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Contribution of turbulent heat fluxes to surface ablation on the Greenland ice sheet

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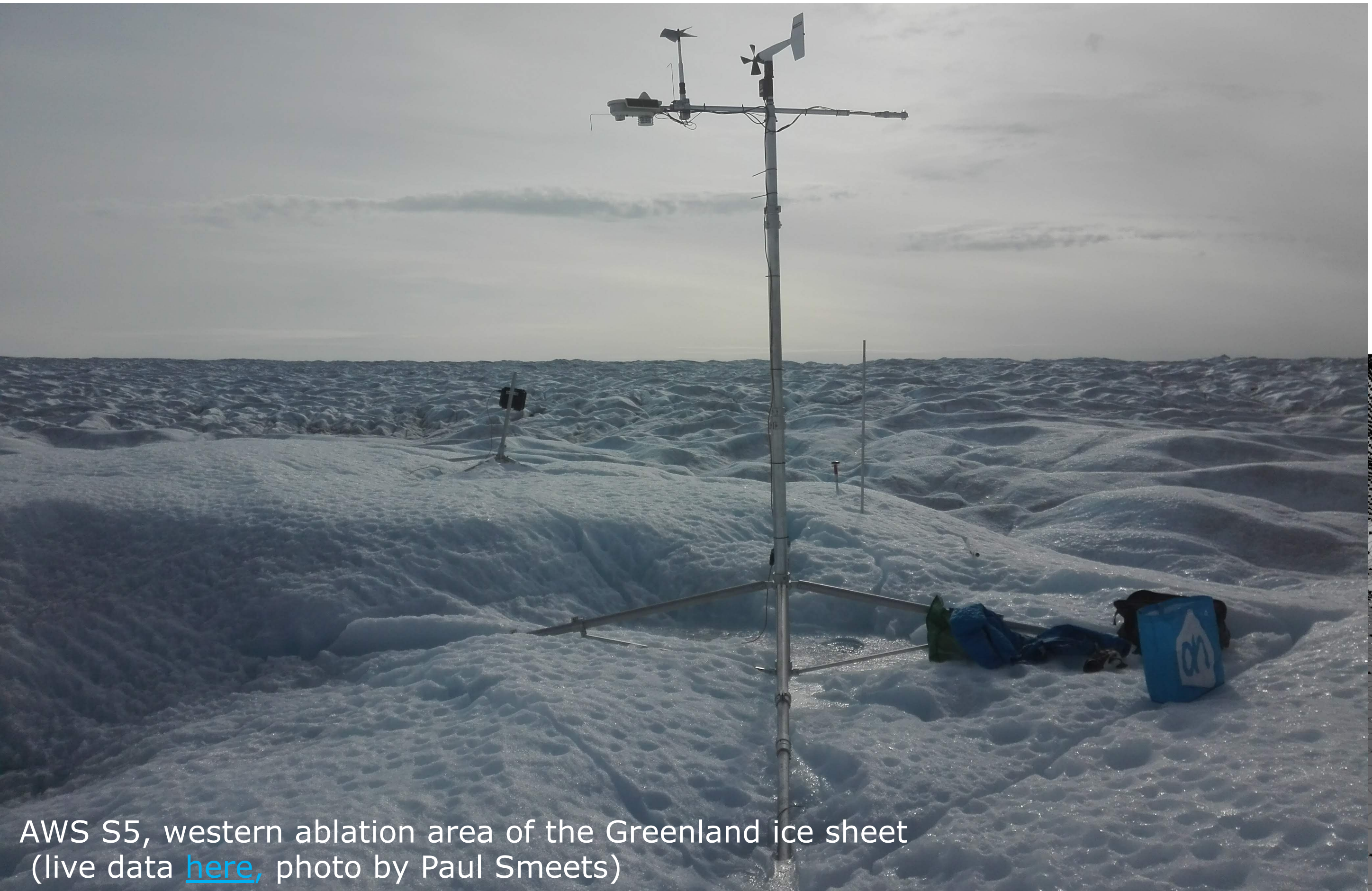
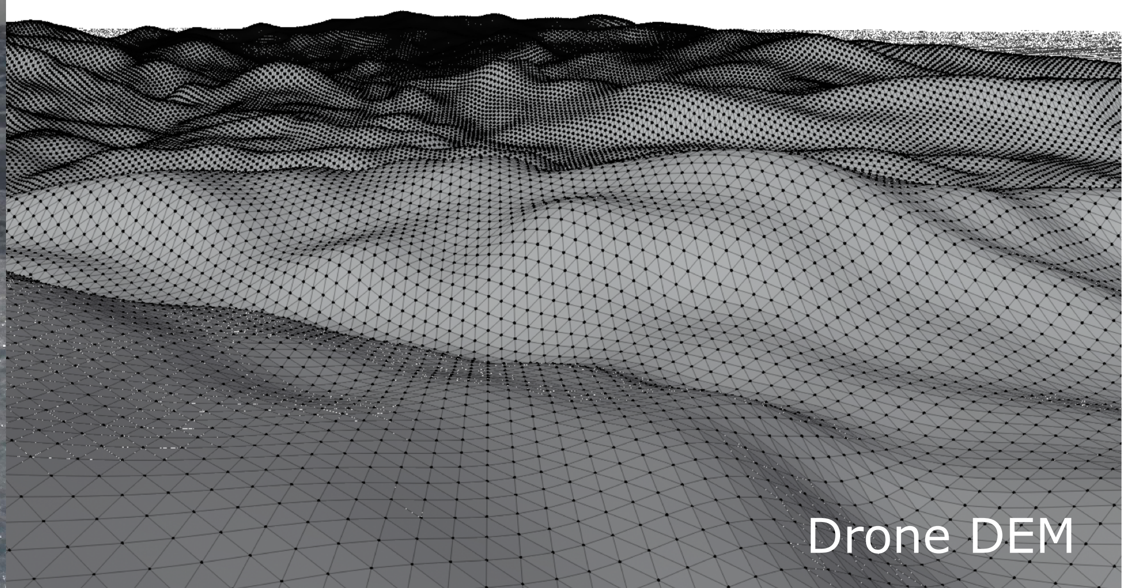
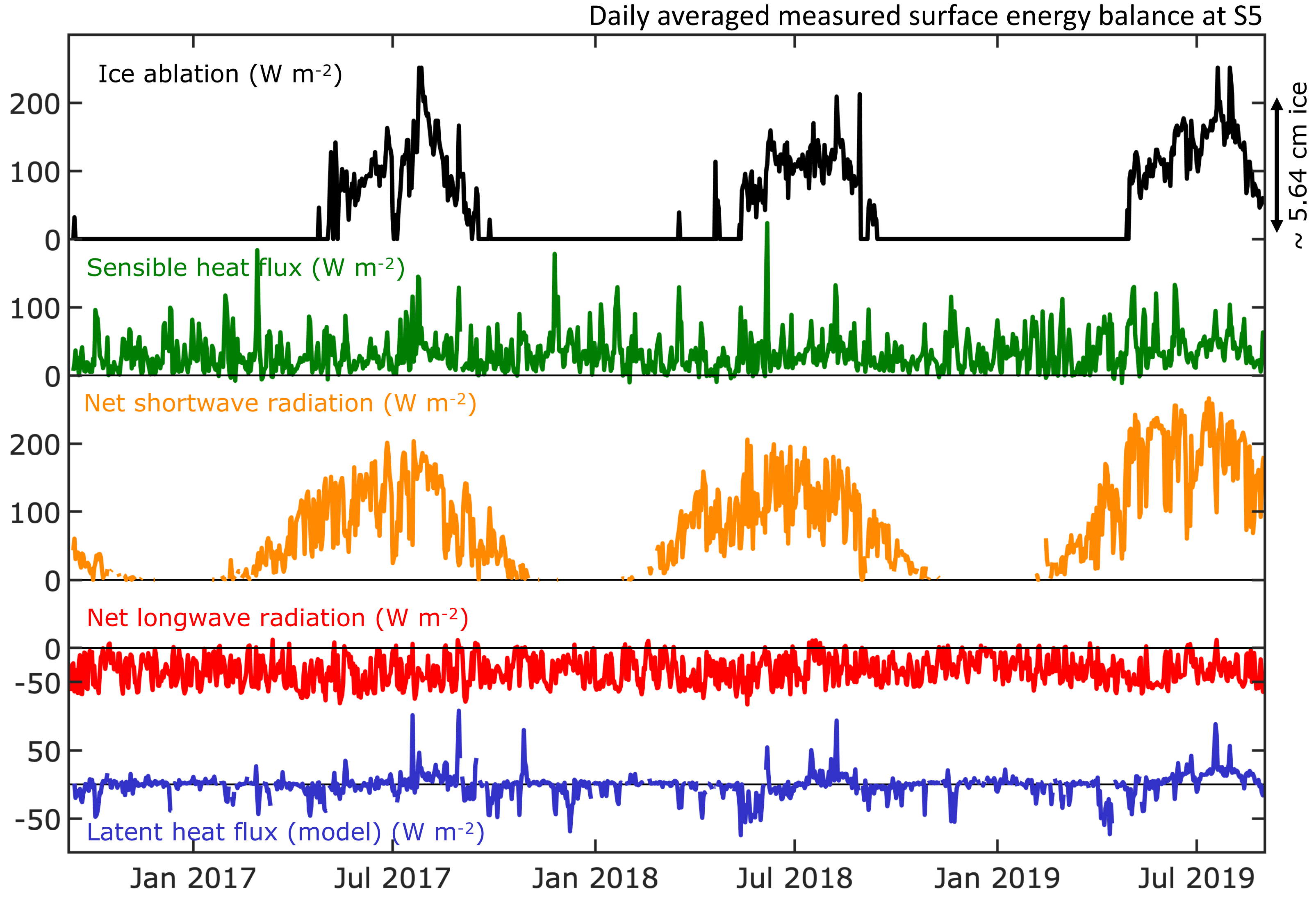


AWS S5, western ablation area of the Greenland ice sheet (live data here, photo by Paul Smeets)



Drone DEM

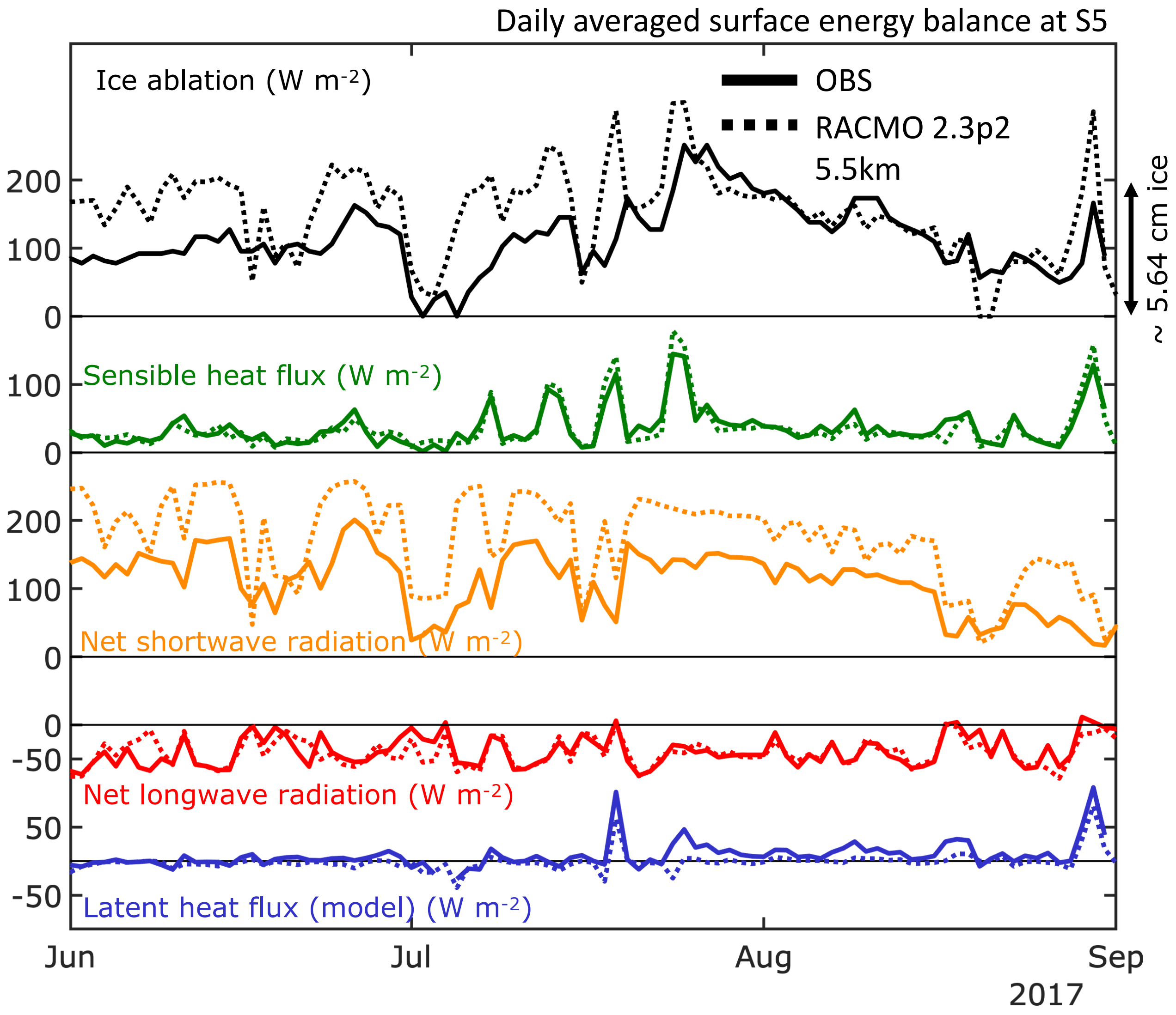
Main Problem 1: What is the best (meteorological) cocktail to generate surface melt ?



- **Surface melt** at lower elevations is mainly explained by sensible heat flux + net shortwave radiation
- For important ablation (~ 200 W m^{-2}) you need:
  1. Warm air (sensible heat flux ~ 100 W m^{-2})
  2. Thin clouds during summer (net longwave radiation ~ 0 W m^{-2}, net shortwave radiation ~ 150 W m^{-2})
  3. Dry air (Latent heat flux > 50 W m^{-2})
  4. Bare ice (low albedo, high net shortwave radiation)
  5. Shake (turbulence)
  6. Voila !

Van Tiggelen M, Smeets P, Reijmer C and van den Broeke M A Vertical Propeller Eddy-Covariance method and its application to long-term monitoring of surface turbulent heat fluxes on the Greenland ice sheet , Boundary-Layer Meteorol. (submitted)

Main Problem 2: Can we reproduce this cocktail ?



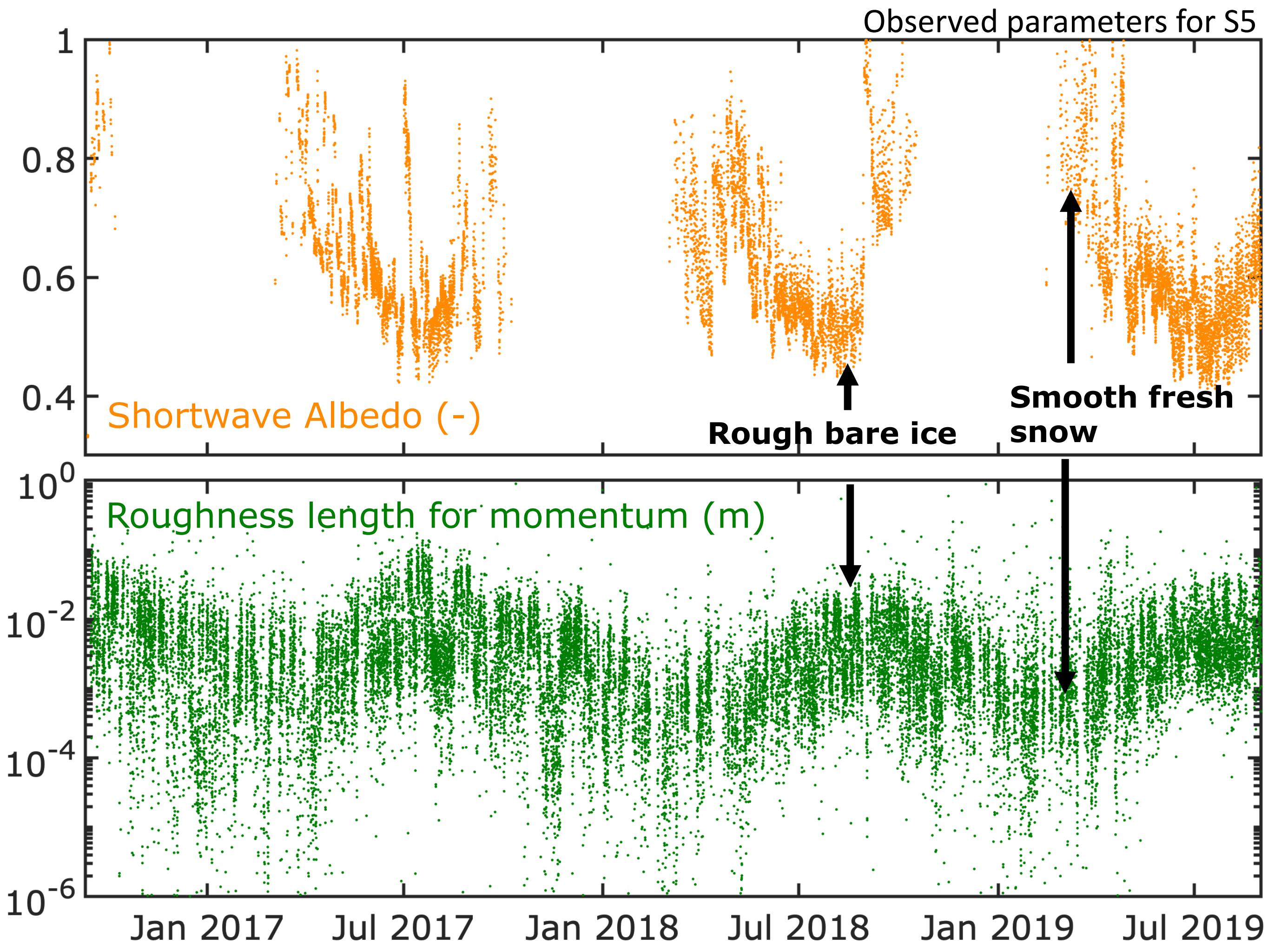
- Point observation remains difficult to compare to climate model (even at 5.5 km resolution) because:
    1. Albedo below the weather station is higher than the surrounding area (rough surface, thus higher net shortwave radiation in model)
    2. Surface melt expected to be very variable within one model grid
    3. Turbulent "fetch" footprint from the measured sensible heat flux and latent heat flux not necessarily representative of model grid box. Nevertheless:

- Peaking sensible heat fluxes and latent heat fluxes during warm and dry events well modelled
- Variability of net shortwave radiation and net longwave radiation due to clouds well captured
- **Observed and modelled cocktails are by definition different but still very similar**

Model : Noël B, van de Berg WJ, Lhermitte S, van den Broeke MR (2019) Rapid ablation zone expansion amplifies north Greenland mass loss. Sci Adv 5 https://doi.org/10.1126/sciadv.aaw0123

Observations : Van Tiggelen M, Smeets P, Reijmer C and van den Broeke M A Vertical Propeller Eddy-Covariance method and its application to long-term monitoring of surface turbulent heat fluxes on the Greenland ice sheet. Boundary-Layer Meteorol. (submitted)

Main Problem 3: What can we do to make a better cocktail?



The surface of the ice sheet is very dynamic in the ablation area because:

- Albedo depends on solar azimuth angle, surface impurities, snow fraction, cloud fraction, roughness of the surface
- Aerodynamic roughness depends on the shape of the surface obstacles, that changes in time because of
  1. Snowfall
  2. Differential Melt
  3. Sublimation
  4. Blowing snow
  5. Ice dynamics
  6. Wind direction (surface anisotropy)

Van Tiggelen M, Smeets P, Reijmer C and van den Broeke M A Vertical Propeller Eddy-Covariance method and its application to long-term monitoring of surface turbulent heat fluxes on the Greenland ice sheet. Boundary-Layer Meteorol. (submitted)