Boundary-layer measurements and surface fluxes in Arctic at the Eureka (Canada) and Tiksi (Russia) climate observatories

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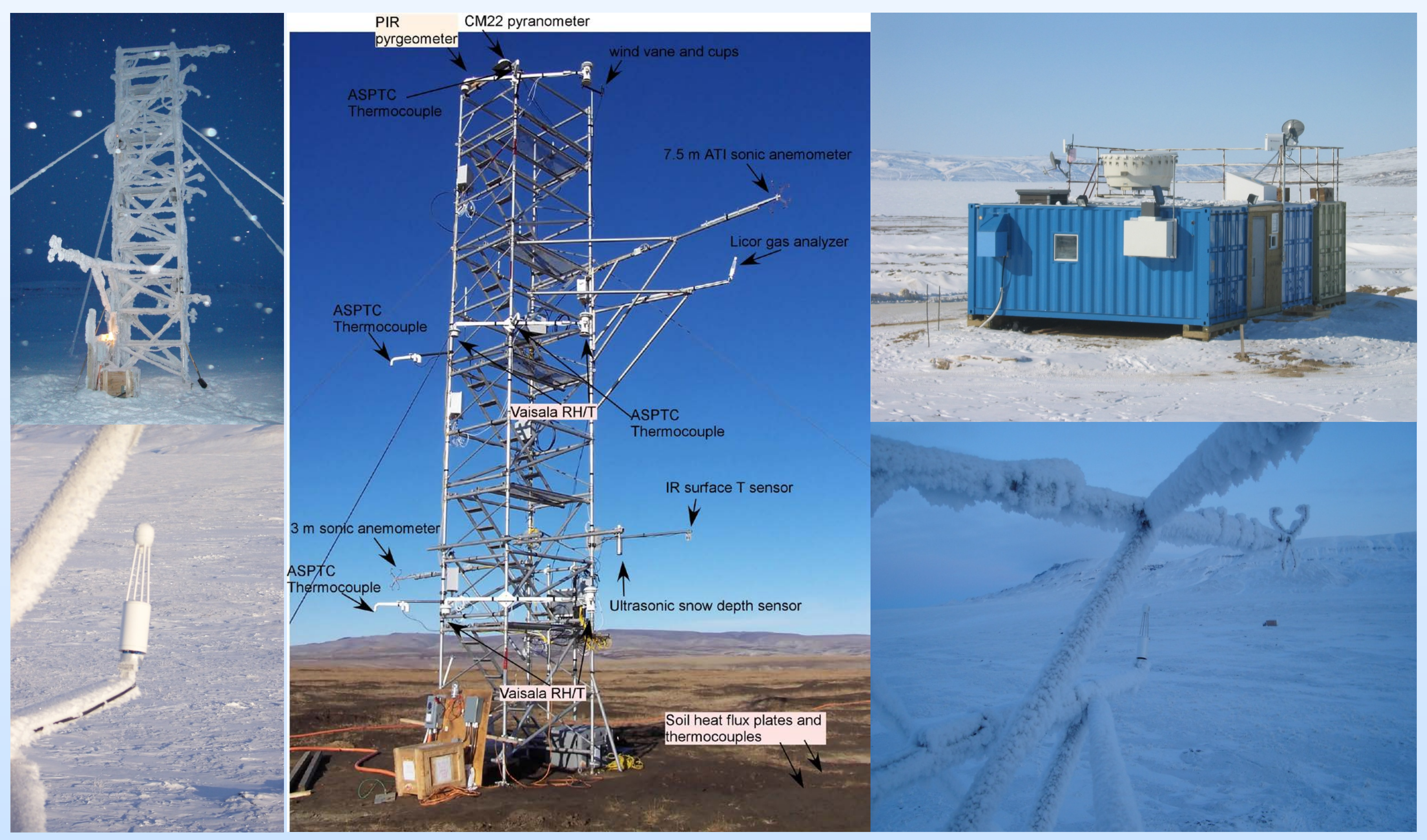
European Geosciences Union, General Assembly 2012, Vienna, Austria, 22–27 April 2012, Session: AS2.3 Boundary Layers in High Latitudes: Physical and Chemical Processes Including Atmosphere-Ice Chemical Interactions (AICI)

Eureka Observatory

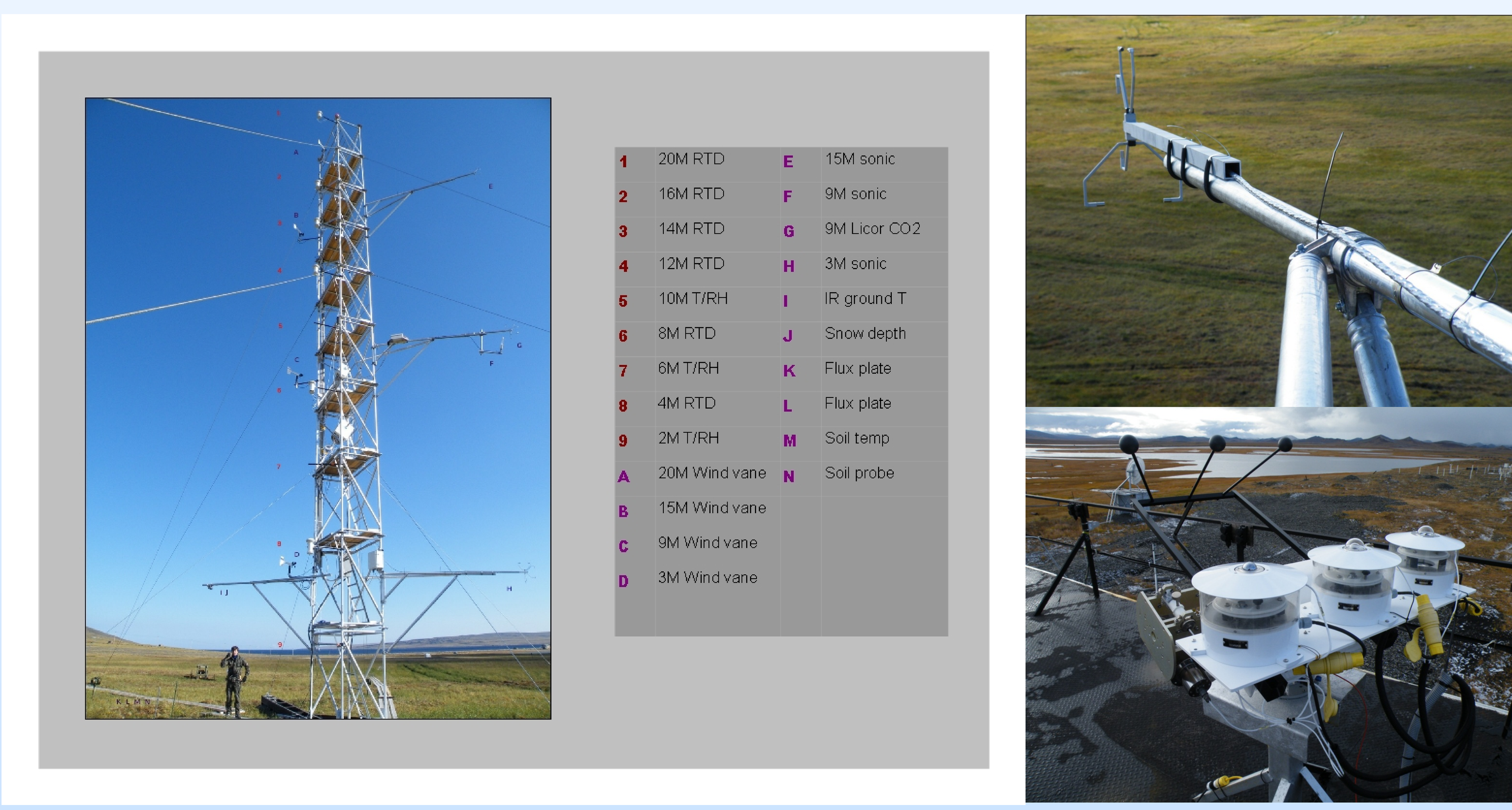
At the Eureka site (80.0 N, 85.9 W) located near the coast of the Arctic Ocean (Canadian territory of Nunavut) many instruments were installed in summer 2007. These include, but are not limited to, a flux tower, a tropospheric ozone lidar and instrumentation that allows Eureka to become a part of the Baseline Surface Radiation Network (BSRN). With IPY funding the level of technical support at the site has been increased to provide an enhanced level of operations and greater operational flexibility, both necessary to pursue measurements of events that are rapidly evolving or have fallen outside normal operational constraints.



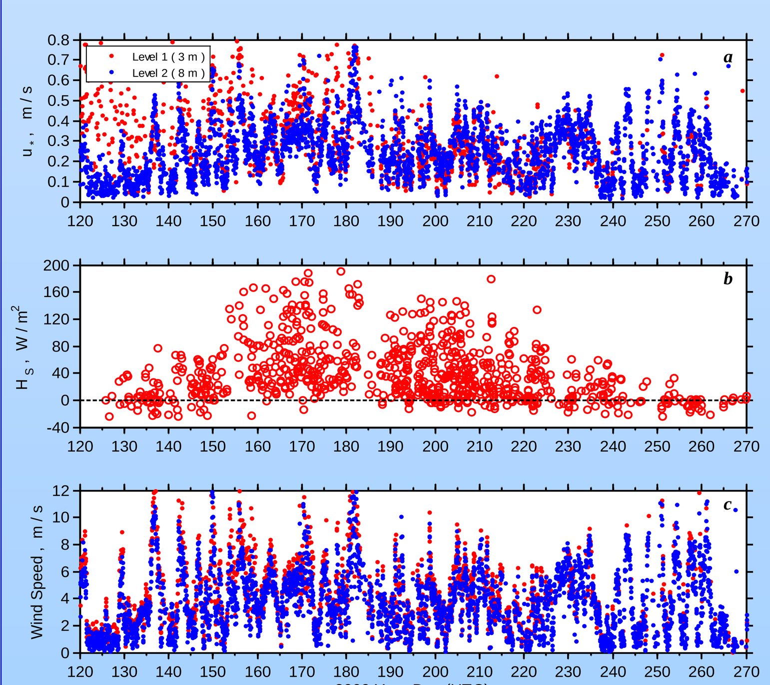
This study focuses on variability of surface fluxes based on measurements made at two different sites located near the coast of the Arctic Ocean at Eureka (Canada) and Tiksi (Russia). Turbulent fluxes and mean meteorological data are measured at various levels on 10-m (Eureka) and 20-m (Tiksi) towers. 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.

Tiksi Observatory

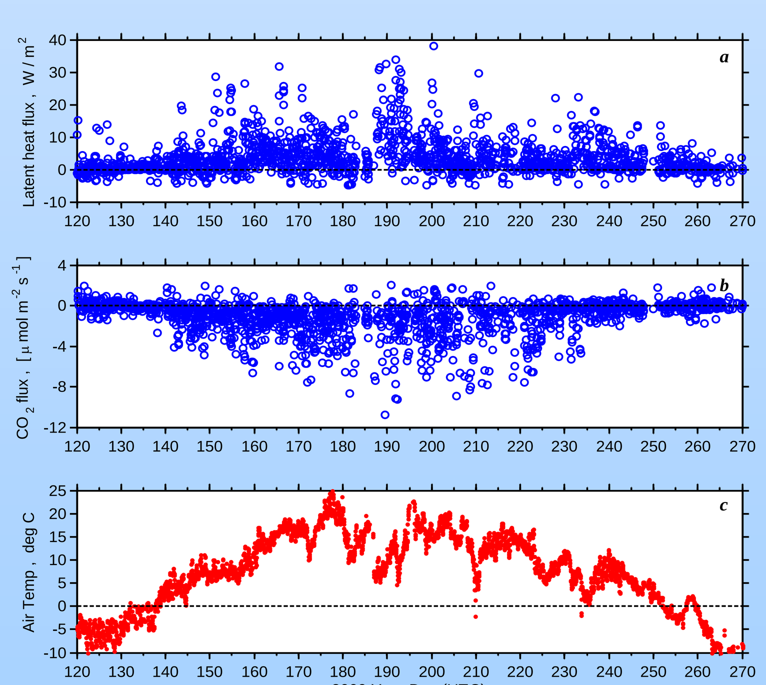
Russian Tiksi weather station located in East Siberia (71.6 N, 128.9 E) was established at the Polyarka settlement on August 12, 1932 by the chief management of the northern sea route that began collecting geophysical data. The "Polyarka" observatory is located five miles out of town Tiksi. This is now the location for a new Intensive Arctic Observatory site representing a partnership between the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). This facility supports the research needs of the International community, across disciplines including supporting Global Atmosphere Watch measurements as well as other climate observations.



Seasonal Cycle of Turbulent Fluxes at Eureka

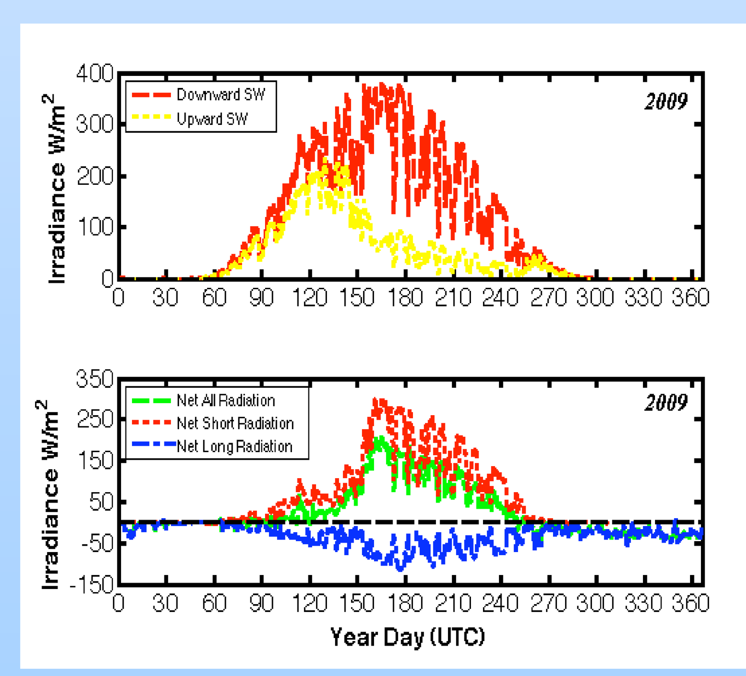


Time series of the hourly averaged (*a*) friction velocity, (*b*) sensible heat flux (H_s), and (*c*) wind speed for the Eureka site obtained during May-September 2009 (YD 120-270). Measurements were made by sonic anemometers located at 3 and 8 m above the surface. Positive values of H_s correspond to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

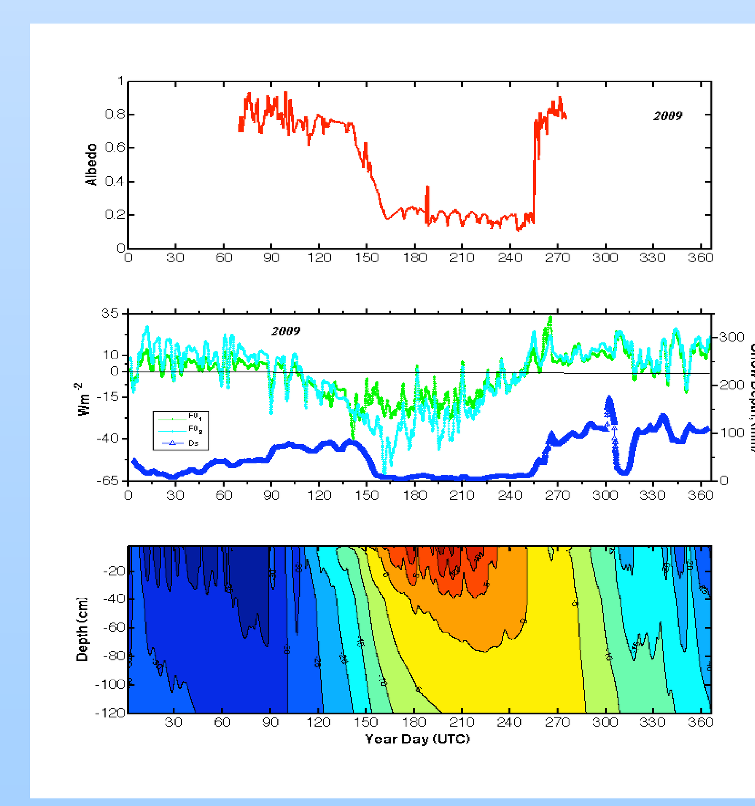


Time series of the hourly averaged fluxes of (*a*) H_2O, (*b*) CO_2, and (*c*) air temperature for the Eureka site obtained during May-September 2009 (YD 120-270). Measurements were made by sonic anemometers and Licor-7500. Negative signs mean downward fluxes and vice versa. Hourly averages of the fluxes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

Seasonal Cycle of Radiative Fluxes at Eureka

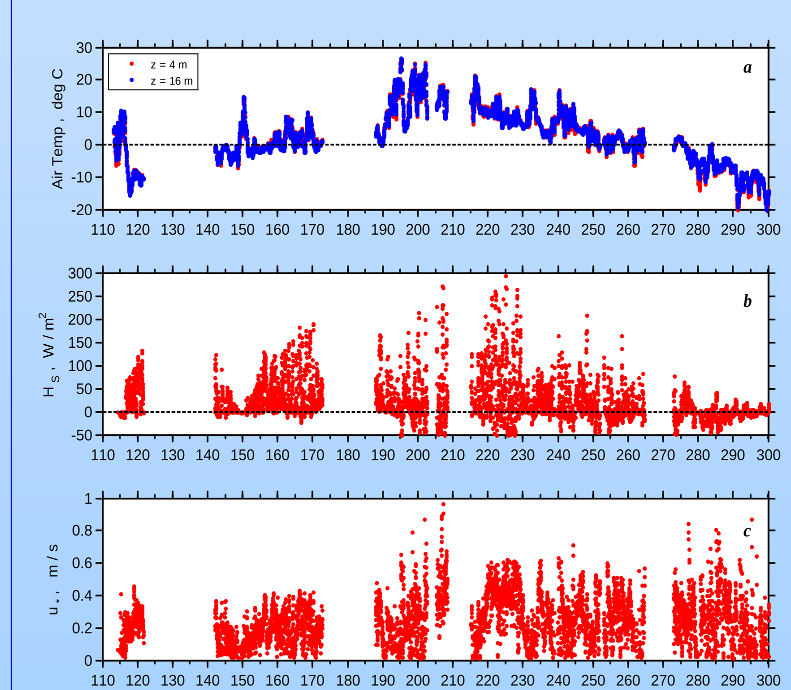


Annual cycles of the daily averaged short-wave radiation (Kipp&Zonen CM22) and the net radiative energy, measured at the Eureka Flux Tower during 2009. Long-wave radiation component was measured by Eppley PIR

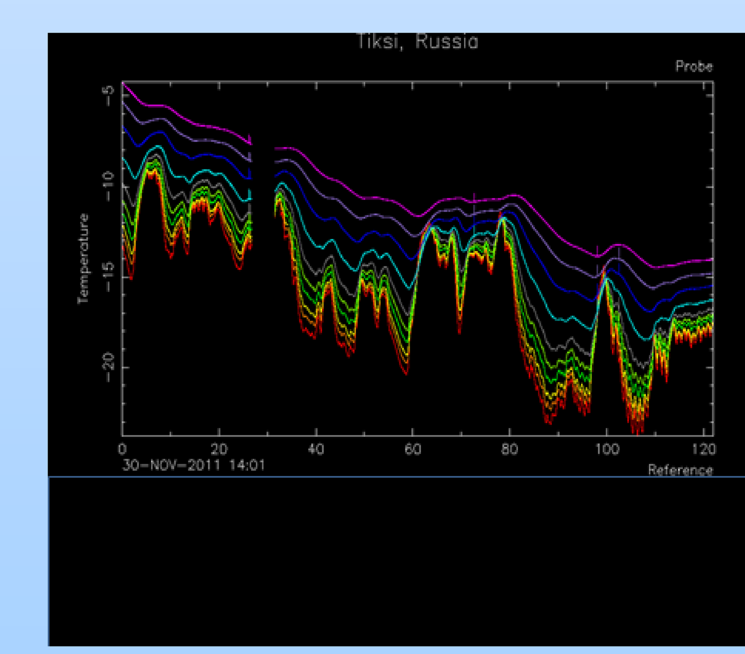


Annual cycles of daily averaged albedo (SWU/SWD); snow depth (5 days averages) (sonic ranging sensor) and daily averaged soil heat flux, plate 1 (placed in the grass area) and plate 2 (placed in raised mud). Contour plot of the daily averaged near surface soil and active layer temperatures, measured at the 11 levels (2, 5, 10, 15, 20, 25, 30, 45, 70, 95, 120 cm) below the surface (PRT sensor PT100/MRC soil probe)

Seasonal Cycle of Surface Fluxes at Tiksi



Time series of the 30-min averaged (*a*) air temperature, (*b*) sensible heat flux (H_s), and (*c*) friction velocity for the Tiksi site obtained during April-October 2011 (YD 110-300). Measurements were made at 4 and 16 m above the surface. Positive values of H_s correspond to the unstable (convective) conditions and vice versa. Turbulent fluxes are based on the gradient method.



Time series of the soil temperature at different levels for the Tiksi site obtained during December 2011-March 2012. Note a remarkable a warm event in February 2012, lasting about two weeks, has impacted soil temperature dramatically. The big warm-up event was due to the coupling of the Aleutian Low and high pressure ridge extending well into the Arctic western Canada.