Surface Fluxes and Boundary-layer Measurements in Arctic at the Eureka (Canada) and Tiksi (Russia) Climate Observatories

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In this study we analyze and compare variability of turbulent surface fluxes including water vapor and carbon dioxide transfer based on measurements made at two different sites located near the coast of the Arctic Ocean at Eureka (Canadian territory of Nunavut) and Tiksi (East Siberia). Turbulent fluxes and mean meteorological data are measured continuously and reported hourly at various levels on 10-m (Eureka) and 20-m (Tiksi) flux towers. Sonic anemometers and Licor 7500 infrared gas analyzer are used to measure turbulent fluxes. Tower-based eddy covariance and solar radiation measurements provide a long-term near continuous temporal record of hourly average mass and energy fluxes respectively. The turbulent data are supported by additional atmospheric and surface/snow/permafrost measurements. The data show that sensible heat flux, water vapor and carbon dioxide fluxes were small and mostly irregular in the cold seasons when the ground is covered with snow. However, the turbulent fluxes increase rapidly when air temperatures rise above freezing during spring melt and eventually reach a summer maximum. According to our data, strong upward sensible and latent heat fluxes are observed throughout the summer months indicating unstable (convective) conditions on average. This study also shows that the sensible heat flux, water vapor, and carbon dioxide fluxes exhibit clear diurnal cycles during the Arctic summer. This behavior of the sensible heat flux is similar to the diurnal variations in mid-latitudes in summer. On average the turbulent flux of carbon dioxide was mostly negative (uptake by the surface) in summer indicating that the Eureka and Tiksi Arctic sites are net sinks for atmospheric CO_2 during the growing season. This result is not unexpected as both Eureka and Tiksi have a summer surface that is extensively covered with vegetation. It is also found that in a summer period observed temporal variability of the carbon dioxide flux was generally in anti-phase with water vapor flux (downward CO_2 flux and upward H_2O flux). During late summer and early autumn all turbulent fluxes rapidly decreases in magnitude when the air temperature decreases and falls below freezing. Although the Tiksi and Eureka sites have general similarities in annual surface fluxes, some more detailed differences in net characteristics are investigated resulting from such phenomena as the on-shore flow from the Laptev Sea in Tiksi which is absent at the more land-locked Eureka site.

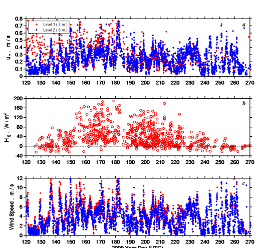

Figure 1. Time series of the hourly averaged (a) friction velocity, (b) sensible heat flux (Hs), and (c) wind speed for the Eureka site obtained during May-September 2009 (YD 120-270). Measurements were made by sonic anemometers located at 3 and 8 m above the surface. Positive values of Hs correspond to the unstable (convective) conditions and vice versa. Hourly averages of the sensible heat flux show large diurnal variations during summer.

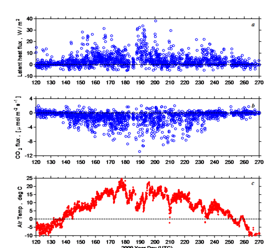

Figure 2. Time series of the hourly averaged fluxes of (a) H_2O, (b) CO_2, and (c) air temperature for the Eureka site obtained during May-September 2009 (YD 120-270). Measurements were made by sonic anemometers and Licor-7500. Negative signs mean downward fluxes and vice versa. Hourly averages of the fluxes and air temperature show large diurnal variations during summer.