The shallow katabatic flows over Dronning Maud Land, Antarctica

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Image Source: Antarctic AVHRR satellite image mosaic, USG
Projection: Polar Stereographic
Cartography: C. Jackson, terra incognita, www.terra-incognit
4 200km FROM CAPE TOWN
NEUMAYER
SANAE IV
TROLL
MAITRI
NOVO
BLUE-1
WASA / ABOA
SVEA
KOHNEN
IISA
SYOWA
DOME FUJI
HELLEHALLET
GIÆVER-RYGEN
RITSCHER-FLYA
AMUNDSENISEN
DRONNING MAUD LAND
COATS LAND
Lutzow-Holm Bay
Brunt Ice Shelf
Schirmacher Oasis
Fimbul-Isen
225 km
729 km
526 km
350 km
348 km
424 km
581 km
555 km
383 km
343 km
600 km
722 km
449 km
1081 km
683 km
1103 km
926 km
800 km
853 km
492 km
454 km
745 km
ALCI

Outline

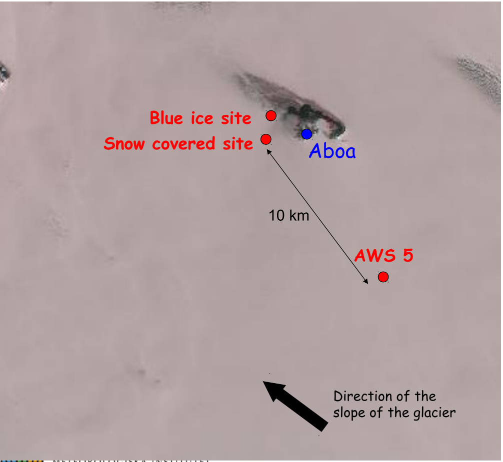
Objectives

- radiative fluxes over the snow and ice
- snow thermodynamic properties in summer
- flux-profile relationships in stable conditions
- the snow and ice surface energy balance
- wind, temperature and himidity profiles up to 2 km
- **Katabatic flows**

Where: Aboa station in Dronning Maud Land, 73°03′S, 13°24′W

When: December 2010 – January 2011.

Who: Priit Tisler, Timo Palo, Rostislav Kouznetsov



Sites:

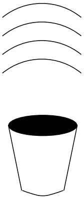
Snow: 10m weather mast,
3D sonic,
Radiation budget,
snow temperature profile

Blue ice: Radiation budget

AWS5: **10m weather mast,**
3D sonics (2m, 10m),
radiation budget,
SUMO, **sodar**,
Tethersonde, Snow pits

Aboa: Cloud camera,
Radiation budget

Sodar Basics



Single antenna:

- Delay – distance. $z = ct/2$
- Frequency shift – radial velocity. $v_r = c\Delta f/(2f)$
- Intensity – intensity of temperature fluctuations..

$$R \propto C_T^2 = C\frac{\varepsilon_\theta}{\varepsilon^{1/3}}$$

Three antennae:

- Wind speed profile
- Variances of radial components.

Sodar and Mast

Latan-3m Sodar:

- 3x120-cm dish antennae
- 6x100 ms signal 1600–2200 Hz
- Parallel operation @ 10 s
- 20 – 800 m range
- Raw echo signals stored

- Campbell 107-type thermometers at 5 levels (0.5, 1.2, 2.4, 4.7, and 10 m),
- 2D Gill WindSonics at same 5 levels,
- Kipp&Zonnen CNR4 radiation budget,
- Väisälä HMP45AC at 2 m,
- Campbell CSAT3 3D sonics at 2 and 10 m.

Sodar

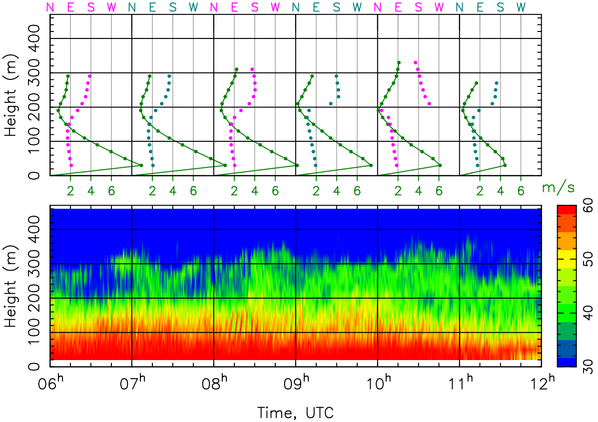
Katabatic winds

Katabatic winds:

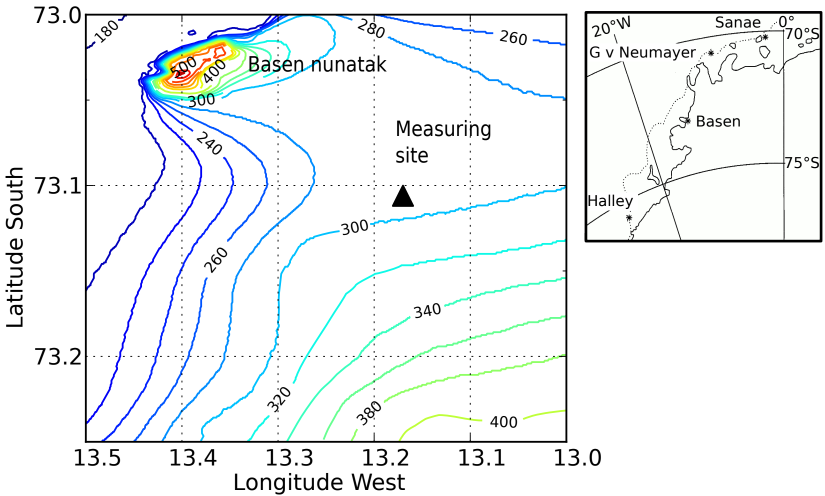
- occur above cold slopes
- driven by gravity
- affected by the Coriolis force over slight slopes

A special case of SBL:

- very shallow surface layer
- challenge for meteorological models
- aviation, wind energy ...

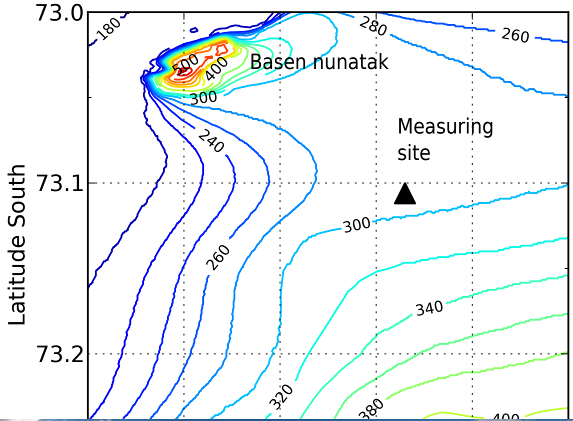


AWS5 site



Basen nunatak
Measuring site
Latitude South
Longitude West
73.0
73.1
73.2
13.5
13.4
13.3
13.2
13.1
13.0
180
280
260
500
400
300
240
260
300
340
320
380
400
20°W
Sanae
0°
70°S
G v Neumayer
Basen
75°S
Halley

AWS5 site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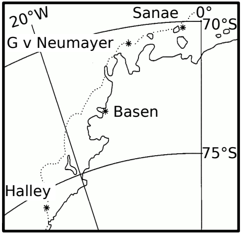
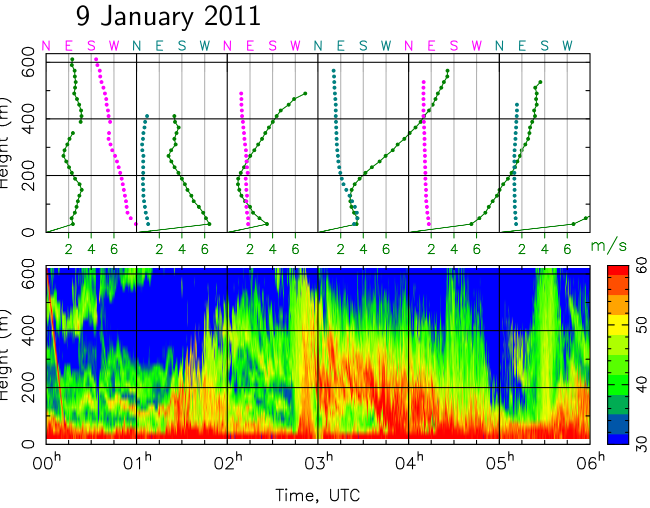

20°W
Sanae
0°
70°S
G v Neumayer
Basen
75°S
Halley

ABL structure



ABL affected by:

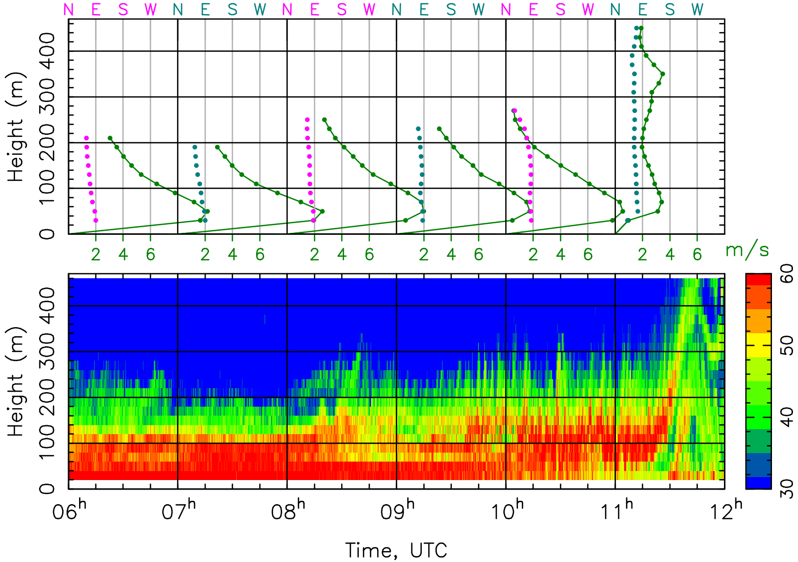
- synoptic-scale phenomena
- diurnal variations
- orography

Results in a complex ABL structure.

About 10 cases of clear steady katabatic flows were observed during 1.5 month campaign.

Deep katabatic flow

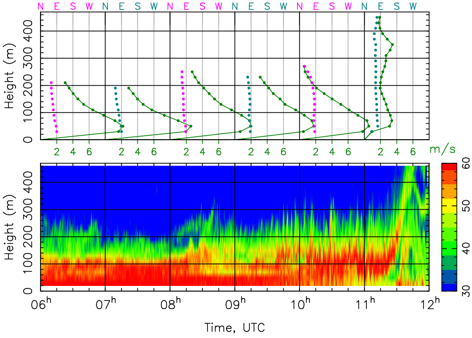
31 Dec 2010

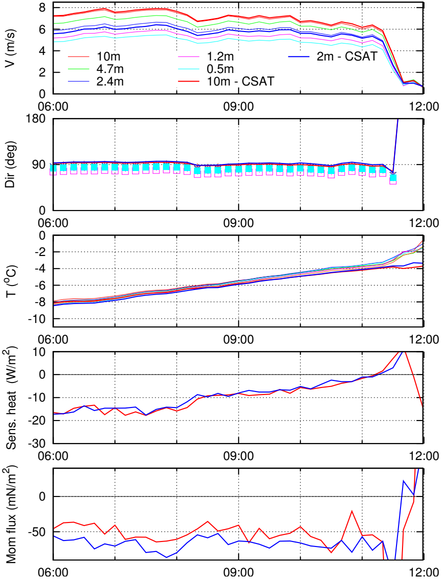


Deep katabatic flow

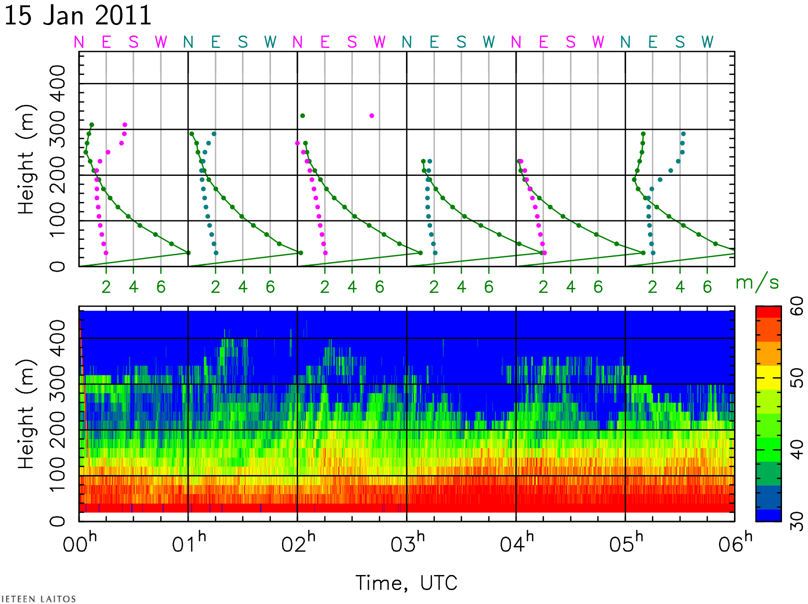
31 Dec 2010

- Very strong mixing
- No directional shear
- Small temperature gradient
- Small heat flux
- Linear heating





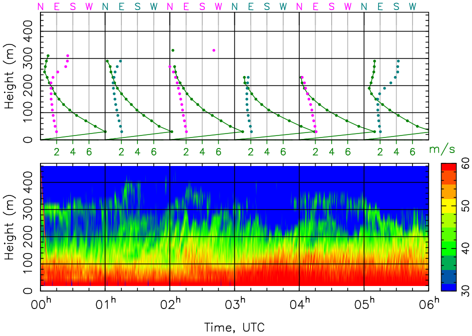
Shallow katabatic flow

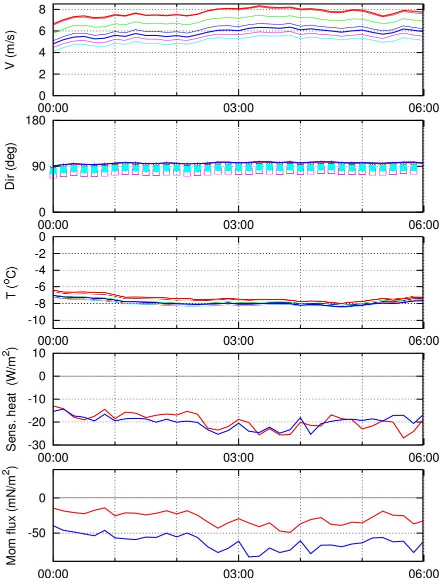


Shallow katabatic flow

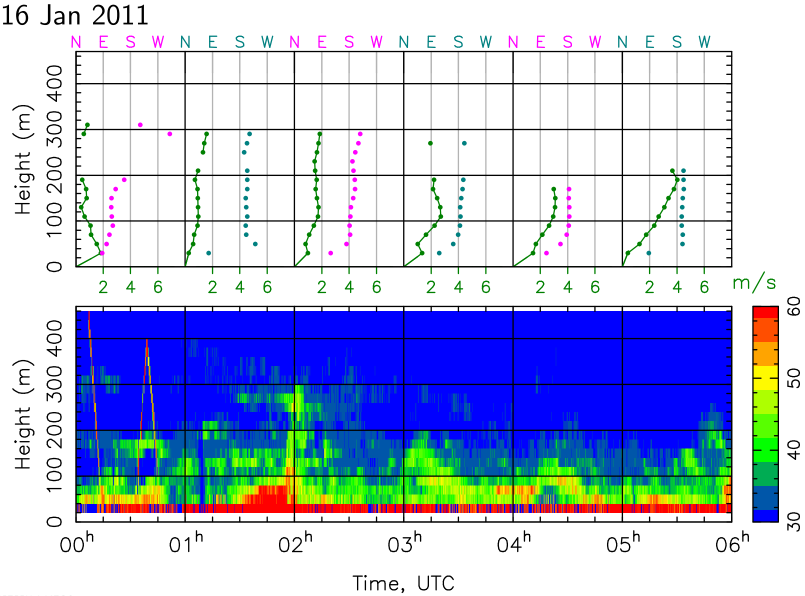
15 Jan 2011

- Strong mixing
- Weak directional shear
- Small temperature gradient
- Large heat flux





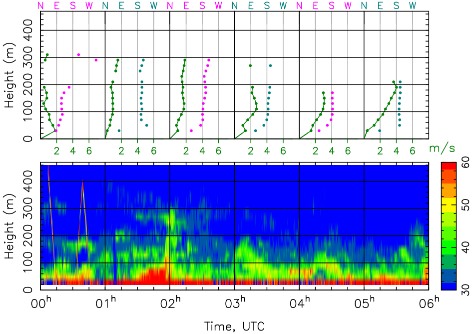
Very shallow katabatic flow

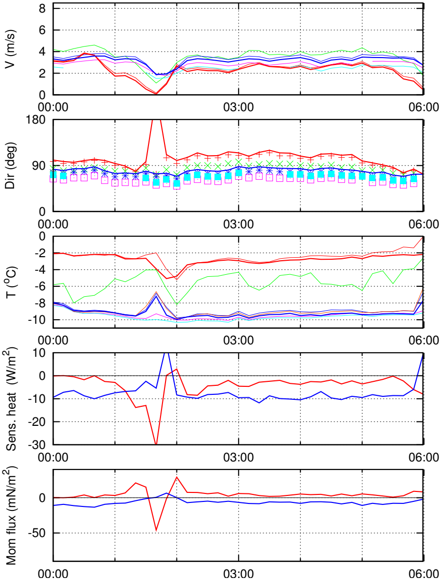


Very shallow katabatic flow

16 Jan 2011

- Weak mixing
- Strong directional shear
- Large temperature gradient
- Small heat flux





Summary

- The 1.5-month data set
- About 10 cases of undisturbed steady katabatic flows were observed
- The jet maximum of the katabatic flows could be as low as 5 m (10–50 m typically)
- Stronger jets – stronger heat flux – lower temperature gradient (and v.v.)
- The cases can be used to test simple 1D models of katabatic flows