P4.1 LONG-TERM TURBULENT FLUX MEASUREMENTS OVER ARCTIC FJORDS IN SVALBARD

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1. INTRODUCTION

The atmospheric boundary layer (ABL) in polar areas is poorly understood, especially where complex topography has an influence on its structure. Air-ice-sea interactions have been studied during several field campaigns (e.g. SHEBA, Uttal et al., 2002) that usually took place further away from coast and from significant influence of topography. In addition, the time series usually remain relatively short due to hard measuring conditions and remote locations. Svalbard, an archipelago in the Arctic Ocean, and its fjords provide an excellent location for long-term monitoring of the atmospheric boundary layer. In the fjords, distinctive meteorological conditions apply due to surrounding mountains, valleys and glaciers that transport cold air from inland regions over the fjords and strongly modify the wind patterns. The state of the ABL is also affected by seasonal sea ice cover and oceanographic phenomena such as polynyas, i.e., openings enclosed by sea ice. The main objective of this observational study is to gather more infromation about the characteristics of the ABL and turbulent fluxes in Arctic fjord systems.

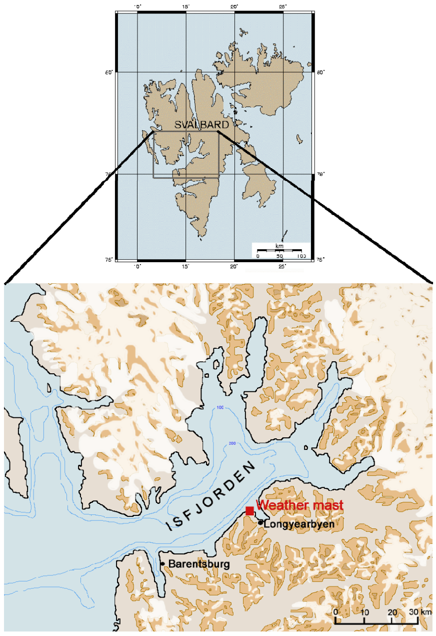

Figure 1. The measurement site on the coastline of Isfjorden Svalbard

2. MEASUREMENTS

In January 2008, long-term meteorological measurements on a 25 m tower on the coastline of Isfjorden, Svalbard (78° 15' N, 15° 28' E) (Figure 1) were started. Isfjorden covers an area of 3,084 km2 and it is orientated in southwest-northeast direction. At the measuring site, situated on the southern coast, there is an over fjord fetch of 25-40 km in the 175° wide sector (Figure 1). The sea ice cover is seasonal and in a normal sea ice year consists of fast ice in the inner part of the fjord and mostly open water with frazil ice and thin ice in the mouth area (Nilsen et al., 2008). Slow response wind speed and wind direction sensors are placed at four levels (at 9.8, 13.8, 18.8 and 24.8 metres above sea level) and temperature and humidity sensors at two levels (at 13.8 and 24.8 metres) on the mast. In addition, a sonic anemometer (CSAT3) placed on the mast (at 15.3 metres) measures turbulence at the rate of 20 Hz. Short-term measurements conducted over several other fjords in Svalbard will also be used to study differences in dissimilar fjords.

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Table 1. Monthly mean values of wind speed U, temperature T, relative humidity RH, stability z/L, momentum flux τ and sensible heat flux H during over fjord fetch

	number of 30-min averages	U (ms^{-1}) at 15.3 m	T (K) at 13.8 m	RH (%) at 13.8 m	z/L at 15.3 m	τ (Nm^{-2})	H (Wm^{-2})
FEBRUARY	256	7.8	261.7	68.8	-1.1	0.17	147.5
MARCH	37	4.3	258.7	69.1	-3.6	0.03	94.3
APRIL	262	6.5	264.1	67.5	-0.8	0.12	72.6

3. PRELIMINARY RESULTS FROM THE FIRST WINTER SEASON 2008

In winter 2008, Isfjorden remained mainly ice-free and due to mostly unstable conditions large amounts of sensible and latent heat were transferred from the sea to the atmosphere (Table 1). As seen in a case of decreasing wind speed, shown in Figure 2, the wind speed at the low level deviates from the logarithmic wind profile during high wind speeds. Further analysis is needed to find reasons for this and to exclude possible flow distortion at the lowest level.

The dimensionless temperature gradient ϕ_h, shown in Figure 3, and the dimensionless wind gradient ϕ_m are defined as:

$$\phi_h = \frac{kz}{\theta_*}\frac{\partial \Theta}{\partial z} \quad (1) \quad \text{and} \quad \phi_m = \frac{kz}{u_*}\frac{\partial U}{\partial z} \quad (2)$$

where k is von Karman constant, z is height, θ_* is scaling temperature, Θ is mean potential temperature, U is mean wind speed and u_* is friction velocity. The dimensionless temperature gradient as a function of stability z/L seems to fit well the commonly used curve of Högström (1996) (shown in Figure 3):

$$\phi_h = 0.95\left(1 - 11.6\frac{z}{L}\right)^{-1/2} \quad (3)$$

The dimensionless wind gradient (not shown) instead seemed to have much lower values in near-neutral conditions compared to the commonly used curve of Högström (1996). This is possibly due to the influence of waves (e.g. Smedman et al., 1999). More detailed analysis will be done to understand reasons for this deviation.

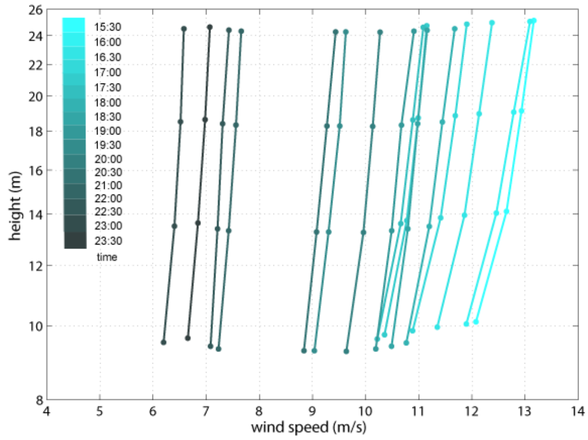

Figure 2. Temporal development of wind speed profile on 17th of April 2008. Stability z/L is decreasing with time from -0.16 to -0.55.

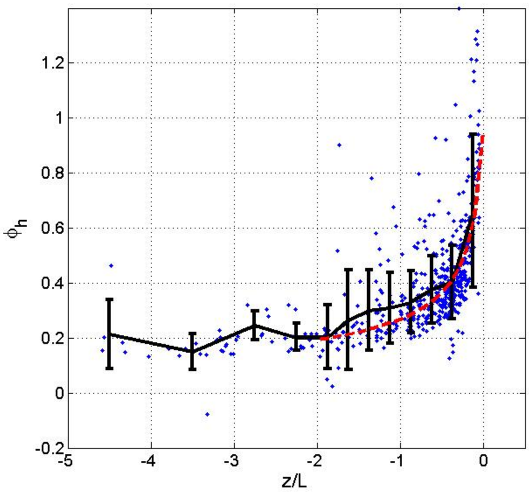

Figure 3. The dimensionless gradient of temperature as a function of stability. The bars show the standard deviation from the bin-averaged values.

REFERENCES

Högström U. (1996): Review of some basic characteristics of the atmospheric surface layer. Bound.-Layer Meteorol.,78, 215-246.

Nilsen F., Cottier F., Skogseth R. and Mattson S. (2008): Fjord-shelf exchanges controlled by ice and brine production: The interannual variation of Atlantic Water in Isfjorden, Svalbard. Continental Shelf Research, doi:10.1016/j.csr.2008.04.015.

Smedman A., Högström U., Bergström H., Rutgersson A. Kahma K. K. and Pettersson H. (1999): A case-study of air-sea interaction during swell conditions. J. Gephys Res., 104(C11), 25833-25851.

Uttal T., Curry J. A., McPhee M. G., Perovich D., Moritz R.E., Maslanik J. A., Guest P. S., Stern, H. L., Moore J. A., Turenne R., Heiberg A., Serreze M. C., Wylie D. P. Persson O. G., Paulson C. A. Halle C., Morison J. H., Wheeler P. A., Makshtas A., Welch H., Shupe M. D., Intrieri J. M. Stamnes K., Lindsey R. W., Pinkel R. Pegau W. S., Stanton T. P. and Grenfeld T. C. (2002): The Surface Heat Budget of the Arctic Ocean. Bull. Amer. Meteorol. Soc., 83, 255-276.