The TEAMx Observational Campaign

Manuela Lehner and Mathias W. Rotach

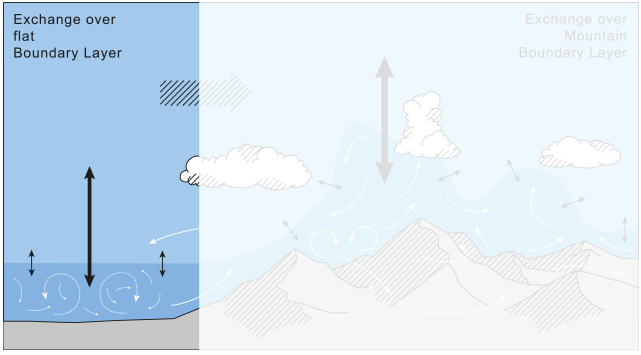
Thanks to the TOC participants and the TEAMx community

ICAM 2025, Poreč, Croatia

TEAMx Multi-scale transport and exchange processes in the atmosphere over mountains—programme and experiment

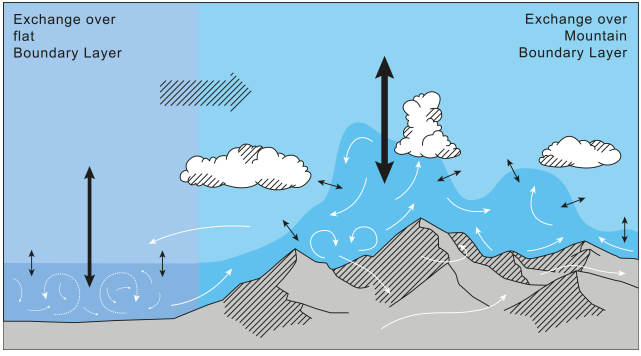
- international research programme with > 40 signatories of the TEAMx Memorandum of Understanding
- one-year long TEAMx Observational Campaign with > 25 participating institutions
- additional smaller measurement campaigns (e.g., HEFEX, PC22)

Mountain Boundary Layer (MoBL)



- Horizontally homogeneous conditions
- Exchange due to vertical turbulent transport
- Turbulence parameterizations based on observations for flat and homogeneous terrain

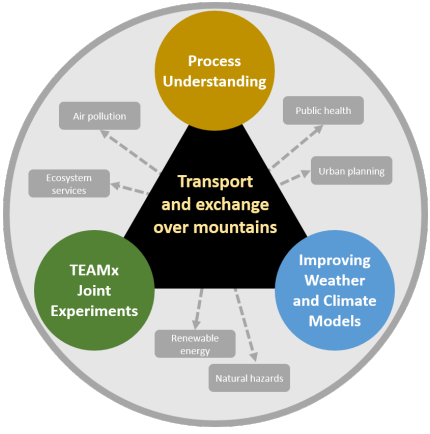
Mountain Boundary Layer (MoBL)



- Wide range of scales
- Process interact
- 3D spatial variability
- Processes that are difficult to measure/model
- Questionable applicability of measurement/modeling techniques

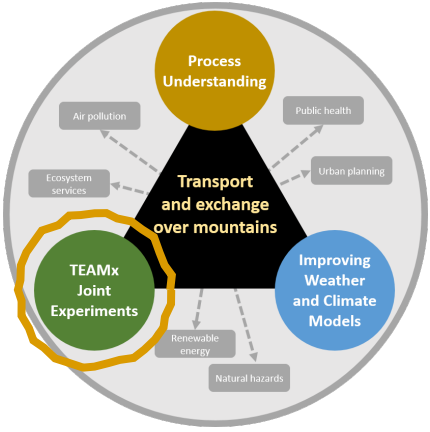
TEAMx Goals

- Improving our understanding of transport and exchange processes between the surface and the atmosphere and within the atmosphere
- Evaluating and improving weather and climate models over complex terrain
- Collecting a unique dataset to study the transport and exchange processes
- Supporting weather and climate service providers

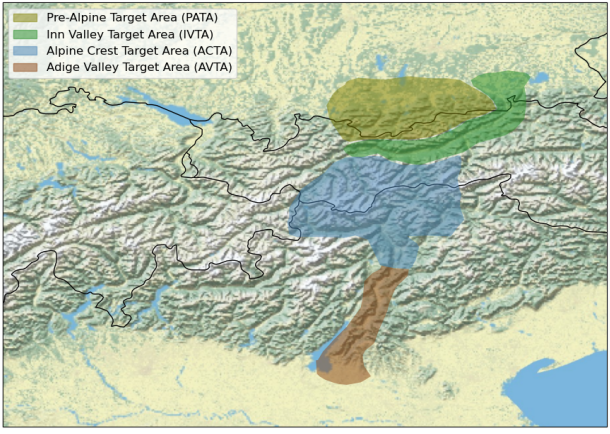


TEAMx Goals

- Improving our understanding of transport and exchange processes between the surface and the atmosphere and within the atmosphere
- Evaluating and improving weather and climate models over complex terrain
- Collecting a unique dataset to study the transport and exchange processes
- Supporting weather and climate service providers



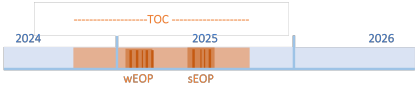
TEAMx Observational Campaign (TOC)



North–south transect through the Alps

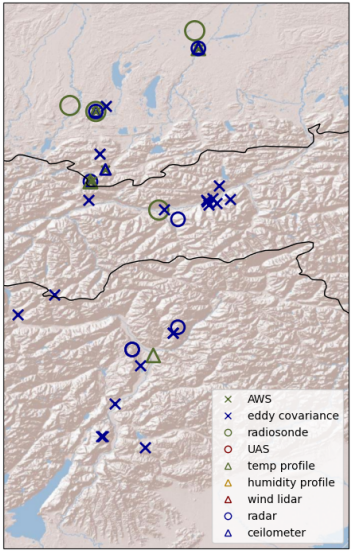
- Pre-Alpine Target Area
- Inn Valley Target Area
- Alpine Crest Target Area
- Adige Valley Target Area

TEAMx Observational Campaign (TOC)



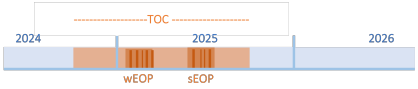
One-year long TOC

- Observations over a longer timescale than most field campaigns
- Increase the density of the existing observational infrastructure



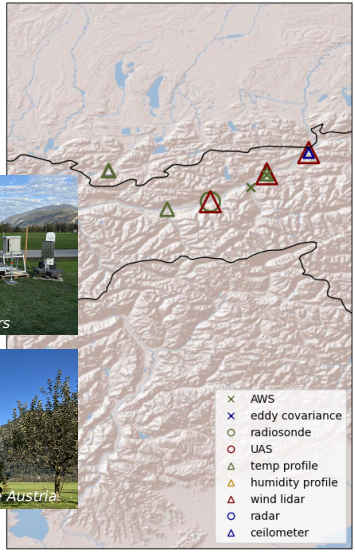
operational sites excluding AWS networks

TEAMx Observational Campaign (TOC)



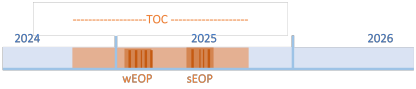
One-year long TOC

- Observations over a longer timescale than most field campaigns
- Increase the density of the existing observational infrastructure



instruments deployed for the TOC

TEAMx Observational Campaign (TOC)



Extended Observational Periods

- Focus on individual processes


Photo: M. Breig

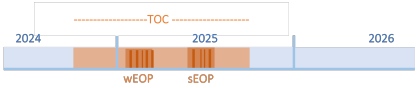

Photo: L. Bennett


Photo: D. Anderson


Photo: J. Vüllers

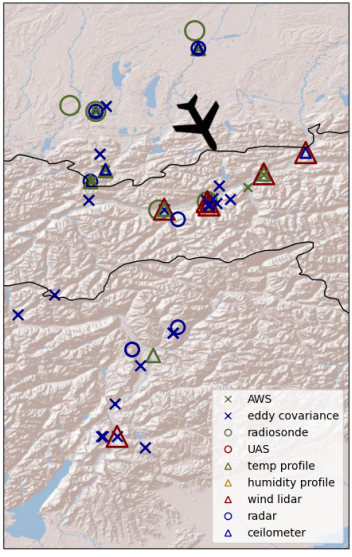

Photo: A. Gohm

TEAMx Observational Campaign (TOC)

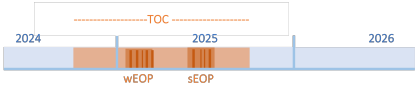


Extended Observational Periods

- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb

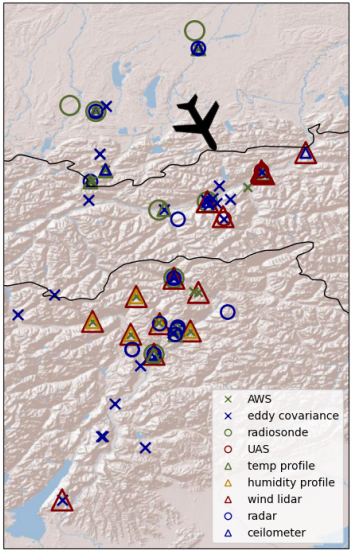


TEAMx Observational Campaign (TOC)

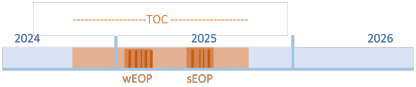


Extended Observational Periods

- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb
- Summer EOP (sEOP): 16 Jun–25 Jul



TEAMx Observational Campaign (TOC)



Extended Observational Periods

- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb
- Summer EOP (sEOP): 16 Jun–25 Jul
- IOPs targeting specific weather conditions

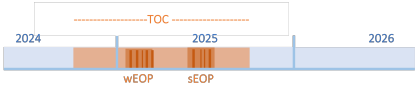

Photo: G. Nitti


Photo: P. Berthelemy


Photo: C. Brun


Photo: M. Rotach

TEAMx Observational Campaign (TOC)



Extended Observational Periods

- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb
- Summer EOP (sEOP): 16 Jun–25 Jul
- IOPs targeting specific weather conditions

3 research aircraft

- NCAS FAAM BAe146
- DLR Cessna Caravan
- TU Braunschweig Cessna F406


Photo: D. Anderson

Operations Center

- Daily meetings during the EOPs
- Weather briefings by four **student forecasters**
- **Scientists in Charge** leading the meetings and compiling IOP summaries and information on the status of field instrumentation

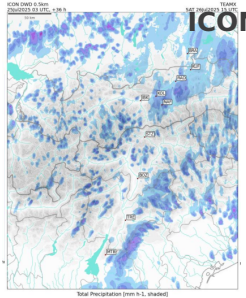

Photo: D. Anderson

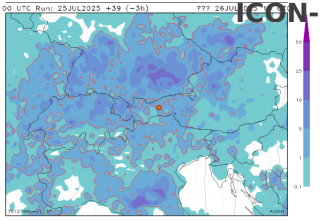

Photo: M. Lehner

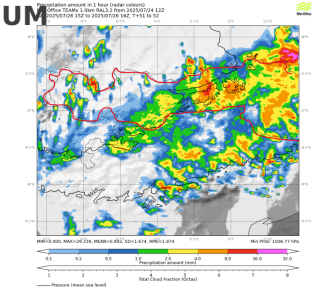
High-resolution NWP forecasts

Daily forecasts supported by

- 500-m ICON runs from DWD
- 1-km ICON runs from Meteo Swiss
- 1-km UM runs from the Met Office



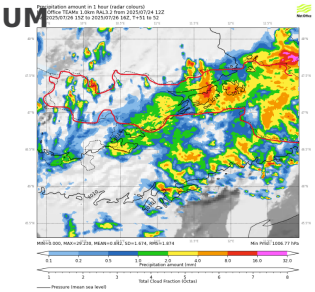


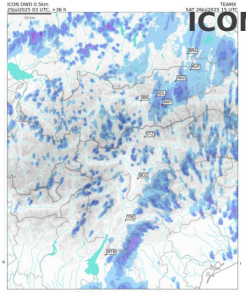


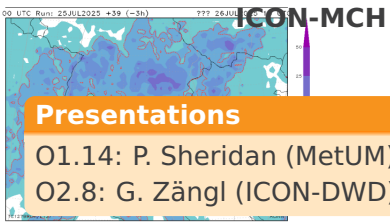
High-resolution NWP forecasts

Daily forecasts supported by

- 500-m ICON runs from DWD
- 1-km ICON runs from Meteo Swiss
- 1-km UM runs from the Met Office





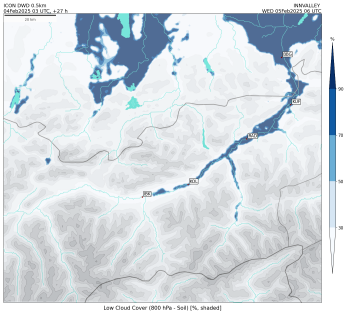


Presentations

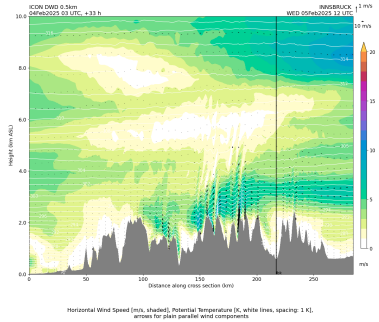
O1.14: P. Sheridan (MetUM)
O2.8: G. Zängl (ICON-DWD)

High-resolution NWP forecasts

500-m DWD ICON runs during the wEOP for daily weather forecasts



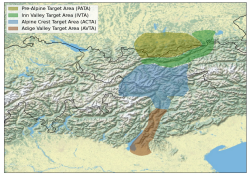
Low-level clouds in the Inn Valley



Wind speed across the Alps (S–N)

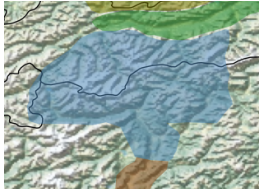
Multi-scale processes

Alpine scale



- Mountain waves
- Mountain-plain wind

Regional scale



- Orographic convection
- Foehn

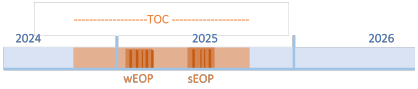
Valley scale

- MoBL structure
- Valley winds
- Mountain venting
- Fog/low stratus

Local scale

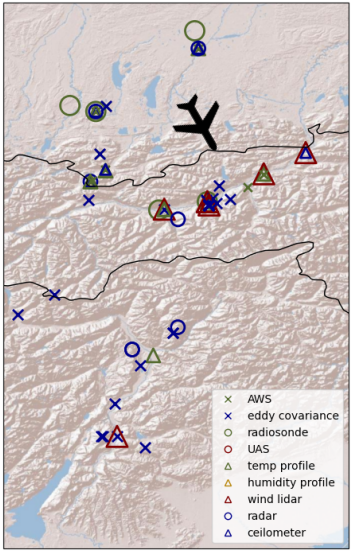
- Slope winds
- Turbulence

Winter EOP (wEOP)

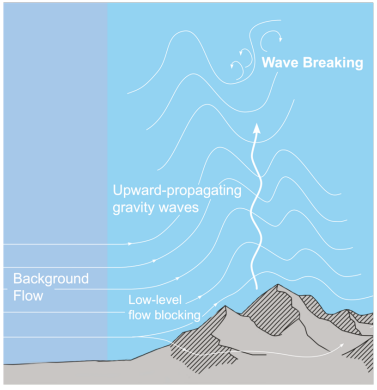


Extended Observational Periods

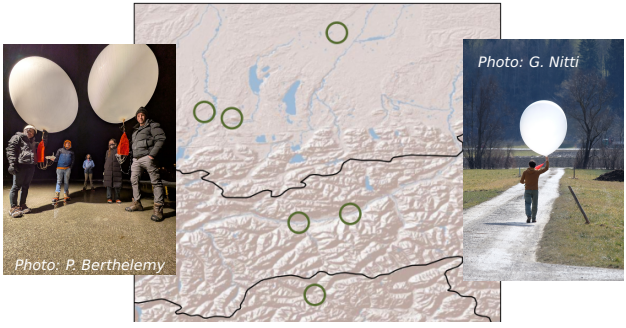
- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb
- Summer EOP (sEOP): 16 Jun–25 Jul
- IOPs targeting specific weather conditions



Gravity waves



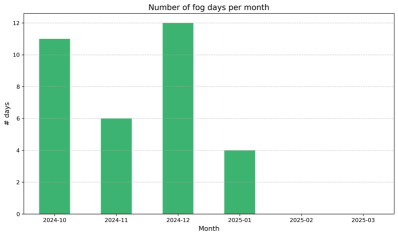
Credit: Andrew Orr



- Improve process understanding (especially gravity-wave drag)
- Improve understanding of how drag is resolved and parameterised in NWP and climate models at all scales

Fog and low stratus

Karlsruhe Low-Cloud Exploratory Platform (KLOCX): Life-cycle phases of **low-level stratiform clouds and fog**



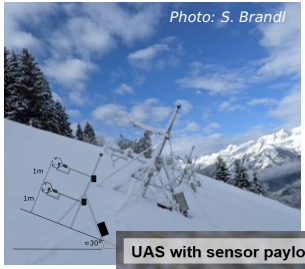
Credit: Jutta Vüllers

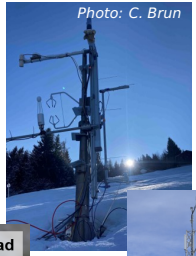
wEOP: Downslope winds over a snow-covered slope

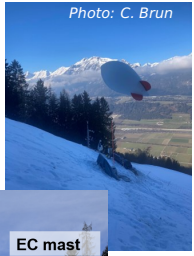
3D structure of **mean and turbulent flow properties**

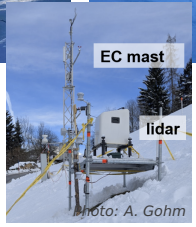
wEOP: Downslope winds over a snow-covered slope

3D structure of **mean and turbulent flow properties**



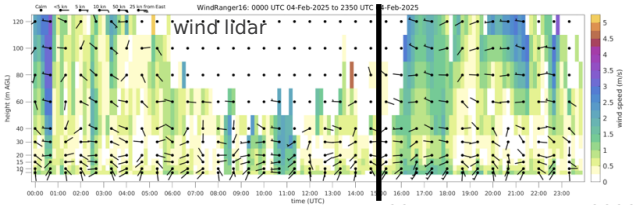






wEOP: Downslope winds over a snow-covered slope

3D structure of **mean and turbulent flow properties**

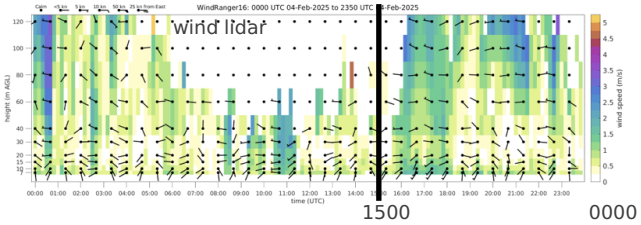


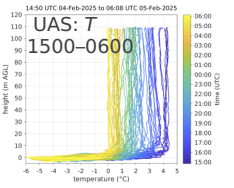
- Transition from downslope (S) to down-valley (W) winds
- Shallow southerly katabatic jet

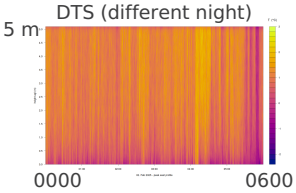
Credit: Alexander Gohm, Lena Pfister, Ivana Stiperski

wEOP: Downslope winds over a snow-covered slope

3D structure of **mean and turbulent flow properties**





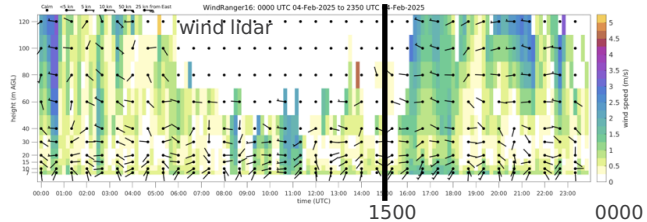


- Transition from downslope (S) to down-valley (W) winds
- Shallow southerly katabatic jet
- Shallow temperature inversion: 5–10 m

Credit: Alexander Gohm, Lena Pfister, Ivana Stiperski

wEOP: Downslope winds over a snow-covered slope

3D structure of **mean and turbulent flow properties**

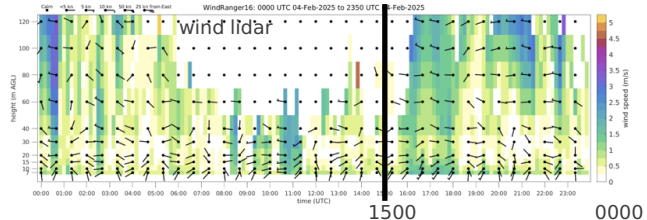


- Transition from downslope (S) to down-valley (W) winds
- Shallow southerly katabatic jet
- Shallow temperature inversion: 5–10 m
- Along-slope variations in turbulent fluxes

Credit: Alexander Gohm, Lena Pfister, Ivana Stiperski

wEOP: Downslope winds over a snow-covered slope

3D structure of **mean and turbulent flow properties**



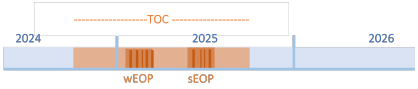
- Transition from downslope (S) to down-valley (W) winds
- Shallow southerly katabatic jet
- Shallow temperature inversion: 5–10 m
- Alo… turi…

Credit: A… Pfister, I…

Presentation
O2.6: C. Brun

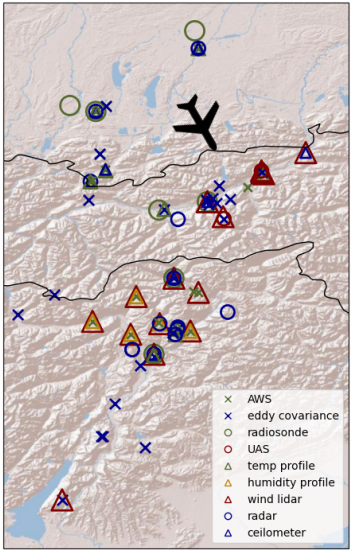
Poster
P1.9: M. Ghirardelli

Summer EOP (sEOP)



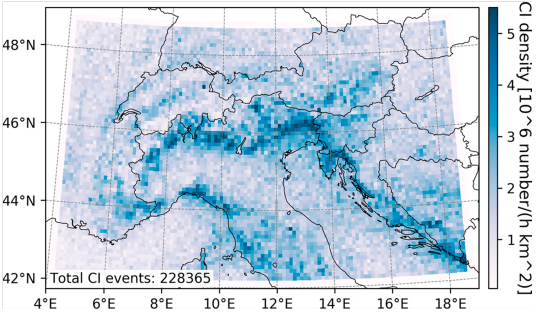
Extended Observational Periods

- Focus on individual processes
- Winter EOP (wEOP): 20 Jan–28 Feb
- Summer EOP (sEOP): 16 Jun–25 Jul
- IOPs targeting specific weather conditions



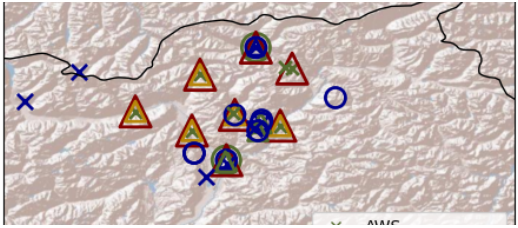
sEOP: Convection

Sarntal Alps: Hotspot of convection initiation



Manzato et al. (2022) : A pan-Alpine climatology of lightning and convection initiation. Monthly Weather Review.

sEOP: Convection



- Dense network of remote-sensing instrumentation + radiosoundings


Photo: M. Rotach


Photo: L. Bennett

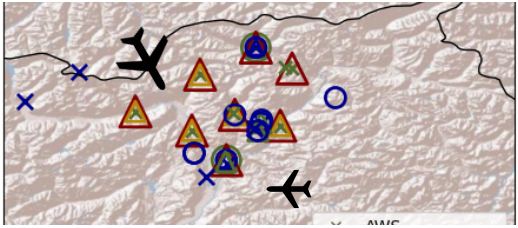

Photo: D. Corradini

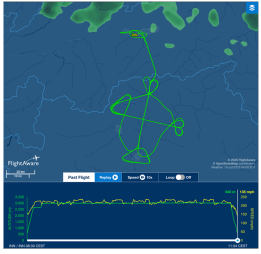

Photo: M. Breig

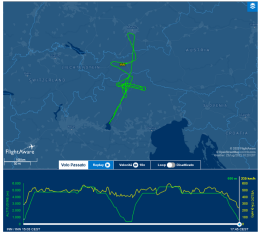

Photo: M. Rotach


Photo: M. Rotach

sEOP: Convection

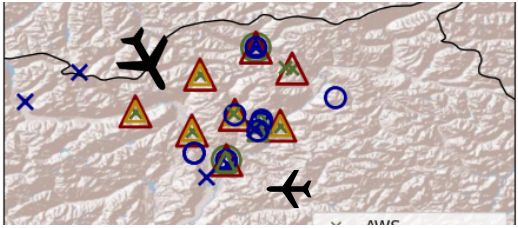






- Dense network of remote-sensing instrumentation + radiosoundings
- Aircraft: TU Braunschweig Cessna + NCAS FAAM

sEOP: Convection



- Dense network of remote-sensing instrumentation + radiosoundings
- Aircraft: TU Braunschweig Cessna + NCAS FAAM


Photo: T. Feuerle


Photo: C. Probst

Presentation
O2.3: P. Gasch

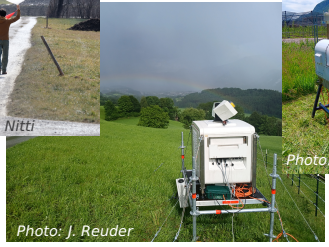
Poster
P1.11: M. Dorninger

sEOP: MoBL + thermal winds

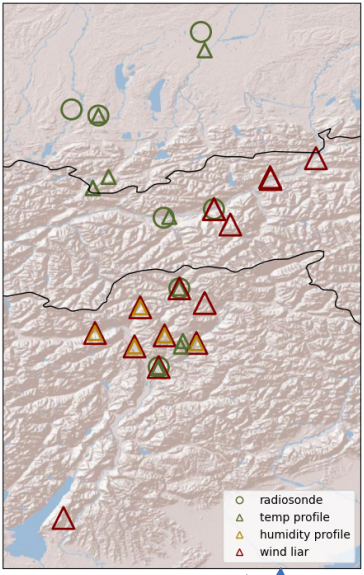
Spatially distributed vertical profiles

Radiosoundings

T/RH profilers

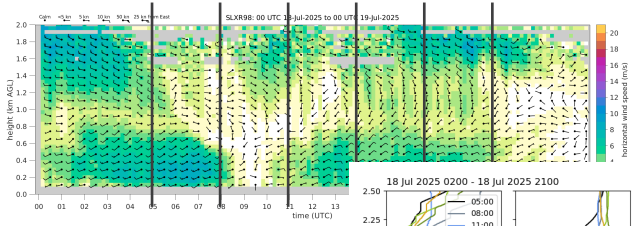


Wind lidars

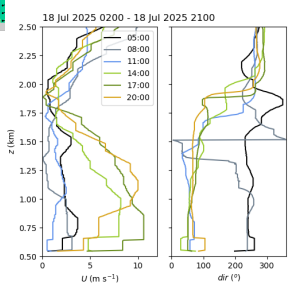


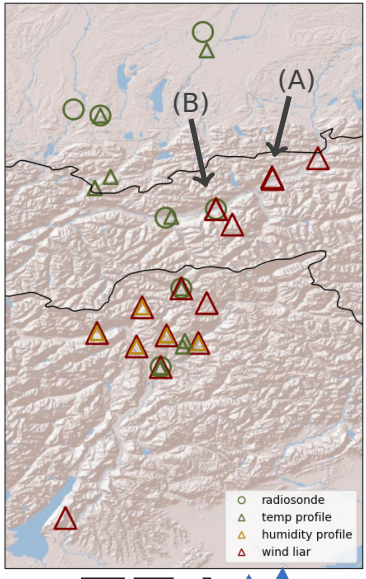
sEOP: MoBL + thermal winds

(A) Wind lidar (*Credit: Alexander Gohm)*



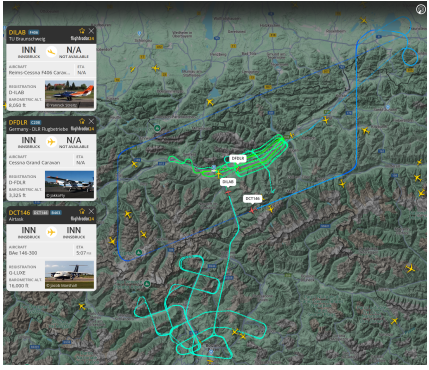
(B) Radiosounding





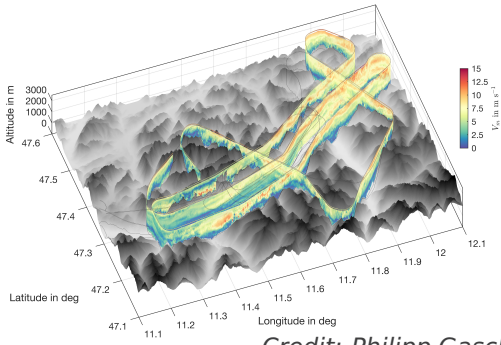
sEOP: MoBL + thermal winds

Airborne measurements



Source: flightradar24.com

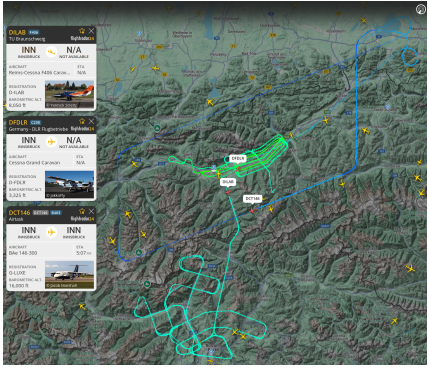
Wind speed (TU Braunschweig Cessna)



Credit: Philipp Gasch

sEOP: MoBL + thermal winds

Airborne measurements

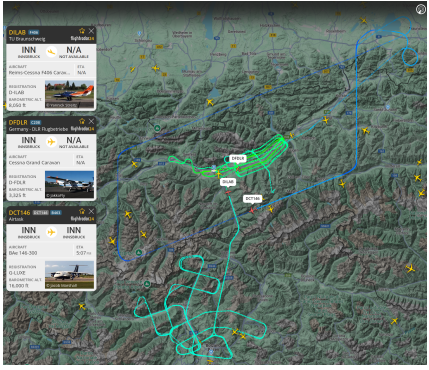


Source: flightradar24.com

UAS: vertical profiles + spatially distributed measurements

sEOP: MoBL + thermal winds

Airborne measurements



Source: flightradar24.com

UAS: vertical profiles + spatially distributed measurements

Presentations

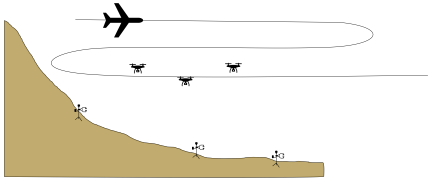
O2.2: M. Rotach
O2.3: P. Gasch
O2.5: M. Kossmann

Posters

P1.10: A. Gohm
P1.14: S. Paratoni

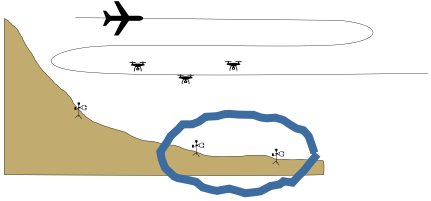
sEOP: Turbulence in the MoBL

Observing turbulence throughout
the valley atmosphere

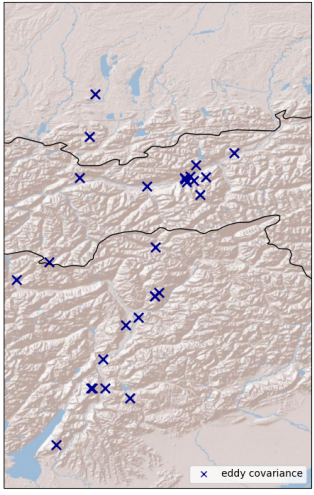


sEOP: Turbulence in the MoBL

Observing turbulence throughout the valley atmosphere

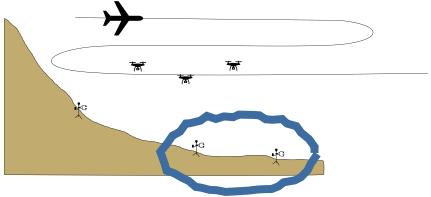


Surface layer: (networks of) eddy-covariance stations

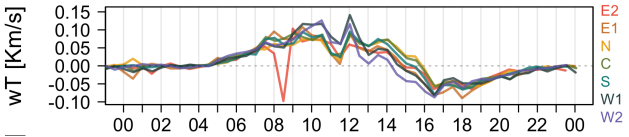


sEOP: Turbulence in the MoBL

Observing turbulence throughout the valley atmosphere



Network of EC stations (IVTA)

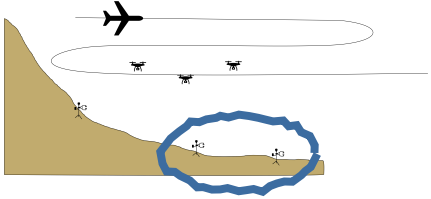


Credit: Ivana Stiperski

Surface layer: (networks of) eddy-covariance stations

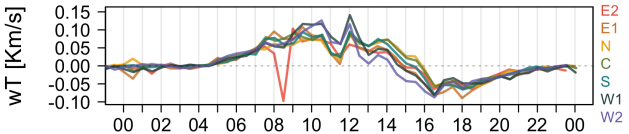
sEOP: Turbulence in the MoBL

Observing turbulence throughout the valley atmosphere



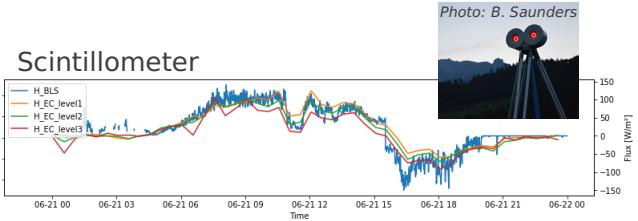
Surface layer: (networks of) eddy-covariance stations

Network of EC stations (IVTA)



Credit: Ivana Stiperski

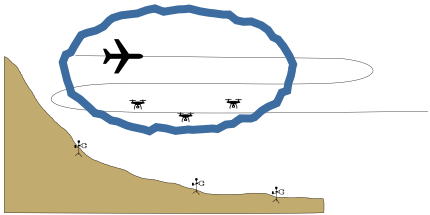
Scintillometer



Credit: Lena Zelger

sEOP: Turbulence in the MoBL

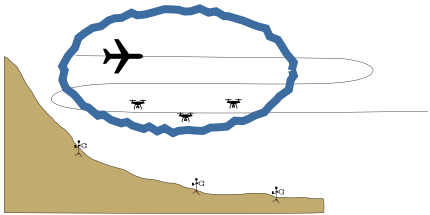
Observing turbulence throughout the valley atmosphere



Valley atmosphere: aircraft + (swarms of) UAS

sEOP: Turbulence in the MoBL

Observing turbulence throughout the valley atmosphere



Valley atmosphere: aircraft + (swarms of) UAS

Presentation

O2.4: A. Alexa

TOC Summary

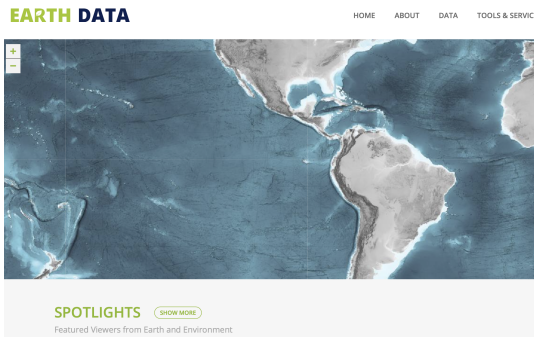
> 25 participating institutions

wEOP	sEOP
6 weeks (20 Jan–28 Feb)	6 weeks (16 Jun–25 Jul 2025)
18 IOPs (gravity waves, MoBL, and katabatic winds)	24 IOPs (gravity waves, convection, MoBL, valley-exit jets, slope winds)
1 aircraft (24 flight hours on 3 days)	3 aircraft (>200 flight h on 21 days)
≈250 radiosoundings (4 sites)	≈550 radiosoundings (6 sites)
≈10 profiling sites	≈ 20 profiling sites
hundreds of UAS and tethered-balloon flights	
multiple AWS, eddy-covariance stations, ...	

Data availability

TOC data will be ...

- made publicly available one year after the TOC
- published in public repositories (e.g., PANGAEA, zenodo, ...)
- accessible through the **Earth Data Portal**

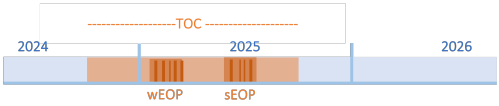


https://earth-data.de

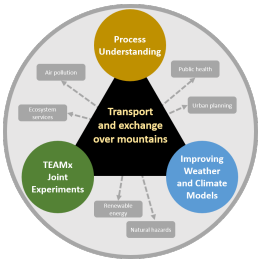
TEAMx **Multi-scale transport and exchange processes in the atmosphere over mountains—programme and experiment**

Web: www.teamx-programme.org

Contact: teamx-pco@uibk.ac.at



TEAMx Observational Campaign: one-year long campaign to collect a unique dataset to study transport and exchange processes over mountainous terrain



Thank you to all TOC participants!