On the state of the i-Box

Ivana Stiperski, Mathias W. Rotach, Brigitta Goger, Eleni Sfyri

Institute of Atmospheric and Cryospheric Sciences, University of Innsbruck (Austria); ivana.stiperski@uibk.ac.at

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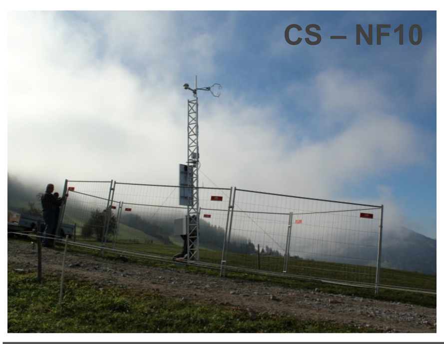


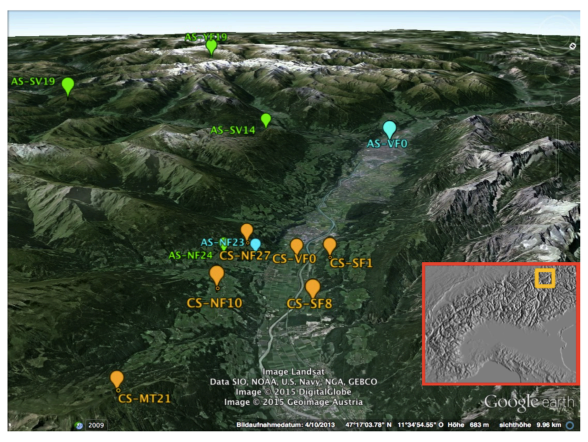
INTRODUCTION

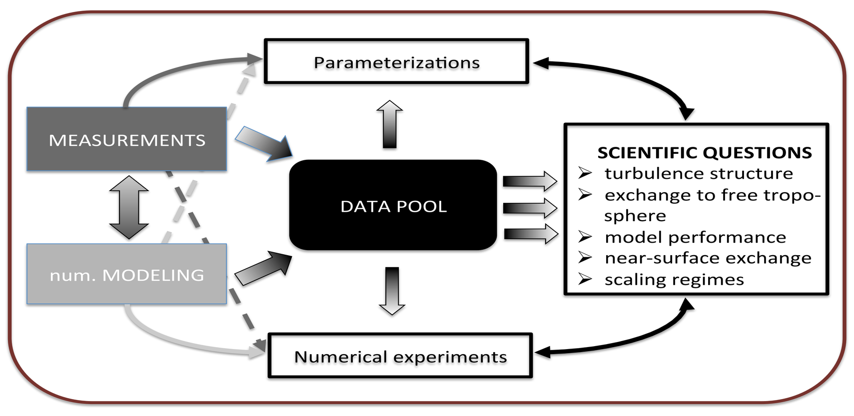
- Turbulence structure and exchange processes in the atmospheric boundary layer over truly complex mountainous terrain (TCMT) substantially contribute to the 'earth-atmosphere interaction' over such terrain, i.e. the exchange of energy, mass and momentum from and to the free atmosphere.
- Boundary layers in TMCT are at the very forefront of boundary layer research. Their understanding is limited due to their complexity (inhomogeneity, slope, many scale of motion…) and limited observational datasets/systematic modelling efforts which leads to the lack of theory of turbulent exchange in such a setting

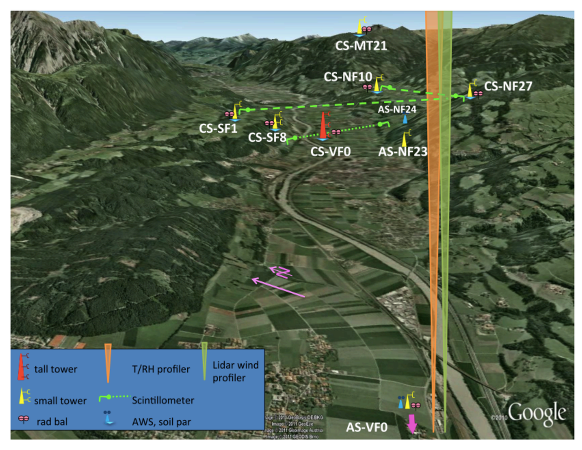
THE i-BOX CONCEPT

i-Box is a platform for studying boundary layer processes in TCMT. i-Box concept rests on integrating:

> **multi-year measurements at representative sites** - consisting of turbulence towers and surface based remote sensing
> **very high resolution numerical modelling** - reproducing full flow characteristics and forcing fields for certain flow situations
> **short term intensive campaigns** - SOPs for a more in depth investigation of specific phenomena with additional observational efforts







DATA SETS

Station Name	Identification	Slope Angle	Altitude	Characteristics	Data Availability 1999 - 2012	2012	2013	2014	2015
Kolsass	CS – VF0	0	545	mixed agricultural					
Terfens	CS – SF8	8	575	agricultural, car parking					
Eggen	CS – SF1	1	829	alpine meadow					
Weerberg	CS – NF10	10	930	alpine meadow					
Hochhäuser	CS – NF27	27	1009	alpine meadow					
Arbeser	CS – MT21	21	2015	high-alpine vegetation					
University	AS - VF0 - HATPRO	0	578	urban (university building)					
	AS - VF0 - HALO								
AfU #1	AS – NF24	24	867	alpine meadow					
AfU #2	AS – NF23	23	710	alpine meadow					
Ellbögen	AS – SV14	14	1069	high-alpine vegetation					
Sattelberg	AS – SV19	19	2111	high-alpine vegetation					
Obergurgl	AS – YF19	19	1938	parking / rural					

- i-Box observations are performed in a 'box' due to 3D nature of phenomena under investigation.
- Core measurement area is located in Inn valley, Austria, with 6 core turbulence sites (CS).
- Locations for individual sites were chosen according to surface characteristics to cover *characteristic locations with respect to (mainly) slope, exposition and land use.*
- Measurements at some core sites span more than 3 years.

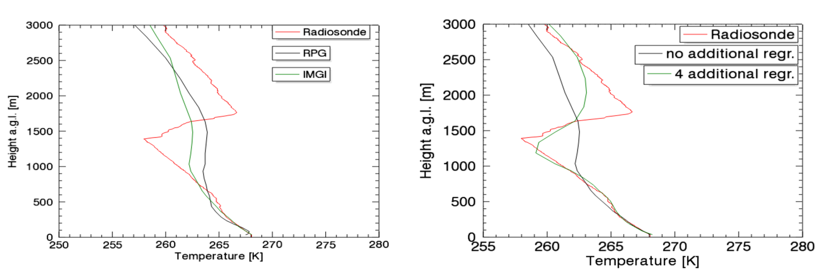
Type of measurement	Type	sites
turbulence	C-SAT METEK	all CS-MT21
fast response hygrometer	EC150/EC155 KH20	CS/AS-VF0 All CS
scintillometry	BLS2000	experimental
radiation	CMP21 /CGR4 CNR4	CS-VF0 CS-NF10/NF27/MT21
Mean T/RH	HC2-S3	all
Wind speed profile	Cup	CS – NF27/MT21
soil moisture	PICO 64	CS-NF10/NF27/VF0
pressure	Tetra273	all
ground heat flux	HFP01-7565	CS-NF10/NF27/VF0
T/RH profile (0-10km)	HATPRO	AS - VF0
wind profile (0-3 km)	Stream Line	AS - VF0

FIRST RESULTS

CHALLENGES AND MEASUREMENT ADVANCES

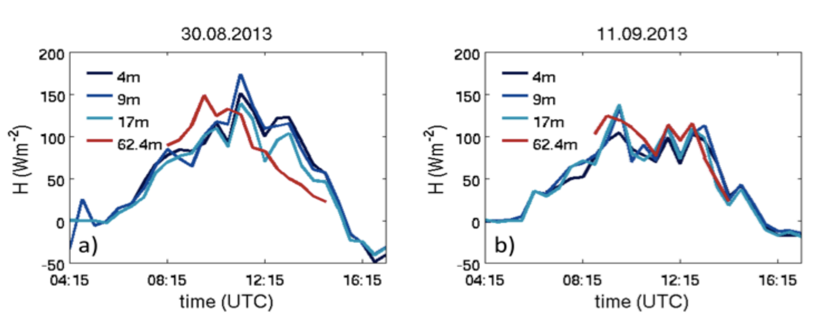
See O 7.3

- Operating instrumentation in TCMT is challenging due to instrumentation assumptions (e.g. surface layer scaling, homogeneity, footprint) and post-processing (e.g. coordinate rotation, low frequency motions). See Stiperski and Rotach (2015)



Massaro et al (2015)

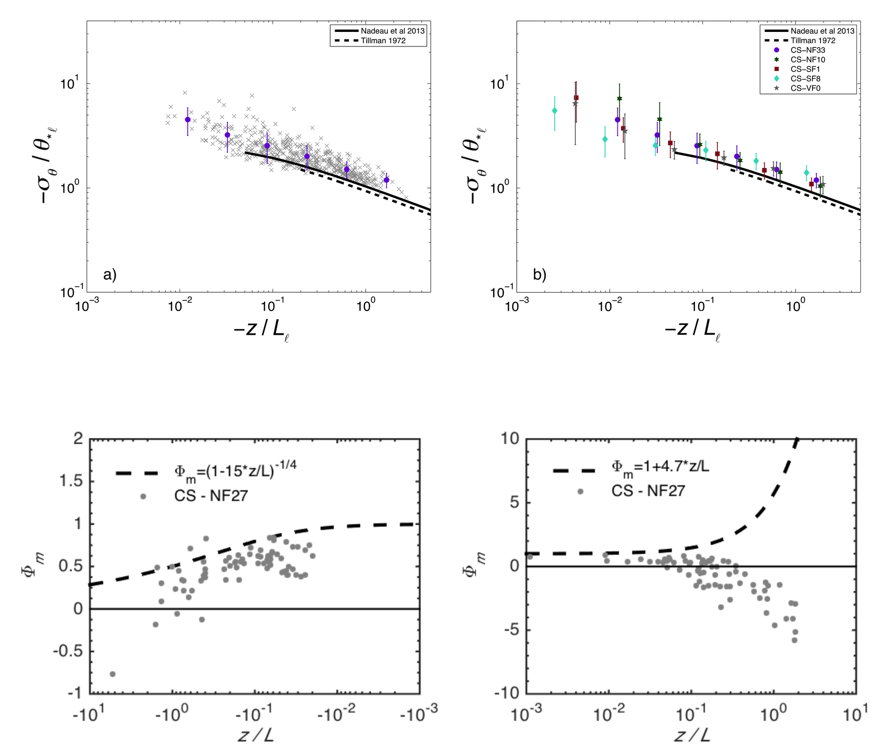
- For a passive Microwave T/RH profiler in TCMT to properly resolve high level inversions: extensive radio-sounding dataset and additional measurements from mountain stations are necessary (Massaro et al. 2015)



- Large aperture scintillometer was operated across the valley during SOP1.
- Non-constant fluxes over the height of the tower (1 day) show that tower is also outside Surface Layer.
- On second day fluxes were constant up to 60m.

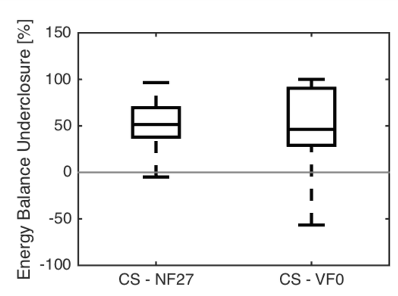
LOCAL SCALING

See P 2.35

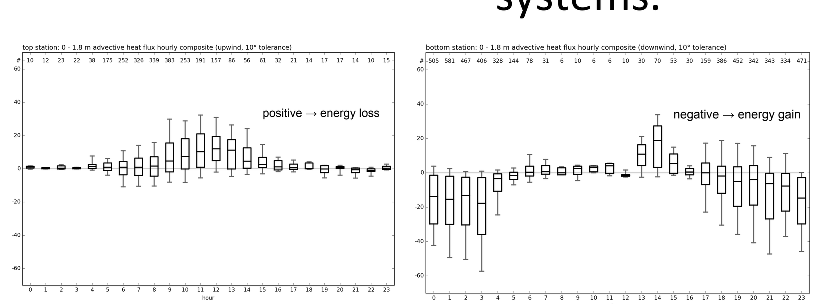


- Data do not conform to Monin-Obukhov Similarity Theory (MOST) but imply local scaling.
- Larger scatter than over HHF .
- In the free convection limit the -1/3 slope is observed as predicted over HHF.
- Magnitude of negative non-dimensional temperature fluctuations is larger than for HHF and from another steep slope, possibly due to proportionally larger momentum fluxes in TCMT.
- Non-dimensional wind speed gradients show large departure from MOST due to katabatic winds.

ENERGY BALANCE CLOSURE



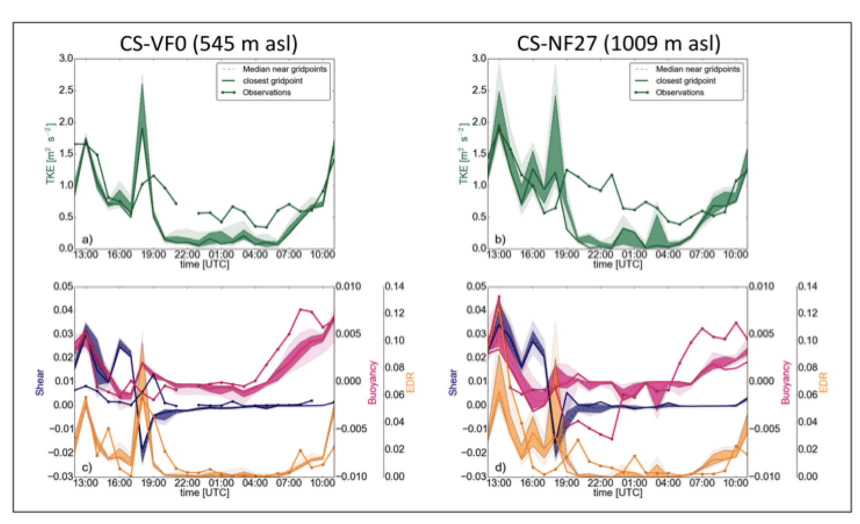
- Sites in TCMT show significant under-closure of energy balance of on average 50 %.
- The potential source of missing energy (on average 200 W/m² at CS – NF27) could be advection with the valley and slope wind systems.



- Estimates of advection along a slope show only ~ 30 W/m² that can be attributed to horizontal temperature advection

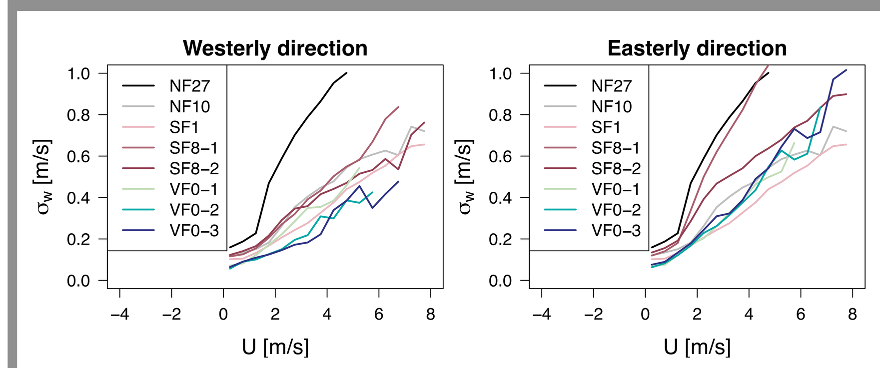
NUMERICAL MODELLING

See O 13.6



- Real terrain simulations with COSMO 1 numerical model (1.1 km, 80 vertical levels).
- Modeled and measured magnitude of TKE show very good fit for CS-VF0 and NF27 during daytime. During nighttime TKE is underestimated and in evening transition overestimated.
- Contributions to TKE budget (shear, buoyancy, dissipation) reproduced well.
- One dimensional TKE scheme not sufficient for TKE in TCMT

TURBULENCE REGIMES IN SBL



- Different turbulence generating mechanisms in SBL are clear for different stations.
- Importance of bulk shear for turbulence generation more visible for steeper stations and easterly wind directions

REFERENCES

Massaro J, Stiperski I, Pospichal B, Rotach MW, 2015: Accuracy of retrieving temperature and humidity profiles by ground-based microwave radiometry in truly complex terrain, *Atmos. Meas. Tech.*, 8, 3355-3367

Stiperski I, Rotach MW, 2015: On the measurement of turbulent fluxes in complex mountainous terrain, *Bound. Layer Meteorol.*, in print.