Local climate of Zachariae ice stream, North East Greenland

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Introduction

In August 2016, two Automatic Weather Stations (AWS) were placed on Zachariae ice stream, Greenland, as part of a project to study the surface mass balance, ice velocity and calving conditions. These stations provide insight in the local climate of North East Greenland, a region for which only limited in-situ data is available.

Local setup

Zachariae ice stream is an outlet glacier of the North East Greenland Ice stream (Fig. 1a). The AWS were installed at ~145 m a.s.l., ~13 km from the glacier front (S23), and at ~535 m a.s.l., ~35 km from the glacier front (S22). They measure air temperature, wind speed and direction, relative humidity, air pressure, and short and long wave incoming and outgoing radiation (Fig. 1b). In addition, they measure snow accumulation (sonic height ranger) and ice melt, (draw wire) and glacier surface velocity (GPS). Data is available over the period Aug. 2016 - Dec. 2019. From Aug. 2017 to Dec. 2019 only Argos transmitted data is available, limiting data availability and quality.

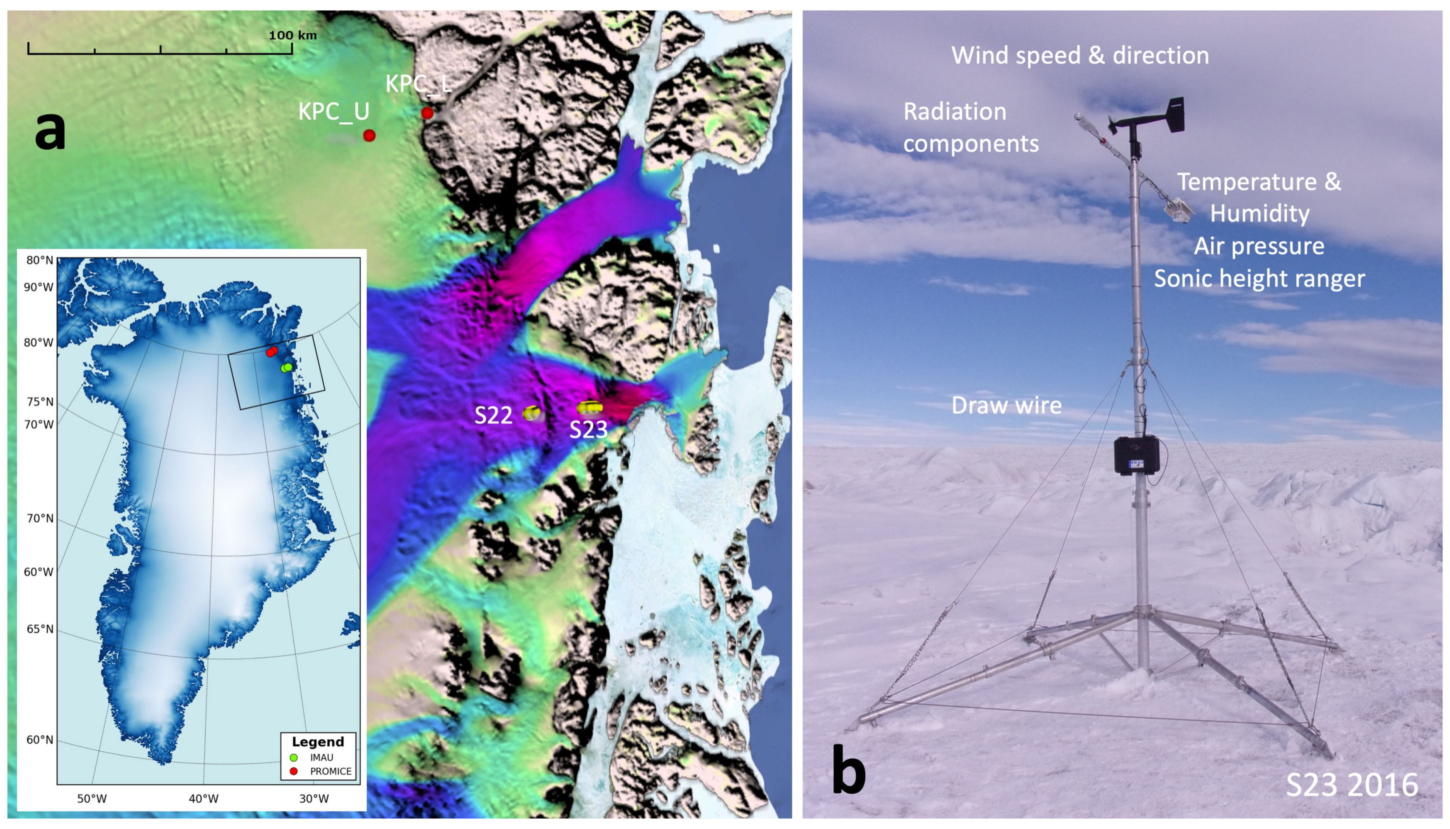

Fig. 1: *a) Satellite derived ice velocity [1]. Inset elevation map of Greenland shows the location of area. In both maps the locations of the IMAU and Promice weather stations are marked. b) Photo of site S23, marking the instrumentation.*

Average Climate

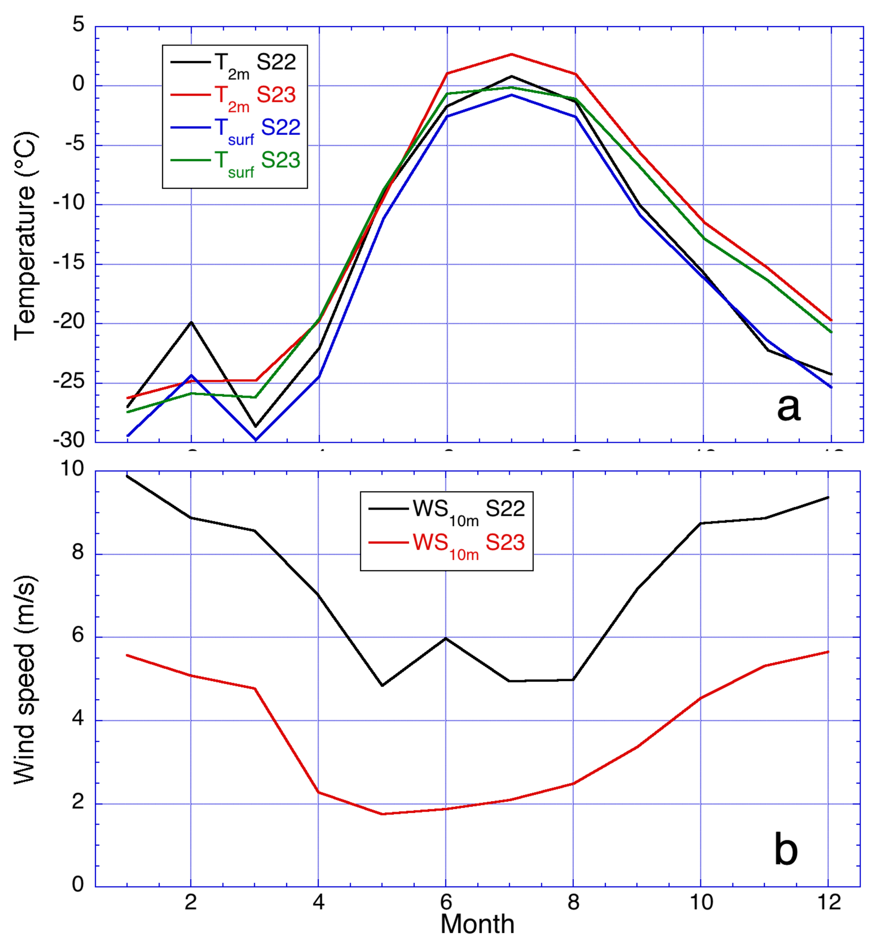

Fig. 2: *Monthly climatology of a) air temperature (T_{2m}) and surface temperature (T_{surf}), and b) wind speed (WS_{10m}).*

The annual mean air temperature, is -15.5°C (S22) and -13.2 °C (S23). The difference is explained by the elevation difference (lapse rate of -0.59 K/100m). At both sites temperatures reach melting point in summer (Fig. 2a). Conditions are dominated by a katabatic flow with highest wind speeds in winter (Fig. 2b), and directional constancies of 0.93 (S22) and 0.84 (S23). The on average higher wind speeds at S22 are due to its higher elevation and more exposed location. At both sites katabatic wind direction and large scale flow is from the north to north west (Fig. 3), where the the large scale flow has a more northerly component, indicated by the negative surface temperature inversion and higher wind speeds.

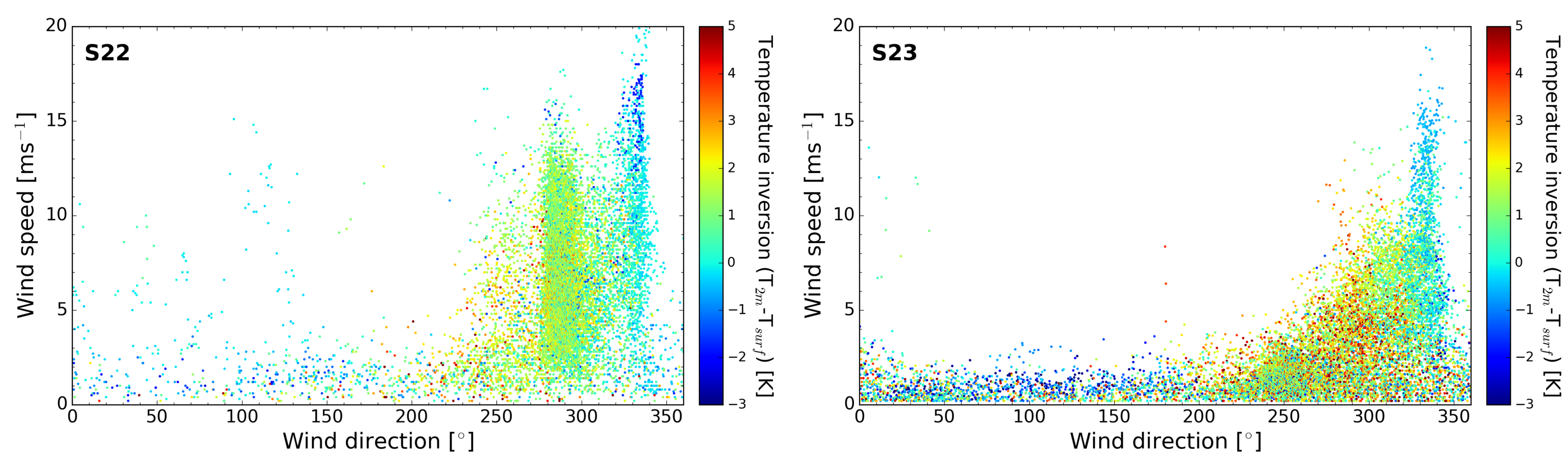

Fig. 3: *Hourly surface temperature inversion (T_{2m}−T_{surf}) as a function of wind speed and direction at S22 and S23.*

Mass Balance

Mass balance observations show that S22 is close to the equilibrium line, and S23 is in the ablation zone. S23 shows ~2 m ice melt per year and little accumulation, only the large events in 2018 are evident at both sites (Fig. 4a). This is due to wind redistribution of snow and the rough surface topography. High albedo values in spring at S23 do indicate some snow on the surface (Fig. 4b). At S22 the albedo drops to ~0.5 in summer 2017 and 2019, characteristic for old or wet snow.

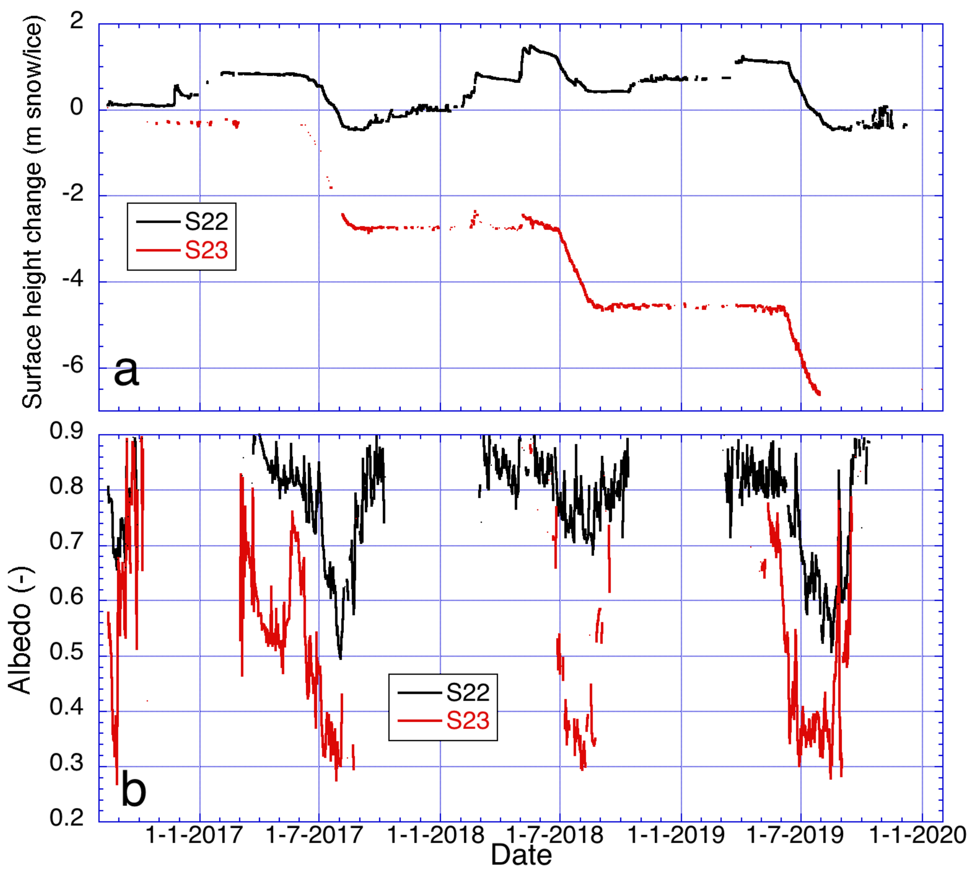

Fig. 4: *Daily averages of a) mass changes expressed as surface height changes with respect to start observations, and b) surface albedo.*

Ice Velocity

Both IMAU AWS are located on the lower part of the **North East Greenland Ice stream** and experience period average velocities of 0.7 km/yr (S22) and 1.7 km/yr (S23), which is similar to the satellite derived values (Fig. 1a) [1]. Both stations show an increase in velocity in time as they move into faster flowing regions (Fig. 5), in addition to the melt water forced seasonal increase in early spring (June/July) (inset in (Fig. 5)).

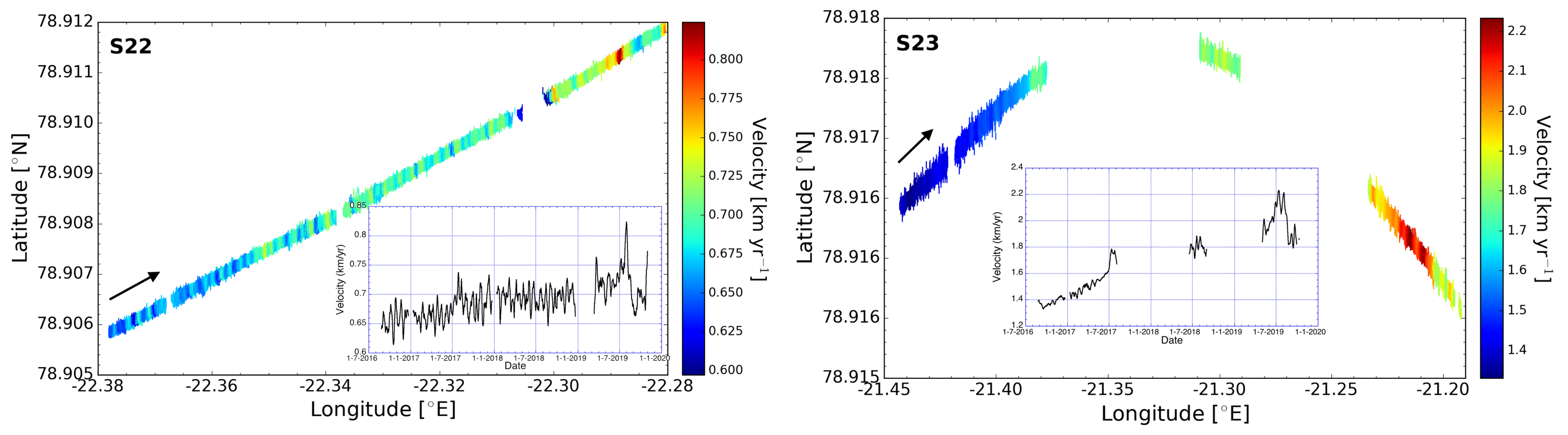

Fig. 5: *Ice velocity as a function of latitude, longitude location. Arrow indicates flow direction. Insets show velocity as a function of time. a) S22 and b) S23. Values are 240 hr running averages.*

Application: Model evaluation

Regional climate model (RACMO2.3p2) [3] results are evaluated with the AWS data. We include data from two Promice stations [2]: KPC_U (870 m a.s.l) and KPC_L (370 m a.s.l.) (Fig. 6). RACMO 2m temperature is too high and the difference increases with decreasing temperature. This can not be explained by model and station elevation differences. In line with the temperature, the model moisture content is also too high. Wind speed compares reasonable, and comparison is best for the two higher sites S22 and KPC_U. At S23 local topography not represented at the resolution of RACMO likely reduces wind speed resulting in a model overestimation, while at KPC_L the RACMO slope is likely underestimated.

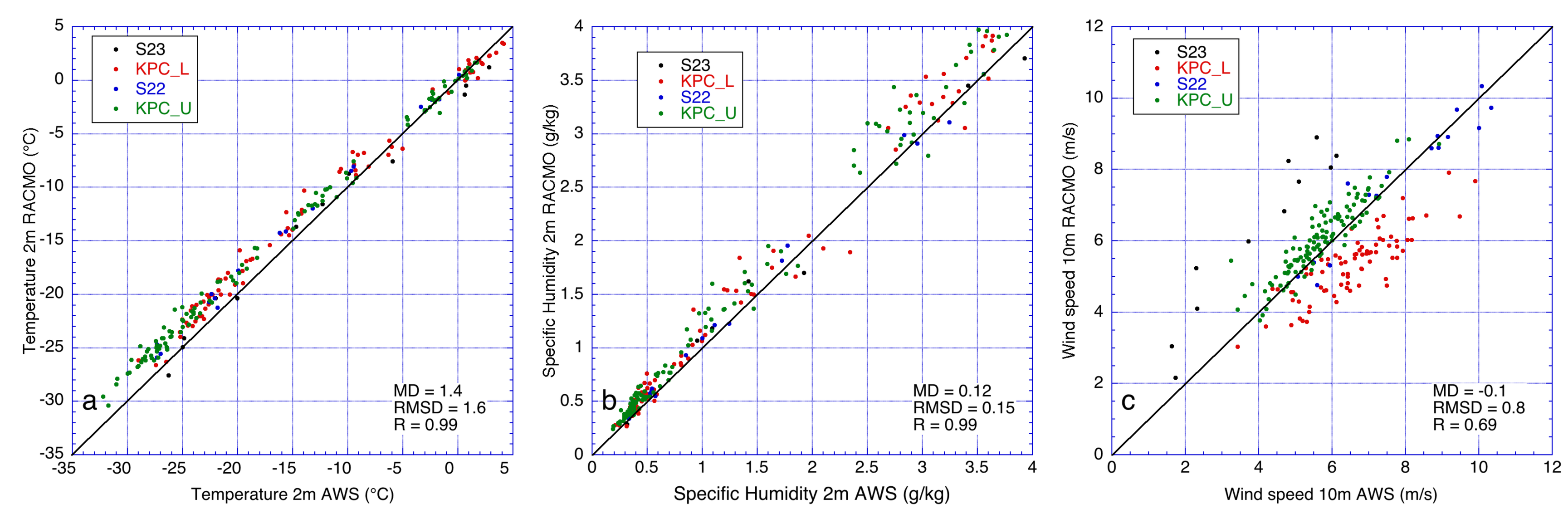

Fig. 6: *RACMO2.3p2 output as a function of observations of a) 2m temperature, b) 2m specific humidity, and c) 10m wind speed. Closest RACMO grid point is taken.*

References

[1] Rignot and Mouginot, 2012. *Geophys. Res. Lett.*. Doi: 10.1029/2012GL051634.
[2] PROMICE: https://promice.org/.
[3] Noël et al., 2018. *The Cryosphere*. Doi: 10.5194/tc-12-811-2018.