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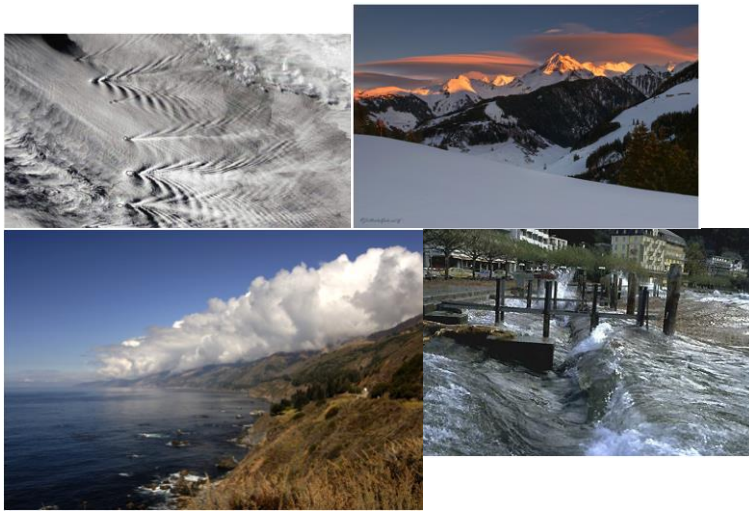
# A coordinated effort to investigate Transport and Exchange Processes in the Atmosphere over Mountains-Experiment (TEAMx)

**Ivana Stiperski,** Mathias W. Rotach, Marco Arpagaus, Joan Cuxart, Stephan De Wekker, Vanda Grubišić, Norbert Kalthoff, Dan Kirshbaum, Manuela Lehner, Stephen Mobbs, Alexandre Paci, Stefano Serafin, Dino Zardi

# Mountain Weather and Climate

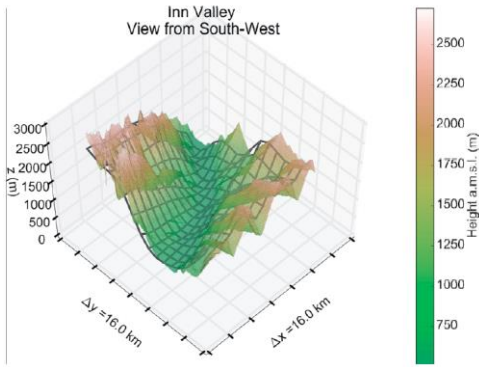
- traditionally: impact of mountains on *weather*
  → orographic precipitation
  → gravity waves, ~ breaking
  → blocking, Föhn, Bora & co
  → dynamic features



- Alpex, Pyrex, MAP, MATERHORN, ….

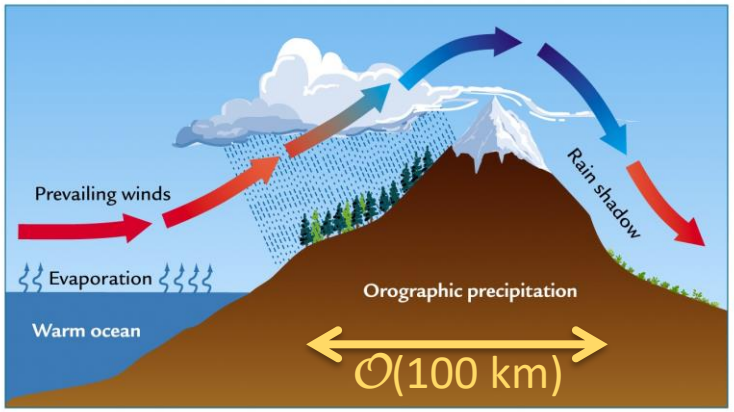
Recent developments (since MAP):

- *climate* change additionally in the focus
  → requires models able to (also) realistically reproduce mountain climate (impact modeling)
- model resolution ↑ - but not (?) corresponding physics
- new observational possibilities
  → commercial Doppler wind lidars, satellites

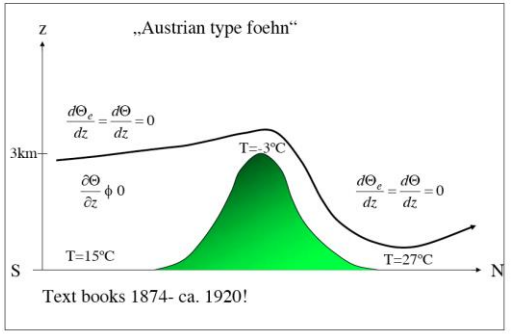


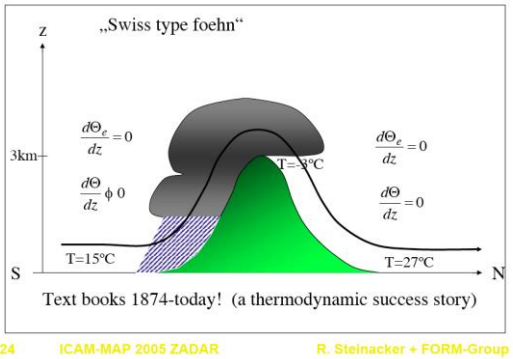
# Mountain Weather → Climate

- **weather (traditional):** mountain → atmosphere perspective
  → how does 'the mountain' modify the precipitation regime
  → how does 'the mountain' trigger downslope wind storms
  → surface characteristics of $\mathcal{O}$(100 km)




http://kbkb-wx.blogspot.co.at/2014/04/orographic-precipitation.html




Steinacker et al. (2005)

# Mountain Weather → Climate

- **climate** (and climate change)
  → treats the same atmosphere...
  → requires impact modeling
  → need: (e.g.*) the right temperature* at moutain surface (not only the mtn. sfc. temperature that yields the 'right precipitation')
- Mountain (surface) ⟷ atmosphere perspective
- how does 'the mountain' influence the atmosphere?
- what near-surface atmosphere is produced close to the mountain?
  → impact modeling

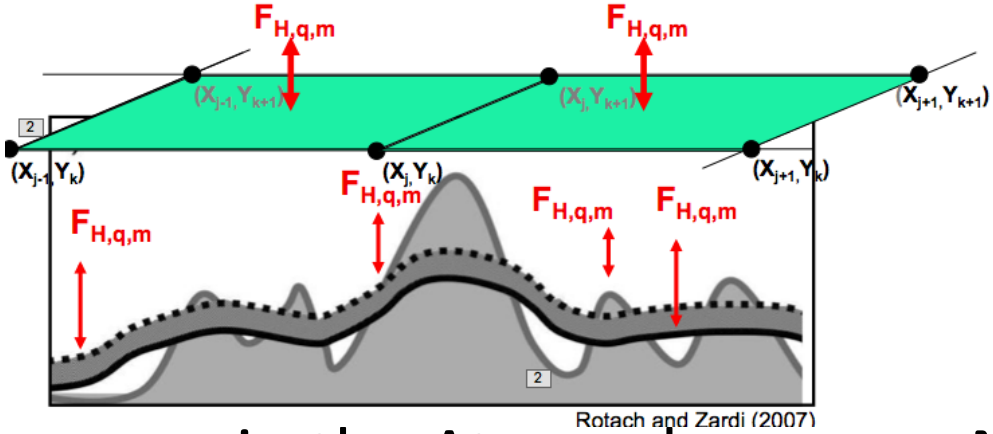


# Mountain Weather → Climate

- climate/atmosphere system:
  → 'mountain' is part of the surface
  → character of the surface

http://www.panoramio.com/photo/1724212

- character of the surface
  → determines the *exchange* between the atmosphere and the earth
  → *coupling* of the atmosphere with the surface

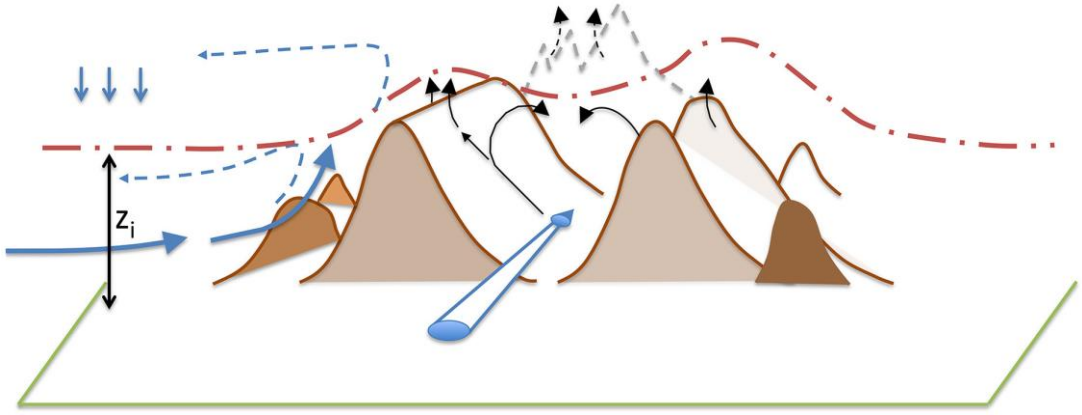



Rotach and Zardi (2007)

Exchange processes in the Atmosphere over Mountains

# Mountain ↔ Atmosphere perspective

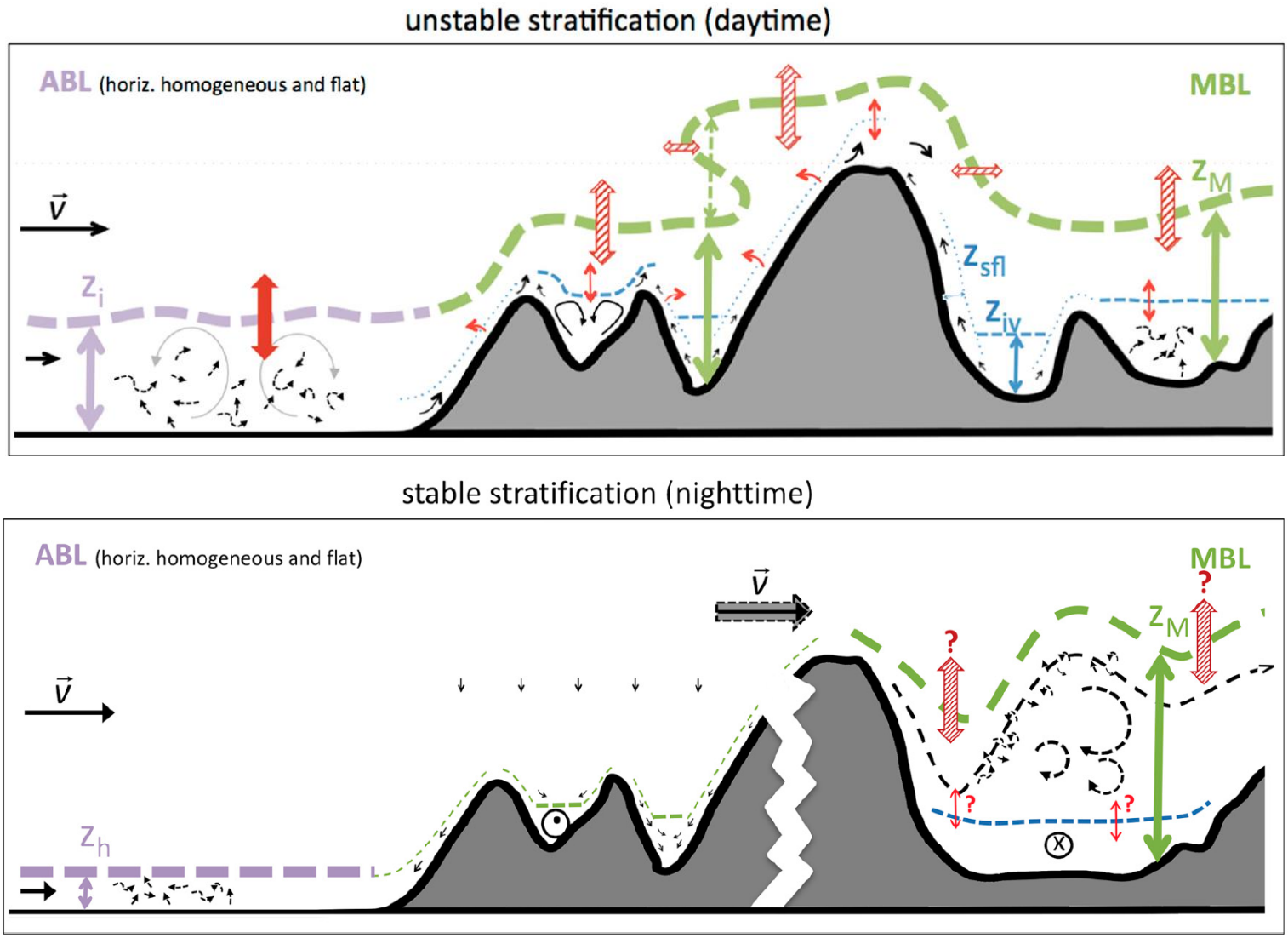
- Exchange
  → heat, mass and momentum *at the surface*
- traditionally: this is the role of the boundary layer
  → transport to the ground / away from the ground
- over mountainous surface
  → interaction with meso-scale mountain flows




Rotach et al. 2015

→ 'Mountain Boundary Layer'

# Mountain Boundary Layer (Lehner & Rotach 2018)



# A new international initiative

**TEAMx**

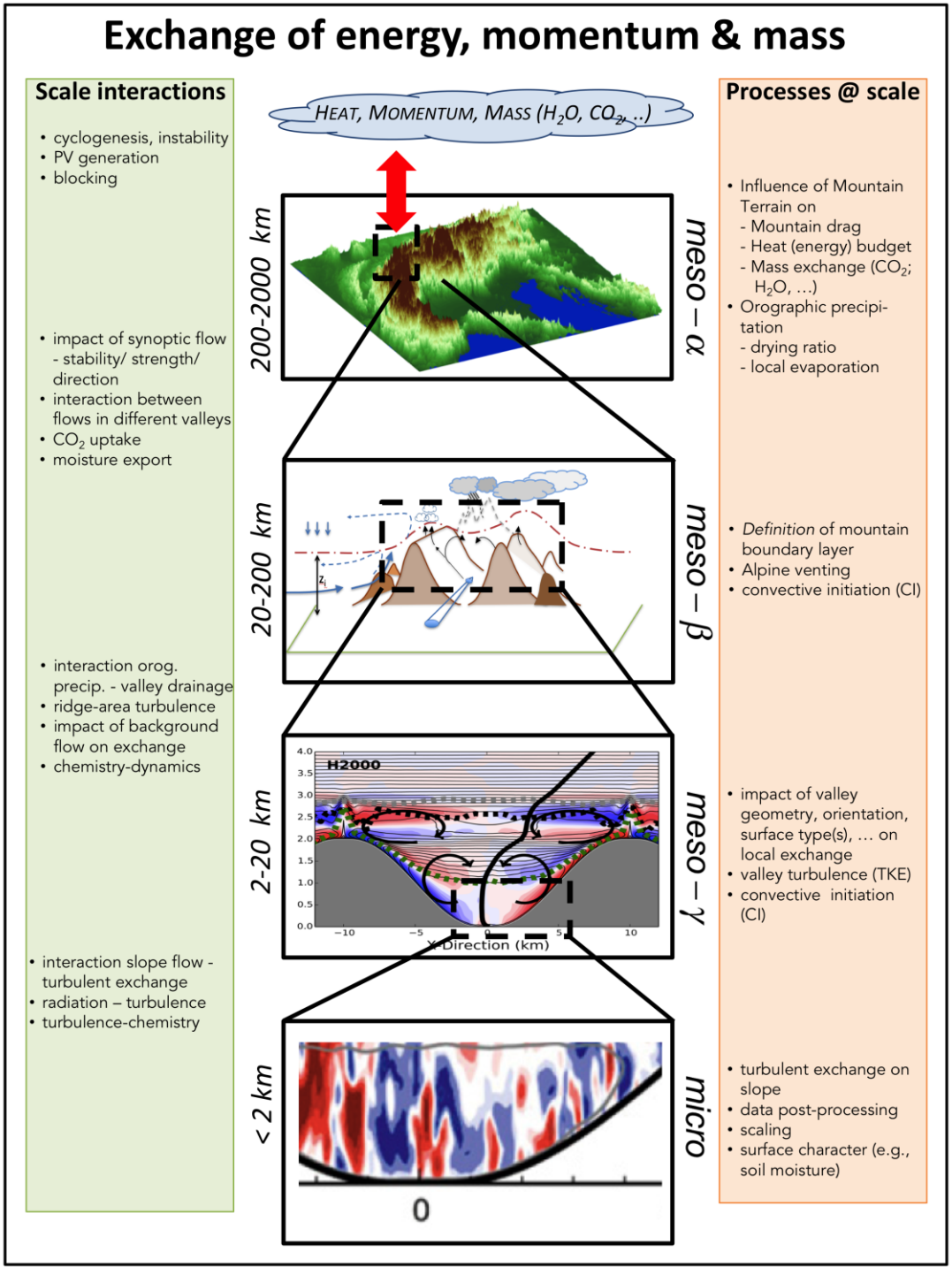
**Transport and Exchange processes in the Atmosphere over Mountainous terrain - programme and eXperiment**


- discussion started: after ICAM-2015
- meetings aside conferences
- **C**oordination and **I**mplementation **G**roup established (9/2017)
- White Paper in preparation, special issue 'Atmosphere'
- *Program Office:* @UIBK ('crowd funded')

  → coordination;

  → int. embedding – WWRP, WCRP;

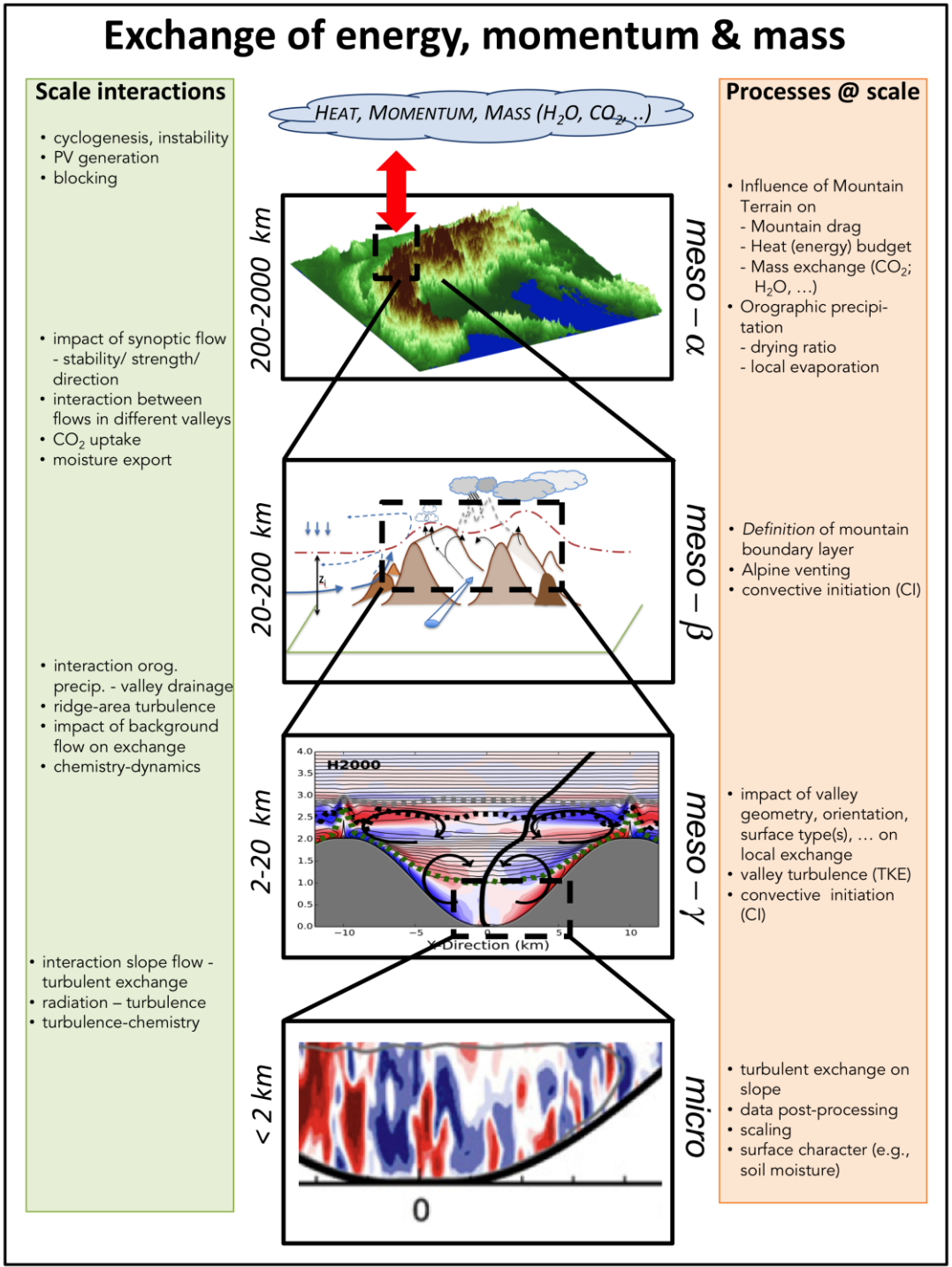
  → joint projects (H2020, …);




**topics:**

- BLs in complex terrain
- thermally driven flows
- dynamic transport (waves, breaking, …)
- convection & orography
- impact on orogr. precip.
- stable BLs
- pollutant transport and dispersion

→ ***and their interactions***




**methods:**

- numerical modeling
  - → NWP (km scale, LES)
  - → regional climate
  - → processes and parameterizations
- observations
  - → turbulent exchange
  - → Lidar, scintillometer
  - → obs strategies

**goal:**

**→ coordinated *experiment***

# TEAMx

## Research questions

→ how does mountainous terrain impact *exchange* to the free atmosphere of energy, mass and momentum? (which processes, interaction, abundance, ...)

→ do we understand the relevant processes quantitatively?

→ are current models (regional climate, NWP) able to adequately reproduce these processes?

→ do we need a sgs-parameterization (*as for gravity wave drag*) for $\mathcal{O}$(10 km) grid spacing models?

→ how does mountainous terrain affect air quality?

# TEAMx

**partners** (so far…)**:**

- University of Innsbruck
- University of Leeds (NCAS)
- Karlsruhe Institute of Technology (KIT)
- Mc Gill University
- University of Trento
- University of Virginia
- MeteoSwiss
- Meteo France (CNRS)
- NCAR
- ZAMG

Additional partners with innovative ideas and commitment (very) welcome!

# White paper – Atmosphere Special Issue

## "Atmospheric Processes over Complex Terrain"

- Lehner and Rotach (2018): **Current Challenges in Understanding and Predicting Transport and Exchange in the Atmosphere over Mountainous Terrain**
- Serafin et al. (2018): **Exchange Processes in the Atmospheric Boundary Layer Over Mountainous Terrain**
- Vosper et al. (2018): **Current Challenges in Orographic Flow Dynamics: Turbulent Exchange Due to Low-Level Gravity-Wave Processes**
- Kirschbaum et al. (2018): **Moist orographic convection: Physical mechanisms and links to surface-exchange processes**
- Emais et al. (2018): **High-resolution observation of transport and exchange processes in mountainous terrain**
- De Wekker et al. (2018): **Meteorological Applications Benefiting from an Improved Understanding of Atmospheric Exchange Processes over Mountains**
- Hacker et al. (2018)**: Challenges and Opportunities for Data Assimilation in Mountainous Environments**
- Chow et al. (2018): **Crossing multiple gray zones in the transition from mesoscale to microscale simulation over complex terrain**

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# Thank you for your attention!

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# TEAMx

- Memorandum of Understanding
  → states importance of topic
  → signatories concur with general 'need for action'
  → founding members (Partner list A) sign it
  → as many supporting institutions as possible (Partner list B) sign as well (ICAM 'countries' / institutions, AMS MM Committee, GEWEX, individual institutions, departments, ..)

- Support of TEAMx-seed (program office @UIBK)
  → bilateral contracts
  → tasks / deliverables specified
  → two years ('seed')