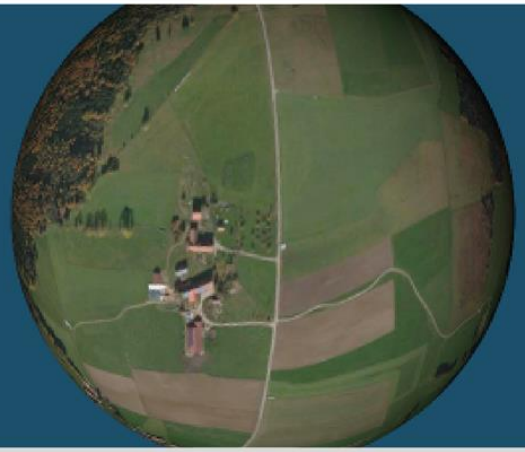
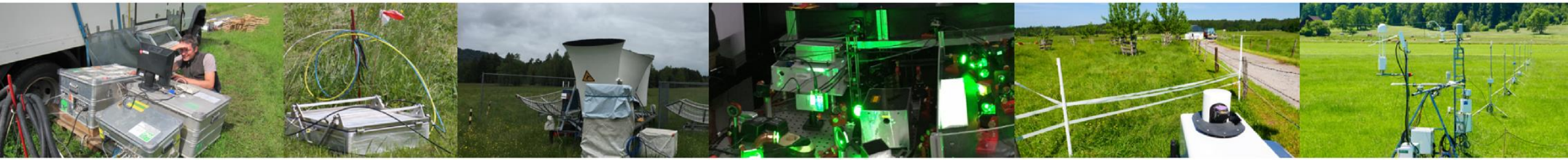
HELMHOLTZ ASSOCIATION ATMO | TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATIONS | ICOS INTEGRATED CARBON OBSERVATION SYSTEM | KIT-Campus Alpin IMK-IFU: Atmospheric Environmental Research | KIT Karlsruhe Institute of Technology

ScaleX

Multidisciplinary intensive campaigns in the TERENO–preAlpine observatory



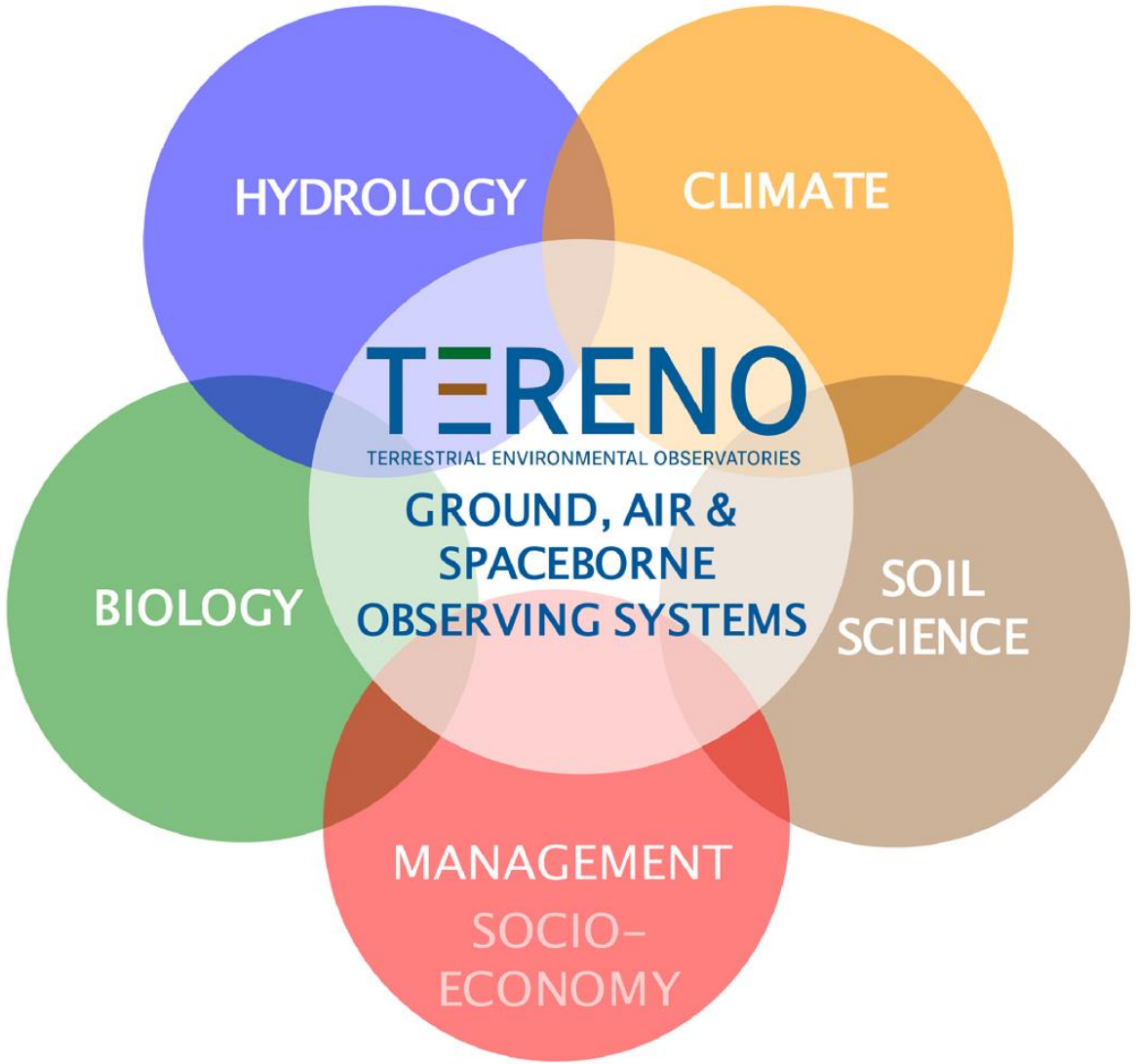
Presented by:
Matthias Zeeman



Wolf *et al.* (2017) Bull. Am. Meteorol. Soc.:

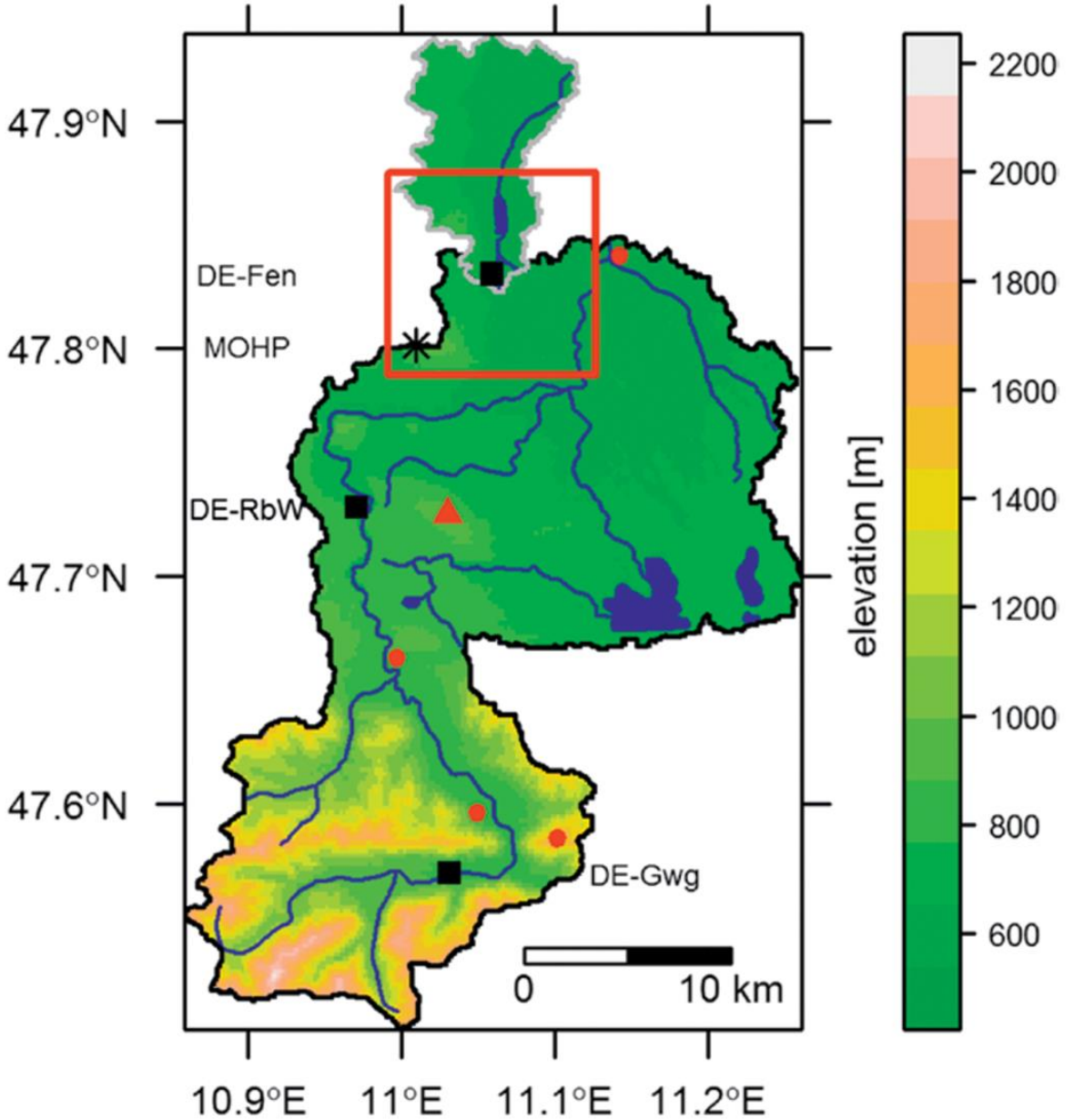
Augmenting long-term ecosystem-atmosphere observations with ***multidisciplinary intensive campaigns*** *aims at*

- ***closing gaps in spatial and temporal scales of observation*** *for energy- and biogeochemical cycling*
- ***stimulating collaborative research****.*



Modified from: Bogena *et al.*, LTER-D Jahreskonferenz 2010

Source: Wolf *et al.* 2017

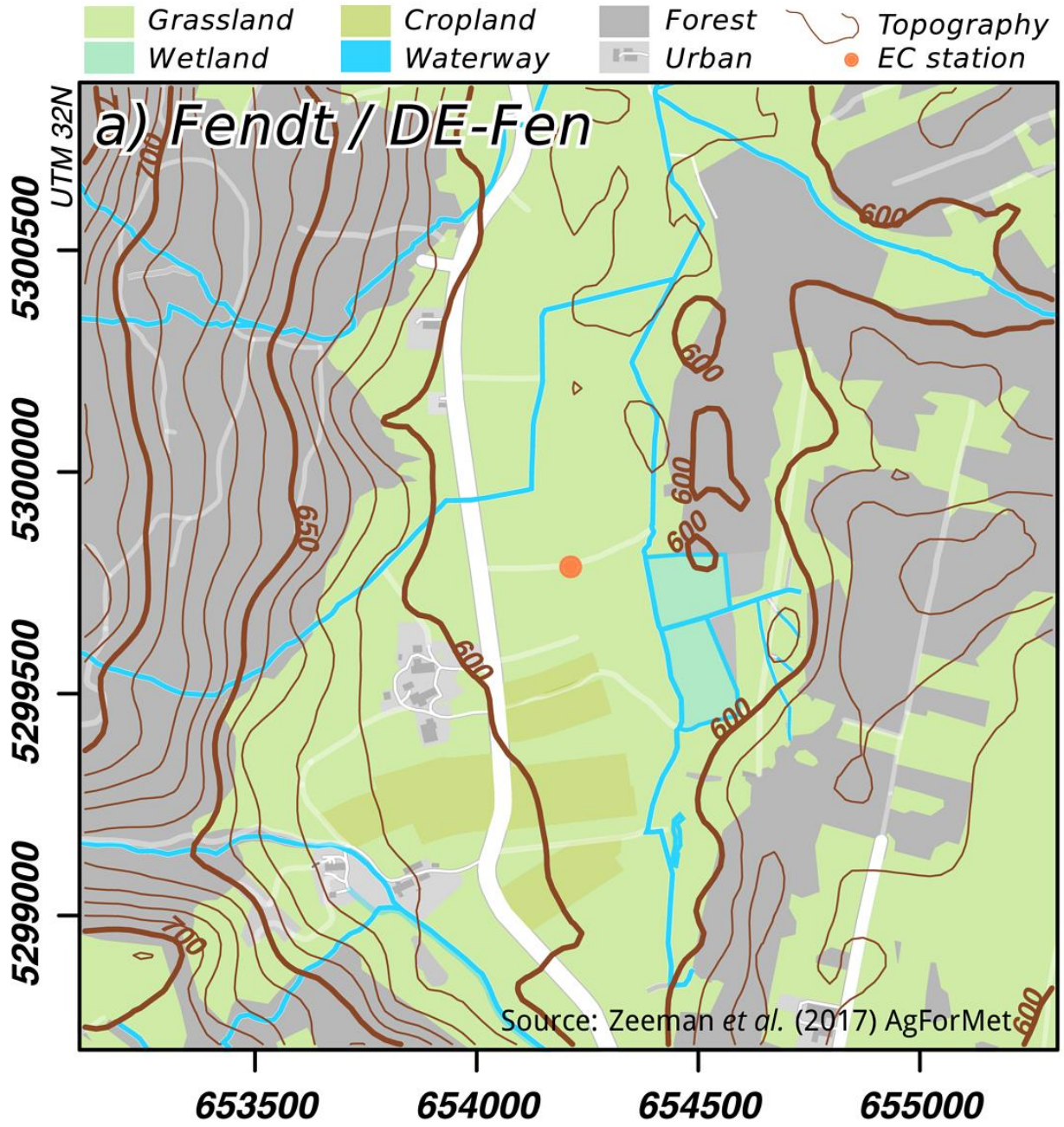


A partnership with farming community Fendt.

Permanent Infrastructure:

- Lysimeter Cluster
- Eddy Covariance (EC) & Hydrometeorology (MET)
- Soil Sensor Network, incl. Cosmic Ray probe
- Vertical profilers, incl. Ceilometer

Situated in a shallow valley, a former lake bed



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Partnerships ScaleX 2016

- 65+ researchers
- 20+ international groups
- BSc/MSc/PhD projects

DLR
DWD
EMPA
GFZ
GWU Group
KIT IMK-IFU
KIT IMK-TRO
LMU
METEK
MPI Jena
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U Wien/BOKU
Vaisala

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WP1 The impact of complex terrain on biosphere–atmosphere exchange processes

WP2 The nocturnal boundary layer: vertical transport, trace gas distribution and budget

WP3 Patterns of precipitation and soil moisture from site to regional scale

WP4 Regional water and energy budgets and balances analysis by modeling and observation in the catchments of Rott and Ammer

WP5 Distributed modeling of biosphere–atmosphere GHG exchange

\+ **UAV** Working group on Unmanned Aerial Vehicles

ScaleX 2016 Partnerships & Work Packages (WPs)

IMK-IFU | matthias.zeeman@kit.edu | 26.9.2017

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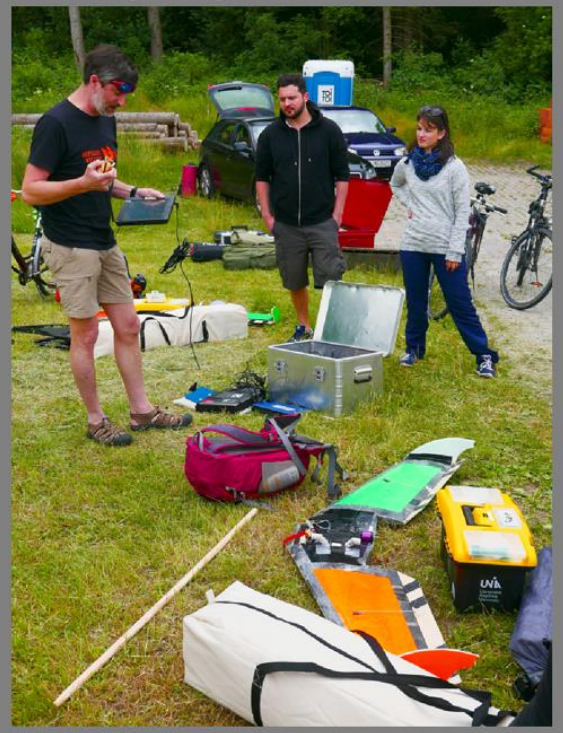
Working group on Unmanned Aerial Vehicles

IMK–IFU | matthias.zeeman@kit.edu | 26.9.2017

Andreas Philipp *et al.*
Uni Augsburg



Caroline Brosy *et al.*
KIT IMK–IFU

Martin Kunz *et al.*
MPI Jena

C Brosy, K Schäfer

UAV

Claire Brenner *et al.*
Uni Wien / BOKU

Oliver Kosak *et al.*
Uni Augsburg / ISSE

Airspace traffic coordinator:
Erik Petersen
Uni Augsburg

Andreas Philipp (U Augsburg)

UAV

- Simultaneous deployment of multiple fixed-wing UAVs in a 1 km^2 area
- Temperature, humidity, wind speed and wind direction profiles up to 1000m above ground

Working group on Unmanned Aerial Vehicles

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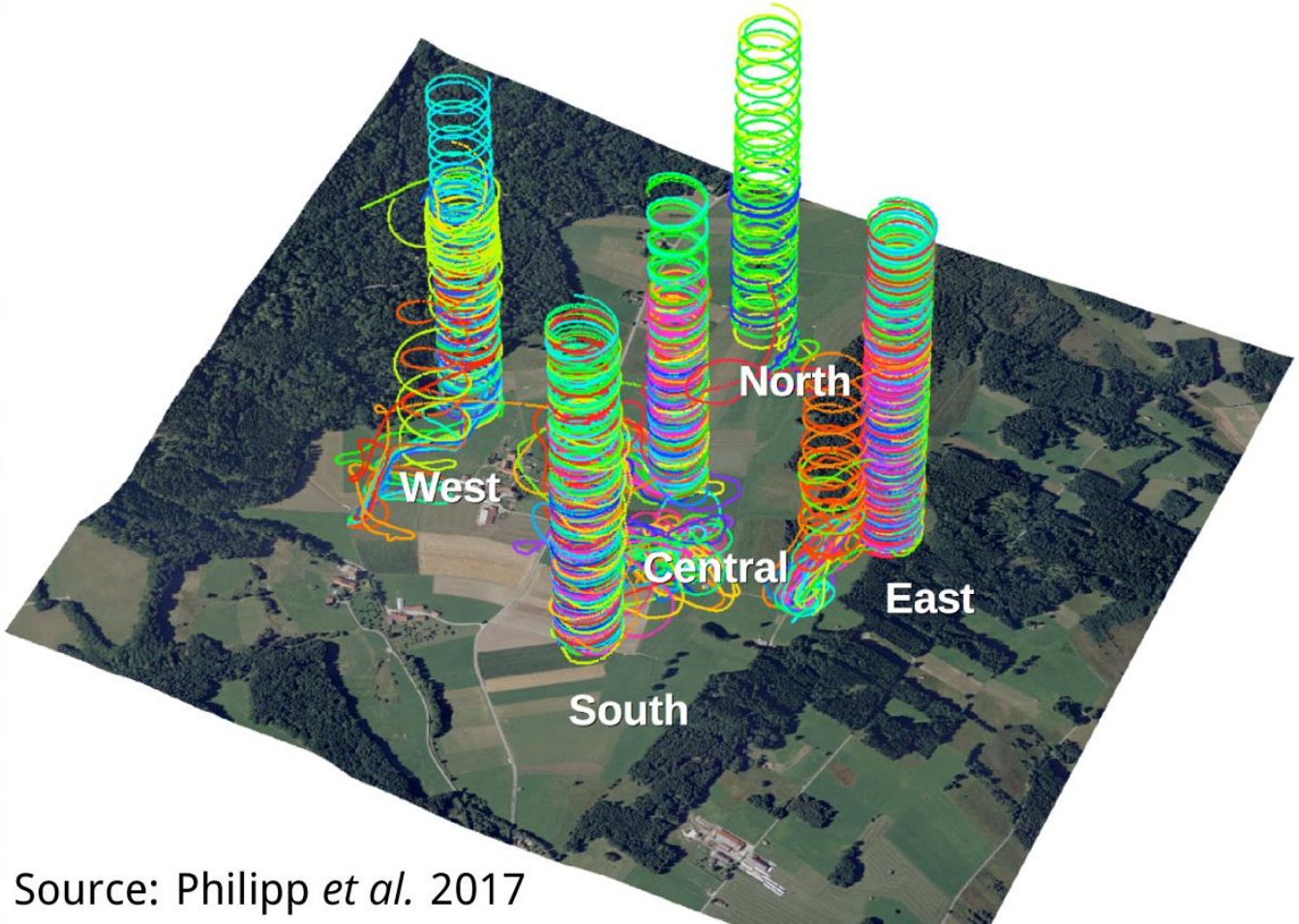

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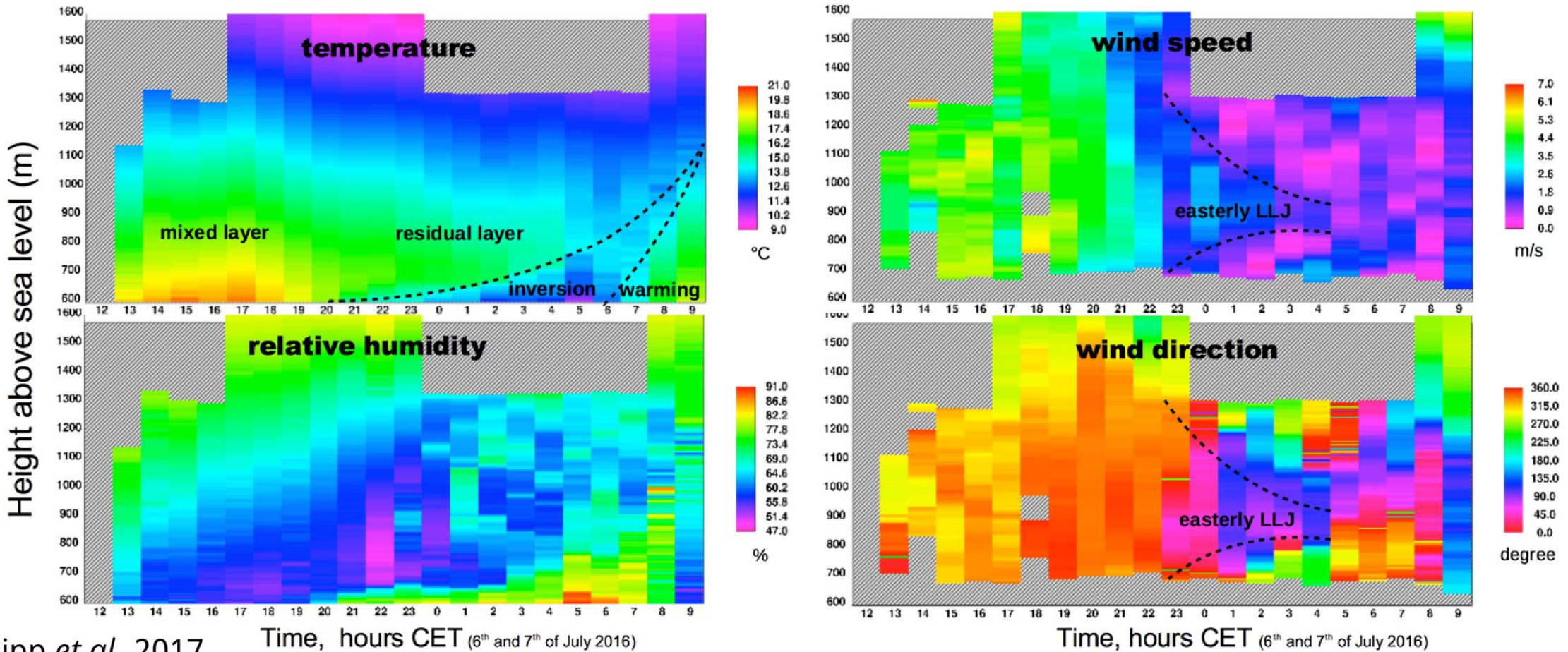

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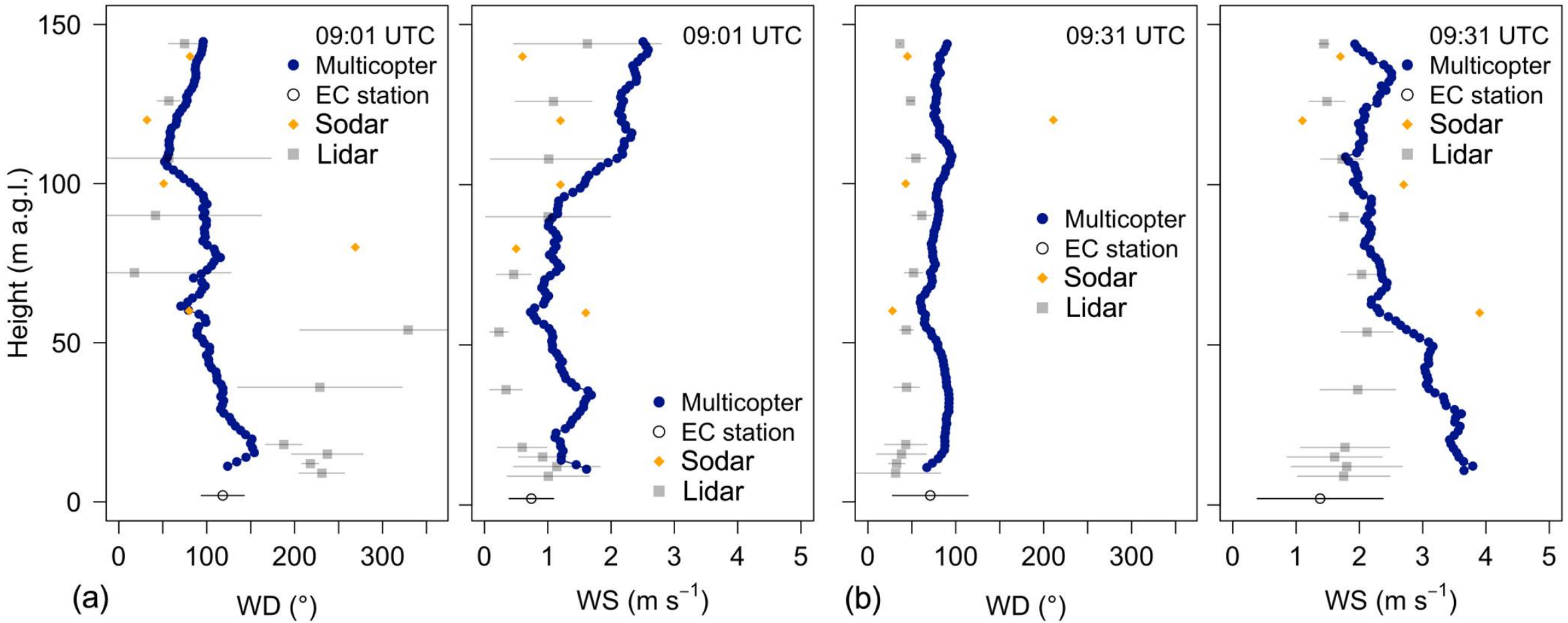
Working group on Unmanned Aerial Vehicles

C Brosy, K Schäfer, M Zondlo (U Princeton), M Kunz (MPI Jena), J Lavric (MPI Jena), R Grant (U Purdue)

UAV

WP2

- Wind speed and direction observations using a hexacopter UAV
- *In situ* sampling of profiles up to 150m above ground (lightweight sensor)



Source: Brosy *et al.* 2017

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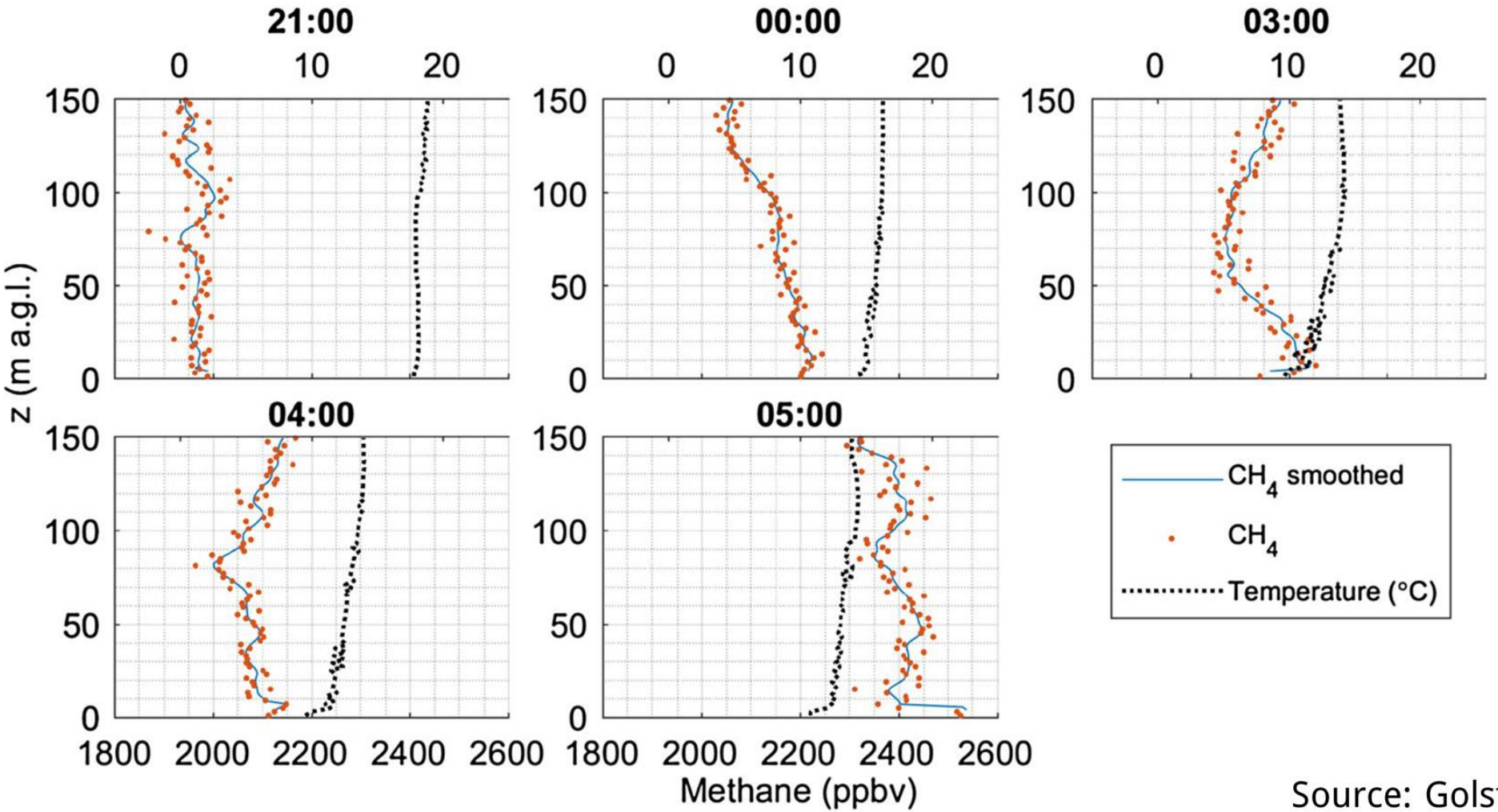

Source: Golston *et al.* 2017

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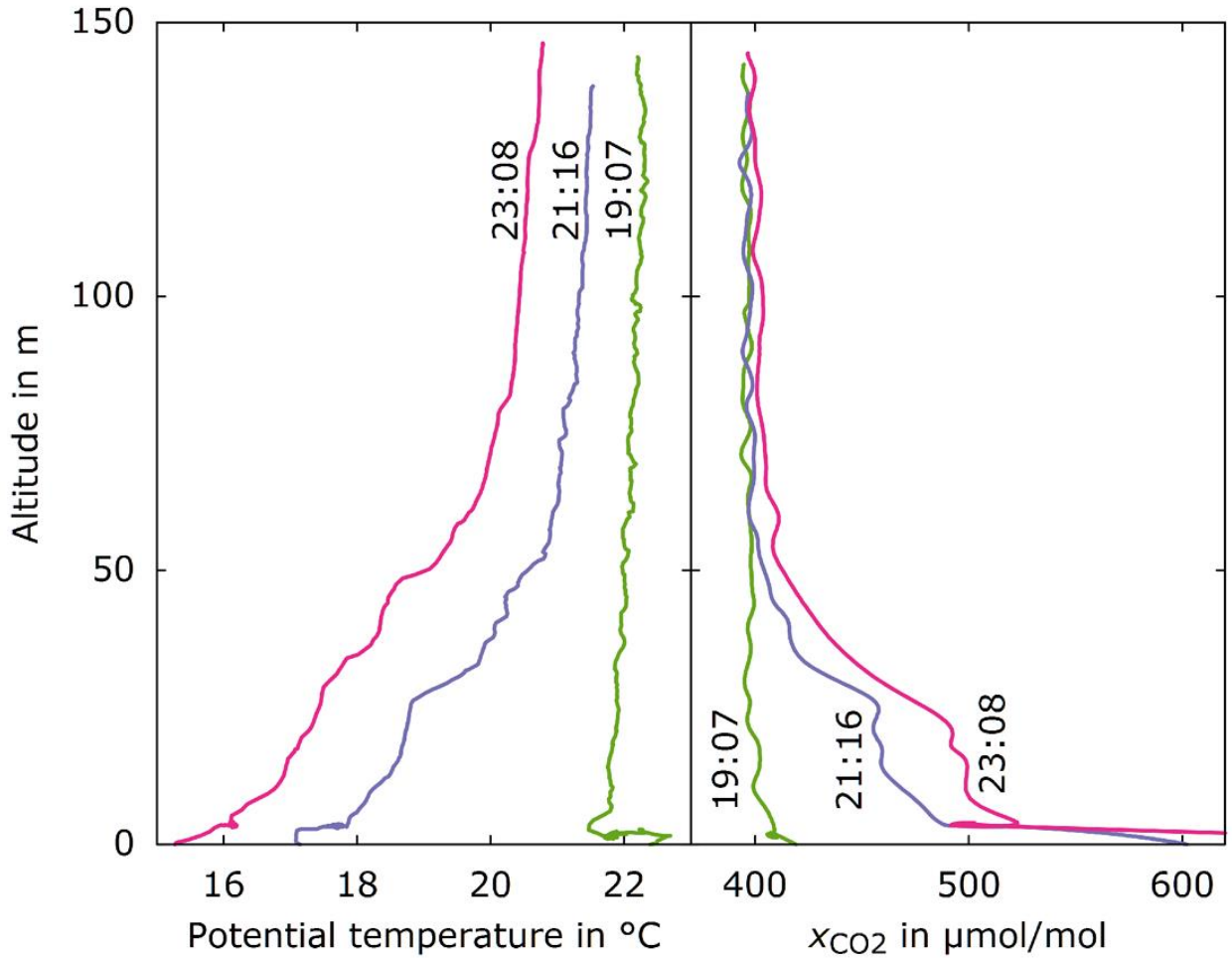

Source: Kunz *et al.*, in prep.

Oliver Kosak (U Augsburg/ISSE)

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- Autonomous deployment of temperature sensing cable by an ensemble of multicopter UAVs and a ground-based roving robot
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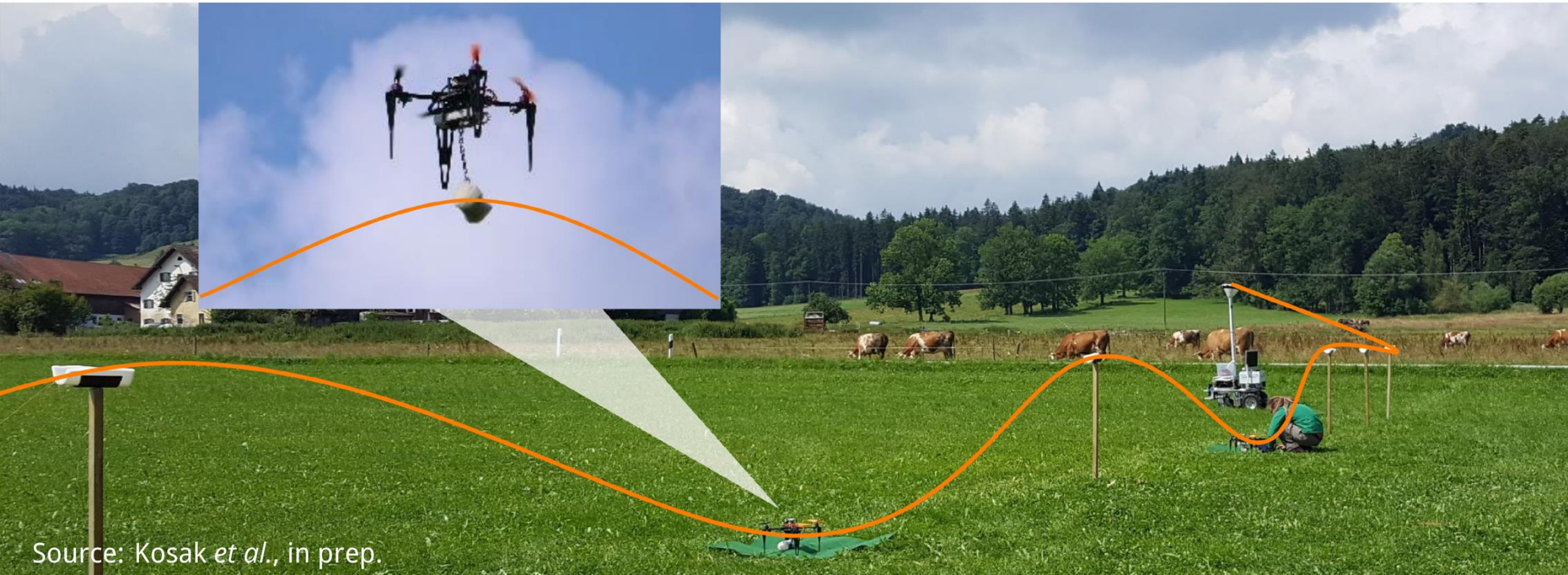

Source: Kosak *et al.*, in prep.

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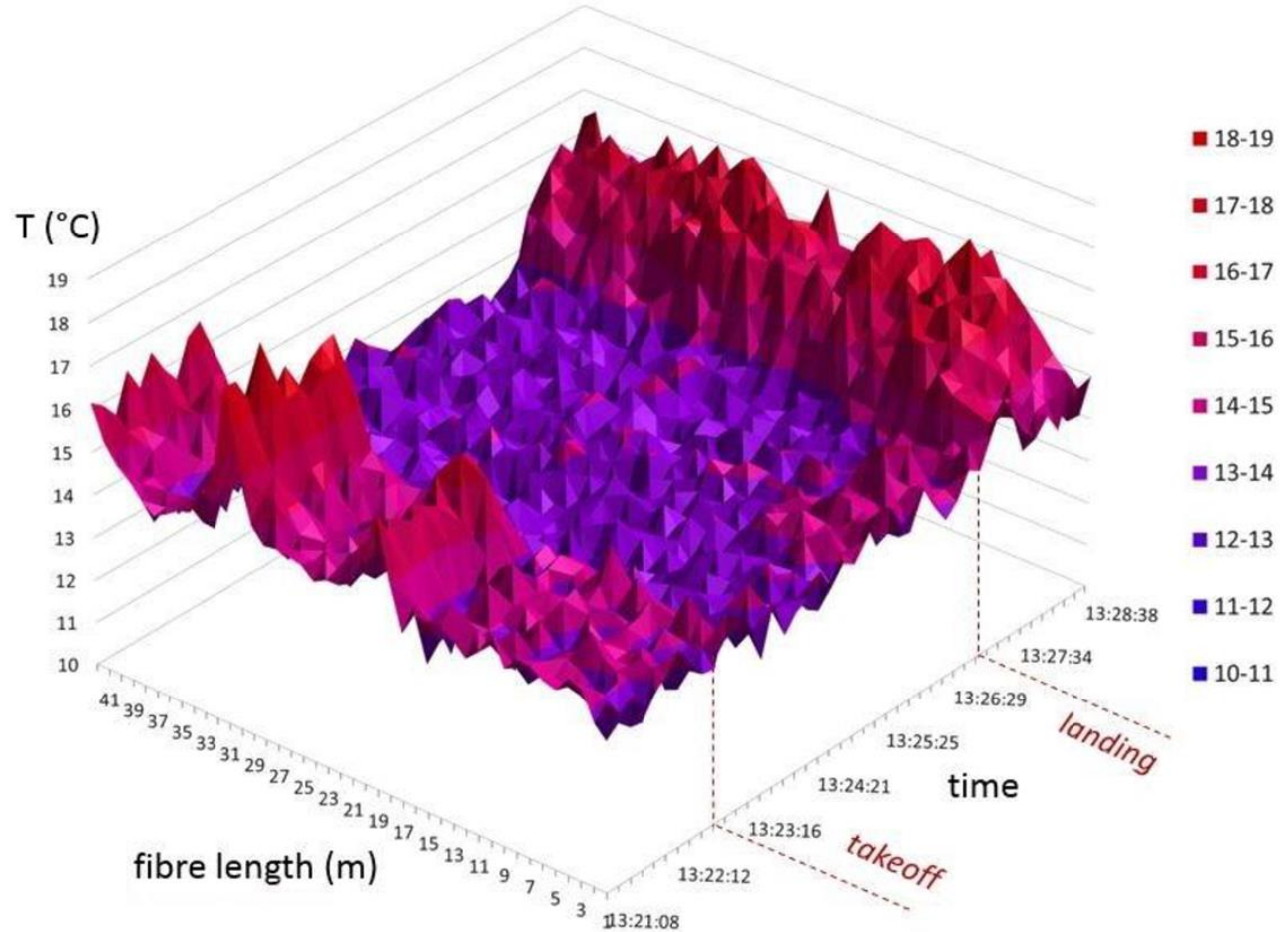
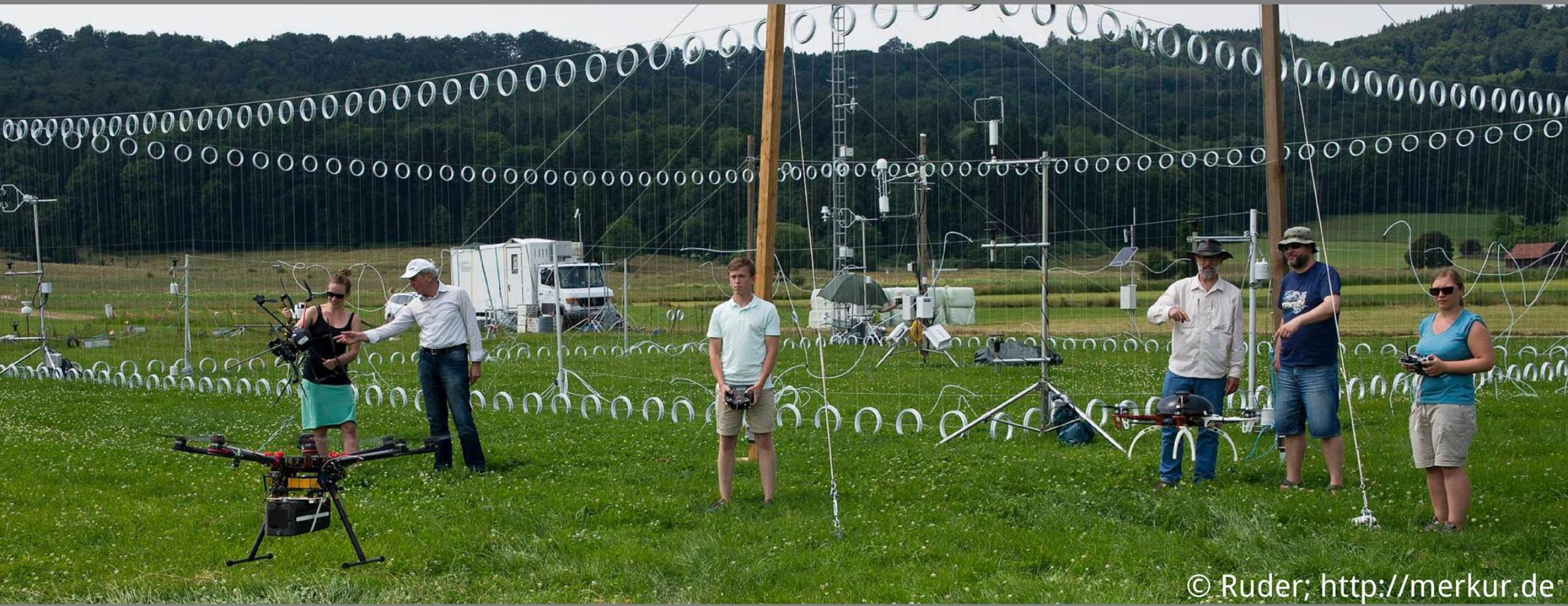


Source: Kosak *et al.*, in prep.

Complementary ground-based observations

In the background of the airborne activities, additional observations where made on the ground



Ground-based GHG Observations network

IMK-IFU | matthias.zeeman@kit.edu | 26.9.2017

B Wolf, R Gasche, K Schäfer, M Mauder, M Zeeman

WP5 WP2 WP1 **WP1**

Vertical profiles

BSc Thesis Kevin Wolz

Soil Chambers

Ground-based Wind Sensing Network

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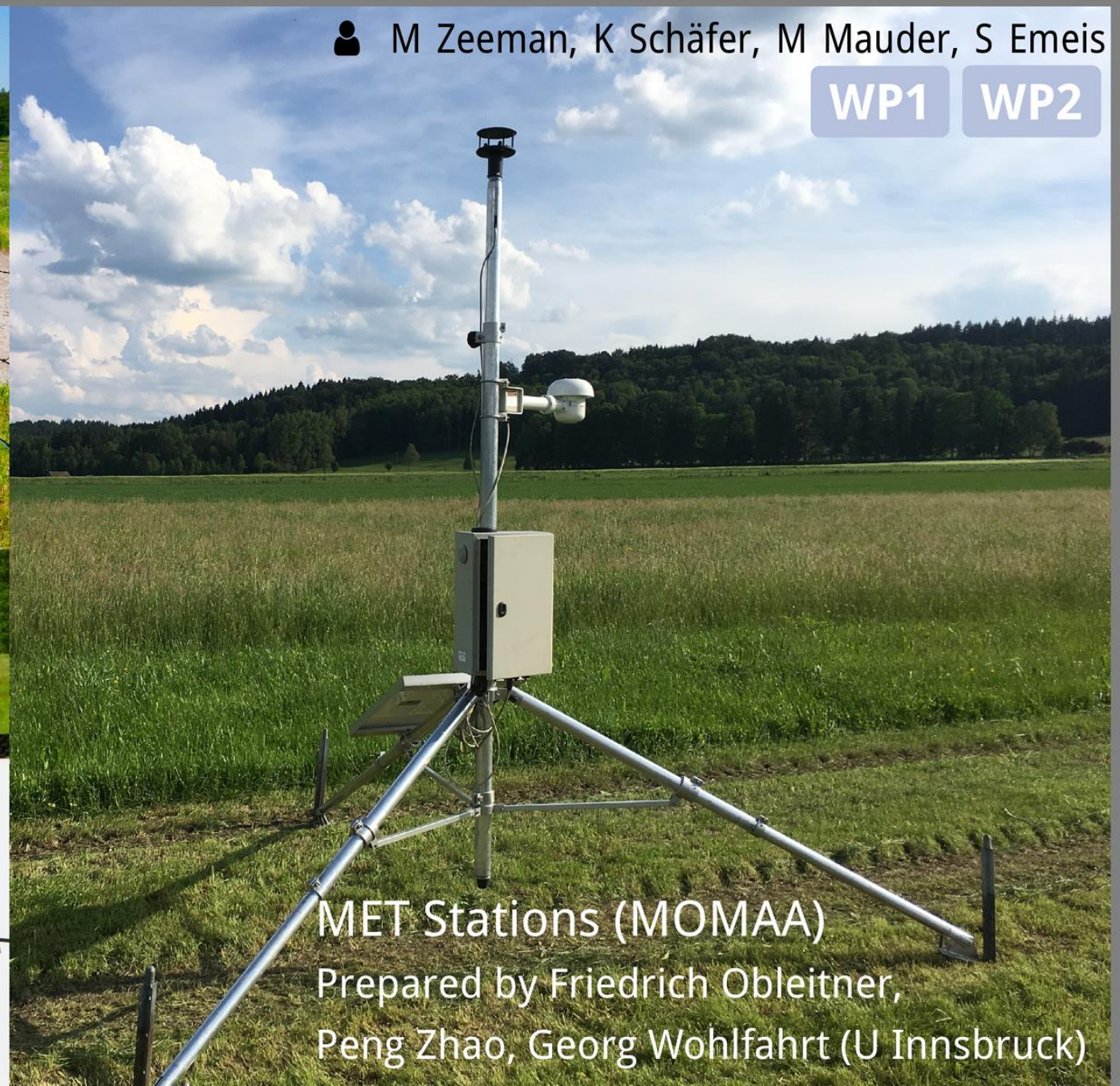
Ground-based Remote Sensing

Doppler WindLiDAR

SoDAR/RASS



M Zeeman, K Schäfer, M Mauder, S Emeis

WP1 WP2

MET Stations (MOMAA)

Prepared by Friedrich Obleitner,
Peng Zhao, Georg Wohlfahrt (U Innsbruck)

Ground-based Wind Sensing Network

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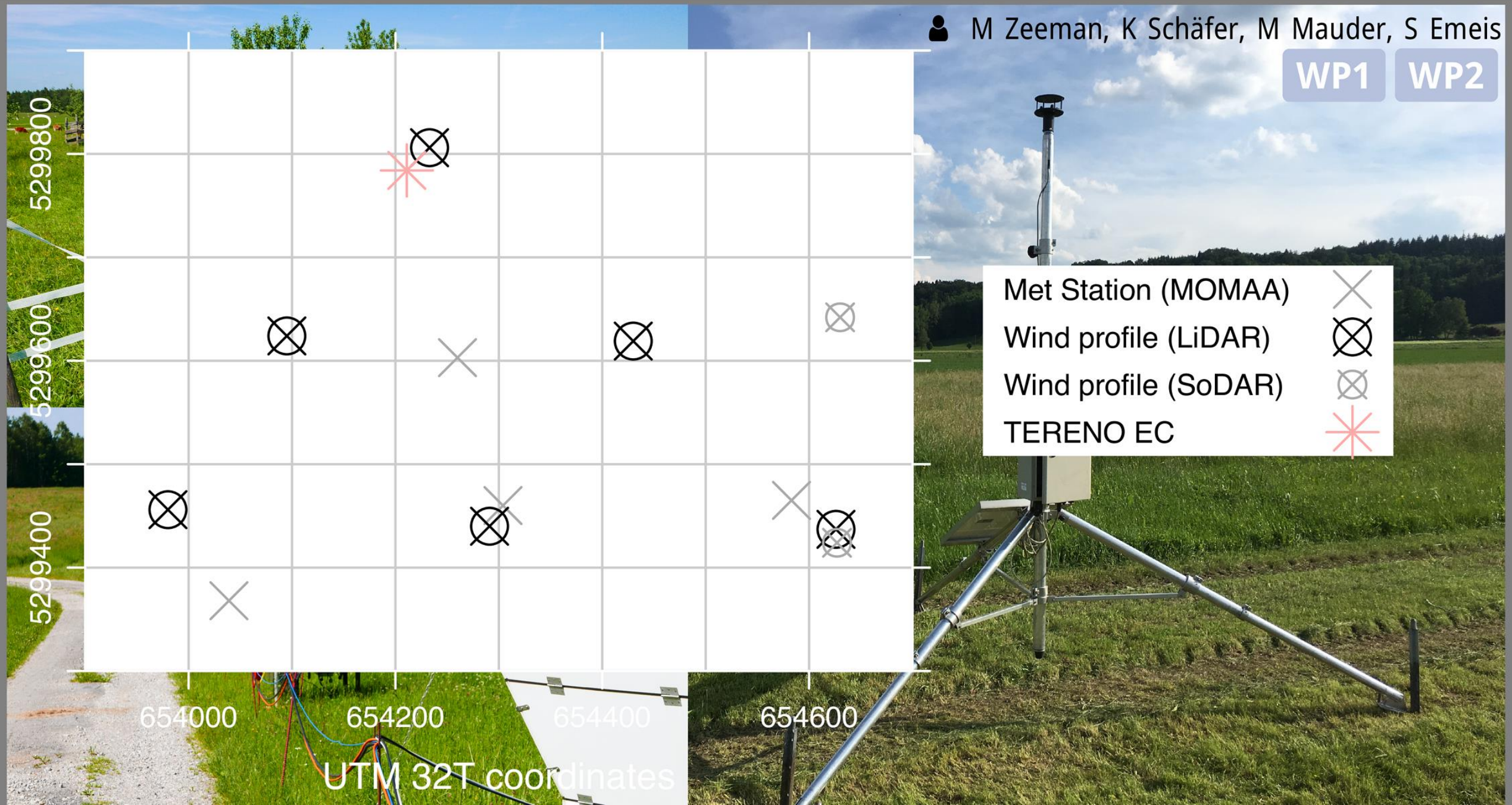
M Zeeman, K Schäfer, M Mauder, S Emeis

WP1 WP2



Ground-based EC/MET Stations network

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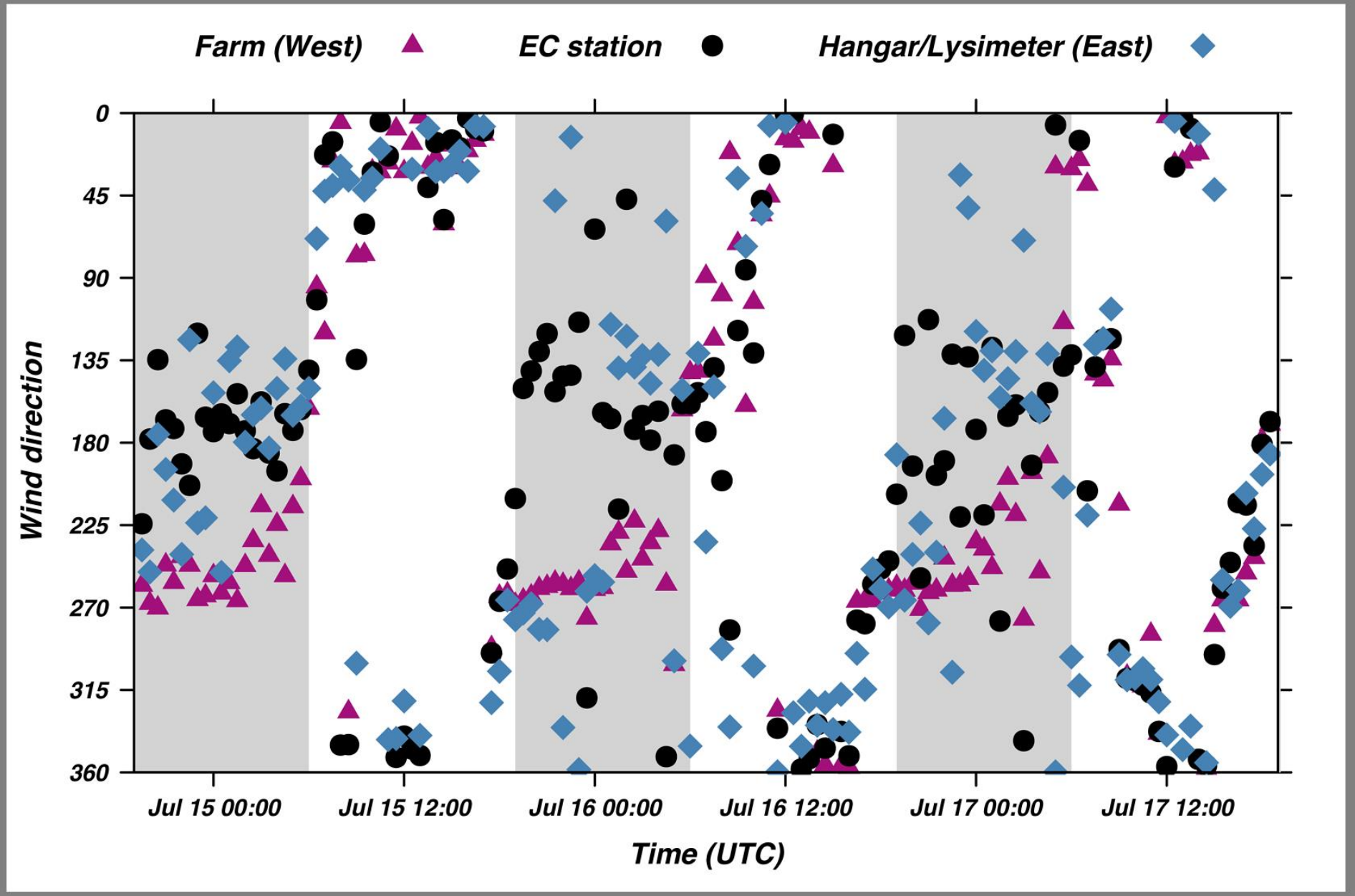
M Zeeman

Valley-bottom wind direction

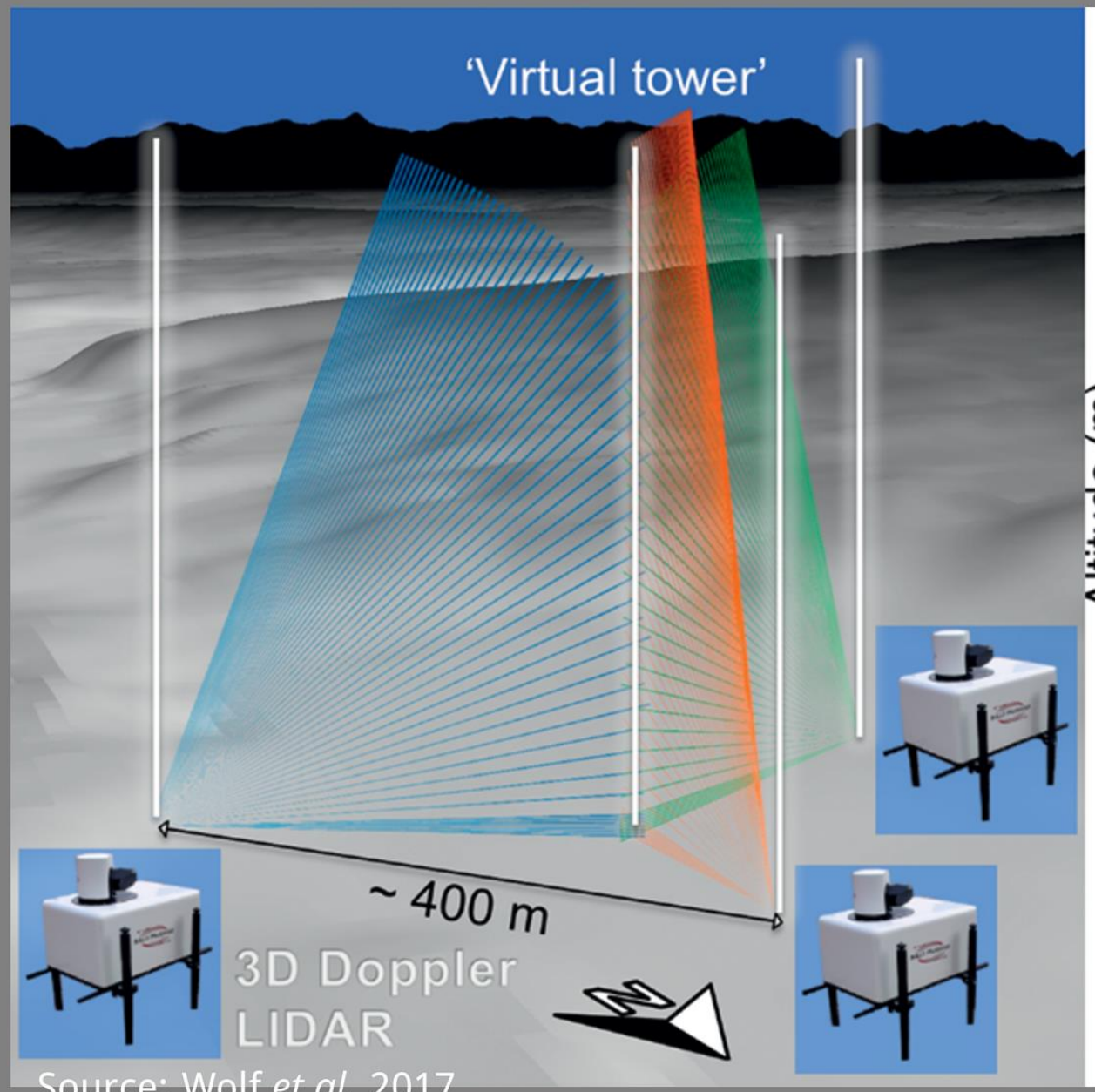
Day: **NNW**

Night: SW (Farm)
S
SE (Lysim.)

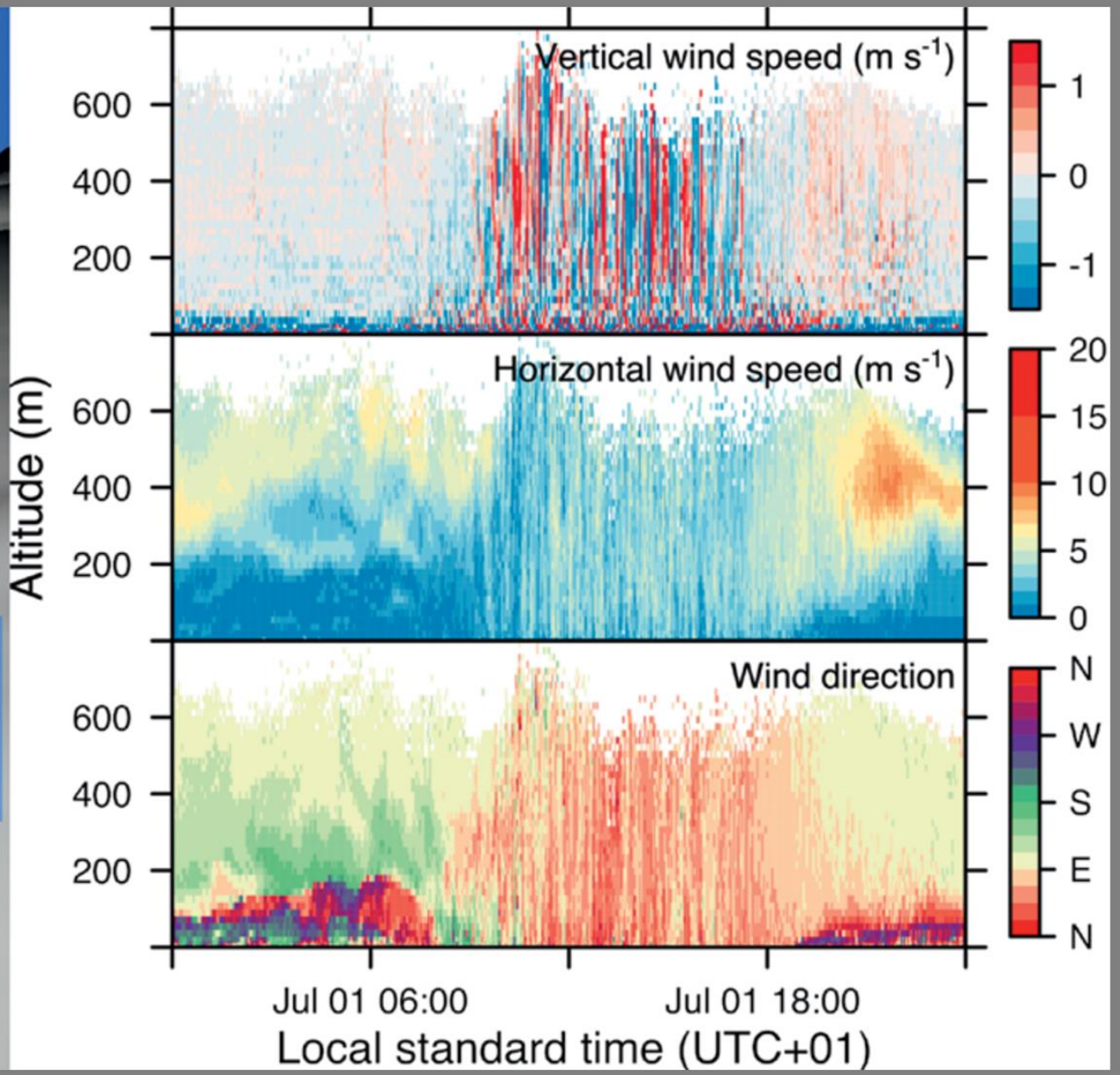


Ground-based remote sensing network

M Zeeman



Source: Wolf *et al.* 2017

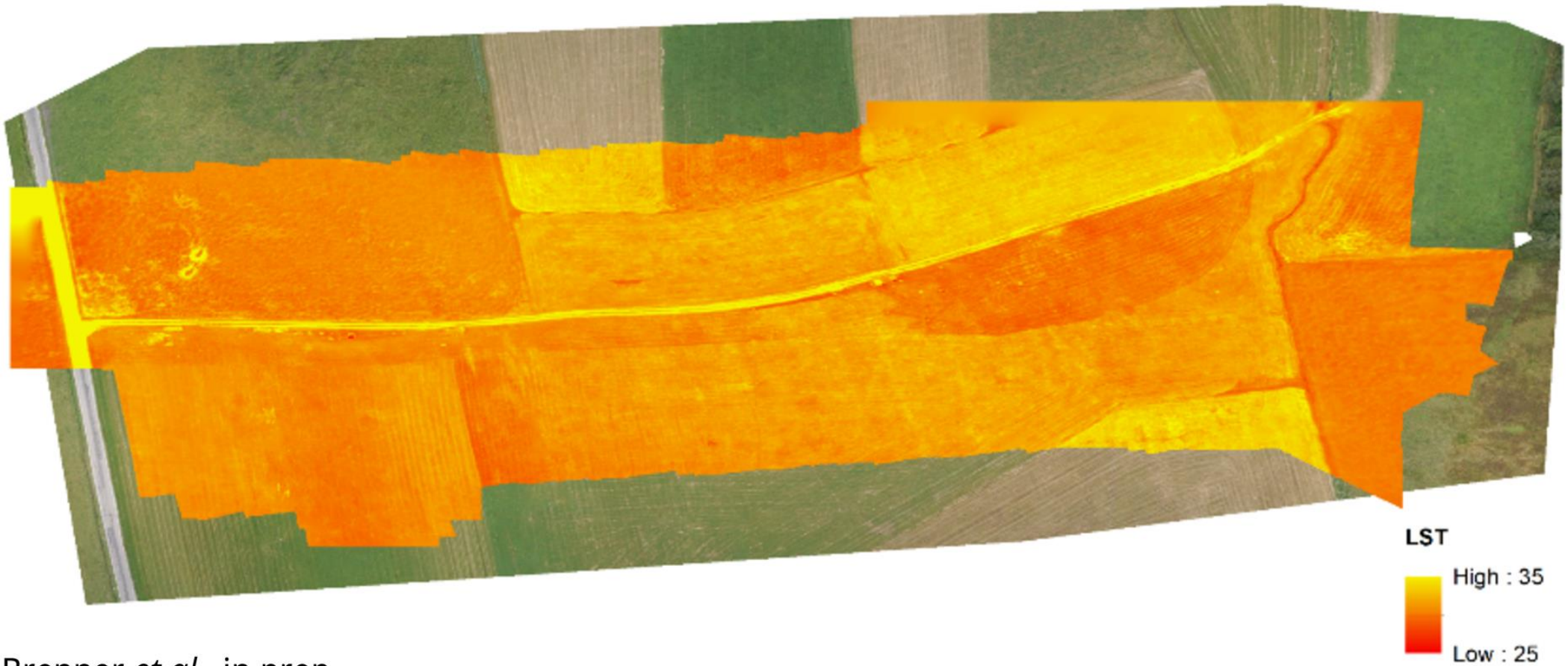


Temperature near the surface

- Frequent airborne surveys of surface temperature — Claire Brenner (BOKU)
- Continuous observation of sub-surface properties (SoilNet) — B Fersch
- Continuous observation of surface and air temperature — M Zeeman

UAV

WP5



Source: Brenner *et al.*, in prep.

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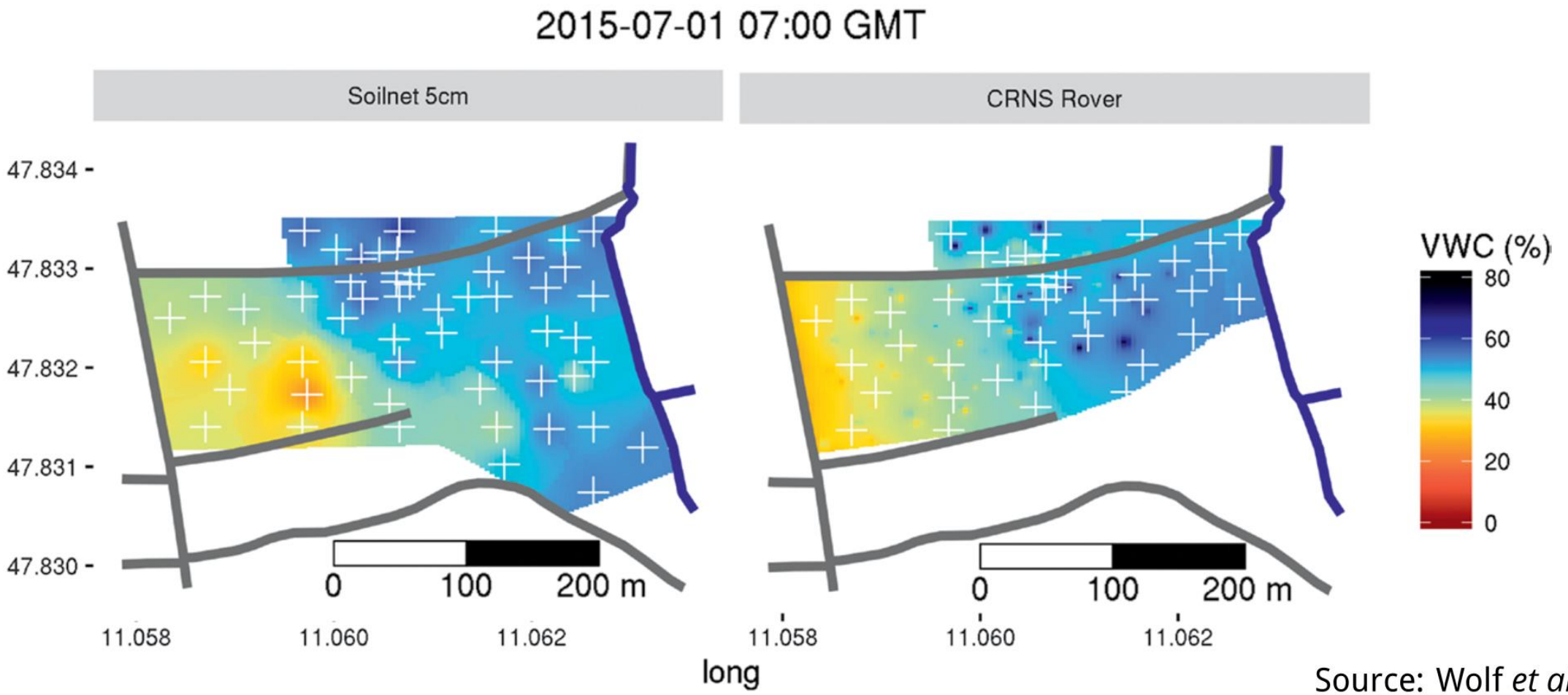

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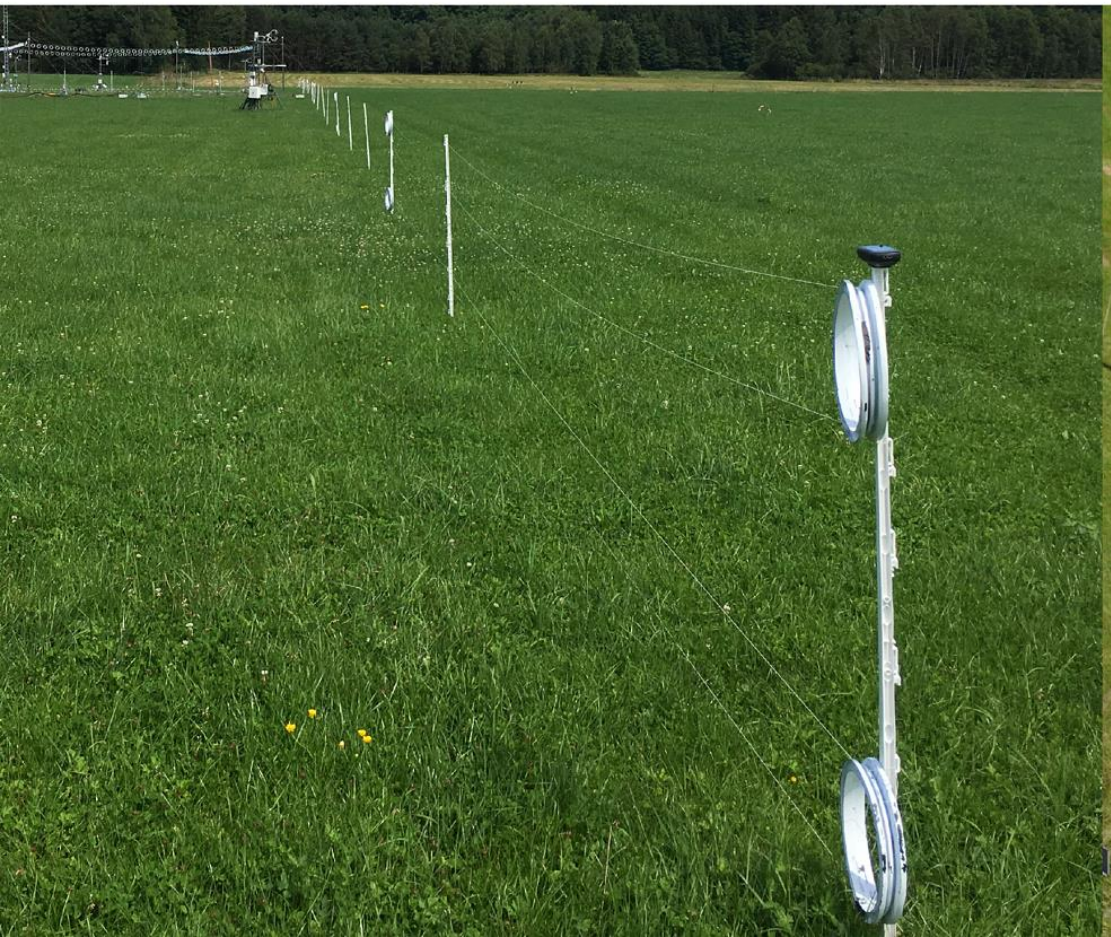

Photo: Claire Brenner

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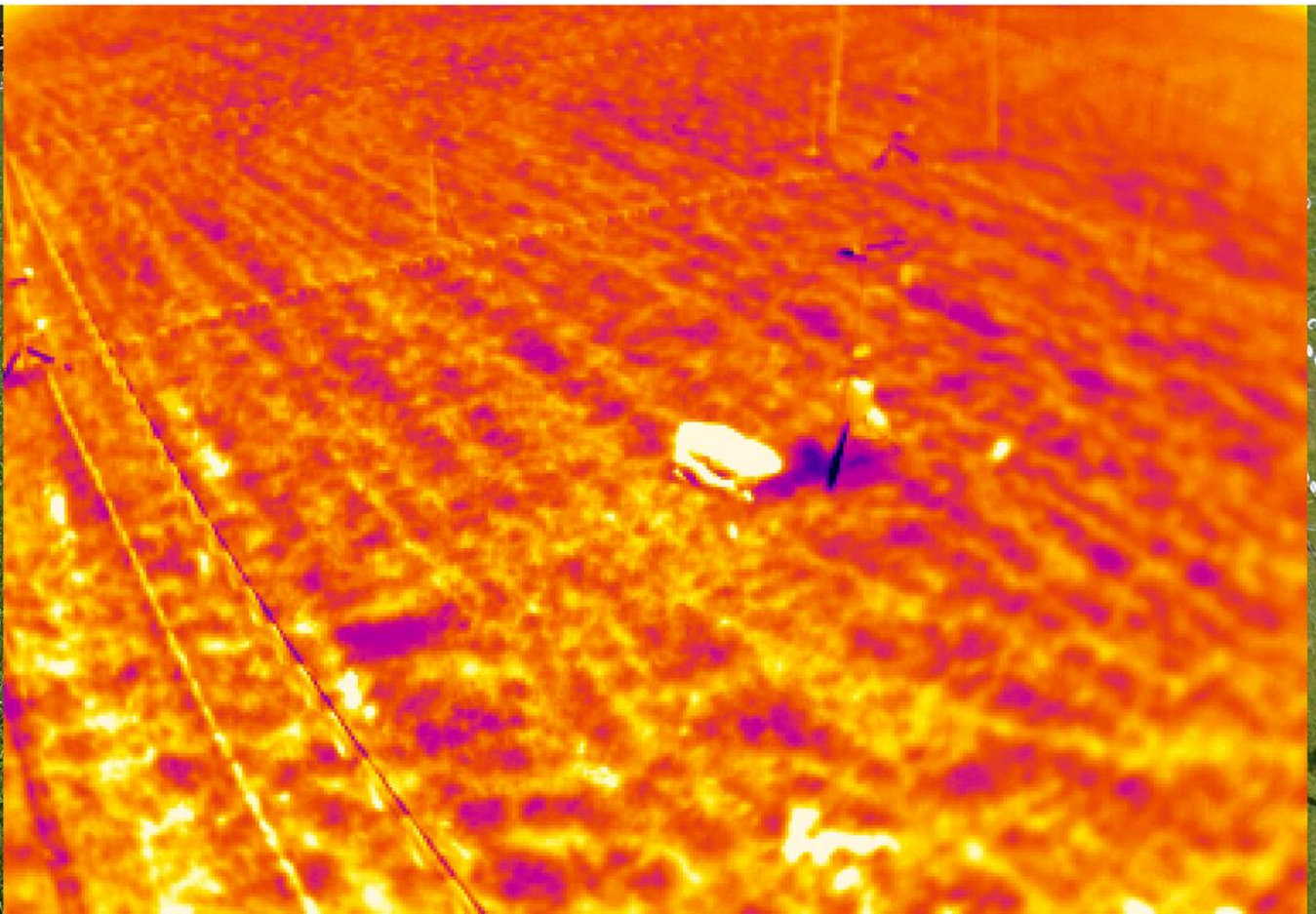

Photo: Claire Brenner

Relationships TERENO / ScaleX infrastructure

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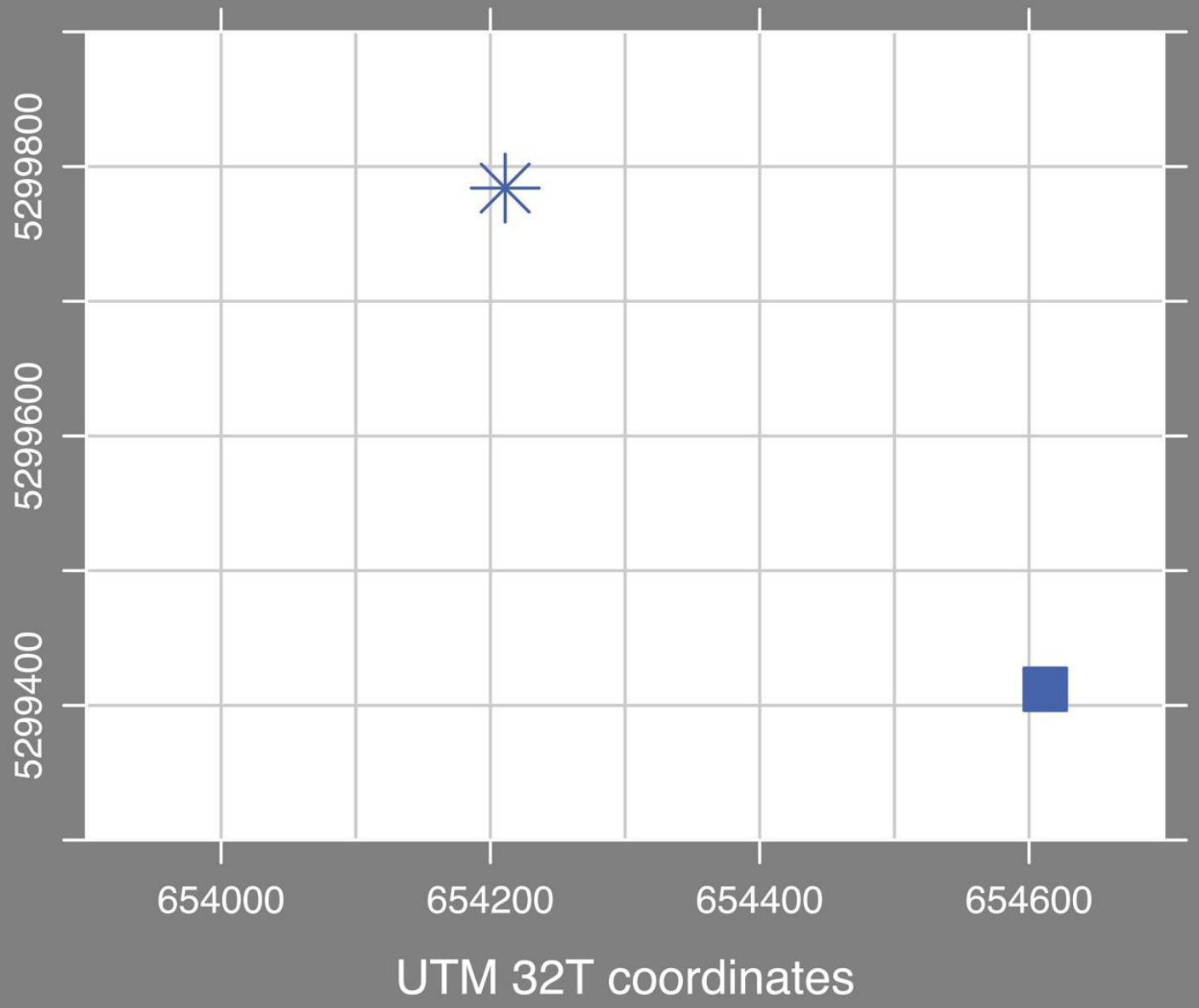

- EC
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- Wind profile (SoDAR)
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- Backscatter & cloud profile (Ceilometer)
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- TERENO EC
- TERENO Lysimeter cluster
- TERENO+ SoilNet
- TERENO+ SoilNet (Cosmic Ray)

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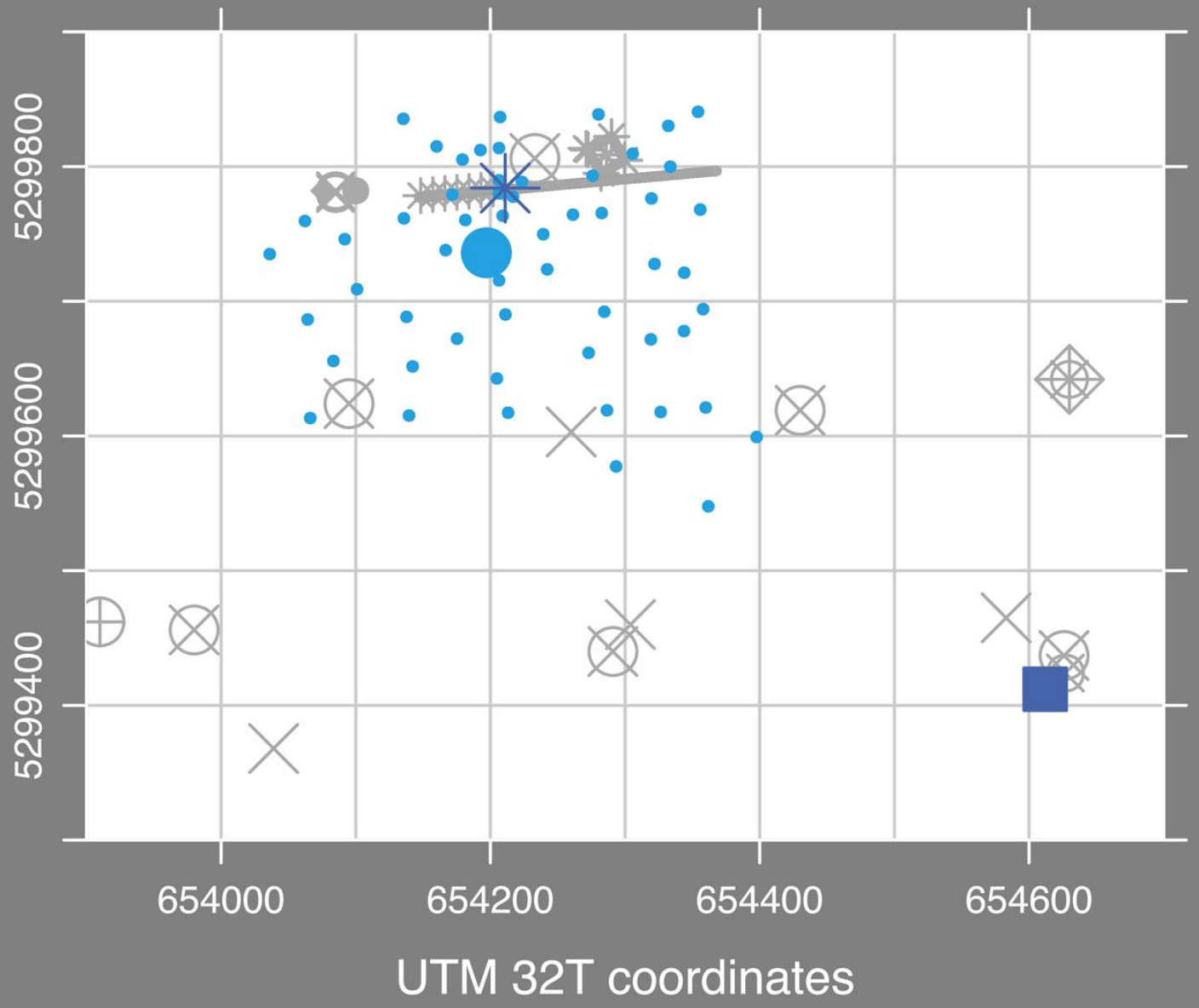

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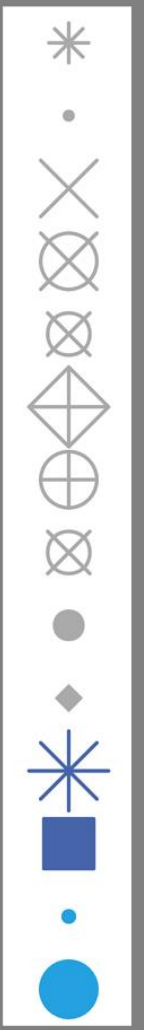

... and many, many more.

ScaleX Campaigns help establish a community of interest

- Community collaboration on TERENO long-term sites
- Community use of TERENO data
- Cross-discipline participation in campaigns *and* workshops

ScaleX Campaigns contribute to TERENO interests

- Extending scales; including spatial scale, resolution, variable space
- Complementary observations support cross-validation
- Supplementary observations help full-fill requirements for modeling

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Further information

Online: http://scalex.imk-ifu.kit.edu

Coordinator: Matthias Zeeman <matthias.zeeman@kit.edu>

Contacts : Caroline Brosy <caroline.brosy@kit.edu>
Klaus Schäfer <klaus.schaefer@kit.edu>
Andreas Philipp <andreas.philipp@geo.uni-augsburg.de>
Martin Kunz <mkunz@bgc-jena.mpg.de>
Jost Lavric <jlavric@bgc-jena.mpg.de>
Richard Grant <rgrant@purdue.edu>
Mark Zondlo <mzondlo@princeton.edu>
Oliver Kosak <oliver.kosak@informatik.uni-augsburg.de>
Claire Brenner <claire.brenner@boku.ac.at>
Benjamin Wolf <benjamin.wolf@kit.edu>
Benjamin Fersch <benjamin.fersch@kit.edu>
Matthias Mauder <matthias.mauder@kit.edu>
Stefan Emeis <stefan.emeis@kit.edu>
HaPe Schmid <hape.schmid@kit.edu>

Acknowledgments

- We thank the Scientific Team of ScaleX Campaign 2016 for their contribution.
- The TERrestrial Environmental Observatory (TERENO) preAlpine infrastructure is funded by the Helmholtz Association and the Federal Ministry of Education and Research.
- Facilities, Technical & Administrative support (at KIT IMK–IFU):

  Frank Neidl, Robert Neuner, Bernhard Thom, Josef-Michael Burger, Stefan Schmid, Uwe Heinz, Christoph Sörgel, Reiner Müller and Marta Kern
- and (last but not least) the Jungwirth family.

References (this presentation)

- Wolf *et al.* 'The SCALEX Campaign: Scale-Crossing Land Surface and Boundary Layer Processes in the TERENO-preAlpine Observatory', *Bull. Am. Meteorol. Soc.*, June **2017**.
- Brosy et al. 'Simultaneous multicopter-based air sampling and sensing of meteorological variables', *Atmos. Meas. Tech.*, 10, 2773–2784, **2017**.
- Golston *et al.* 'Lightweight mid-infrared methane sensor for unmanned aerial systems', *Applied Physics B* , 123:170, **2017**.

- Philipp *et al.* 'Distributed sounding of the boundary layer using multiple unmanned aerial systems during the ScaleX campaign 2016', *Geophysical Research Abstracts*, Vol. 19, EGU2017-15183, **2017**.
- Kunz *et al.* 'Atmospheric Profiles of Carbon Dioxide Obtained with a UAS: Constraints on Square Kilometre Scale Carbon Budgets', *AGU Fall Meeting*, Dec **2016**.
- Wolz *et al.* 'Multi-Scale Observation and Modelling of Energy and Matter Exchange in the Atmospheric Boundary-Layer (ScaleX Campaigns)', *AGU Fall Meeting*, Dec **2016**.
- and further journal submissions and meeting contributions, incl. AGU, EGU, AMS, ...

ScaleX Campaigns – Conditions versus 1900–2016

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2015

May: **Wet**

Jun: nominal

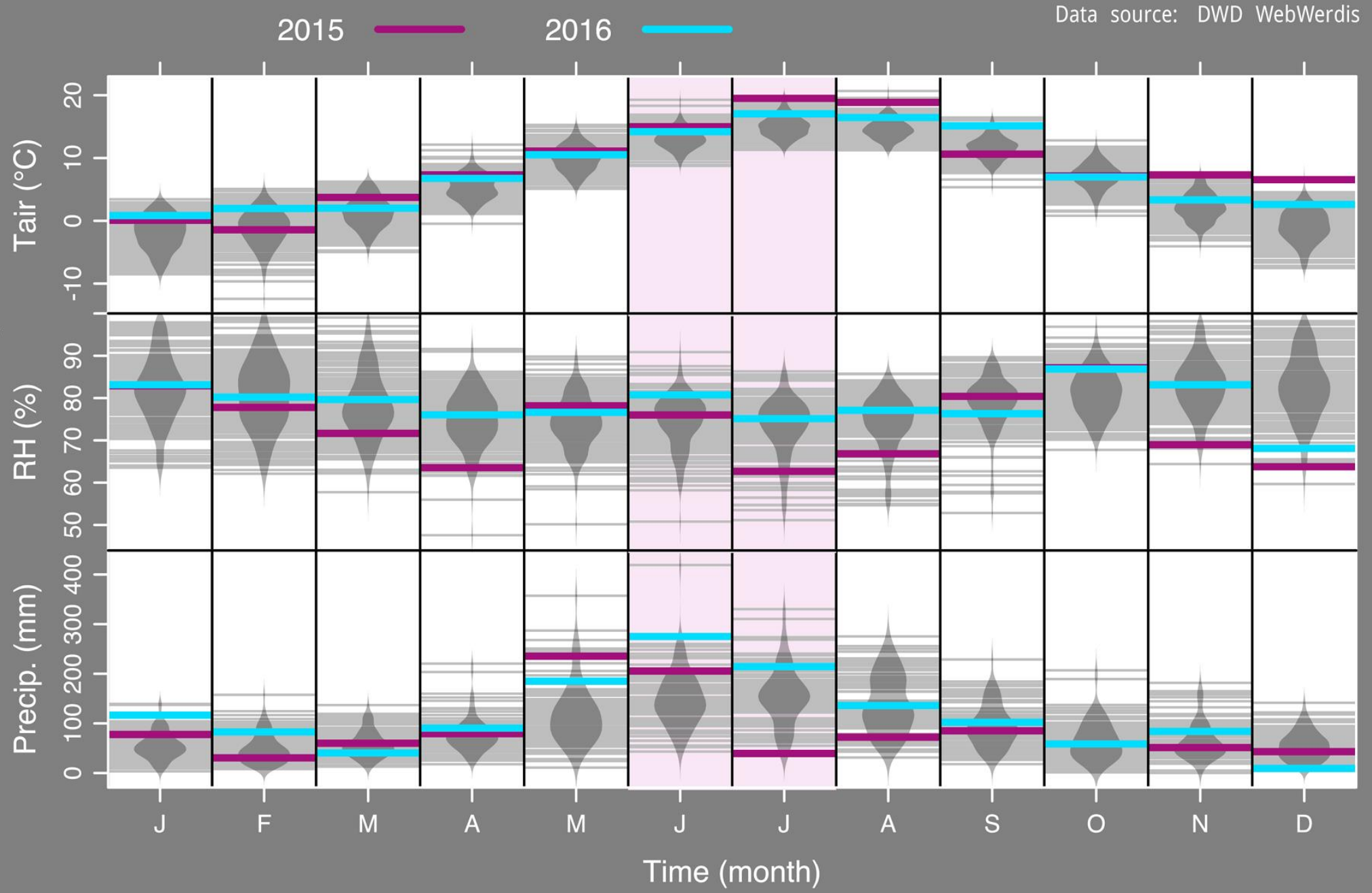
Jul: **Hot+Dry**

2016

May: **Wet**

Jun: **Wet**

Jul: **Wet**



Agreement on use of ScaleX data:

1. “Inform those who contributed the data on your plans to use the data and any plans for publication; the data contributors should be given the opportunity to contribute substantively to publications and, as result, to be a co-author.”
2. “The term ‘ScaleX’ should be mentioned in the abstract or the keywords (if applicable) and the acknowledgement section of publications using the data, including meeting contributions. Please refer your audience to http://scalex.imk-ifu.kit.edu for further details about ScaleX.”
3. “Please acknowledge TERENO and its funding partners as well as the ScaleX Scientific Teams in publications using the data, including meeting contributions. The members of the Scientific Teams are listed on the ScaleX website (http://scalex.imk-ifu.kit.edu). Suggested phrase: ‘The TERrestrial Environmental Observatory (TERENO) pre-Alpine infrastructure is funded by the Helmholtz Association and the Federal Ministry of Education and Research. We thank the Scientific Team of ScaleX Campaign 2016 for their contribution.’”