Extreme Events at Summit, Greenland: 3 days, 3 years, and 33 summers

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Photo: Christopher Cox

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3 Perspectives

Summit Station
Elevation 3255 m
72°35'N
38°25'W

3 days

July 11, 2012 the Greenland Ice Sheet melt extent reached the Summit Station location for the first time since 1889. Low-level clouds present for three consecutive days.

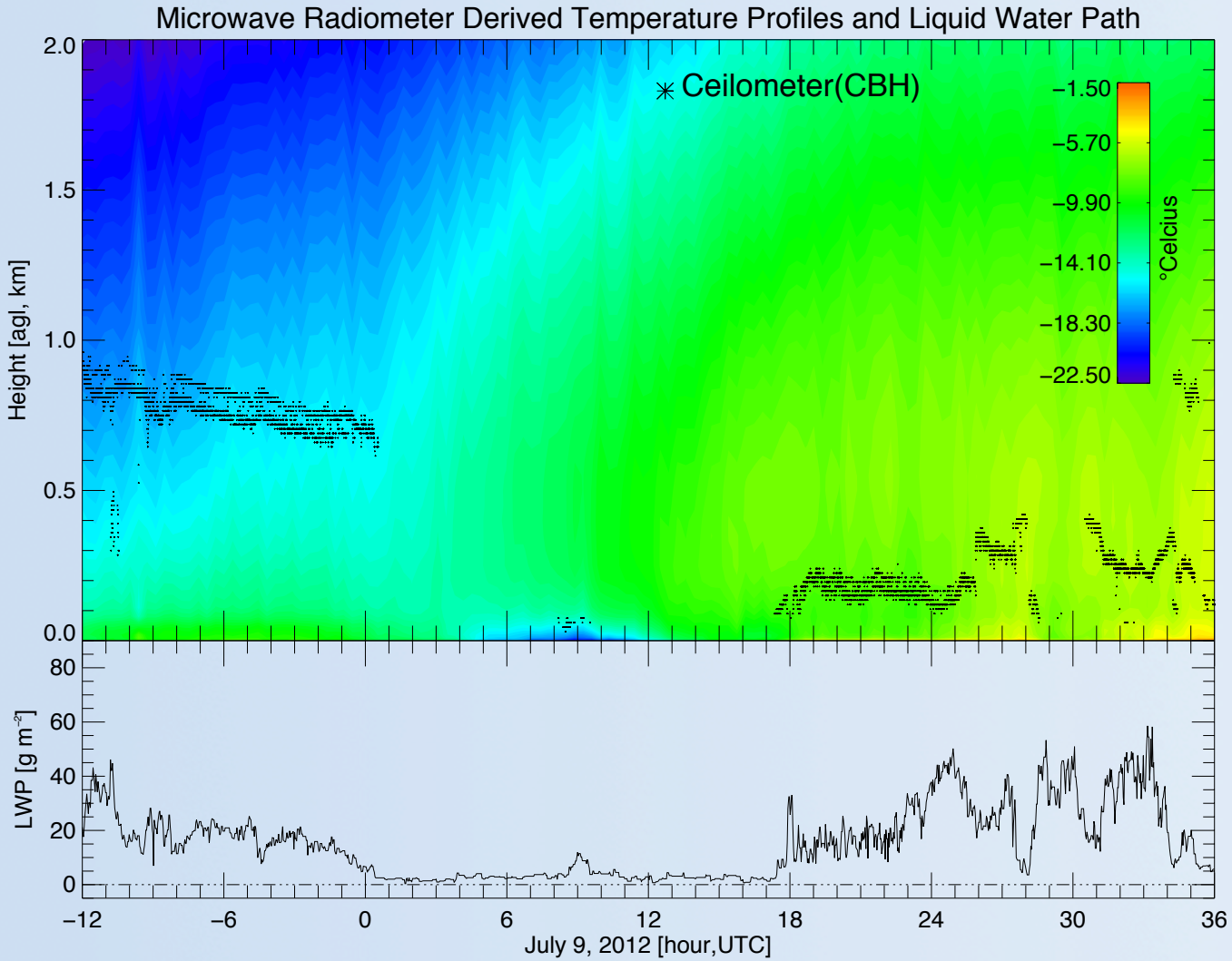
3 years

"An Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit" (ICECAPS) provides measurements from June 2010 – present. Using Summit data we can examine what parameters ERA-Interim captures well and where there are deficiencies.

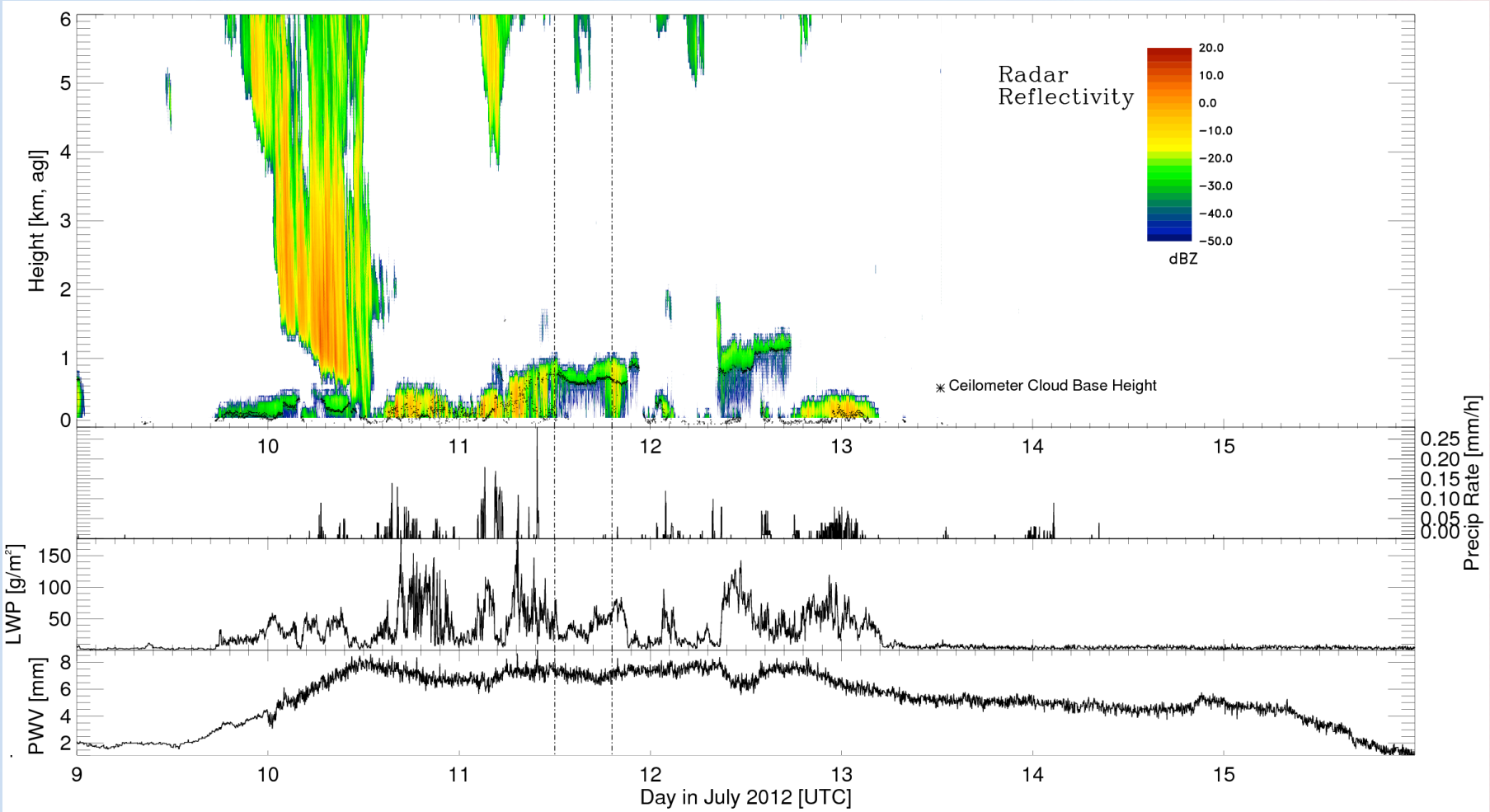
33 summers

ERA-Interim reanalysis data from 1980-2012 expands the time frame in order to investigate relatively recent trends.

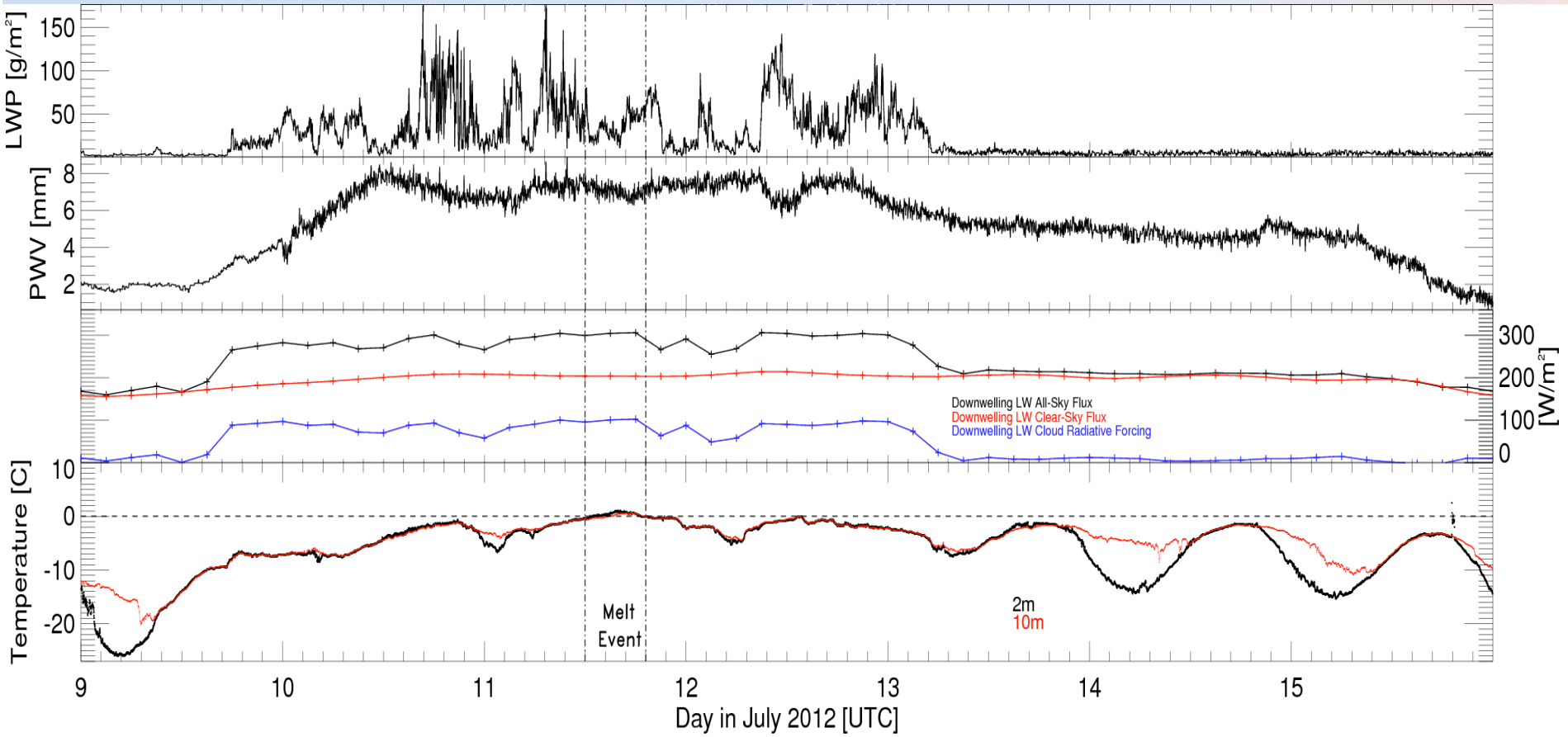
Setting the stage for the melt event



- Warm front arrives on July 9th 2012
- A surface-based temperature inversion develops during the clear-sky scene
- Thin liquid-bearing clouds present on July 10th

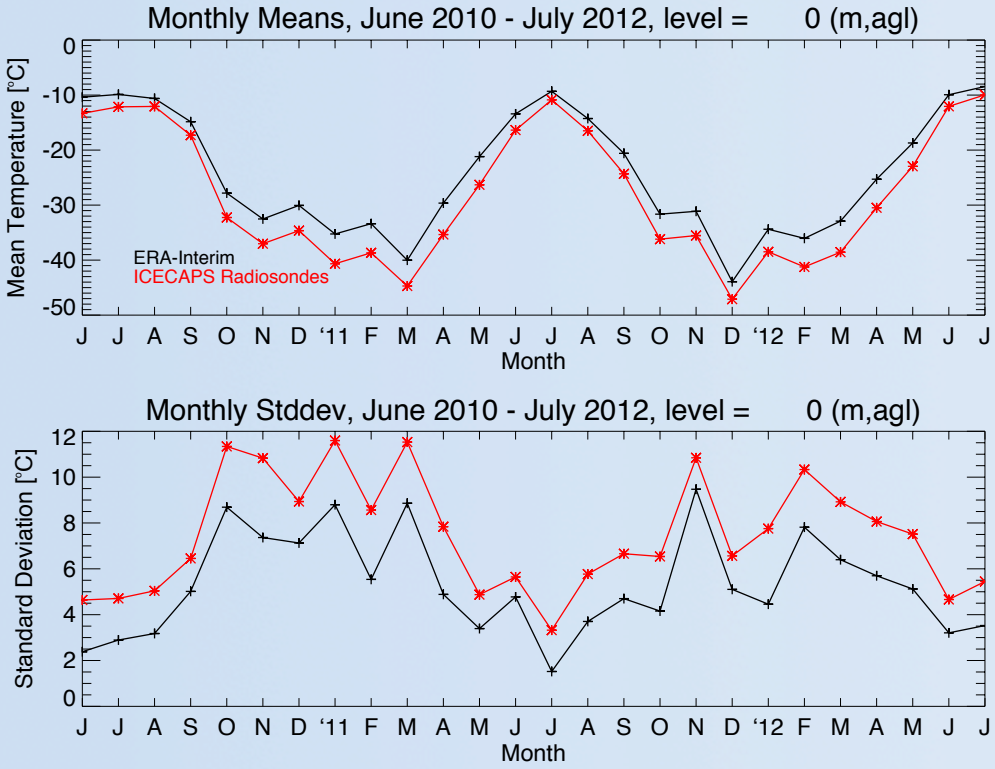


- An increase in precipitable water vapor (PWV) enhances the amount of moisture available for cloud formation.
- Radar observations indicate that the cloud is prominently liquid phase during the surface melt event.



- The presence of liquid-bearing clouds corresponds to weaker temperature inversions and an increase in the downwelling longwave radiation.
- The melt event was set up by advection of warm, moist air, while thin liquid-bearing clouds played an important role in warming the surface above the melting point. Without a specific range of cloud optical depth the surface temperature would not have reached above -3°C [Bennartz et. al. 2013, *Nature*].

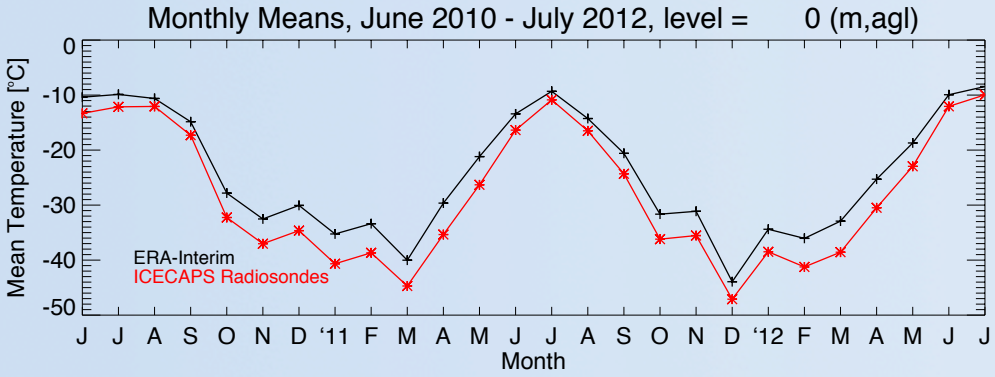
Monthly Temperature

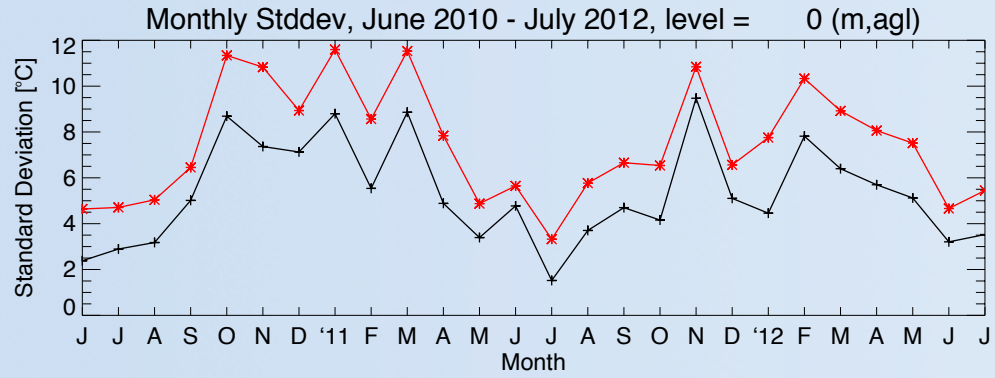


- ERA-Interim surface temperatures are biased high with lower variability.

Twice daily ICECAPS Radiosondes compared to ERA-Interim profiles.

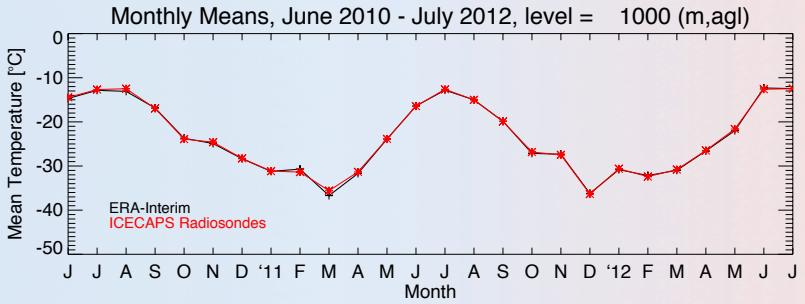
Monthly Temperature

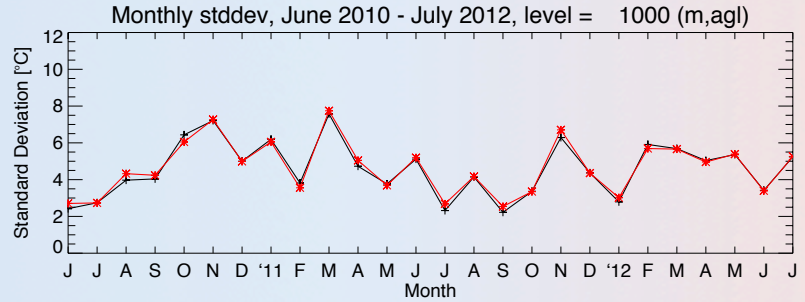


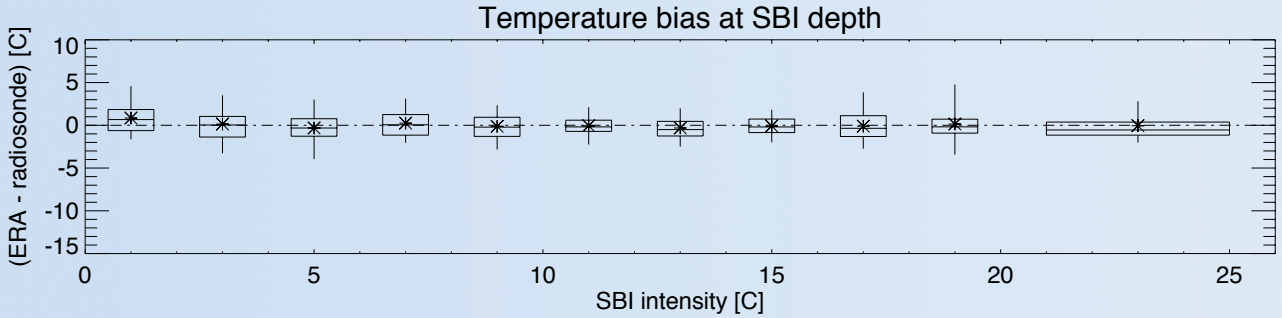


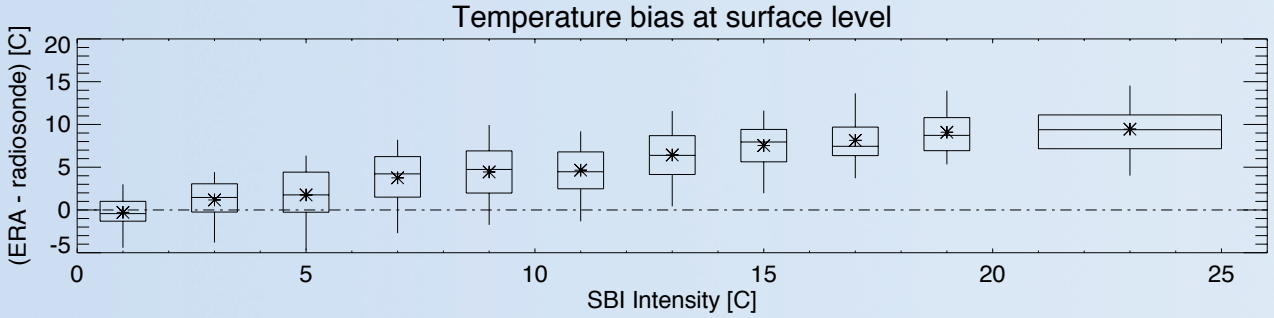
Twice daily ICECAPS Radiosondes compared to ERA-Interim profiles.

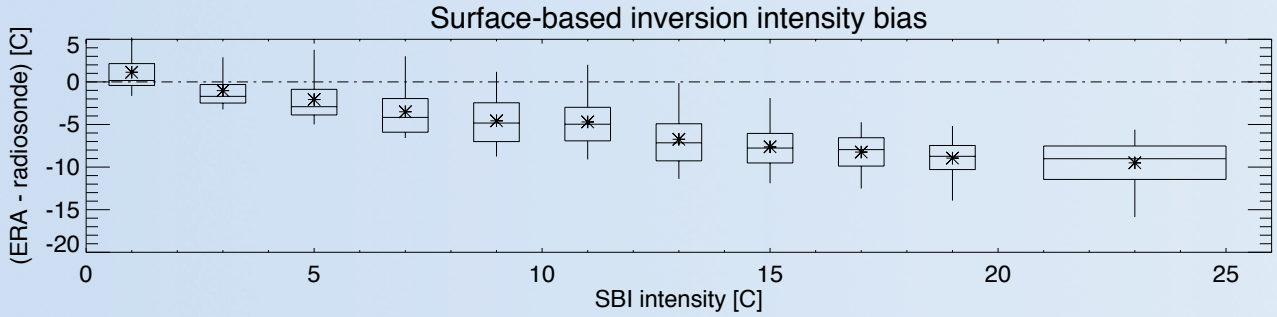
- ERA-Interim surface temperatures are biased high with lower variability.
- The temperature and variability at elevated atmospheric levels are well represented.







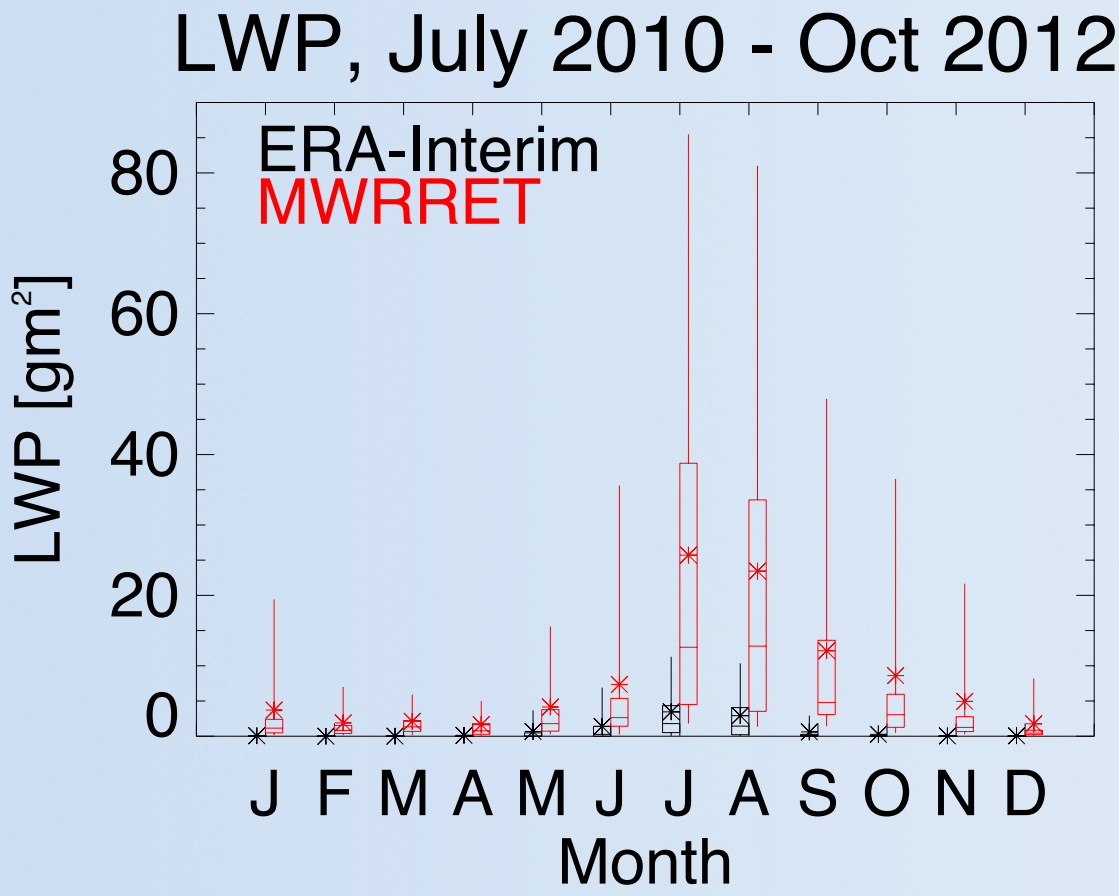




Box 25-75%
Whiskers 5-95%
median
* mean

- The temperature at the top of the surface-based inversion (SBI) is not as biased compared to the bias in the surface values.
- Perhaps the model is having difficulty capturing the shape of the inversion, especially the strong inversions.
- The bias in the ERA-Interim SBI intensity increases for stronger inversions.

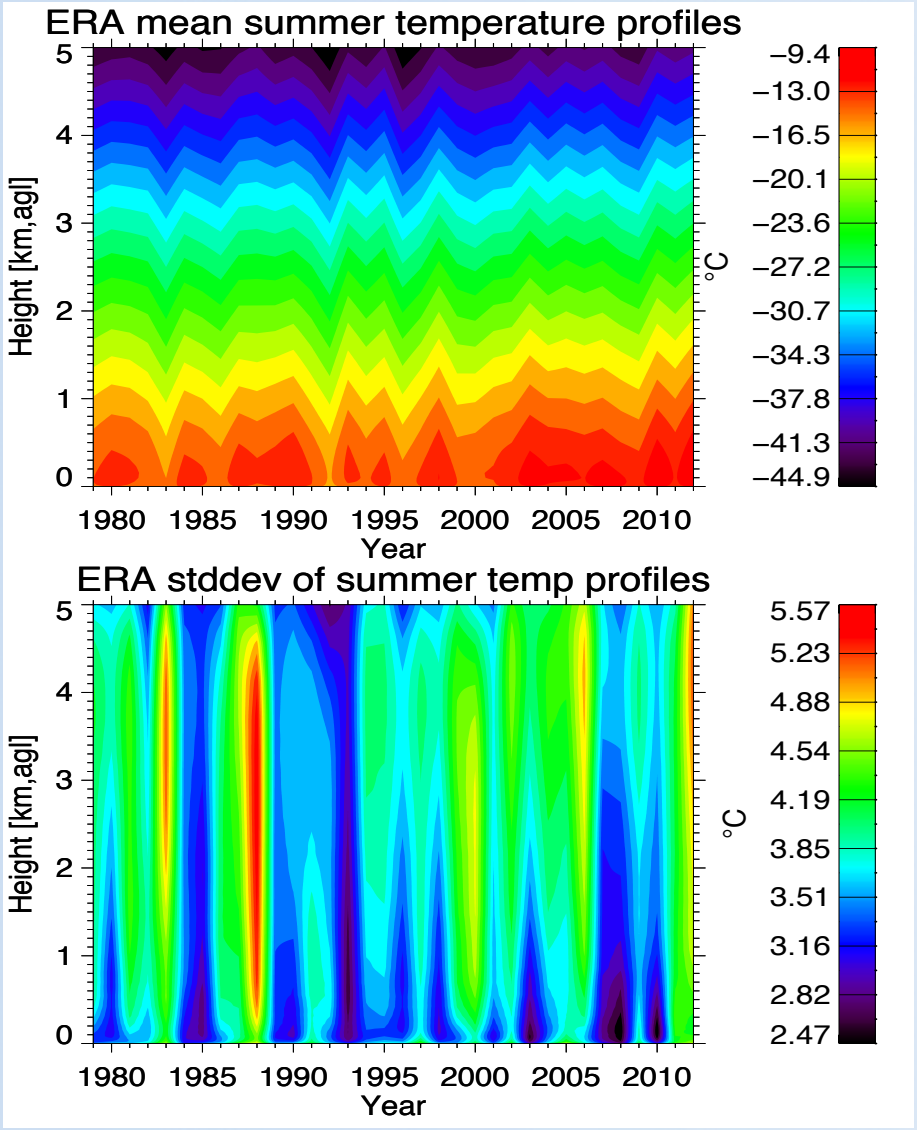
Liquid Water Path



- LWP underestimated by ERA-Interim forecast fields as compared to the MWR derived LWP values, MWRRET (Turner et al. 2007, *TGRS*).

Box 25-75%
Whiskers 5-95%
—— median
* mean

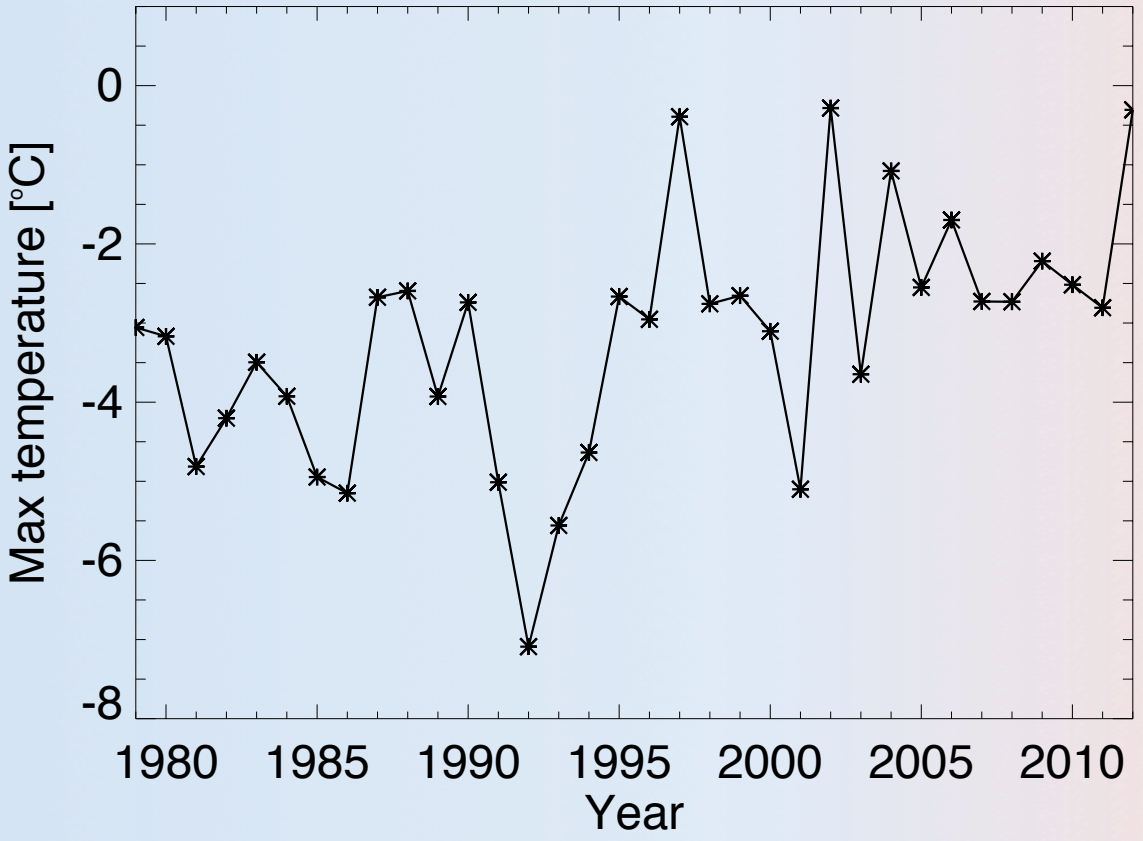
ERA-Interim Profiles: summer means and variability

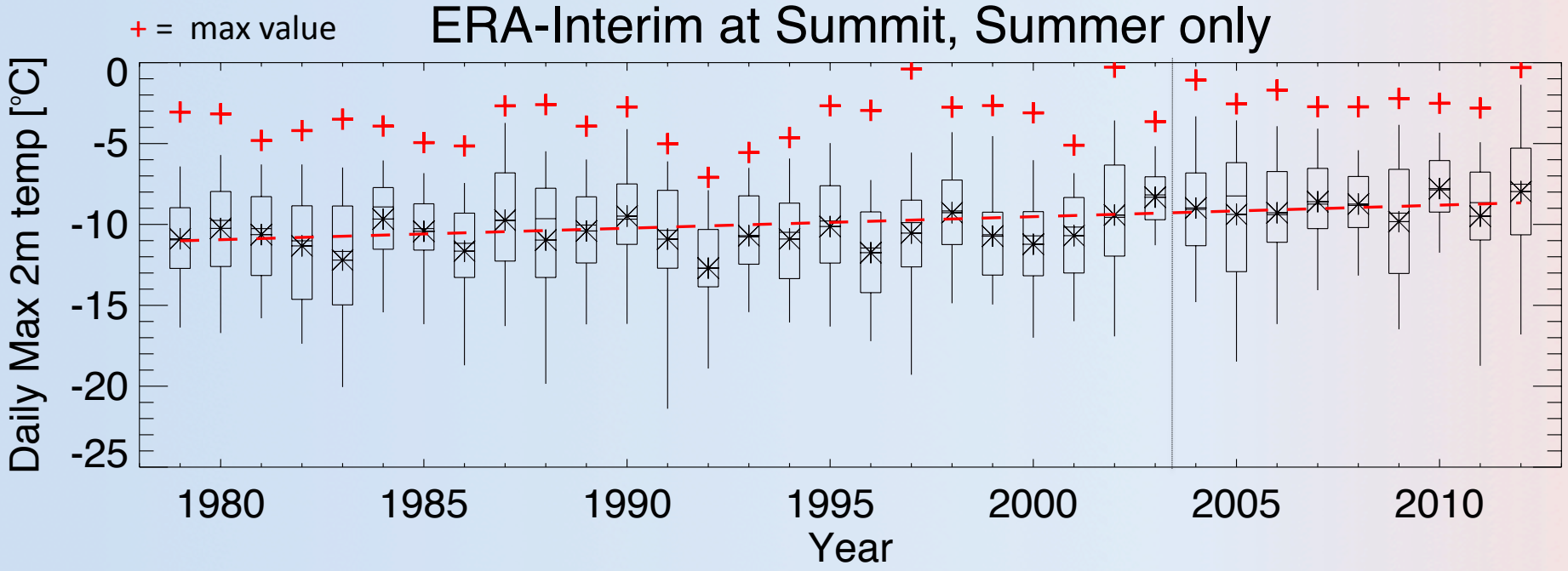


- The average temperature of the free atmosphere for the last 3 summers is warmer than previous years.
- The temperature variability at elevated levels is higher for certain years including 2012.

ERA-Interim 2m temperature forecast fields vs. NOAA 2m tower data from 2008-2012:

- ERA-Interim 2m daily maximum temp:
  - Bias = -0.46 K
  - RMSE = 3.12 K
- ERA-Interim 2m daily minimum temp:
  - Bias = 5.78 K
  - RMSE = 7.00 K





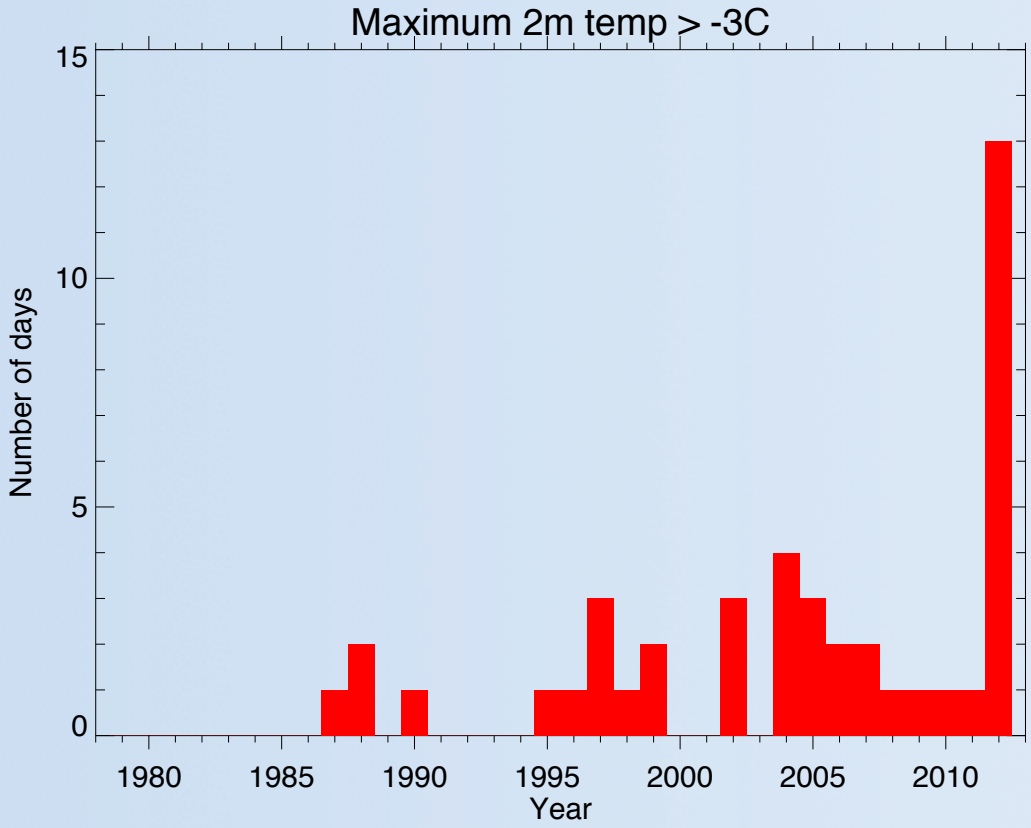
Linear Regression of:	
Median	Standard Dev
1979-2012	1979-2012
[1979-2003]	[1979-2003]
[2004-2012]	[2004-2012]
0.071**	0.0015
[0.030]	[-0.0050]
[0.124]	[0.0163]

(°C/year)

Box 25-75%
Whiskers 5-95%
median
* mean

** 2 sample t-test (first 5 yrs and last 5 yrs) indicates significant differences to the 99% confidence level.

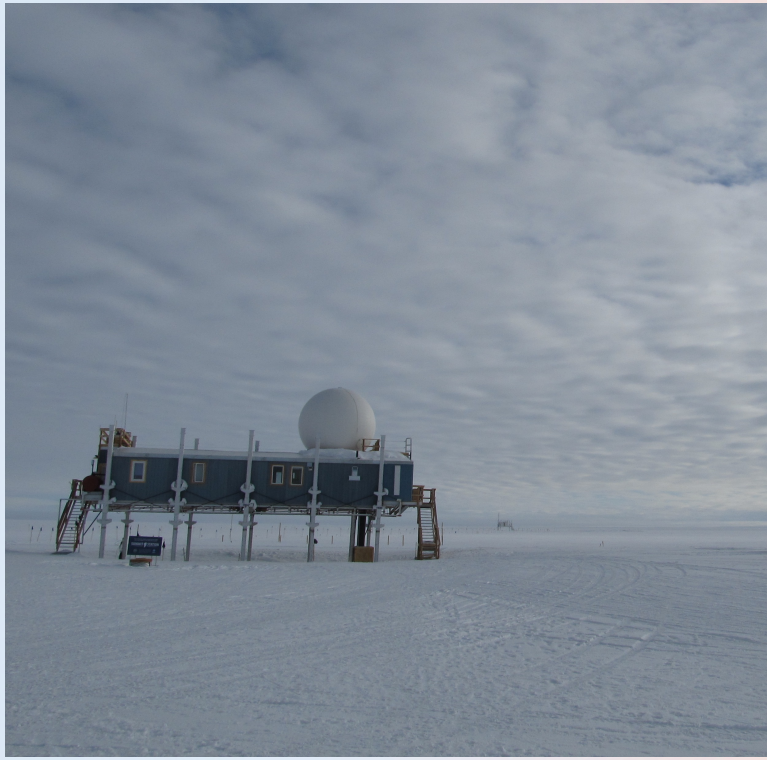
Opportunity for low-level liquid clouds to induce melting at Summit, Greenland



- 2012 had 13 days when the maximum temperature exceeded -3°C.
- The ICECAPS' MWR derived occurrence of summer low-level (thin) liquid-bearing clouds
  - 2010 - 73% (32%)
  - 2011 - 63% (28%)
  - 2012 - 58% (26%)

Conclusions

- July 2012 melt event at Summit influenced by the arrival of warmer than normal air aloft and enhanced surface warming due to 3 days of thin low-level liquid-bearing clouds.
- 3 years of ICECAPS data indicates ERA-Interim has inadequacies capturing liquid water path values, yet more accurately estimates the daily maximum temperatures.
- 33 years of ERA-Interim reanalysis data indicates a relatively recent warming trend in the median summer daily maximum temperatures.
- The opportunity for thin low-level liquid-bearing clouds to push surface temperatures above freezing was much greater in 2012 compared to previous years.



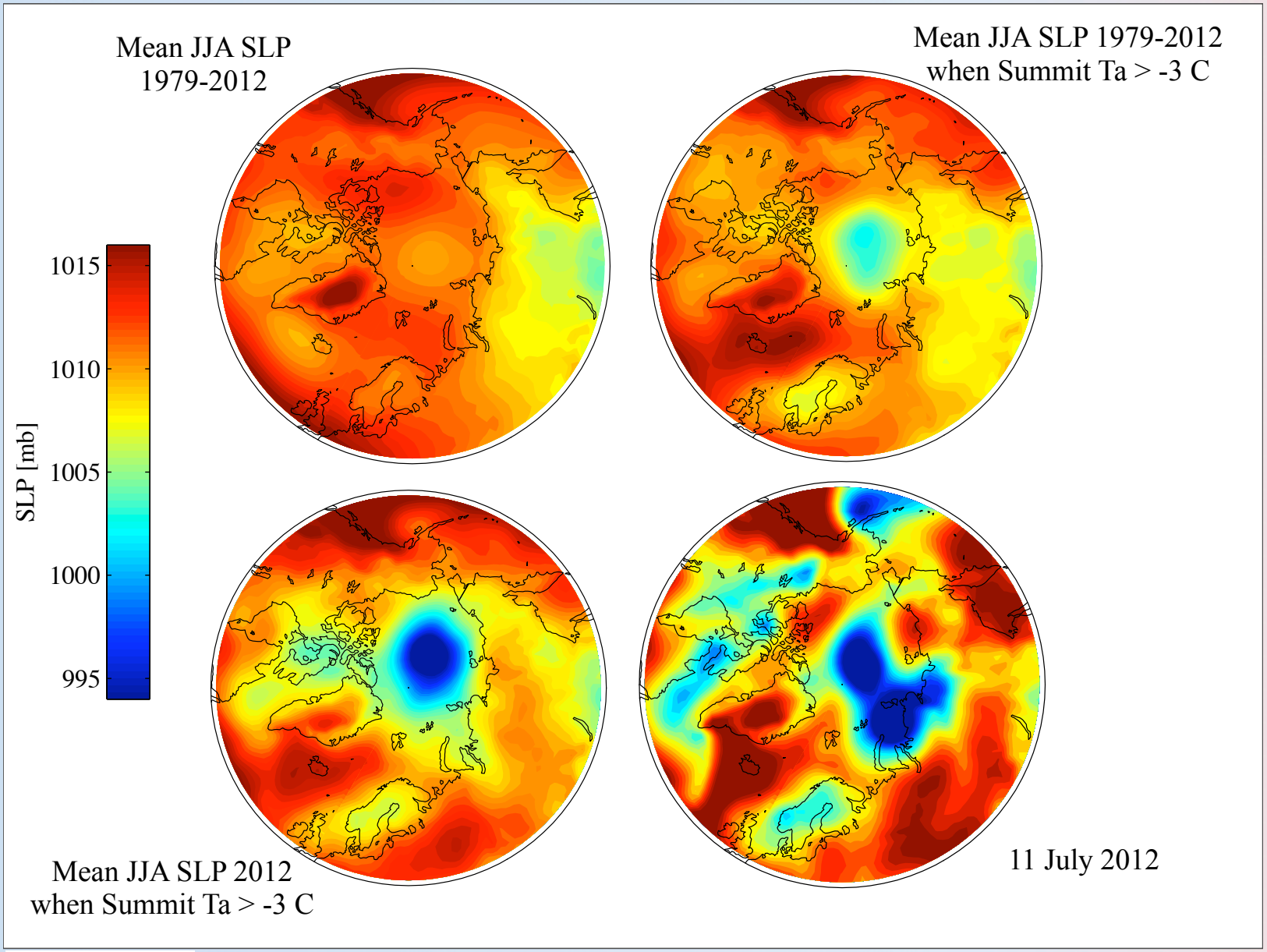
Data Sources

- ICECAPS is supported by the National Science Foundation under grants No. 0904152, 0856559, 0856773.

- Near surface meteorological data was provided by NOAA's Global Monitoring Division.

- ECMWF ERA-Interim forecast field data used in this study have been obtained from the ECMWF data server.

- ERA-Interim Profile values were obtained from NCAR's CISL Research Data Archive.



Tuesday, March 26, 2013

Figure: Chris Cox