Wrap-up Session H

Break-out groups

Group 1 Convective MoBL	Group 2 Stable MoBL	Group 3 Moist Convection	Group 4 Meso. Interactions	Group 5 Mountain Climate
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Frederica Gucci	Giovanni Bonafè	Silvio Davolio	Kristian Horvath	Nikolina Ban
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Jason Knievel	Charles Chemel	Vincenzo Mazzarel	François Lott	Barbara Früh
Branko Kosovic	Enrico Ferrero	Marcello Miglietta	~~Haraldur Olafsson~~	Isabelle Gouttevin
Manuela Lehner	Heather Holmes	Yann Seity	Andrew Ross	Sven Kotlarski
Stefano Serafin	Rebecca Mott-G.	Lukas Strauss	Juerg Schmidli	Justin Minder
Bowen Zhou	Chantal Staquet	Christoph Wittman	Miguel Teixeira	Elisa Palazzi
			Simon Vosper	Pier Luigi Vidale

Chairs and Rapporteurs

Wrap-up part on White Paper (Friday, plenary)

Group 1: Convective MoBL

- Numerical experiments of low to high complexities: evaluated based on traditional, process-based, and application/end-user based metrics
- Objective assessment of high-res deterministic vs. low-res ensemble forecasts for complex terrain
- **Wish**: Design a field campaign that is uniquely different from previous campaigns: e.g., uniquely long, covering a uniquely diverse region (i.e. urban, glaciers, marine conditions, …)
- Comment: compile list of previous campaigns, open questions

Group 2: Stable MoBL

- **WP:** Air pollution, atmospheric chemistry, or atmospheric composition was missing from the white paper. Section 2.1.7 in the WP needs to be rewritten to be in line with the current state of that art in chemistry of mountain-valley basins (air composition), it should become a section on the science versus the tools that can be used to look at the air composition.
- **Numerical experiments**: Design numerical experiments with increasing complexity to address the impacts of orographic variations, snow cover, and vegetation on transport, heat and mass budgets, and turbulence for stable conditions in complex terrain.
- **Wish**: Measurements of the vertical profiles of turbulence fluxes and vertical distribution of the atmospheric composition (e.g., thermodynamic properties for fog/low stratus cloud formation and air chemistry).
- **Comment**: need to know dimension of valley/target area to plan numerical experiments

Group 3: Moist Convection

- **model improvements loop**: process study --> NWP model improvement of this process --> long term model evaluation --> benefit for end users (need to iterate loop several times)
  What is focus TEAMx: process improvement vs long-term improvement for end users?
- **To start, we propose :**
  - build a list of problematic forecast cases over different regions focusing on the primary convection triggering
  - have a look at the already available operational CRM model results (at least ~5 are covering the Alps + associated EPS)
  - try to identify key ingredients in those models
  - step by step, simplify the problem (same initial conditions...)
  - rerun semi-idealized simulations
  - consider GCM with parameterized convection as well
- **Our wishes concerning observations**
  - Raman Lidars, Doppler wind LIDAR, Disdrometers, MW radar, Cloud radar, GPS, Thetered balloons, Mesonets, Multple Doppler radars.
  - Proposal for DOE/ARM (mobile facility).
  - Airborne instruments.
- Connection to other groups identified (group 5, group 1, group 4)

Group 4: Mesoscale Interactions

- idealized experiments using multiple ridges (from simple to complex synoptic forcing)
- realistic experiments (preTEAMx simulation 2021)

    - Alpine valley system
        - moisture valley budget
        - clouds as tracer
        - summer DC
        - big lake for simple sfc fluxes
        - ensemble to investigate predictability
        - setup: 100x100km, dx=250m
        - obs: cloud radar, ceilometer, doppler lidar
    - complete alpine experiment
        - Foehn climatology
        - Alpine precip bias (wet bias in central Alps)
        - tropo-strato exchange
        - range of models: COSMO-MeteoSwiss 1km, LAM N-S slice 500m, CORDEX climate over EU 2-3km
- see PPTX slide

Group 5: Mountain Climate

- Improve climate models to provide more realistic and reliable simulation of present and future climate
    - analysis of existing simulations (CORDEX FPS conv, ...)
    - improve process fidelity in different models: GCMs, NWP, RCMs, CRMs
        - test sequence of configurations on climate scales
        - pre-TEAMx prototype (short term 1-5 years)
        - post-TEAMx: proper climate experiments
- better understand climate processes over complex terrains and how they can change in a warmer climate
    - idealized to real experiments
    - high fidelity and robust input to impact models!!!
- wish: long-term spatial and temporal high-resolution observations
- see PPTX slide for more details

Wrap-up part I on White Paper (Thursday, in session H)

Group 1: Convective MoBL

- need very high resolution, need good surface coupling
- surface layer
    - need for modification/extension of SL theory (beyond MOST; lacking observations)
    - definition of SL height in complex terrain?
    - machine learning to develop SL parametrization schemes? --> needs a lot of data
- model setup
    - soil/hydrology, soil input very important (e.g. use hydrology model to create input), lateral water flows
    - uncertainty (grid resolution, random perturbations, ...) --> estimate uncertainty
- multi-scale-interactions: two-way nesting may be important
- not/little included in WP: wild fires, (high-res) data assimilation, use of satellite data

Group 2: Stable MoBL

- air quality not well covered; need to re-write 2.7.1 to represent current state of science
- similarly, need to cover air quality modelling tools
- better separate / discuss stable vs convective / SBLs over snow
- coverage of air quality in 3.3 inadequate
- link to climate: climate and temperature inversions

Group 3: Moist Convection

- WP 2.3: introduce LES; convection parameterization development foreseen?
- WP 2.3.1: IBM
- WP 2.3.2: IC: need more data to better constrain model: slopes, ridges
- WP 2.3.3: microphysics is missing (aerosols, fog, CCN), link to air quality, (to CI)
- WP 2.3.4: predictability may be higher/lower over mountains; need to work to optimize perturbations in EPS (e.g. regime-dep. physical perturbations)
- WP 3.3: strength aspects concerning renewable energy (reduce cost/storage)
- model evaluation: to show benefit we need long-term model evaluation

    - be more precise in WP about the limits of TEAMx
- need to refine classical NWP scores (e.g. based on area, dominant flux, type of convection)
- development chain: process study > NWP model development > longterm evaluation > benefit for end users - can TEAMx cover more than the first two points?

Group 4: Mesoscale Interactions

- **model paramterisation development specific to mountains:**
    - unified parameterisation of gravity wave drag, blocking and form drag (investigate partitioning in different model)
    - add source of GWD to TKE equation (works in ICON but not in UM, IFS, LMD)
    - 3D parameterisation of radiation (shadows and hill-side heating contrast)
    - snow cover as function of orography
    - water flowing down into the valley
    - surface conditions as function of height
    - tile approach could be extended to variable height tiles
- **other model development aspects**
    - numerical issues of sloping surfaces should be surveyed
    - machine learning approaches for dynamics, physics or data assimilation could be explored (COSMO 1km simulations since 2016 from Meteo Swiss over complete Alps could be used as training data set)
    - soil moisture needs to be evaluated with observations
- **other suggestions**
    - add soil hydrology as modeling and observations emphasis
    - add data assimilation: soil moisture unknown over mountains
    - predictability issues should receive more focus --> ensembles
- **observations**
    - aim to observe integrated variables that can be compared to models
        - MoBL height, cloud base, valley estimated surface fluxes, snow melting level etc

Group 5: Mountain Climate

- climate not thoroughly covered
- WP focuses on regional scale (and not global)
- motivation: matching emerging obs capabilities and computing capabilities

Wrap-up part II on Joint Numerical Experiments

Group 1: Convective MoBL

- compile list of previous experiments (to learn)
- start with experiment without obs, then replace with TEAMx-case
- field campaign: rather one site with longer obs
- use physical modeling for verifying idealized experiments
- idealised experiments
    - cold pool and mixout
    - diurnal cycle of temperature (flat vs complex terrain)
    - entrainment at BL-top
    - predictability studies in complex terrain, dependence on synoptic situation
    - trade-off resolution vs ensemble

Group 2: Stable MoBL

- effects of land cover/heterogeneity (...) on stable layers in CT
- heat and mass budgets: what controls evol of SBL?
- suggested domain size as in WP
- ancillary data: high-resolution difficult, need information on snow cover
- may need analysis / re-analysis
- what is focus of TEAMx: tracers vs chemistry?
- experiments to address uncertainty: sensitivity to valley geometry, trees, sloping valley floor, land cover, snow, large-scale forcing, CCN (fog), grid size
- key: snow cover, forest, orography variations (towards field site orog), ...

Group 3: Moist Convection

- main focus on semi-idealised experiments, two cases:
    - cases of stationary cells (large amounts of rain in small areas)

    - cells moving to the plains with more organized structure
- numerical support during the IOPs (not specified in WP)?
- workflow suggested
    - build list of **problematic** forecast cases over different regions (primary convection);
    - try to indentify key ingredients and simplify the problem
    - rerun semi-idealized simulations
- do we need to know the target area first?
- quite a few high-resolution models running over the Alps
- discussion
    - model guidance: extra models (additional to opr) needed? - no concensus

Group 4: Mesoscale Interactions

- moisture exchange experiment: valley circulations & moisture
    - use water vapour and clouds as tracers to check model dynamics (mass / moisture exchange experiment, not valley wind experiment)
    - verify: location, timing, ...
    - obs: cloud radar; cameras?
    - option: use water body as lower BC (easier to model fluxes; what about obs over water?)?
- hierarchy of experiments: from idealized to realistic
    - semi-idealised experiment for a valley
    - real-case experiment for the Alps ("föhn")

Group 5: Mountain Climate

- important processes
    - fluxes in 3d
    - convection
    - feedbacks
- focus
    - mnt and weather and climate extremes
    - elevation-dep climate change
    - long exp: pseudo CC
- reasons / goals
    - difference between mountain regions
    - improved process fidelity
    - simplified / conceptual models for downscaling
- experiments
    - analysis of existing simulations (CORDEX FPS, HighResMIP, DYMOND)
    - idealised experiment: analytical mountain with PGW / surrogate warming
    - task 2: sequence of configurations
        - pre-TEAMx prototype
        - "operational models"?
        - longer / climate runs after TEAMx (?)
    - coordinated experiments for FPS on mountain climate
        - encourage efforts on other domains
        - validate weather & climate model with TEAMx obs
        - domain: (large) Alpine domain; EU
        - obs requirements: relate short-term obs to long-term obs
- other issues
    - HPC: massive amounts of output data; do online-analysis; internalise process-based diagnostics
    - prioritiy to processes and attributable quantities that are observable
- idealised: time scale? - like other experiments, but cold start (run long enough such the Ics are no longer important)

General discussion

- Do a summer and winter experiment would surely be useful
- WG 4 is really a mass exchange experiment, different to WG 1
- Explore overlap between experiments is surely a good idea!
- large-scale experiments (WGs 4 & 5) could be combined.
- Probably primarily organise WGs around processes / scientific topics
- Target Areas:
    - Innsbruck: yes, no strong objections

    - Lake Garda?
    - large/diverse enough that most people would be happy
    - Experiments should be realistic (but not overly) ambitious. - Nature is always more complex than we expect and hence more difficult to model.
- Role of applications: How do we keep track of improvements for applications and users?
    - Applications should be a guidance to validation / verification scores used / employed.
- Discussion on working groups and funding