Surface Energy Budget at Summit, Greenland

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ICECAPS

Atmospheric State and Cloud Properties

Shupe et. al. 2013, BAMS

Summit Station

Broadband Radiation

- Swiss Federal Institute (ETH)
- NOAA – Global Monitoring Division

Subsurface temperature, 10m, 2m measurements

- Noone research project

10m, 2m measurements

- NOAA – Global Monitoring Division

Temperature profiles (July 2013 – June 2014)

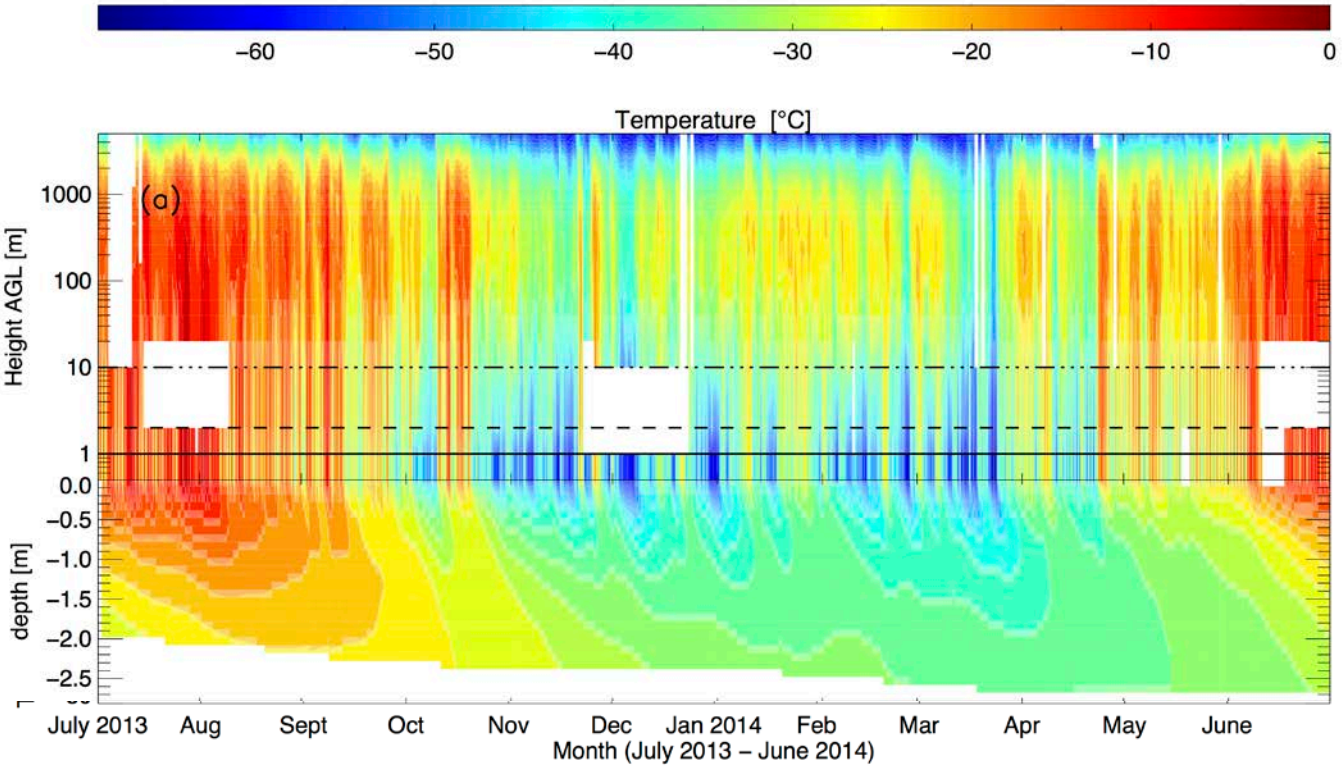
Interpolated radiosondes

10m

2m

Tsurf

Subsurface thermistors



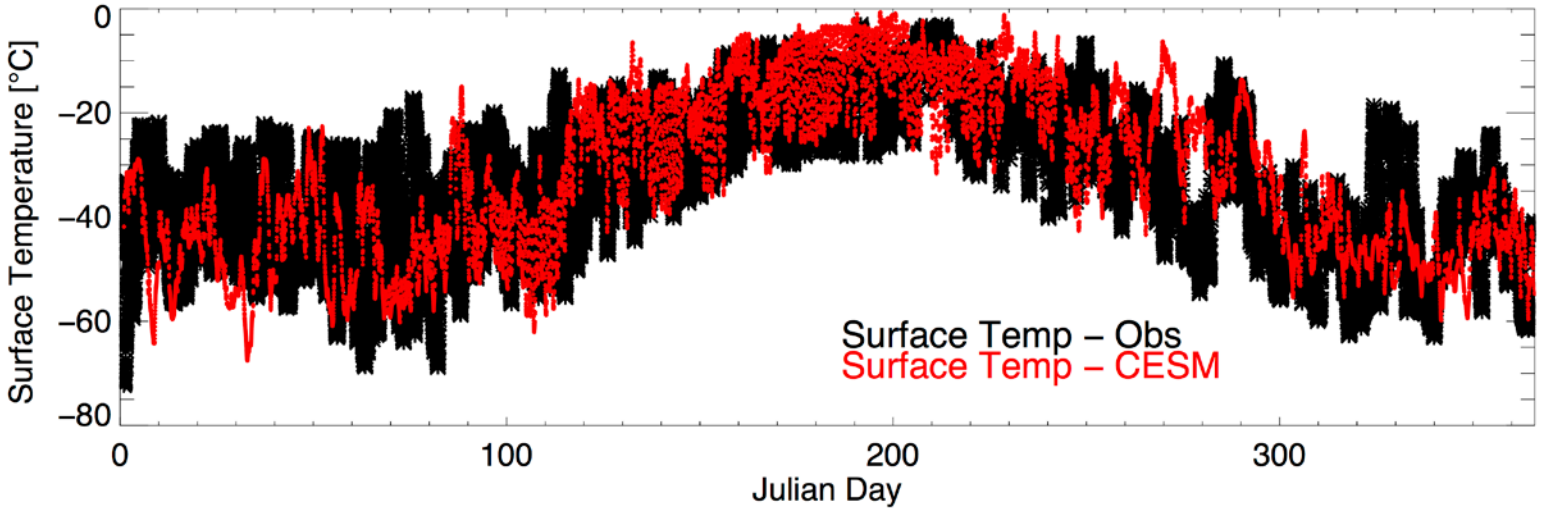
CESM 1-year representative run

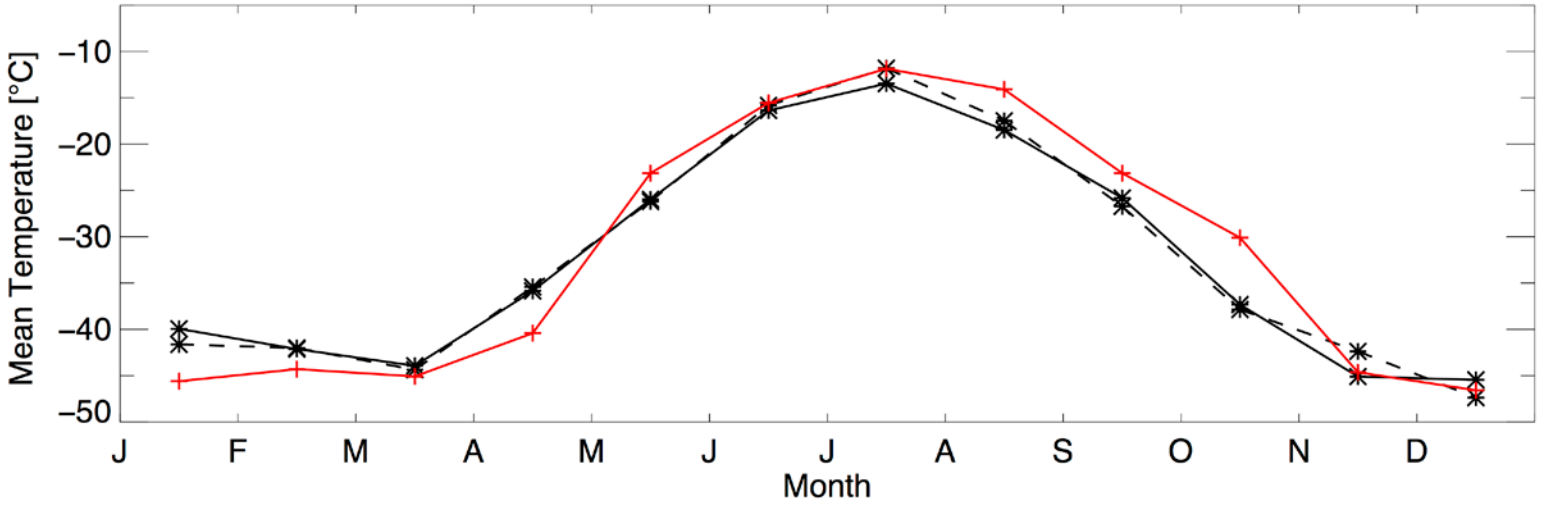
- data provided by Jan Lenaertz

- Test version of CAM5.5 (improved liquid containing clouds compared to CAM5)
- Community Land Model CLM4.0
- Forced SST
- GHG forcing from 2000

NCAR UCAR | CESM COMMUNITY EARTH SYSTEM MODEL

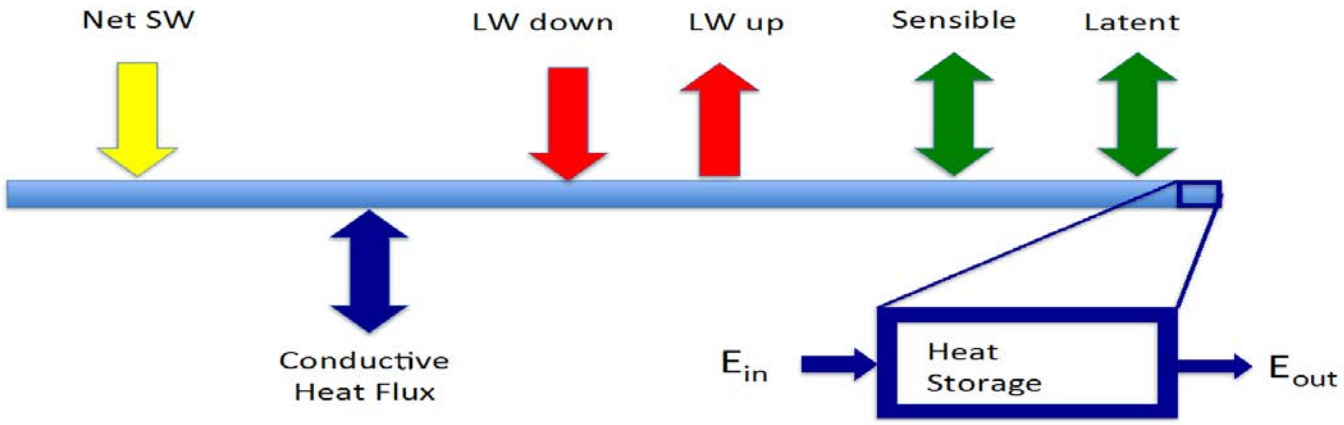
Surface temperature Comparison





Surface Energy Budget

Define a positive flux as warming the surface



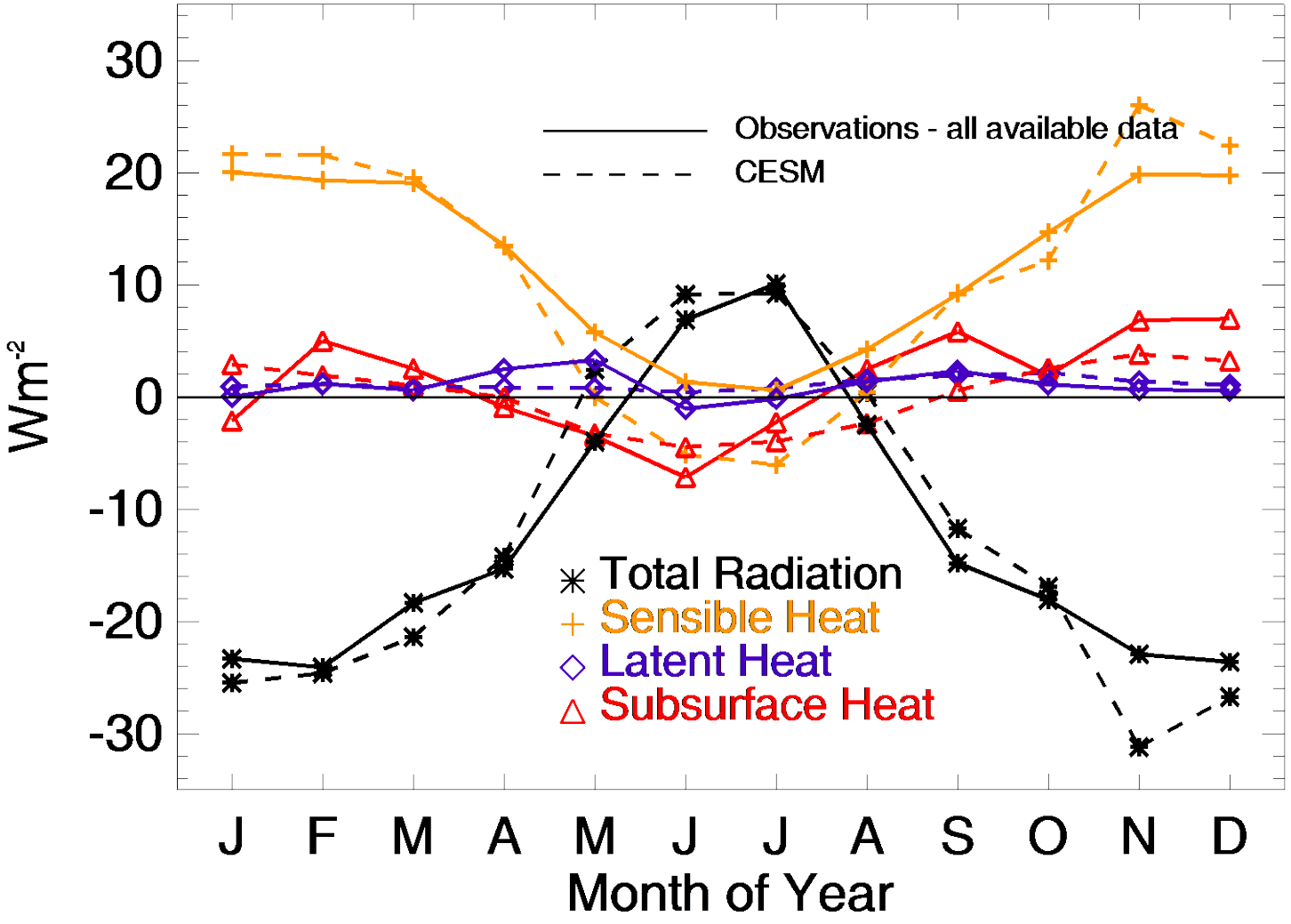
$$SEB = SW_{down} - SW_{up} + LW_{down} - LW_{up} + H_{sensible} + H_{latent} + C + S$$

All components available for 1 year

July 2013 – June 2014

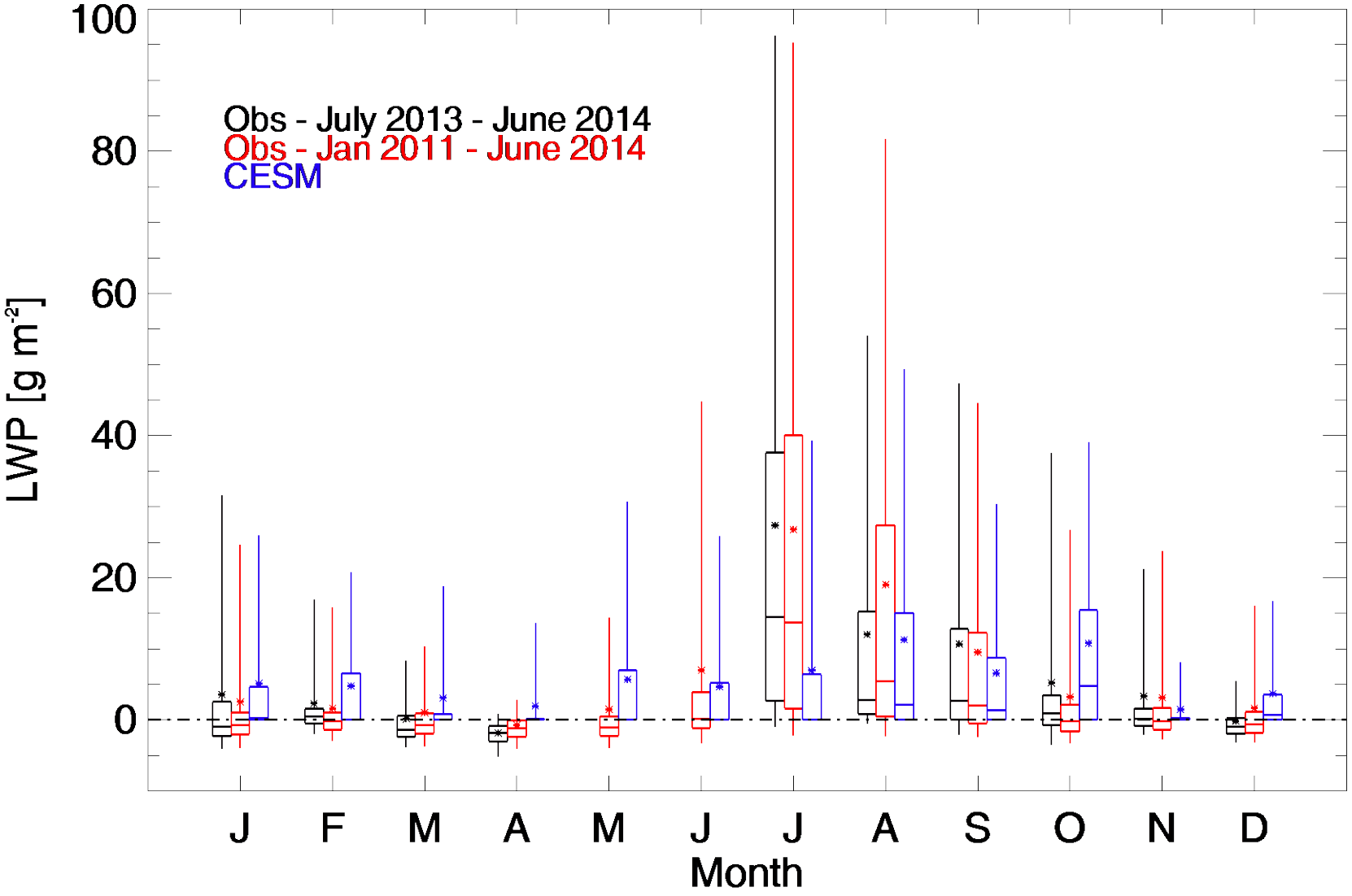
- Broadband Radiation - Swiss Federal Institute (ETH)
- Sensible heat Flux - Bulk Aerodynamic method (Persson et. al. 2002, JGR)
- Latent Heat Flux - Gradient 2-level method
- Conductive Heat Flux (C) - Thermistor String
- Heat storage (S) - Thermistor String

Surface Energy Budget Observations and CESM



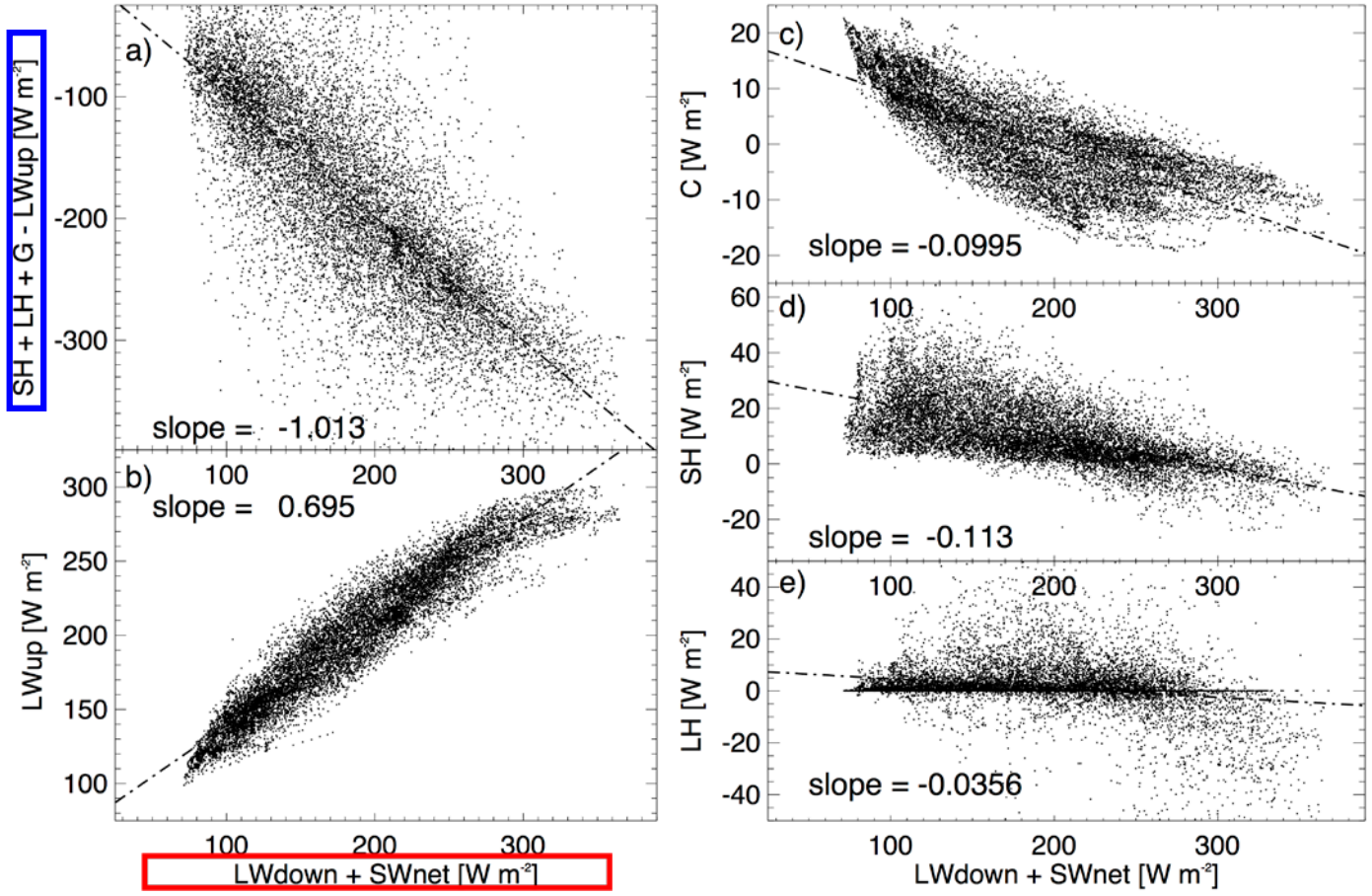
Subsurface Heat = C + S
Heat Storage in the upper layer of snow plus conductive flux below this layer.

Liquid Water Path



Observational Response to Changes in “Driving” radiation

-1 slope of the linear fit of the Response terms $SH + LH + G - LW_{up}$ vs. the Driving terms (LW_{down} +SW net)



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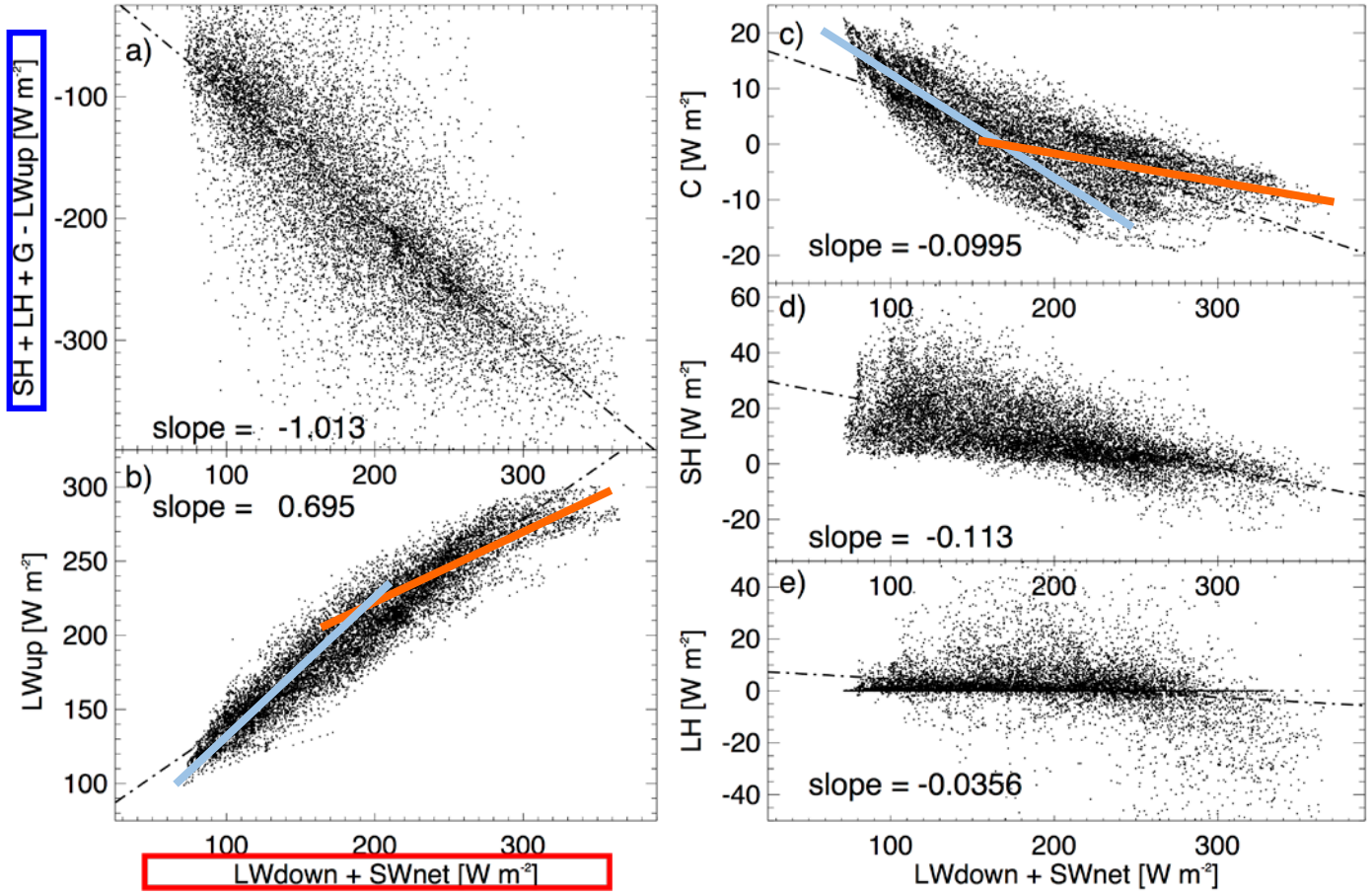
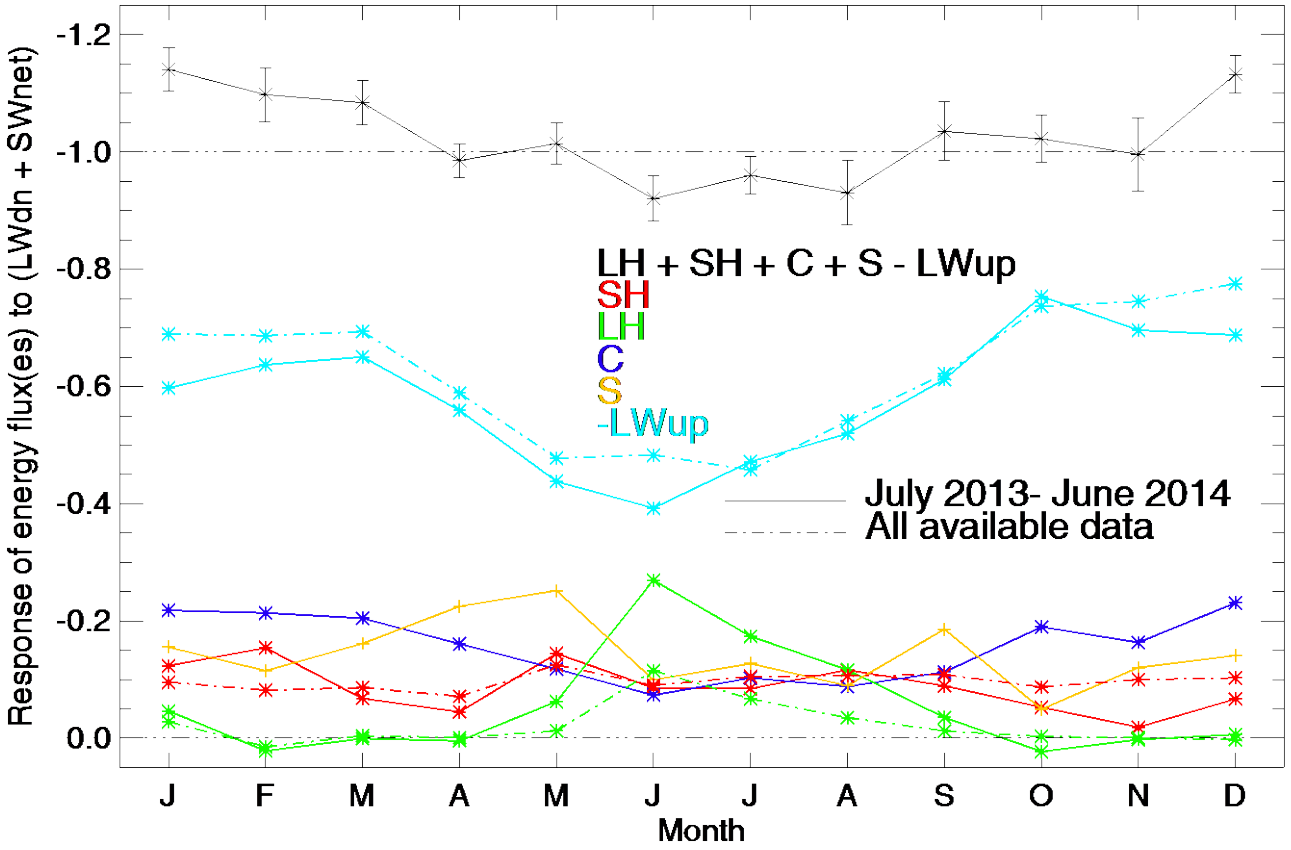


Annual Cycle of response (observations)

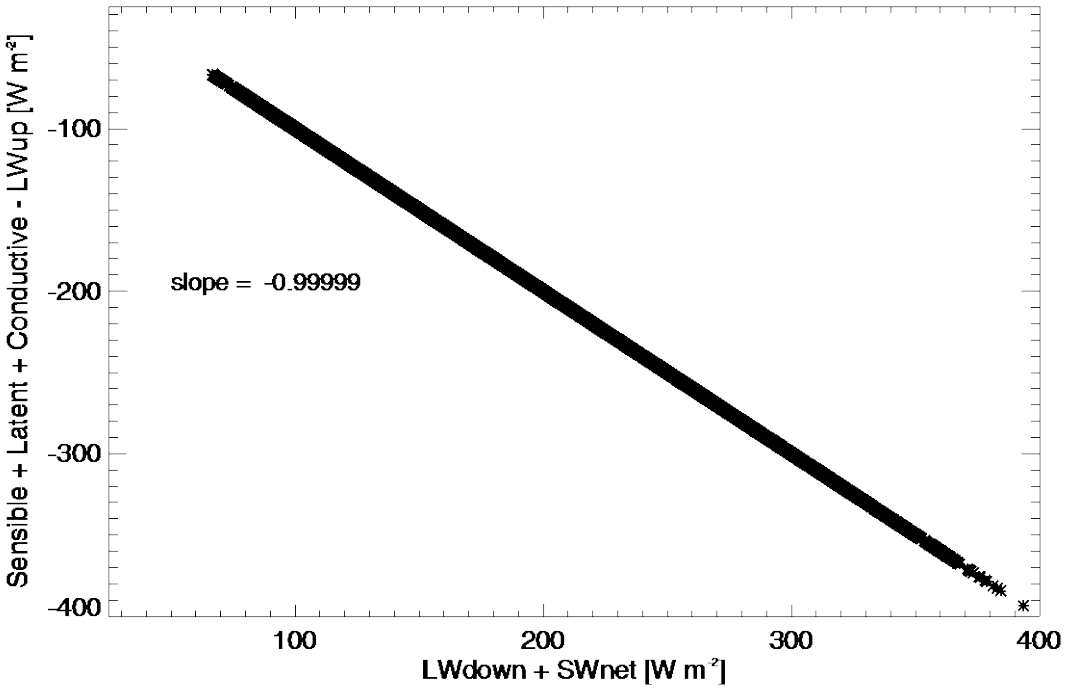


This technique offers a way to evaluate the feedbacks to the driving terms.

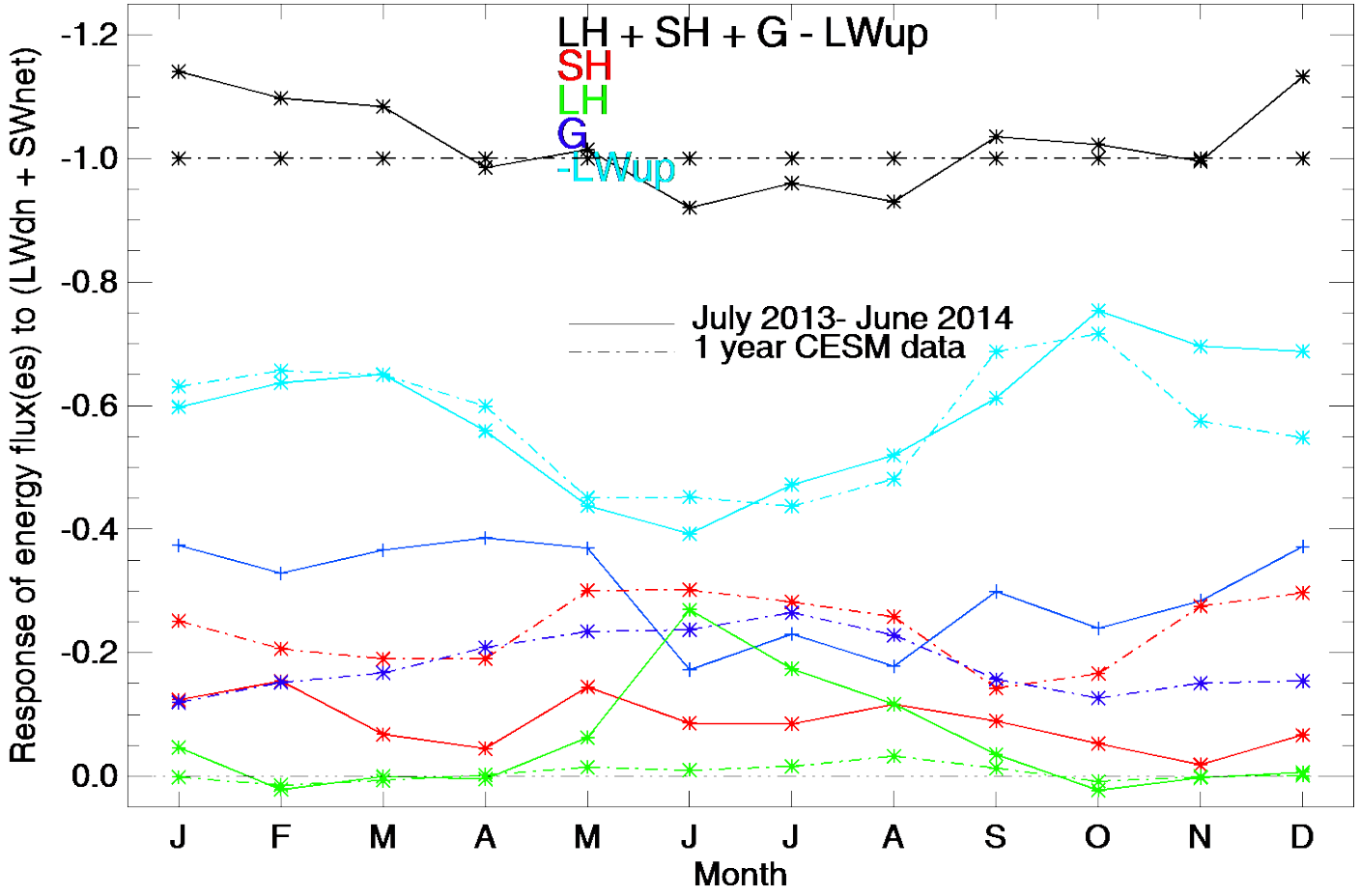
Even if the clouds are not represented perfectly are the ice/atmosphere processes realistic?

CESM response to driving terms

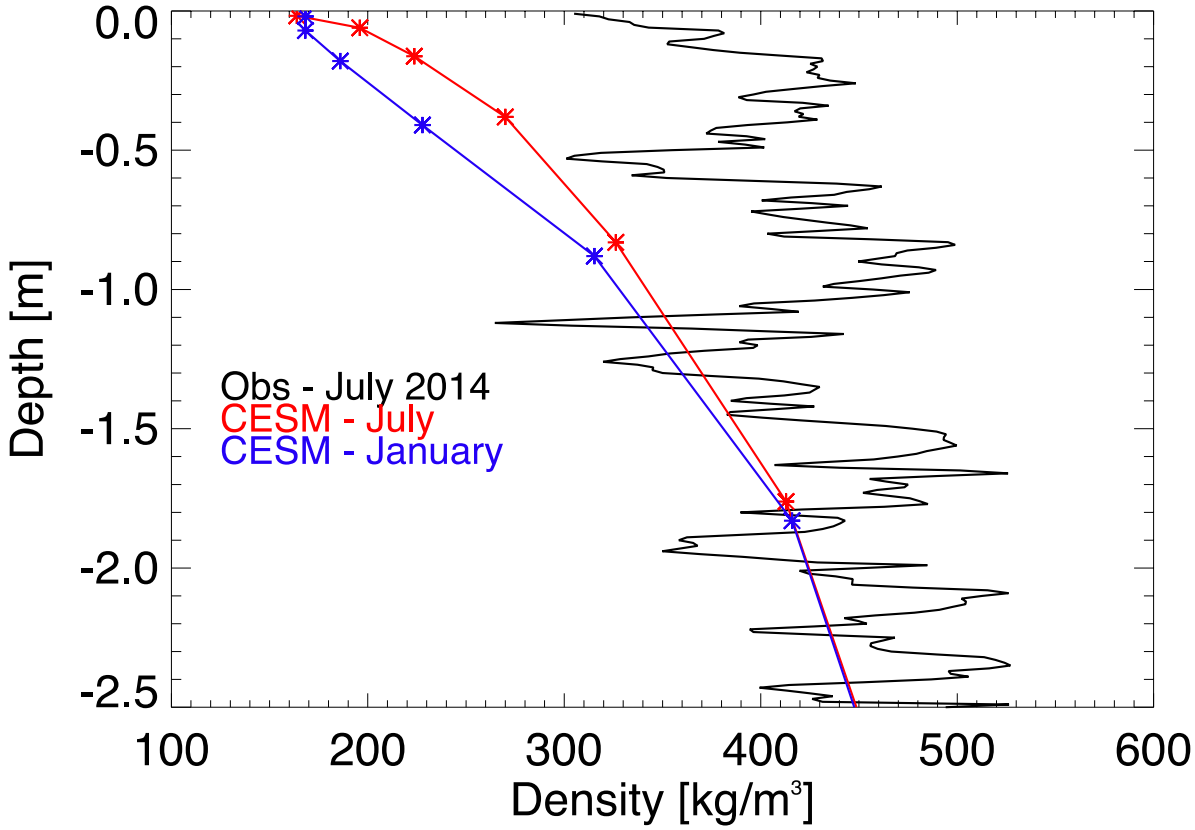
For each 30-minute time step the energy budget is closed



Annual Cycle of response (Observations and CESM)



Snow Density Profile



Conclusions

- Initial comparisons in central Greenland
  - Surface temperature compares well in June and July
  - LWP is more realistic than CAM5 but still too low in July

- Relationships between energy fluxes at the surface leads to enhanced understanding of the physical processes that occur at the ice/atmosphere interface.
  - CESM response of subsurface flux is lower in the winter compared to observations.
    - Investigate snow density.
  - CESM response of latent heat flux is lower in the summer compared to observations.
    - Investigate near-surface moisture gradients.
  - CESM response of the sensible heat flux is higher compared to observations
    - Investigate near-surface stability.

Thank you

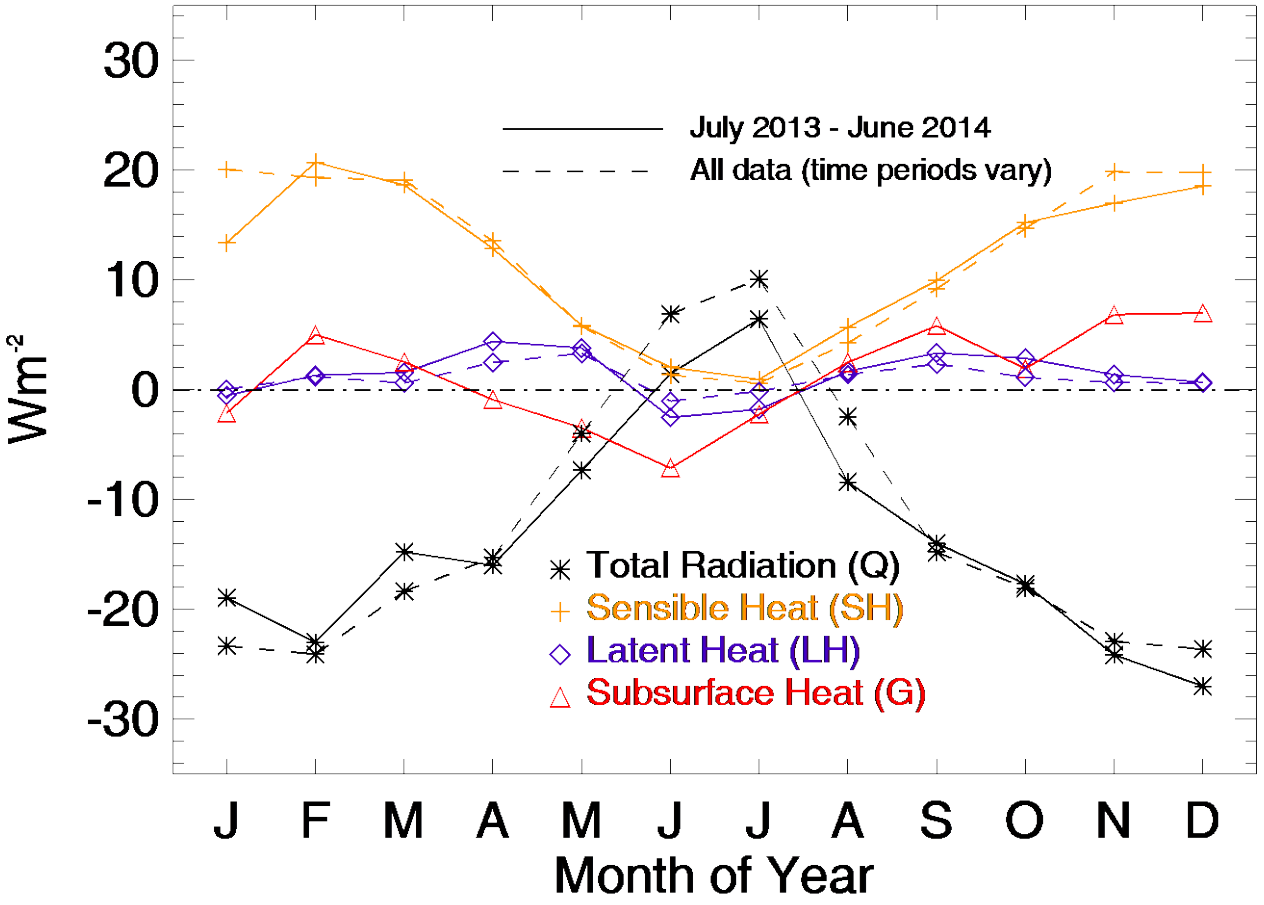
- This research is supported by the National Science Foundation under grants PLR1303879 and PLR1314156.

- The Swiss Federal Institute (ETH) provided the ETH broadband radiometer measurements.

- Additional broadband radiation measurements, ozonesonde soundings, CO_2 measurements, and near- surface meteorological tower data are provided by the National Oceanic and Atmospheric Administration's Global Monitoring Division.

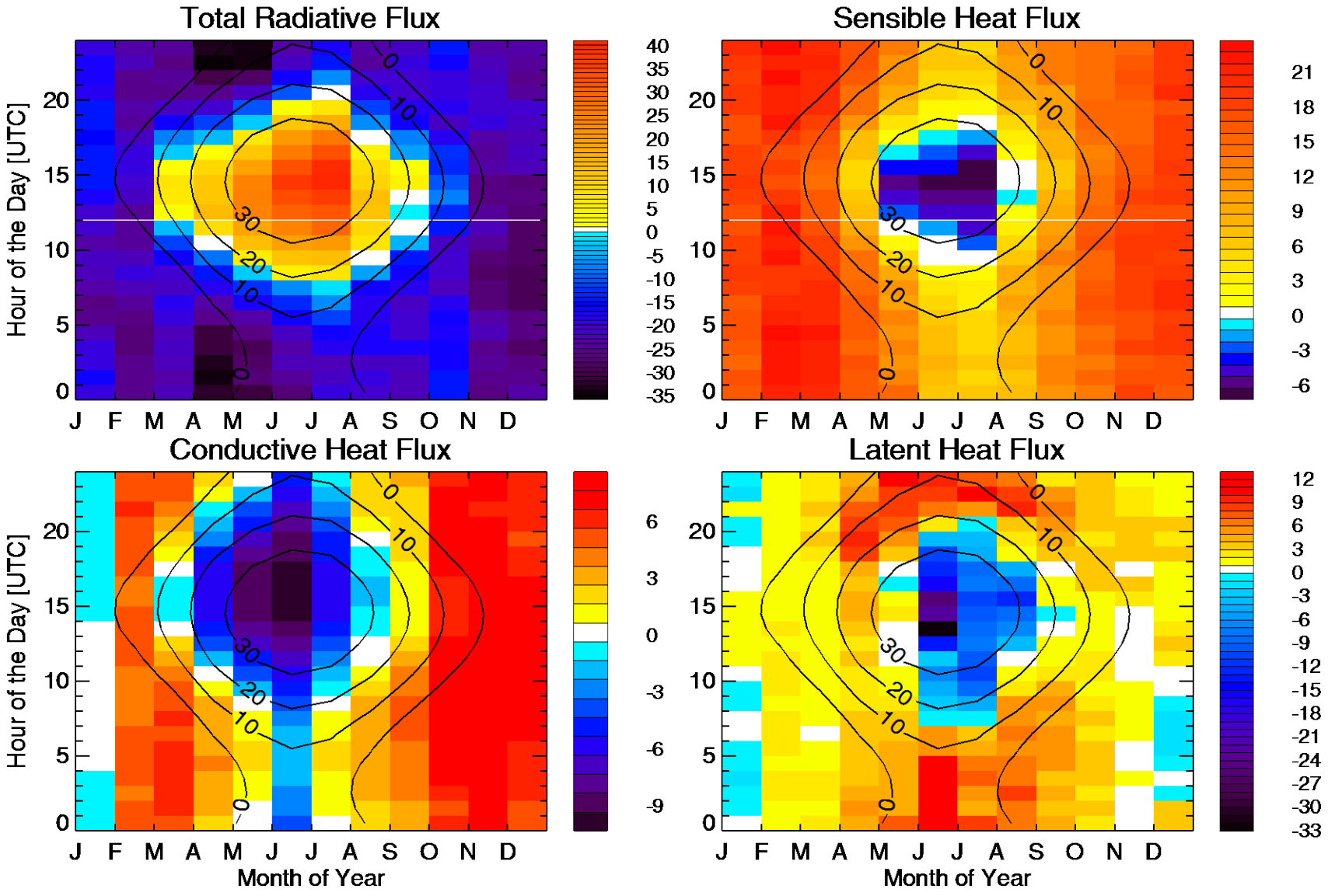
- Thanks to Polar Field Services and the various science technicians for their excellent support of the field experiments at Summit Station.

Surface Energy Budget Observations



G = C + S

Heat Storage in the upper layer of snow plus conductive flux below this layer.


Total Radiative Flux
Sensible Heat Flux
Conductive Heat Flux
Latent Heat Flux
Hour of the Day [UTC]
Month of Year
J F M A M J J A S O N D
0 5 10 15 20
0 10 20 30
40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35
21 18 15 12 9 6 3 0 -3 -6
6 3 0 -3 -6 -9
12 9 6 3 0 -3 -6 -9 -12 -15 -18 -21 -24 -27 -30 -33