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

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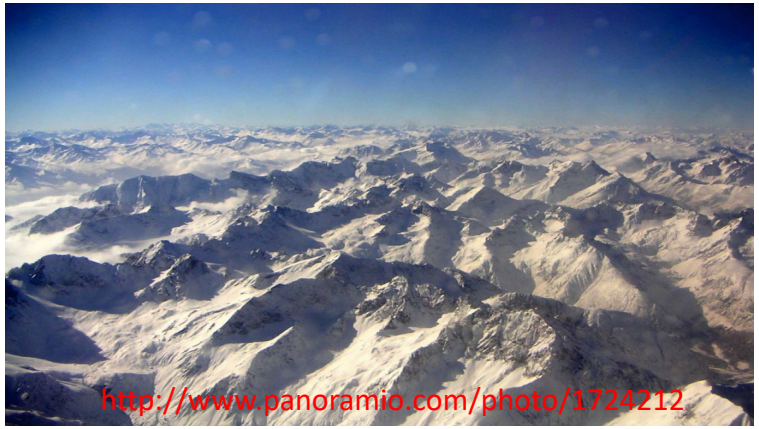
www.teamx-programme.org

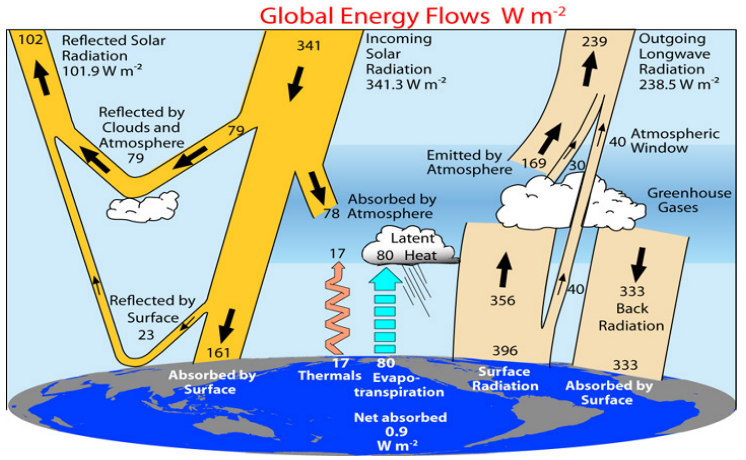
It is about … exchange processes over mountains

Momentum



- orographic blocking
- gravity wave breaking
- orographic drag parameteri-zations in general circulation models

Heat

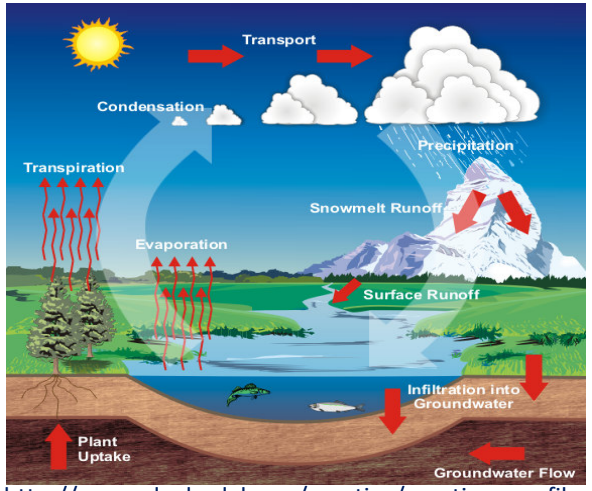


https://scied.ucar.edu/longcontent/energy-budget

- thermally driven breezes
- cold air pooling
- interaction meso- ↔ local scales
- no parameterizations

It is about … exchange processes over mountains

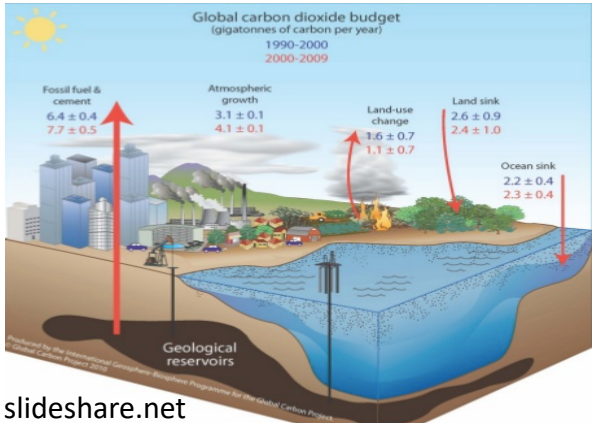
Mass: water



http://www.algebralab.org/practice/practice.aspxfile=Reading_WaterCycle.xml

- orographic precipitation
- triggering of convective precipitation
- “water towers” for the surrounding plains

Mass: CO_2 (trace gas)

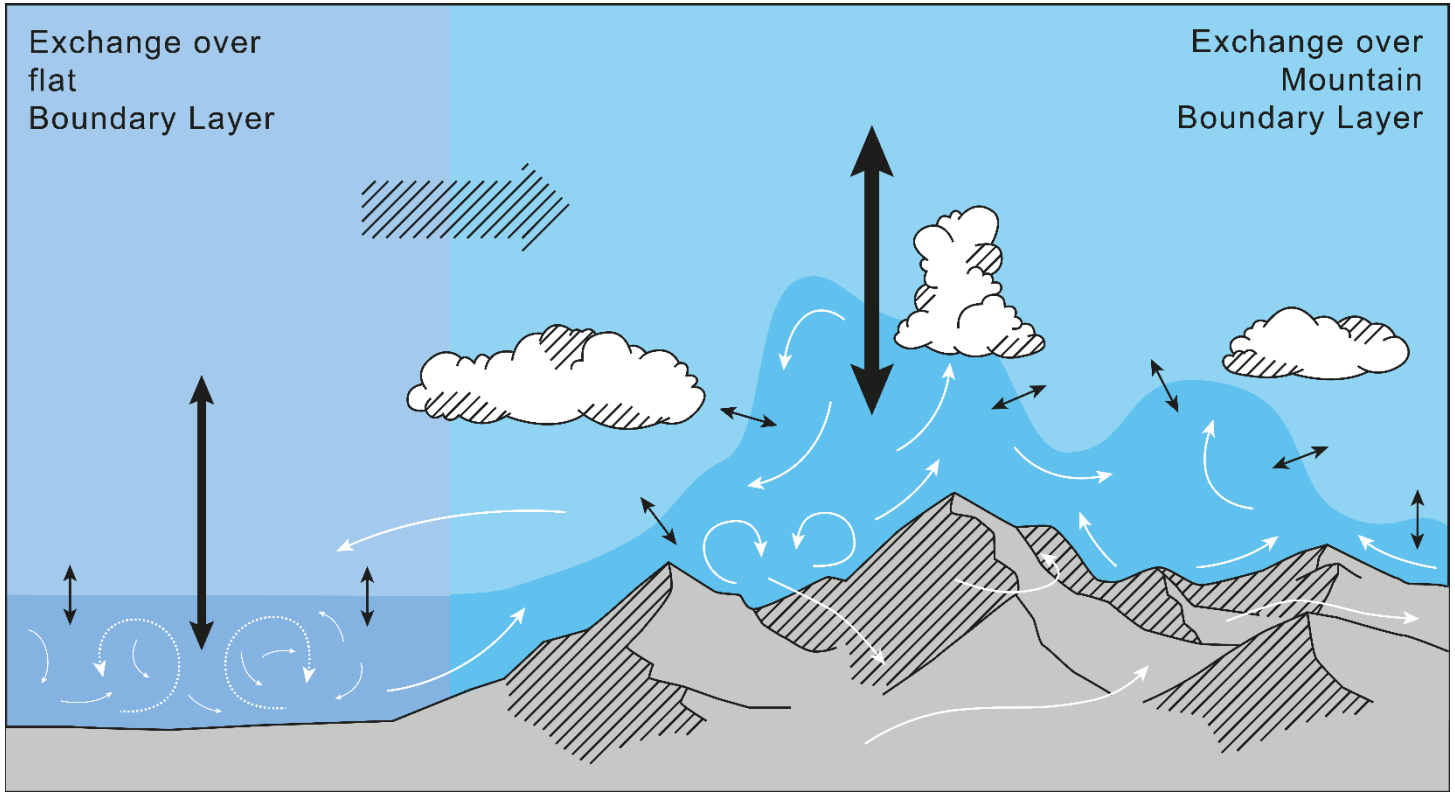


slideshare.net

- global (regional) budgets most uncertain over land
- poorly represented exchange over orography may be one reason for ‘missing sink’

The Mountain Boundary Layer (MoBL)

- Traditionally, earth-atmosphere exchange through the **Atmospheric Boundary Layer**
  → *vertical*
- Over mountains: interaction with mesoscale flows
  → thermally driven
  → dynamically forced

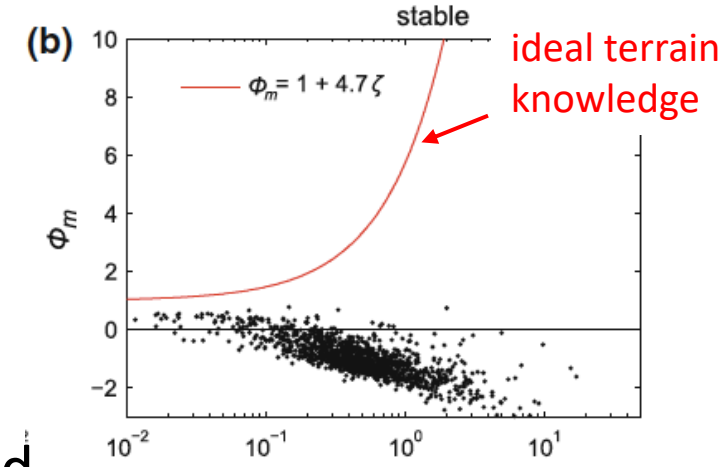


- 3-dimensional: Mountain Boundary Layer **MoBL**
- spatially inhomogeneous

Atmospheric processes over mountains

example

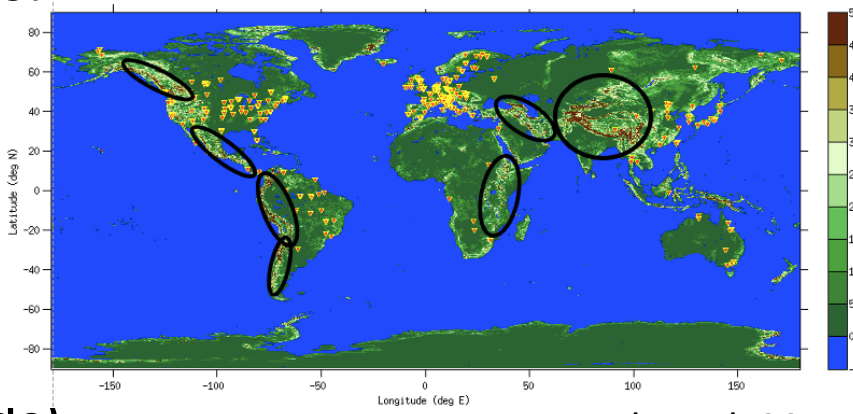
- Processes often not understood
  - turbulent exchange → based on HHF
- numerical models
  - inadequate physics
  - steep terrain → num instability
  - expensive → high resolution required



Nadeau et al 2013

- data
  - measurement principles: assumptions violated
  - spatial density

Flux towers in mountain ranges



Rotach et al. 2014

- Weather & Climate services (W&CS)
  - limited by input data quality
  - often mountain specific (e.g., flash floods)

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 – what is it?

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

- ...a bottom-up financed research program on weather, climate & air pollution in mountain areas
- in the 'tradition' of international mountain meteorology programs (ALPEX, PYREX, MAP → **TEAMx**)
- Institutional 'crowd funding' for a Programme Coordination Office (*PCO* - @ UIBK)

TEAMx – what do we do?

Activities

- coordination and collaboration
  - → special issue 'Atmosphere' on Atmospheric Processes over Complex Terrain
  - → White Paper
  - → Working Groups, joint proposals
  - → meetings
- TEAMx Observational Campaign (TOC)
  - → 2023-2024 (EOPs and IOPs)
- Numerical experimentation
  - → reference cases
  - → parameterizations
  - → weather ↔ climate

Serafin et al 2020, ISBN 978-3-99106-003-1

Relation to WWRP strategic plan

General

- International collaboration
  → >170 scientists, 15 countries
  → different fields (interdisciplinary)
- collaboration between operational and research institutions
  → CIG funding: 3 MHSs, 2 natl. res institutions, 3 universities
- more accurate forecasts / seamless prediction
  → addressing processes/modeling/data issues
  → mountain weather and climate communities
  → '*cross cutting project*' of GEWEX Hydroclimate Panel
- relevant for society

First TEAMx Workshop
Rovereto (Italy), 28-30 August 2019

Relation to WWRP strategic plan

High Impact Weather

- many types of high-impact weather *typically* in the mountains
  → flash floods, avalanches, landslides, air pollution trapped, downslope wind storms, ..
- modeling these (services!, forecast) requires
  → correct input data ↔ process understanding, good atmospheric models
- Climate perspective
  → services

Saint-Martin Vesubie (F), Oct 5 2020, suedkurier.de

Relation to WWRP strategic plan

Water

- HIW …
- water towers
  → drinking water (living water….)
  → energy
- not only ‘too much water’ (HIW): droughts
  → ‘downstream population’
- again: climate perspective
  → services

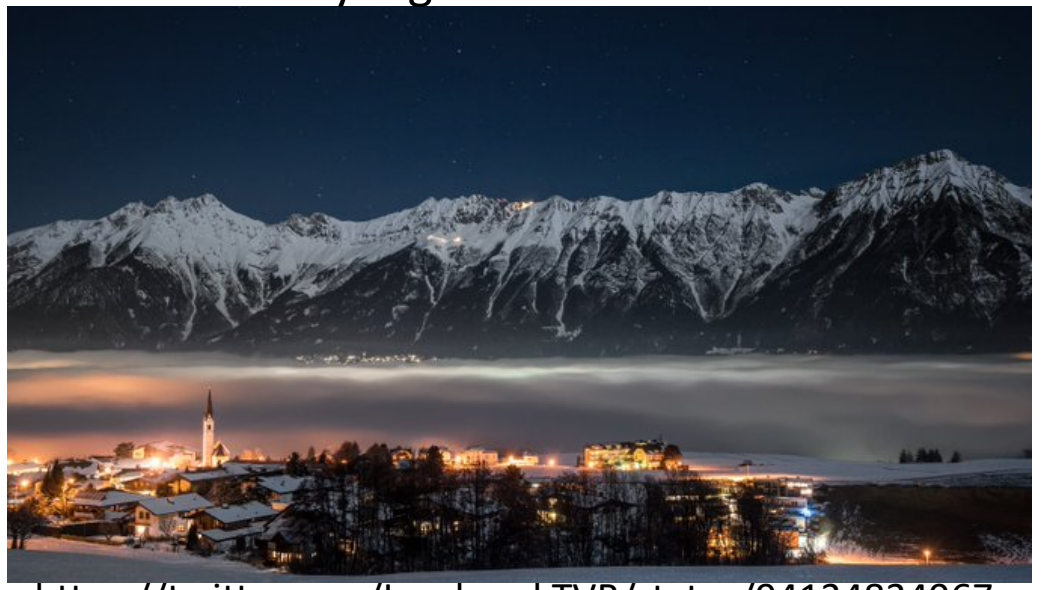
https://www.grimselstrom.ch,

Relation to WWRP strategic plan

Urbanization

- urban population in mountainous areas
  → double penalty
- two target areas of the TOC
  → Innsbruck / Bolzano&Trento
  → urban (air quality) supersite
- scale interactions
  → urban vs complex terrain

Innsbruck by night – and under the cloud

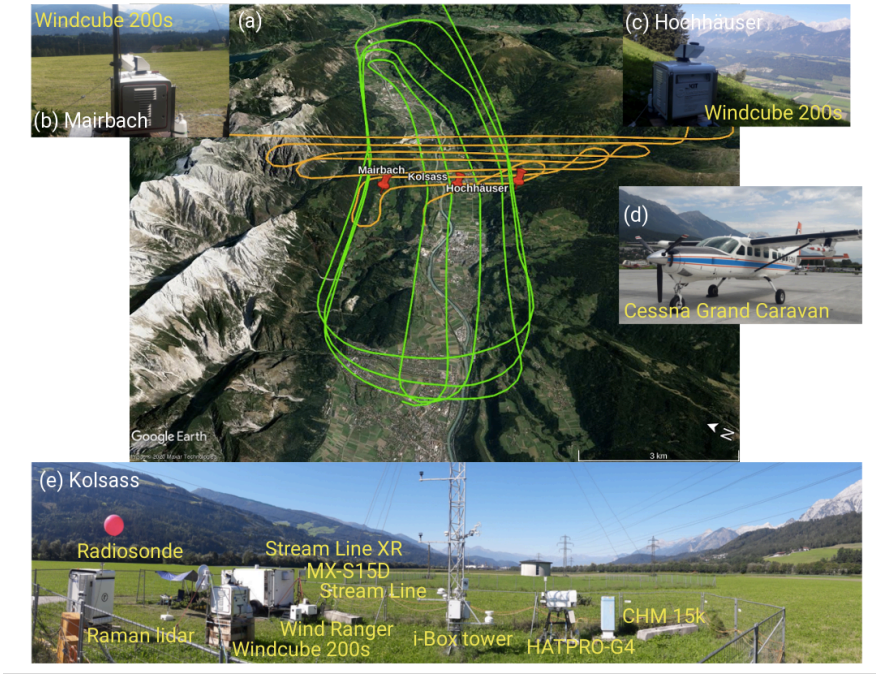


https://twitter.com/InnsbruckTVB/status/941348349676081153/photo/1

Relation to WWRP strategic plan

Evolving technology

- high-resolution modeling: a must
  → additional challenges
- many (new) observation technologies
  → based on HHF assumption
  → not plug and play
- Chance for ‘new combinations’
  → combine different types of instruments



Adler et al 2020, BAMS

Summary

- Bottom-up financed research project on exchange processes over mountainous terrain
- TEAMx Observational Campaign: 2023-2024
- numerical experimentation → model improvement
- addresses the key challenges of WWRP Strategic plan
  → for mountainous terrain

Thanks for endorsement by WWRP SSC as a WWRP RDP!