Status and Drivers of the Arctic Surface Energy Budget

Last update: 26.11.2020 Jacqueline Oehri

Project description

The Arctic is subject to rapid climate change and severe increases in temperature and precipitation are predicted for the end of the 21st century. Changes in temperature and humidity reflect changes in the surface energy budget (SEB), which captures important earth system processes that also tightly couple the carbon and water cycles. However, despite its importance, the knowledge on the state and potential development of the Arctic SEB is scattered and outdated.

Therefore, in this project, we update the current knowledge on the terrestrial Arctic surface energy budget by synthesizing results from published literature and datasets. Specifically, we will assess the magnitude & temporal change of Arctic SEB-components as a function of different SEB-drivers (e.g. vegetation type, soil characteristics, precipitation, cloud cover; Fig. 1 below). Additionally, we aim at investigating the relative importance and the interrelation of the Arctic SEB-components & SEB-drivers. Finally, we will identify current knowledge gaps and uncertainties of estimates derived from the collected literature.

Our analyses will contribute to the understanding of important but understudied aspect of the earth system in a region that faces rapid environmental and climatic changes, which have the potential to affect the earth system not only at the local but also at the global scale.

Sketch of planned research synthesis paper

Title - “Status and Drivers of the Arctic Surface Energy Budget”
Authors - see preliminary author list
Aim - Synthesize knowledge on the status of surface energy budgets (SEB) across the Arctic and the relevance & interrelation of environmental SEB-drivers (see Fig. 1).
Structure (Methods, Results) - 2 parts: part 1 summarizes the coverage, representativeness & uncertainties of knowledge derived from literature collected on the Web of Science; part 2 makes a quantitative assessment of SEB climatology and recent trends for a subset of published data on open-access repositories (FLUXNET, Ameriflux, PROMICE, AON, GC-Net,..) (and if possible, published data covered in collected literature). SEB climatologies and trends will be investigated primarily as function of different locations, times & CAVM vegetation types, optionally other drivers as well.

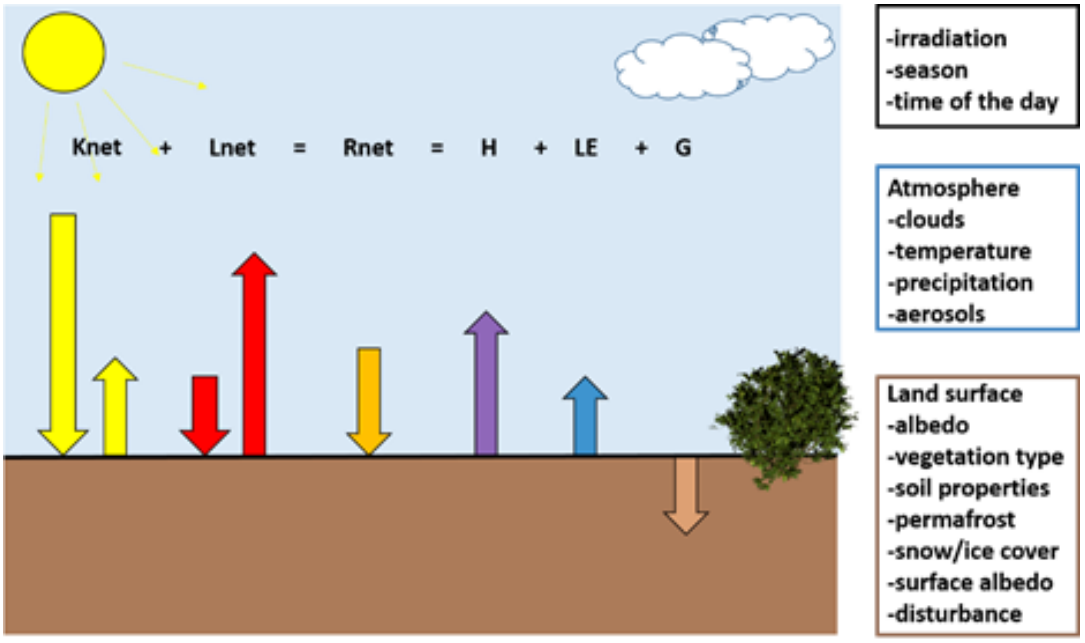


Fig. 1. Schematic overview of the components of the surface energy budget (SEB; colored arrows) and a list of important SEB-drivers (black, blue and brown boxes, respectively). Knet: net shortwave radiation; Lnet: net longwave radiation; Rnet: net radiation; H: sensible heat flux; LE: latent heat flux; G: ground heat flux.

Progress report

10.03.2021 Jacqueline Oehri

- Proceed data analysis and results
- Establishment of a first manuscript draft..
- Information to all co-authors will follow soon..

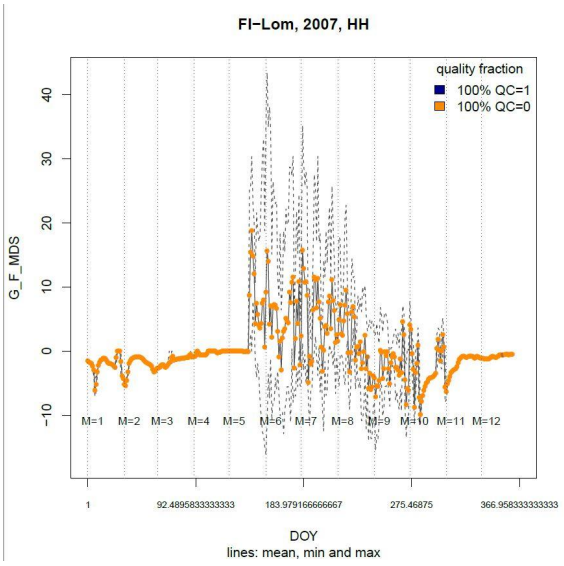
26.11.2020 Jacqueline Oehri

- AGU poster overview of project: agu2020fallmeeting-agu.ipostersessions.com/Default.aspx?s=6E-A4-57-7E-F3-BE-87-DE-91-02-D5-80-FF-D2-1C-8C
- Finish extraction and aggregation of SEB-components from open-access networks FLUXNET, Ameriflux, GC-Net, PROMICE, AON (66 locations >60°N on tundra or glacier)
- Finish extraction of SEB-drivers for each site
    - including **environmental covariates** such as CAVM vegetation type, MAT, annual precipitation, permafrost type, average cloud cover, snow,...).
    - **including essential metadata** about the SEB components from different sources, such as flux direction convention, instrumentation, measurement height.

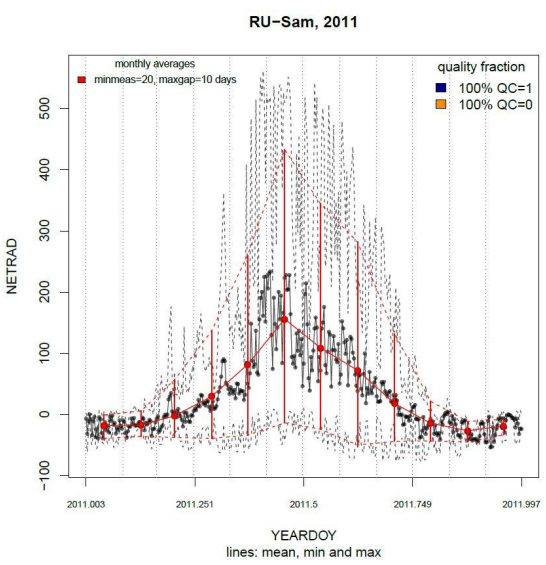
06.07.2020 Jacqueline Oehri

- Scripts/functions for extraction & aggregation of SEB-components (e.g. Rnet, H, LE, G, Lnet, Knet)
- Processed sites include FLUXNET (20), Ameriflux (27, 3 overlap with FLUXNET), GC-Net (10,contributed by B.Vandecrux) and PROMICE (25, **Fig 2**).
- For each site-network, there exists each 1 dataset for aggregated data (cf. **Fig 3**).

a)



b)



c) **d)**

Fig 1. Examples for the different types of data aggregation. These plots are a subset of control graphs fabricated in the data aggregation process. **a)** Hourly or half-hourly data was aggregated to daily means, minima and maxima **b)** Daily data was aggregated to monthly averages of means, minima & maxima.

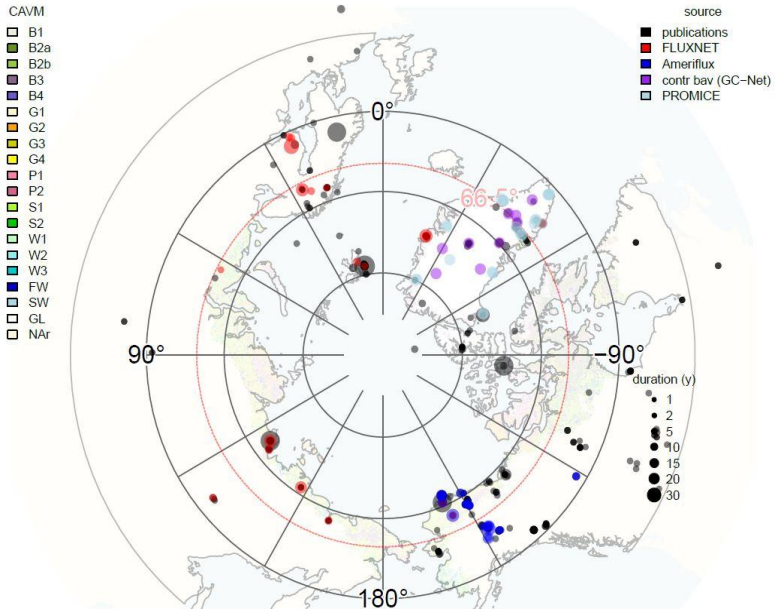


Fig. 2. Overview of locations where in-situ SEB components are available. Black dots: locations where SEB measurements are reported in publications collected in literature review; coloured dots: locations for which in-situ SEB data are available (& already downloaded) from open-access data networks. Please note that there are several further open-access data networks not (yet) included here (i.e. GEBA, BSRN, AON, ARM…).

a) **b)**

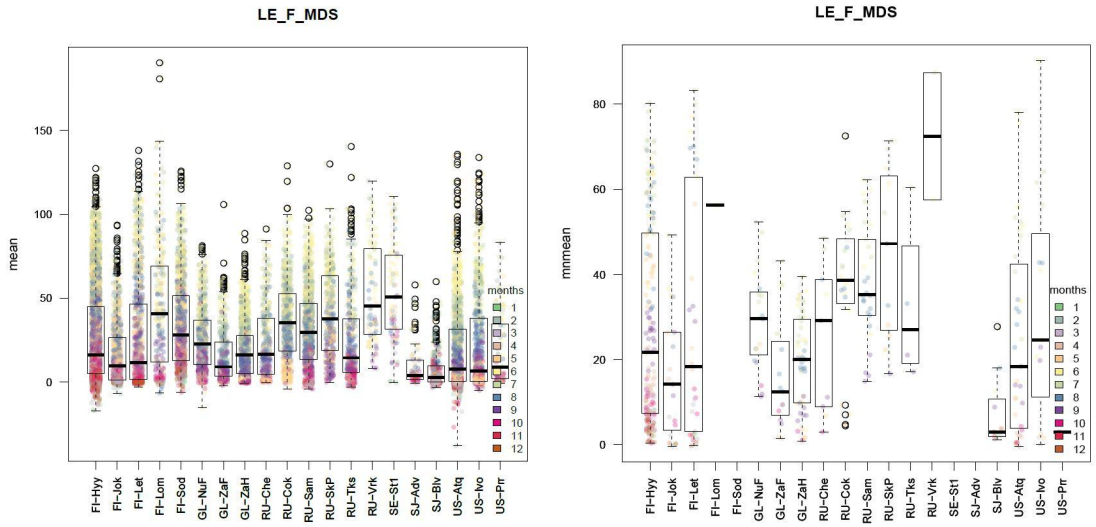


Fig 3. Examples of variables present in aggregated datasets. a) Subset of daily means for the latent heat flux variable and the FLUXNET sites. b) Subset of monthly averages of means for the latent heat flux variable and the FLUXNET sites.

25.05.2020 Jacqueline Oehri

- We conducted a **Web of Science literature research** and found 197 publications suitable for inclusion into our research synthesis.
- To stay faithful to the published results, we asked corresponding study-authors to **electronically share with us the data underlying their results** on Arctic SEB components and their drivers (see a list of variables we asked for below**).
- **We collected data contributions until the end of July 2020.**
- We started **integrating the already collected datasets from study authors and open access repositories** (including Fluxnet, Ameriflux, GC-Net, PROMICE).

****Which variables are we looking for? – Essential and Nice-to-have variables!**

We kindly asked study-authors to share **data** (and metadata) on the following **A) essential & B) nice-to-have variables** - only in case they are covered in the respective publications.

A) Essential variables

Key-variables at the heart of our arctic SEB synthesis. Please prioritize these variables.

1) **Timestamp**(time of measurement)
2) **Rn** (net radiation)
3) **H** (sensible heat flux)
4) **LE** (latent heat flux)
5) **G** (ground heat flux)
6) **Tair** (air temperature)
7) **Rh** (relative humidity)
8) **Ws** (wind speed)
9) **Albedo** (albedo)
10) **Tsurf** (surface temperature)
11) **Kin** (surface incoming shortwave radiation)
12) **Kout** (surface outgoing shortwave radiation)
13) **Lin** (surface incoming longwave radiation)
14) **Lout** (surface outgoing longwave radiation)
15) **Knet** (surface net shortwave radiation)
16) **Lnet** (surface net longwave radiation)
17) **E** (evapotranspiration)
18) **Tsoilx** (soil temperature at height x)
19) **VWC** (soil volumetric water content)

B) Nice-to-have variables

Variables that would be nice to have for our arctic SEB synthesis. Please consider these variables as well.

1) **precip** (precipitation)
2) **VPD** (vapor pressure deficit)
3) **SWE** (snow water equivalent)
4) **Cloud cover**
5) **LWP** (cloud liquid water path)
6) **Snow cover**
7) **Snow density**
8) **EBC** (closure of surface energy budget)
9) **ALT** (active layer thickness)
10) **OLT** (organic layer thickness)
11) **pH** (soil pH)
12) **z0** (surface roughness)
13) **soil depth**
14) **k** (soil thermal conductivity)
15) **LAI** (leaf area index)
16) **NDVI** (normalized difference vegetation index)
17) **SLA** (specific leaf area)
18) **KinTOA** (incoming shortwave radiation at top of atmosphere)

Next steps

10.03.2021 Jacqueline Oehri

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