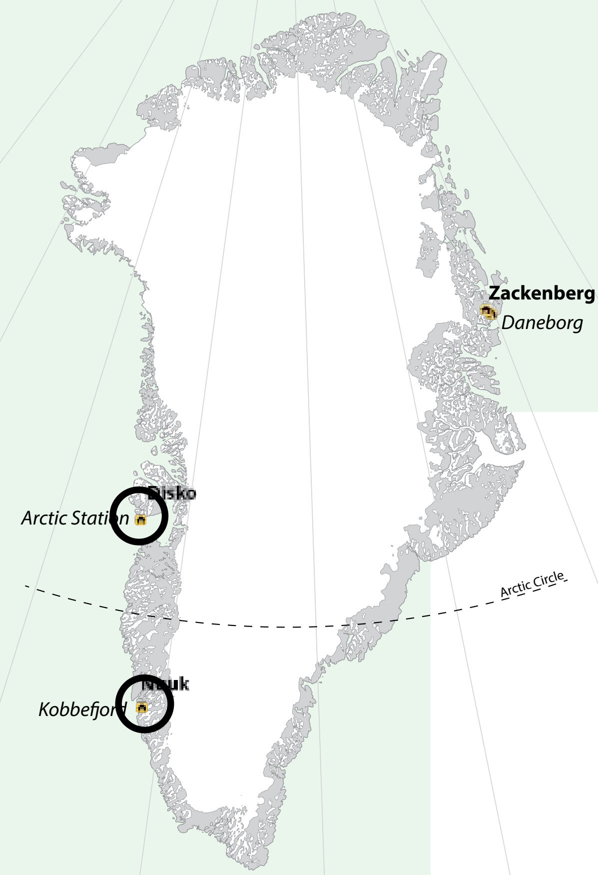
SCALING UP

IMPROVING A KNOWLEDGE



Arctic amplification, referring to more rapid increases in air temperatures in the Arctic compared to other parts of the globe, is causing widespread melting of snow and ice, sea-ice retreat, rise in the global sea level and changes in the surface energy budget leading to an acceleration of the hydrological cycle. Quantifying the surface energy balance at regional scales is key for better understanding Arctic ecosystem response and vulnerability to these changes.

Surface air temperatures in the Arctic have shown a significant increase, especially in the past few decades (Serreze and Barry, 2011). Increases in precipitation and local evaporation in the Arctic are leading to an acceleration of the hydrologic cycle, transforming the Arctic into a warmer place. Arctic regions, largely dominated by tundra, are witnessing unprecedented changes in response to climate warming. These include increases in river discharge (Bintanja and Selten, 2014) and significant changes in vegetation such as Arctic greening (Bhatt *et al*., 2010), among others.

The hydrologic response of the Arctic ecosystems is dynamically coupled to the region's surface energy balance. A wide range of ecosystem dynamics depend on the combined changes in energy partitioning and hydrology. For a better understanding, this requires improved techniques for spatiotemporal characterization of land-atmosphere exchanges of water and energy at regional scales (Cristóbal *et al*., 2017). Due to remoteness, harsh winter conditions, and the high costs of maintaining ground-based measurement networks in the Arctic, remote sensing represents the only economically feasible and reliable source of information to infer surface energy fluxes at regional scales.

In 2018, the Greenland Ecosystem Monitoring (GEM) ClimateBasis programme with joint support from the Greenland Research Council and in collaboration with GEM GeoBasis programme, United States Agricultural Department, NASA, started an initiative to improve the current knowledge on the surface energy balance and how to scale-up surface energy fluxes from the plot to the regional scale using

Figure 1. Collecting data by the Arctic Station flux station (Disko Island) using a LiCor LAI-2200 Plant Canopy Analyzer. Photo: Jordi Cristóbal in 1st September 2018.

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Source:

GEM ClimateBasis – Radiation

GEM ClimateBasis – Surface energy balance

GEM GeoBasis – Flux measurements

Data can be accessed on: www.data.g-e-m.dk

SURFACE ENERGY FLUXES:
GAP IN THE ARTIC HYDROLOGICAL CYCLE

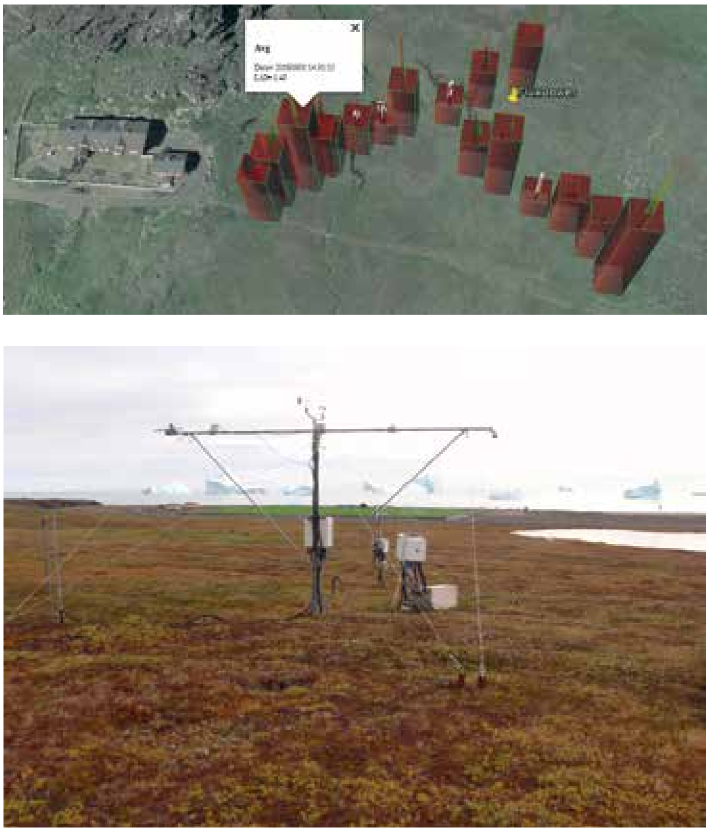

Figure 2. Upper panel: LAI data at the Arctic Station flux tower (Disko Island) in 1st September 2018 (background image courtesy of Google Earth). To show plot spatial variability, LAI field measurements are displayed in red columns. Lower panel: Arctic Station flux tower. Photo: Jordi Cristóbal.

remote sensing data. Two main activities are being carried out: a) calibration and evaluation of thermal remote sensing data based on a two source energy balance model (TSEB) for tundra at local scales with leaf area index (LAI) remote sensing inputs (Cristóbal *et al*. 2017) and; b) field data collection of LAI at Disko and Kobbefjord for model upscaling (Fig. 1, 2 and 3, respectively). Preliminary results show mean turbulent flux errors at local scales (Fig. 4) of around 50 W•m^{-2} at half-hourly timesteps, similar to errors typically reported in surface energy balance modelling studies conducted in Arctic regions. Thanks to these findings, we are currently building toward a regional implementation of this model for Greenland Arctic tundra. This model will utilise multiplatform and multitemporal thermal satellite remote sensing to assess the response of surface fluxes to the acceleration of the hydrological cycle in the Arctic.

References

Bhatt, U.S. *et al.* 2010. Circumpolar Arctic Tundra Vegetation Change Is Linked to Sea Ice Decline. Earth Interactions, 14: 1-20.

Bintanja, R. & Selten, F.M. 2014. Future increases in Arctic precipitation linked to local evaporation and sea-ice retreat. Nature, 509: 479-482.

Cristóbal, J. *et al.* 2017. Estimation of surface energy fluxes in the Arctic tundra using the remote sensing thermal-based Two-Source Energy Balance model. Hydrol. Earth Syst. Sci., 21: 1339-1358.

Serreze, M.C. & Barry, R.G. 2011. Processes and impacts of Arctic amplification: A research synthesis. Global and Planetary Change, 77: 85-96.

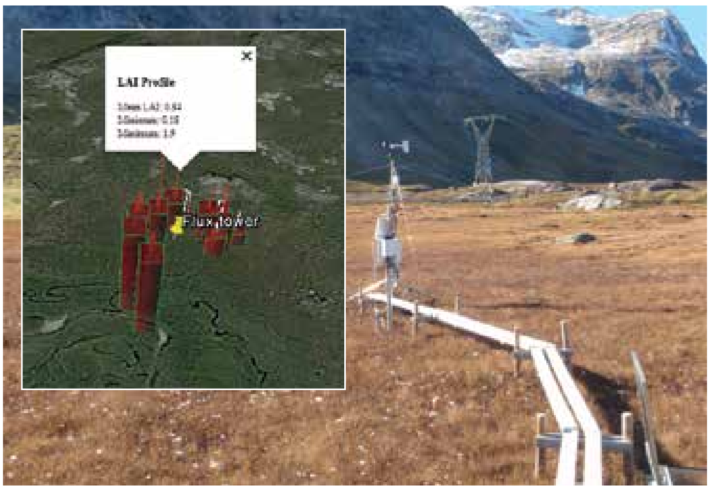

Figure 3. Insert panel: LAI data collected at Kobbefjord's fen flux tower (Nuuk) in 18th September 2018 (background image courtesy of Google Earth). To show plot spatial variability, LAI field measurements are displayed in red columns. Background photo: Fen station flux tower. Photo: Jordi Cristóbal.

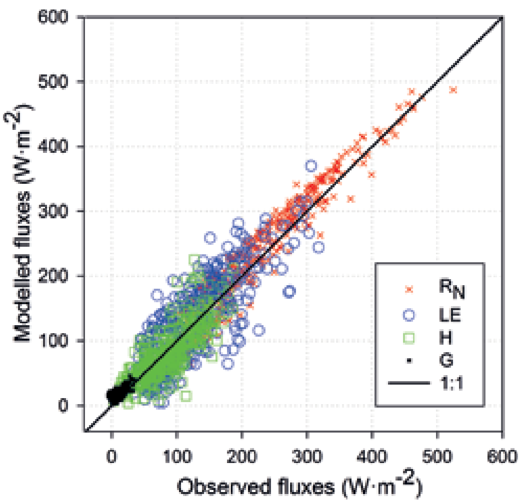

Figure 4. Preliminary comparison of modelled vs. measured half-hourly fluxes with residual closure at the fen flux tower at Kobbefjord (see Figure 3.) from June to September 2012. The 1:1 line represents perfect agreement with observations.