

TEAMx



The TEAMx Observational Campaign—Recent and upcoming activities

Manuela Lehner (University of Innsbruck)

... and the TEAMx PIs, Coordination and Implementation Group, Task Teams, Working Groups, Committees, Target Area Representatives, and the whole TEAMx community

HErZ seminar series, 8 May 2025

TEAMX

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

www.teamx-programme.org

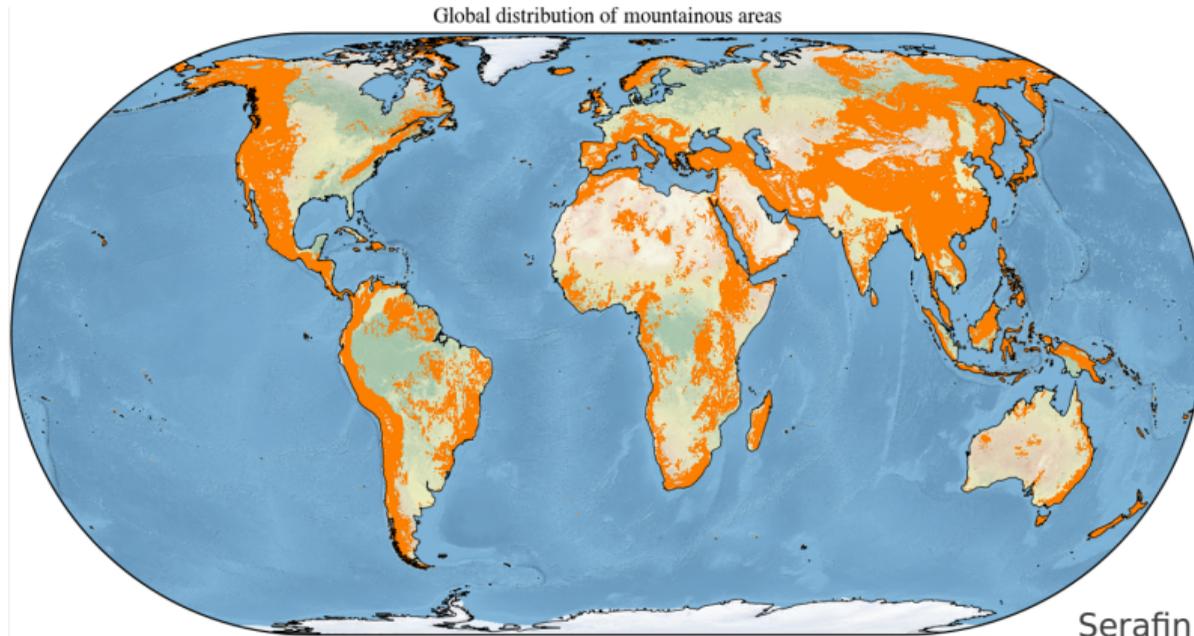
... endorsed by



... a cross-cutting project of the **GEVEX** Hydroclimate Panel

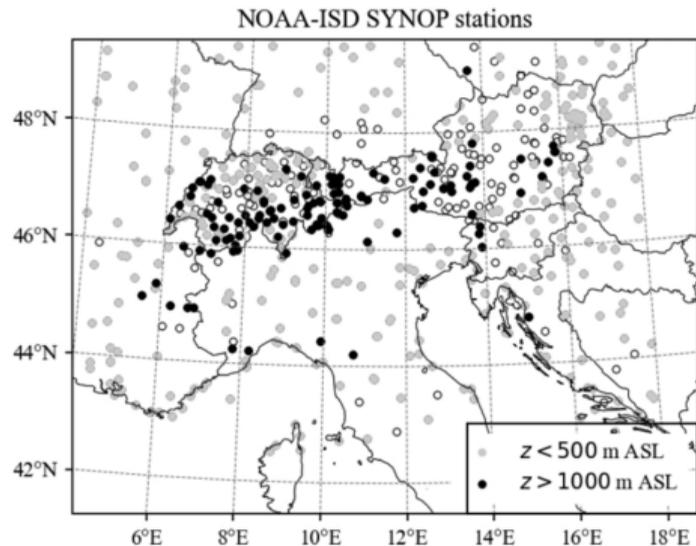
Mountain areas

30%–50% of the earth's land surface can be classified as complex terrain

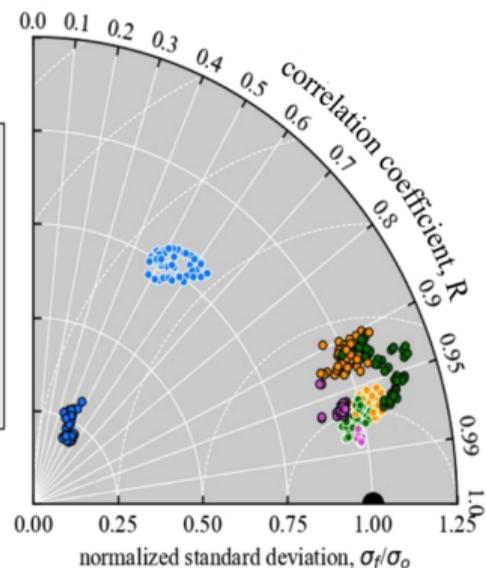


Serafin et al. (2020)

Mountain areas

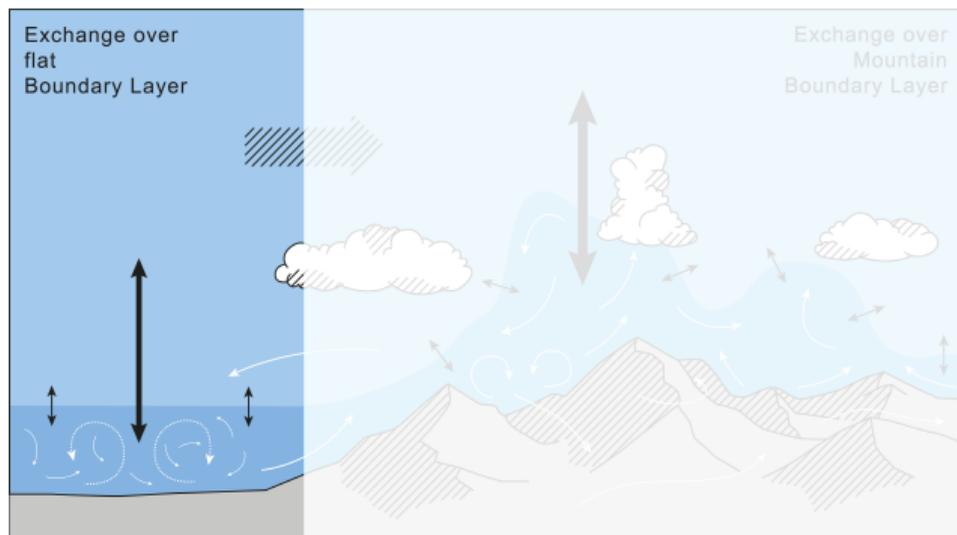


- 10-m ff, $z < 500$ m ASL
- 10-m ff, $z > 1000$ m ASL
- 2-m T , $z < 500$ m ASL
- 2-m T , $z > 1000$ m ASL
- 2-m T_d , $z < 500$ m ASL
- 2-m T_d , $z > 1000$ m ASL
- ρ , $z < 500$ m ASL
- ρ , $z > 1000$ m ASL



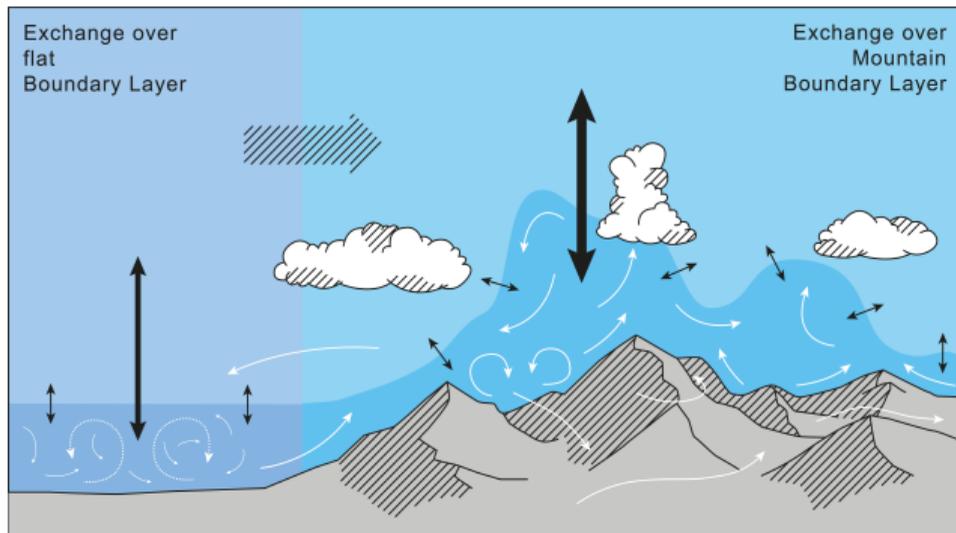
ECMWF IFS, analysis period: 2016–2019, 0–48 h forecasts of the 12 UTC runs (Rotach et al. 2022, BAMS)

Mountain Boundary Layer (MoBL)



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

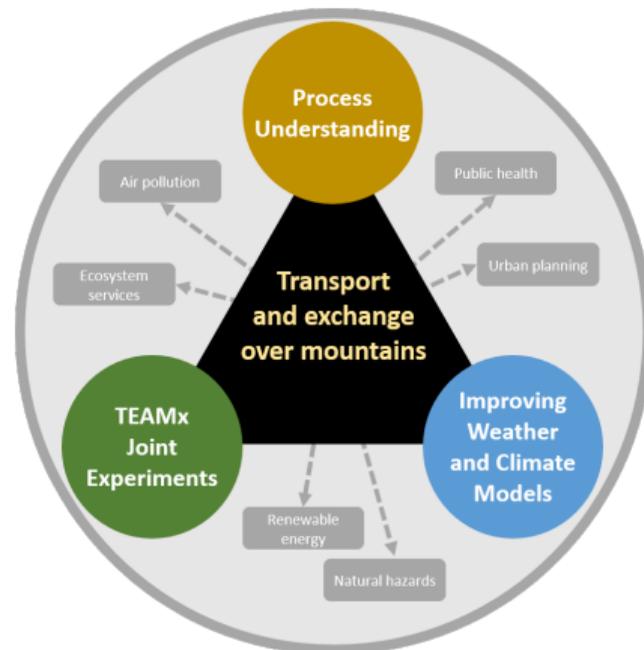
Mountain Boundary Layer (MoBL)



- ▲ 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
- ▲ Reducing errors in impact models



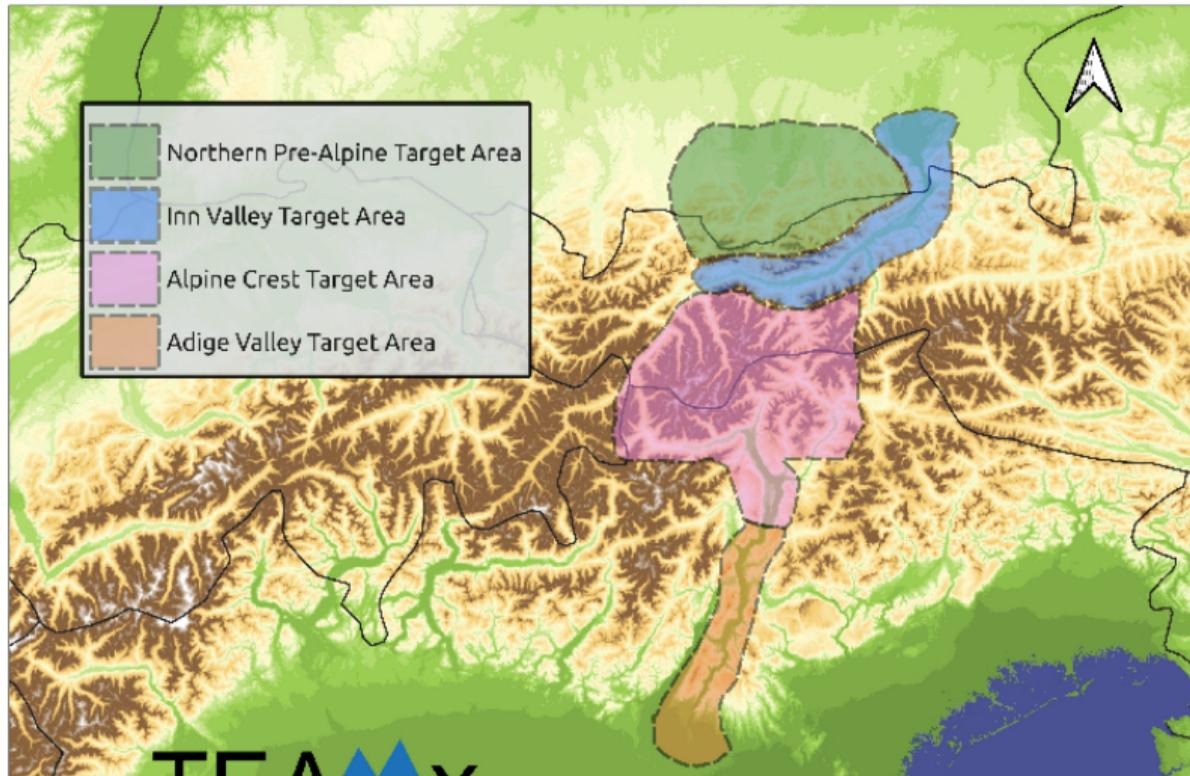
TEAMx community

 UNIVERSITY OF VIRGINIA	 METEO FRANCE	 UNIVERSITY OF TRENTO - Italy	 universität innsbruck
 MeteoSwiss	 C2SM Center for Climate Systems Modeling	 McGill UNIVERSITY	 KIT Karlsruher Institut für Technologie
 National Centre for Atmospheric Science	 ISAC	 ARPAL Agenzia Regionale per la Protezione e Protezione Ambientale del Veneto	 Met Office
 GeoSphere Austria	 Icelandic Met Office	 University of Colorado Boulder	 ARPA FVG meteo
 ETEMPS European Centre for Terrestrial and Environmental Modelling and Simulation	 University of Reading	 Wageningen Centre UNH	 DHMZ
 DLR	 WSL ILR	 EMBRY-RIDDLE Aeronautical & Astronautical University	 Deutscher Wetterdienst Wetter und Klima aus einer Hand

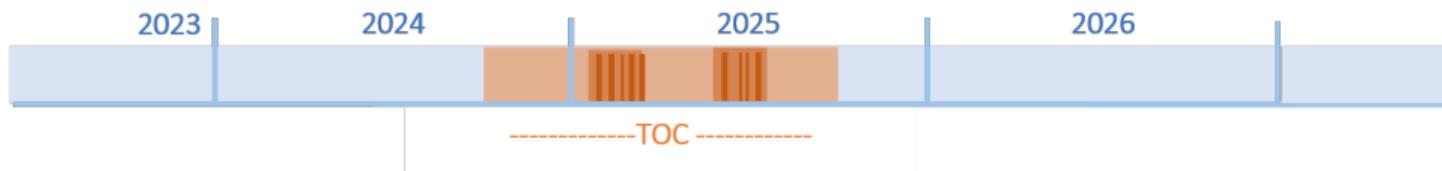
42 signatories of the Memorandum of Understanding

 UNIVERSITY OF ICELAND	 UEA University of East Anglia	 universität wien	 BOKU Universität für Bodenkultur Wien
 ARPAV Agenzia Regionale per la Protezione e Protezione Ambientale del Veneto	 MOUNTAIN RESEARCH INITIATIVE	 CHARLES UNIVERSITY	 CONICET
 UNIVERSITÉ DE BOURGOGNE	 Universität Basel	 LMU MIM	 UNIVERSITY OF BERGEN
 ESSL European Centre for Medium-Range Weather Forecasts	 PROTEZIONE CIVILE	 Consiglio Nazionale delle Ricerche	 UGA Université Grenoble Alpes
 UNIVERSITÄT ZU KÖLN	 UNIVERSITÀ CATTOLICA del Sacro Cuore		

TEAMx Observational Campaign (TOC)



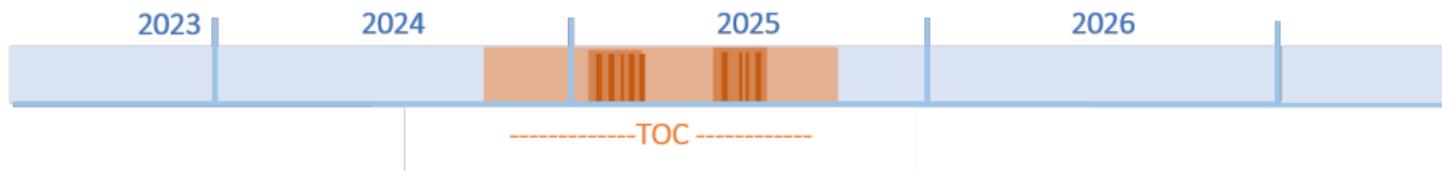
TEAMx Observational Campaign (TOC)



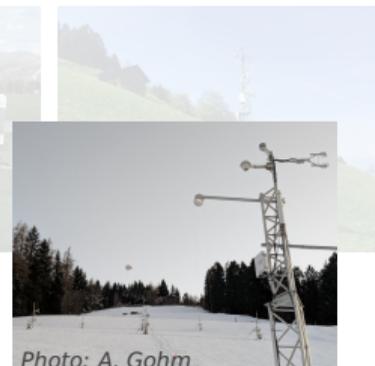
▲ One-year long TOC



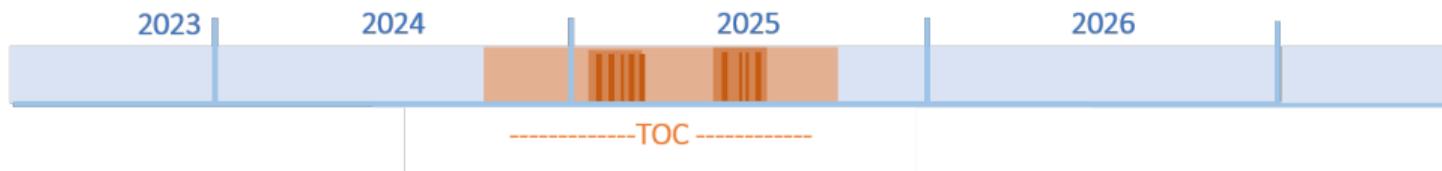
TEAMx Observational Campaign (TOC)



- ▲ One-year long TOC
- ▲ Winter EOP (wEOP): 20 Jan–28 Feb
- ▲ Summer EOP (sEOP): 16 Jun–25 Jul



TEAMx Observational Campaign (TOC)



- ▲ One-year long TOC
- ▲ Winter EOP (wEOP): 20 Jan–28 Feb
- ▲ Summer EOP (sEOP): 16 Jun–25 Jul
- ▲ IOPs targeting specific weather conditions

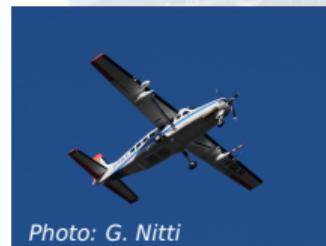


Photo: G. Nitti



Photo: P. Berthelemy

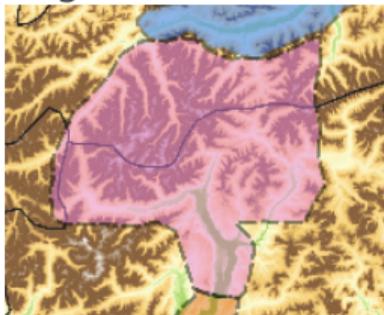
Multi-scale processes

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

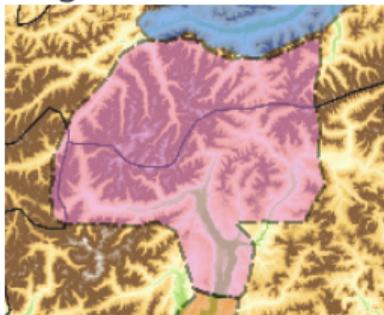
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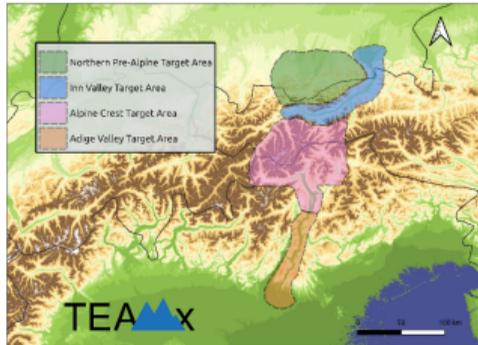
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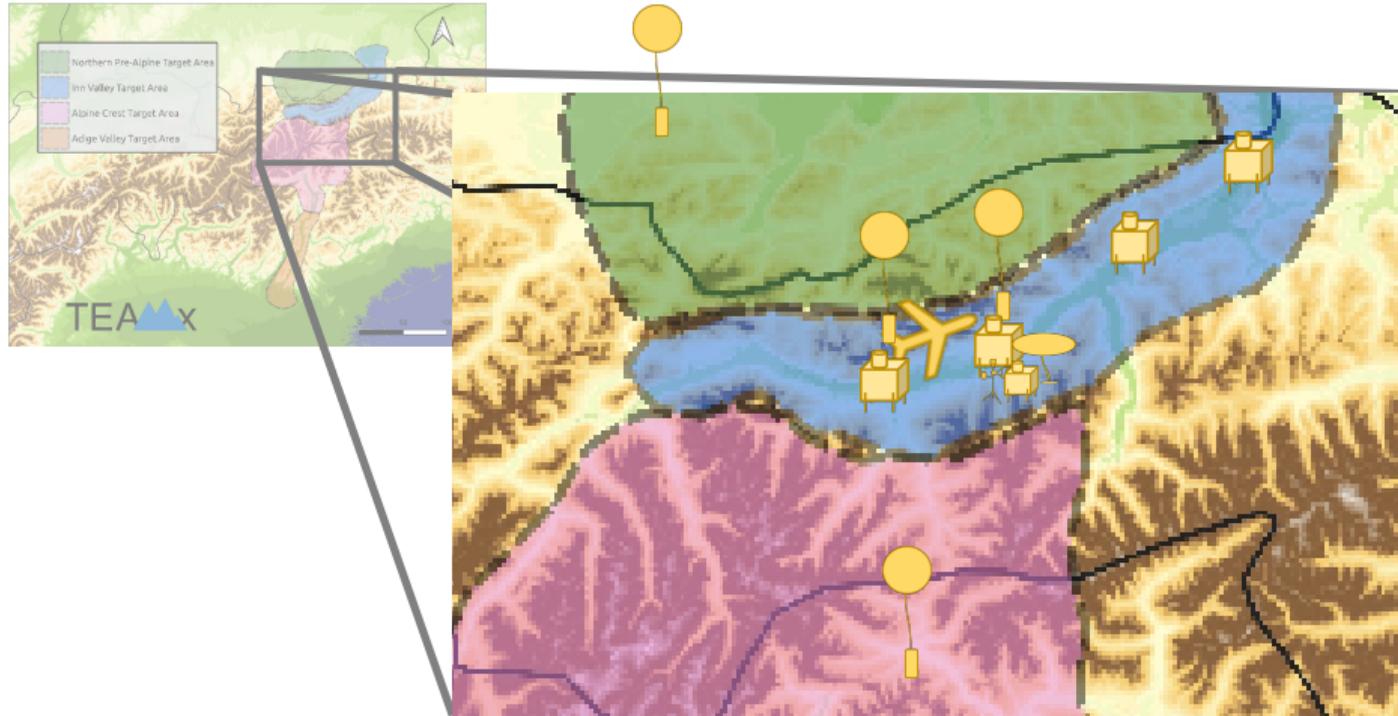


- Slope winds
- Turbulence

TEAMx winter EOP (wEOP)

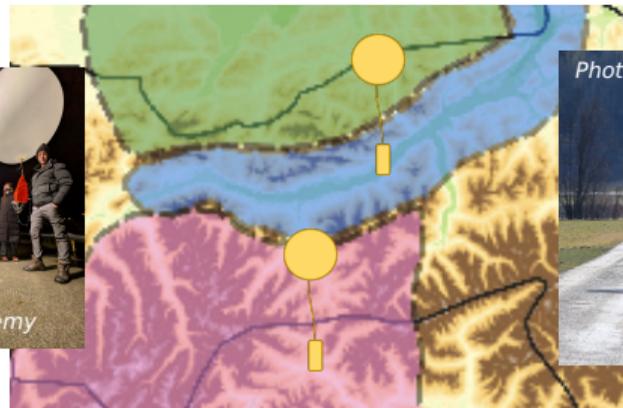
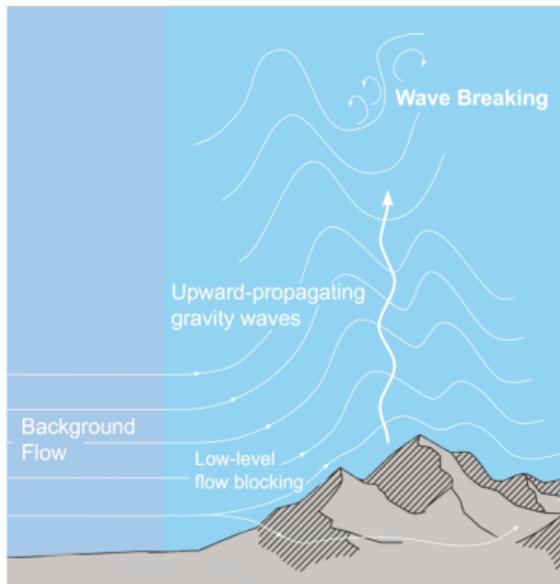


TEAMx winter EOP (wEOP)



Gravity waves

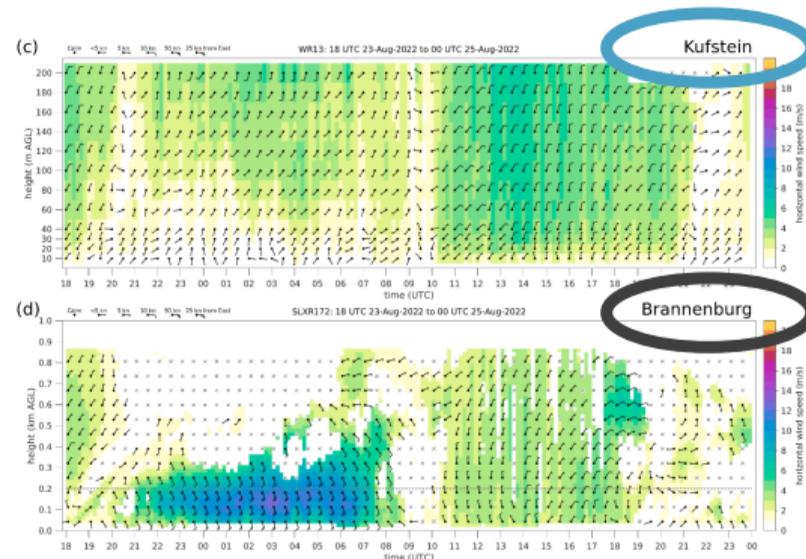
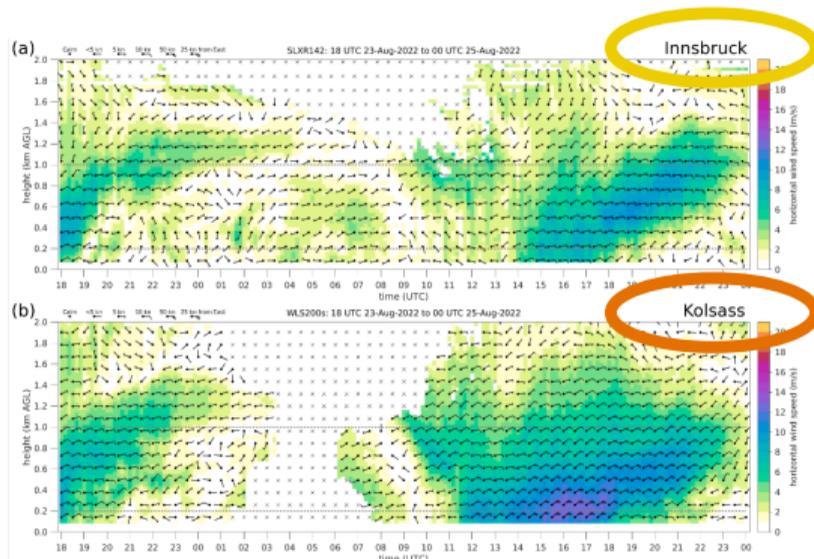
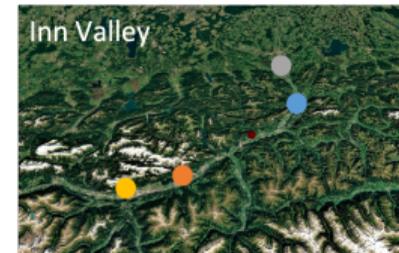
TEAMx-FLOW



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

Credit: A. Orr  British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

MoBL structure



Pfister et al. (2024) : The TEAMx-PC22 Alpine field campaign—objectives, instrumentation, and observed phenomena. Met Z

MoBL structure

- ▲ Winter valley atmosphere
- ▲ Turbulence anisotropy

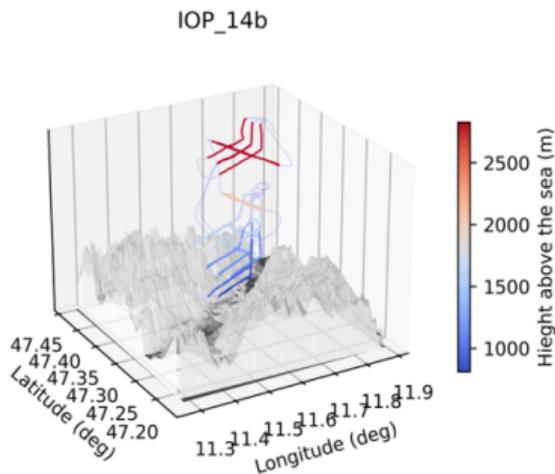


Figure courtesy: Q. Berthier



3 flight days (6 flights)

- ▲ thermally driven (2 d)
- ▲ dynamically forced (1 d)

Credit: M. Rotach  universität
innsbruck

MoBL structure

- ▲ Winter valley atmosphere
- ▲ Turbulence anisotropy

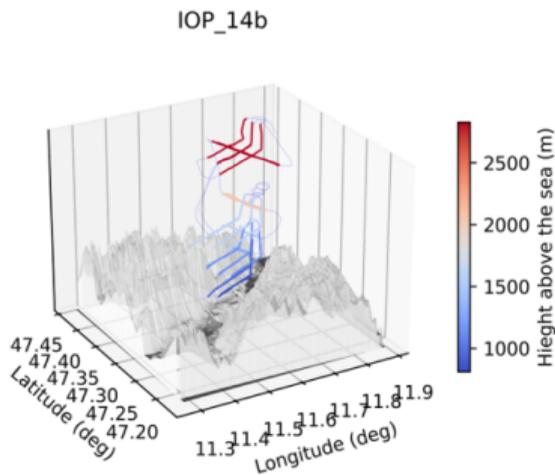
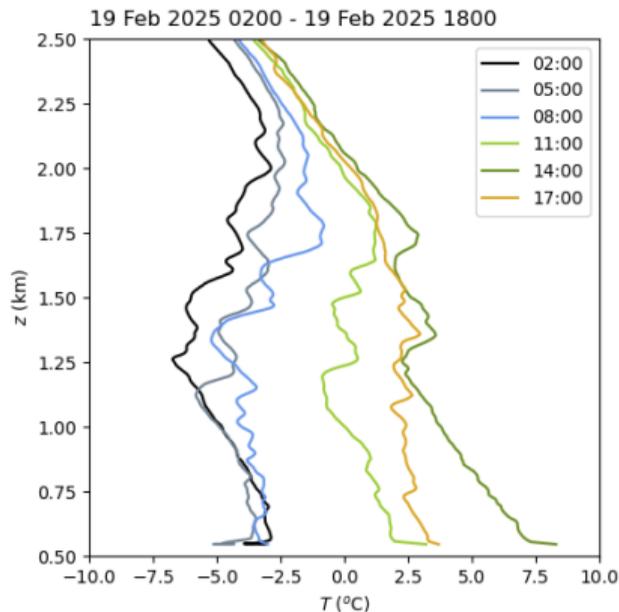


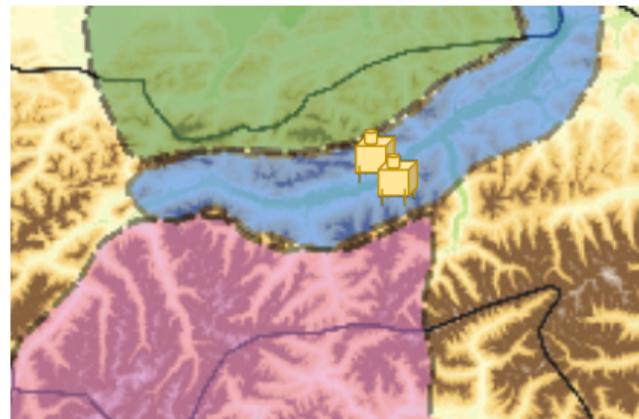
Figure courtesy: Q. Berthier

3-h radiosoundings



Fog and low stratus

Karlsruhe Low-Cloud Exploratory Platform (KLOCX)

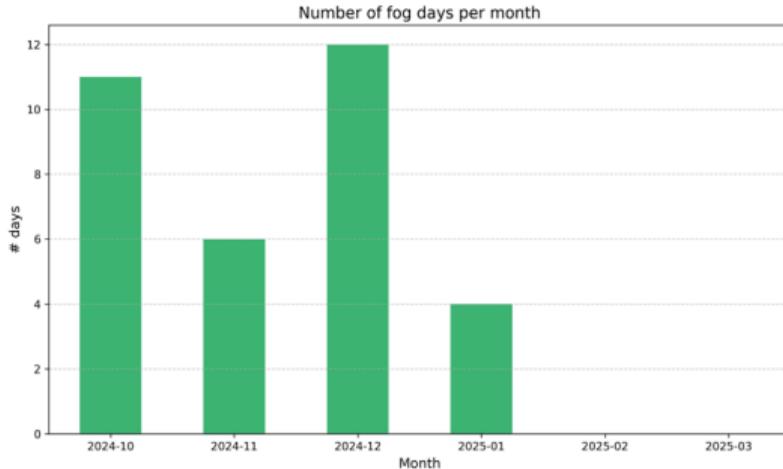


- ▲ 25 Sep 2024–31 Mar 2025
- ▲ Life-cycle phases of low-level stratiform clouds and fog

Credit: J. Vüllers 

Fog and low stratus

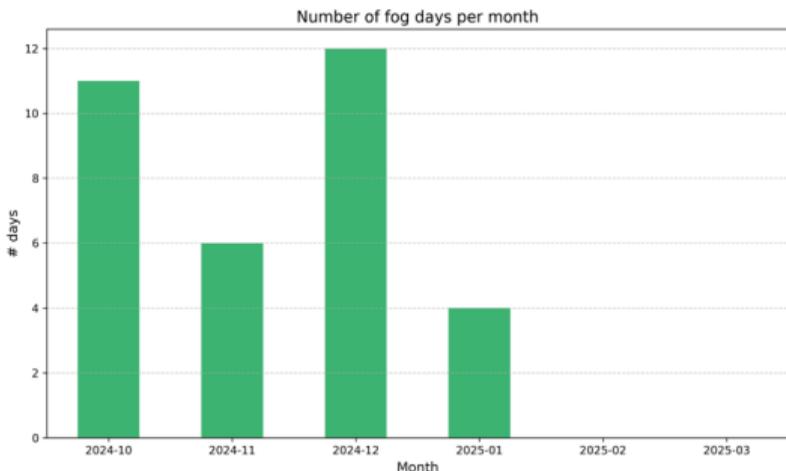
▲ 33 days with fog (Oct–Jan)



Credit: J. Vüllers  KIT
Karlsruhe Institute of Technology

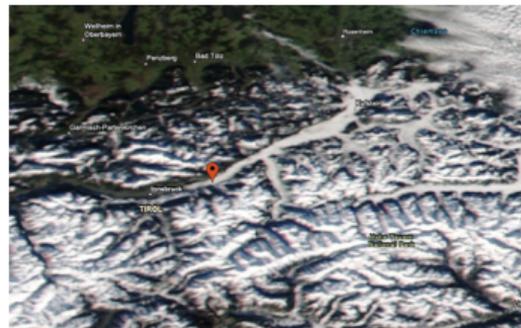
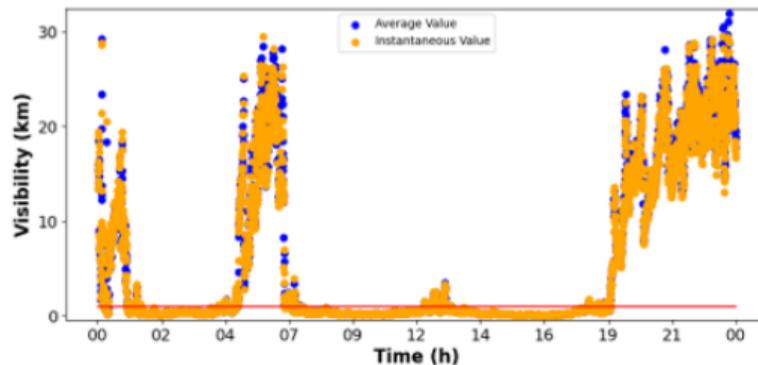
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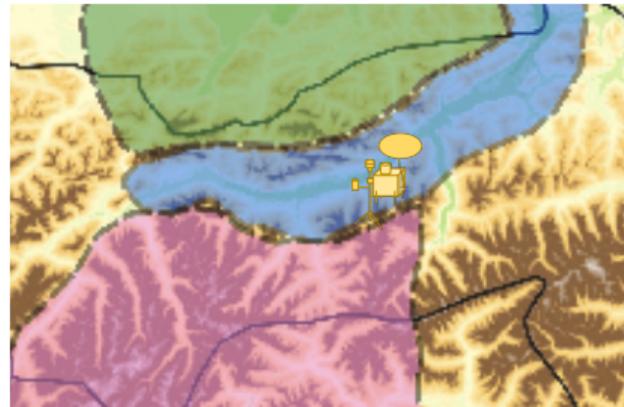


Credit: J. Vüllers  KIT
Karlsruhe Institute of Technology

Case study—17 Dec 2024



Katabatic winds



- ▲ 3D structure of mean and turbulent properties
- ▲ Surface boundary conditions for models over complex terrain
- ▲ Wide range of weather conditions (6 katabatic IOPs, multiple foehn episodes)

Credit: I. Stiperski, A. Gohm, L. Pfister  universität innsbruck, C. Brun  UGA Université Grenoble Alpes

Katabatic winds



Vertical profiles



Credit: I. Stiperski, A. Gohm, L. Pfister

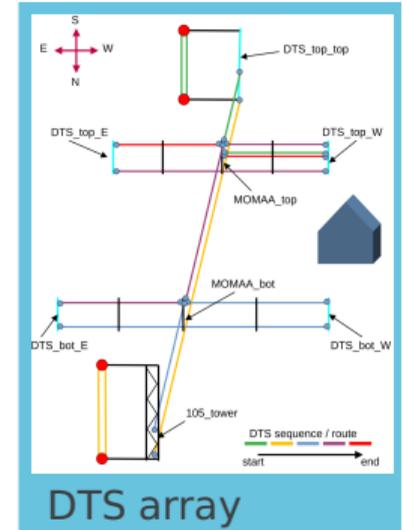
universität
innsbruck, C. Brun

UGA
Université
Grenoble Alpes

Katabatic winds



Spatial structure

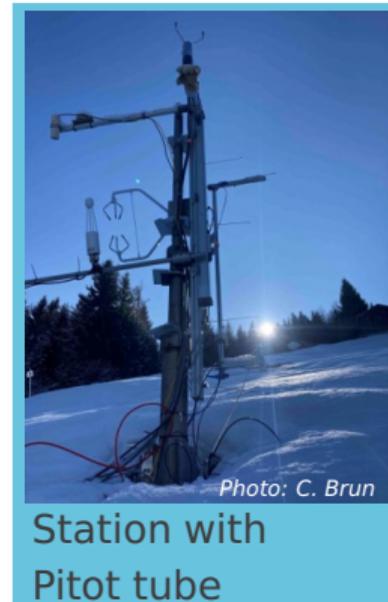
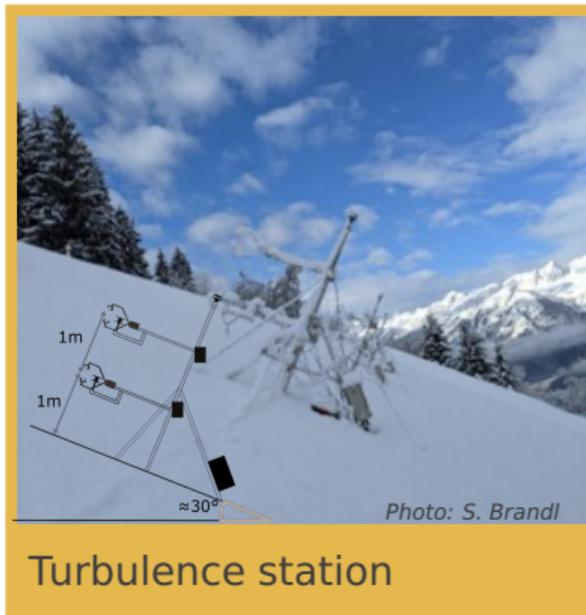


Credit: I. Stiperski, A. Gohm, L. Pfister  universität innsbruck, C. Brun  UGA Université Grenoble Alpes

Katabatic winds

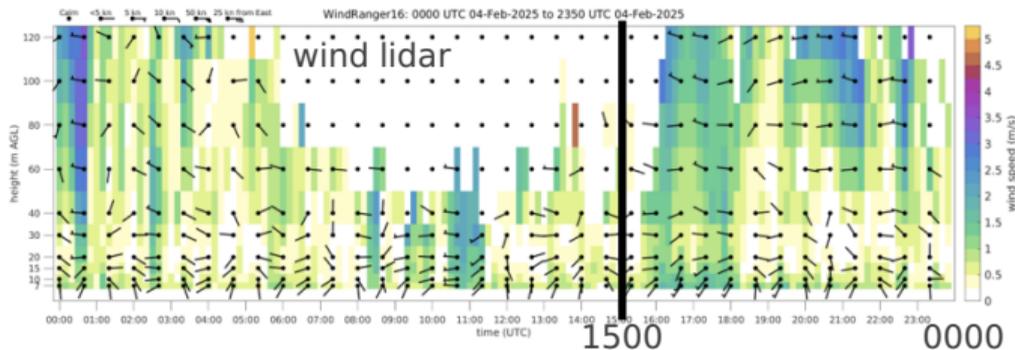


Turbulence



Credit: I. Stiperski, A. Gohm, L. Pfister  universität innsbruck, C. Brun  UGA Université Grenoble Alpes

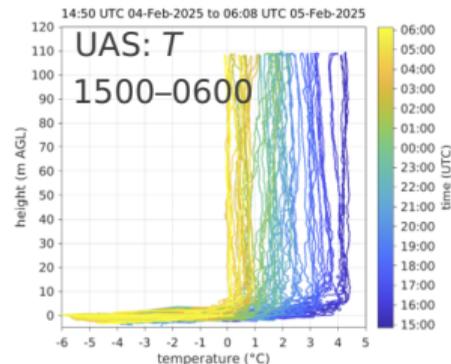
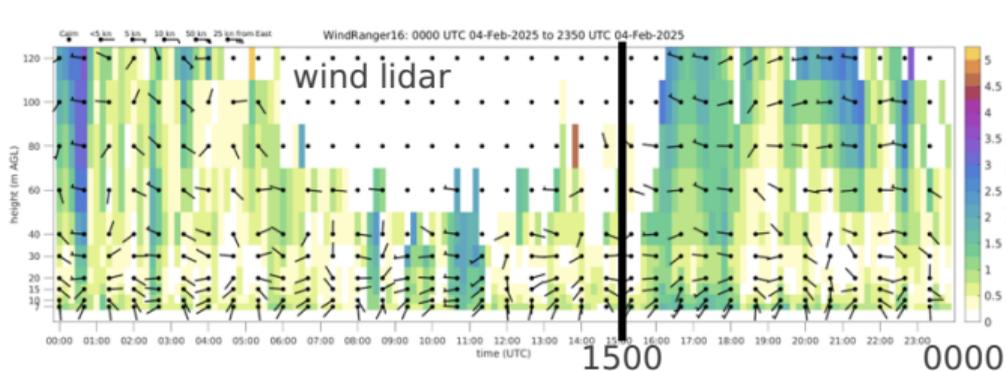
Katabatic winds—Vertical profiles



- ▲ Shallow katabatic jet: peak < lowest lidar level
- ▲ Transition from downslope (S) to down-valley (W) winds

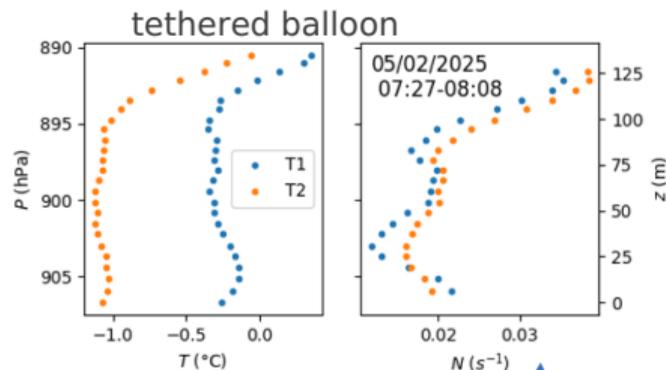
Credit: A. Gohm, C. Brun, L. Pfister

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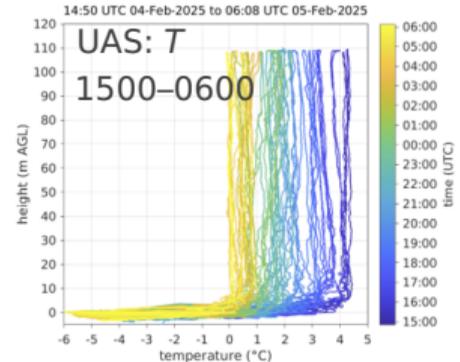
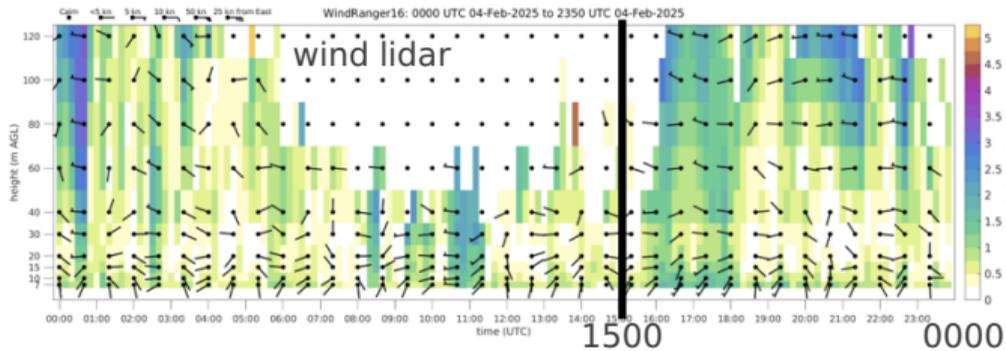


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- ▲ Shallow temperature inversion: 5–10 m

Credit: A. Gohm, C. Brun, L. Pfister

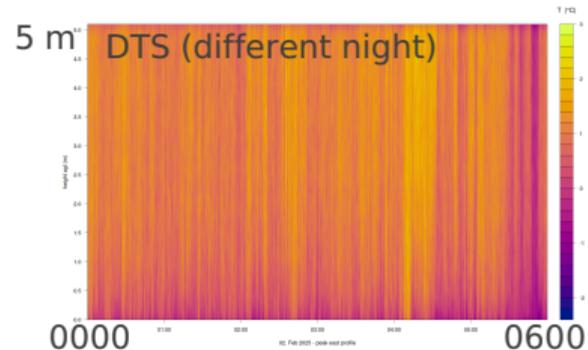


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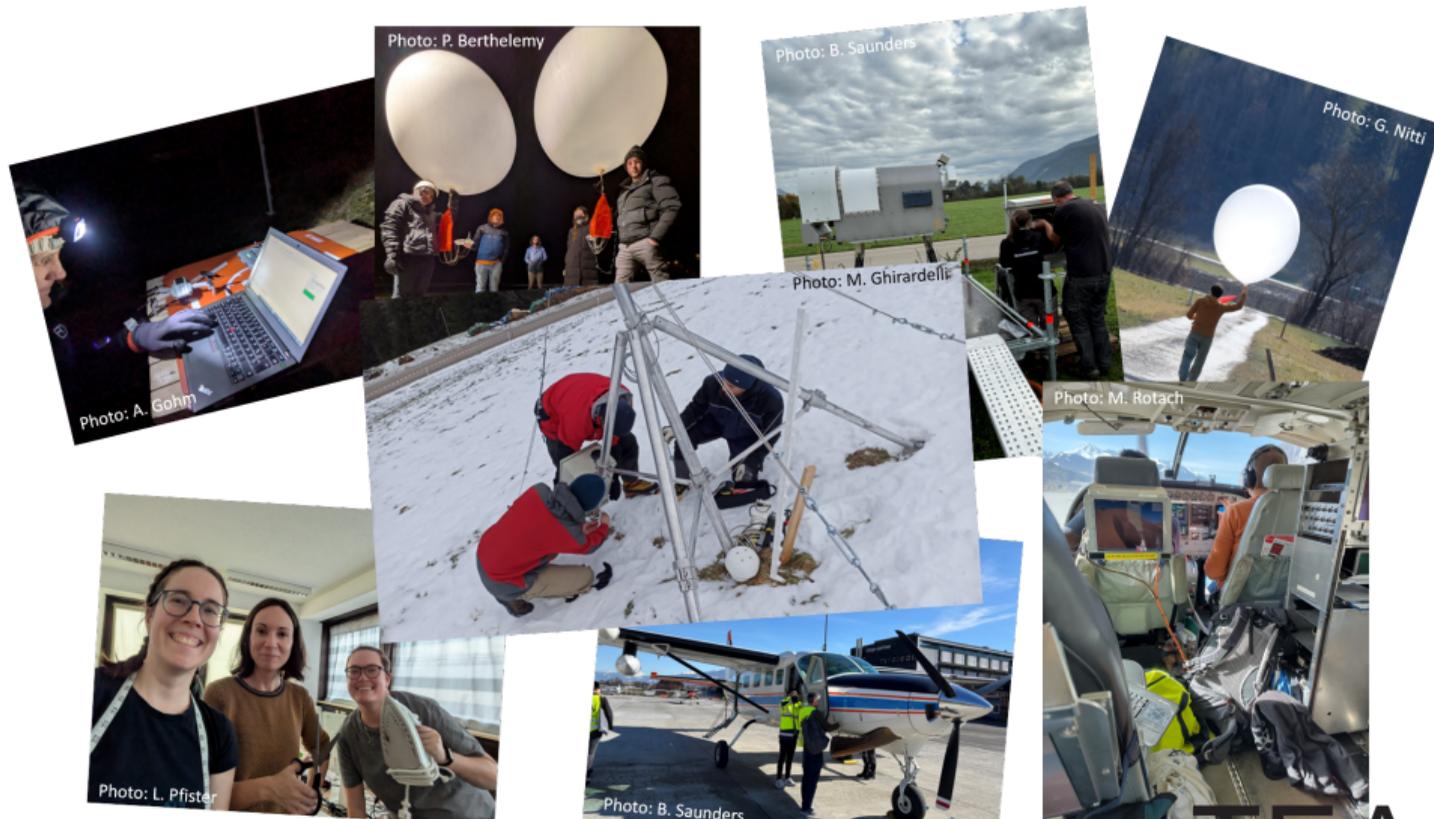


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Thanks to all the participants!



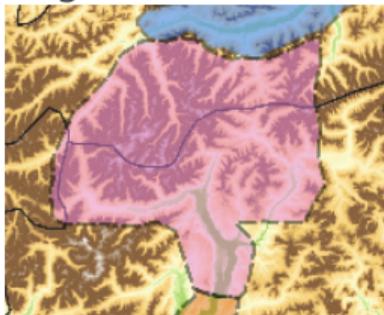
TEAMx summer EOP (sEOP)

Alpine scale



- Mountain waves
- Mountain-plain wind

Regional scale



- Orographic convection
- Foehn

Valley scale



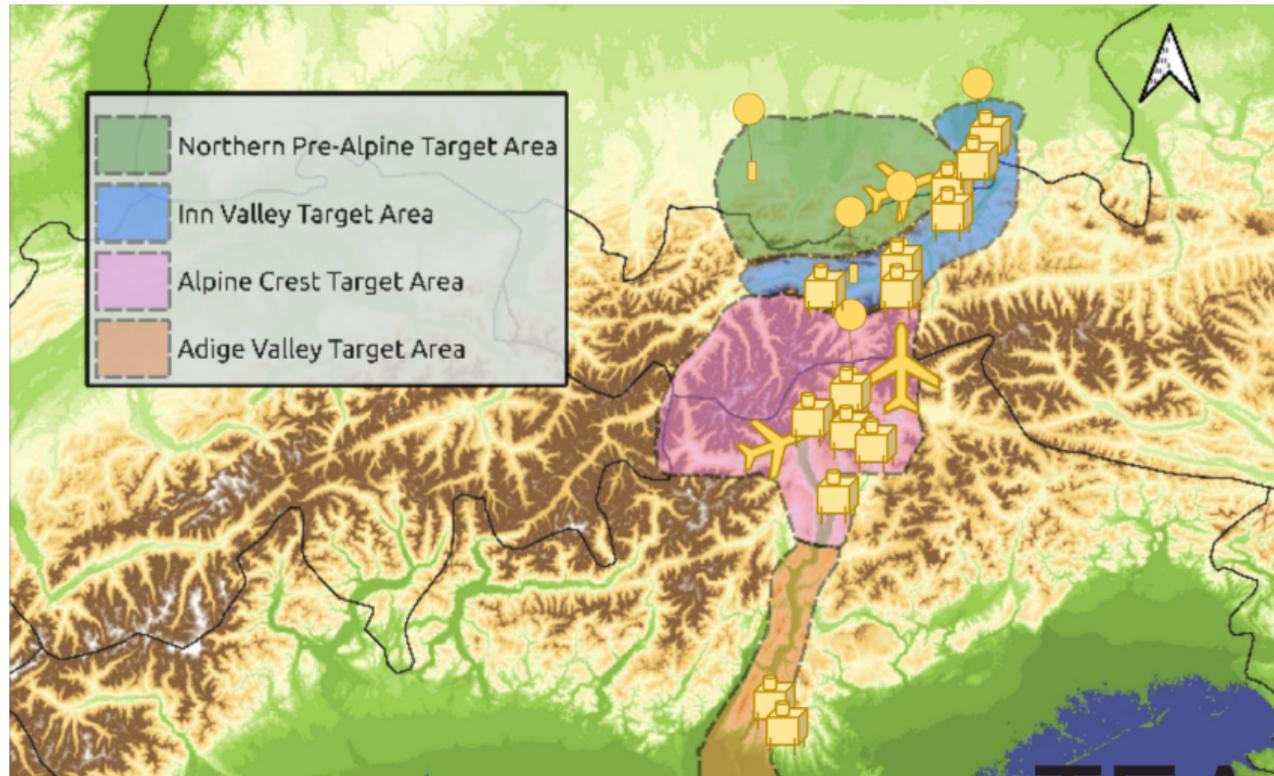
- MoBL structure
- Valley winds
- Mountain venting
- Fog/low stratus

Local scale



- Slope winds
- Turbulence

TEAMx summer EOP (sEOP)



TEAMx summer EOP (sEOP)

Coordinated flights in ACTA desired, vertically stacked?

Coordinated flights in IVTA, vertically stacked

 **Low level**
Cessna Caravan



Credit: DLR (CC BY-NC-ND 3.0)

IVTA, PATA

 Technische Universität Braunschweig

Low-mid level
Cessna F406



Credit: Florian Szczepanek, AviationMedia.com

IVTA, ACTA

FAAM  **Mid-up level**
BAe146



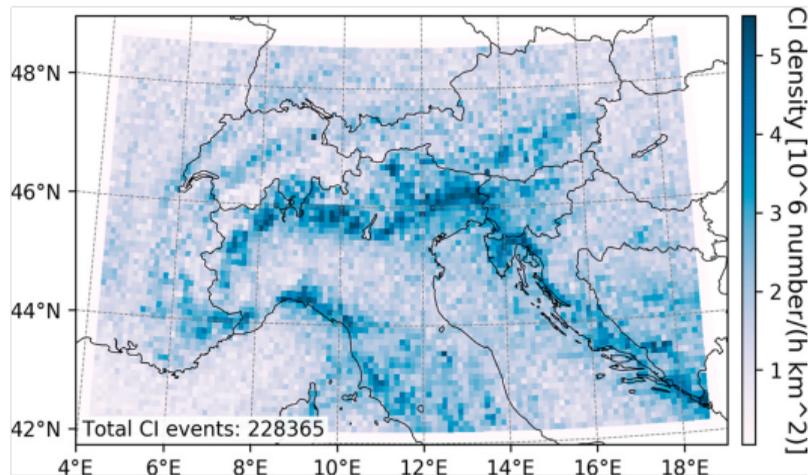
Credit: FAAM (CC BY-NC-SA 2.0)

 **National Centre for Atmospheric Science**
NATURAL ENVIRONMENT RESEARCH COUNCIL

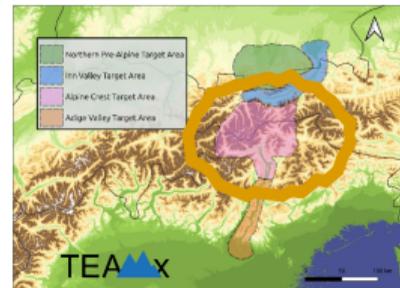
ACTA

Credit: Philipp Gasch 

Convection initiation and development

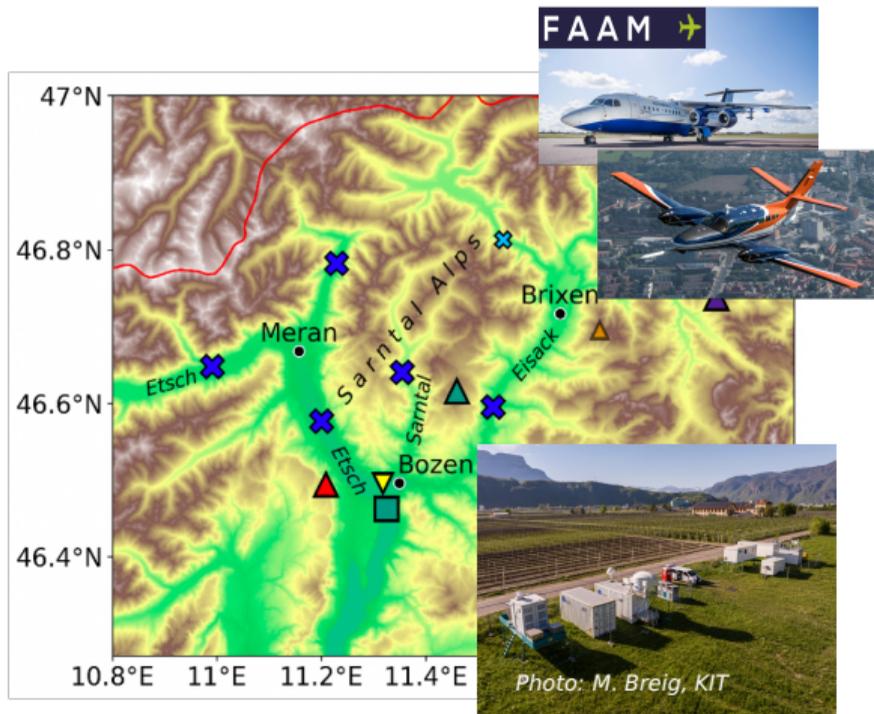


Manzato et al. (2022) : A pan-Alpine climatology of lightning and convection initiation. *Monthly Weather Review*.



▲ Sarntal Alps: hotspot of convection initiation

Convection initiation and development

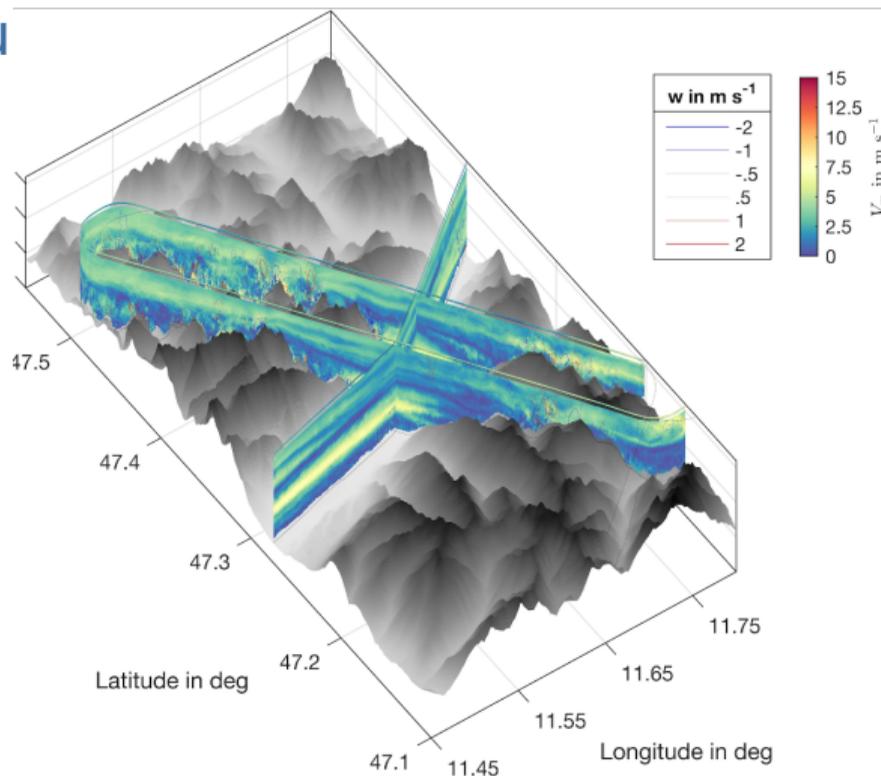


- ▲ Sarntal Alps: hotspot of convection initiation
- ▲ Terrain influence on location, timing, and strength of convection
- ▲ Aircraft + network of radars, wind lidars, and DIAL

Credit: J. Handwerker, A. Wieser 

Convection and MoBL stru

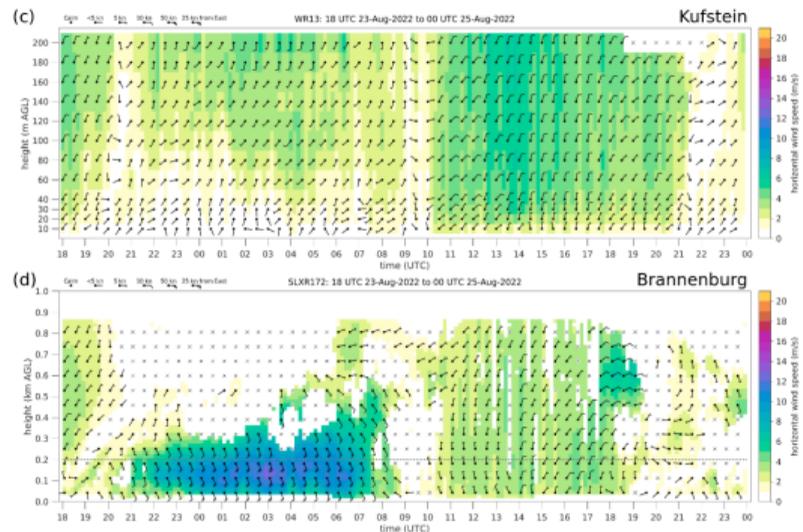
- ▲ AIRflows: novel 5-beam lidar onboard the TUBS Cessna F406
- ▲ Developed by KIT
- ▲ 3D wind field at 100-m resolution



Credit: Philipp Gasch 

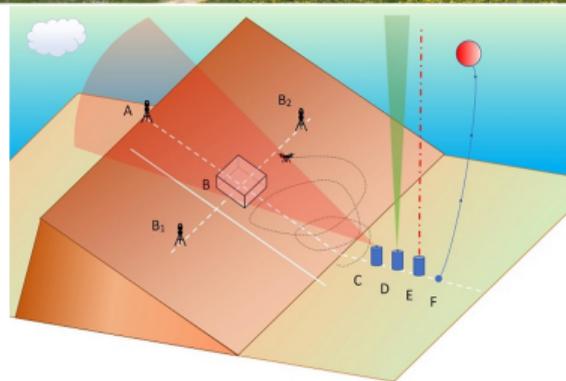
Thermally driven flows

Valley-exit jets (Inn Valley exit)



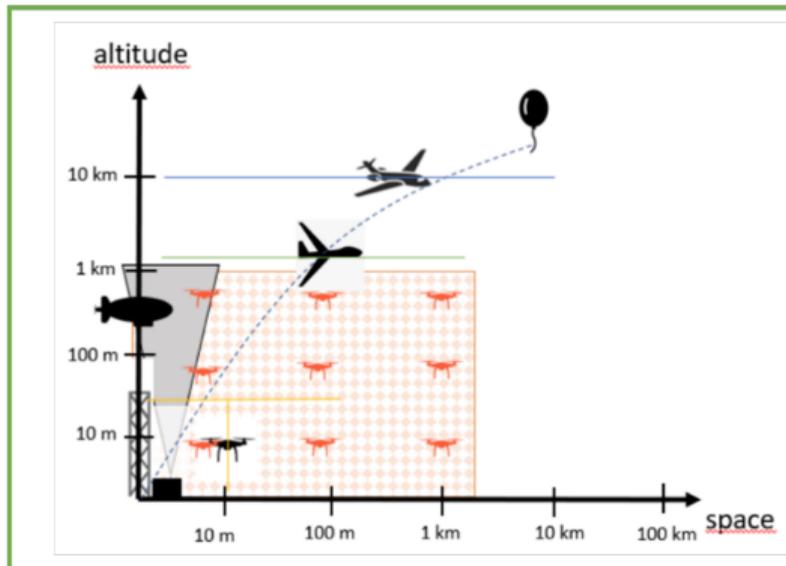
Pfister et al. (2024), *Meteorologische Zeitschrift*

Upslope flows (Monte Baldo, Adige Valley)



Credit: Dino Zardi (University of Trento)

Turbulence in the MoBL



Credit: Norman Wildmann (DLR)



Photo: G. Nitti

Aircraft



Photo: N. Wildmann

UAS

EC stations

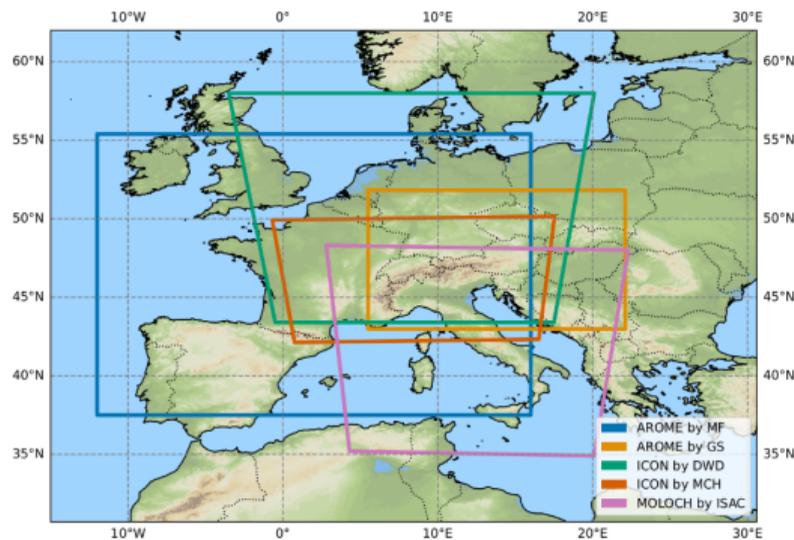


Photo: M. Lehner

High-resolution NWP forecasts

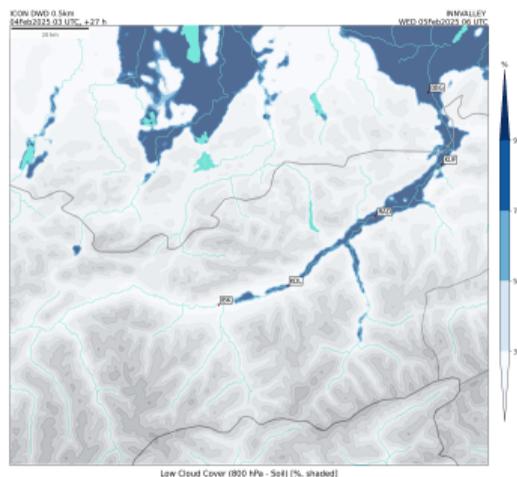
High-resolution NWP forecast runs to guide IOP planning and for model development

- ▲ ICON (DWD): 2.2/0.5 km
- ▲ ICON (MeteoSwiss): 1.1/0.5 km
- ▲ AROME (GeoSphere Austria): 2.5/1.0 km
- ▲ AROME (Météo-France): 1.3/0.5 km
- ▲ MOLOCH (CNR ISAC): 1.25 km
- ▲ UM (UK Met Office): 1.0 km
- ▲ ALARO (DHMZ): 4.0/1.3 km

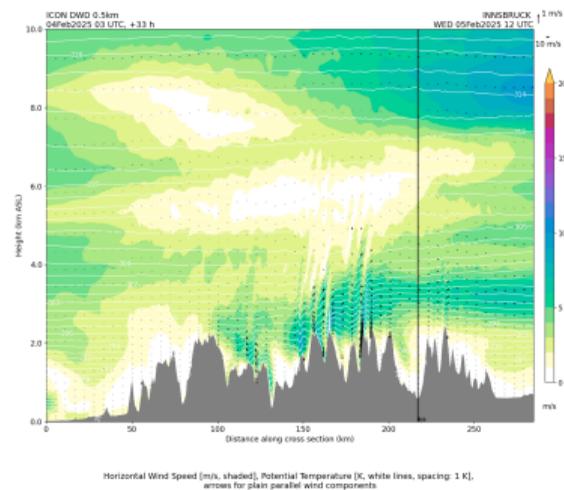


High-resolution NWP forecasts

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)

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

Web: www.teamx-programme.org

Instagram: #TEAMxcampaign

Contact: teamx-pco@uibk.ac.at

TEAMx winter EOP



- ▲ 3D structure of gravity waves
- ▲ 3D structure of the wintertime MoBL
- ▲ Life cycle of fog and low-level stratiform clouds
- ▲ Mean and turbulent characteristics of katabatic winds over a snow-covered slope

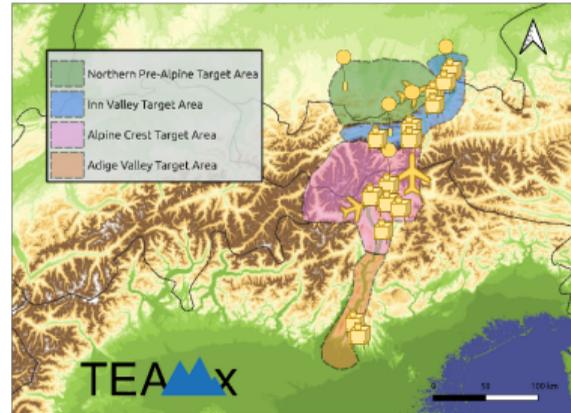
TEAMx Multi-scale transport and exchange processes in the atmosphere over mountains—programme and experiment

Web: www.teamx-programme.org

Instagram: #TEAMxcampaign

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Outlook—summer EOP



- Aircraft
- Radiosondes
- Fleets of UAS
- Wind lidars
- T/RH lidars
- T/RH profilers
- Radars
- EC stations
- ...

- ▲ 3D structure of gravity waves
- ▲ 3D structure of the MoBL at different scales
- ▲ Development of orographic convection
- ▲ Mean and turbulent structure of slope winds

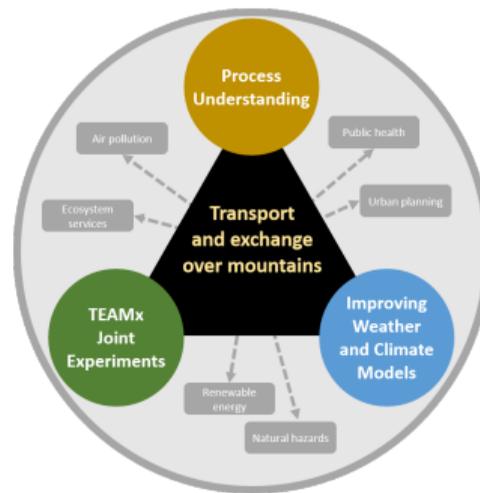
TEAMX Multi-scale transport and exchange processes in the atmosphere over mountains—programme and experiment

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Outlook—beyond the TOC



▲ Observational data for process analysis and for model evaluation and development