universität innsbruck

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

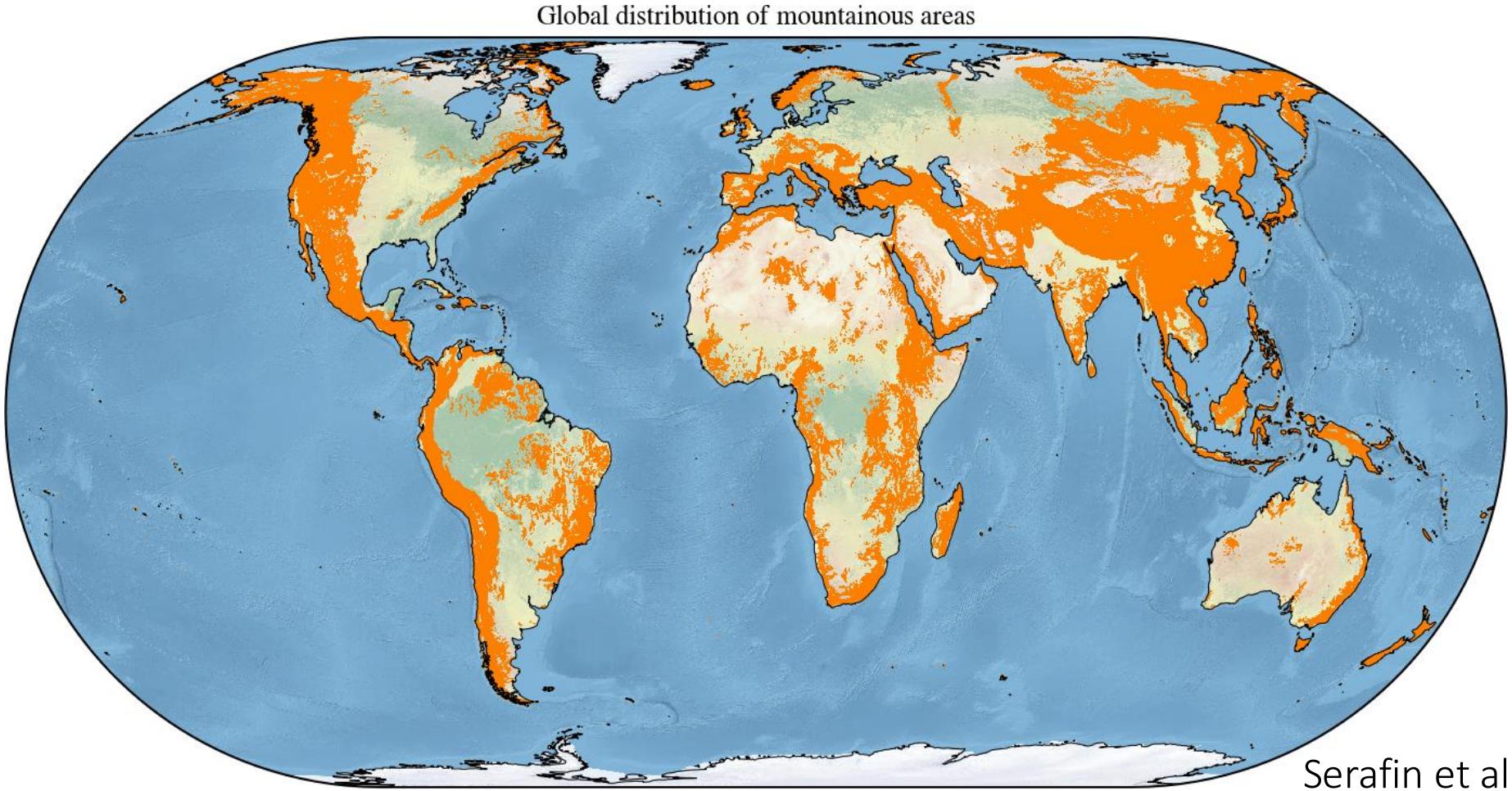
Manuela Lehner (Universität Innsbruck)

TEAMx Coordination and Implementation Group (CIG):
Mathias Rotach, Marco Arpagaus, Daniel Kirschbaum, Peter Knippertz, Manuela Lehner, Stephen Mobbs, Alexandre Paci, Elisa Palazzi, Stefano Serafin, Helen Ward, Christoph Wittmann, Dino Zardi

www.teamx-programme.org

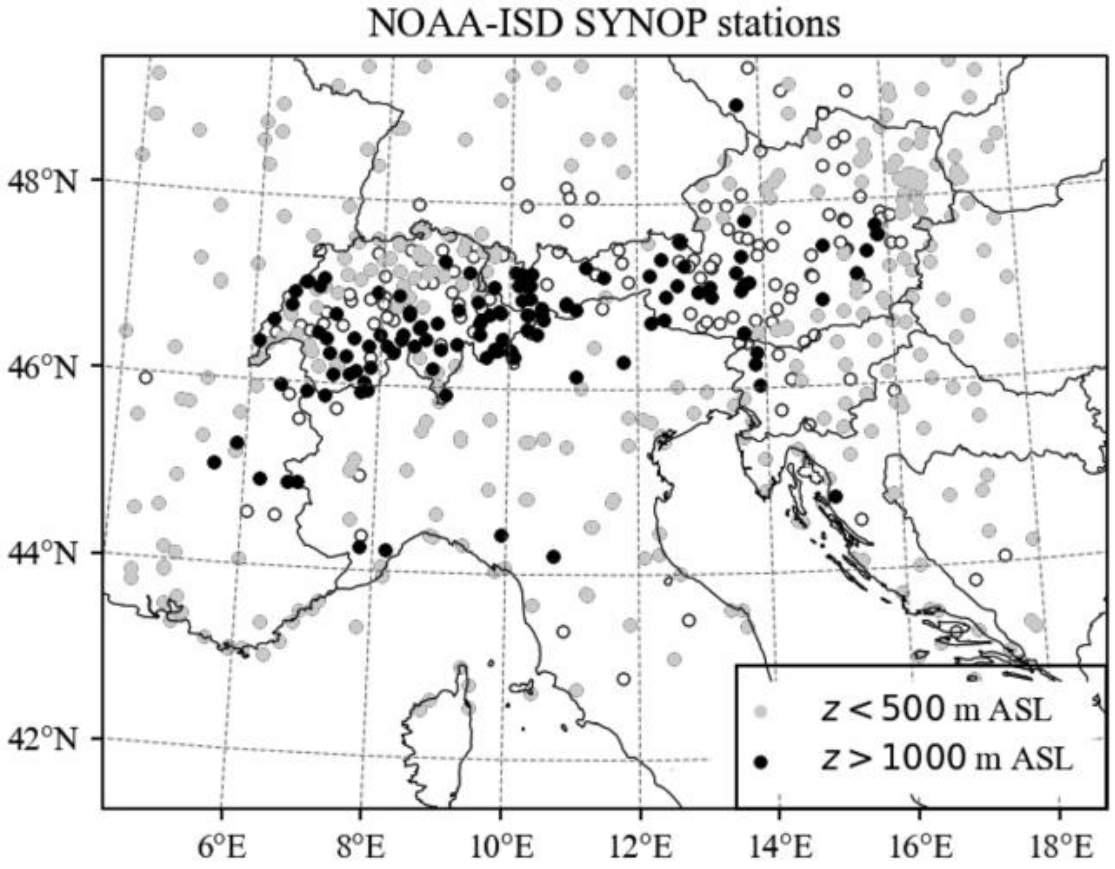
Hintergrund

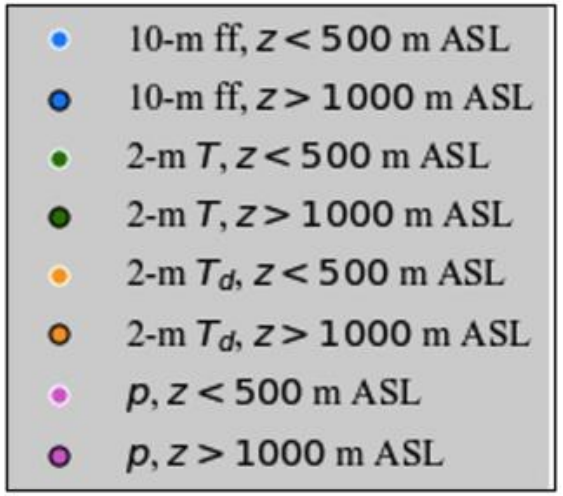
30-50% der Landoberfläche können als komplexes Gelände klassifiziert werden.

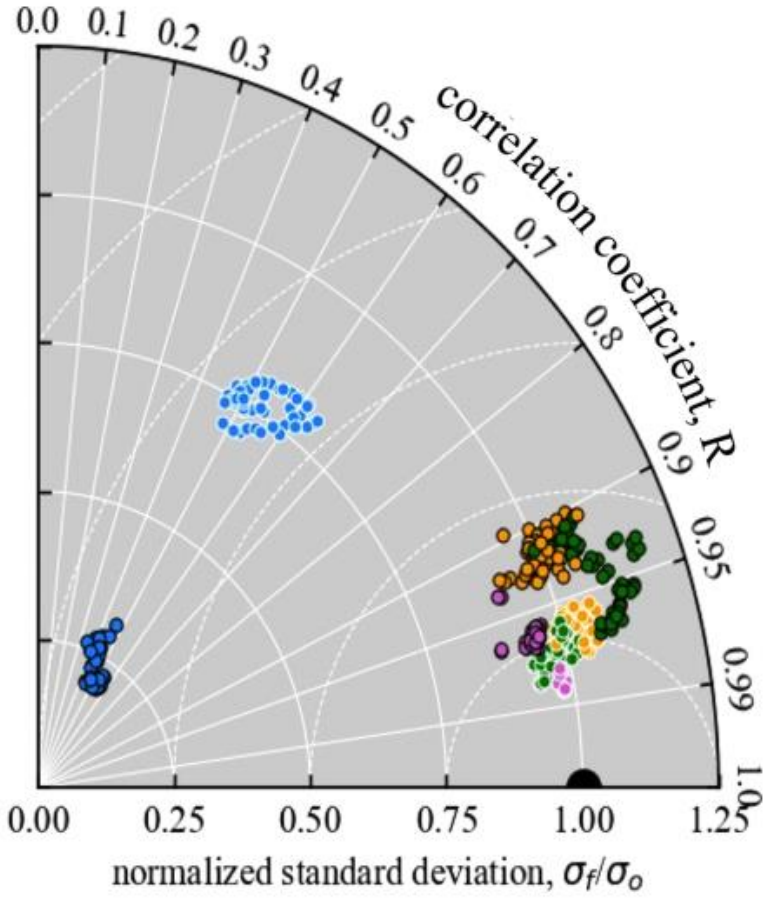


Serafin et al. (2020)

Hintergrund



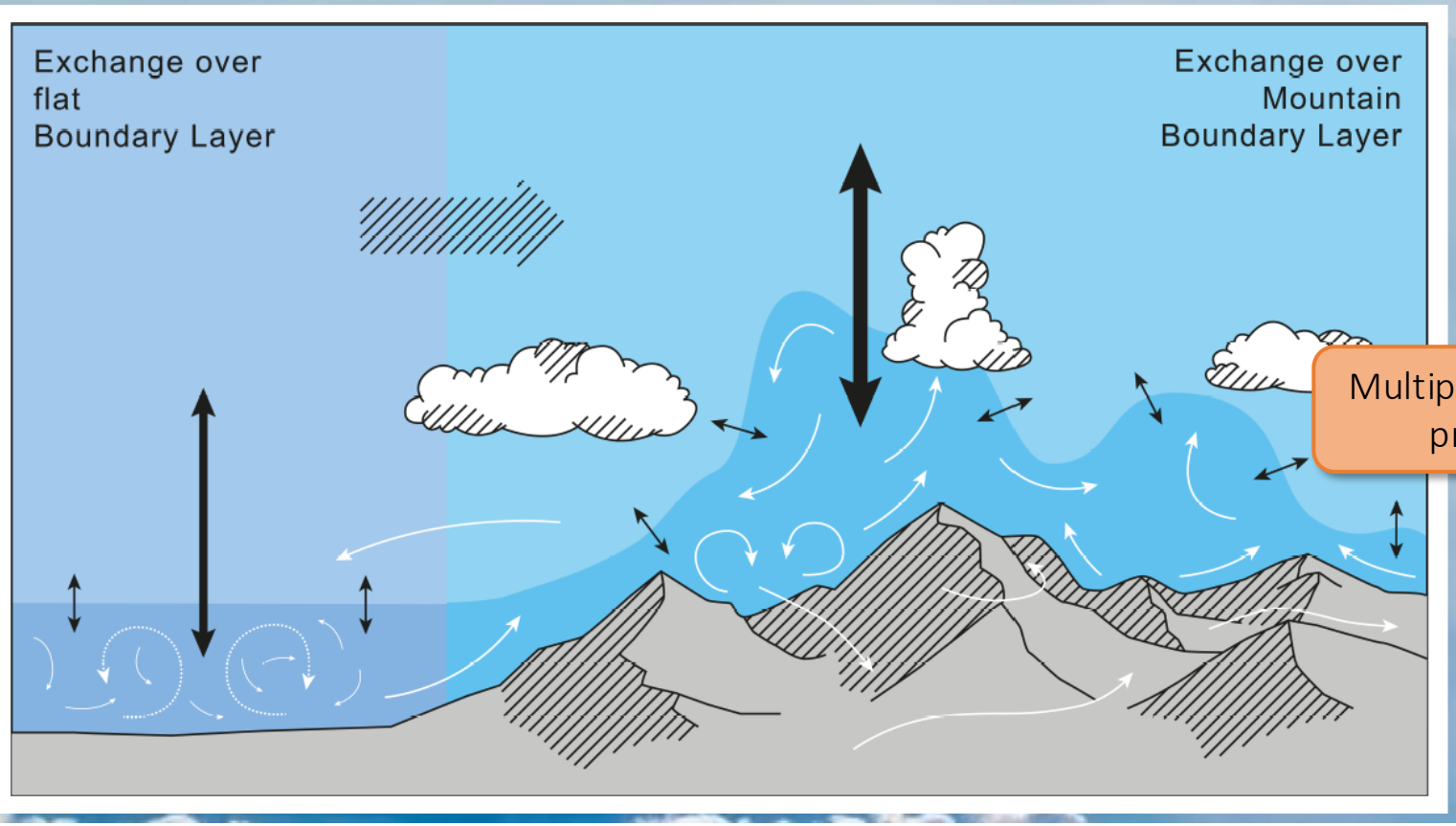




Rotach et al. (2022), BAMS

ECMWF IFS, Zeitraum: 2016-2019, 0-48 h Vorhersagen des 1200 UTC Laufs

Mountain Boundary Layer



Questionable applicability of measurement/modelling techniques

Processes that are difficult to measure/model

Multiple interacting processes

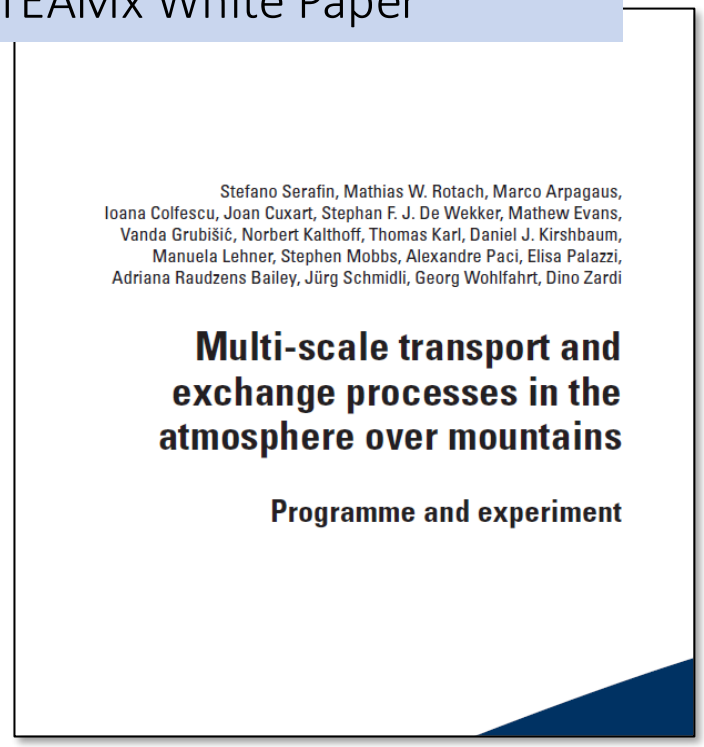
Wide range of scales

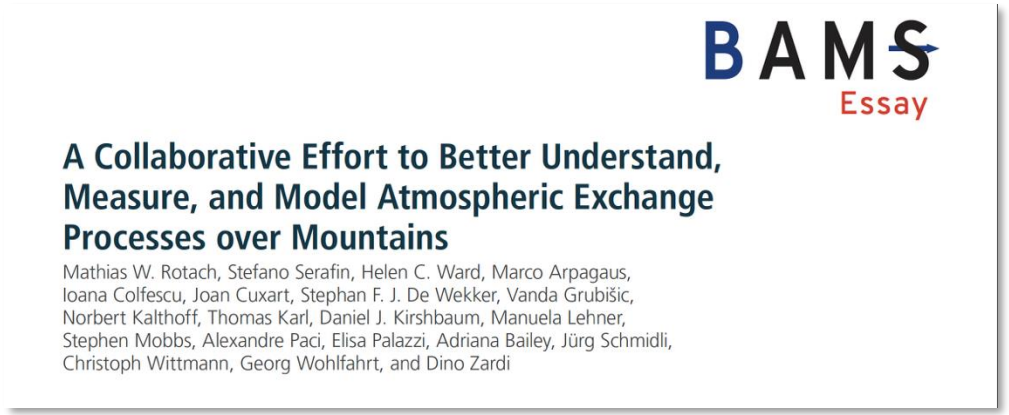
Considerable 3D spatial variability

TEAMx Ziele

TEAMx ist ein internationales Forschungsprogramm, das darauf abzielt, das Verständnis von Austauschprozessen in Gebirgsregionen zu verbessern und die Parametrisierung dieser Prozesse in numerischen Wetter- und Klimamodellen voranzutreiben

TEAMx White Paper





Atmosphere special issue

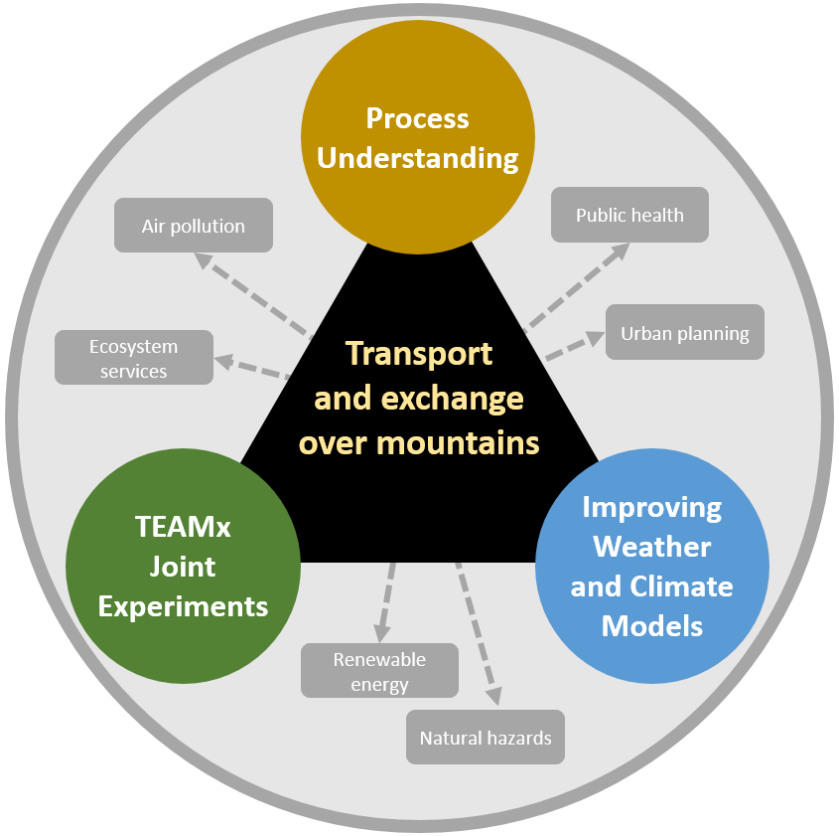
TEAMx Ziele

- **Verbesserung des qualitativen und quantitativen Verständnisses von Transport- und Austauschprozessen**, sowohl zwischen der Oberfläche und der Atmosphäre als auch innerhalb der Atmosphäre.

- **Evaluierung und Verbesserung von Wetter- und Klimamodellen** in bergigem Gelände.

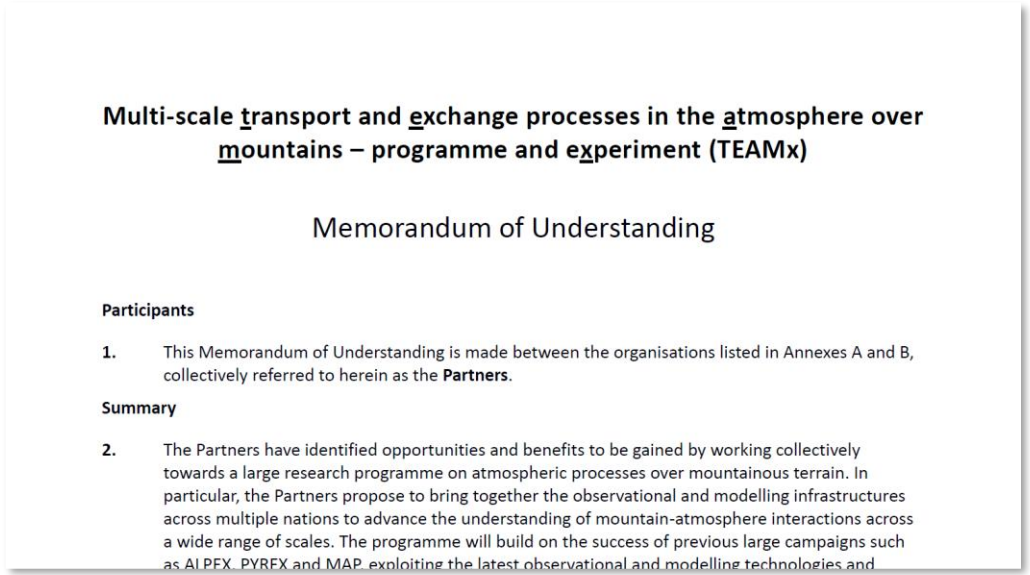
- Bereitstellung eines **einzigartigen Beobachtungsdatensatzes**, der zur Untersuchung des breiten Spektrums von Transport- und Austauschprozessen in gebirgigem Gelände und ihrer räumlich-zeitlichen Variabilität verwendet werden kann.

- **Verringerung der Fehler in Impact Modellen** durch Weitergabe der gewonnenen Erkenntnisse an Wetter- und Klimadienstleister.



TEAMx Partner

TEAMx wird von Universitäten, Forschungseinrichtungen und operativen Zentren im Rahmen einer Absichtserklärung (Memorandum of Understanding) zwischen interessierten Parteien unterstützt.



Multi-scale transport and exchange processes in the atmosphere over mountains – programme and experiment (TEAMx)

Memorandum of Understanding

Participants

1. This Memorandum of Understanding is made between the organisations listed in Annexes A and B, collectively referred to herein as the **Partners**.

Summary

2. The Partners have identified opportunities and benefits to be gained by working collectively towards a large research programme on atmospheric processes over mountainous terrain. In particular, the Partners propose to bring together the observational and modelling infrastructures across multiple nations to advance the understanding of mountain-atmosphere interactions across a wide range of scales. The programme will build on the success of previous large campaigns such as ALPEX, PYREX and MAP, exploiting the latest observational and modelling technologies and

TEAMx Partner

TEAMx ist eine **bottom-up finanzierte Initiative**, die durch koordinierte nationale, bi-nationale und multinationale Forschungsprojekte durchgeführt wird.

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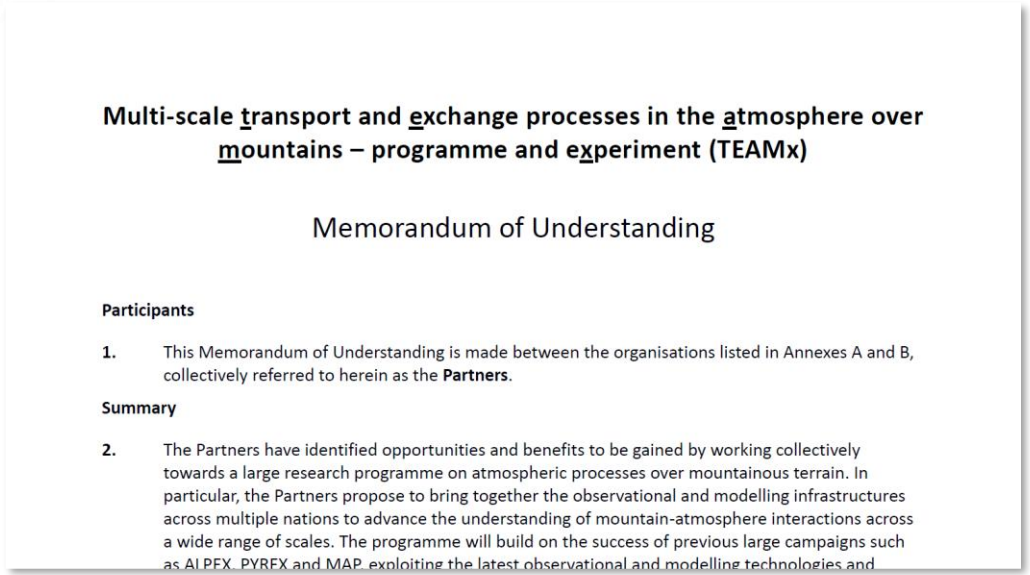

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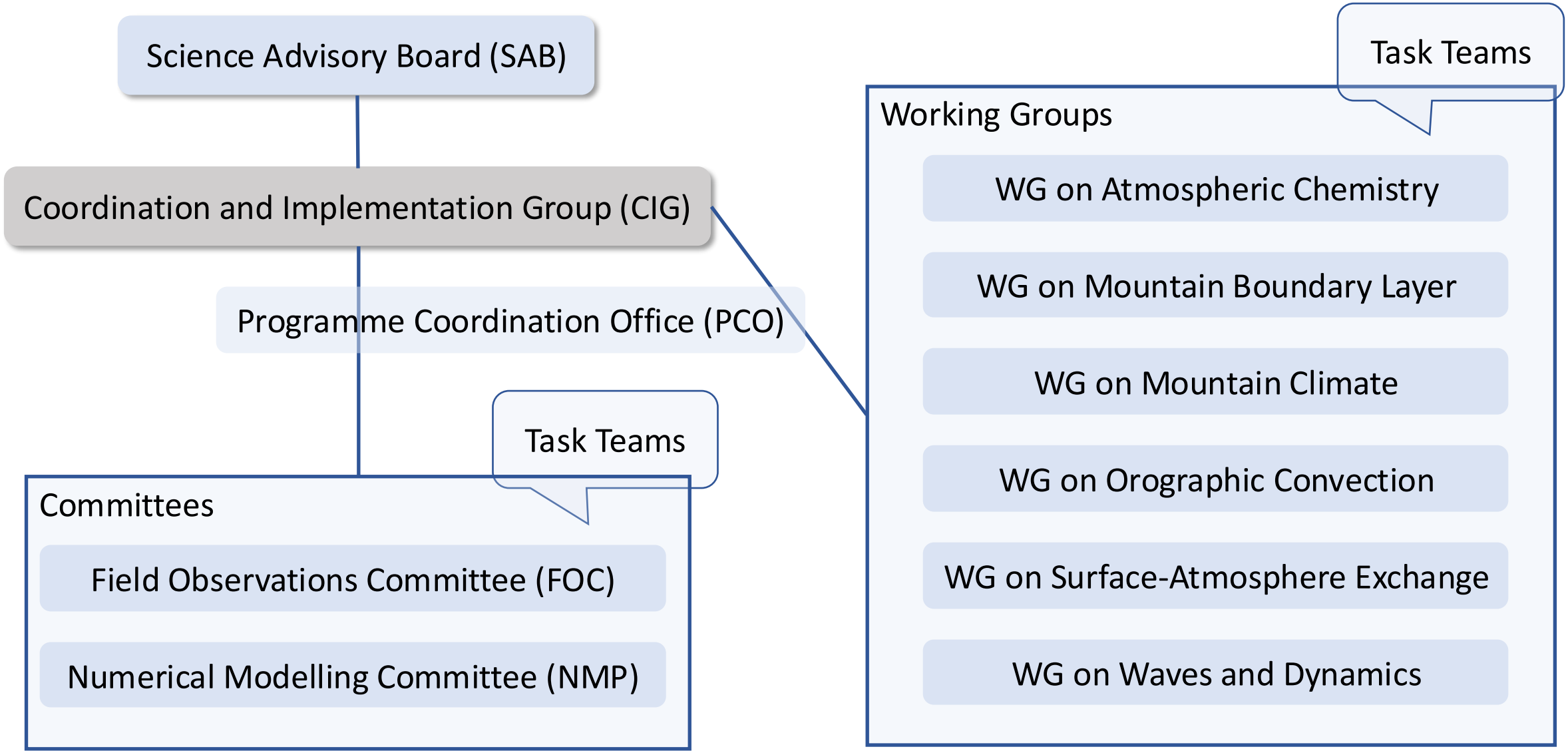
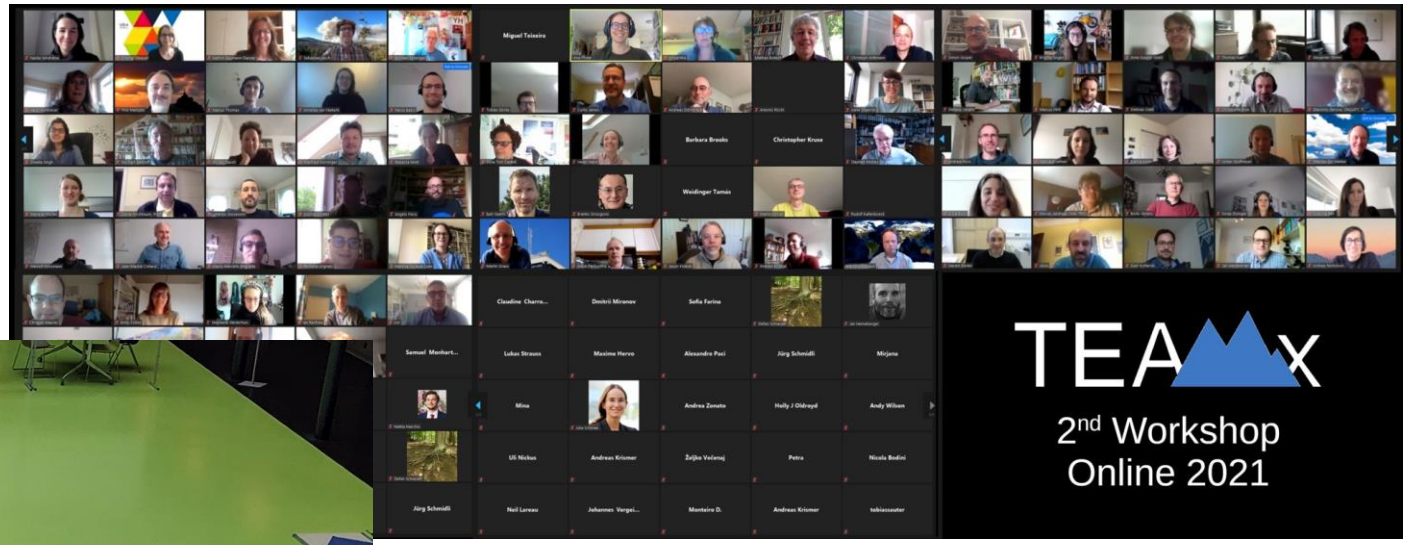
TEAMx Organisation



TEAMx Aktivitäten

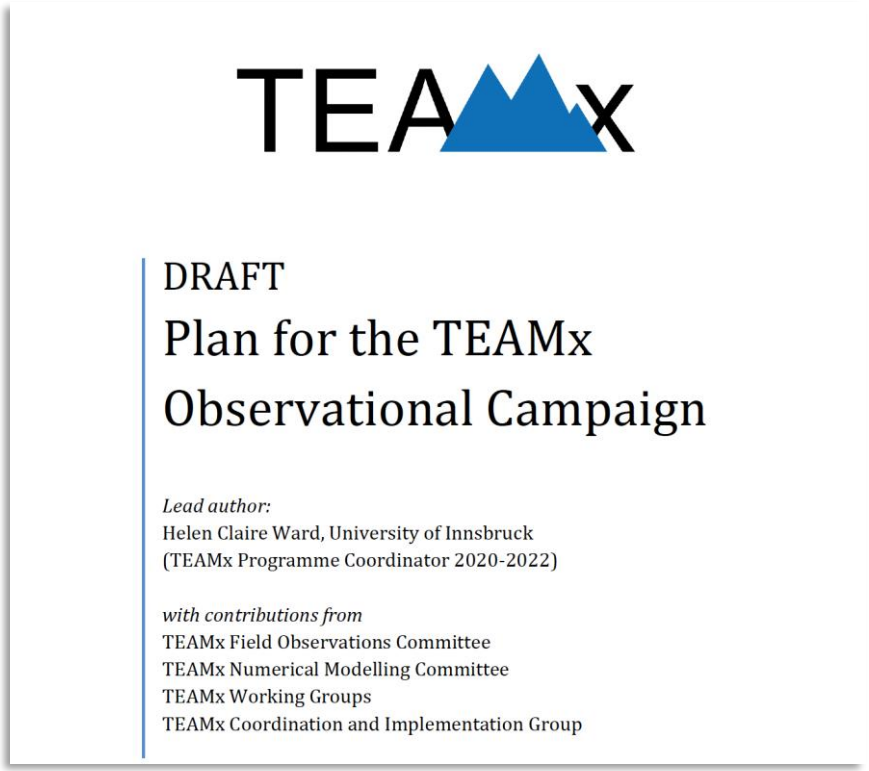
3 TEAMx Workshops (2019, 2021, 2023)



TEAMx Aktivitäten

Messungen und Analyse von Beobachtungsdaten

- TEAMx Observational Campaign (TOC)
- Pre-Campaigns: PC22, HEFEX-II



TEAMx

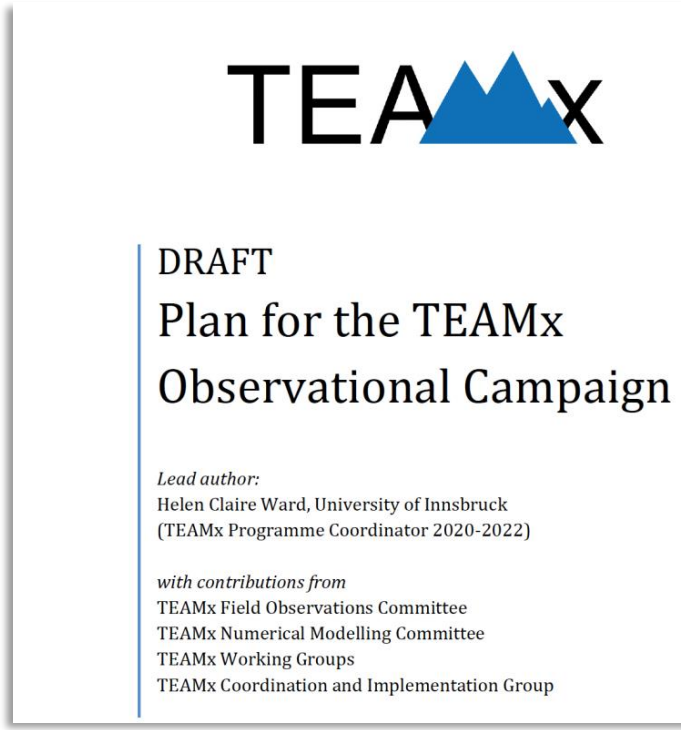
DRAFT

Plan for the TEAMx Observational Campaign

Lead author:
Helen Claire Ward, University of Innsbruck
(TEAMx Programme Coordinator 2020-2022)

with contributions from
TEAMx Field Observations Committee
TEAMx Numerical Modelling Committee
TEAMx Working Groups
TEAMx Coordination and Implementation Group

TEAMx Aktivitäten



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Specific goals identified by the working groups

A. Atmospheric Chemistry

A1. Improve understanding of the interaction between dynamics and chemistry at relevant scales using chemical composition measurements and high-resolution modelling.

A2. Improve understanding of sources, transport and chemical processing of trace species and their precursors.

A3. Develop parameterizations to better represent chemical processes in large-scale models using remote sensing and regional atmospheric models capable of resolving important atmospheric processes in complex topography.

A4. Investigate the role of gravity waves on the chemical composition of the atmosphere (particularly on stratosphere-troposphere exchange) by developing parameterisations for chemical transport models and comparing with observations of the chemical composition within breaking gravity waves.

A5. Use long-term chemical atmospheric observations to address the knowledge gaps in the evolution of air pollution sources in the Alps.

B. Mountain Boundary Layer

B1. Characterise the spatial and temporal structure of the convective and stable MoBL (at sub-hourly to seasonal timescales), particularly the three-dimensional distribution of turbulence. Compare findings to ideal terrain expectations.

B2. Develop and test objective methods to determine the vertical extent of the MoBL.

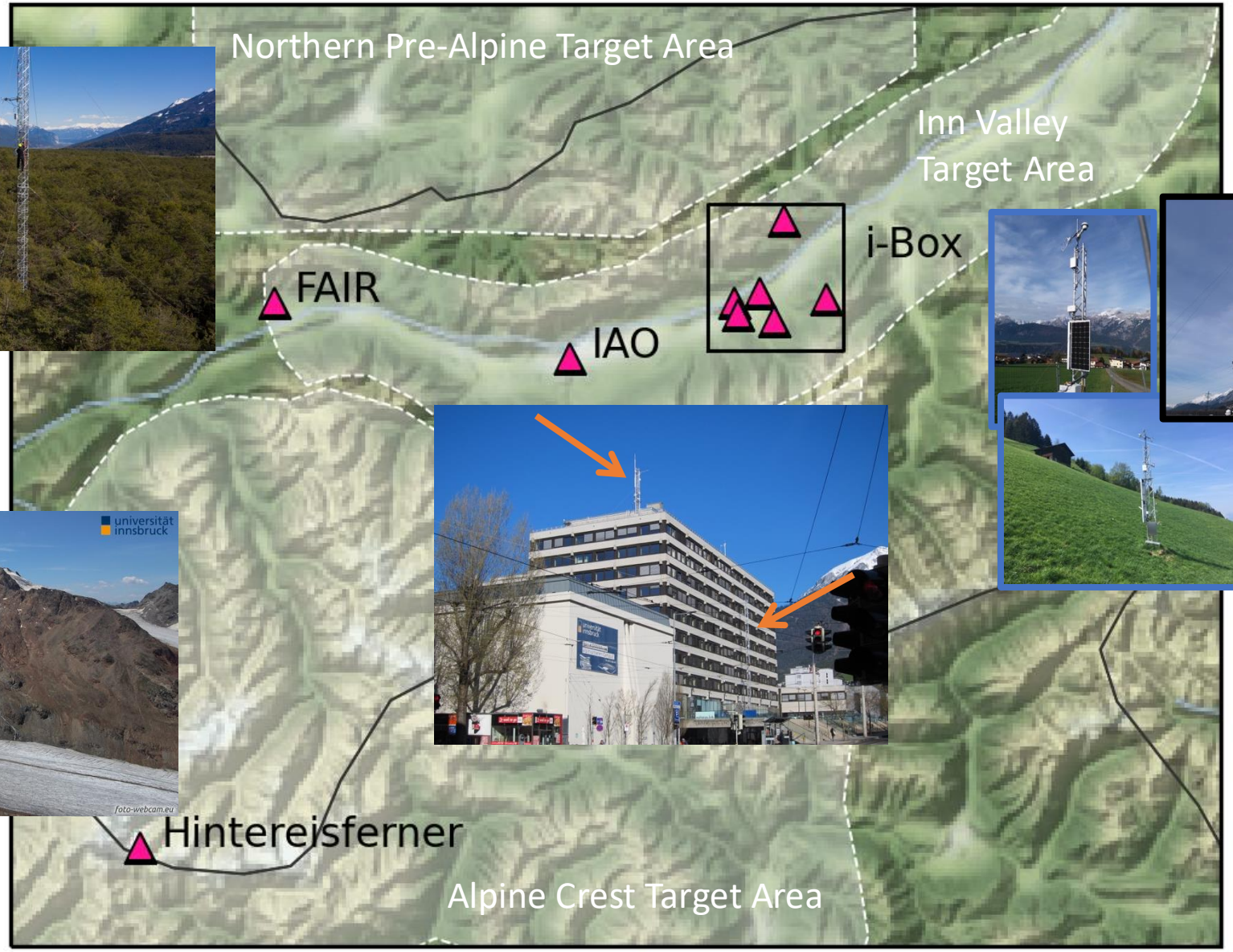
B3. Observe phenomena at the interface between the MoBL and the free atmosphere for a variety of weather conditions, to infer the sources, transport pathways and residence times for atmospheric constituents (e.g. water vapour)

TEAMx Observational Campaign (TOC)

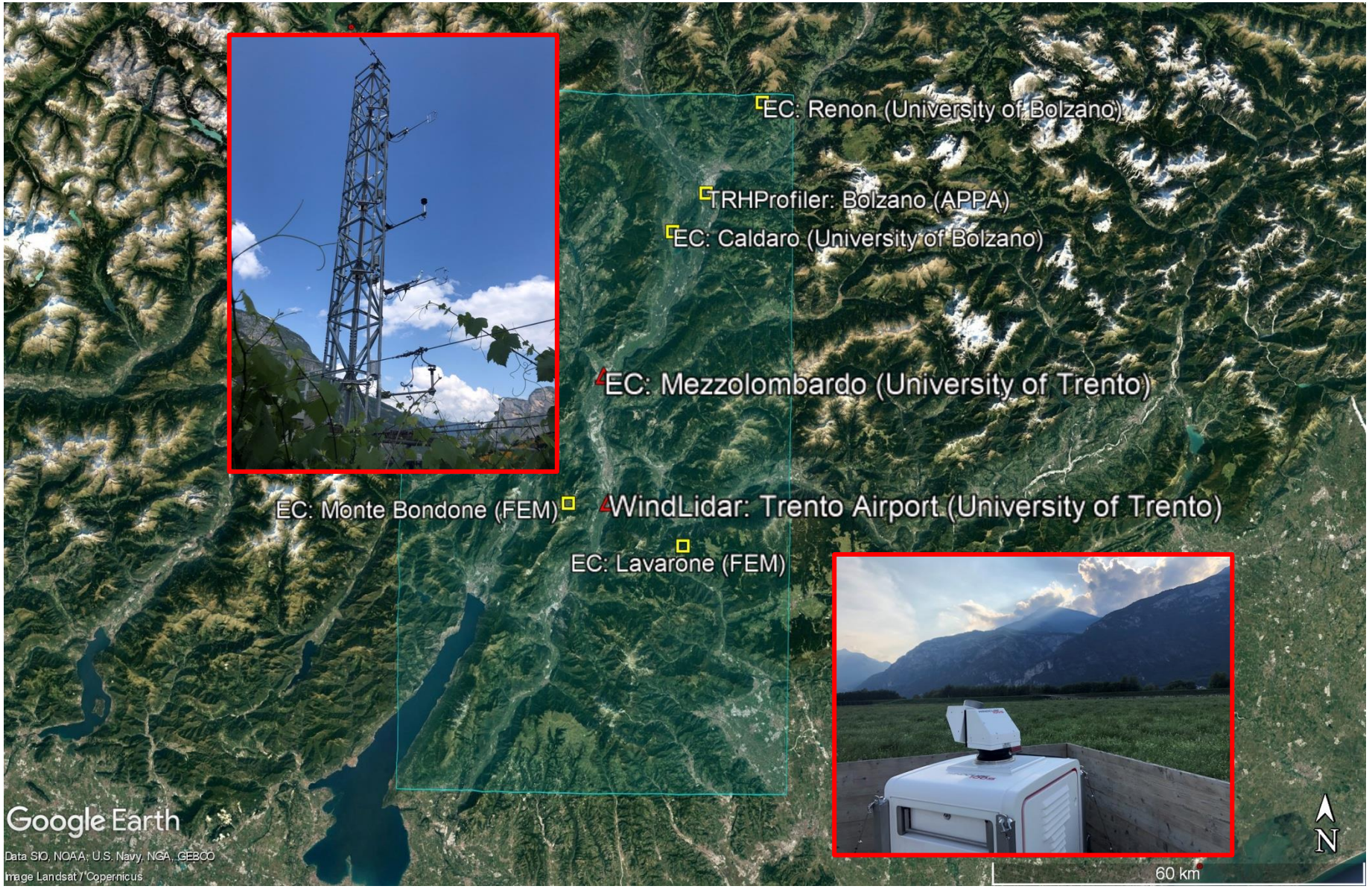
Auf Grundlage wissenschaftlicher Ziele, bisheriger Forschungsaktivitäten und existierender Messinfrastruktur wurden fünf Target Areas festgelegt:

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

Permanente Infrastruktur – Inn Valley Target Area

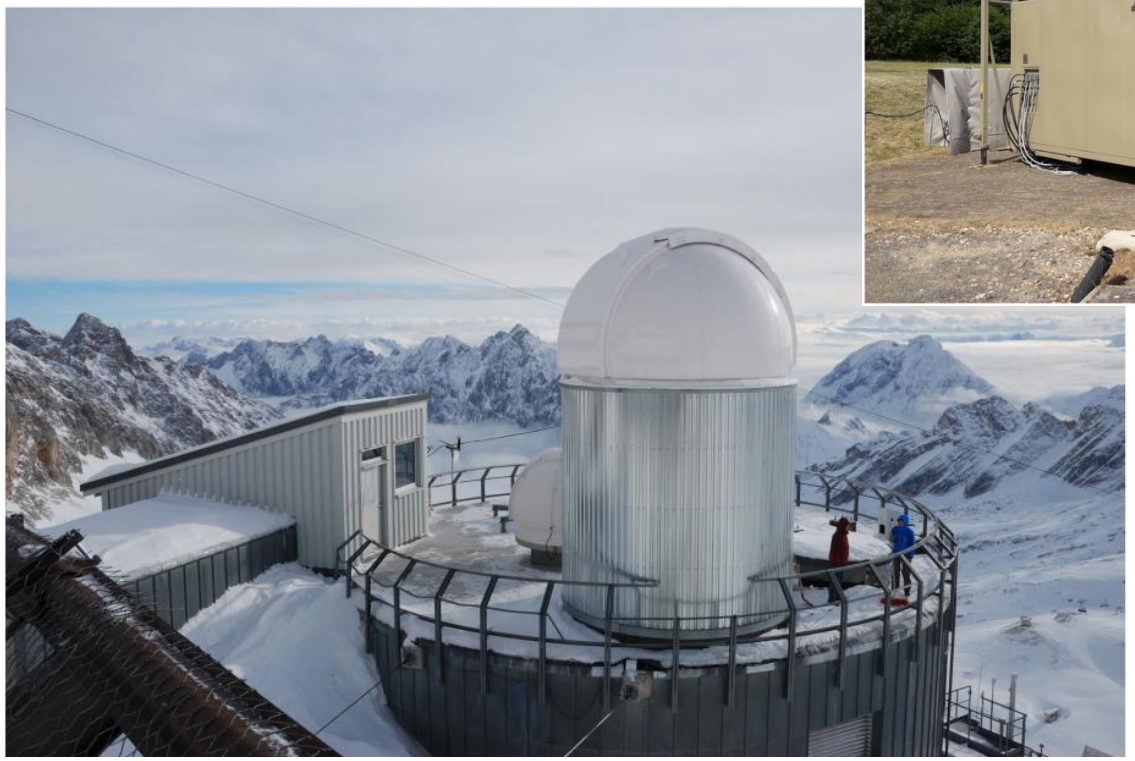


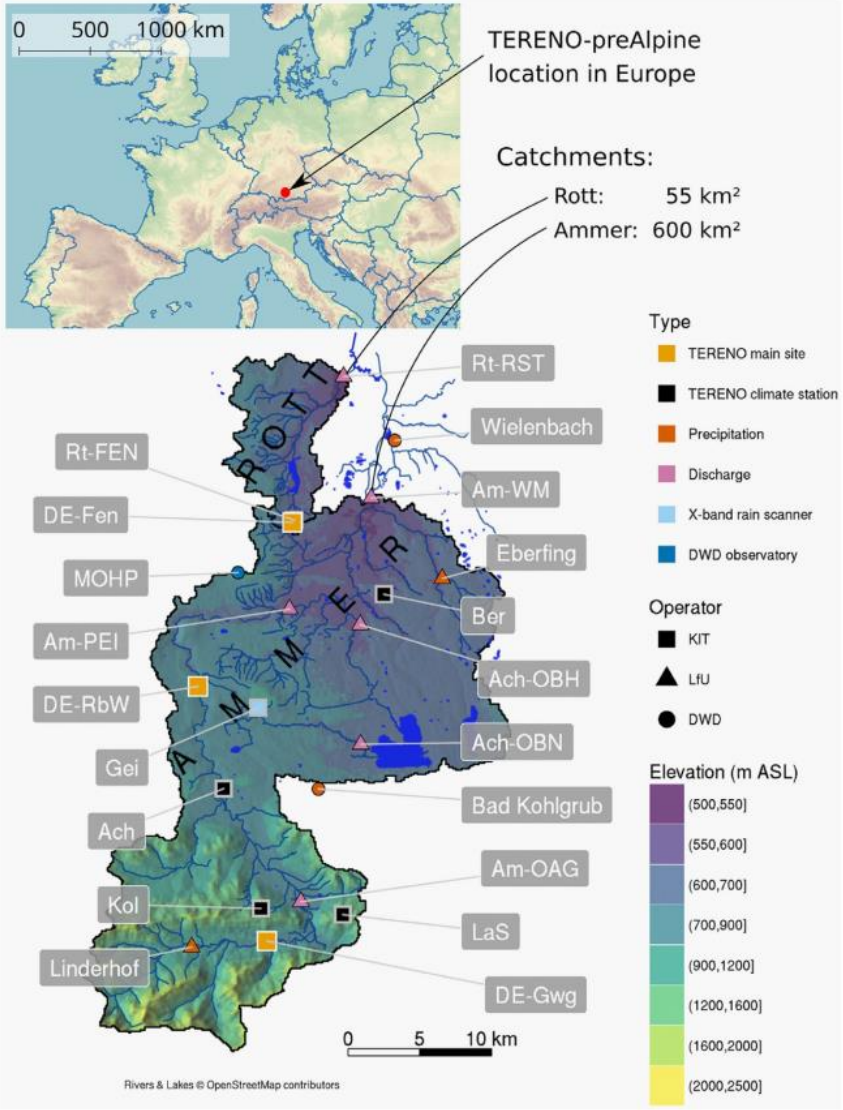
Permanente Infrastruktur – Adige Valley Target Area



Permanente Infrastruktur – North Pre-Alpine Target Area

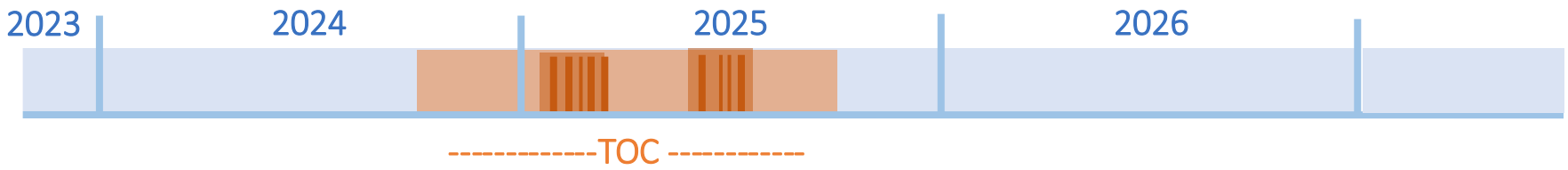
- Zugspitze/Schneefernerhaus
- KIT Campus Alpin – Garmisch
- TERENO Pre-Alpine Observatory





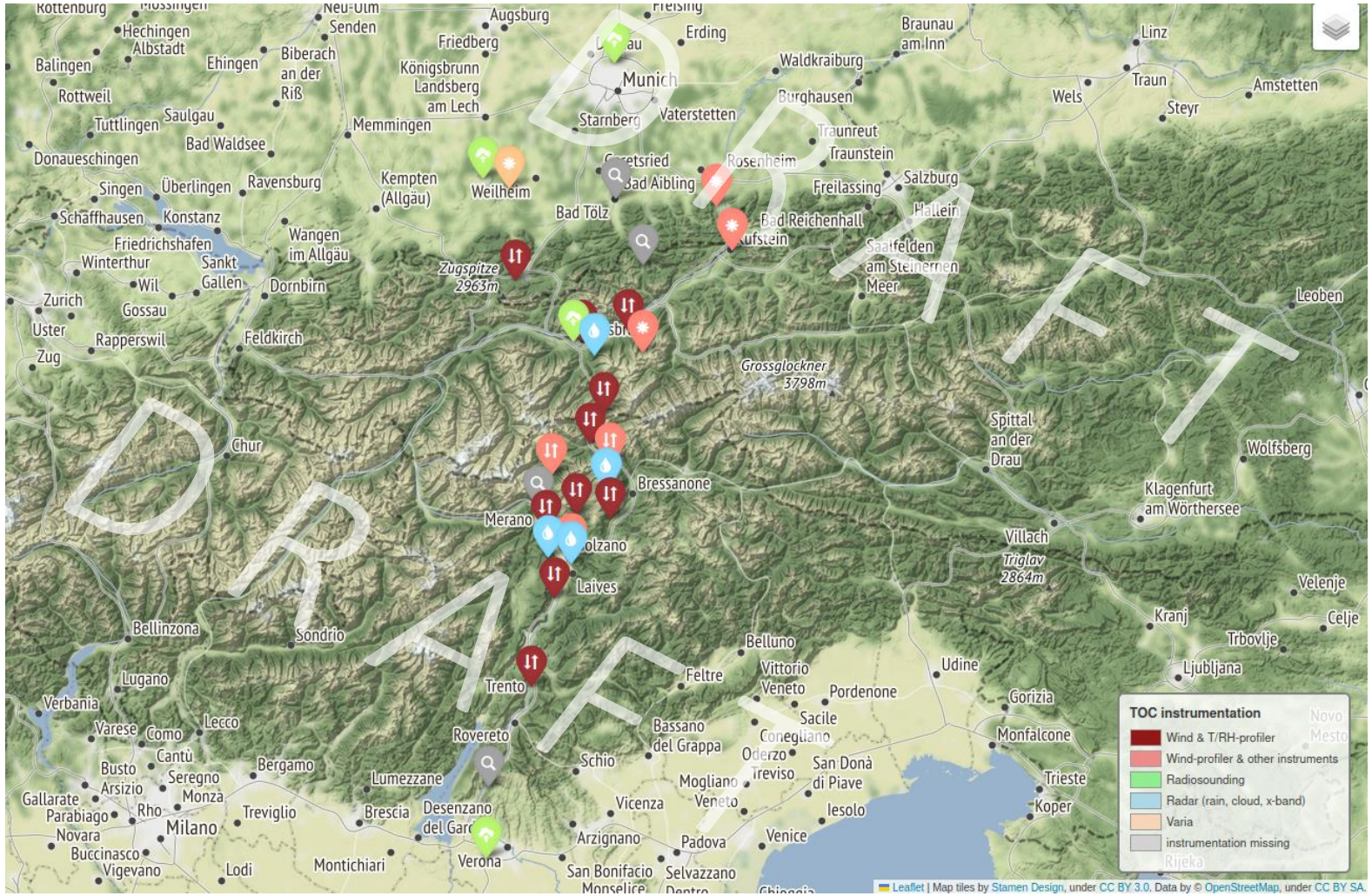
TEAMx Observational Campaign (TOC)

- Eine einjährige Messkampagne von **September 2024 bis September 2025** mit kontinuierlichen Messungen, vor allem an Standorten mit Langzeitbeobachtungen.



- Zwei erweiterte Beobachtungszeiträume (**Extended Observation Periods, EOPs**) in 2025 mit einer hohen Dichte an zusätzlichen Instrumenten.
  - Winter (Januar/Februar)
  - Sommer (Juni/Juli)
- Mehrere intensive Beobachtungszeiträume (**Intensive Observation Periods, IOPs**) mit zusätzlichen speziellen Messungen (Forschungsflüge, Radiosondierungen, Tracer-Experimente, usw.).

TEAMx Observational Campaign (TOC)



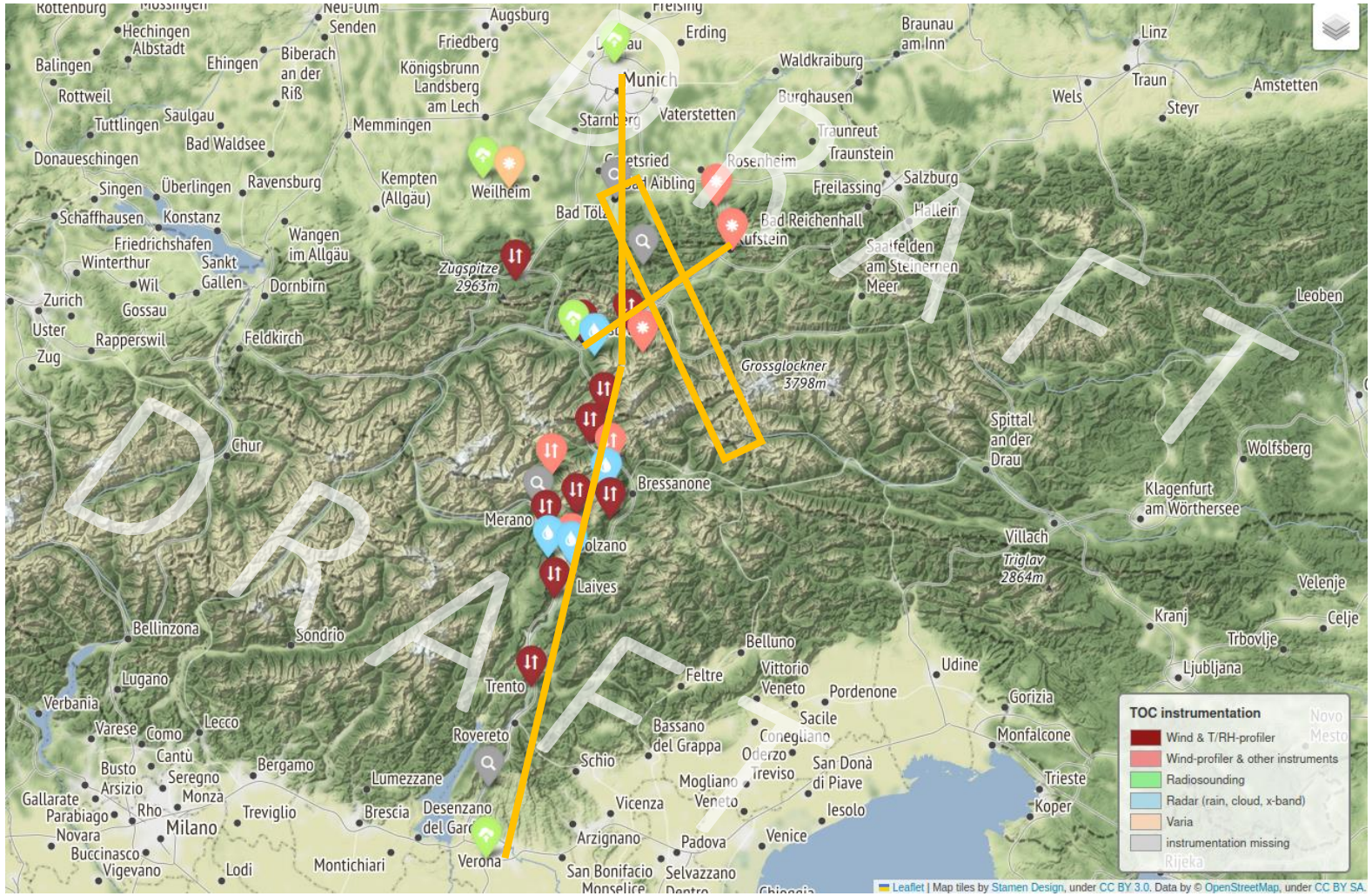
TOC Backbone

- Nord-Süd Querschnitt durch die Alpen

Wissenschaftliche Themen

- Konvektion
- Grenzschichtstruktur
- Thermische Winde (Talwinde, Alpines Pumpen)
- Kaltluftseen

TEAMx Observational Campaign (TOC)

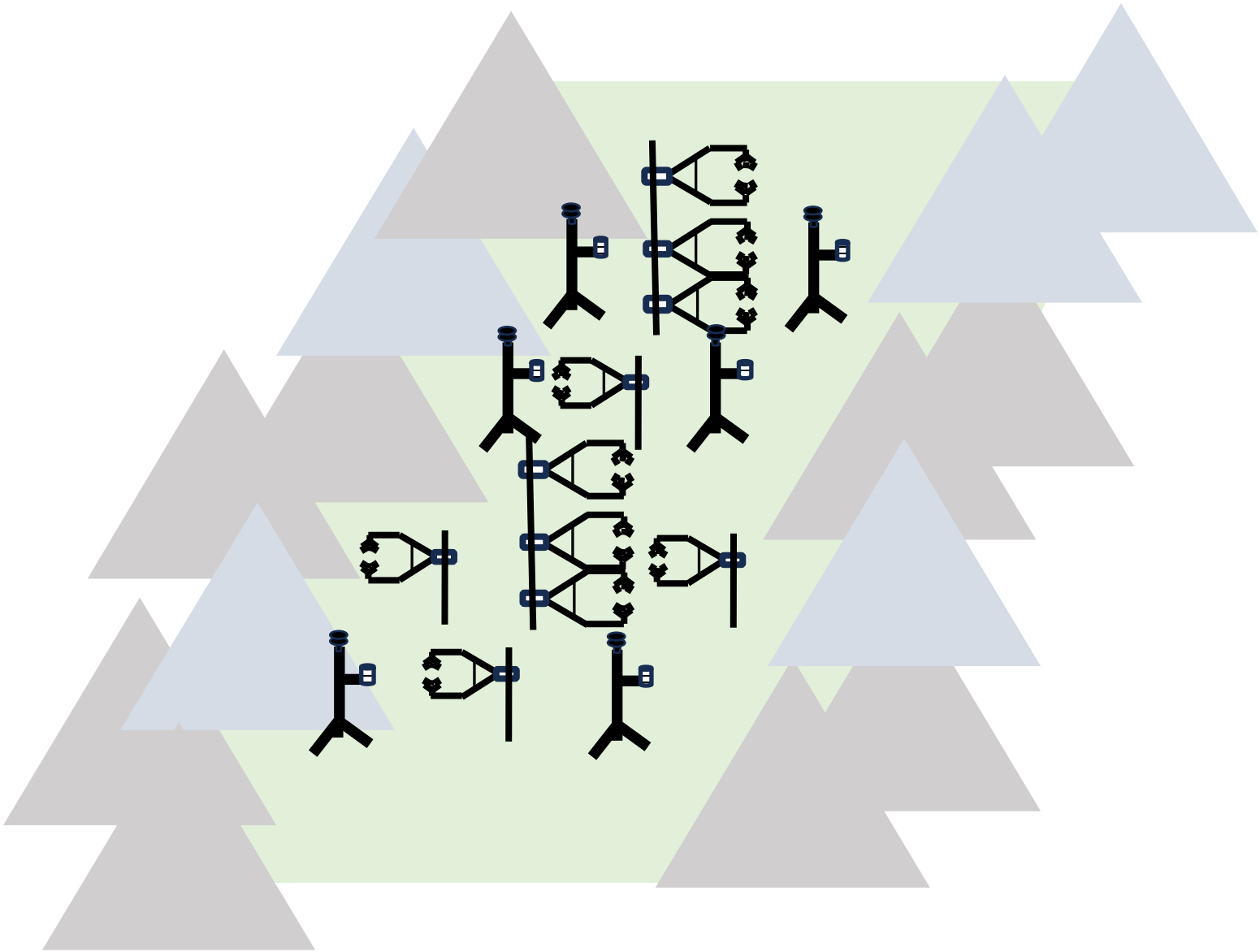


Flugmessugen

Wissenschaftliche Themen

- Schwerewellen
- Transport von Spurengasen
- Grenzschichtstruktur
- Thermische Winde (Talwinde, Alpines Pumpen)

TEAMx Observational Campaign (TOC)



Bodennahe Messungen

- AWS
- Turbulenzmessungen
- Atmosphärenchemie

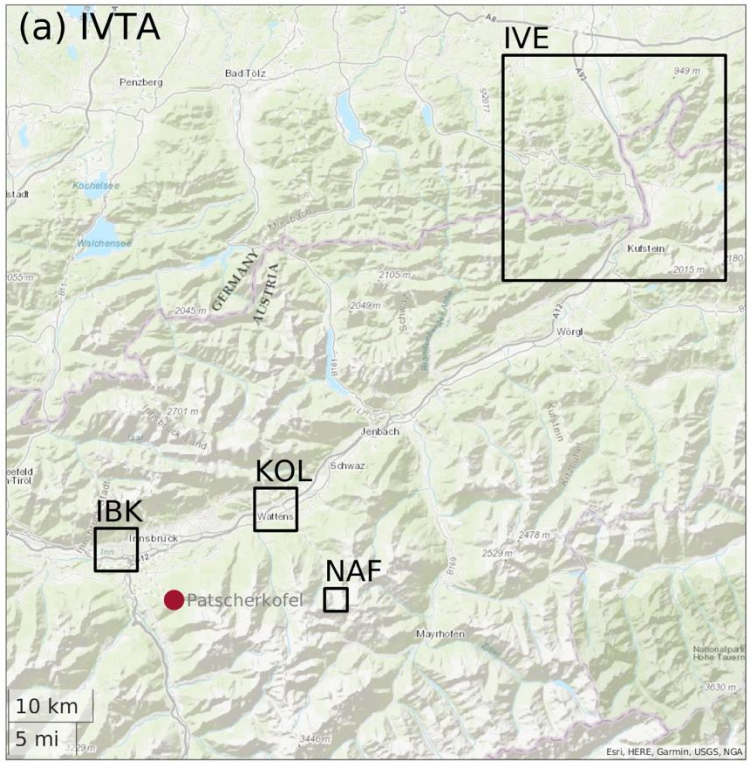
Wissenschaftliche Themen

- Thermische Winde (Talwinde, Hangwinde)
- Austausch zwischen Boden und Atmosphäre
- Turbulenzcharakteristika
- Advektionsprozesse
- Submesoskalige Prozesse

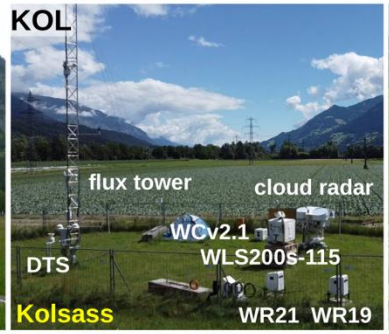
TEAMx Pre-Campaign 2022 (PC22)

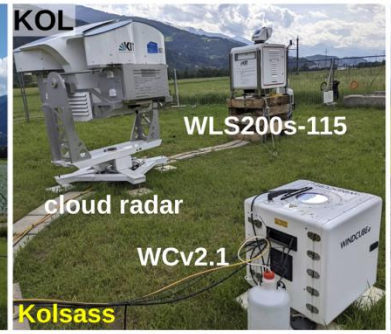
Testen von

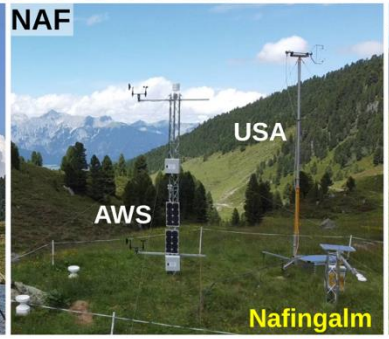
- Instrumenten
- Messstandorten

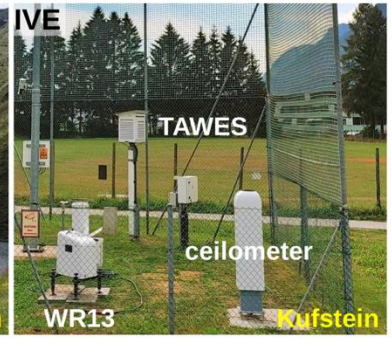


Pfister et al., in preparation

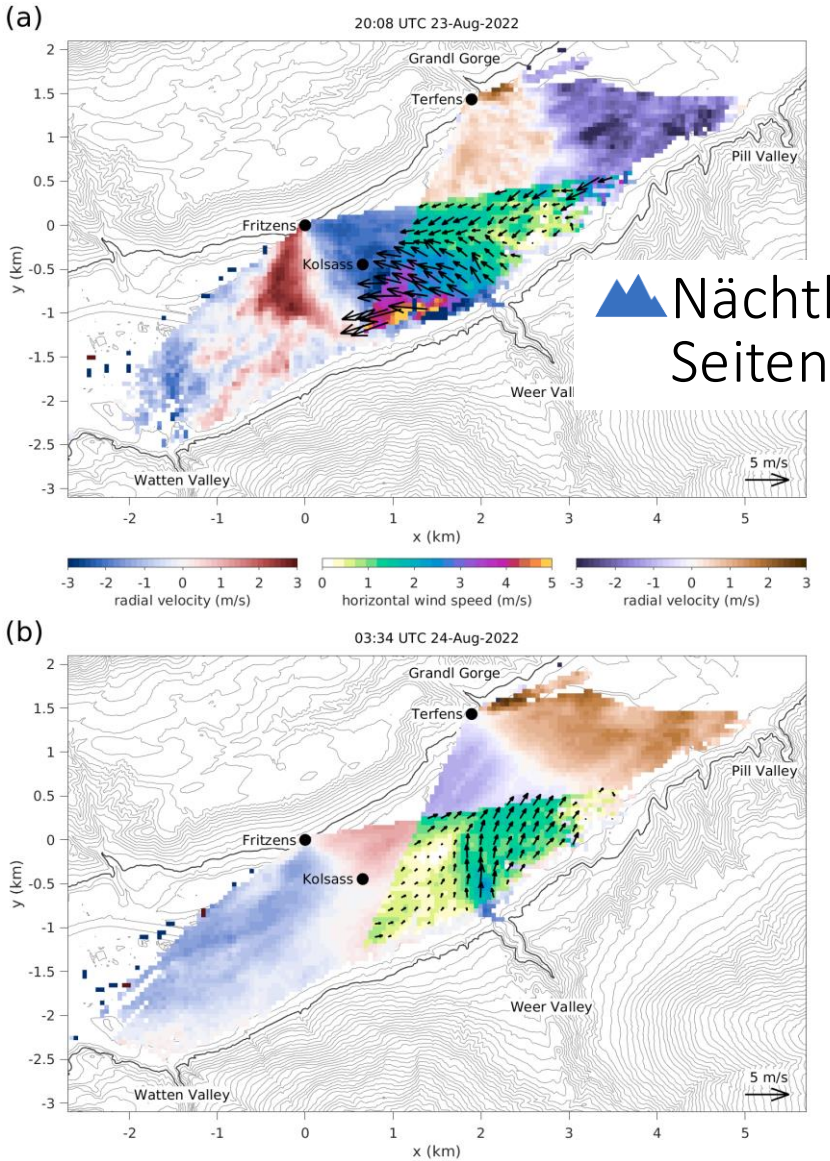








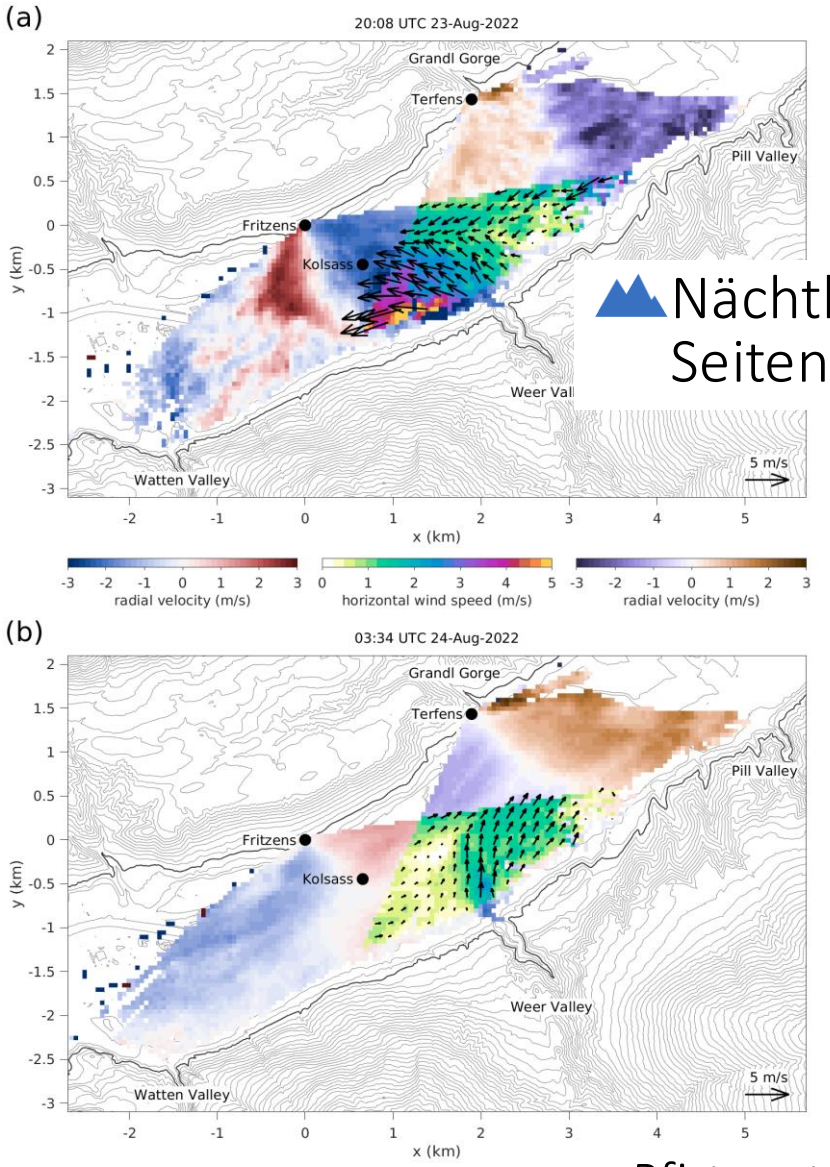
TEAMx Pre-Campaign 2022 (PC22)



- Nächtliches Ausfließen aus Seitentälern

Pfister et al., in preparation

TEAMx Pre-Campaign 2022 (PC22)



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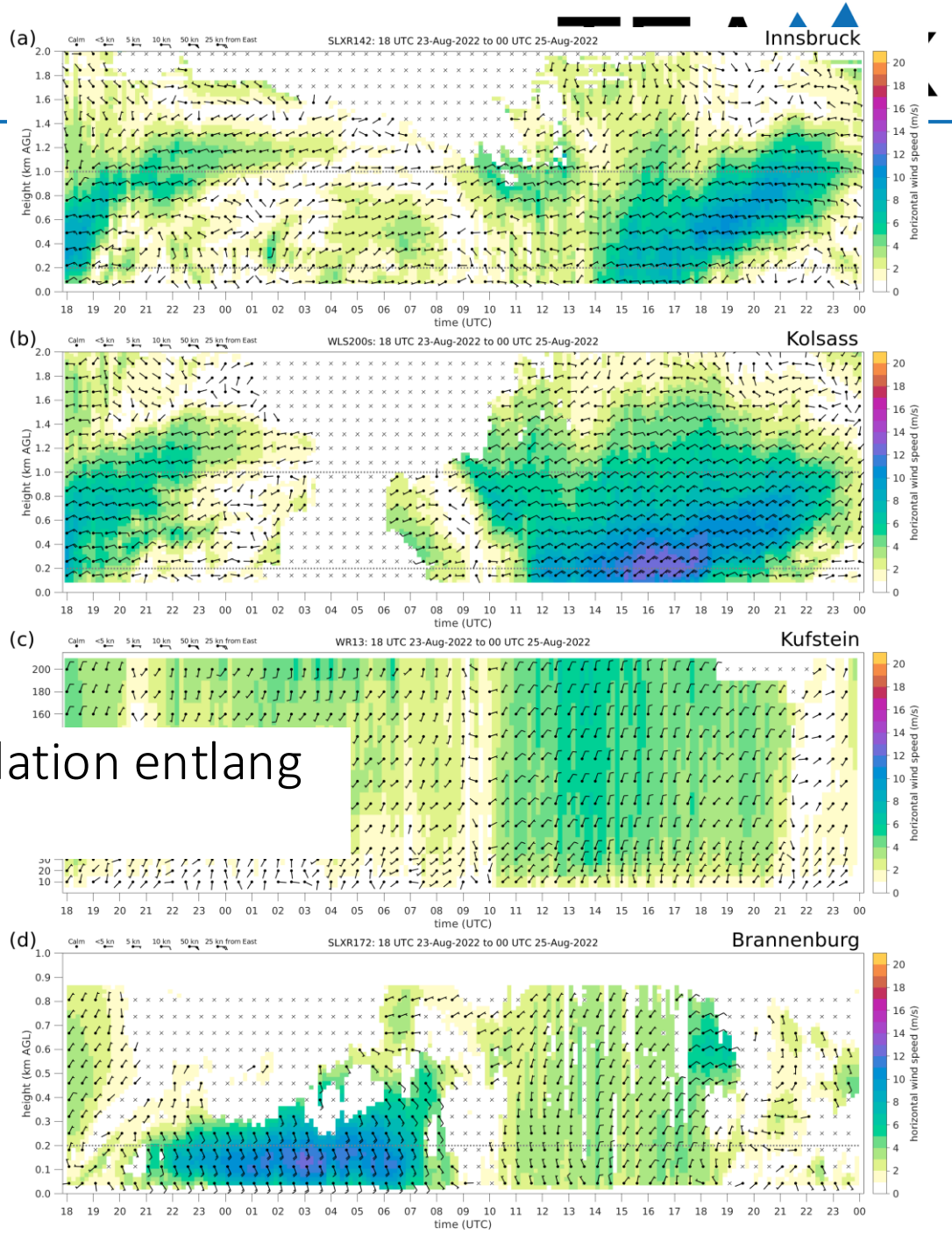


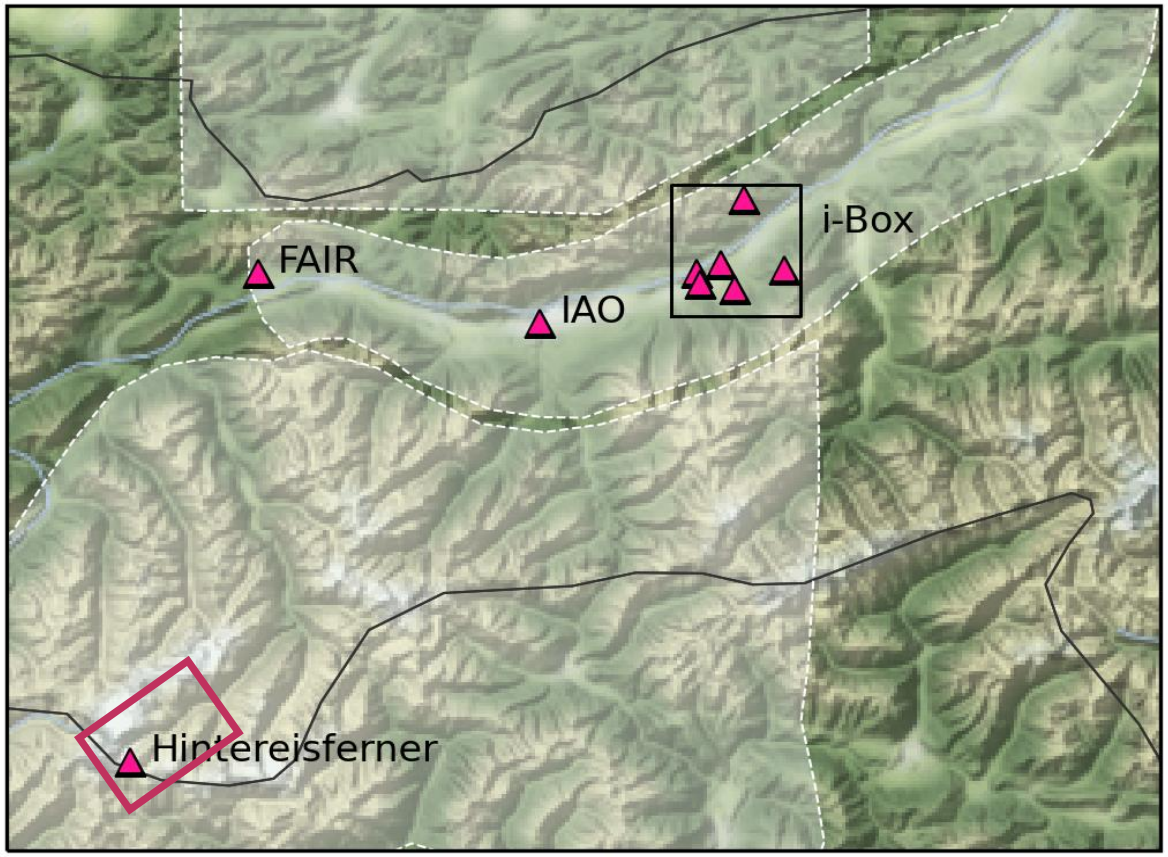
- Talwindzirkulation entlang der Talachse

Pfister et al., in preparation

HEFEX-II Field Experiment 2023

- Messkampagne am Hintereisferner in Österreich
- Gruppen aus Österreich, Deutschland, Schweiz, Frankreich und Großbritannien

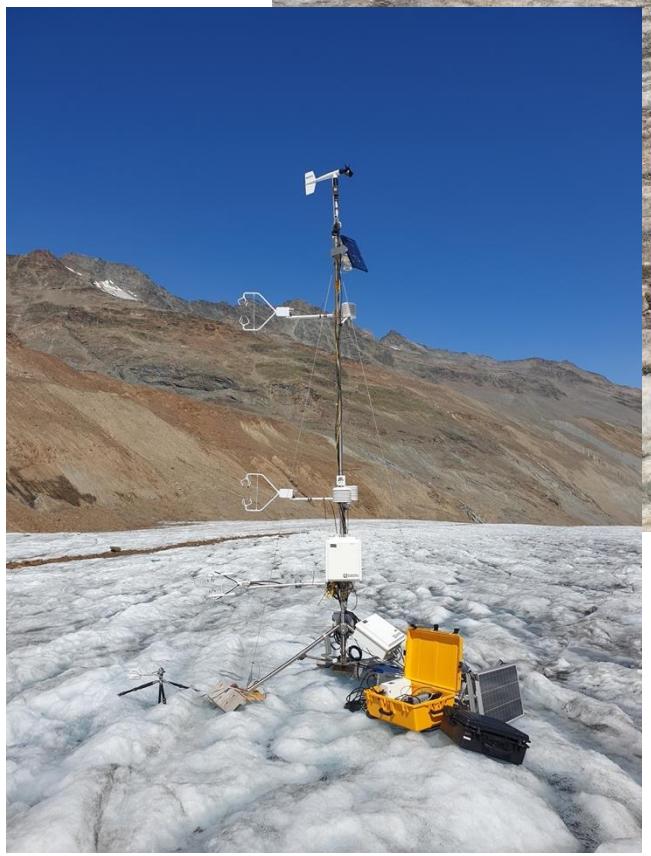
- Gletschergrenzschicht und Austausch zwischen Boden und Atmosphäre
- Interaktionen zwischen thermisch und dynamisch angetriebenen Windsystemen
- Räumliche und zeitliche Variabilität mikrometeorologischer Bedingungen
- Aufnahme von CO2 durch geröllbedeckte Gletscher

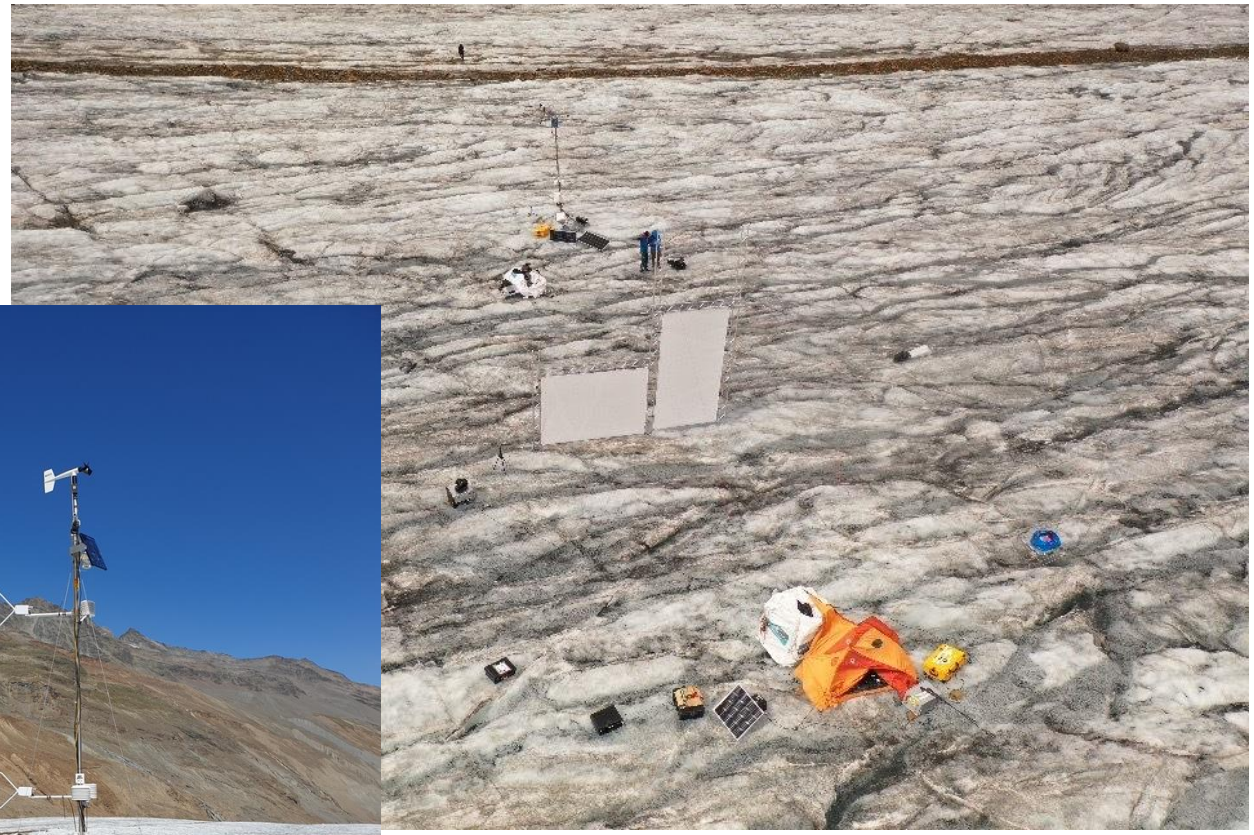


HEFEX-II Field Experiment 2023

- Messkampagne am Hintereisferner in Österreich

- Turbulenzmessungen, AWS
- UAVs, Infrarotkamera, Lidar





TEAMx Aktivitäten

Messungen und Analyse von Beobachtungsdaten

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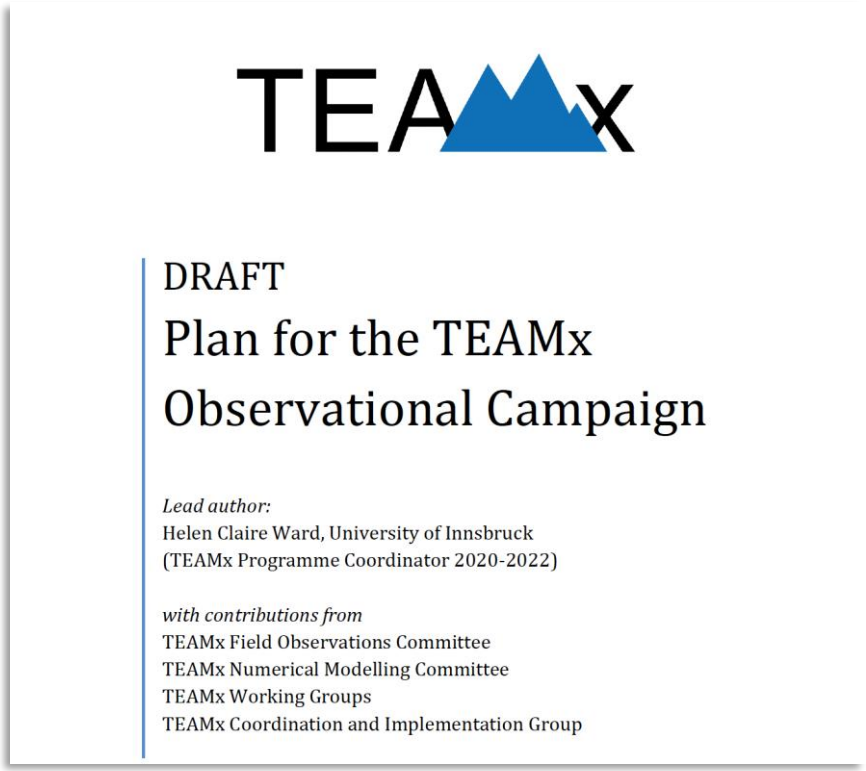
- Pre-Campaigns: PC22, HEFEX-II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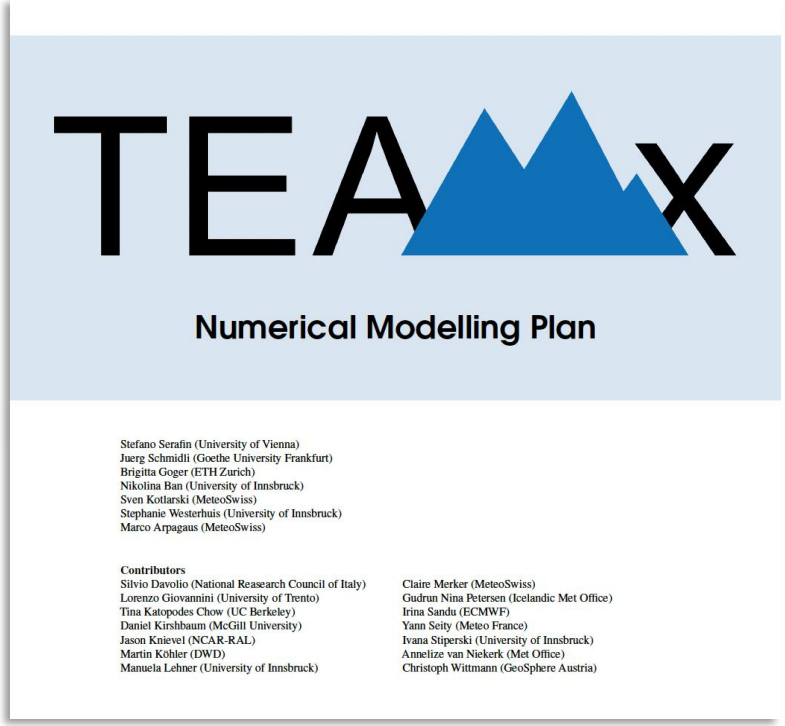
Modellstudien

- Modellvergleichsstudien
- Operationelle Unterstützung der TOC
- Hochaufgelöste Reanalyse für die TOC
- Hochaufgelöste Klimasimulationen


TEAMx

Numerical Modelling Plan

Stefano Serafin (University of Vienna)
Juerg Schmidli (Goethe University Frankfurt)
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Nikolina Ban (University of Innsbruck)
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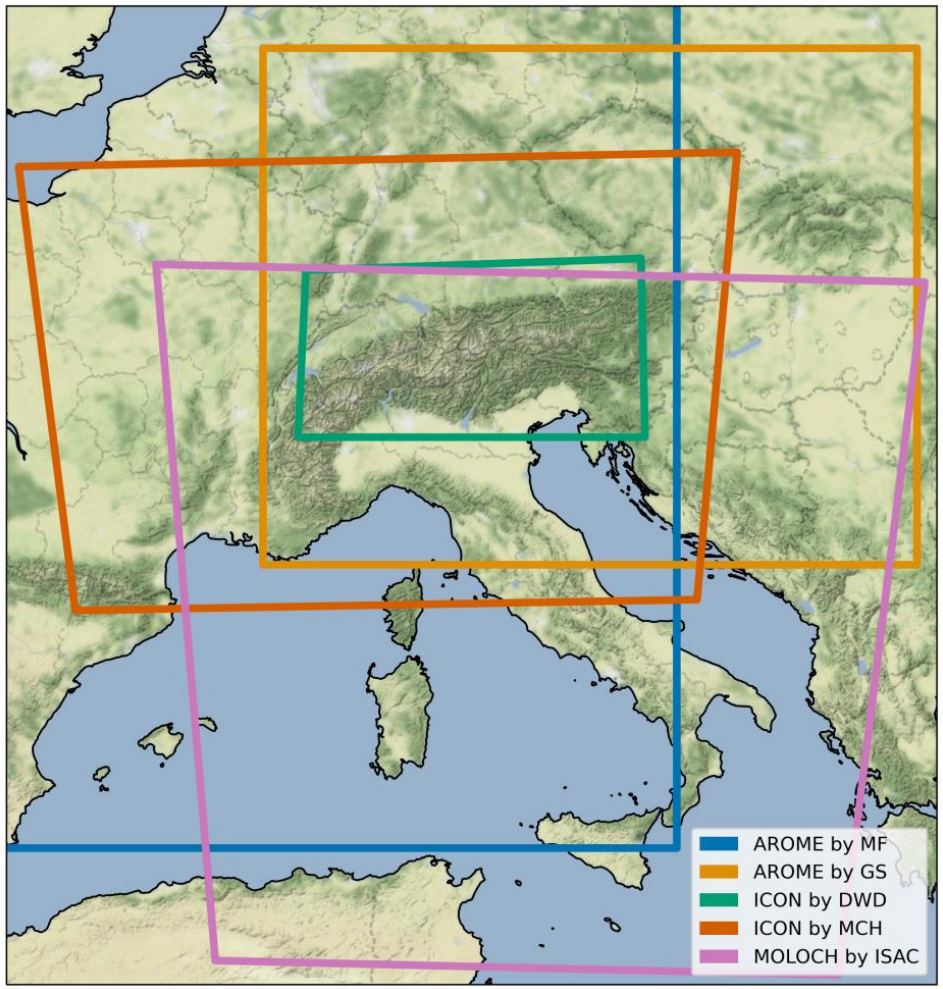
Irina Sandu (ECMWF)
Yann Seity (Meteo France)
Ivana Stiperski (University of Innsbruck)
Annelize van Niekerk (Met Office)
Christoph Wittmann (GeoSphere Austria)

NWP Unterstützung während der TOC



Unterstützung durch 5 nationale Wetterdienste

- DWD
- GeoSphere Austria
- Météo France
- MeteoSwiss
- ISAC (Italienisches Institut für Atmosphärenwissenschaften und Klima)

TEAMx Modellvergleichsstudien

Fünf laufende Modellvergleichsstudien

Fallstudien – Evaluierung mit Beobachtungsdaten

- Kaltluftseen
- Thermische Winde
- Konvektion

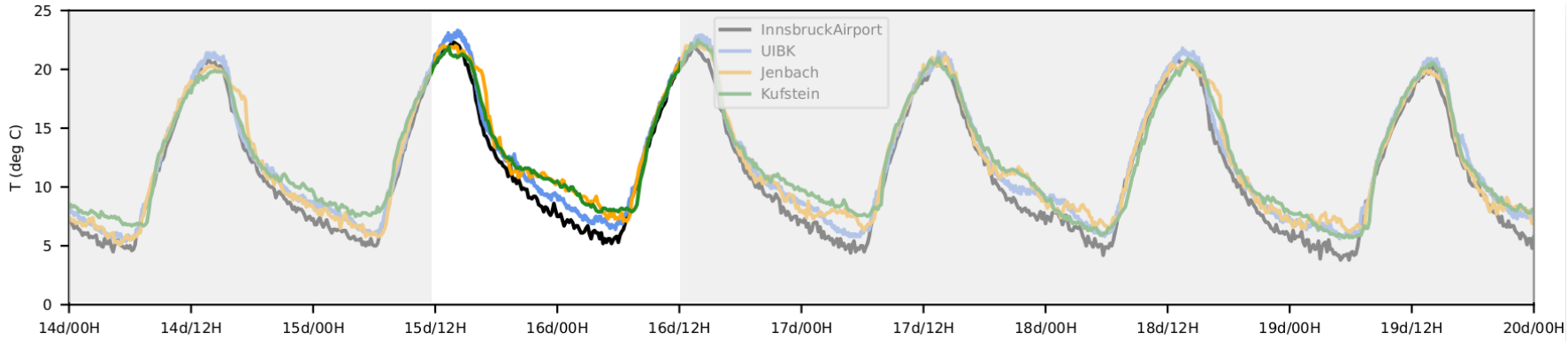
Semi-idealisierte Simulationen

- Orographic drag – Einfluss der Modellauflösung
- Konvektion - LES

Model	OD	CAP	TDF	CON	LES
ECMWF-IFS	✓				
ICON	✓	*	*	✓	
AROME			*	*	
MESO-NH		✓		✓	✓
UM		✓			
WRF		✓	*	*	✓
CM1					*
ARPS					✓
GRAMM-SCI			✓		

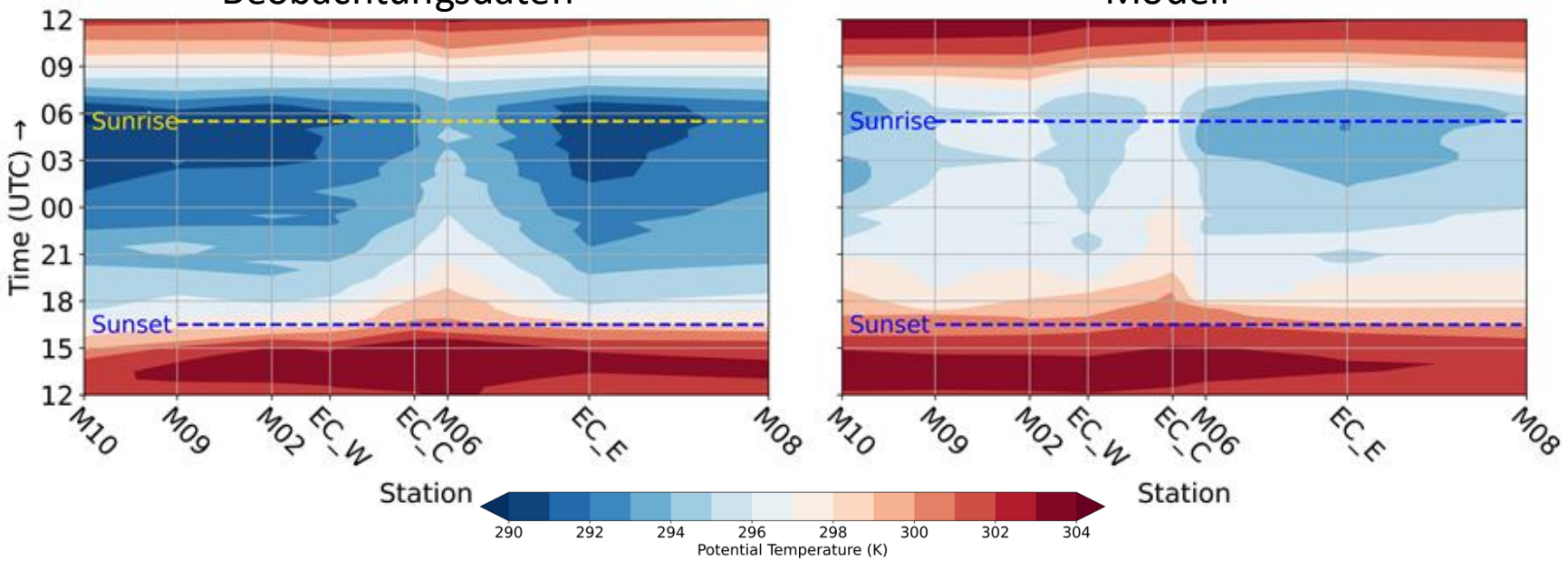
* mehrere Modellversionen (z.B. verschiedene Parametrisierungen)

Modellvergleichsstudie Kaltluftseen: Fallstudie im Raum Innsbruck (PIANO Messkampagne)



Beobachtungsdaten

Modell



Beispiel: ICON Simulation
Schöni et al. (2023), ICAM Poster

TEAMx – weitere Informationen

TEAMx ist ein **internationales Forschungsprogramm**, das darauf abzielt, das **Verständnis von Austauschprozessen in Gebirgsregionen zu verbessern** und die Parametrisierung dieser Prozesse in numerischen Wetter- und Klimamodellen voranzutreiben

- TEAMx Website: www.teamx-programme.org
- TEAMx White Paper: DOI 10.15203/99106-003-1
- BAMS paper: DOI 10.1175/BAMS-D-21-0232.1
- TEAMx mailinglist: https://lists.uibk.ac.at/sympa/info/teamx