Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

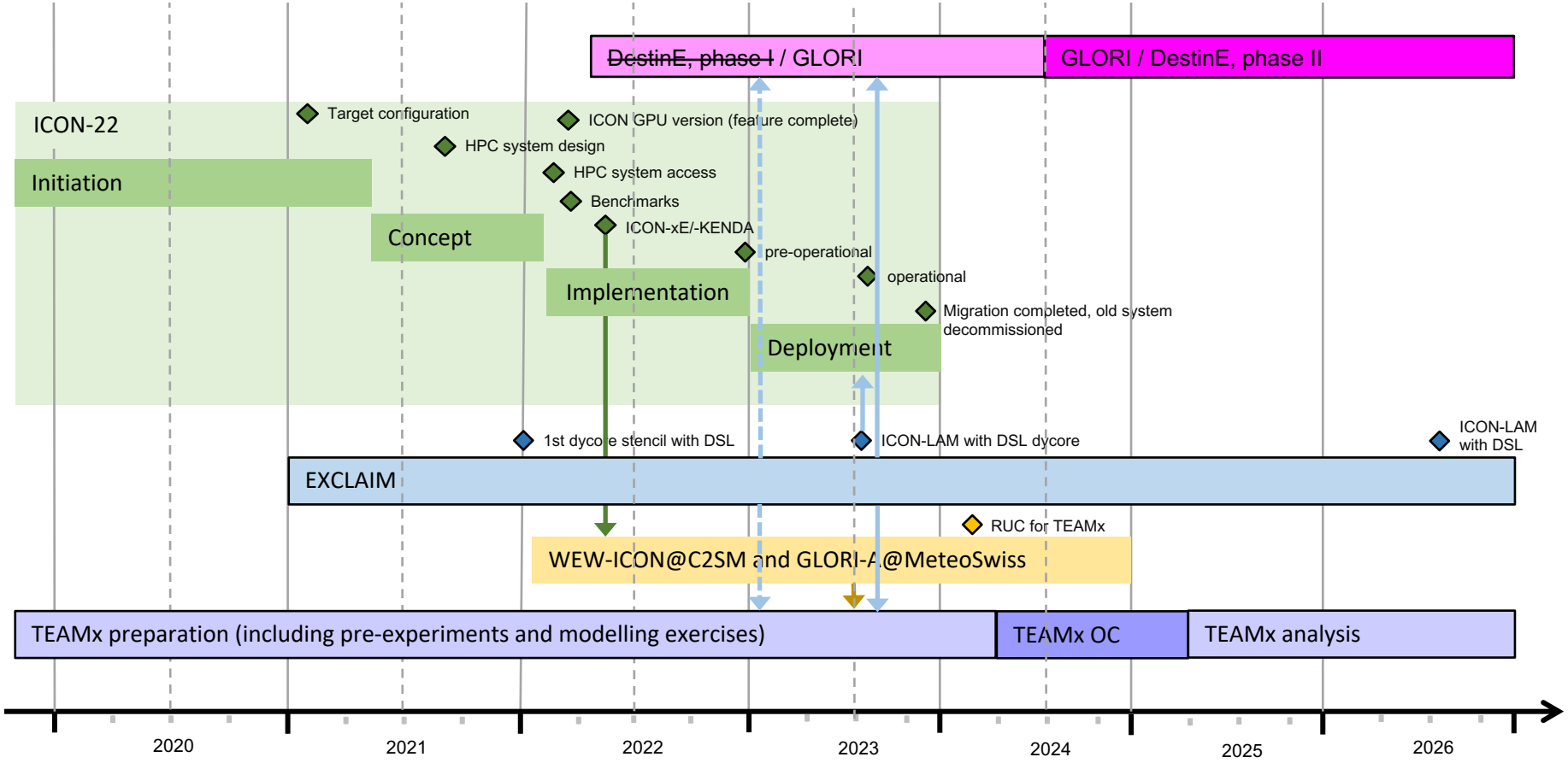
Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

GLORI-A and TEAMx – an update

Marco Arpagaus & colleagues

ICON projects and timeline overview



Destination Earth (DestinE)
an initiative of the European Commission

→ → →

GLObal-to-Regional ICON (GLORI) Digital Twin
a tri-lateral project between

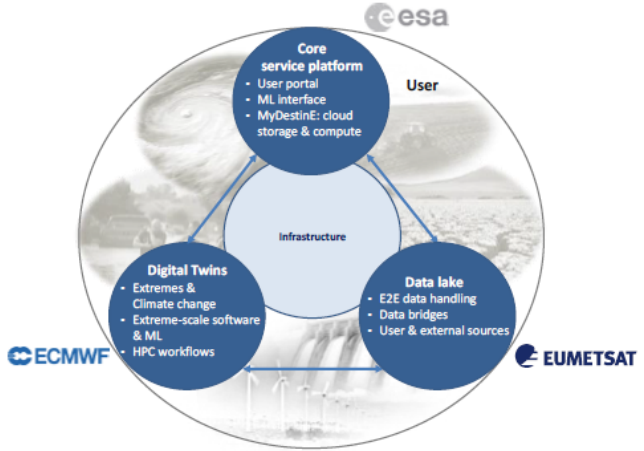
- Germany: DWD, KIT, FZJ
- Italy: ItaliaMeteo, MeteoAM, CMCC, ARPAE-SIMC
- and Switzerland: MeteoSwiss

Destination Earth (DestinE): part of European Commission Green Deal and Digital Strategy

https://ec.europa.eu/digital-single-market/en/destination-earth-destine

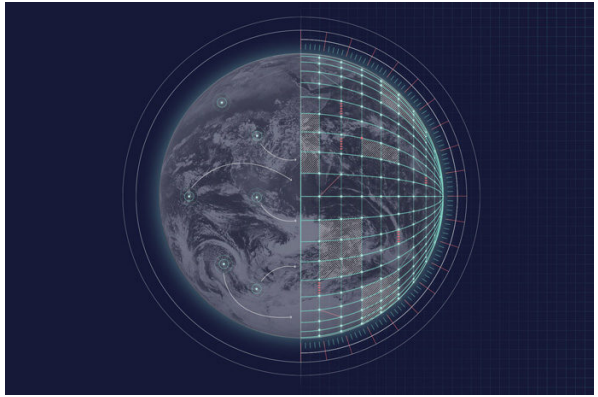
The objective of the Destination Earth initiative is to develop a very high precision digital model of the Earth to monitor and simulate natural and human activity, and to develop and test scenarios that would enable more sustainable development and support European environmental policies.

- **ESA (~50 Million €)**:
  key role of system integrator
  and implementer of the core platform
- **EUMETSAT (~40 Million €)**:
  responsible for the big data lake and data integration
- **ECMWF (~60 Million €)**:
  Digital Twin (DT) implementer
  - DT1: Weather-induced and Geophysical Extremes
  - DT2: Climate Change Adaptation



DestinE: Digital Twins

- DestinE will be implemented gradually over the next 7-10 years, starting in 2022.
- One aim is to create Digital Twins (DT) of the Earth.
- The digital twins created in DestinE will give expert and non-expert users tailored access to high-quality information, services, models, scenarios, forecasts and visualisations (→ easy-to-use APIs, “data lake” exchange platform)
- Digital climate and NWP/extreme twins: planned to have on-demand capabilities over Europe, running on EU HPC infrastructures.

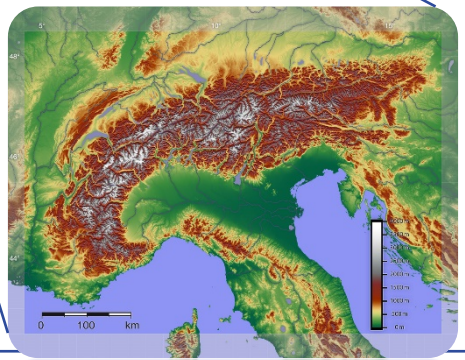


Global-to-Regional-ICON Alpine Twin (GLORI-A)

Work on the GLORI-Alps Twin has started

Tri-lateral Cooperation
Germany, Italy, Switzerland

DestinE
2nd Phase Option



The **GLORI** (Global-to-Regional ICON) **Alpine Digital Twin** (DT) is a **configurable on-demand** global-to-regional high resolution Digital Twin based on the prediction capability of the ICON earth system model and the Data Assimilation Coding Environment DACE developed by the COSMO Consortium.

GLORI-Alps Characteristics

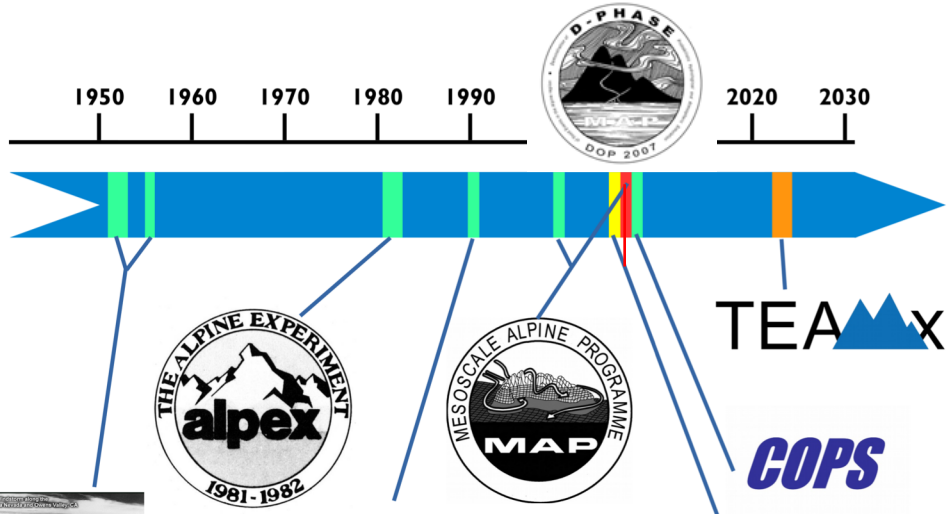
- Global storm-resolving and regional km-scale
- Configurable and on-demand
- Frequent innovation uptake though data assimilation (global and km-scale):
  - Global-Nest Ensemble Data Assimilation
  - KENDA at high resolution, assimilation of radar reflectivity volumes over the Alps
- Uncertainty estimation (global and regional ensembles), also in the data assimilation
- High-resolution, down to 500 m
- Run on heterogeneous GPU-CPU architecture
- ART Mineral Dust ENERGY
- ART Pollen HEALTH Application
- Flood forecasting as user-oriented system evaluation

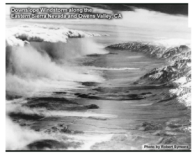
TEAMx

an international bottom-up science initiative in mountain meteorology

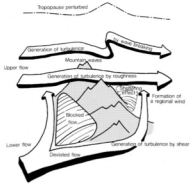
Multi-scale Transport and
Exchange Processes in the
Atmosphere over
Mountains –
Programme and experiment

Major experiments in mountain meteorology





Sierra Wave



PYREX Experiment

T-REX Experiment

TEAMx technological drivers

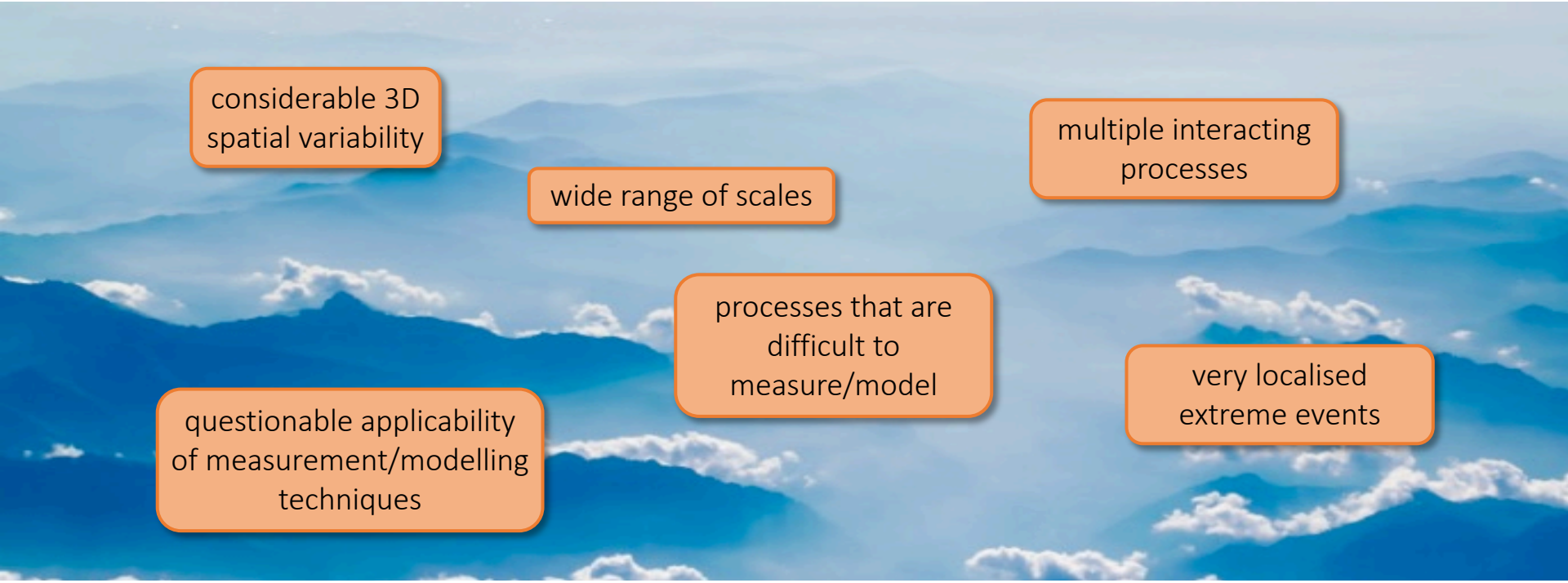
Observational advances w.r.t. historical campaigns:

- Remote sensing: ground based (radar, lidar, boundary-layer profiling) and satellite-based (resolution, parameters retrieved).
- Airborne sampling and remote sensing.

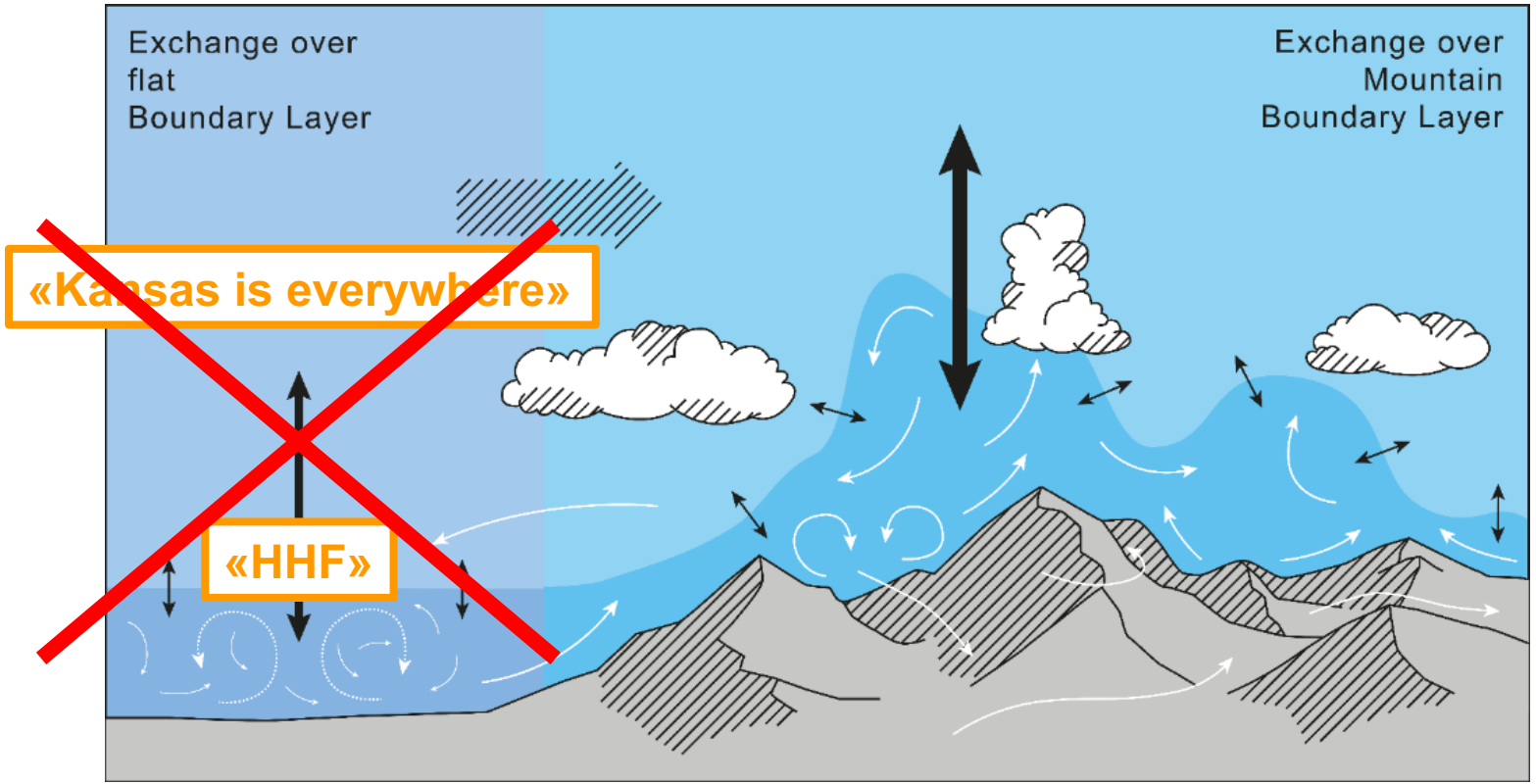
Model advances:

- Steadily increasing resolution.
- High resolution implies challenges in model initialisation, parameterization of sub-grid-scale physical processes, model evaluation.

Complex terrain brings many challenges



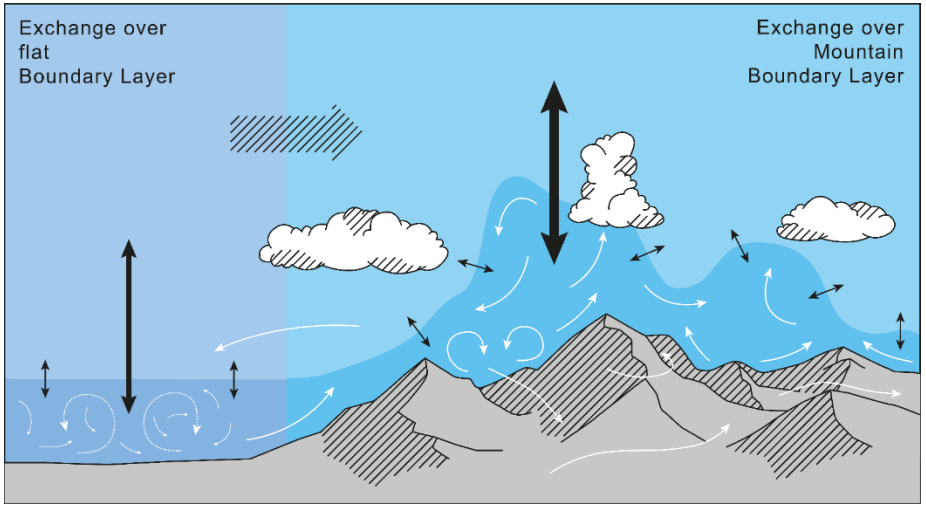
The Mountain Boundary Layer (MoBL)



The Mountain Boundary Layer (MoBL)

- Traditionally: earth-atmosphere exchange through the Atmospheric Boundary Layer
- vertical, only

- Over mountains: interaction with mesoscale flows
  - thermally driven
  - dynamically forced
- 3-dimensional: **Mountain Boundary Layer (MoBL)**
- spatially (very) heterogeneous



TEAMx WG Mountain Climate

chairs: Nikolina Ban and Sven Kotlarski

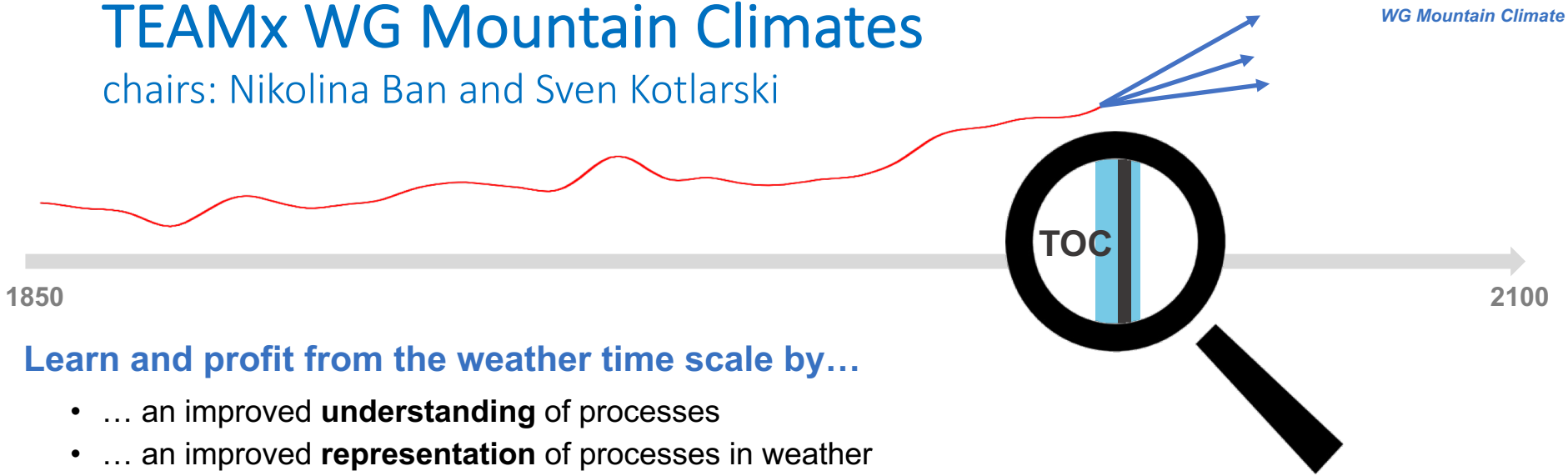
"The primary goal of this working group is to **better understand and model the processes by which mountains are shaping regional climates and their spatial and temporal variability**. Filling existing research and knowledge gaps will enable **more confident projections of future mountain climates** and will hence **improve mitigation and adaptation strategies** for mountain ecosystems and societies."

- Currently ~15 members
- White paper outlining scope and challenges and role within TEAMx in preparation (to be finished by September 2022)
- How can high-resolution modelling and improved description of surface atmosphere exchange contribute to a better understanding of past/current/future alpine climate change and to improved climate scenarios for alpine environments?

TEAMx WG Mountain Climates

chairs: Nikolina Ban and Sven Kotlarski

TEAMx
WG Mountain Climate



Learn and profit from the weather time scale by…

- … an improved **understanding** of processes
- … an improved **representation** of processes in weather and climate models (or at least an improved understanding of systematic model biases)

Focus (not very complete though, guided by EMCVs)

- **Surface atmosphere exchange**
- **Boundary layer** representation (incl. 2m temperature)
- **Dynamic processes at meso scale or below** (e.g. foehn)
- **Inversions**, cold air pools
- Moist **convection** and intense precipitation

Identify large scale drivers

TEAMx Science Plan

Objective	Primary Focus	Target
Process understanding	Micro- and meso-scale processes within and above the *mountain boundary layer* (MoBL); Interaction between scales.	Quantitative understanding of momentum, energy and mass exchange over mountainous terrain
TEAMx Joint Experiment(s)	Collaborative use of multi-platform instrumentation to sample the spatial heterogeneity of turbulence and mesoscale circulations over and near mountains	Quality-controlled observational data pool, available for process investigation, high-resolution model verification, parameterization development
Improving Weather and Climate Models	*Models right for the right reason*, i.e., identification and reduction of model biases and uncertainties over complex terrain	Weather forecasts and climate simulations over mountains as good as over flat terrain, and less reliant on model output post-processing
Support to Weather and Climate Service Providers	Air pollution, hydrology, climate change scenarios (e.g., elevation-dependent climate change).	Smaller uncertainty of impact models, due to reduced errors in weather and climate information.

Serafin et al. 2020

TEAMx Observational Campaign in 2024-2025

The TEAMx Observational Campaign will take place in our backgarden!

Coordinated field campaign from Spring 2024 to Spring 2025, including two Extended Observational Periods (EOPs) → one in summer, one in winter

Focus: **European Alps** (target sub-areas)

Specialized instrumentation to be assembled: eddy covariance stations, wind/T/RH profilers, ceilometers, weather radars, atmospheric chemistry, research aircraft, …

TEAMx and GLORI-A are ideal show cases for EXCLAIM developments and will increase the impact and visibility of the project.

They are aligned both in terms of timeline and strategic interests:

- improve understanding and modelling of Alpine meteorology & climatology, at the highest possible resolution
- promote ICON(-LAM), both for Research & Development as well as for operations

Interested in TEAMx (and GLORI-A …) show case are (source: EXCLAIM Roadmap; Sep 2021): MeteoSwiss (APN & APK), Michael Sprenger, and Sonia Seneviratne – **Anyone else?**

ICON configuration for TEAMx and GLORI-A

- highest possible resolution: **500m mesh-size**, including **data assimilation at the same resolution**
- domain: as needed;
  possible synergies if domain is large enough to serve TEAMx, GLORI-A, and MeteoSwiss needs simultaneously

Compute resources

- apply for compute resources as one of the EXCLAIM show cases

ICON projects and timeline overview