OBSERVATIONS OF BOUNDARY LAYER STRUCTURE FROM AIRCRAFT AND THE INTERNATIONAL TEAMx PROGRAM

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SESSION 6 : INSIGHTS FROM OTHER REGIONS
Multi-scale flow interactions and boundary layer structure

Whiteman, 2000

**BOUNDARY LAYER STRUCTURE FROM AIRCRAFT**

**In-situ measurements**

'-simple' cross-valley and along valley flight legs

Lack of observations over ridges and slopes

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**TRACT – Rhine Valley - Black Forest, Germany, Kossmann et al. 1998**

**MAP – Riviera Valley, Switzerland, De Wekker et al. 2004**

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Do–128 flight 2–2 09/16/92 12:30–13:59 CEST \( \odot \) (K)

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Do–128 flight 2–2 09/16/92 12:30–13:59 CEST \( \hat{v}_e \) (m s\(^{-1}\))
BOUNDARY LAYER STRUCTURE FROM AIRCRAFT

In-situ measurements of turbulence kinetic energy

Fig. 2.24. Cross section of modeled TKE (m$^2$ s$^{-2}$) at 1300 UTC. The location of the west-east cross section is depicted in Fig. 2.1. The asterisks denote the height of the along-valley flight legs. The 0.03 m$^2$ s$^{-2}$ isoline and the CBL height calculated from the $Ri$-method are shown by the solid and dashed line, respectively.

De Wekker et al. 2002
BOUNDARY LAYER STRUCTURE FROM AIRCRAFT

Remote sensing measurements
donlooking aerosol lidar

De Wekker 2002, 2015

Henne et al., 2004

Multi-layer-structure
Spatial heterogeneities
PBL height vs. aerosol layer height
BOUNDARY LAYER STRUCTURE FROM AIRCRAFT

Remote sensing measurements *downlooking Doppler lidar*

Accumulation of aerosols eastern part of valley

Salinas Valley, CA, De Wekker et al., 2012

Accelerating valley flow -> sinking motions

Navy Twin Otter
The UWOW can collect measurements at stationary fixed location AND as it travels along the roads and highways.

BOUNDARY LAYER STRUCTURE FROM GROUND VEHICLE (UVA – Wind Observatory on Wheels- UWOW)

Wind profiles from about 100 m to ~3000 m or more (depending on atmospheric conditions and lidar settings) at ~1 km horizontal spacing and 30 m vertical spacing.

Great opportunities to merge with mobile chemistry labs!
When focus is on investigating boundary layer structure, experimental design for airborne observations often relatively simple and straightforward.

What happens if the project becomes multi-disciplinary?


\[ F_{CO2} = \int_{Z_5}^{Z_t} \frac{dC_{CO2}}{dz} \, dz \]
Conflicting thoughts about optimal experimental design. Large challenges in attempting to ‘measure it all’

Quite chaotic flight patterns every mission is unique
incomplete observations of boundary layer structure make it difficult to quantify uncertainties in applying boundary layer budget method for estimating CO$_2$ fluxes
TEAMx is an international research program with the general aim to measure exchange processes in the atmosphere over mountains and to evaluate how well these are parameterized in NWP and climate models.

Steering committee:
Mathias W. Rotach¹, Marco Arpagaus², Joan Cuxart³, Stephan De Wekker⁴, Vanda Grubišić⁵, Norbert Kalthoff⁶, Dan Kirshbaum⁷, Manuela Lehner¹, Stephen Mobbs⁸, Alexandre Paci⁹, Elisa Palazzi¹⁰, Stefano Serafin¹, Dino Zardi¹¹

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

TEAMx Memorandum of Understanding between the institutions of the CIG members. Signed by 9 institutions (U. Innsbruck, Meteo Swiss, Meteo France, U. Virginia, McGill U, U. Trento, C2SM, NCAS, KIT. Open to new partners

Publication of 9 review articles in special issue “Atmospheric Processes over Complex Terrain” (editors M. Rotach and D. Zardi) in journal “Atmosphere”

https://www.mdpi.com/journal/atmosphere/special_issues/Complex_Terrain

White paper. Draft available. To be finalized soon

www.teamx-programme.org
Workshop topics (addressed in White Paper)

Mountain Boundary Layer Flows
Land atmosphere exchange
Orographic convection
Orographic flow dynamics
Air chemistry and atmospheric dispersion modelling
Climate processes / climate change in mountains

Strategy for field experiment
Strategy for numerical modelling
Some examples of research questions

• What processes contribute to daytime/nighttime exchange in the mountain boundary layer? How can the “overall exchange” be quantified?

• What vertical and horizontal length scales are most relevant for mountain BL exchange? How do we define the mountain BL height?

• Do current models account for exchange processes in the mountain BL?

• Is subgrid-scale parameterization of mountain-induced exchange of heat and mass necessary for O(10 km) grid-spacing models? (e.g., similar to orographic drag)
Field experiment

• Planned for 2023
• In the European Alps
• various ‘super sites’ addressing multi-scale processes
• One of the supersites near Innsbruck, Austria – “i-Box” (network of surface flux stations)
• Request of UK and German research aircraft planned
• US efforts are planned (e.g. request of aircraft, ground-based observing facilities, SPO, EDO) - air chemistry component currently not well developed
• Scoping meeting on Wednesday 9 October at NCAR (after UCAR meeting), 5 – 7 PM MT (remote participation possible)

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