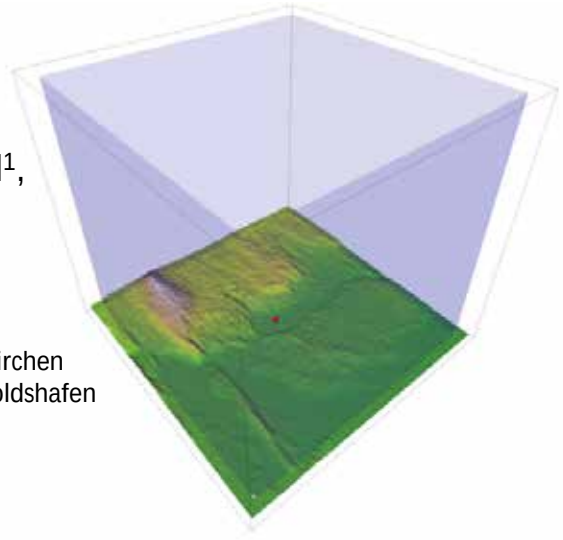
“The Scale**X** campaign: observations **crossing** scales in the TERENO pre-alpine observatory”

Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU)

B. Wolf[1], B. Adler[2], C. Brosy[1], P. Brugger[1], C. Chwala[1], F. De Roo[1], B. Fersch[1], J. Garvelmann[1], E. Haas[1], W. Junkermann[1], N. Kalthoff[2], O. Kosak[3], R. Krieg[4], R. Merz[4], A. Philipp[5], W. Reif[3], T. Rödiger[4], N. Ruehr[1], K. Schäfer[1], H. Vogelmann[1], I. Völksch[1], C. Wanninger[3], J. Werhahn[1], **M. Zeeman[1]**, A. Arneth[1], K. Butterbach-Bahl[1], M. Dannenmann[1], S. Emeis[1], R. Kiese[1], H. Kunstmann[1], M. Mauder[1], P. Suppan[1], R. Sussmann[1] and H. P. Schmid[1]

[1] Institute of Meteorology and Climate Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen
[2] Institute of Meteorology and Climate Research (IMK-TRO), Karlsruhe Institute of Technology (KIT), Eggenstein-Leopoldshafen
[3] Institute for Software & Systems Engineering (ISSE), University of Augsburg
[4] Department of Catchment Hydrology, Helmholtz Centre for Environmental Research (UFZ), Halle/Saale
[5] Institute of Geography (IGUA), University of Augsburg

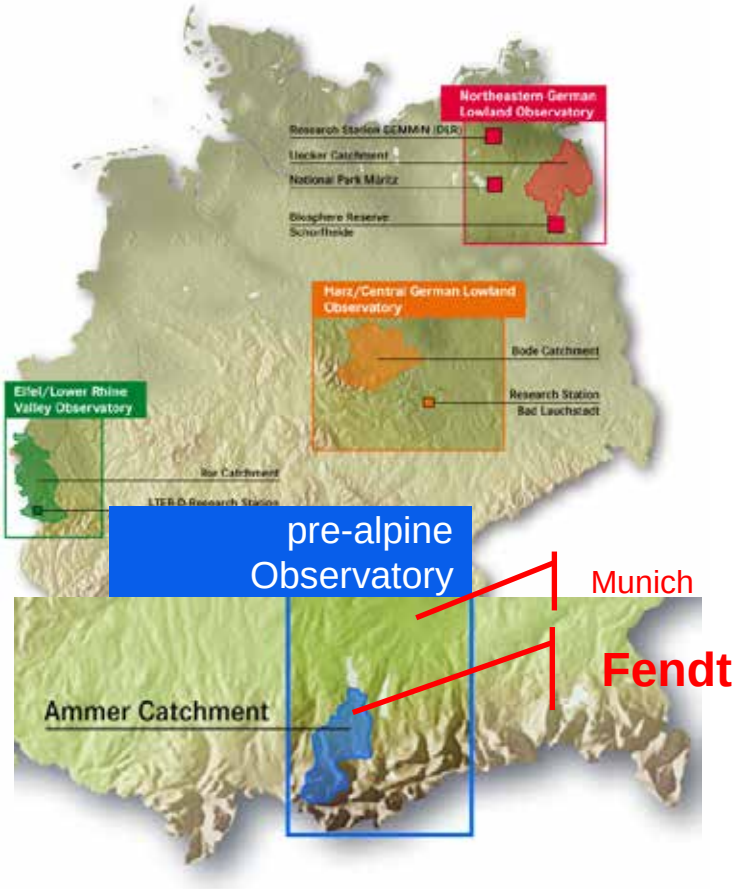


Motivation

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

"aims to determine the long-term ecological and climatic impact of global change at regional level"

The TERENO Network



- the effects of Global Change on terrestrial systems are regionally differentiated

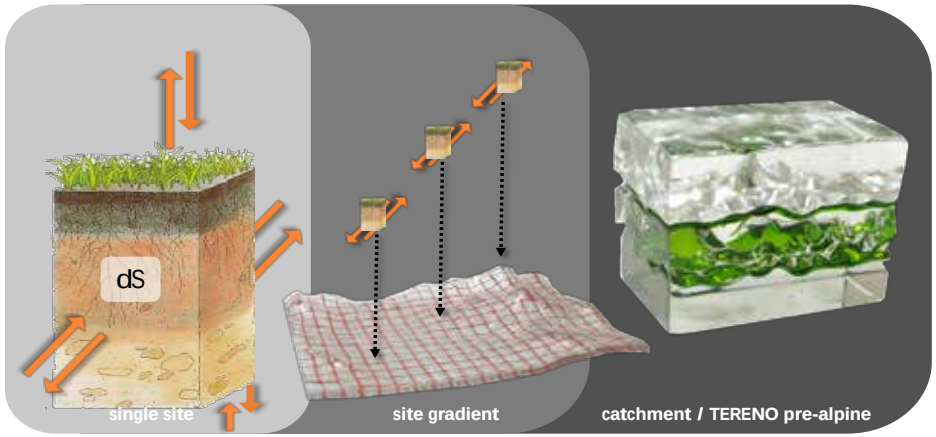
  à requires a network approach
- … with complex feedbacks between compartments (soil, water, bio-, atmosphere)

  à requires a platform approach
- long-term observation
  - as non-manipulative field experiment
  - detection of trends
  - validation of terrestrial environmental models
- TERENO pre-alpine: 3 principle sites

  focus today on Fendt site (600 m.a.s.l.)

Motivation for the 2015 “ScaleX” campaign

- TERENO operational since 2009/2010; focus on single sites and site gradients



- **But mountain regions are complex environments**

  think: terrain features, aspect, soil types, vegetation, land use, …

- **That complexity, in relation to scale, is a challenge for experimental observation and modelling**

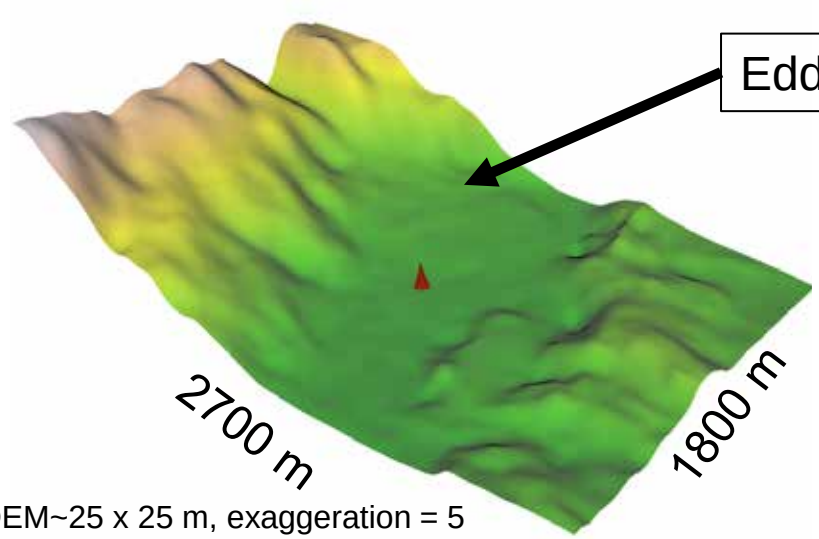
  think: land-atmosphere exchange, boundary layer dynamics, precipitation, …

Research question:

How well can our observations constrain modeling uncertainties of biogeochemical cycles, and close the balances of energy and matter flows?

The impact of complex terrain on biosphere-atmosphere exchange processes

- Approaches to determine biosphere-atmosphere exchange often assume one-dimensional fluxes and horizontally homogeneous conditions



EU-DEM~25 x 25 m, exaggeration = 5

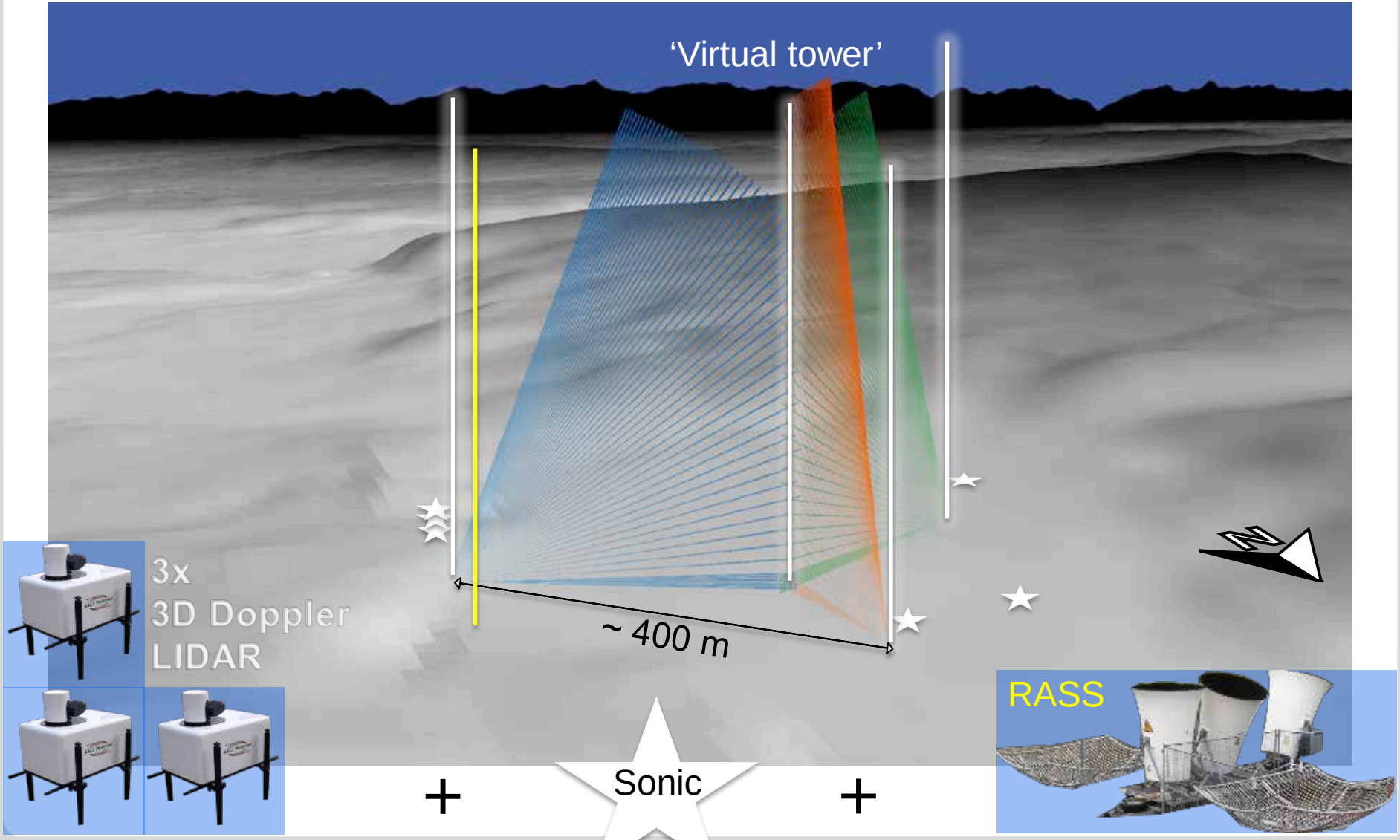
- Assumptions are not entirely met in reality

  à depends in part on terrain complexity (topography / land cover)

- Local flow patterns may result in a so-called energy balance closure problem

Boundary layer flow – ground-based remote sensing

What are the influences of local and regional landscape features?



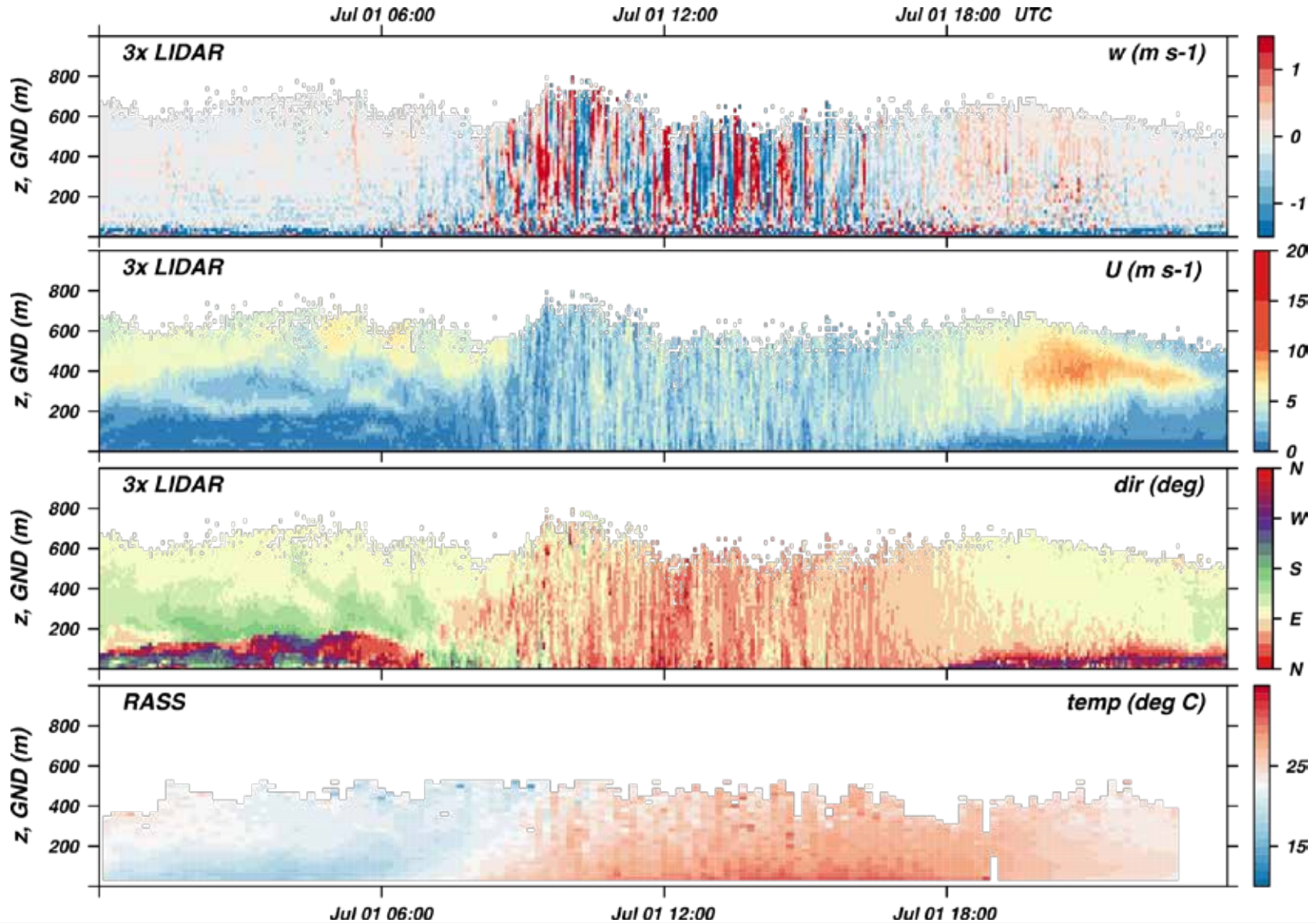
benjamin.wolf@kit.edu

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Boundary layer flow – ground-based remote sensing

'Virtual tower'

RASS

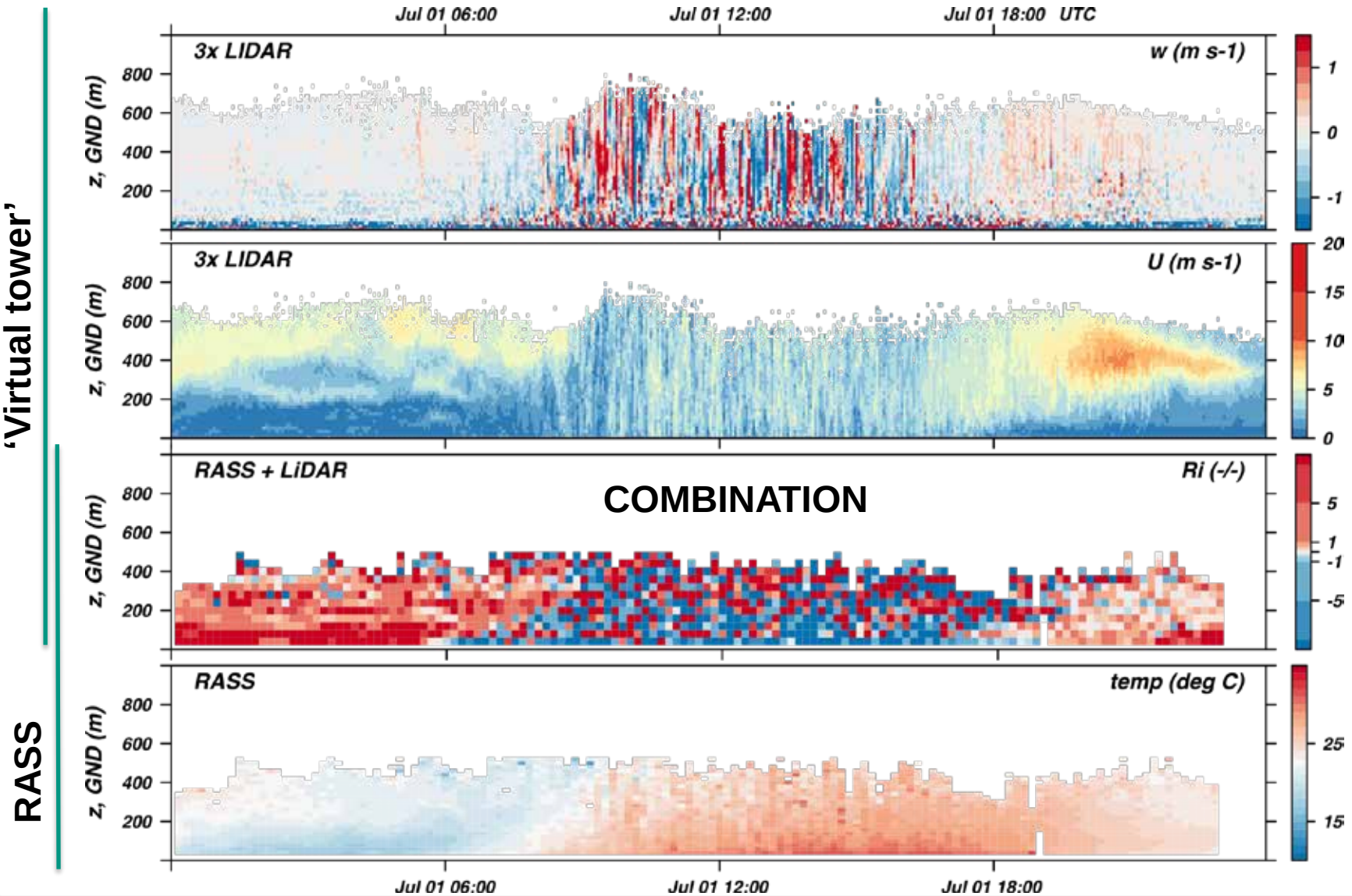


benjamin.wolf@kit.edu

Source: Zeeman, *pers. comm.*

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Boundary layer flow – ground-based remote sensing



benjamin.wolf@kit.edu

Source: Zeeman, *pers. comm.*

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Trace gas in the nocturnal boundary layer (NBL): budget and distribution

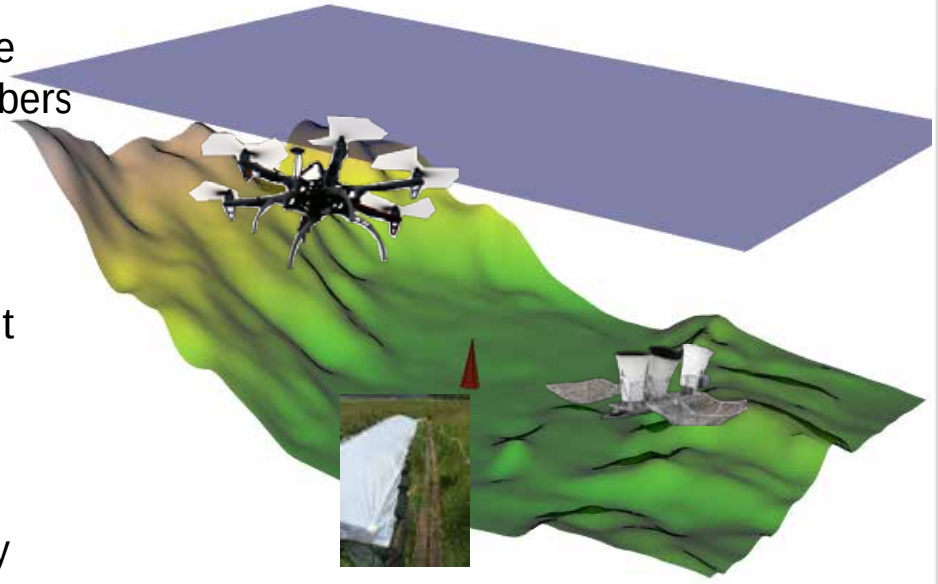
- biosphere-atmosphere exchange of greenhouse gases (GHG) determined by EC and static chambers at **microscale** (up to 1 km, 30 min), while models are usually **mesoscale**

à the ”intermediate observation scale” is relevant for regional model evaluation

- GHG and other emitted constituents can accumulate in the (nocturnal) surface boundary layer (NBL) as stable atmospheric conditions develop

- given a well-mixed NBL, budget methods can be applied to gain mesoscale flux information (e.g Emeis et al. 2008 for CH_4).

à assessment of NBL GHG concentration distribution and dynamics

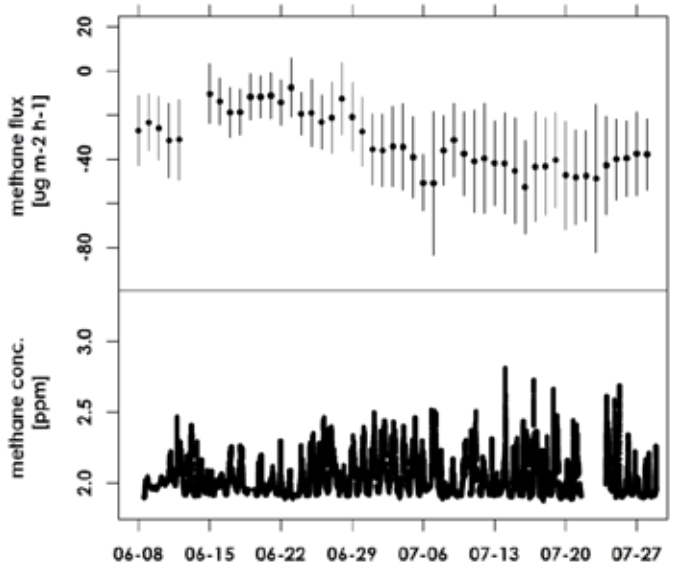


- NBL height and wind by ceilometer and RASS
- GHG profiles by UAV and @ 10m tower
- wetland GHG source strength “big” chambers
- CH_4 source strength @ farm (open path sensors)

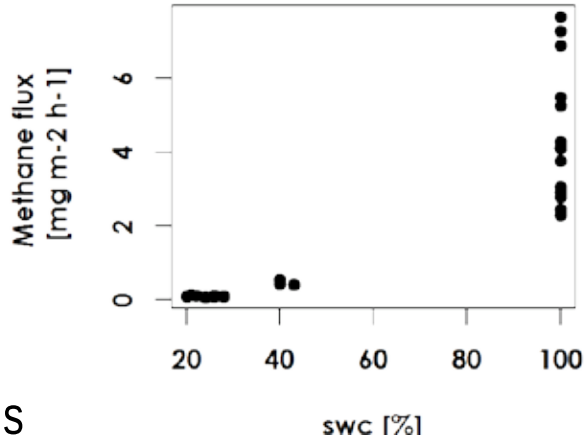
Source: Wolf, *pers. comm.*

Trace gas in the nocturnal boundary layer (NBL): local methane sinks and sources

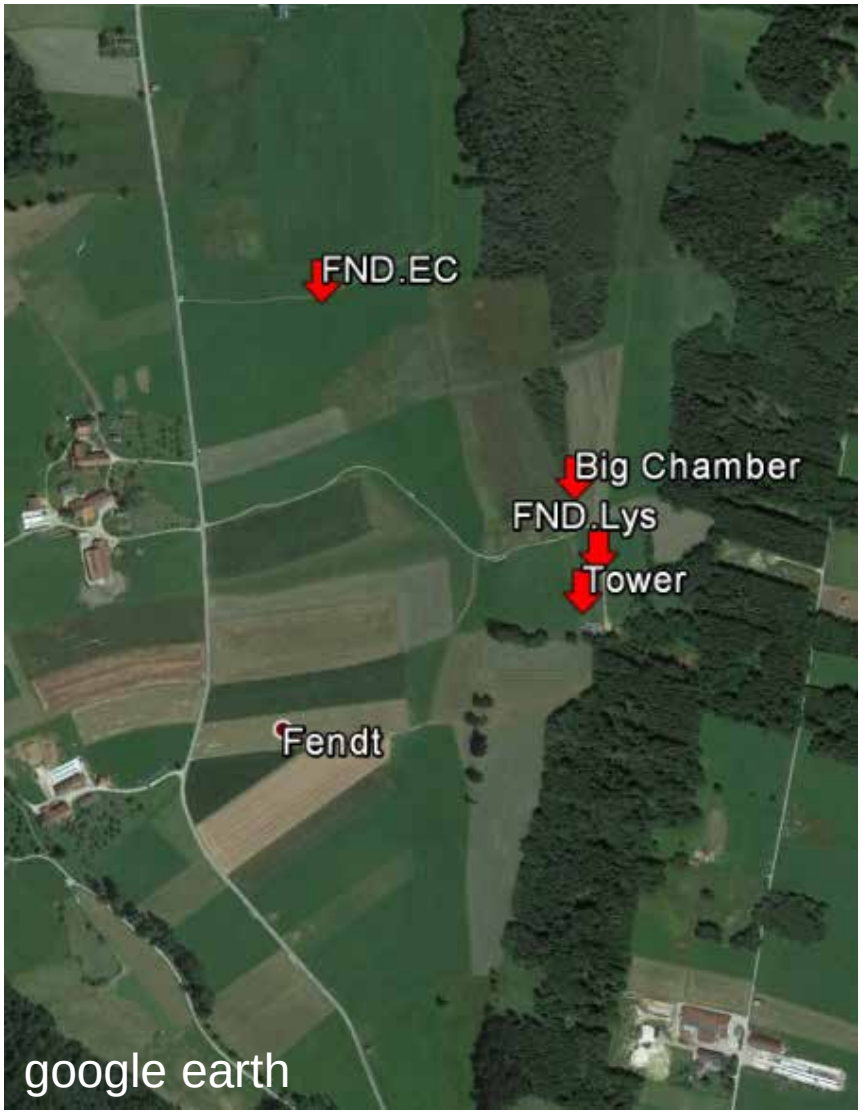
- grasslands



- water saturated grassland patches



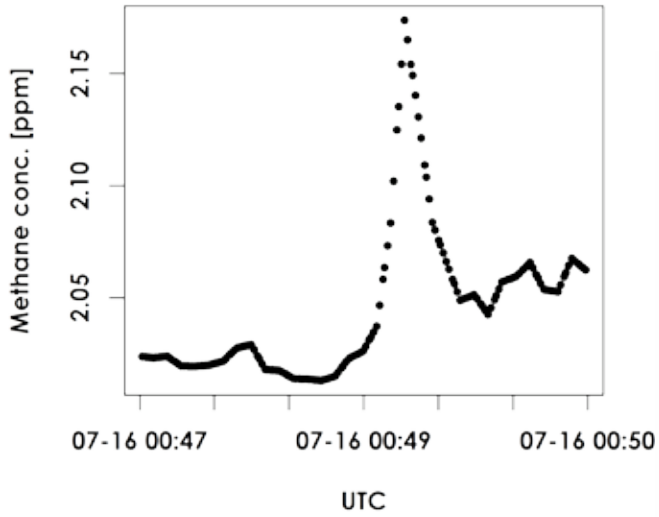
- dairy farms

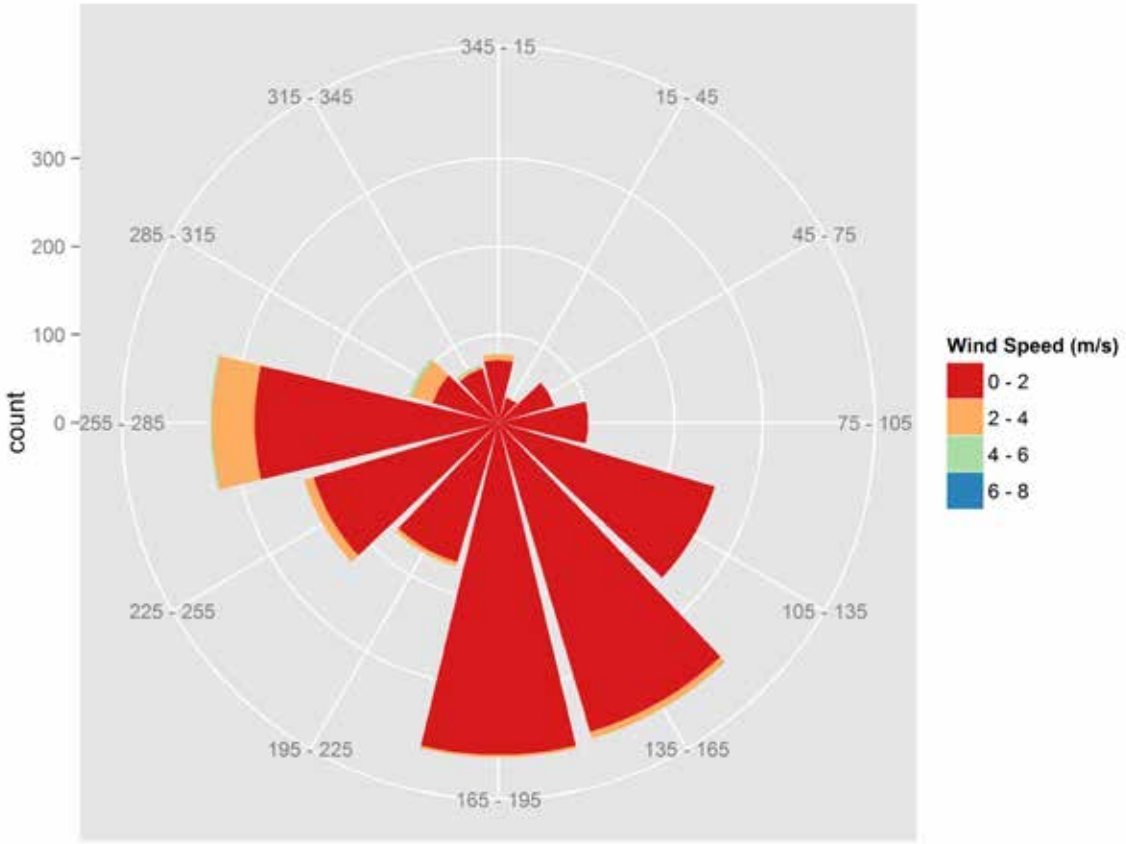


Source: Wolf, *pers. comm.*

Trace gas in the nocturnal boundary layer (NBL): methane concentration dynamics

- Wind directions of concentration modulations



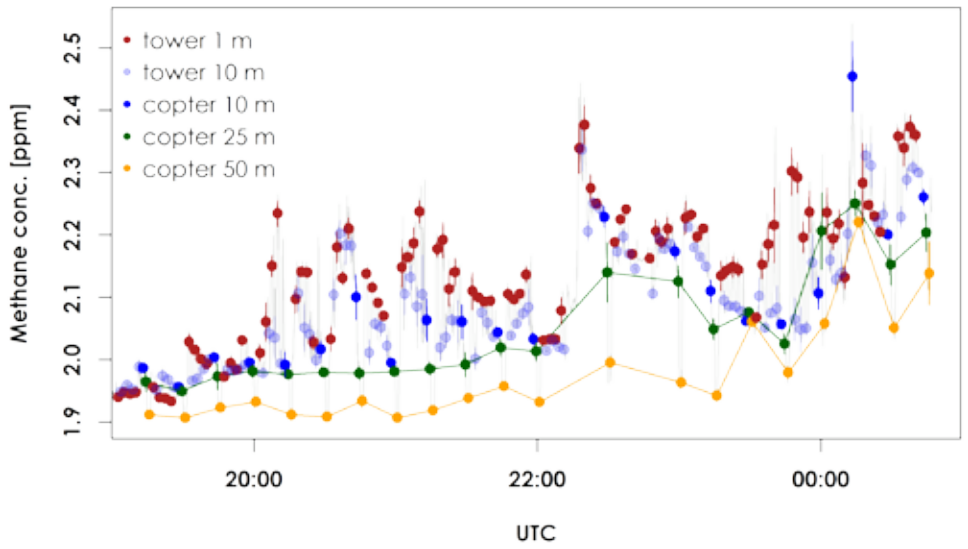


benjamin.wolf@kit.edu
Source: Wolf, *pers. comm.*
Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Trace gas in the nocturnal boundary layer (NBL): methane concentration dynamics - “well mixed”?

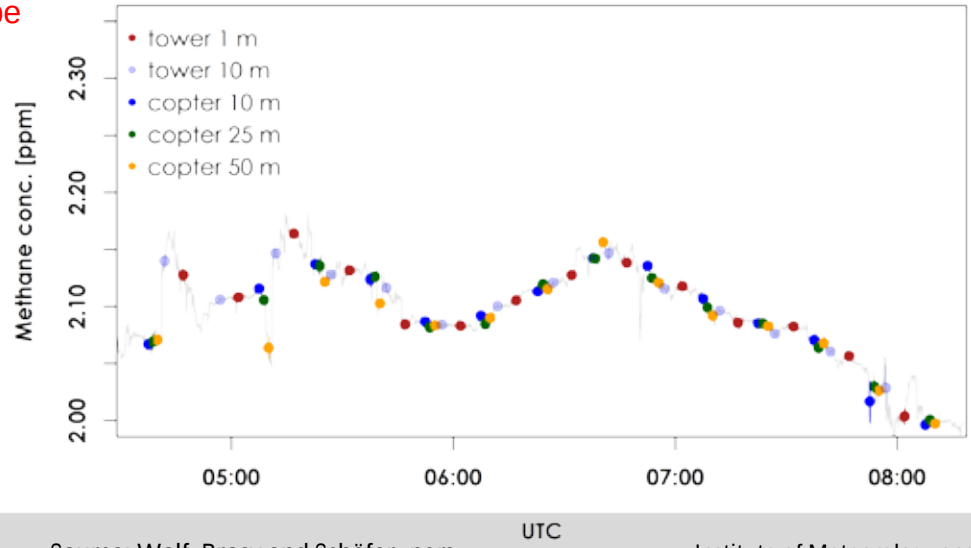
- early night

  (MLH = 100-300 m)



- early morning

  (MLH = 100-120 m)

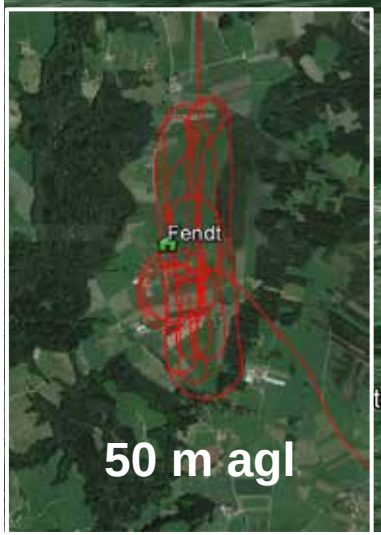


Source: Wolf, Brosy and Schäfer, *pers. comm.*

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Airborne measurements: ultralight aircraft (10x10 km)

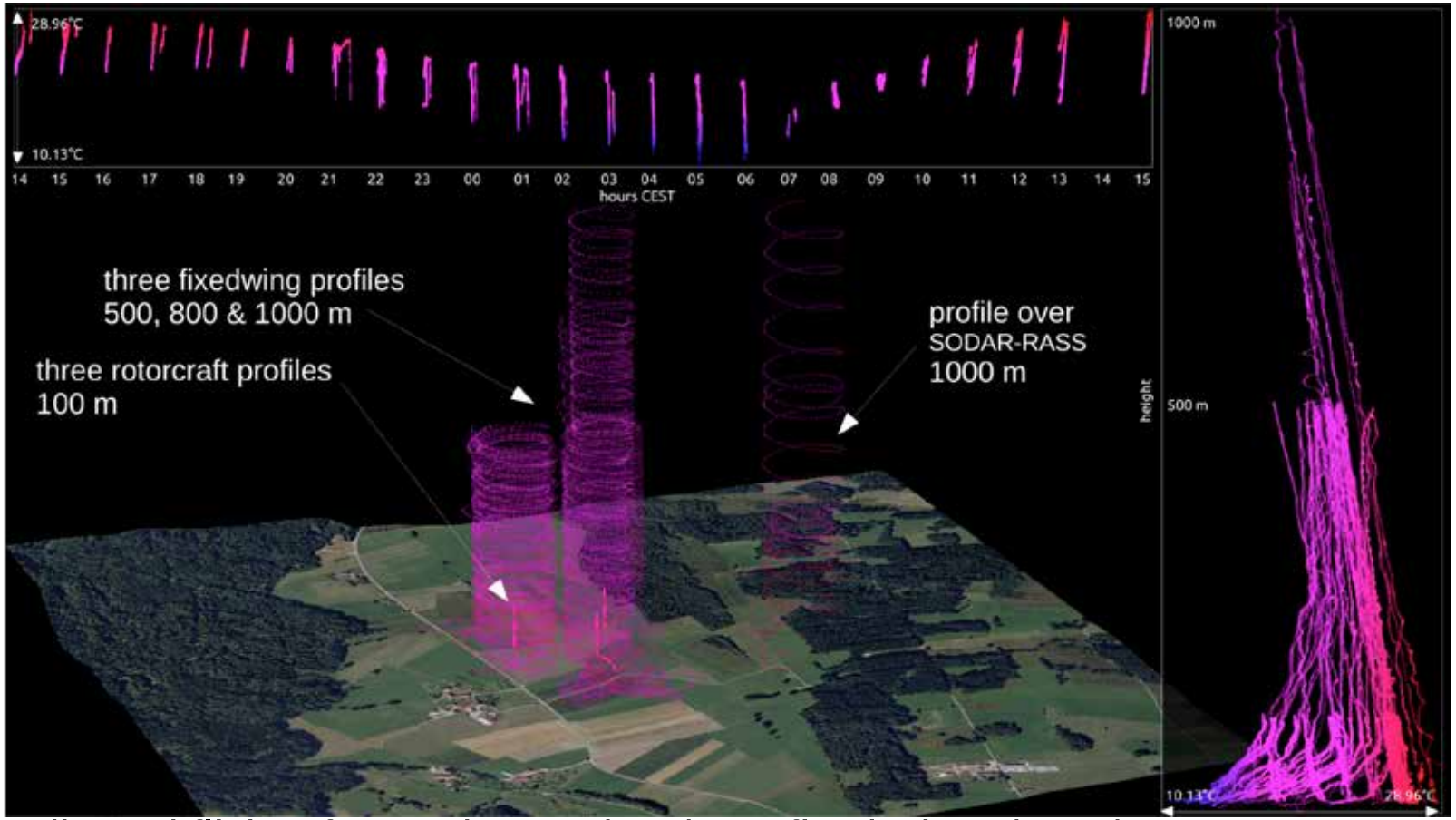
- wind, temperature, humidity, CO_2, O_3, radiation, fluxes, aerosols
- Horizontal scans
- Vertical profiles (50-1800 m) early morning and noon



~1200 m
10 km
10 km
10 km
Hohenpeissenberg
10 km (100 -150 m agl)

Source: Junkermann, *pers. comm.*
Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU)

Airborne measurements:
UAV measurements (0.5x0.5 km)



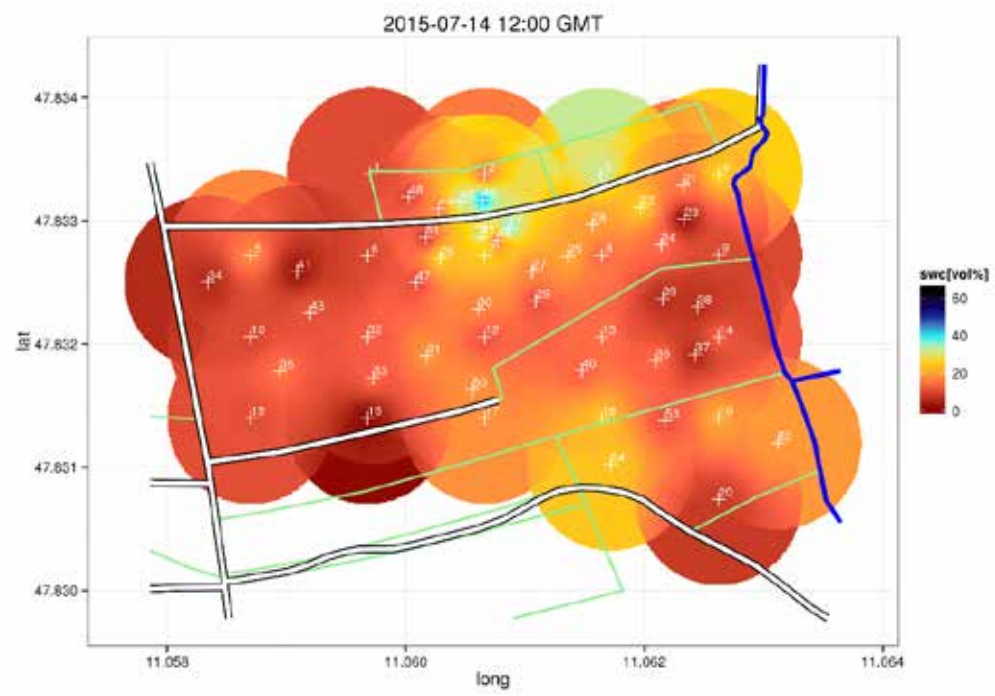
- coordinated flight of 3 quadrotors (ISSE) & 3 fixed wings (IGUA)
- each unit equipped with temperature & humidity sensors (SHT-75)
- goals: variability within model grid cells & comparison with remote sensing

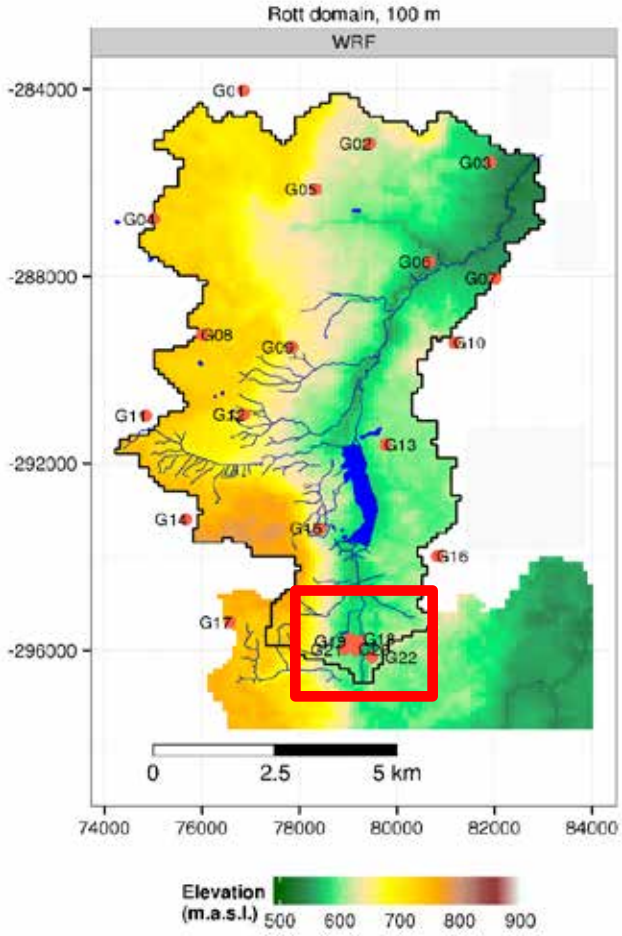
Source: Kosak, Philipp, *pers. comm.*

Ground based observations:

- 22 rain gauges within Rott catchment with high density of gauges at the Fendt site

- Rain gauges at the Fendt site combined with soil moisture probe network

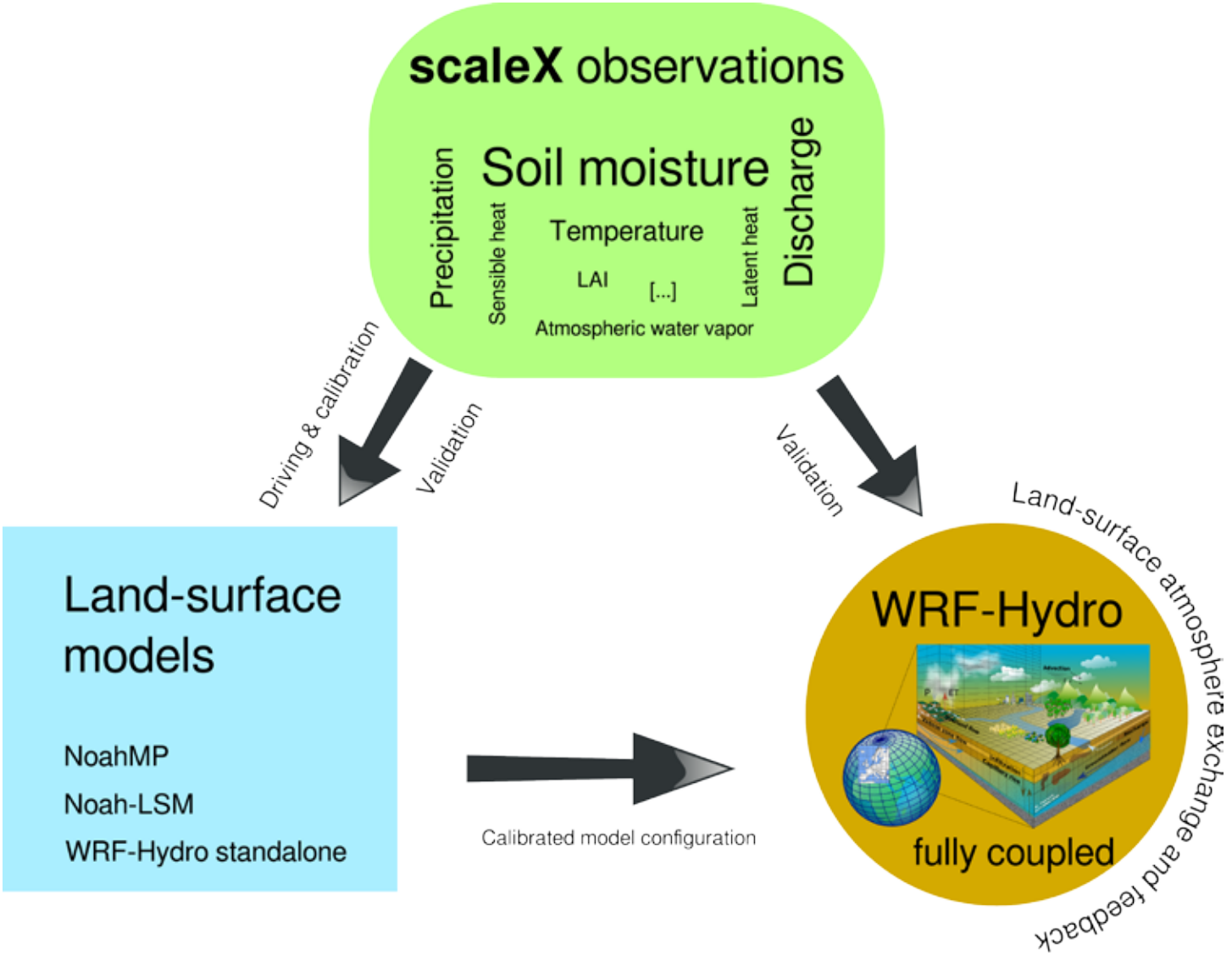




Source: Völksch, Garvelmann and Fersch, *pers. comm.*

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

How about models?



Source: Fersch, *pers. comm.*

Institute of Meteorology and Climate Research,
Atmospheric Environmental Research (IMK-IFU)

Outlook:
2016 ScaleX campaign, June & July 2016!

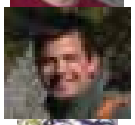
- is a good opportunity for
  - scale X-ing experiments

you need a collaborator for

- joint modeling approaches
- model and instrument comparison

Thank you for your attention! Contact persons:

- **ScaleX** / GHGs in the nocturnal boundary layer: benjamin.wolf@kit.edu



- Hydrological modeling / soil moisture network: benjamin.fersch@kit.edu

- Precipitation variability: christian.chwala@kit.edu

- Scaling plant canopy traits: nadine.ruehr@kit.edu

- Fixed-wing drones: andreas.philipp@geo.uni-augsburg.de

- Coordinated copter flights: kosak@isse.de

- Ultralight aircraft measurements: wolfgang.junkermann@kit.edu

- Boundary layer flow and exchange processes: matthias.zeeman@kit.edu

Karlsruhe Institute of Technology

Universität Augsburg University

Deutscher Wetterdienst

DLR