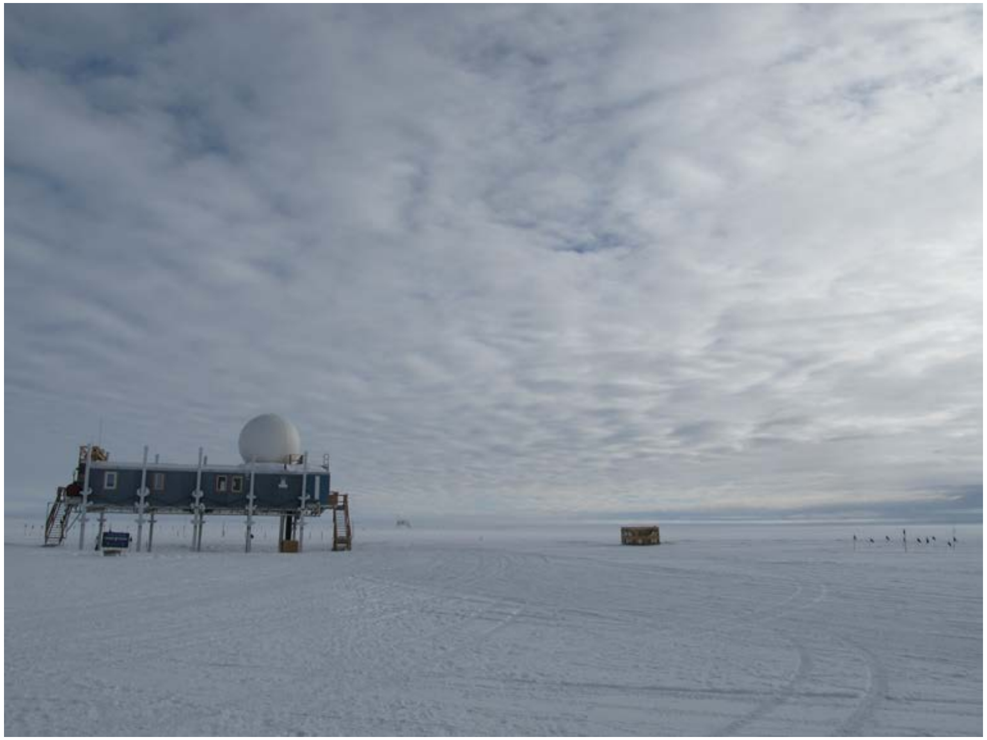
Model Evaluation in Central Greenland using a Comprehensive Set of Atmospheric and Surface Measurements



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Christopher Cox, David Noone, Von Walden, David Turner, Konrad Steffen

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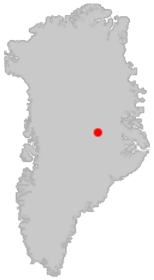
ICECAPS

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

- Closing the Isotope Balance at Summit (CIBS)

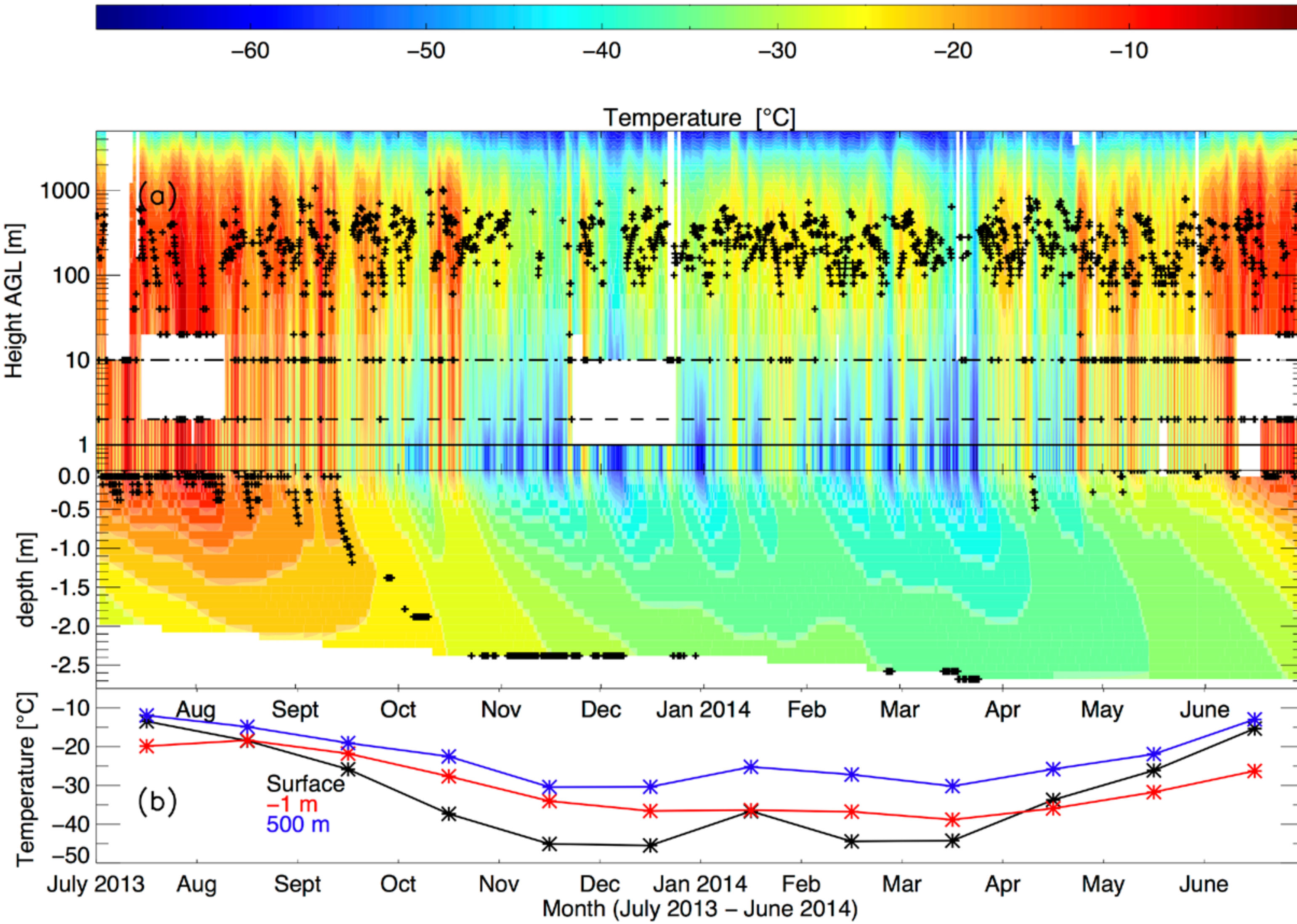
10m, 2m measurements

- NOAA – Global Monitoring Division

Instrumentation

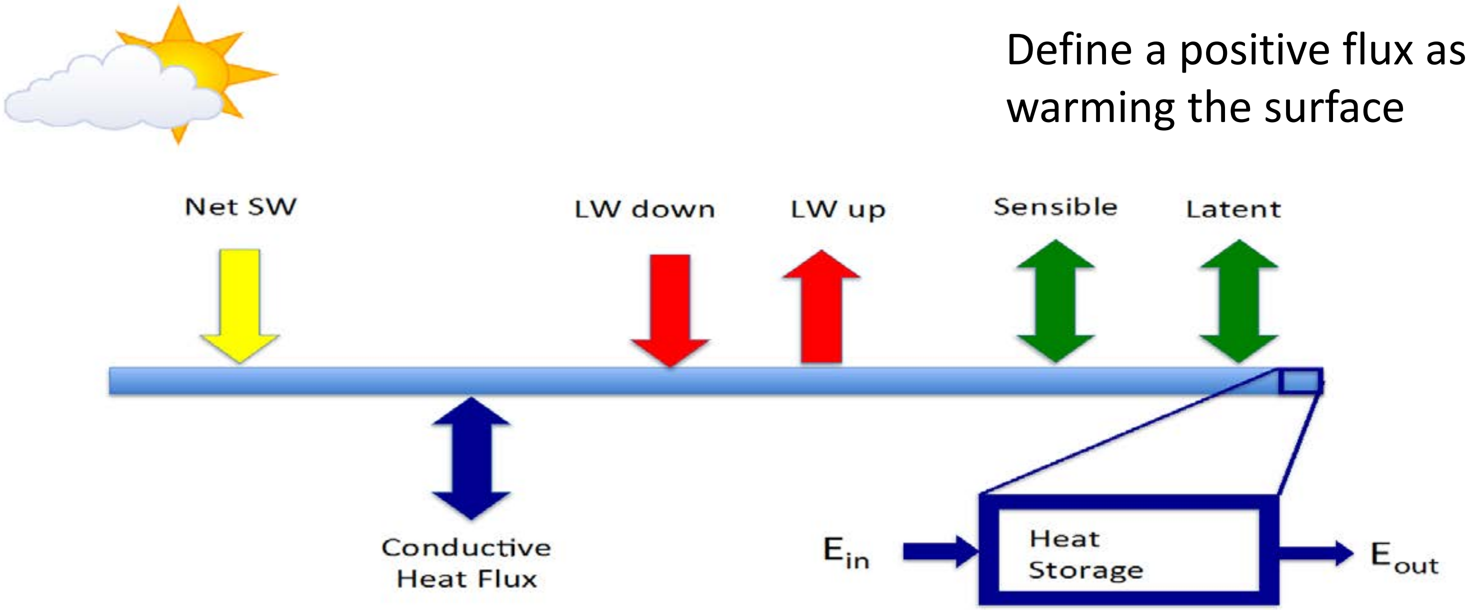
Parameters Measured [≈heights]	Instrument	Project - Location
Atmospheric Temperature Profile	Vaisala RS92 Radiosondes	ICECAPS - MSF
Snow Temperature Profile	Campbell Scientific 107 Temp Probes	CIBS - 50m tower
Surface height	Campbell Scientific SR-50A Sonic Ranger	CIBS - 50m tower
Temperature [2m, 10m]	Logan RTD - PT139 special order	NOAA/GMD - met tower
	Vaisala HMP 155 Temp probes	CIBS - 50m tower
	Metek USA1 Sonic Anemometers	CIBS - 50m tower
Wind Speed [2m, 10m]	Metek USA1 Sonic Anemometers	CIBS - 50m tower
	MetOne 010-CA Cup Anemometers	CIBS - 50m tower
Relative Humidity [2m, 10m]	Vaisala HMP 155 RH probes	CIBS - 50m tower
Water Vapor Mixing Ratio [2m, 10m]	Picarro L2120 spectrometer	CIBS - 50m tower
Barometric Pressure	Setra 270	NOAA/GMD - met tower
LW↓, LW↑	Kipp and Zonen CG4 pyrgeometers	ETH - Radiation Station
	Eppley PIR pyrgeometers	NOAA/GMD - Radiation Station
SW↓, SW↑	Kipp and Zonen CM22 pyranometers	ETH - Radiation Station
	Kipp and Zonen CM22 pyranometers	NOAA/GMD - Radiation Station
Liquid Water Path	RPG Microwave Radiometers - HATPRO and HF	ICECAPS - MSF
Precipitable Water Vapor	RPG Microwave Radiometers - HATPRO and HF	ICECAPS - MSF
Cloud Occurence	Millimeter Cloud Radar - 35 GHz	ICECAPS - MSF

Temperature Profiles



Surface Energy Budget

Define a positive flux as warming the surface



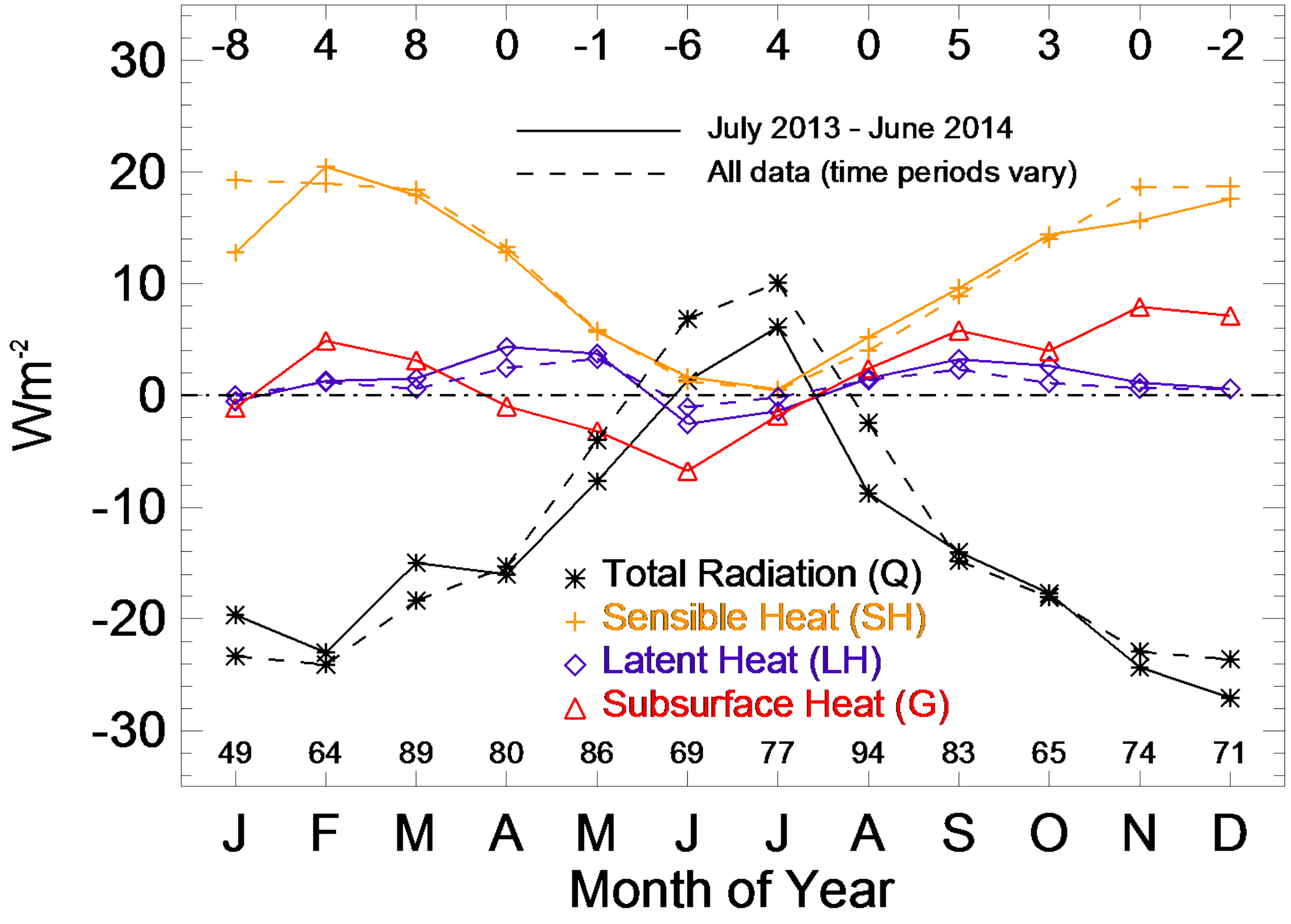
$$SEB = SW_{down} - SW_{up} + LW_{down} - LW_{up} + H_{sensible} + H_{latent} + C + S$$

All components available for 1 year

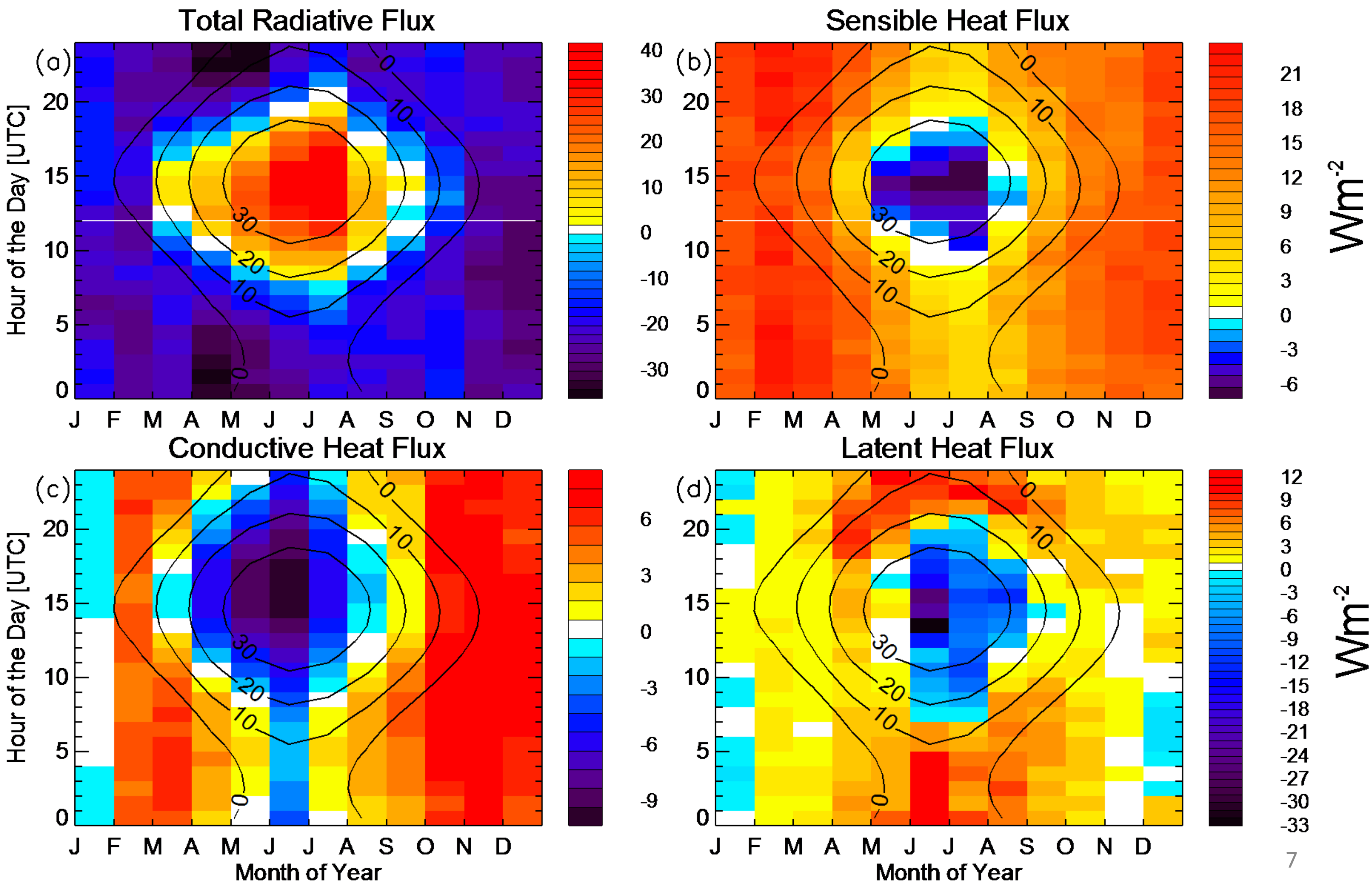
July 2013 – June 2014

- Broadband Radiation - Swiss Federal Institute (ETH)
- Sensible heat Flux - Bulk Aerodynamic method (Persson et. al. 2002, JGR) and Eddy Covariance method
- Latent Heat Flux - Gradient 2-level method Stability Functions from Cullen 2003
- Conductive Heat Flux (C) - Thermistor String
- Heat storage (S) - Thermistor String

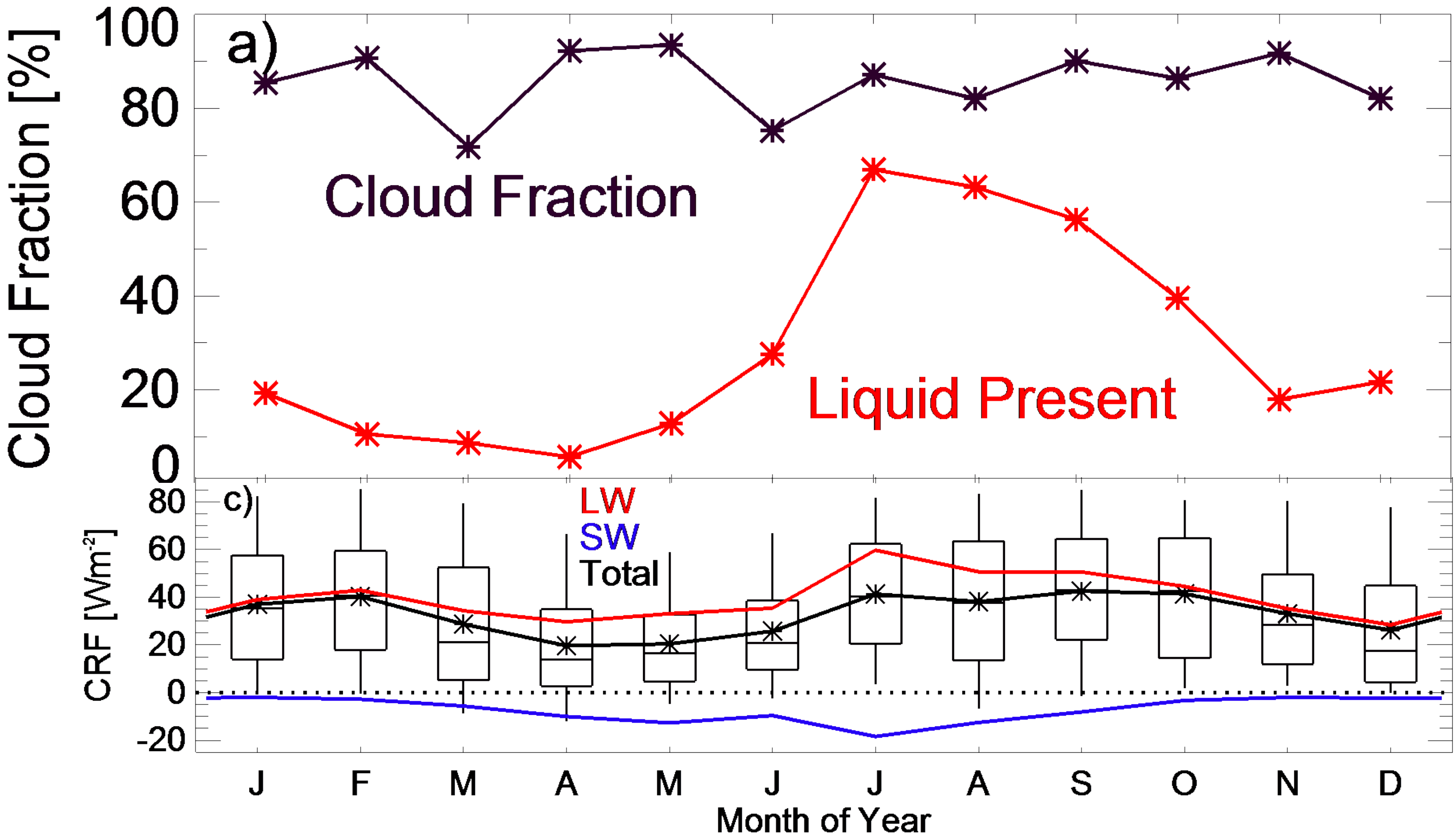
Surface Energy Budget



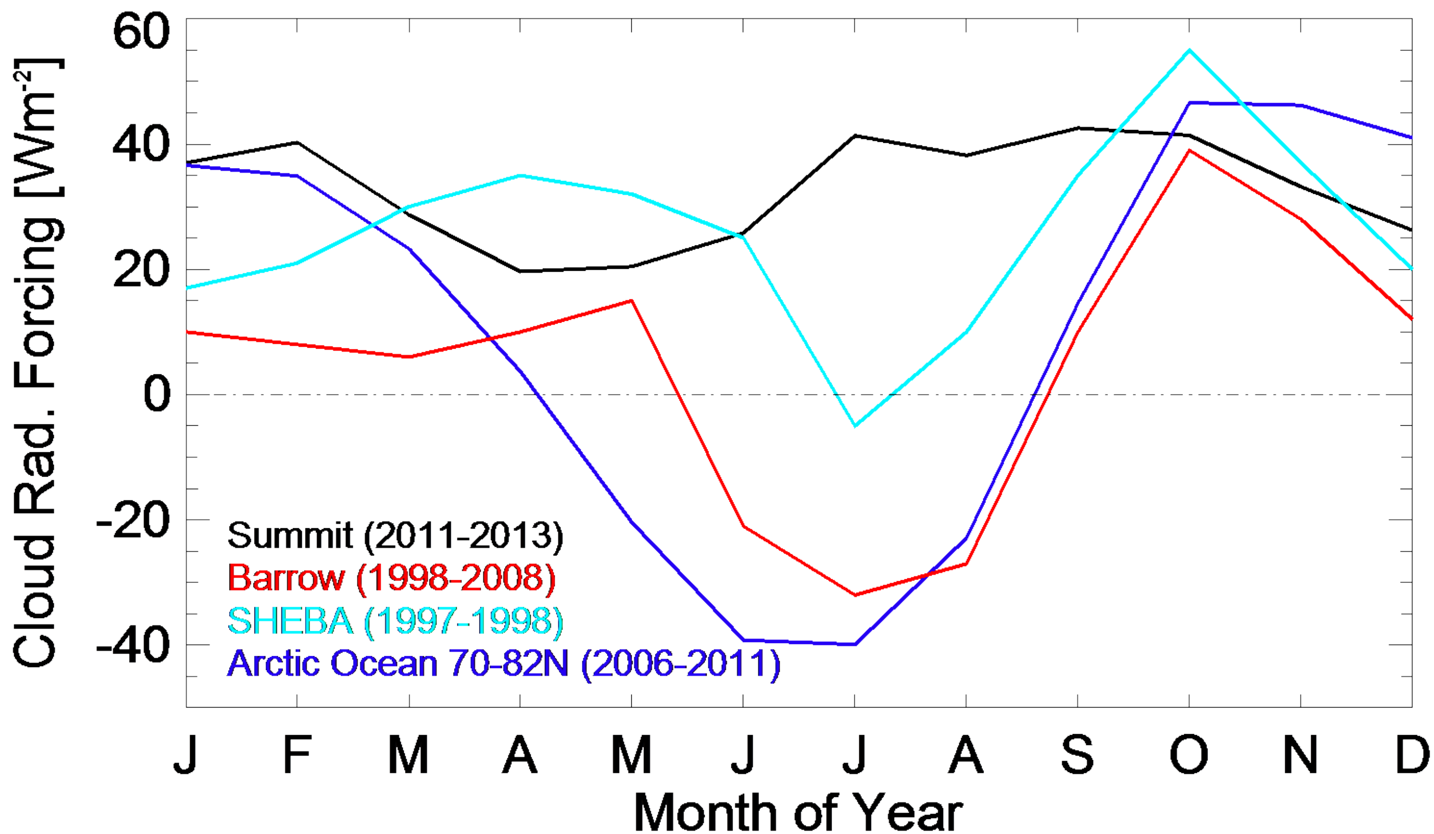
Annual Diurnal Cycle



- High year round cloud fraction – 86%
  - Ice-clouds are important to CRF
- LW CRF magnitude corresponds to the presence of liquid-bearing clouds



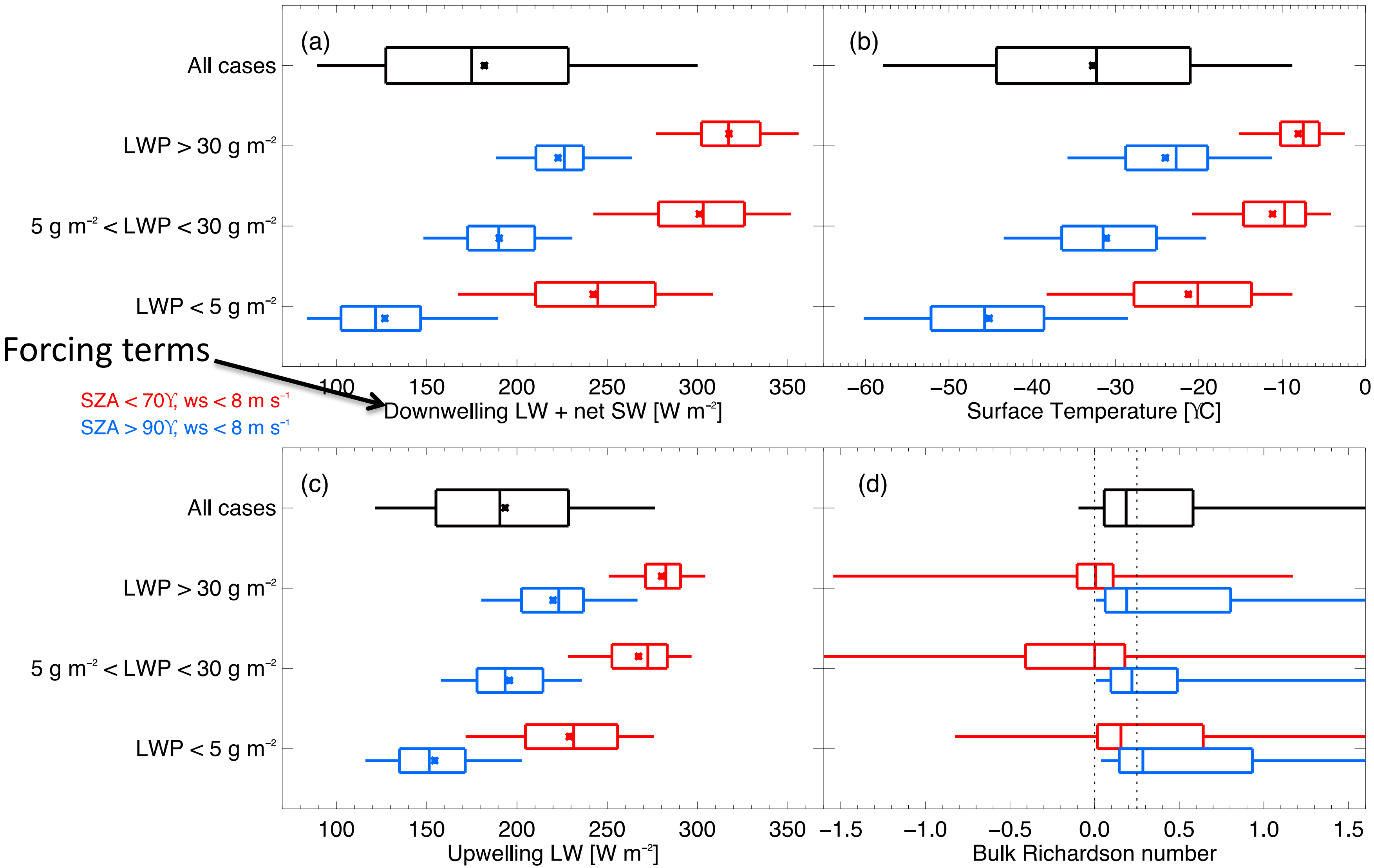
Surface albedo important for CRF



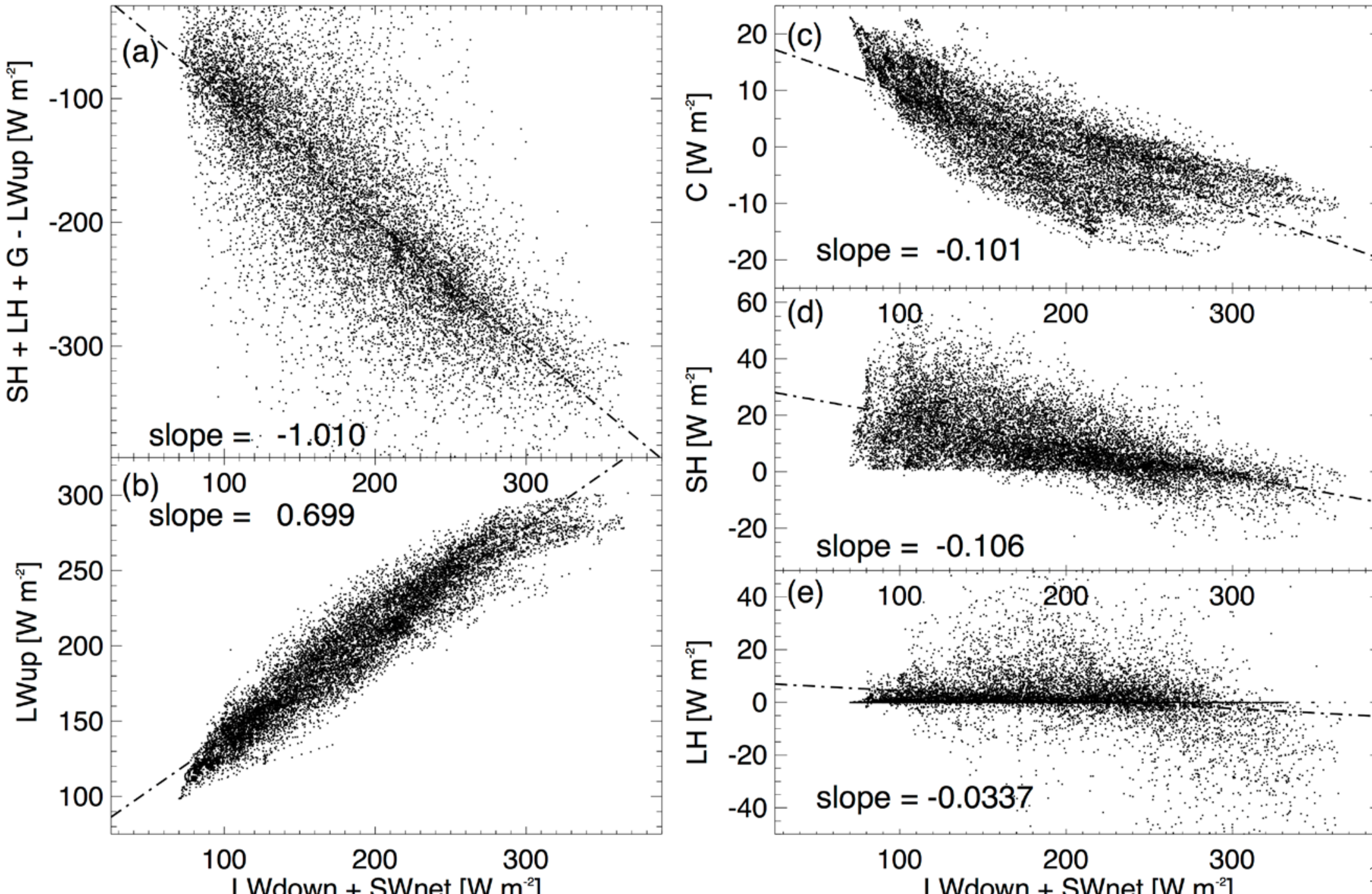
Miller et. al. 2015, J. Climate
Dong et. al. 2010, JGR
Shupe and Intrieri 2004, J. of Climate
Kay and L'Ecuyer 2013, JGR

Central Greenland is a unique Arctic location

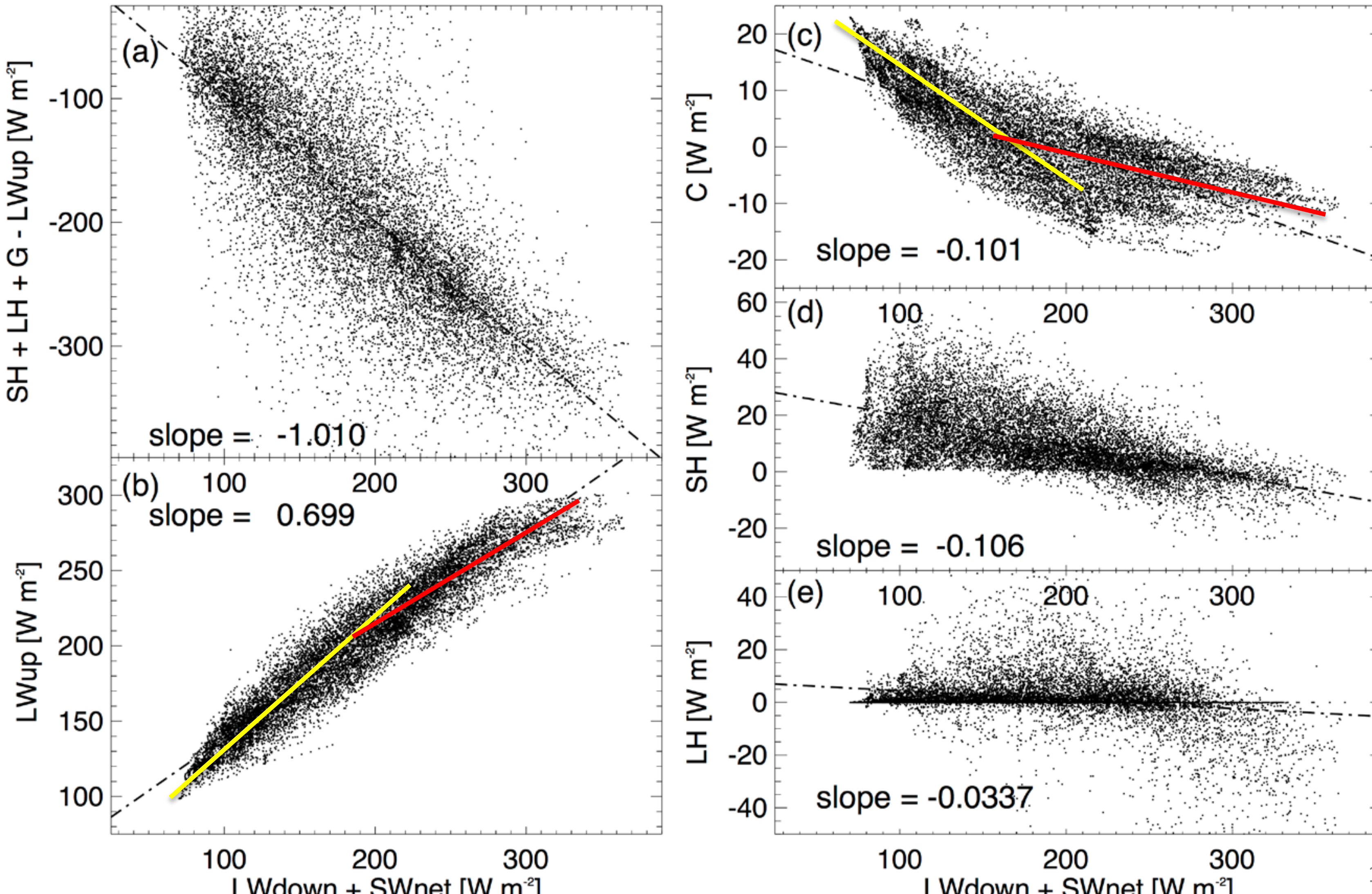
Influence of Liquid-bearing Clouds and Insolation



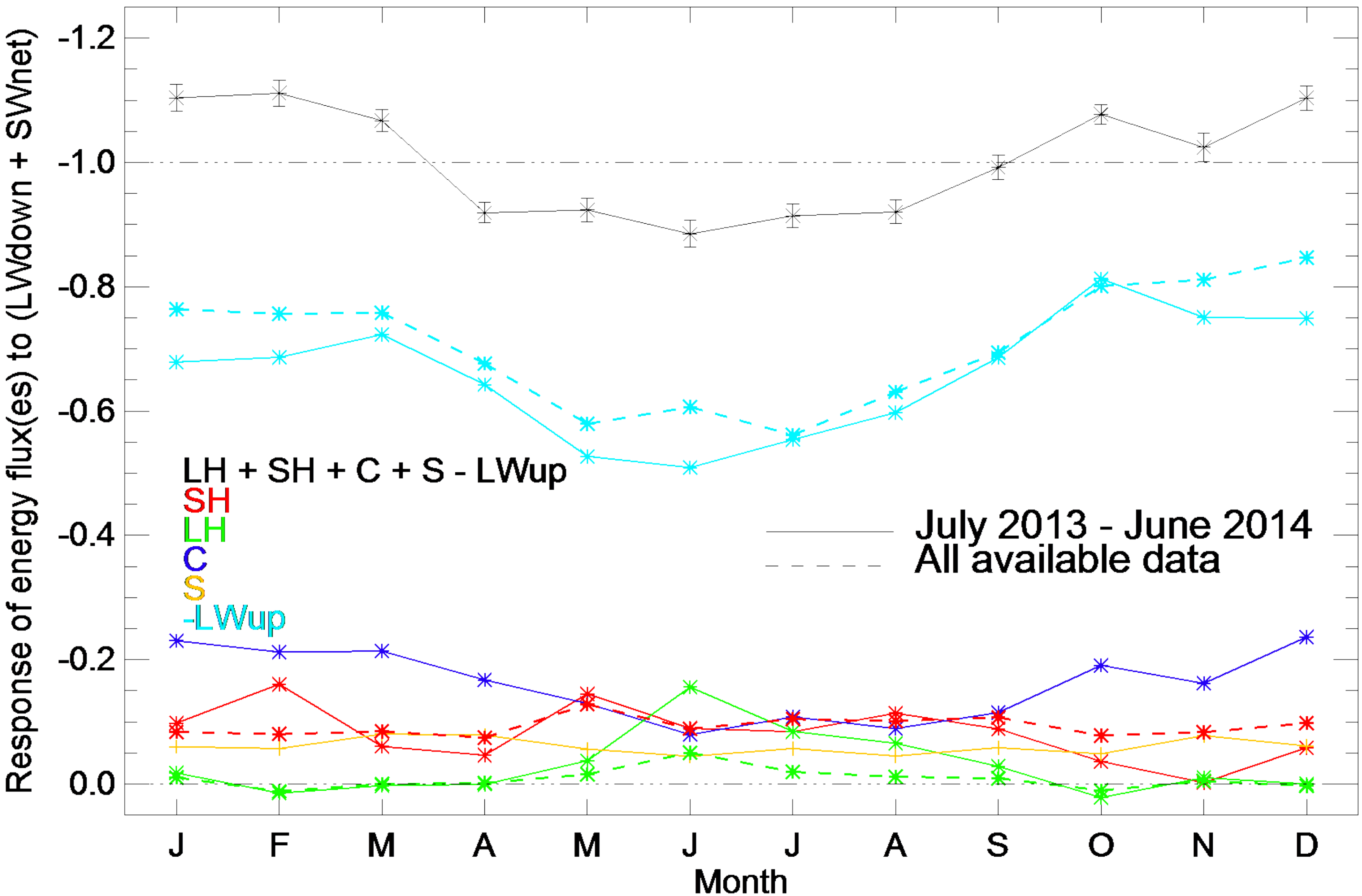
Response to Forcing terms



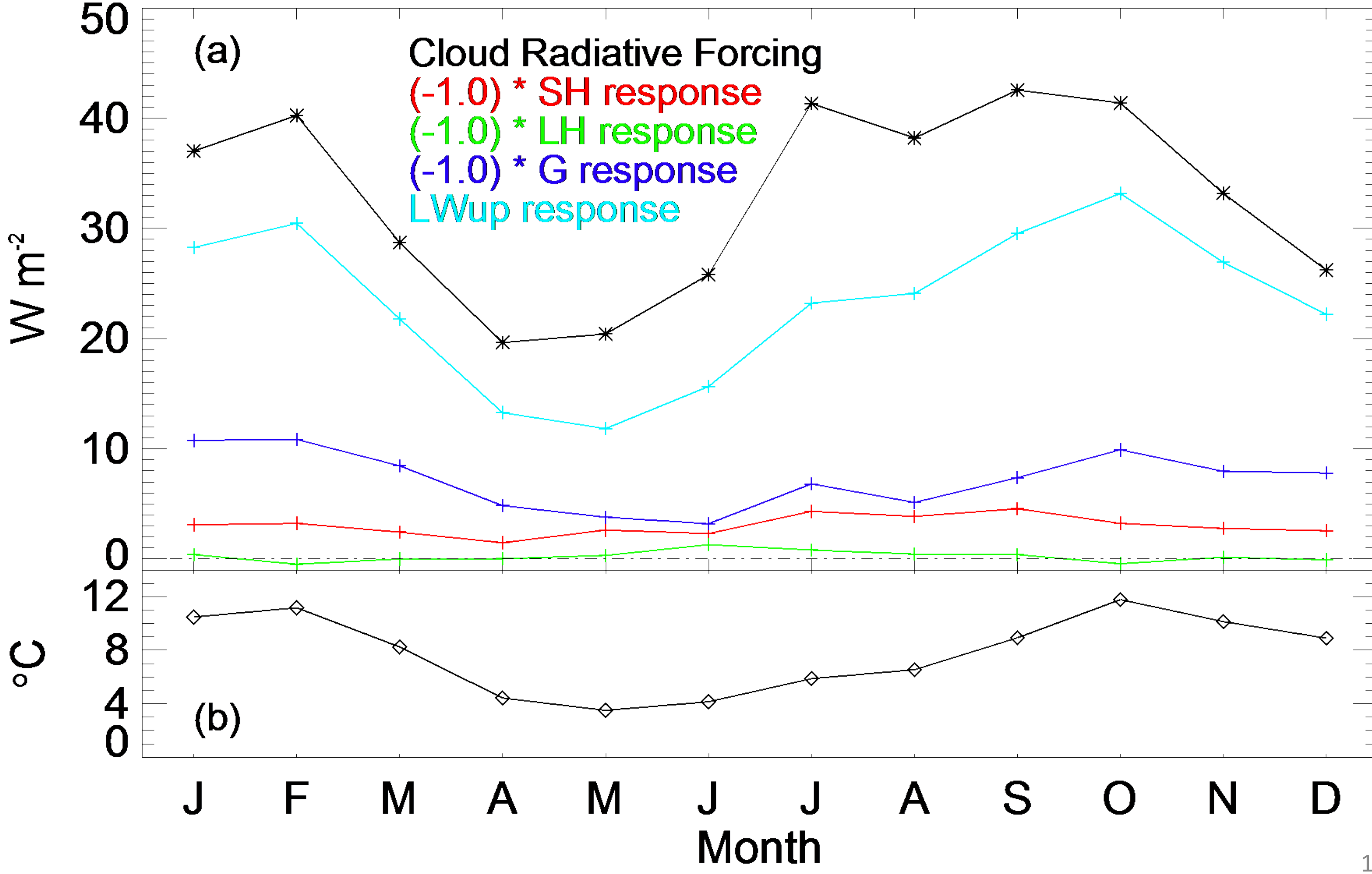
Response to Forcing terms



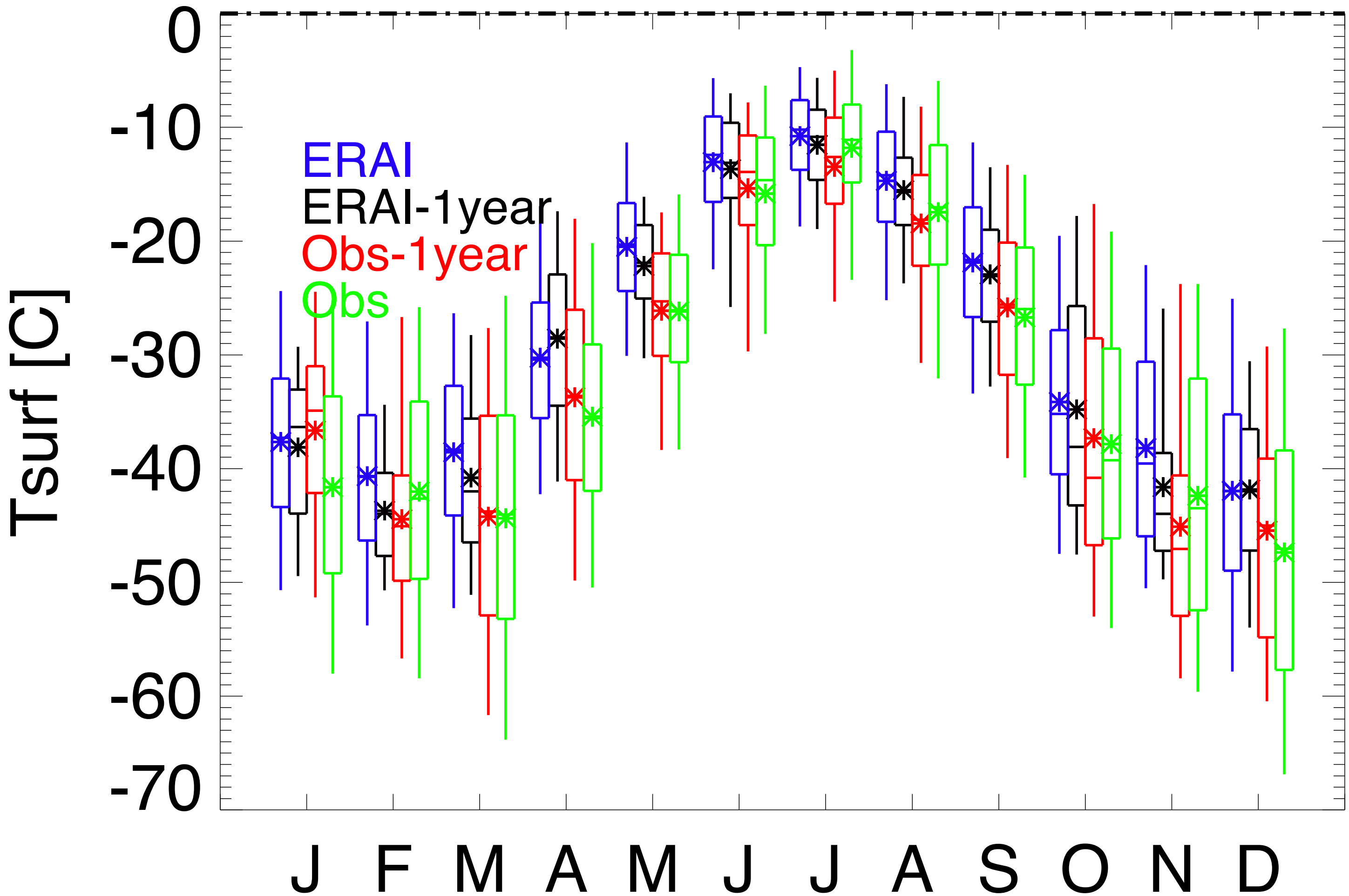
Annual responses



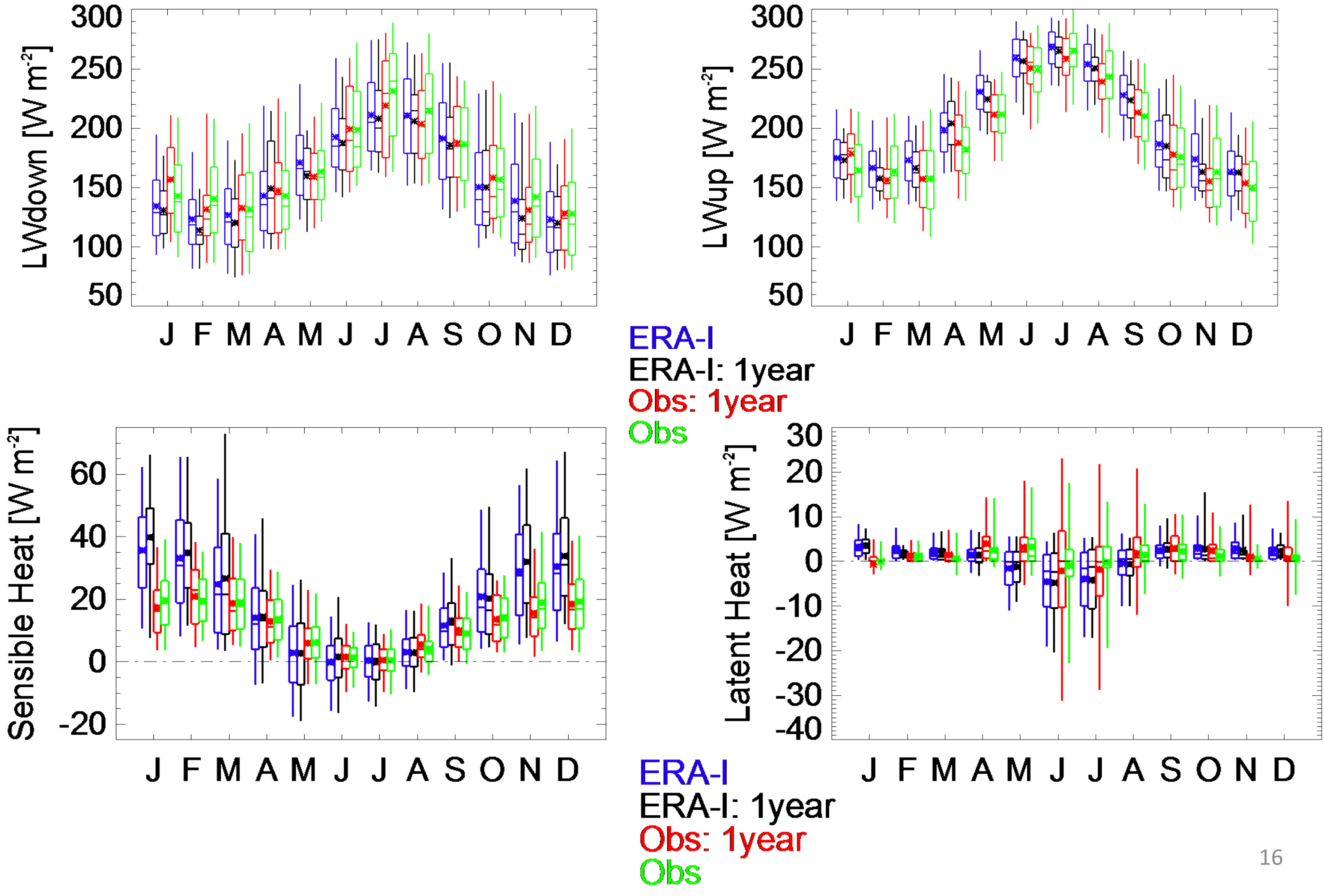
SEB responses to CRF



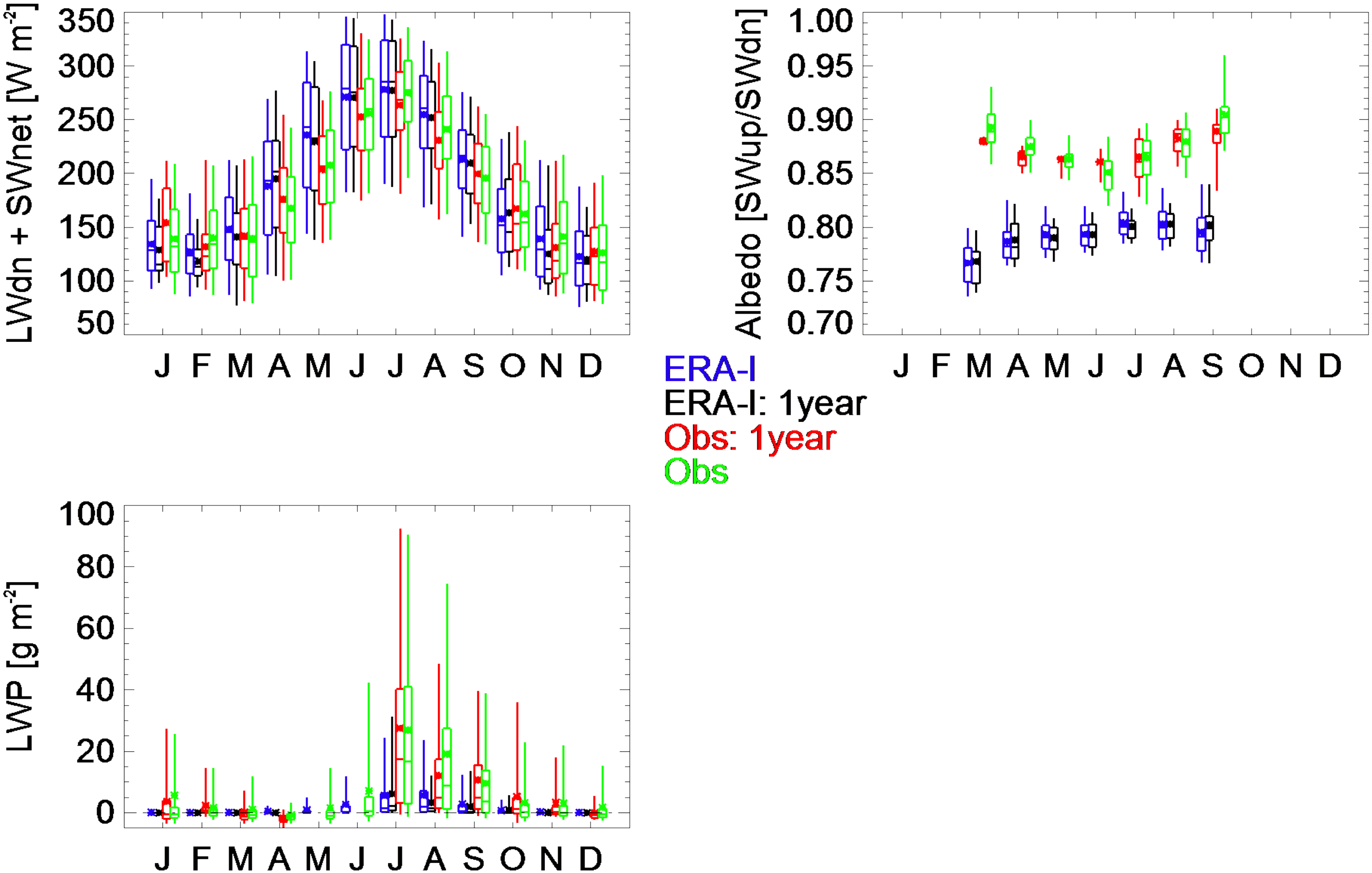
ERA Interim comparisons



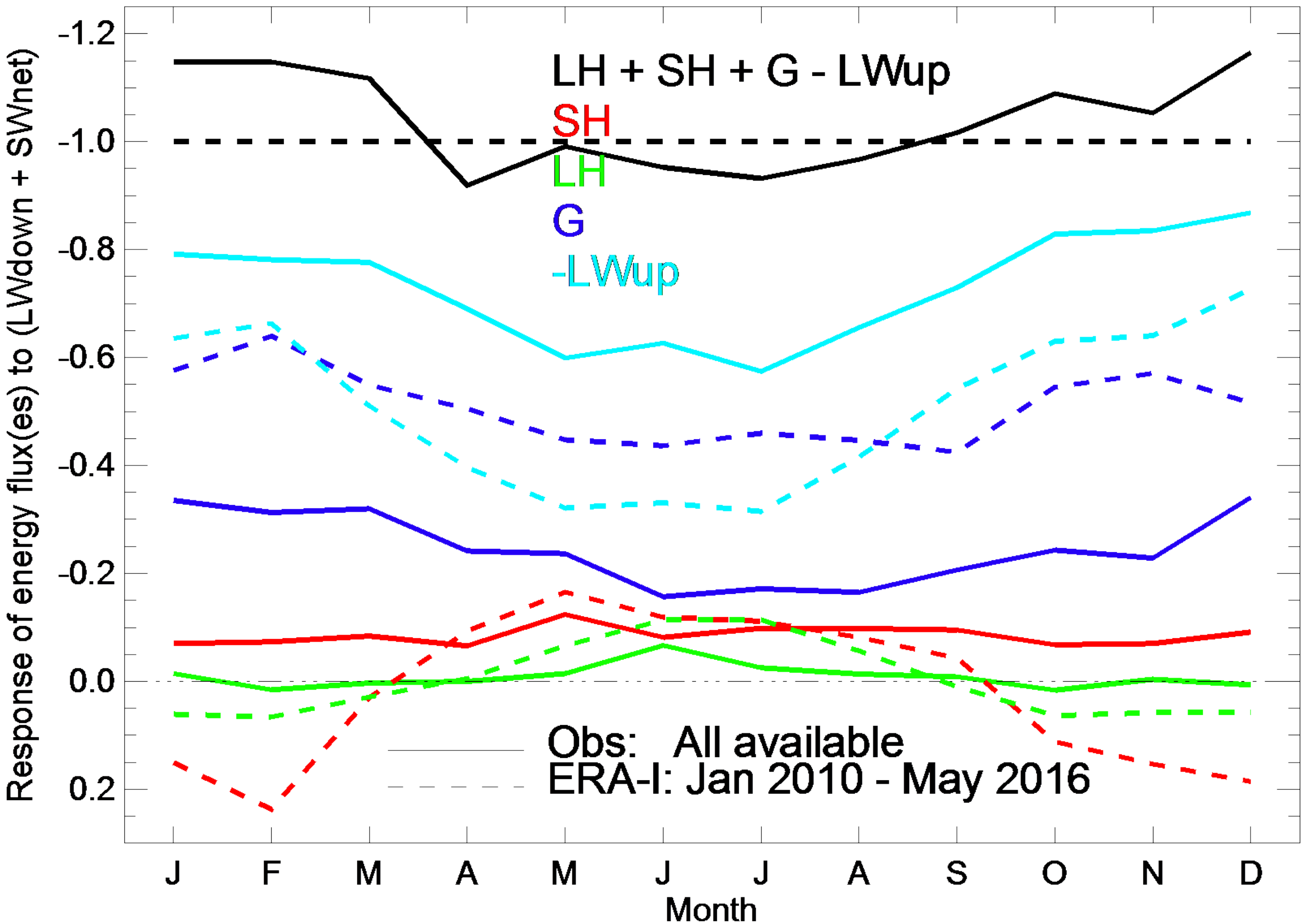
SEB Components



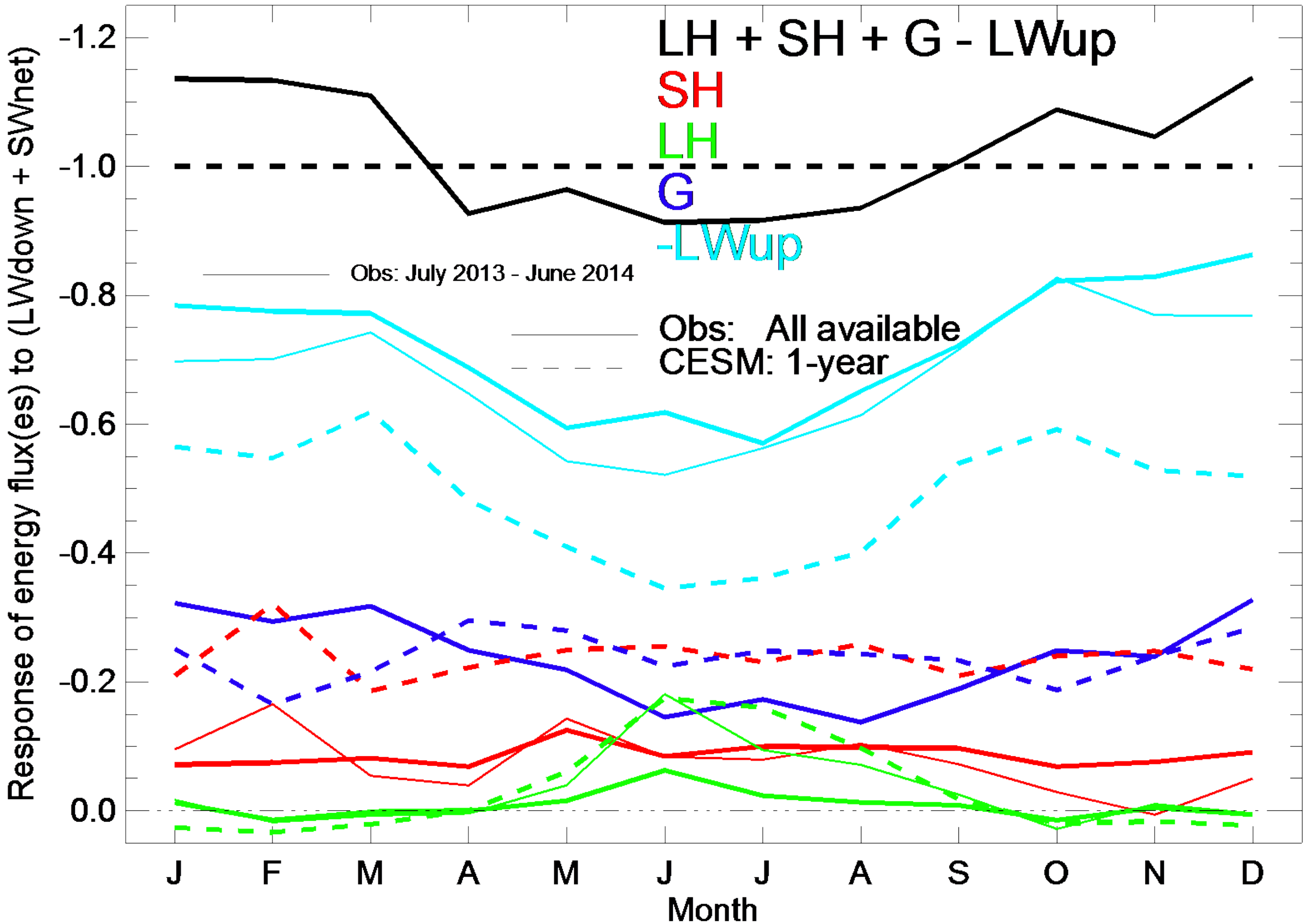
Forcing


LWdn + SWnet [W m-2]
350
300
250
200
150
100
50
J F M A M J J A S O N D
Albedo [SWup/SWdn]
1.00
0.95
0.90
0.85
0.80
0.75
0.70
J F M A M J J A S O N D
ERA-I
ERA-I: 1year
Obs: 1year
Obs
LWP [g m-2]
100
80
60
40
20
0
J F M A M J J A S O N D

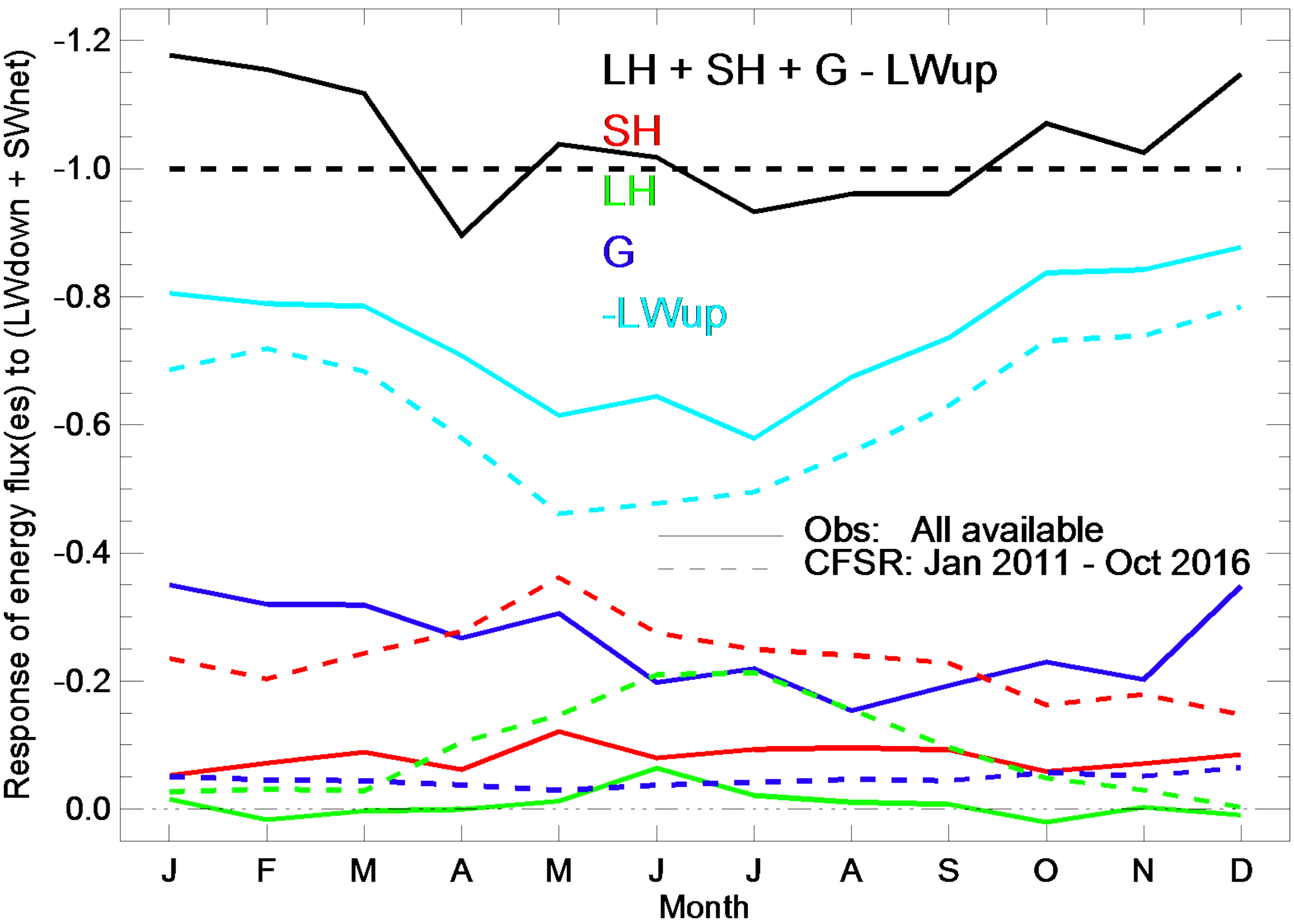
ERA-I Responses



Community Earth System Model Beta07 – CAM6, CLM5



Climate Forecast System Reanalysis



Conclusions

- Highly emissive GIS corresponds to a large response of the surface temperature
  - Strong radiative cooling under clear skies
  - Clouds can induce a warming of the surface on the same order as that of insolation due to the GIS being highly reflective in the shortwave

- Response of the non radiative SEB terms
  - Ground heat flux is the largest response
  - SH flux response is fairly constant throughout the annual cycle.
  - LH flux response is largest in the summer

- Process-based relationships indicate where there are deficiencies in representing GIS surface temperature variability.

- Data available - https://arcticdata.io/catalog/#view/doi:10.18739/A2Z37J

Thank you

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- David Noone’s project - Closing the Isotope Balance at Summit (CIBS)

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