Alfred Wegener Institute for Polar and Marine Research

Potsdam Research Unit

THE NEAR-SURFACE SMALL-SCALE SPATIAL AND TEMPORAL VARIABILITY OF SENSIBLE AND LATENT HEAT EXCHANGE IN THE SVALBARD REGION: A CASE STUDY

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Background and motivation

In this work eddy covariance measurements for determining the sensible heat flux, latent heat flux and the shear stress near the earth's surface are presented. Two systems at different sites are considered in the following investigations, one measures continuously close to the village Ny-Ålesund (N 78° 55.287', E 011°54.851') since September 2010, the other one was located on Kongsvegen glacier (N 78° 50.725', E 012°40.106') for a short period in April 2011 contemporary to the Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project (PAMARCMiP) 2011. The comparison of the measured data for a selected period in April 2011 shows an example of the possible small scale spatial variability of exchange processes depending on the topographic site conditions and synoptic influences. Further, data of November 2010, evaluated at the site Ny-Ålesund are shown as example of the possible small scale temporal variability of exchange processes, in detail the formation of external gravity waves in polar night conditions. All this work shall lead to a better understanding of the exchange processes in the Arctic Atmospheric Boundary Layer.

Sites, methods and results

synchronization

Spatial variability of exchange processes comparing two measurement sites

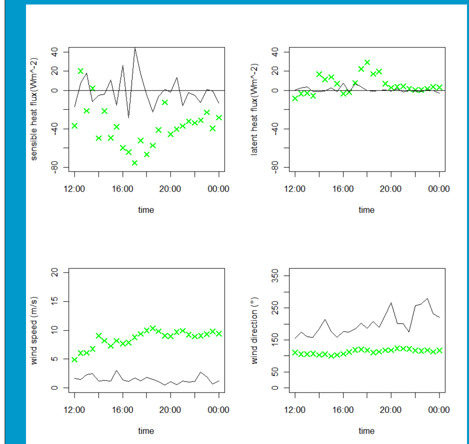

Figure 1: Sensible heat flux, latent heat flux, wind speed and wind direction for the period 8 April 2011 12:00 – 24:00 UTC. The green crosses are values from the Kongsvegen site, the black line from the site near Ny-Ålesund.

Figure 2: The Kongsfjord region on Svalbard (left side), including both measurement sites Ny-Ålesund and Kongsvegen glacier (marked with arrows). The overview picture is taken from Westermann, 2010. The right picture (Papadopoulos, 2010) shows the Kongsvegen glacier in big, where the eddy covariance system was placed approximately where the dot is.

Processes with high spatial variability, mainly depending on the surrounding orography and the surface properties (Figure 1) have been found. On the Kongsvegen glacier the quite high wind speeds (most probably influenced by katabatic outflow) and therefore shear stress lead to negative sensible heat fluxes and positive latent heat fluxes. Nearby Ny-Ålesund the wind is weak at the same time, sensible and latent heat flux are fluctuating around zero. The general synoptic situation is able to neutralize this situation. A synchronization of the sensible and latent heat fluxes at the two measurement sites can then be noticed, if there is for example a low pressure system with wind from western directions passing through (Fig. 3).

Instrumentation for both eddy systems:

- CSAT3 sonic anemometer
- Licor 7500 infrared hygrometer
- data processing for both stations was made with the international compared eddy covariance software TK3 (Mauder and Foken, 2011; Mauder et al., 2008)

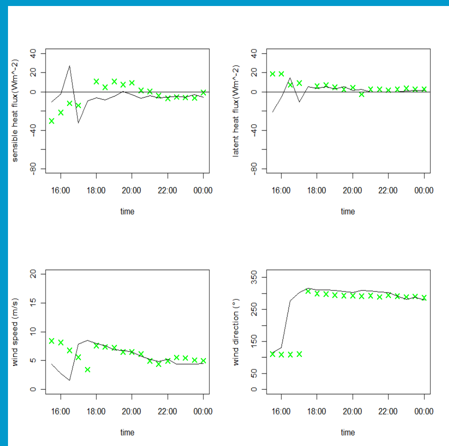

Figure 3: Sensible heat flux, latent heat flux, wind speed and wind direction for the period 9 April 2011 15:30 – 24:00 UTC. The green crosses are values from the Kongsvegen site, the black line from the site near Ny-Ålesund.

Temporal variability of exchange processes at one measurement site

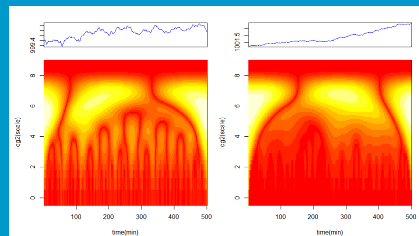

Figure 4: Wavelet coefficients of air pressure in 2 meters height for the period 6 November 2010, 08:00 – 16:00 UTC (left panel). Wavelet coefficients of air pressure in 2 meters height for the period 8 November 2010, 08:00 – 16:00 UTC (right panel). Mexican hat wavelet was used. Scale means in this context delta(signal) * c (c is a continuous numbering vector with the length of the investigated signal range)

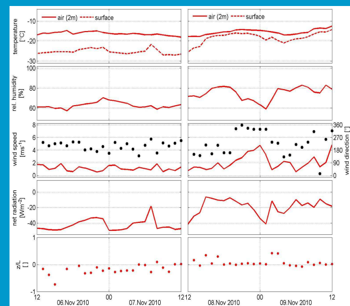

Figure 5: Temperature at 2 m and at the surface, humidity, wind velocity (line) and wind direction (dots), radiation budget and the stability parameter z/L for the time period 6 November 2010 – 9 November 2010 (from the top to the bottom). On the left panel a period with gravity waves is depicted. It is visible, that there occurs an inversion and the wind with quite small wind velocities is coming from about 210°. The radiation budget is negative because of longwave radiation loss of the surface. z/L is negative because of the fictitious positive sensible heat flux, which was measured due to the existence of the gravity waves. On the right panel a period without gravity waves is shown, the inversion is almost gone, the wind speed is larger, the wind direction is different. The radiation budget is nearly around zero because of clouds (less longwave radiation loss), the stability parameter is zero or positive.

Processes with high temporal variability at one site (here Ny-Ålesund) have been found. Under special conditions like clear sky (high longwave radiation loss), calm wind and wind direction between 180 and 240° (Figure 5), external gravity waves are able to develop (Figure 4 left panel), triggered by a strong near-surface temperature inversion and the katabatic outflow of the Broggerbreen glacier in the south-west of Ny-Ålesund. This wave motion shows a strong correlation between temperature and the vertical wind, which would lead to fictitious fluxes using the eddy covariance method.

Included in data processing with TK 3:

- coordinate rotation (double rotation)
- calculation sensible heat from buoyancy flux
- spike detection
- quality flag scheme after Foken (1999)

Details in Mauder and Foken (2011)

Conclusions

The best way to deal with the temporal variability due to gravity waves: filtering the raw turbulence data and so getting rid of the unwanted longwave components. The best way to deal with the spatial variability: operating measurements on different sites and then comparing. Further investigations are required and ongoing.

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