depending on the available instruments

Soil moisture network

- identify and integrate existing soil moisture stations in Baden-Württemberg into an operational network for the COPS period
- identify gaps in the existing soil moisture station network with focus on the key areas as marked by the COPS scientific group
- installation of additional stations during COPS



e.g.: Forstliche Versuchsanstalt Freiburg (10)

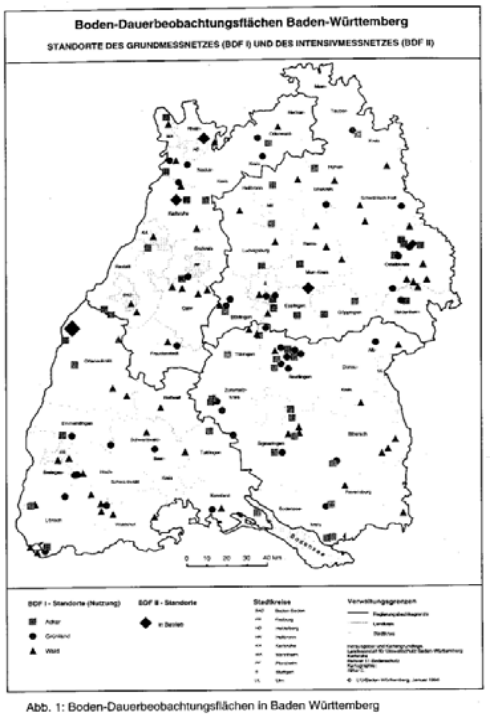


Abb. 1: Boden-Dauerbeobachtungsflächen in Baden Württemberg

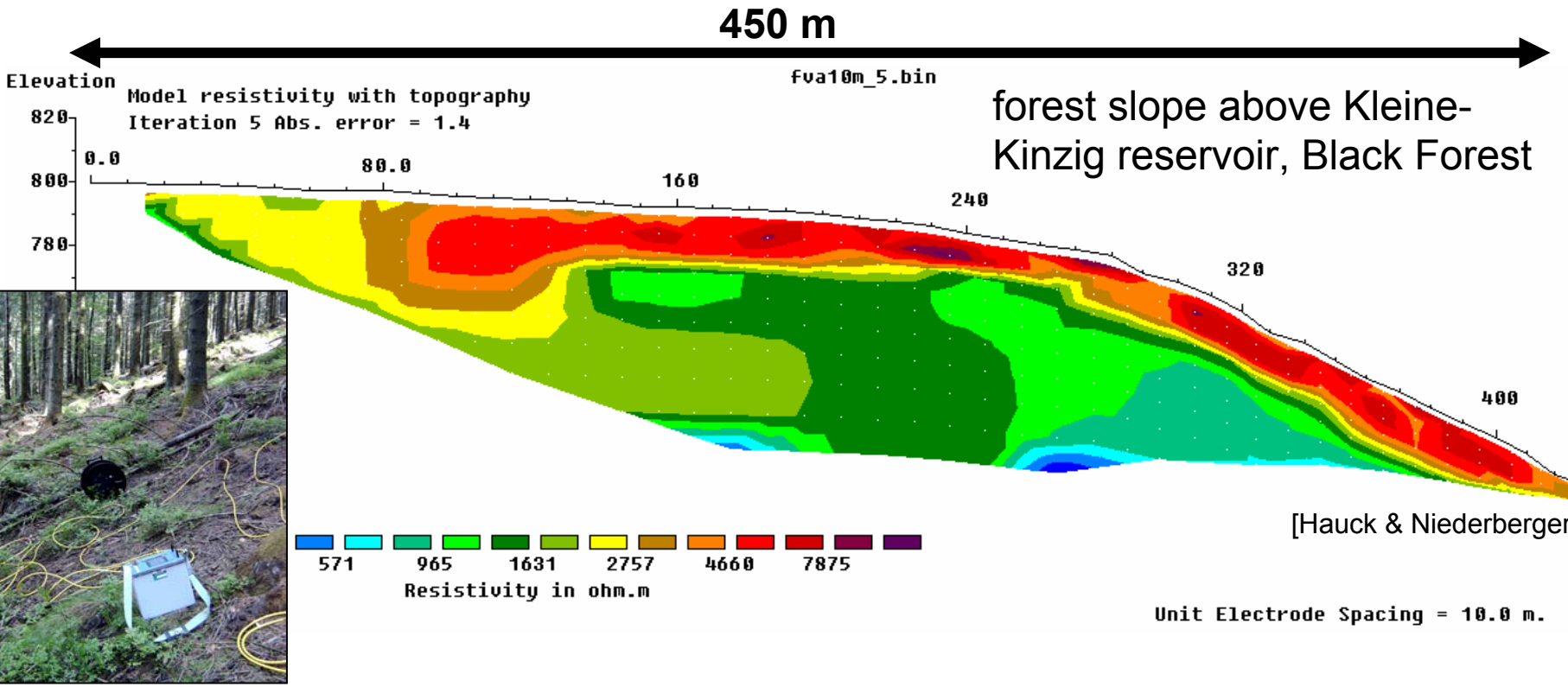
LFU Karlsruhe (5)

Quality control & spatial interpolation

- assess the quality of the soil moisture data using variational methods (e.g. Steinacker et al. 2000) as well as cross-validation with precipitation and soil data
- homogenise spatial and temporal resolution of the existing soil moisture stations wherever possible
- spatial interpolation of the data from the station network on the LM grid
- validation of the spatial interpolation routine through spatial soil moisture measurements

Spatial soil moisture measurements

geophysical monitoring: soil moisture calculation through repeated *electrical resistivity* measurements

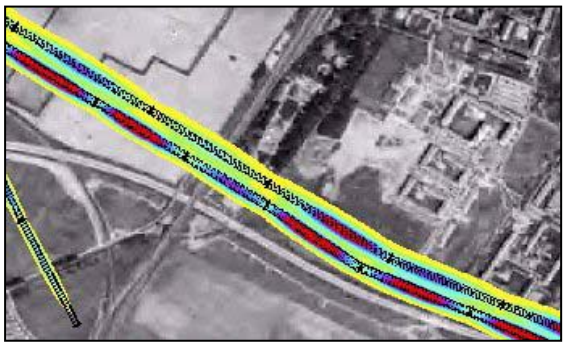


forest slope above Kleine-Kinzig reservoir, Black Forest

[Hauck & Niederberger

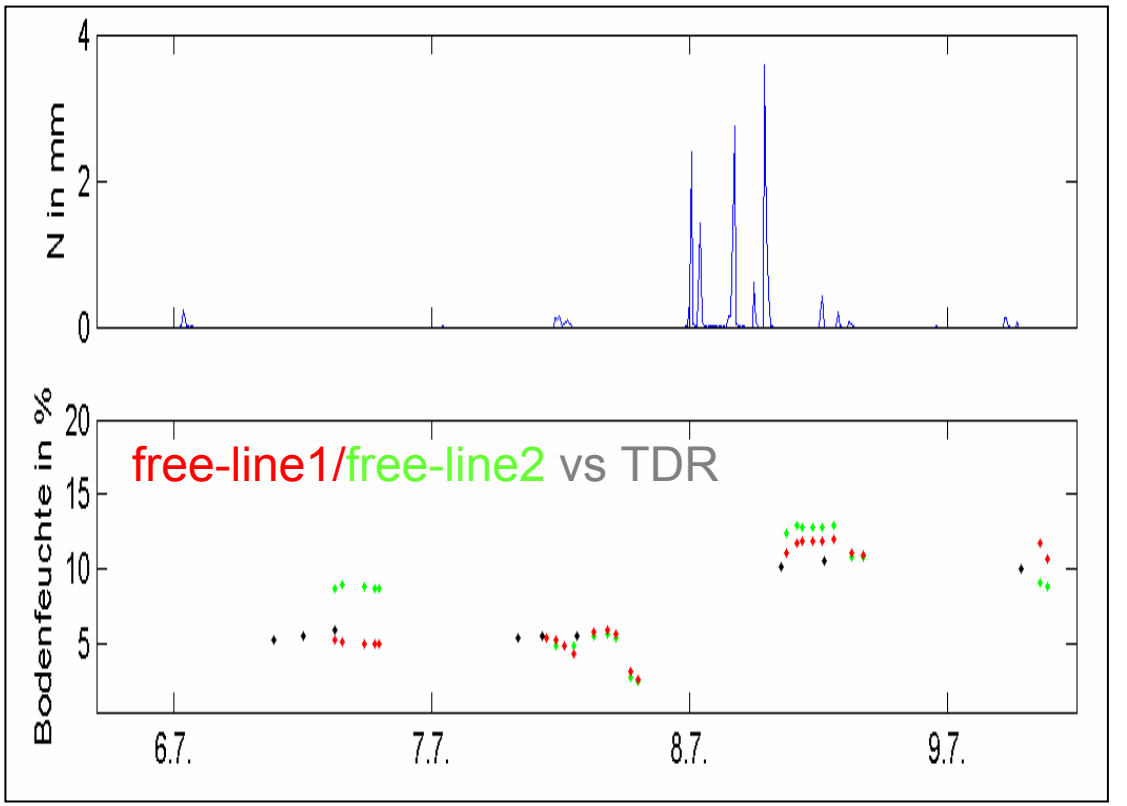
Spatial soil moisture measurements

e.g. FreeLineSensor: integrated soil moisture calculation through measurements along *transmission lines*



EnBW power lines

near-surface transmission lines

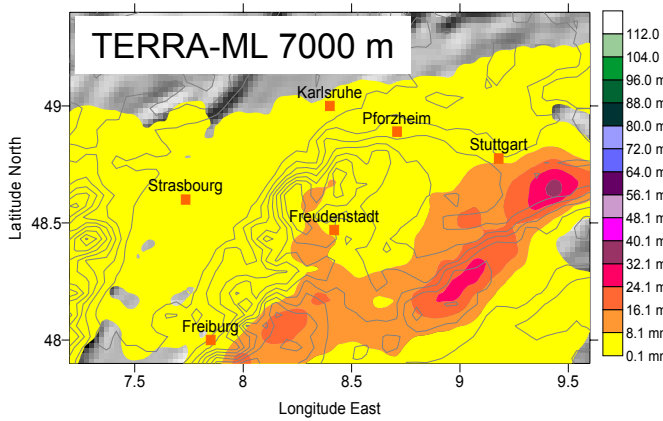


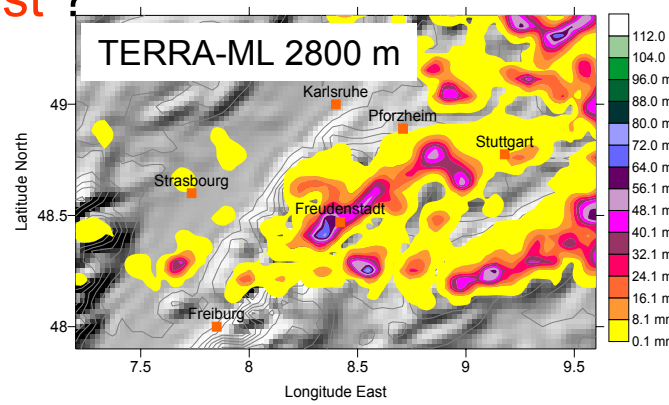
[Wetzke, Königer & Hauck, IMK]

Model & forecast improvement

<u>Model studies (LM/TERRA, LM/Veg3D, 2.8km):</u>

- improved initialisation of the soil moisture field
  - ➔ improved representation of local moisture variability in the PBL
  - ➔ improved initiation of convective processes in the model
  - ➔ improved convective precipitation forecast ?





- Validation of initialised soil moisture field through subset of moisture data and spatial soil moisture measurements
- Validation of PBL parameters through airborne and ground-based measurement systems within the COPS group

[Schädler et al.]

address specific science hypotheses

e.g.:

(3) Is the humidity field or orography more important for convection initiation in the COPS region ?

(5) Does a better representation of the initial soil moisture field improves QPF ?

Summary

- improve convective precipitation forecast through realistic representation of water budget in the subsurface and the PBL

- integrating remote sensing, aircraft- and ground-based station data
- use of existing soil moisture/surface stations
- model based identification of station gaps at most sensitive locations
- installation of additional stations (focus on clusters)
- quality assessment of the data sets during COPS
- process studies with various models – analysis of precipitation forecast improvement