Direct measurements of turbulent fluxes in the near-surface environment at high latitudes applying the eddy-covariance method

ARCTEX

Dr. Johannes Lüers[1] and Dr. Jörg Bareiss[2]
Prof. Dr. Alfred Helbig[3], Jo Olesch[1] (technical support)
and Prof. Dr. T. Foken[1] (advice)

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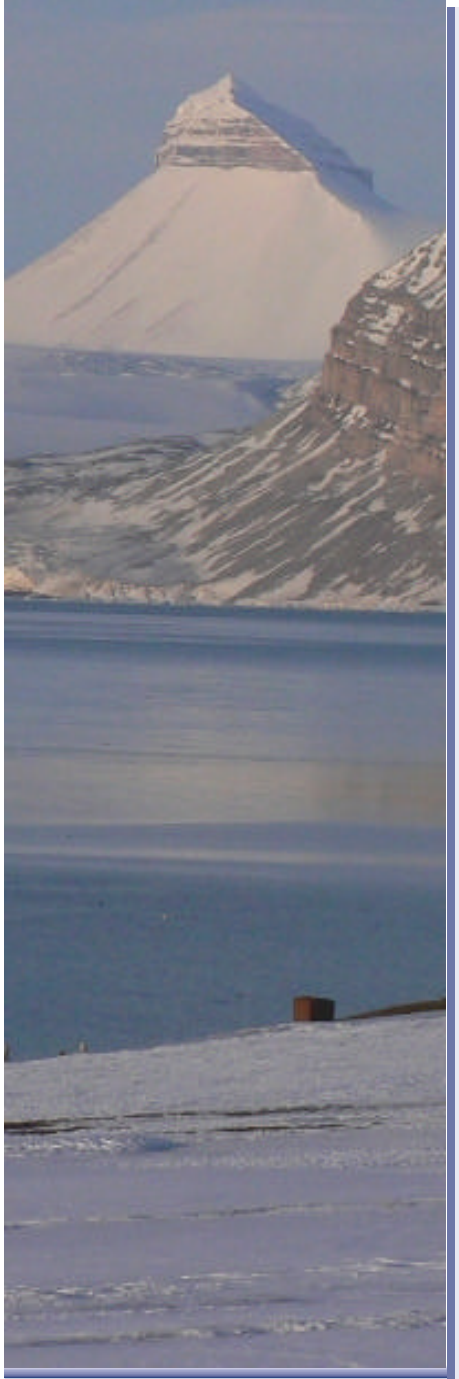
[3] Emeritus (Department of Climatology, University of Trier)

DFG 226/11-1
http://www.arctex.uni-bayreuth.de



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Nov 2006

State of the art

Energy balance (EB) of polar surfaces

- **Energy exchange – the heat transfer between polar surfaces and atmospheric boundary layer especially under neutral and stable conditions is still poorly understood.**

Net ecosystem exchange (NEE) of CO_2 of arctic soils and vegetation

- **In respect to climate warming esp. in arctic regions the quantity of CO_2-fluxes and the annual CO_2-balance is still unsure.**

Experiments e.g. AIDJEX (1970s), MIZEX (1980s), CLEAREX (1988), FINTUREX (1994), SHEBA (1995-2002), SEBISUP (2002/03), ARCTEX (2006)

Deficiencies in polar regions

- **Poor spatial and temporal coverage of energy and CO_2-fluxes.**
- **No state of the art flux data quality assessment techniques and gap-filling routines applicable to deal with polar conditions.**
- **Accuracy of parameterisations of turbulence in models (Up-scaling to landscape scale).**

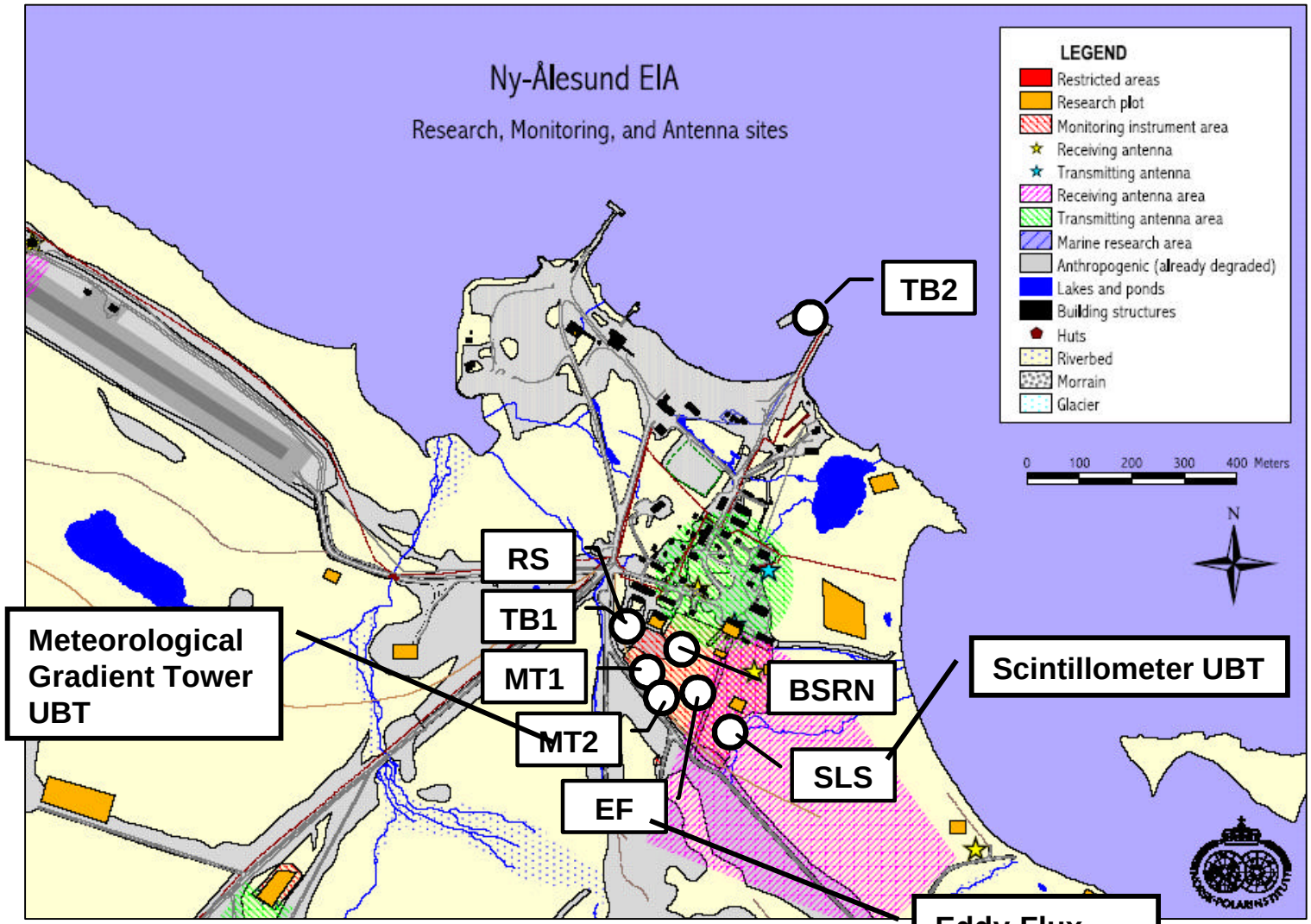
Objectives

1. Continuous measurements of high-resolution (20 Hz) turbulent fluxes near the surface using the eddy-covariance method.
2. Measurements of standard meteorological data sampled at 1s intervals.
3. Pre- and post- processing of high-quality data sets of turbulent fluxes using state of the art flux data quality assessment techniques, footprint approaches and gap-filling routines.

Primary goals

1. Understanding of exchange processes and their parameterisation for neutral and stable conditions.
2. Validation of commonly used sensible and latent heat flux parameterisations (aerodynamic approach, Bowen-ratio method).
3. Validation of atmospheric boundary processes simulated in numerical models and improvement of existing parameterisation schemes.

Field campaign at the Koldewey-Station as part of the joint French-German Research Platform (AWI, IPEV) 2. May to 22. May 2006



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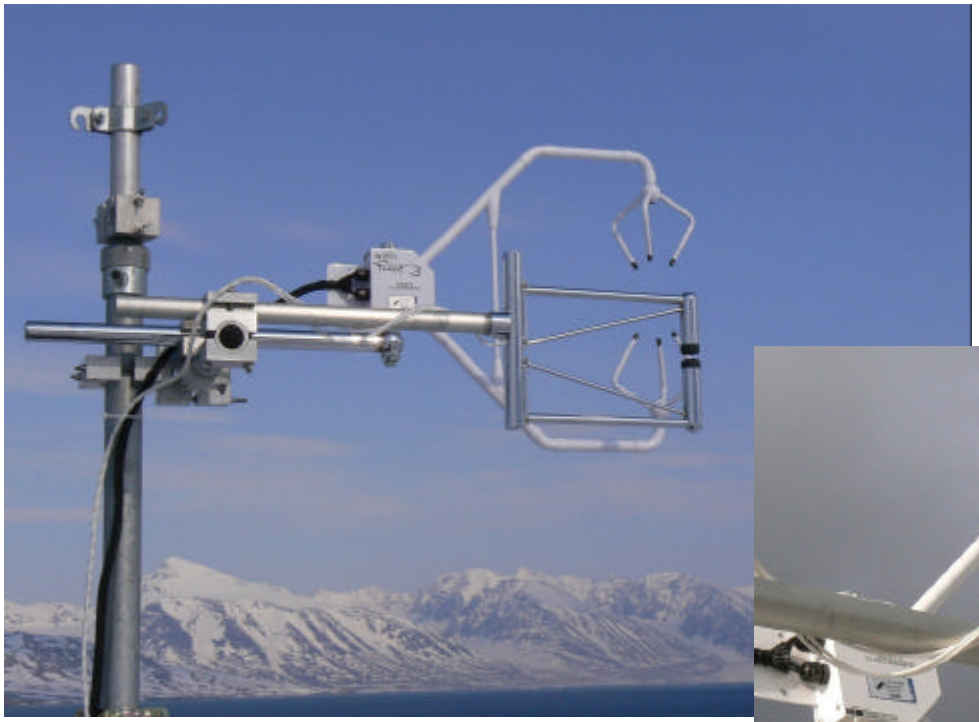
Measurements

Eddy-flux measurement complex: CSAT3 (Ultrasonic) KH20 (H_2O), CR23X (Logger), Mini-PC



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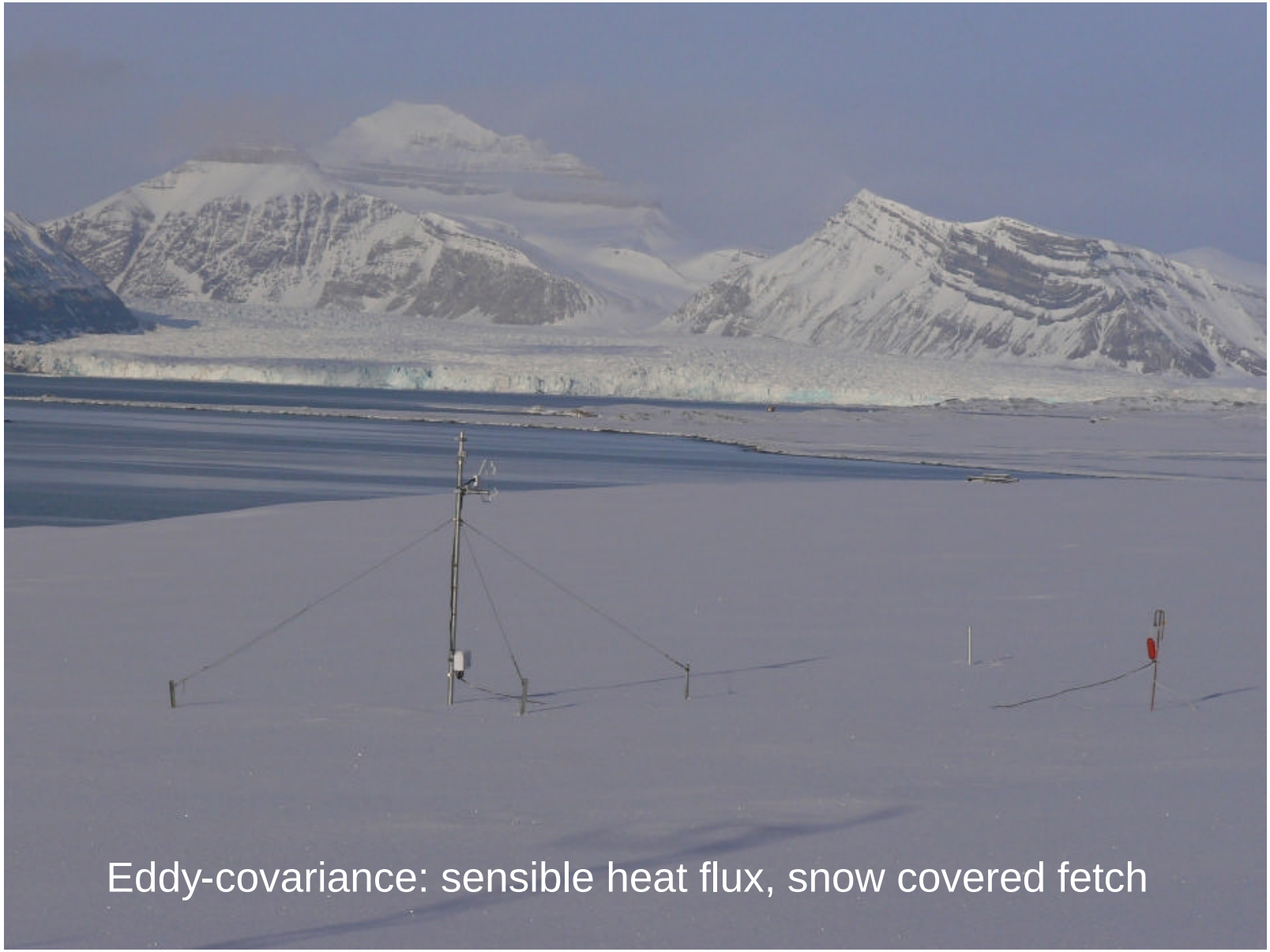

Eddy-covariance: sensible heat flux, snow covered fetch

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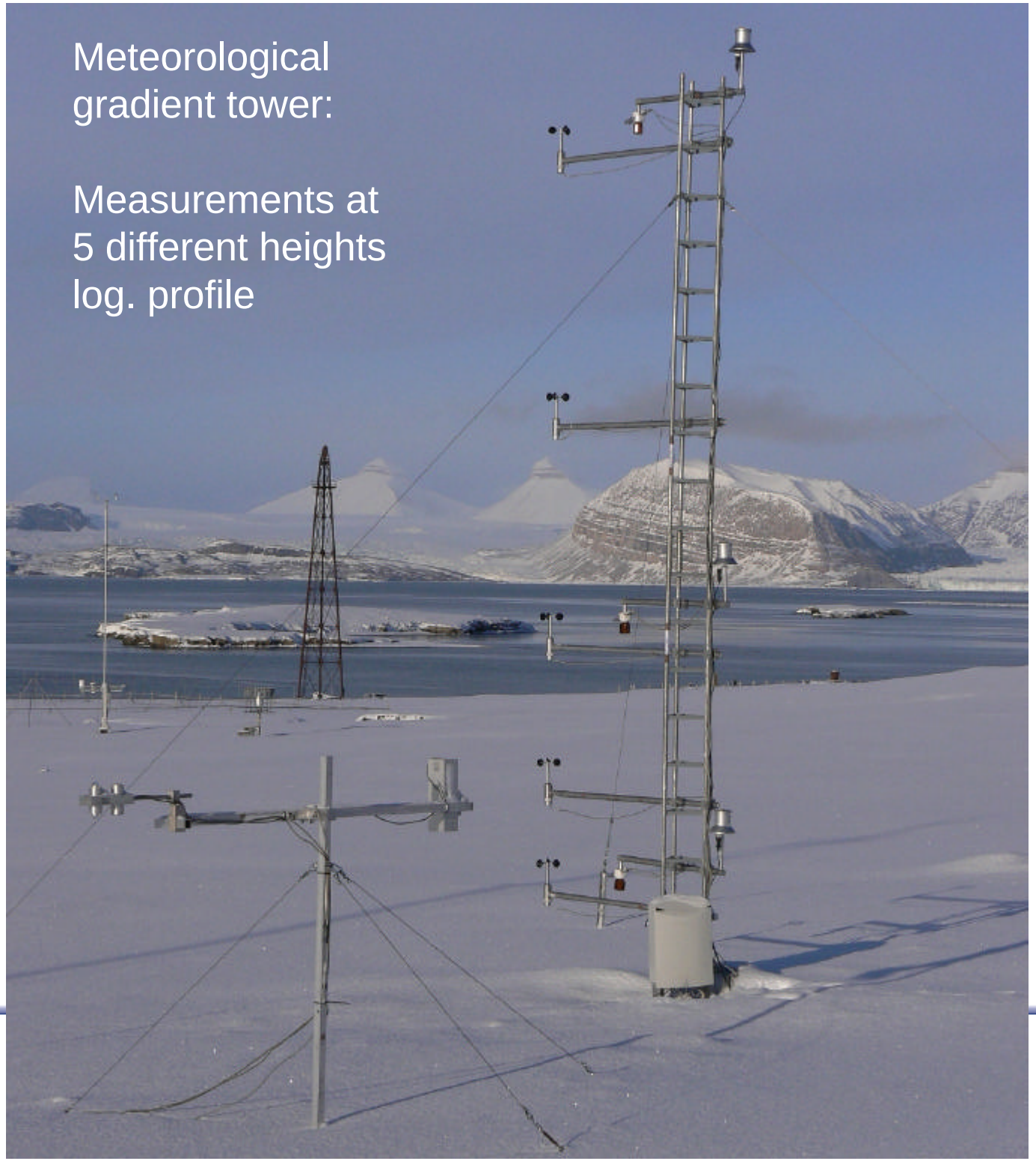
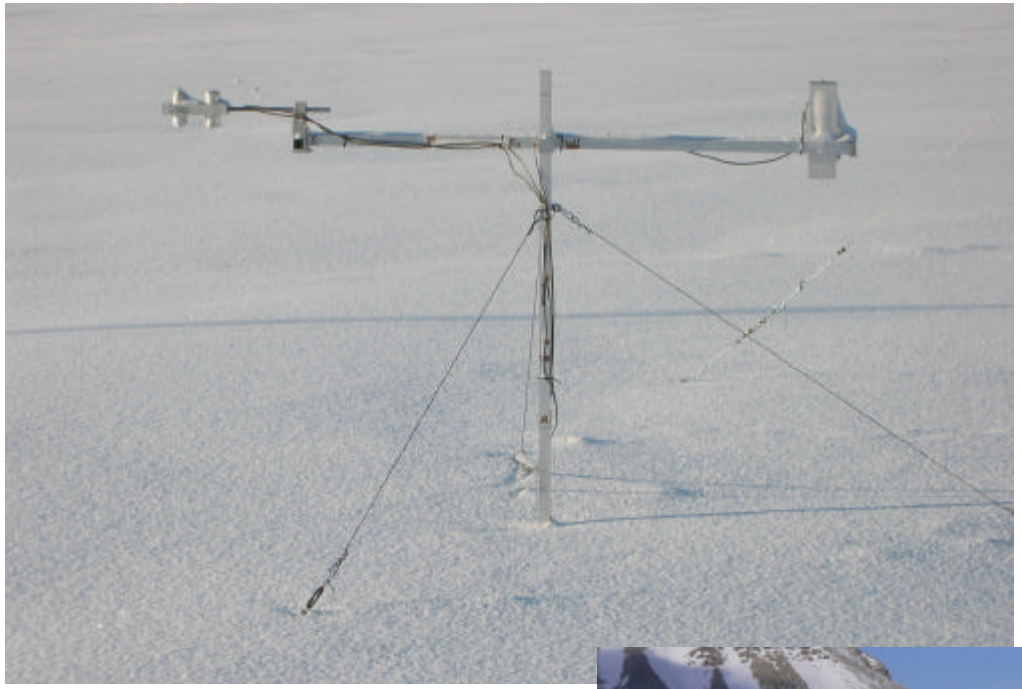
Measurements

Flux-gradient measurement complex: Met. Tower (6 m) Cup anemometers at 5 heights, ventilated thermometers at 3 heights, CNR1 net radiometer, KT15.82 D (IR-thermometer), Data logging system.

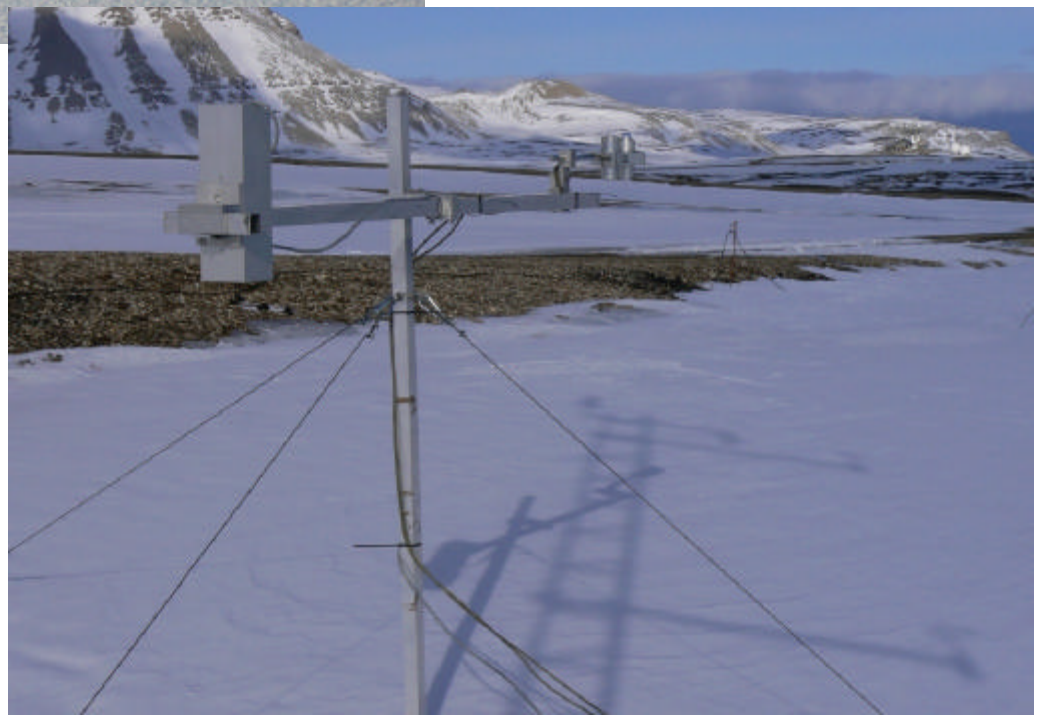




Radiation measurements:

CNR1 radiation balance

KT15 IR-thermometer



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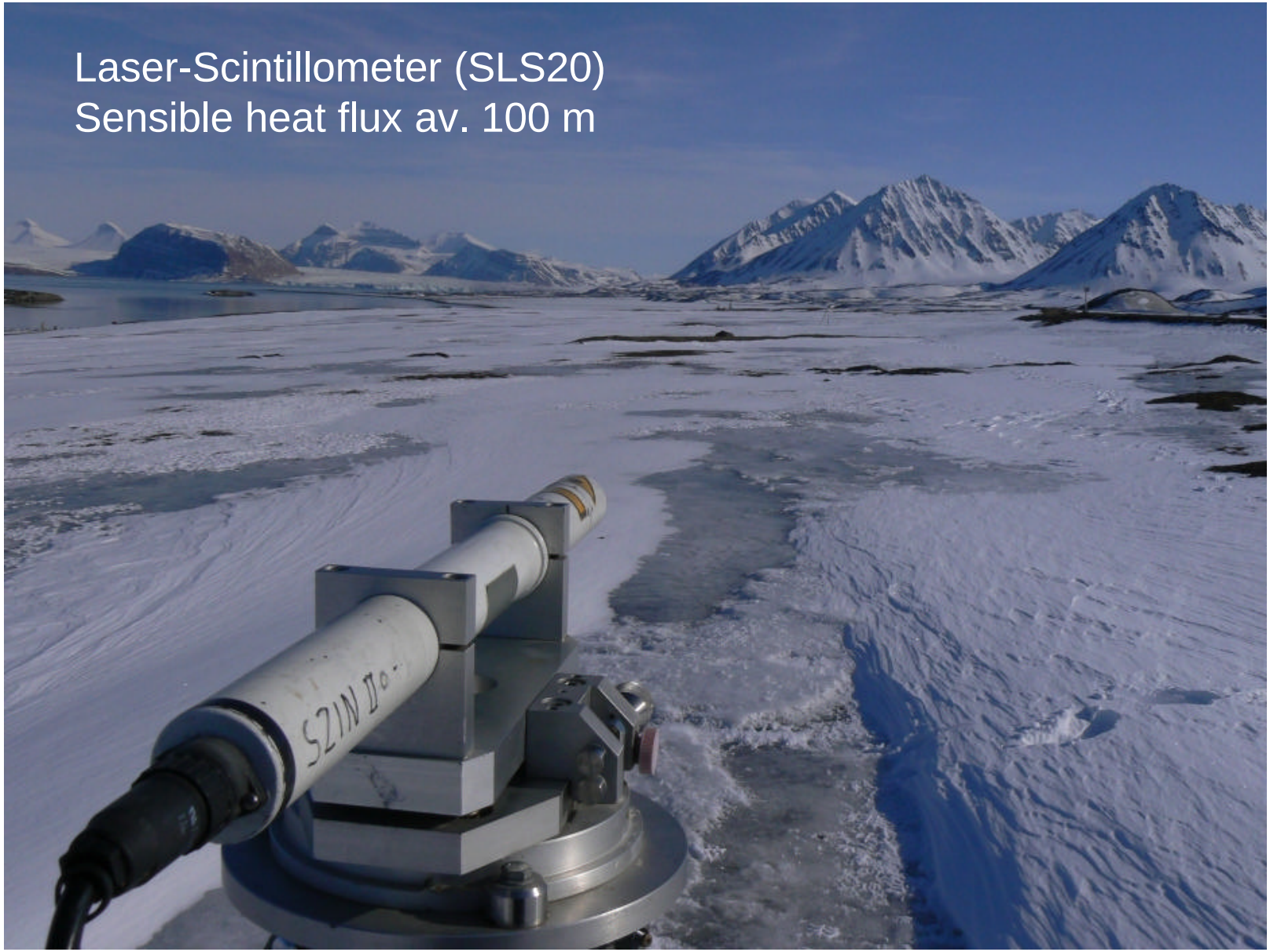


Flux data quality assessment

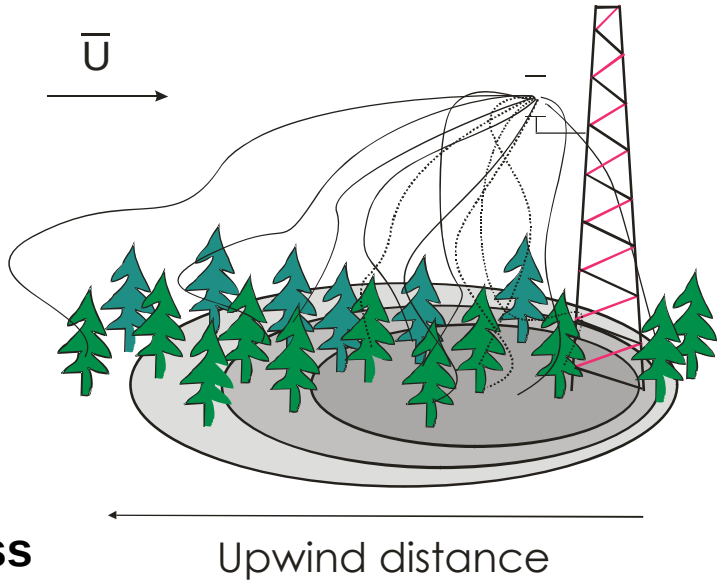
(Internationally standardised QA/QC software package TK2)

1. Corrections, tests, quality assessment

- Plausibility tests (consistency limits, spike detection)
- Corrections to calculated covariances
- Application of planar fit method for coordinate transformation
- Determination of time delay between sensors
- Quality assessment (QA/QC)

2. Footprint analysis

- Source areas of flux and concentration measurements are of different nature and shape and turbulent flow field determines the transport of airborne quantities
- To estimate the representativeness of existing measurements
- To assess the comparability of different techniques



Co-operation

1. Vertical structure of ABL

Dr. M. Maturilli, Anne Theuerkauf,
and Jürgen Graeser, AWI:
Tethered balloon sonde

2. Spatial variability of turbulent fluxes

Prof. Dr. A. Helbig:
Scintillometer measurements

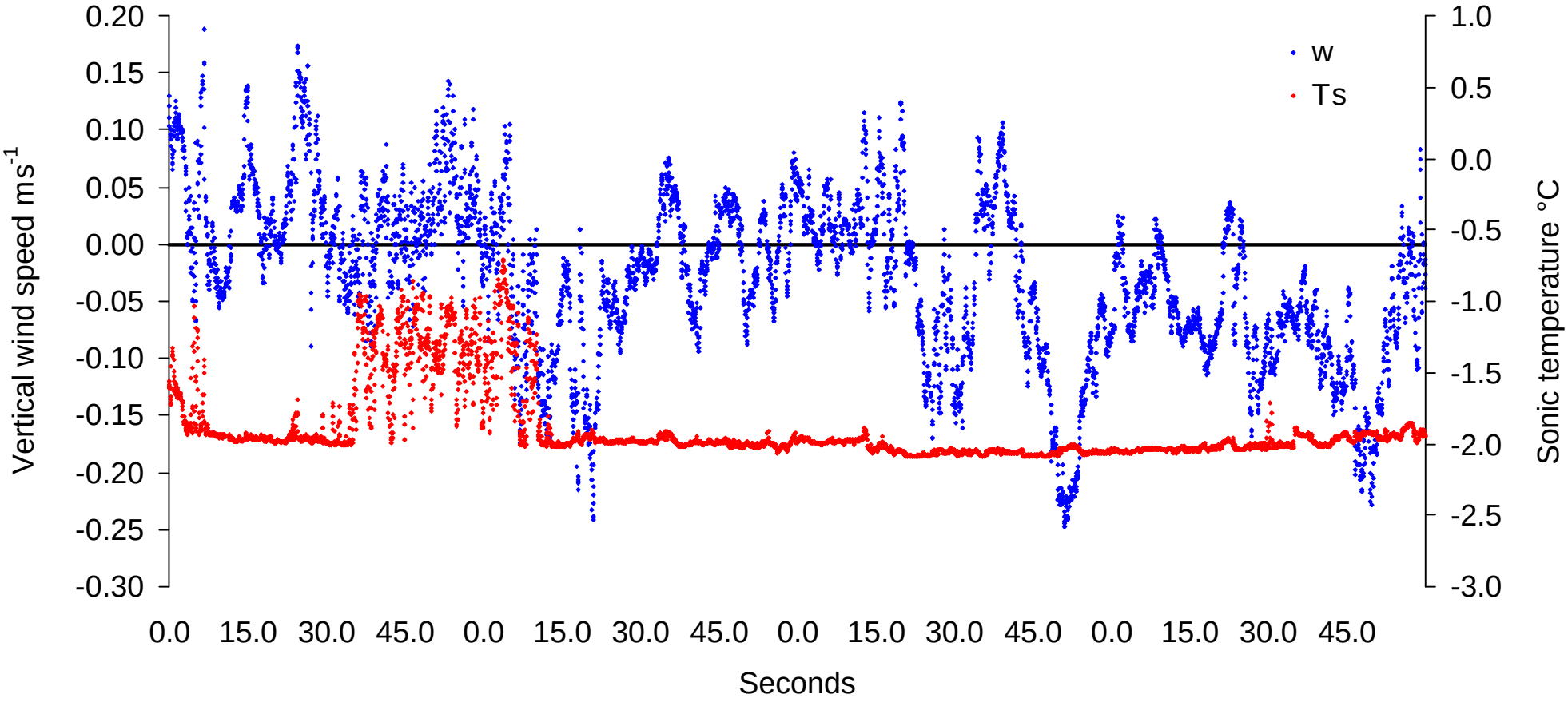
3. Regional atmospheric models

Dr. A. Rinke, Prof. Dr. K. Dethloff (AWI), HIRHAM
Dr. V. Perov (SMHI), HIRLAM-6

4. Surface radiation data (BSRN)

Dr. Andreas Herber (AWI)

High frequency raw data sensible heat flux measurements
ARCTEX May 13, 13:14 h to 13:17 h CET



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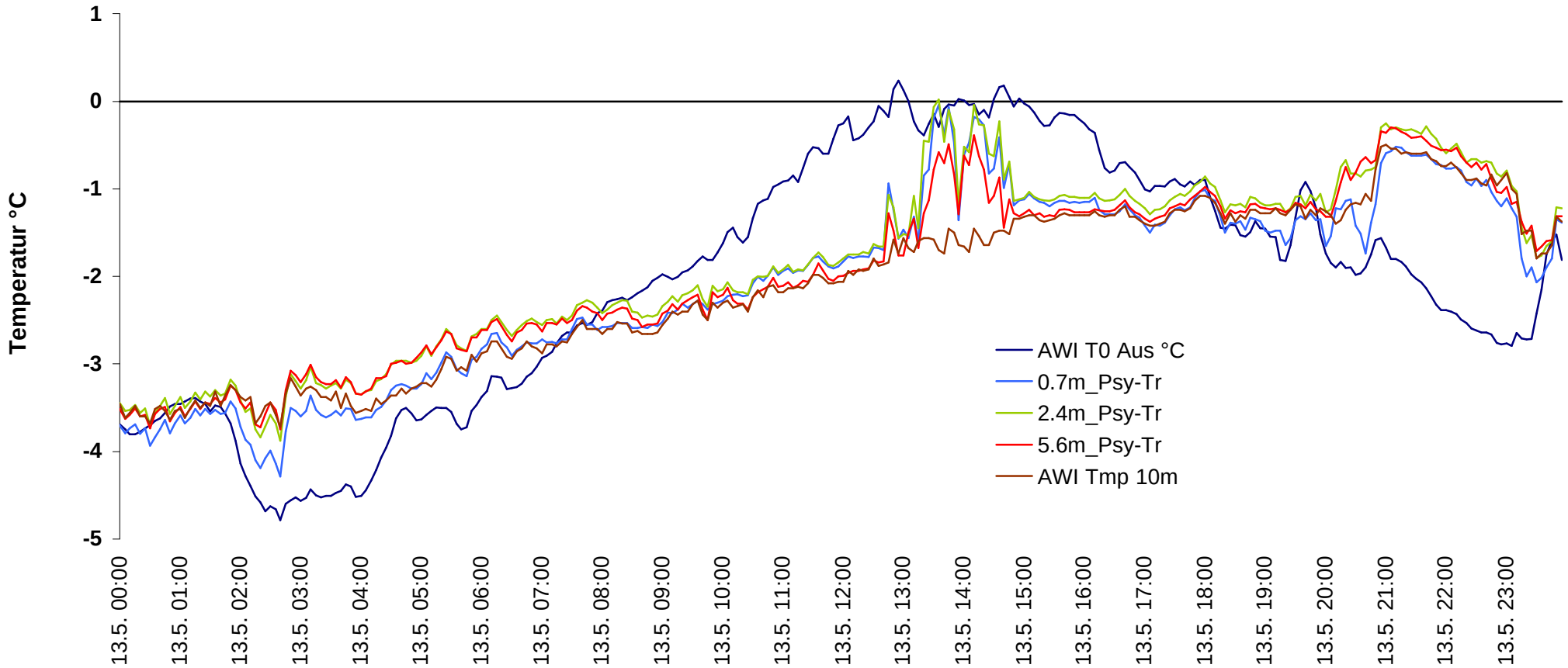
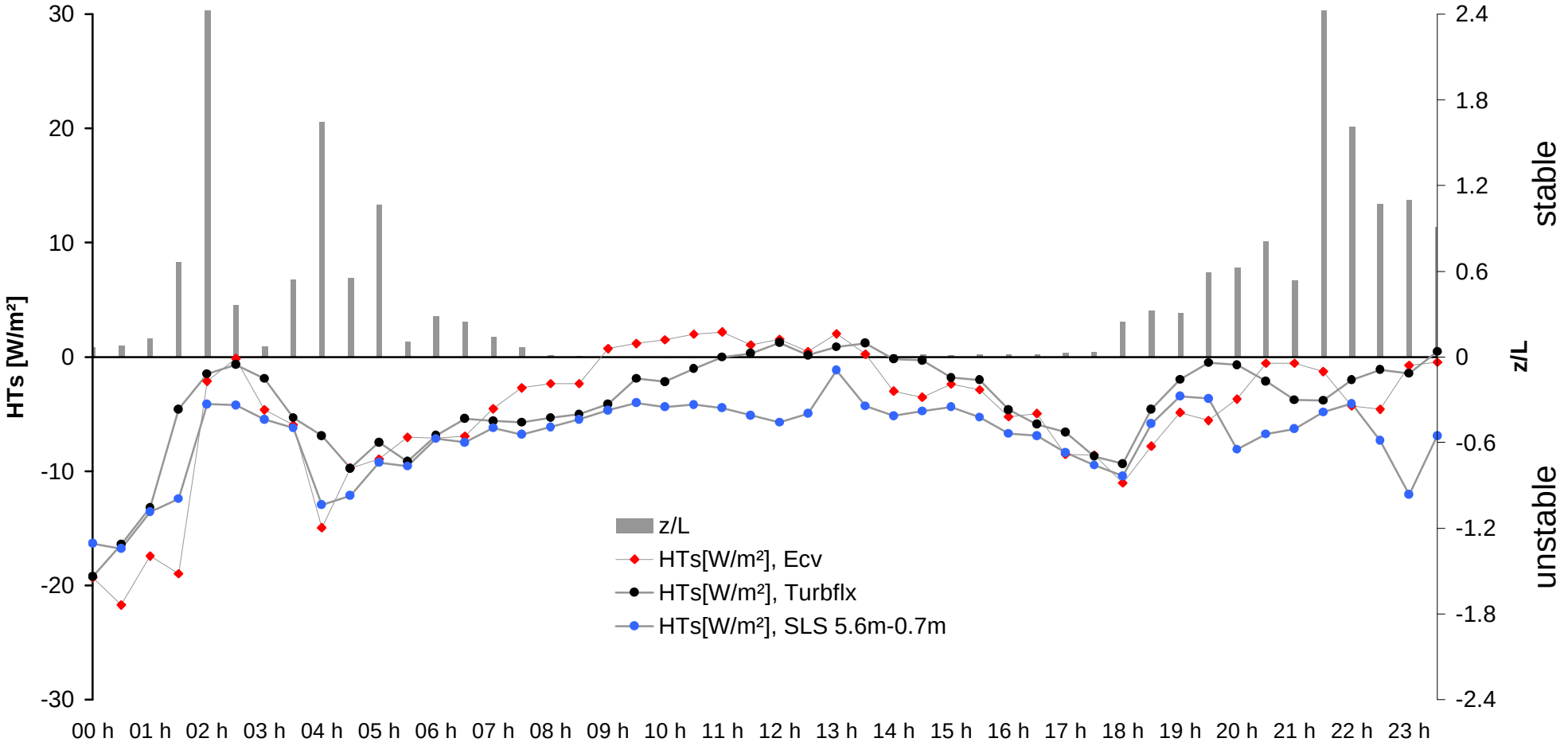
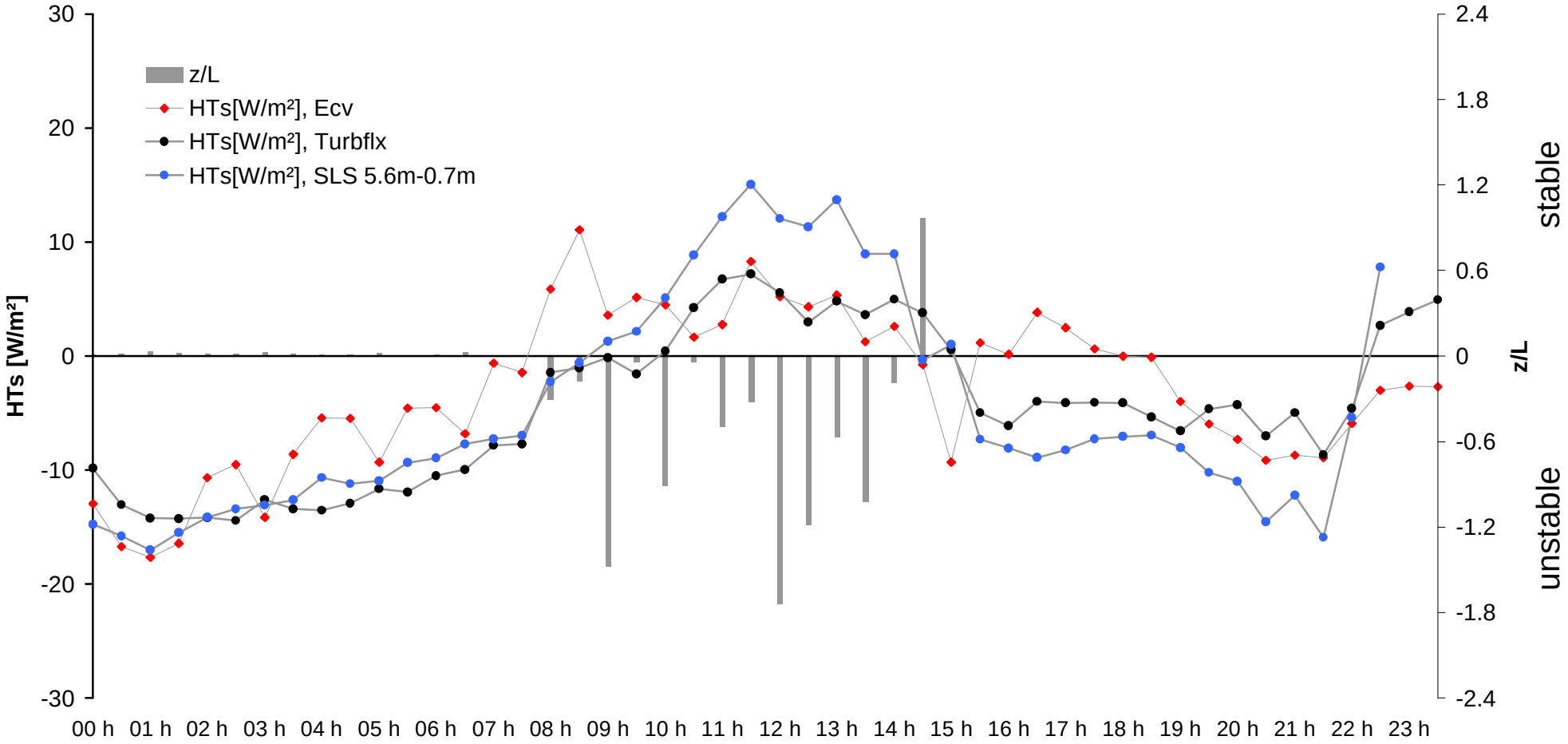
Vertical temperature profile meteorol. towers Univ. BT and AWI
ARCTEX May 13, 0 h to 24 h CET

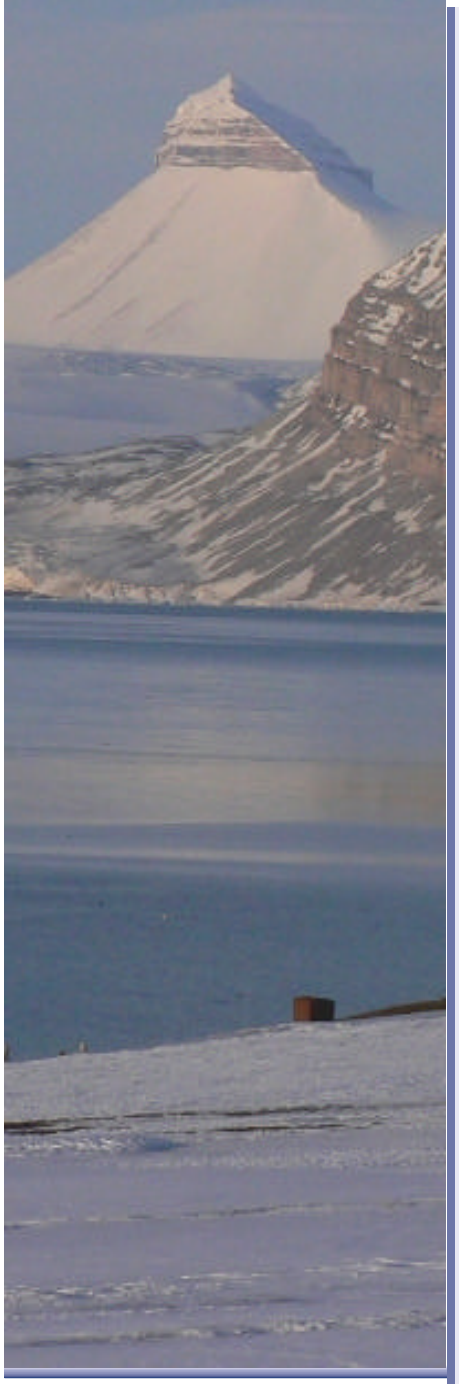


Comparison between measured (Eddy-Cov, SLS) and modelled (Turbflux: Launiainen & Cheng 1995) sensible heat flux. ARCTEX May 11.

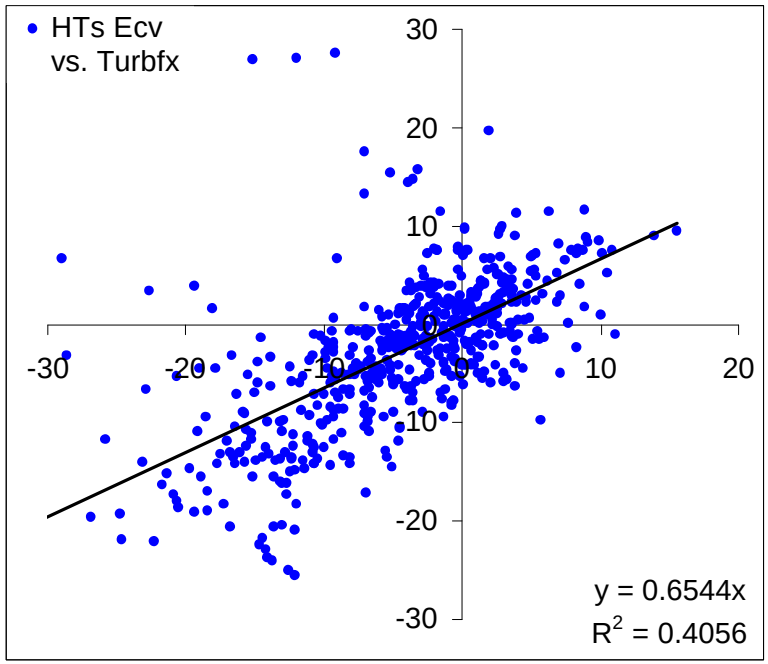


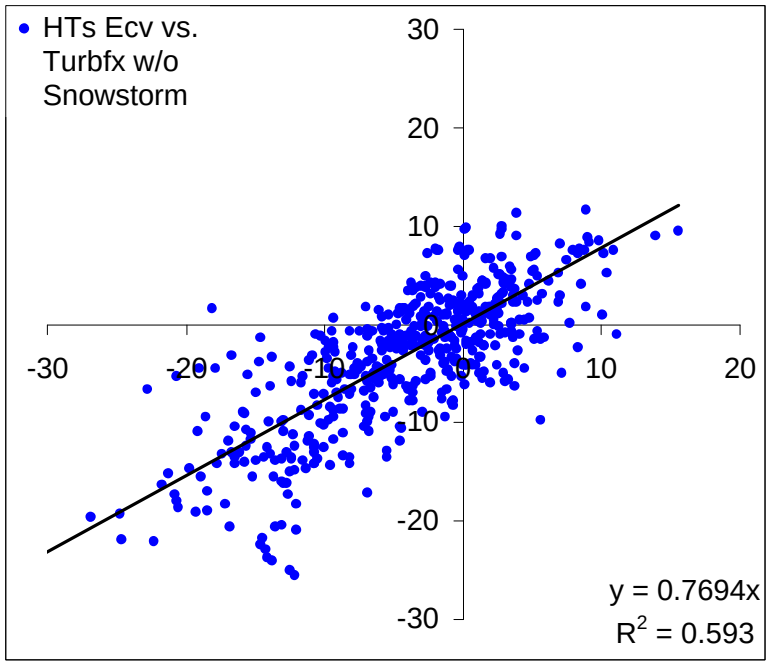
Comparison between measured (Eddy-Cov, SLS) and modelled (Turbflux: Launiainen & Cheng 1995) sensible heat flux. ARCTEX May 16.

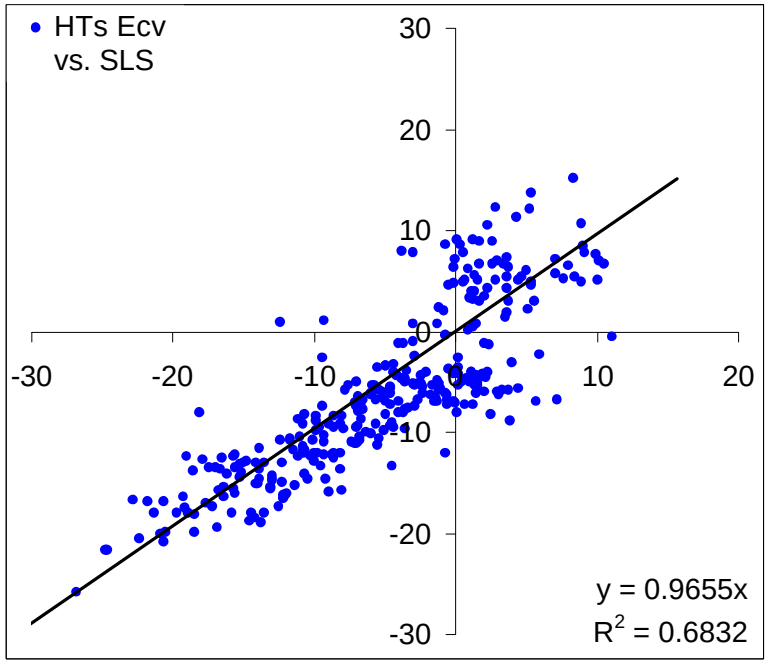


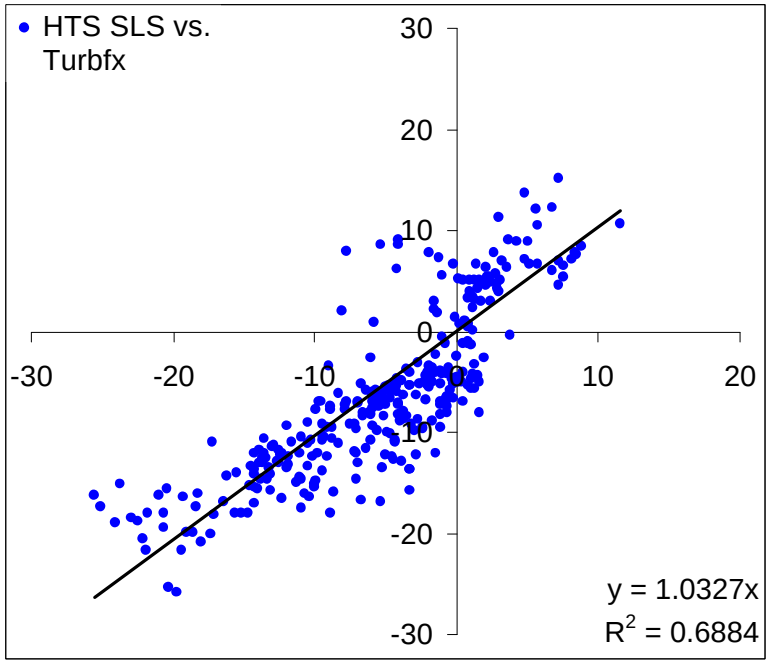


Comparison between measured (Eddy-Cov, SLS) and modelled (Turbflux: Launiainen & Cheng 1995) sensible heat flux









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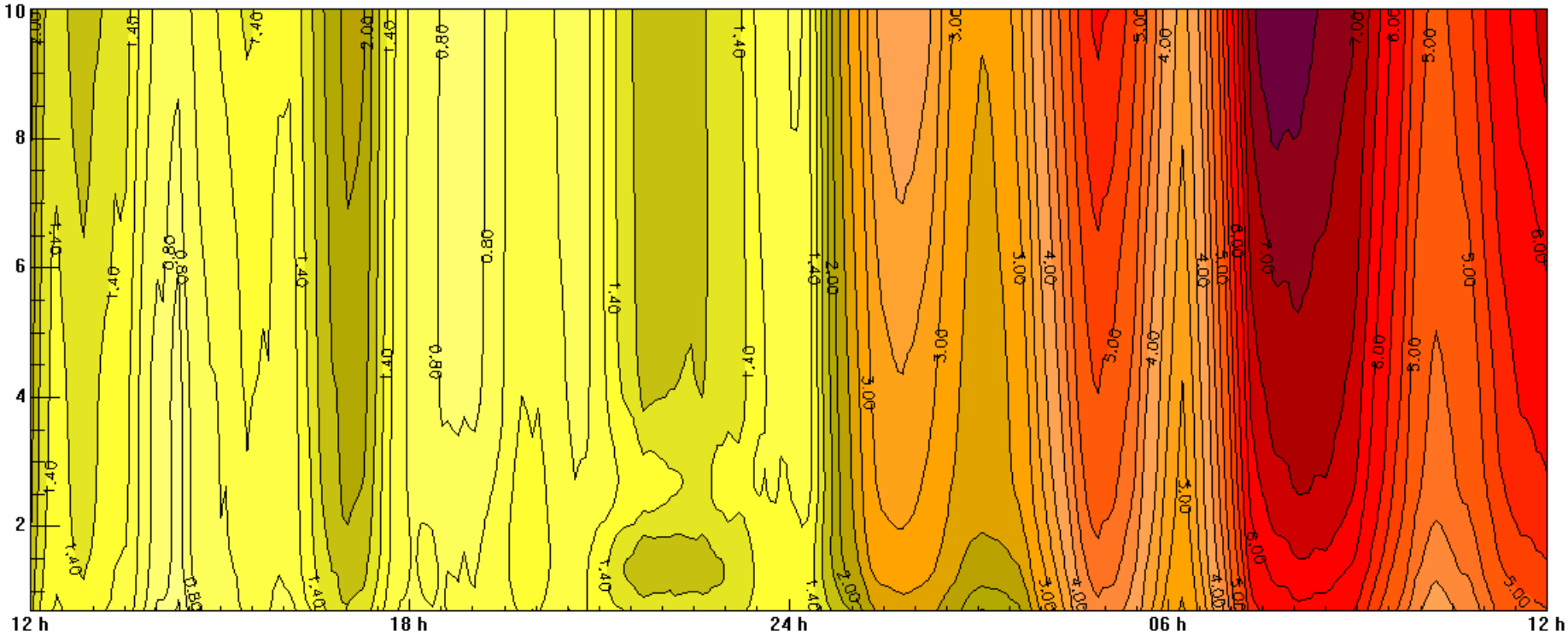
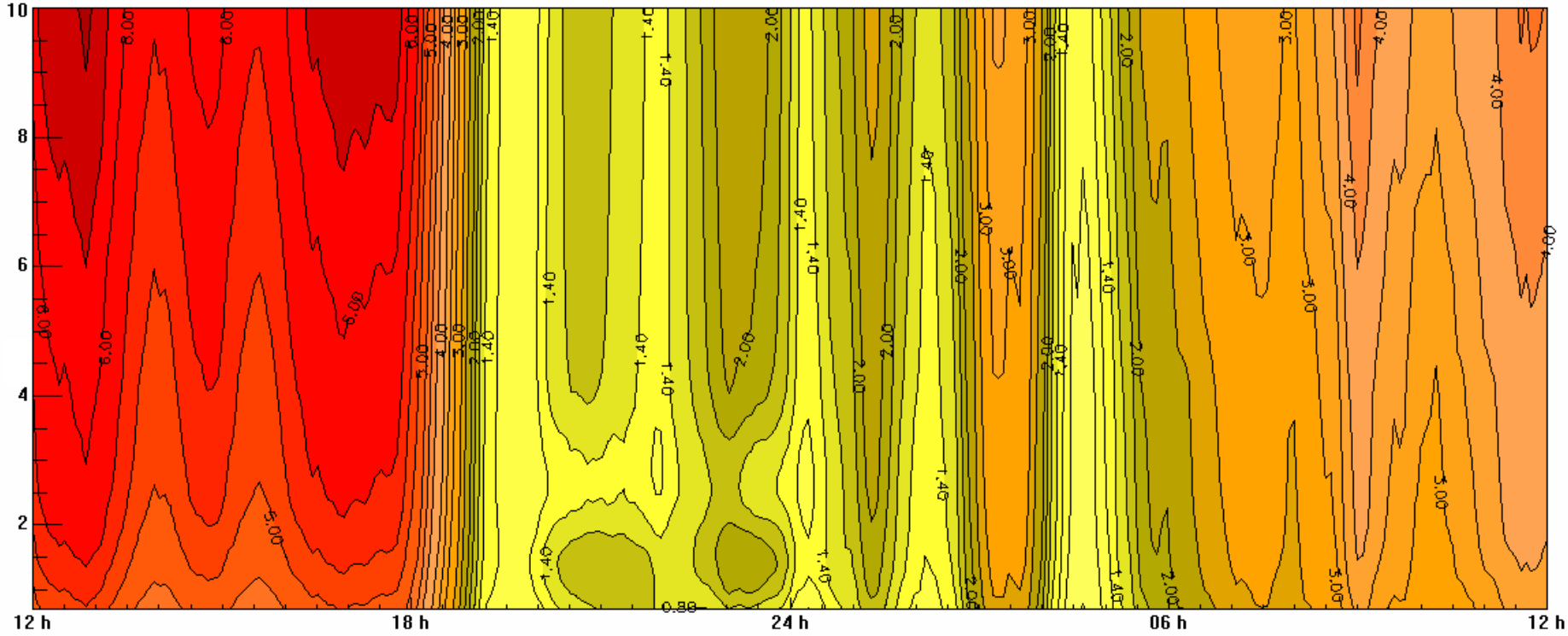
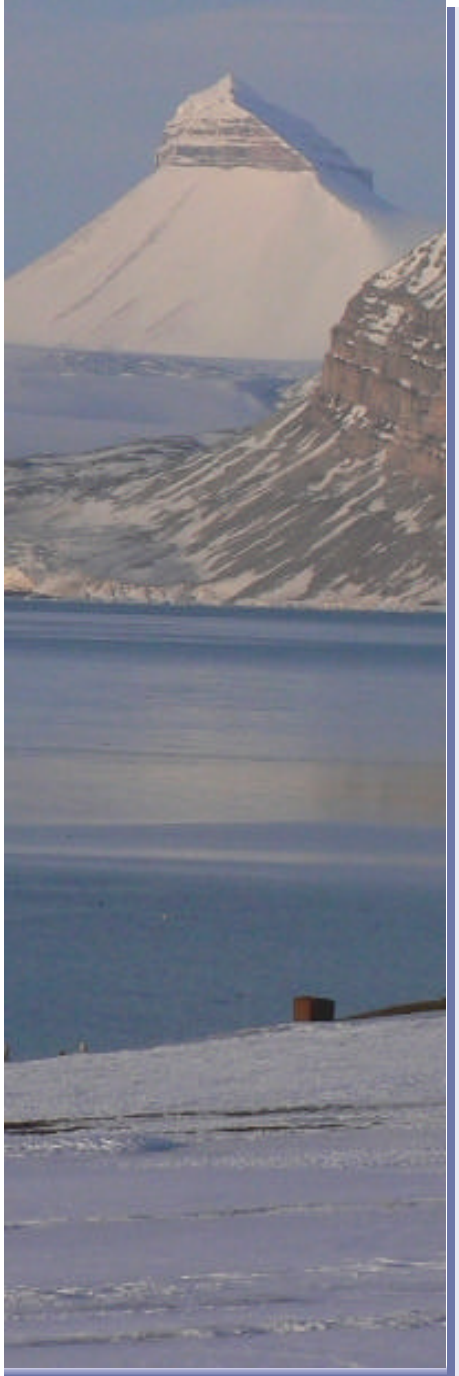
Wind profile Catabatic flows

Polar day
Midnight
May 09
to
May 10

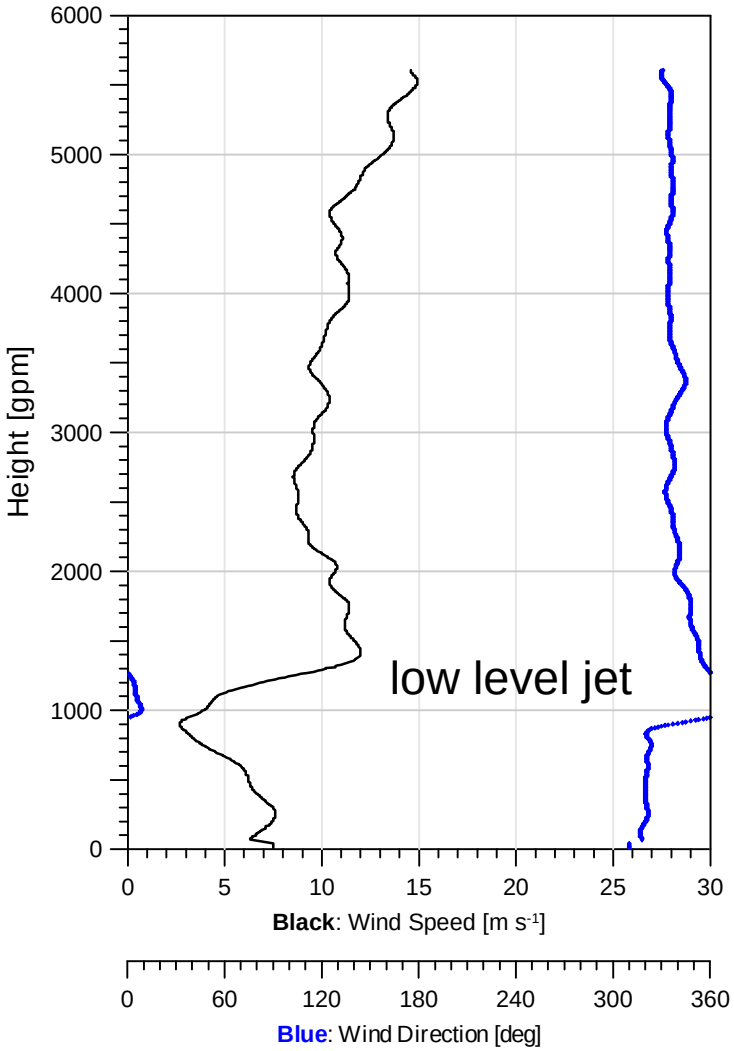


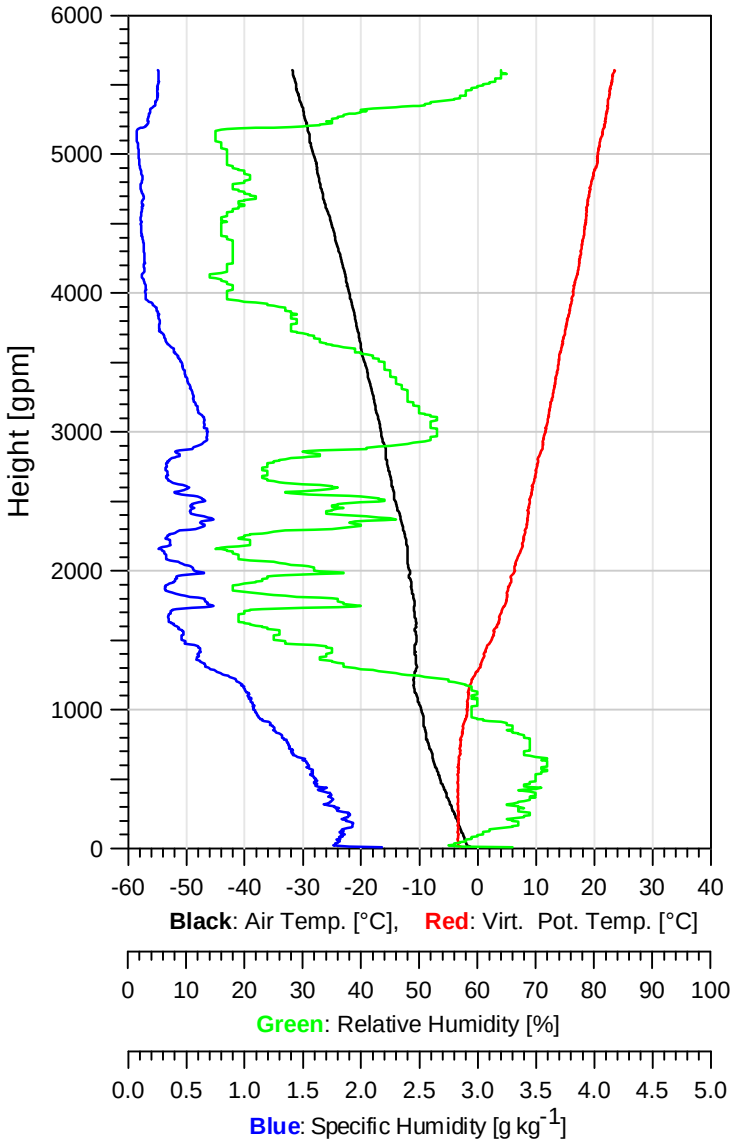
Polar day
Midnight
May 11
to
May 12





Vertical structure of ABL: RAOB Ny-Ålesund





May 10, 15:20 h CET

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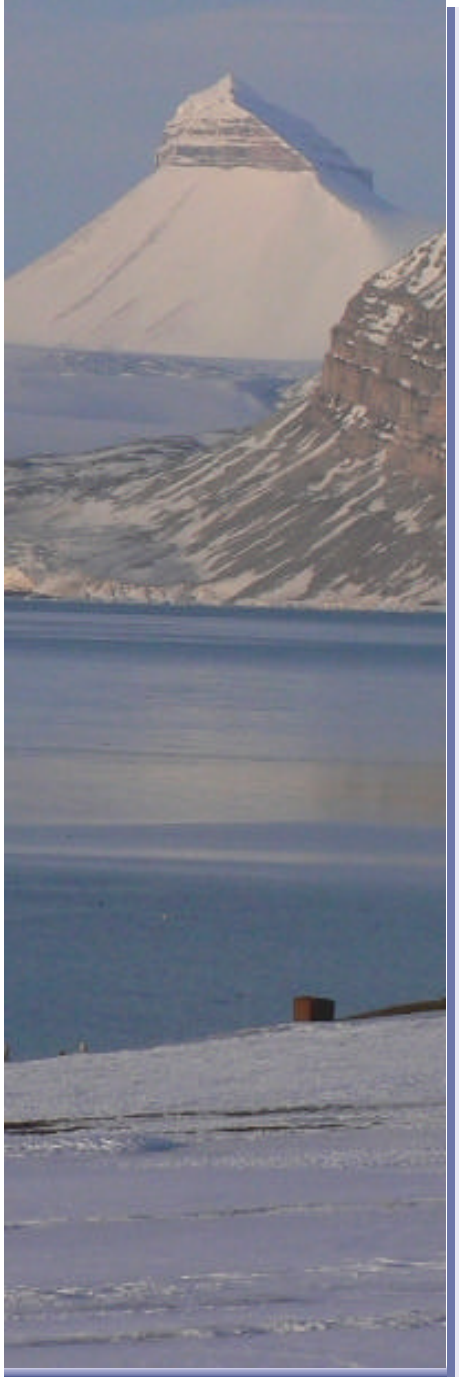
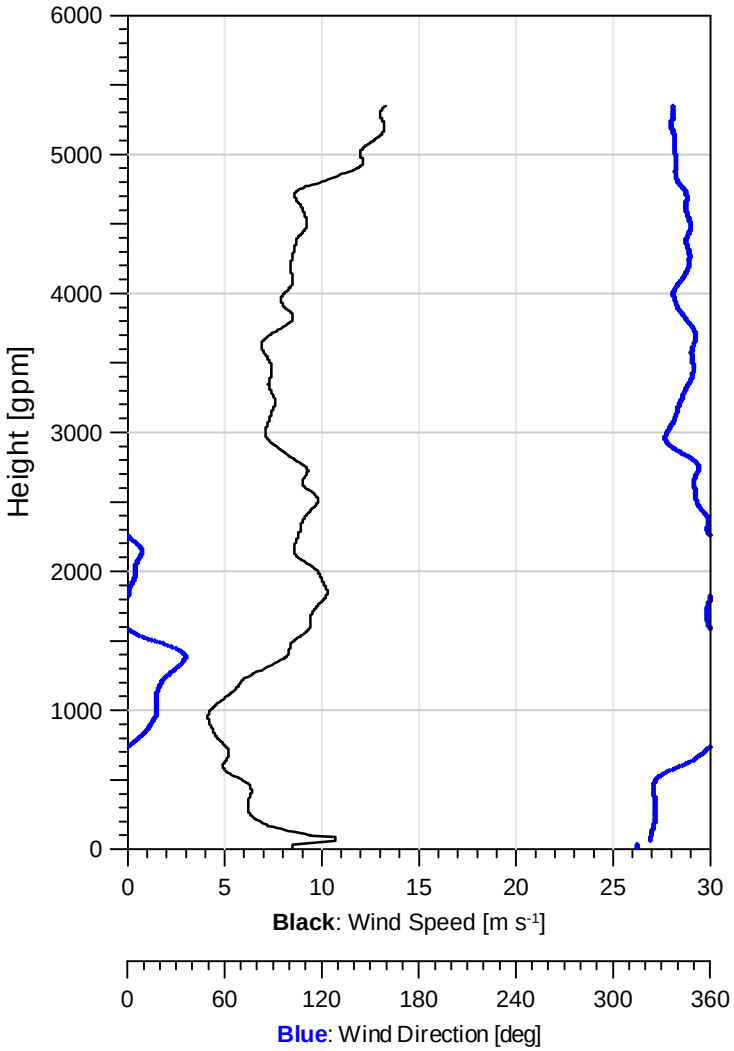
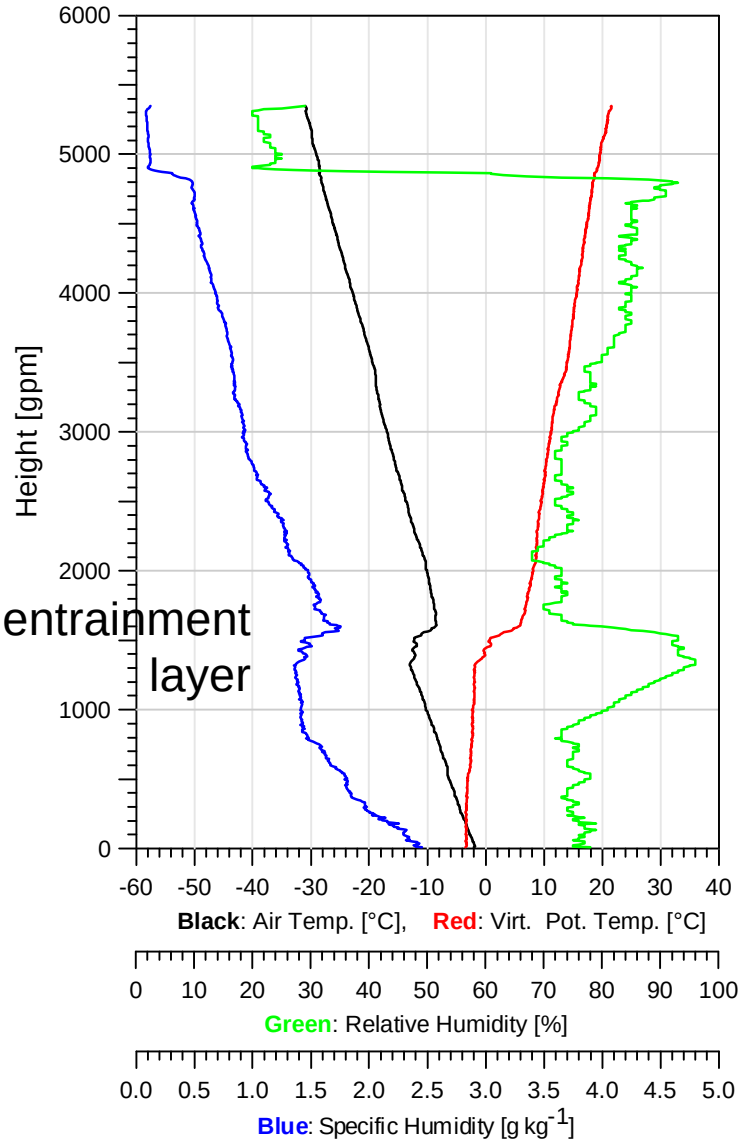


Vertical structure of ABL: RAOB Ny-Ålesund





May 10, 22:30 h CET

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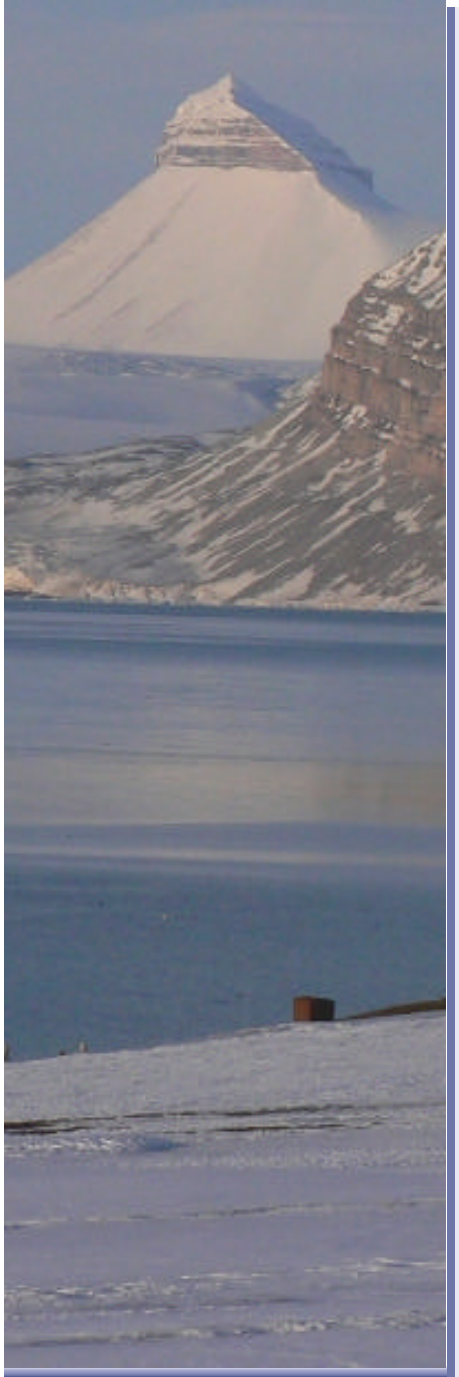
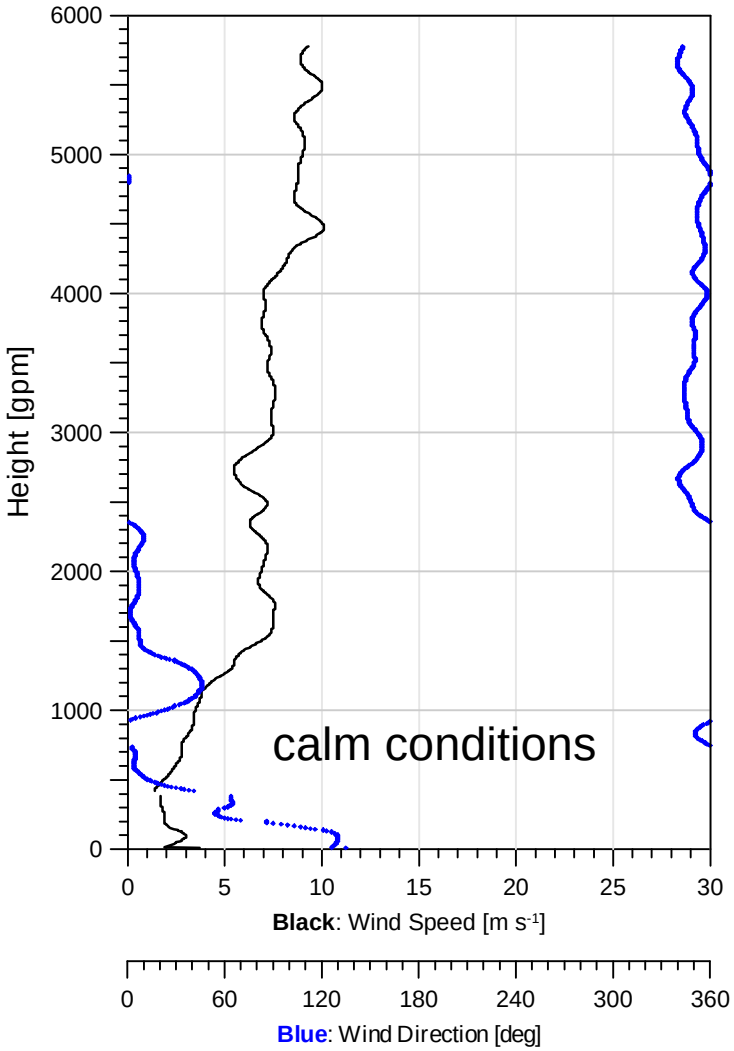
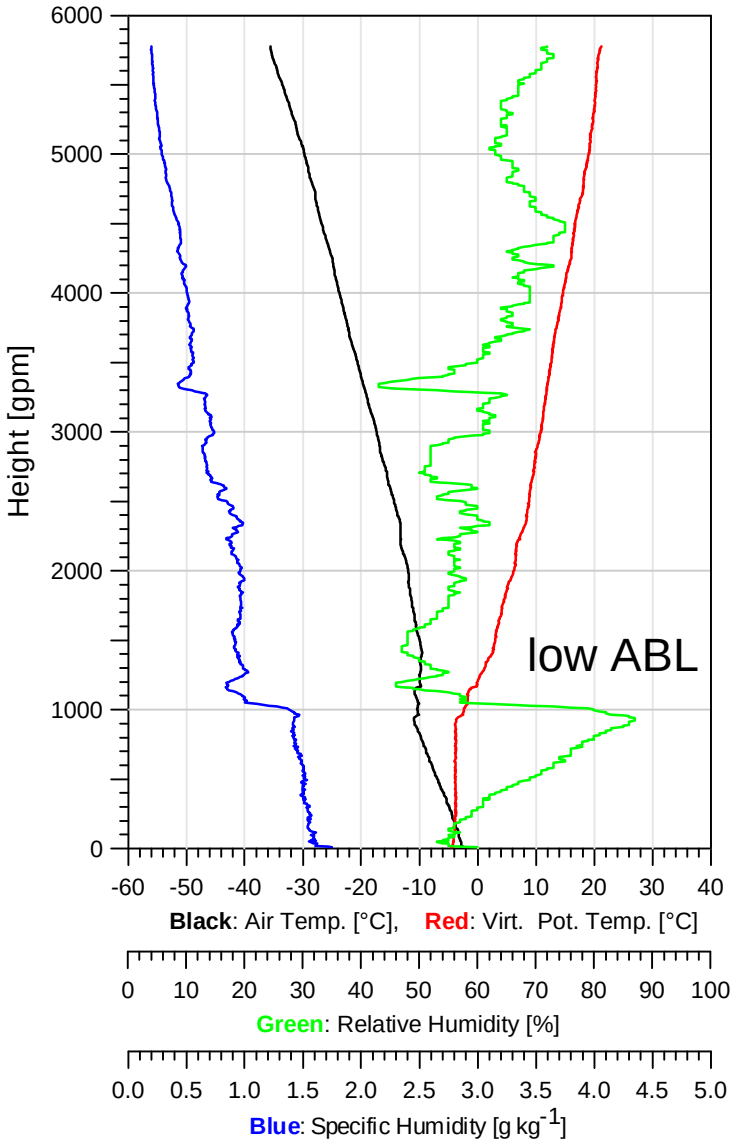


Vertical structure of ABL: RAOB Ny-Ålesund





May 11, 05:00 h CET

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Future plans 2007 to 2010
DFG-Proposal

Long-term measurements of near-surface turbulent fluxes in the Arctic environment

ARCTEX (ARCtic Turbulence EXperiment)

Main applicant: Dr. Johannes Lüers[1]
Co-applicants: Dr. Jörg Bareiss[2] and Dr. Julia Boike[3]
Co-operation: Prof. Dr. Thomas Foken[1]

[1]Department of Micrometeorology, University of Bayreuth, Germany
[2]Department of Climatology, University of Trier, Germany
[3]AWI, Section Periglacial Dynamics, Potsdam, Germany

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AWI Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft

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ARCTEX 2007-2010

Future plans 2007 to 2010

1. **Understanding:**
   Exchange processes and their parameterisation for neutral and stable conditions.
2. **Investigation:**
   Energy balance closure problems; role of coherent structures; gravity waves.
3. **Enhancements:**
   Data quality; footprint; gap-filling: adaptation to polar conditions.
4. **Improvement:**
   Existing parameterisations; Transfer-function to micro- / meso-scale models (in coop. with HGF: VH-NG-203).
5. **Long-term Evaluation:**
   Flux-measurements under rough arctic weather conditions.

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Flug über den Kronebreen-Gletscher, Kongsfjord, Spitzbergen, 79° Nord, 22. Mai 2006, 15 Uhr