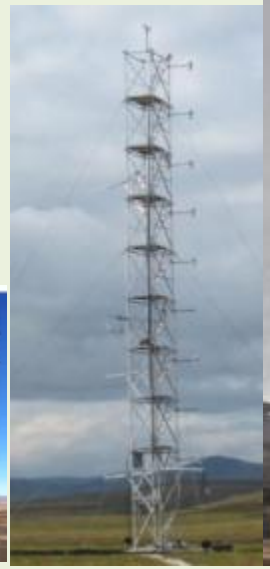
An Observational Arctic Flux Network Supporting the International Arctic Systems for Observing the Atmosphere (IASOA) and Global Cryosphere Watch (GCW)

Taneil Uttal, Andrey Grachev, Irina Repina, Ola Persson, Jeffrey Key
Presented by Bill Neff

Alert
2 m

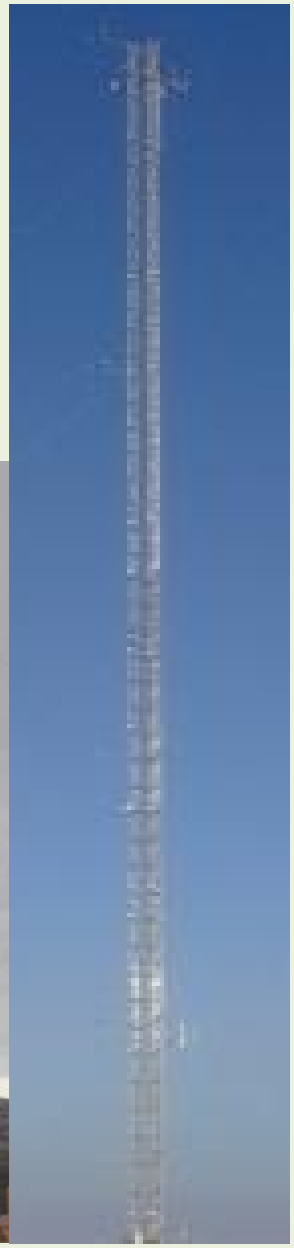
Eureka
10 m

Tiksi
20 m



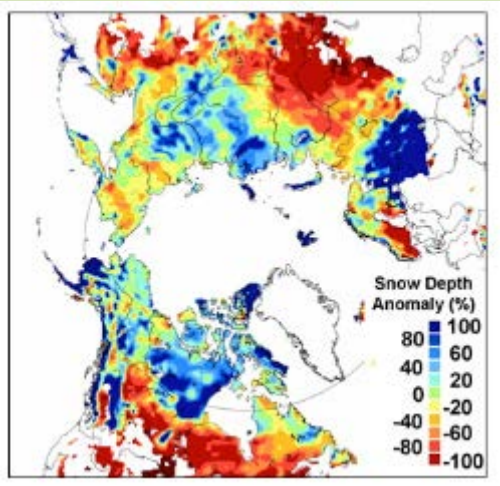
Ny-Alesund
30 m

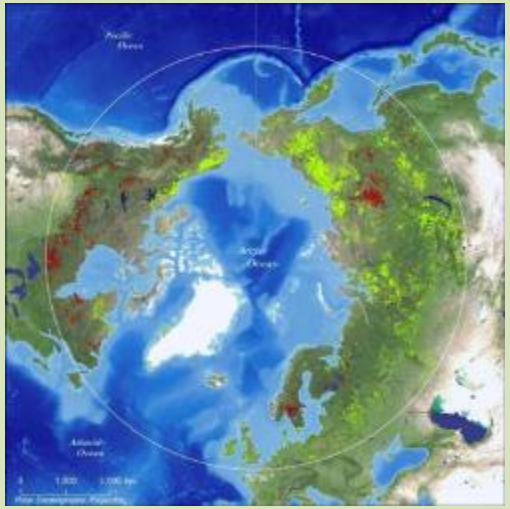
Summit, Greenland
50 m

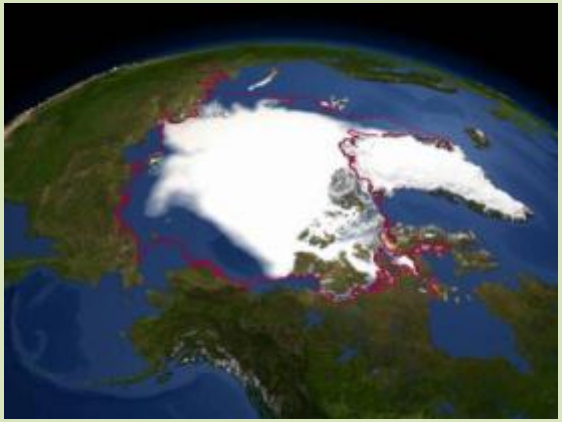


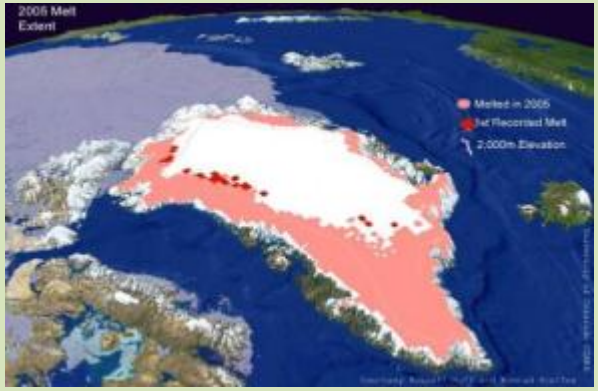
The bottom line (literally) is the W/m^2 (the irradiance) transferred between the atmosphere and the surface - the SURFACE ENERGY BUDGET (SEB)

- Sea Ice Extent
- Seasonal Snow Extent
- Onset of melt and freeze
- Permafrost morphology
- Green house gases fluxes
- Greening of the Arctic
- Glacier melt









Surface Energy Balance

The surface energy balance is usually defined with respect to an active layer of infinitesimal small thickness. In this case the storage of energy in the layer can be neglected and the energy balance equation takes the form:

$$S\downarrow(1-\alpha) + L\downarrow - L\uparrow + H + L_vE = G$$

or, summarizing the radiation fluxes:

$$NR + H + L_vE = G$$

In the Arctic S goes Away for much of the year

In the Arctic α is typically quite large

where

NR:	net radiation
$S\downarrow$:	global radiation
α :	albedo
$L\downarrow$:	atmospheric counter-radiation
$L\uparrow$:	terrestrial emission
H:	sensible heat flux
L_vE:	latent heat flux
G:	Surface heat flux

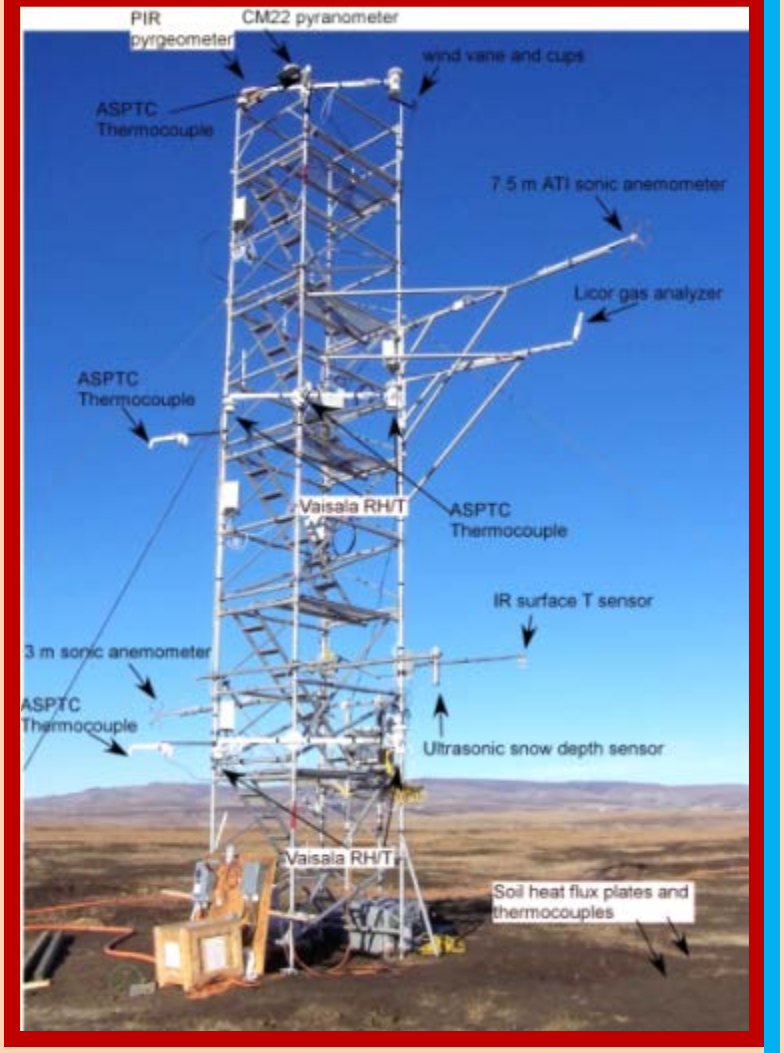
Sign convention
Fluxes are considered positive when directed toward the surface (energy sources) and negative when directed away from the surface (energy sinks). Exceptions are $L\uparrow$ and a $S\uparrow$ (outgoing radiation fluxes), for which a minus sign is explicitly used in the energy balance equation.

http://www.iac.ethz.ch/education/bachelor/climate_systems/notizen/Surface-Energy-Balance.pdf
The Institute for Atmospheric and Climate Science (IACETH) is part of the Department of Environmental Sciences (D-UWIS) of the Swiss Federal Institute of Technology Zurich (ETH Zurich).
The IACETH is active both in research and education.

Measuring the Components

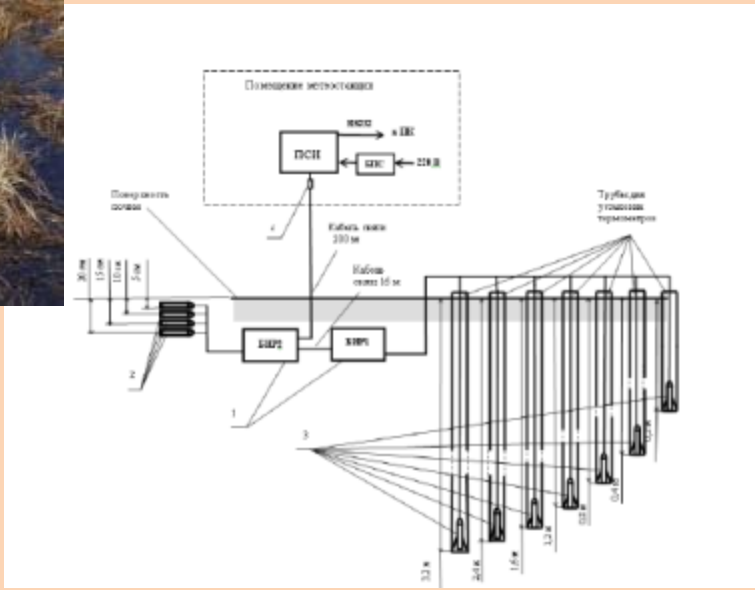
$$S\downarrow(1-\alpha) + L\downarrow - L\uparrow + H + L_v E = G$$

Deploy LOTS of Radiometers, Photometers, Anemometers, Thermometers, Humidity Sensors (Gas Samplers)

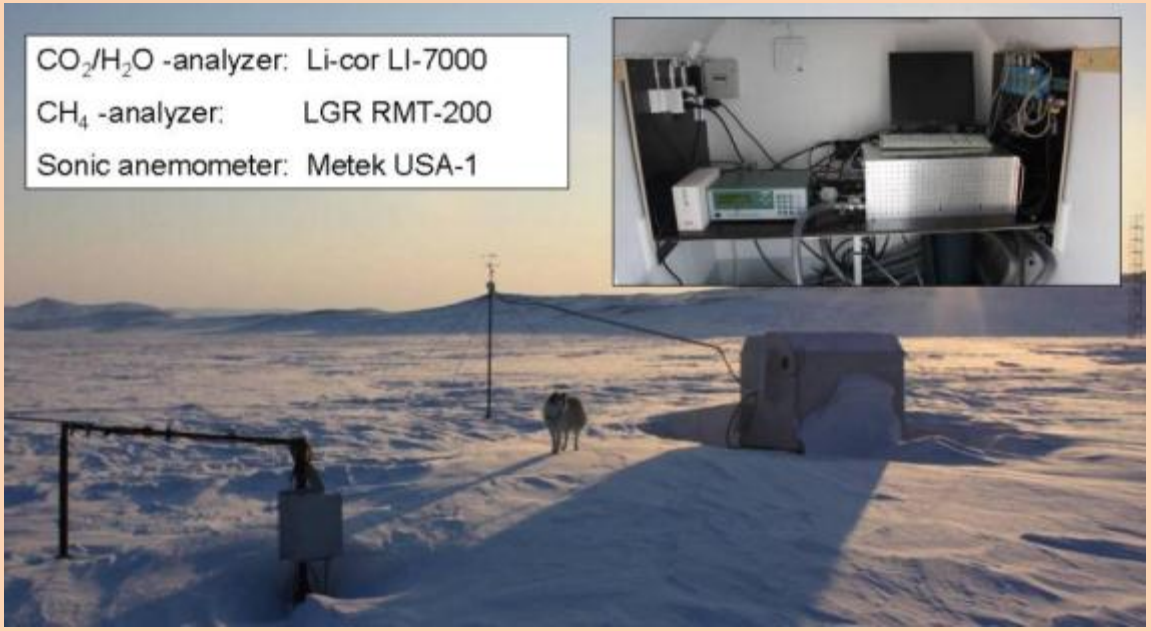


Measurements to Provide Closure

- Active Layer Temperatures
- Snow Depth
- Vegetation Surveys
- Heat Flux Plates



Gas Samplers (CH_4, CO_2, H_20)



Tower Mounted Li-cor Li-7500
ATI SAIK-3K Sonic CO_2 and H_2O

Advance Acknowledgements for Following Slides

- Ola Persson (CIRES)
- Andrey Grachev (CIRES)
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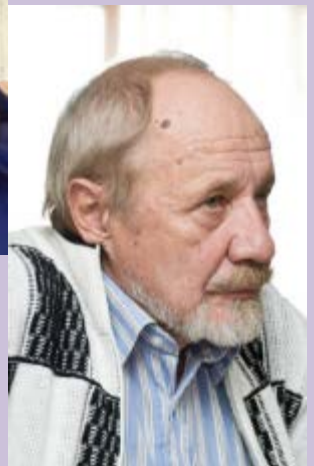
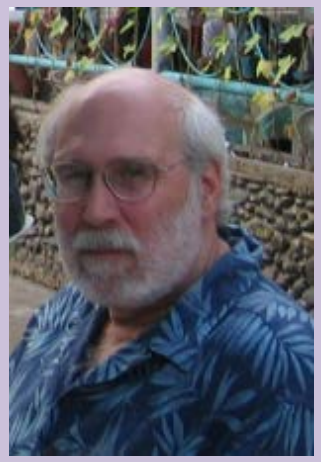
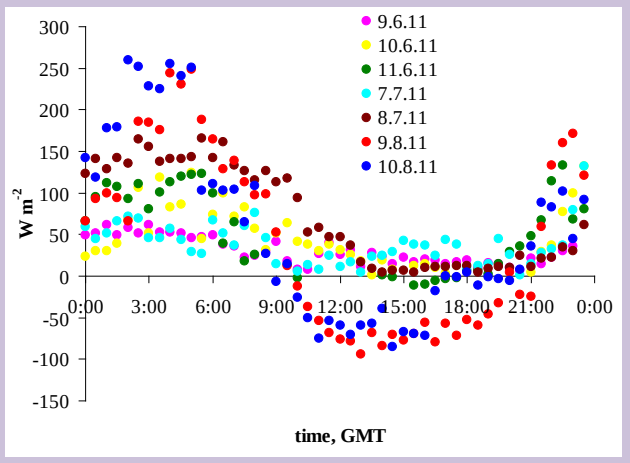
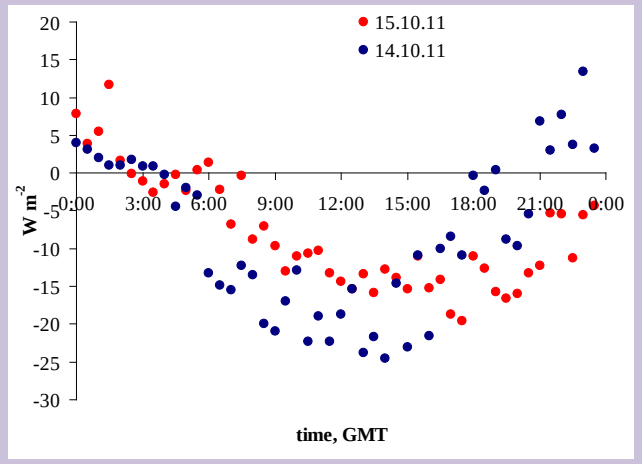
- Arseniy Artamanov (IFARAN)
- Tuomas Laurila (FMI)
- Mika Aurela (FMI)
- Alexander Makshtas (AARI)
- Robert Stone (CIRES)
- Many Others……

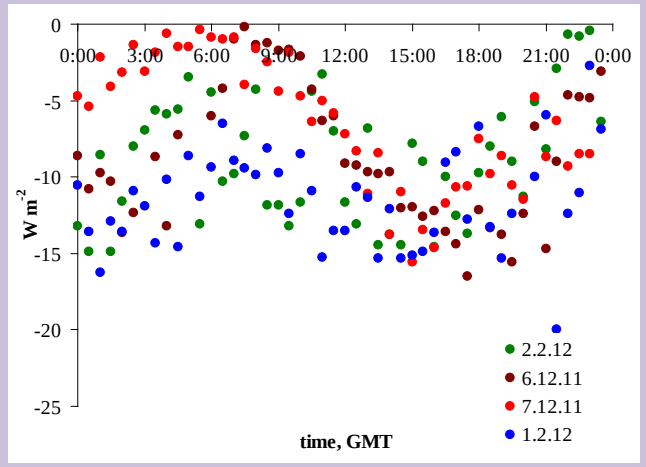



I. Repina and A. Artamanov – Diurnal Variability can be observed in Fluxes for all seasons with net positive flux in the summer and net negative flux in the winter

TIKSI





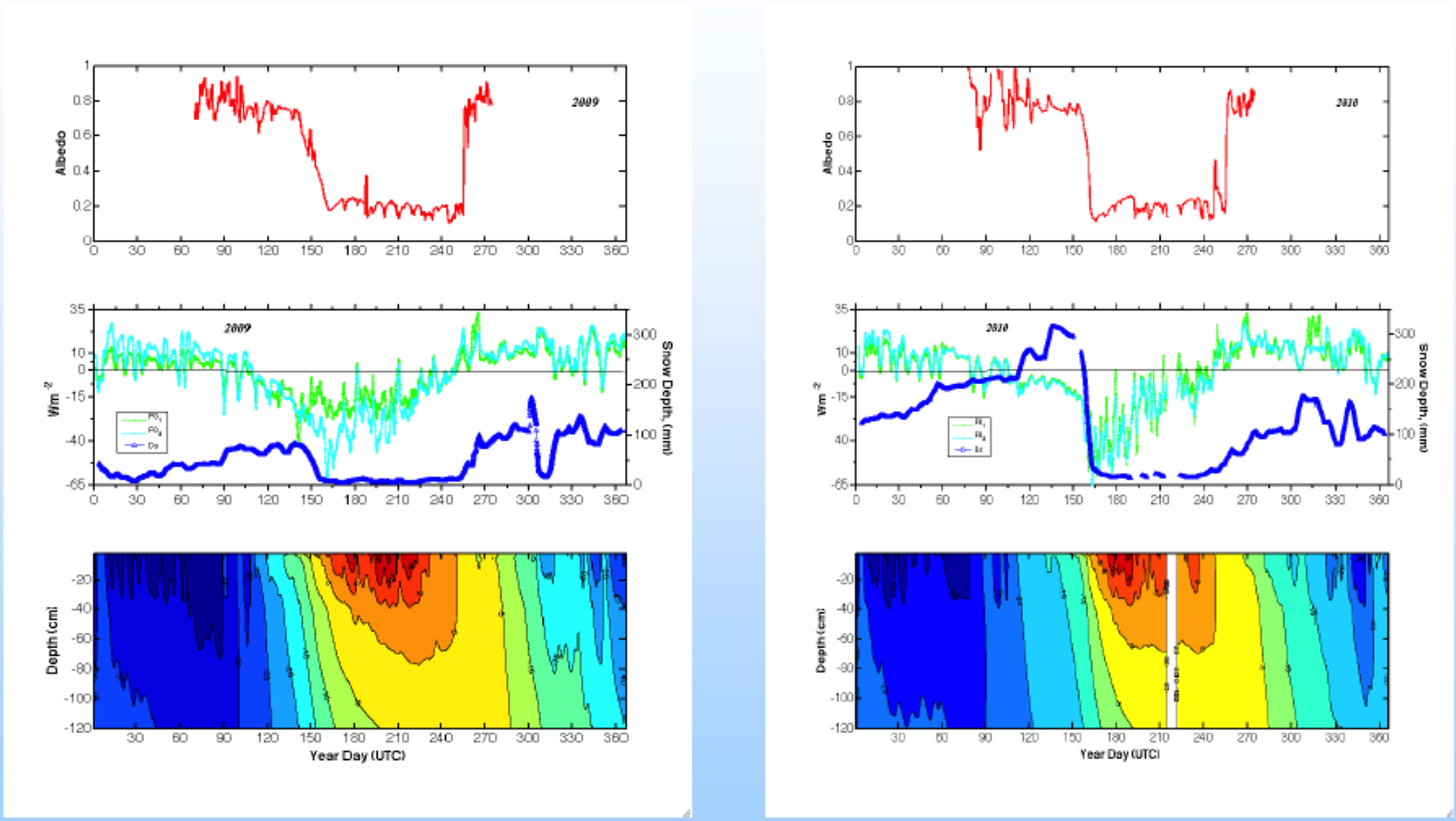


Summer Fall Winter

Measurements were made at 4 and 16 m above the surface. Turbulent heat flux was calculated from gradient method on two level. Positive values of heat flux correspond to the unstable (convective) conditions and vice versa.

A. Grachev and L. Matrosova – Net Heat Flux and Snow Depth can vary considerably from year to year with consequent impacts on the active layer temperature structure

Eureka



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).

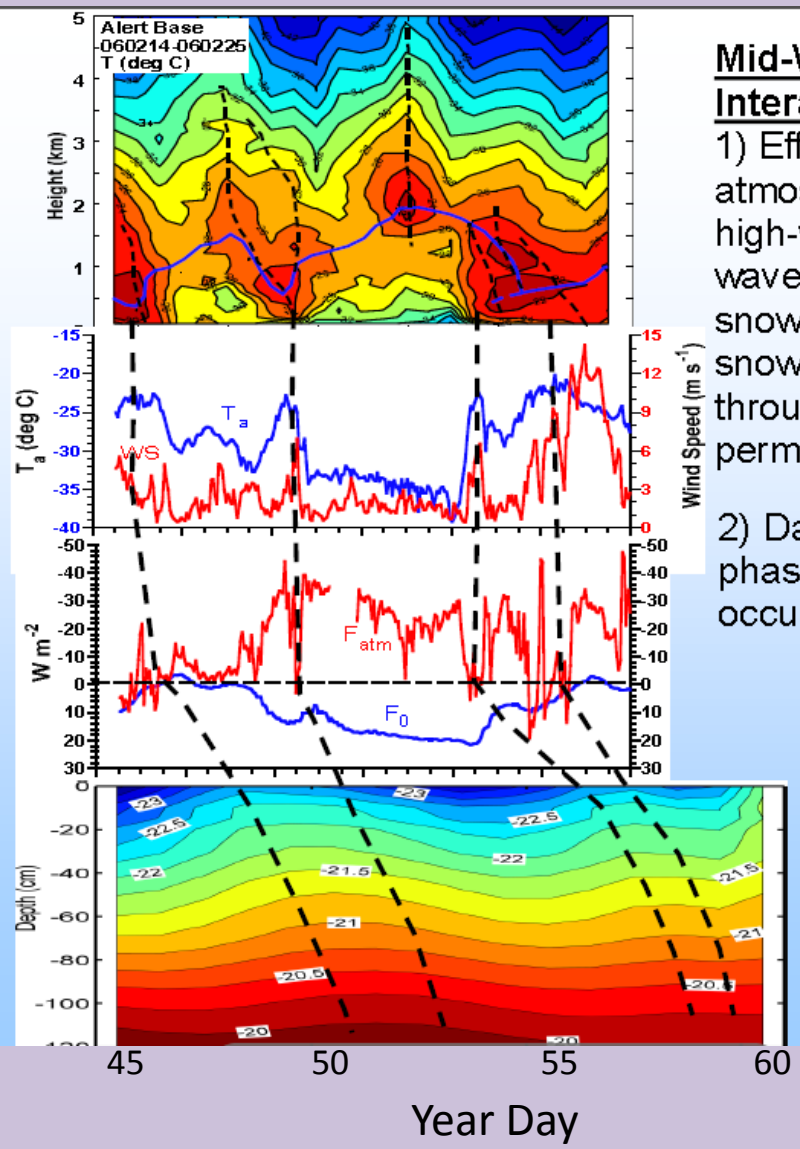
O. Persson – Mesoscale wind regimes and local terrain have impacts on atmospheric structure that is transmitted through the active layer on the scale of days

Atmospheric Temperature 0-5 km

Near Surface Temperature and Wind Speed

Near Surface Measured F_{atm} and F_0

Temperature in soil from surface to 1.2 m depth



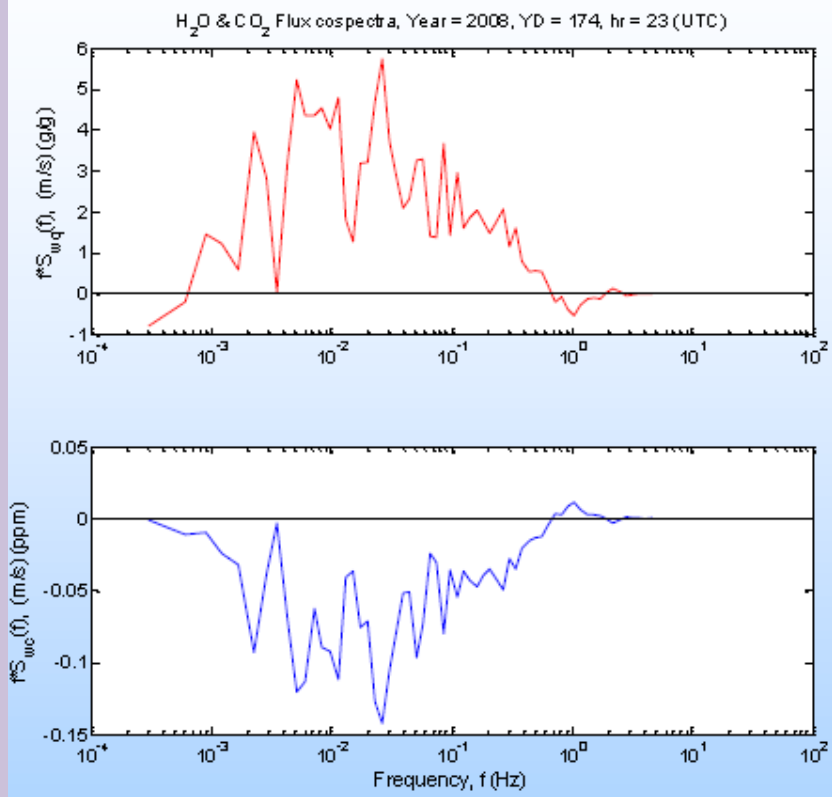
Mid-Winter Atmosphere-Soi Interaction

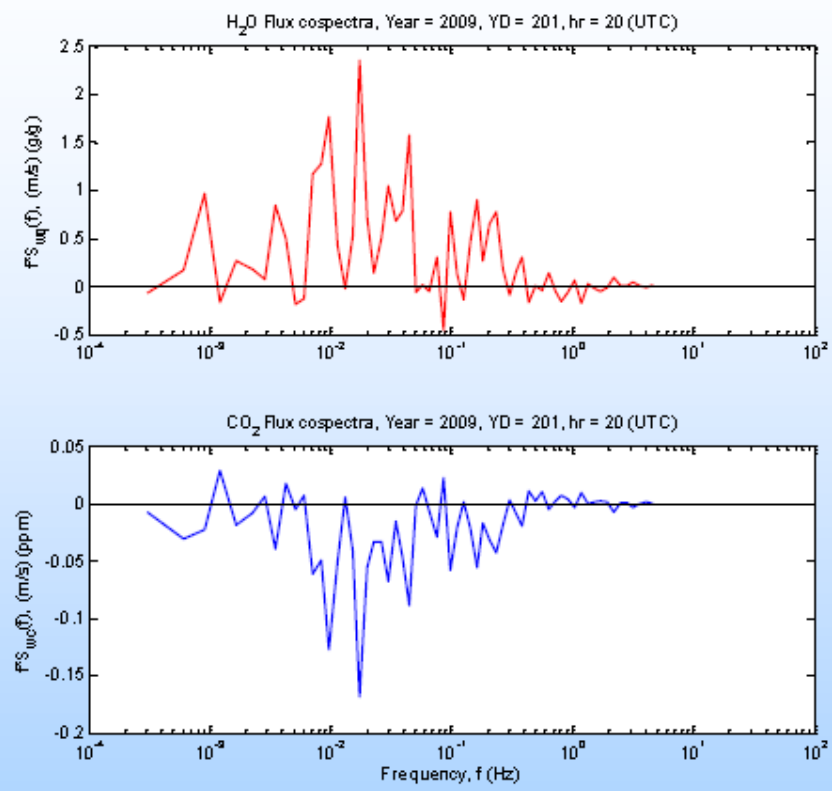
1) Effect of descent of atmospheric inversion with high-wind speed mountain waves can be traced to the snow surface, through the snow to the soil surface, and through the soil into the permafrost at 1.2 m depth.

2) Damping, smoothing, and phase lag of thermal wave occurs in snow and soil.

Alert

A. Grachev – During the summer, raw co-spectra of the H_2O and CO_2 Fluxes are generally in anti-phase and Eureka is a CO_2 sink





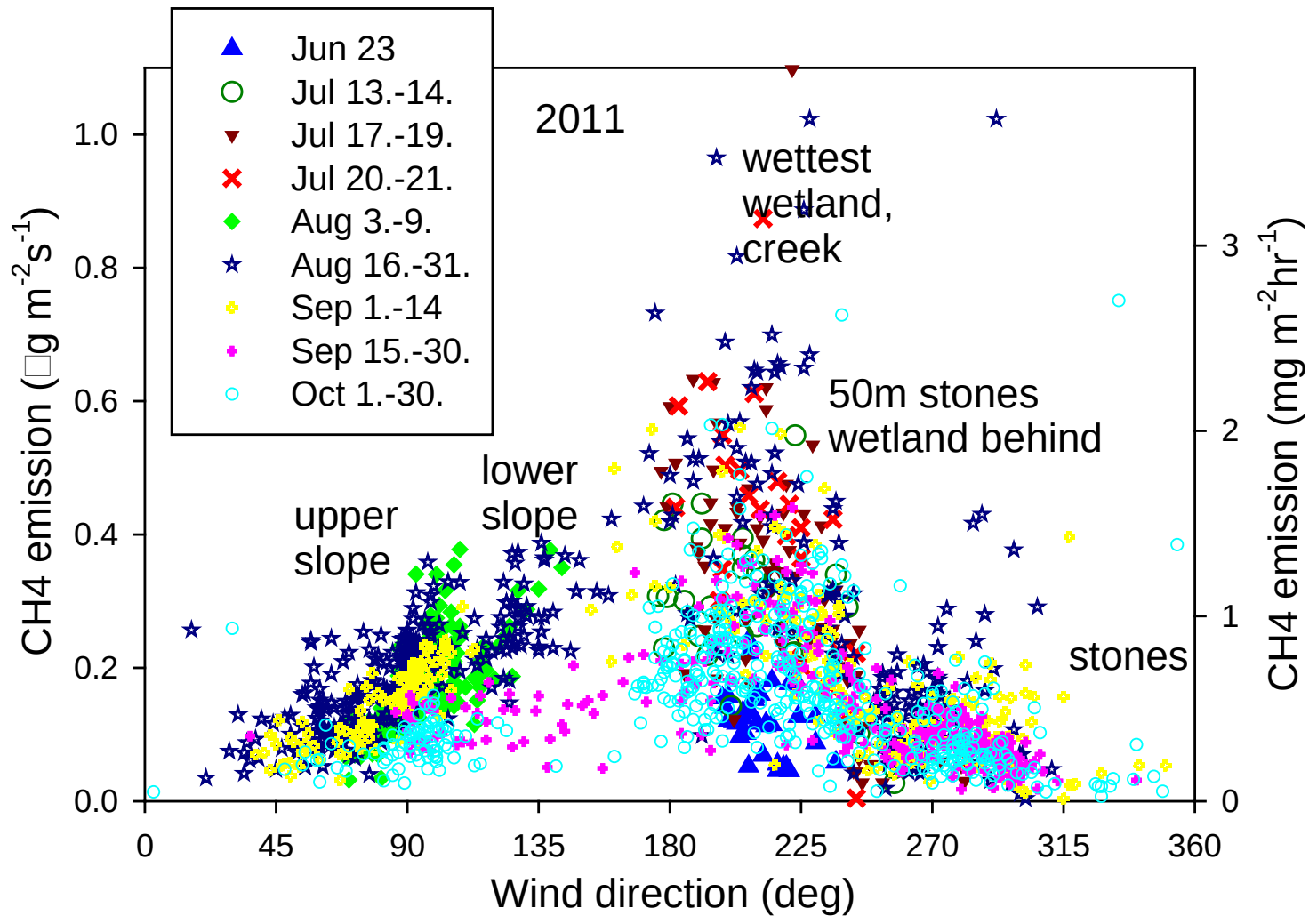
Eureka

Typical raw cospectra of the H_2O (upper panel) and CO_2 (bottom panel) fluxes measured during June 24, 2008, 23:00 UTC ($U = 4.32$ m/s, $T_a = 12.9$ °C, $U_* = 0.28$ m/s, $H_s = 101.21$ W/m^2). Turbulent fluxes are based on one-hour averaging and they were derived through frequency integration of the appropriate cospectra. H_2O flux is upward and CO_2 flux is downward.

Typical raw cospectra of the H_2O (upper panel) and CO_2 (bottom panel) fluxes measured during July 20, 2009, 20:00 UTC ($U = 3.24$ m/s, $T_a = 18.7$ °C, $U_* = 0.23$ m/s, $H_s = 102.21$ W/m^2). Turbulent fluxes are based on one-hour averaging and they were derived through frequency integration of the appropriate cospectra. H_2O flux is upward and CO_2 flux is downward.

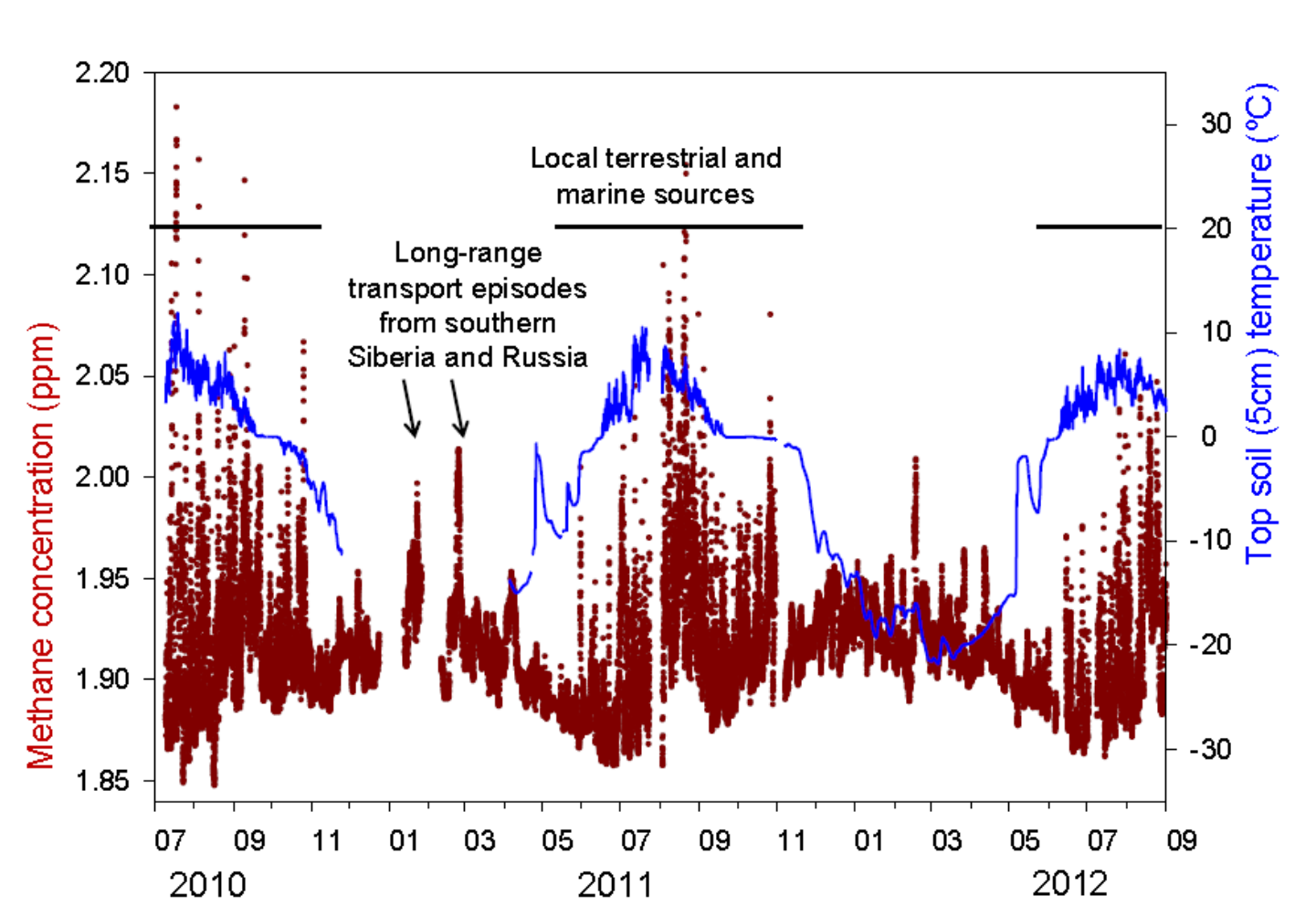
M. Aurela and T. Laurila– Methane Fluxes from Different Wind Directions show Impact of Surface Types

TIKSI

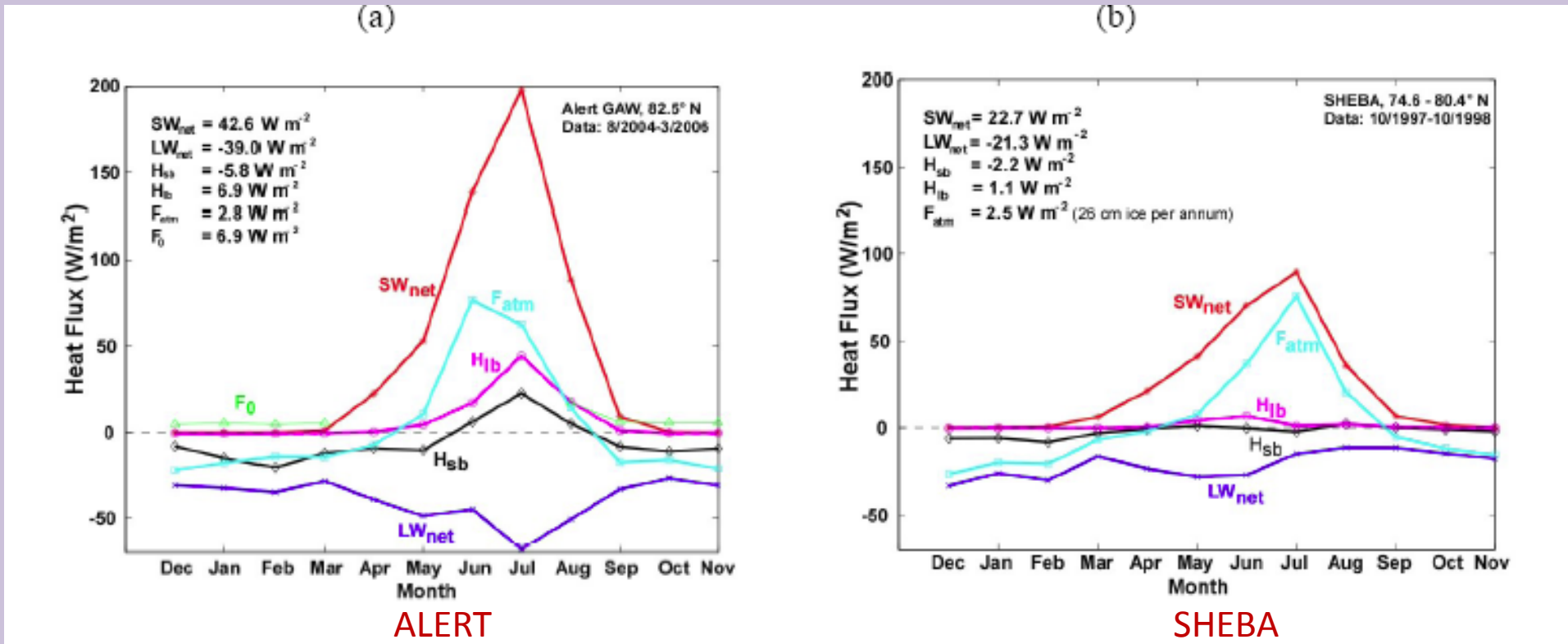


T. Laurila – Examining the relative impacts of local (marine and terrestrial) vs. long-range impacts on local methane concentrations

Tiksi



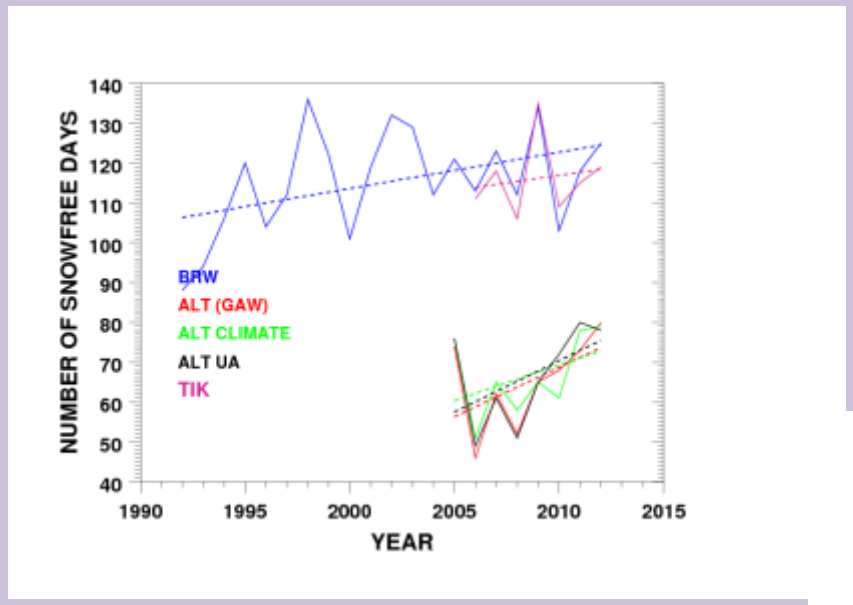
O. Persson: You can get a very similar net annual cycle of atmospheric fluxes with a completely different combination of components implying different mechanisms



ALERT SHEBA

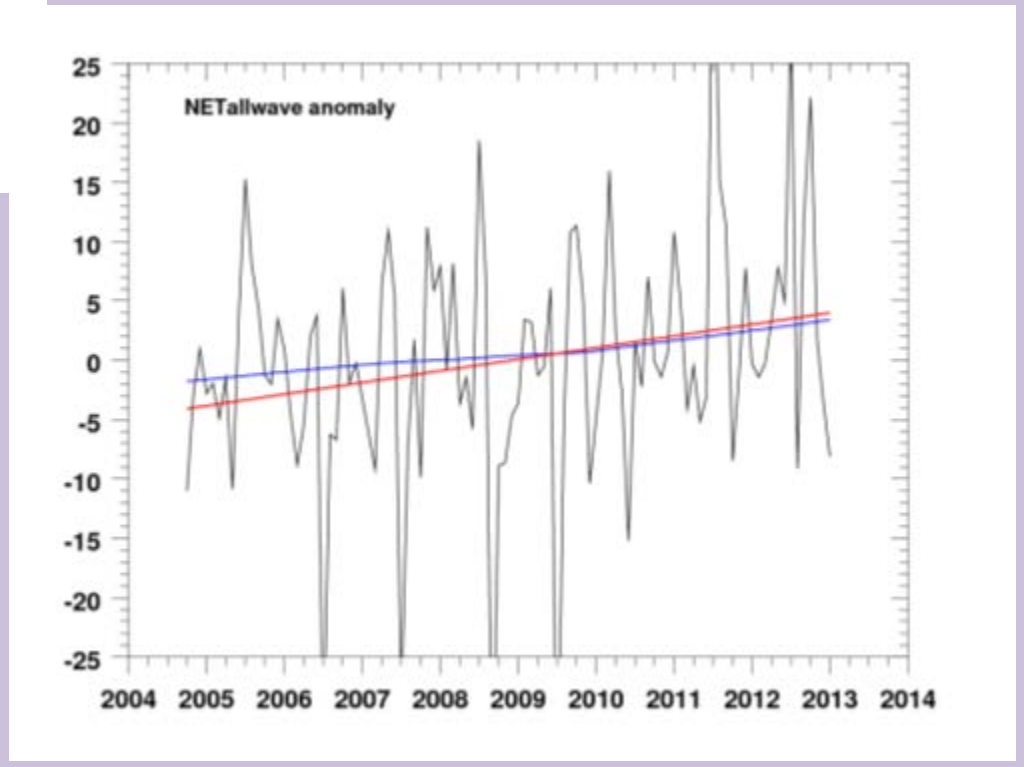
Figure 1: Monthly means of the surface energy budget terms for a) Alert (terrestrial site) and b) SHEBA (pack ice site). The annual mean of the various terms are given to the upper left in each frame.

R. Stone – Impacts on seasonal snow extent



Preliminary Analysis shows that the number of snow free days is increasing at a number of Arctic sites

Alert



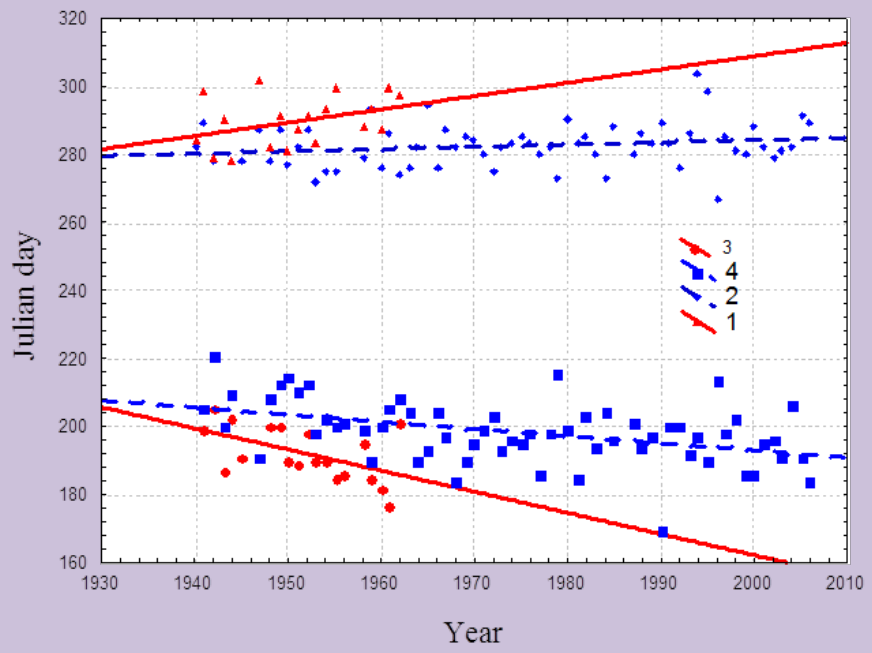
The Alert monthly anomalies show a ~10 W/m^2 increase in NET, mostly attributable to the decrease in upwelling SW irradiance due to longer snow-free periods

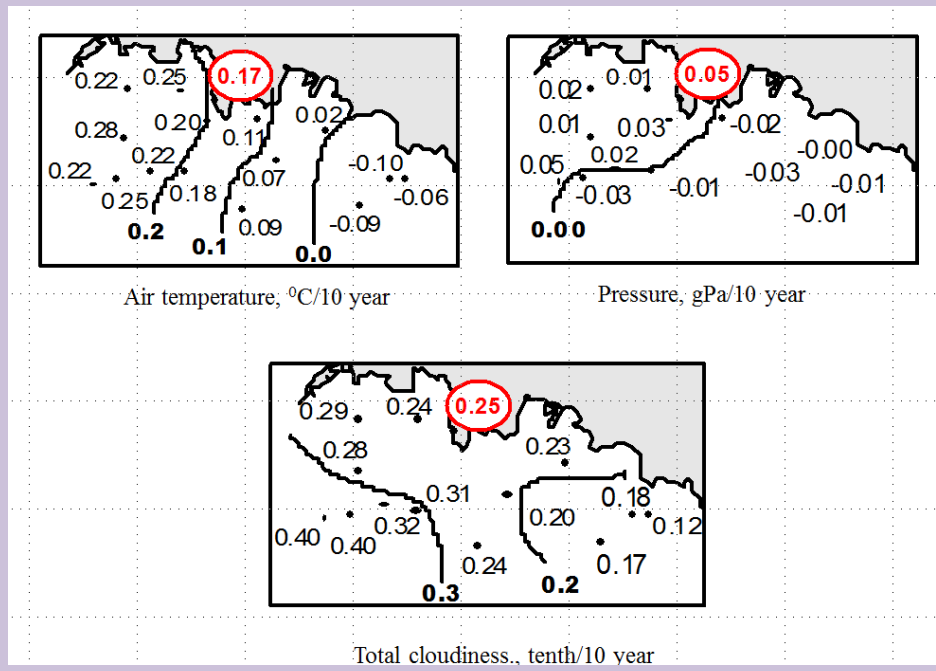
A. Makshtas – Impacts on shore-fast and drifting ice in the Sogo Bay

Tiksi

Long-term historical records show the increase in ice-free days in the Sogo Bay adjacent to Tiksi relating to:

Increased air temperature, increased pressure and increased cloudiness. Tiksi is representative of the region when compared to adjacent weather stations.

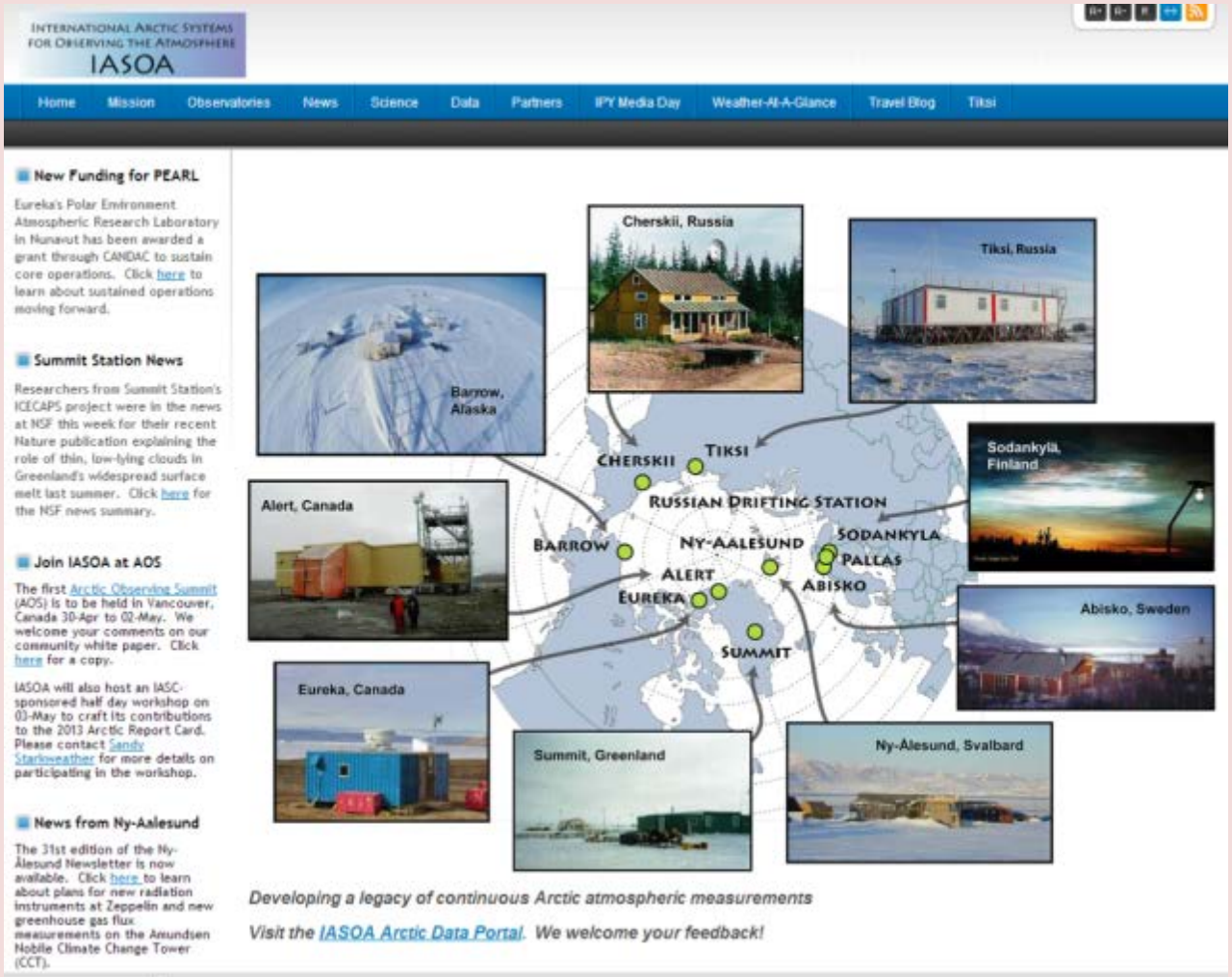




IASOA is the International Arctic Systems for Observing the Atmosphere

The coordination of Arctic Flux data sets and analysis will be facilitated by an IASOA working group (www.iasoa.org)

Many IASOA Observatories are Global Atmosphere Watch Stations



GCW is the Global Cryosphere Watch and is developing an a counterpart program to Global Atmosphere Watch (http://globalcryospherewatch.org/)

The Potential Synergies Between IASOA and GCW are Obvious for providing long-term monitoring and understanding of the atmosphere and the underlying ice-snow surfaces

The "Marriage Bed" will be ISO-Standard Based Data Portals providing rapid access to fundamental digital data sets supporting original research

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