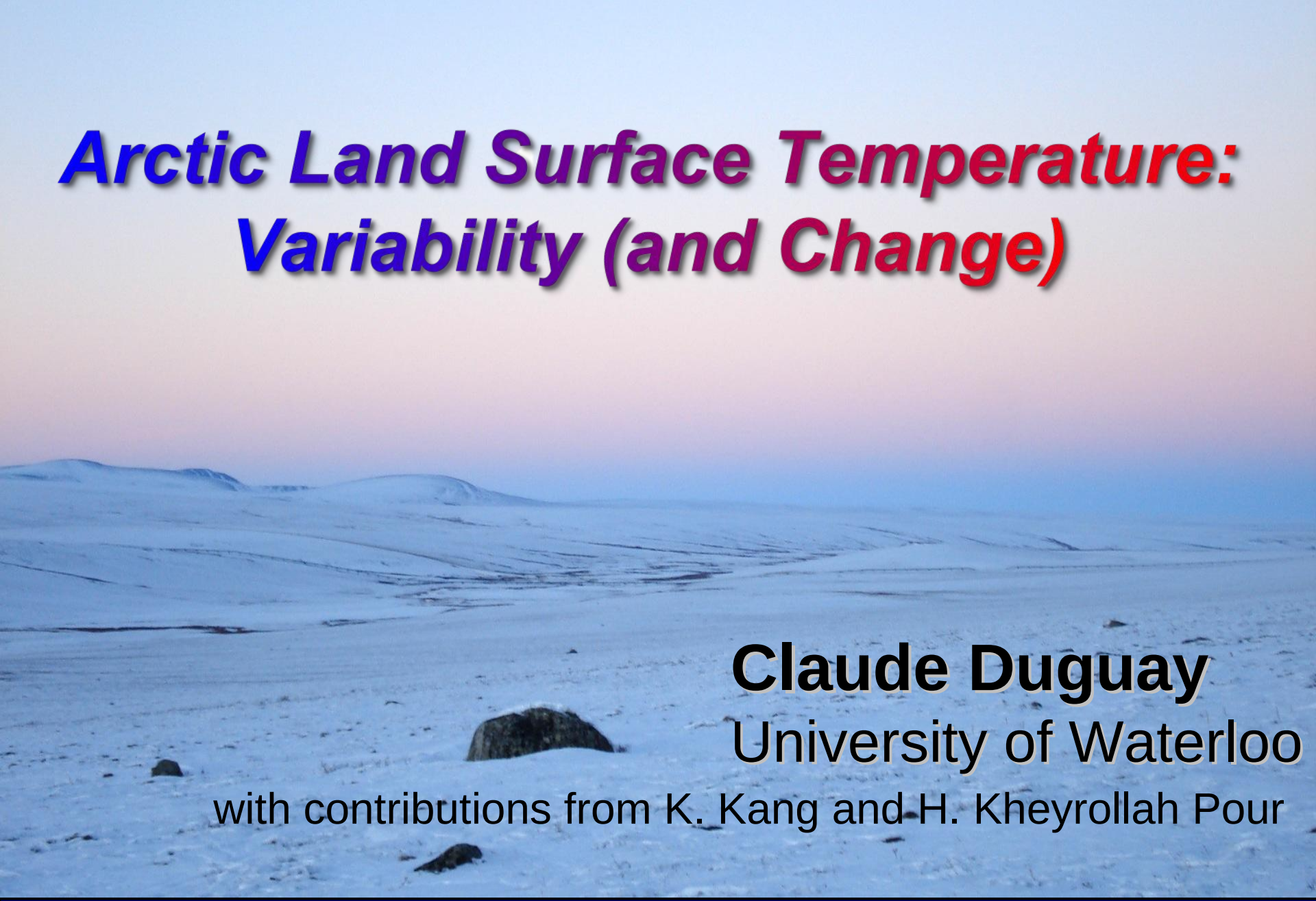


Arctic Land Surface Temperature: Variability (and Change)

Claude Duguay
University of Waterloo
with contributions from K. Kang and H. Kheyrollah Pour

2nd Annual EarthTemp Network Meeting
Surface temperature in data-sparse and extreme regions

EarthTemp Network

12-14 June 2013
Copenhagen, Denmark

Content

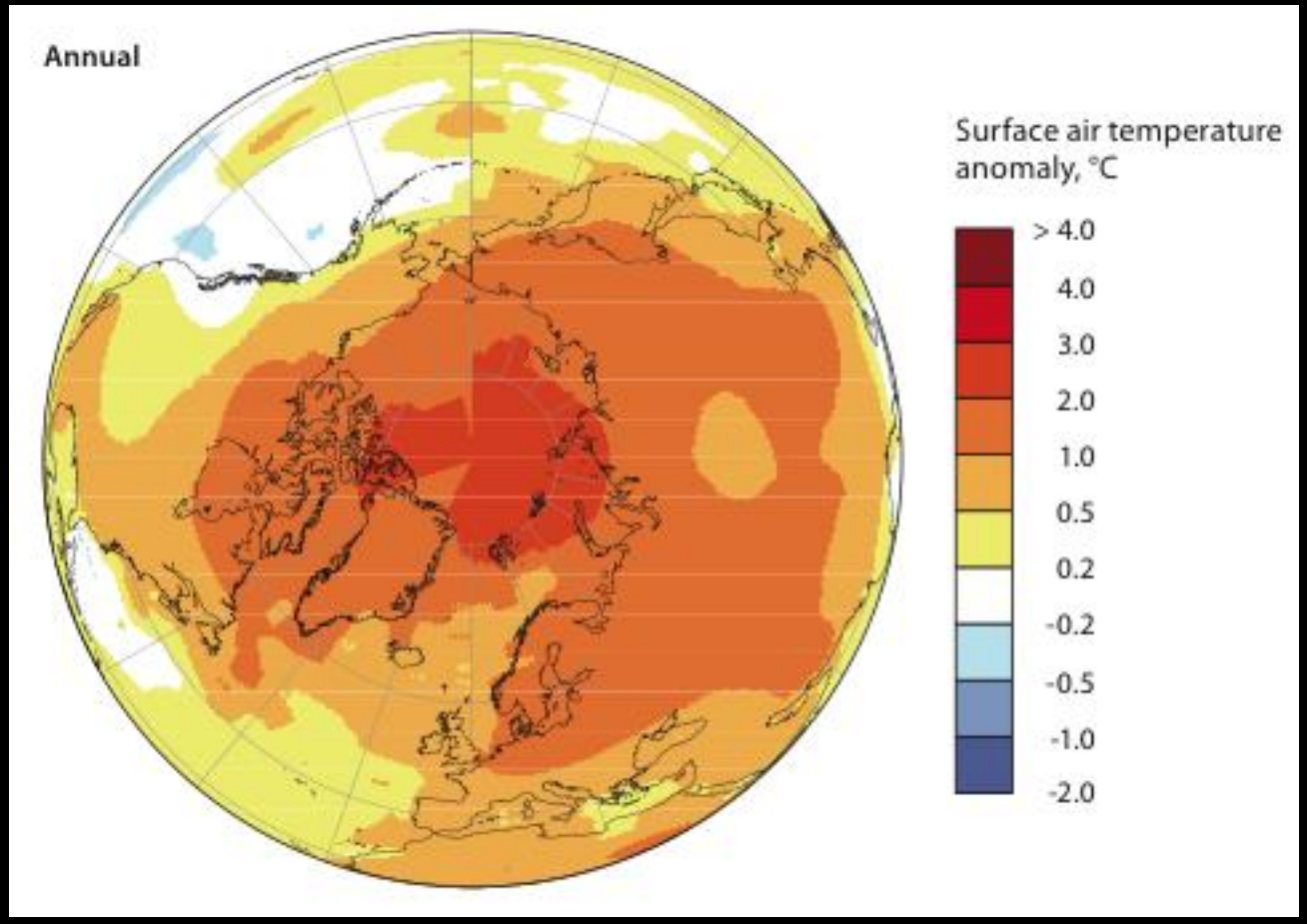
- Recent variability and trends in near-surface air and surface (skin) temperatures
  - *SWIPA (Snow, Water, Ice and Permafrost in the Arctic) Scientific Assessment Report 2011*
  - *Arctic Report Card:* 2012 update

- Arctic land surface temperature (LST) from satellite observations
  - Validation (radiometers) and comparison (near-surface air and ground temperatures) from station measurements
  - Intercomparison: satellite and reanalysis products
  - Recent variations observed by MODIS (2000-2012)

- Concluding remarks

SWIPA

Arctic Climate: Recent Variations



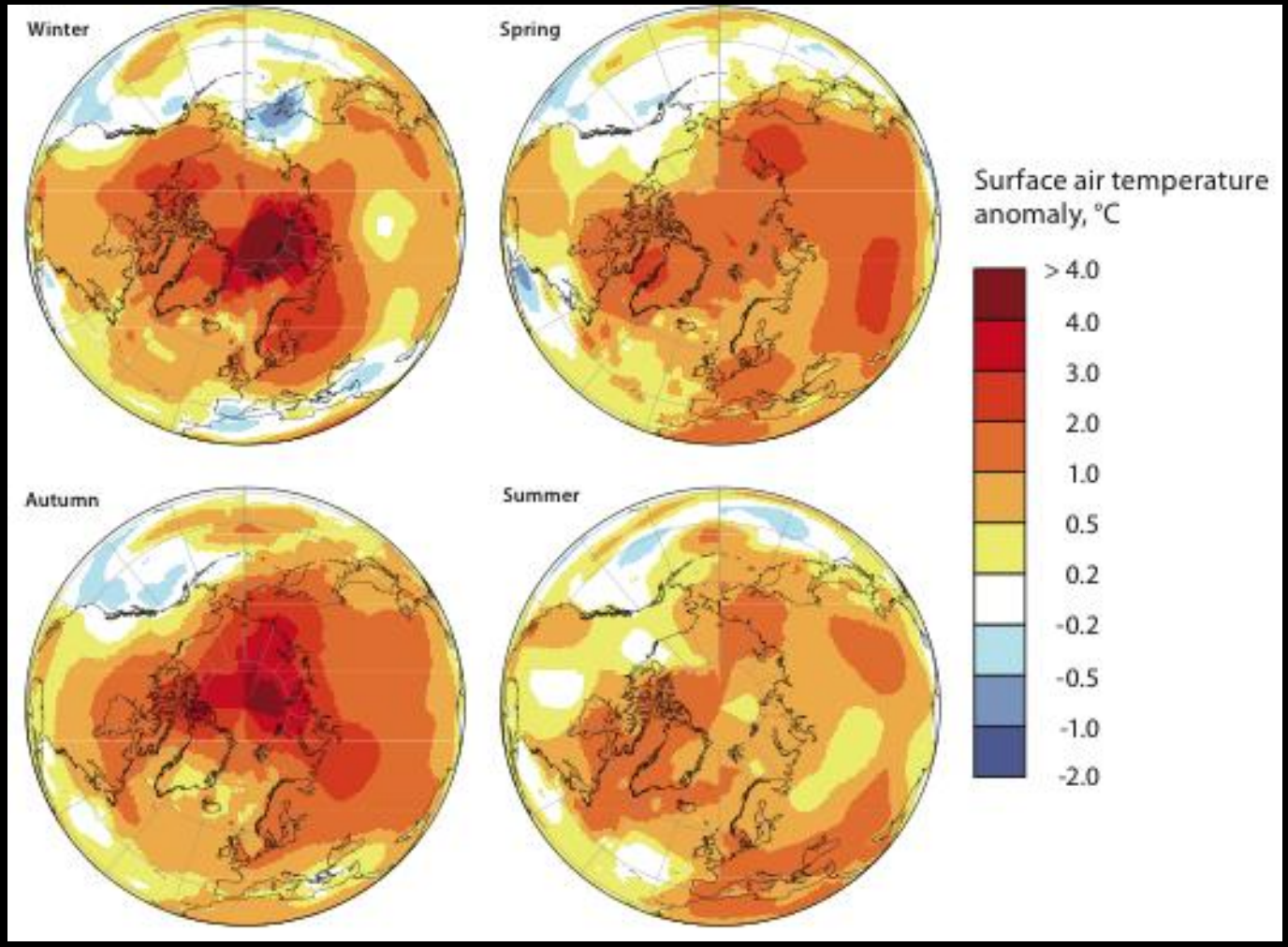
Annual surface air temperature anomalies

2005-2009 relative to 1951-2000 mean

Source: NASA Goddard Institute for Space Studies (http://data.giss.nasa.gov/gistemp)

SWIPA

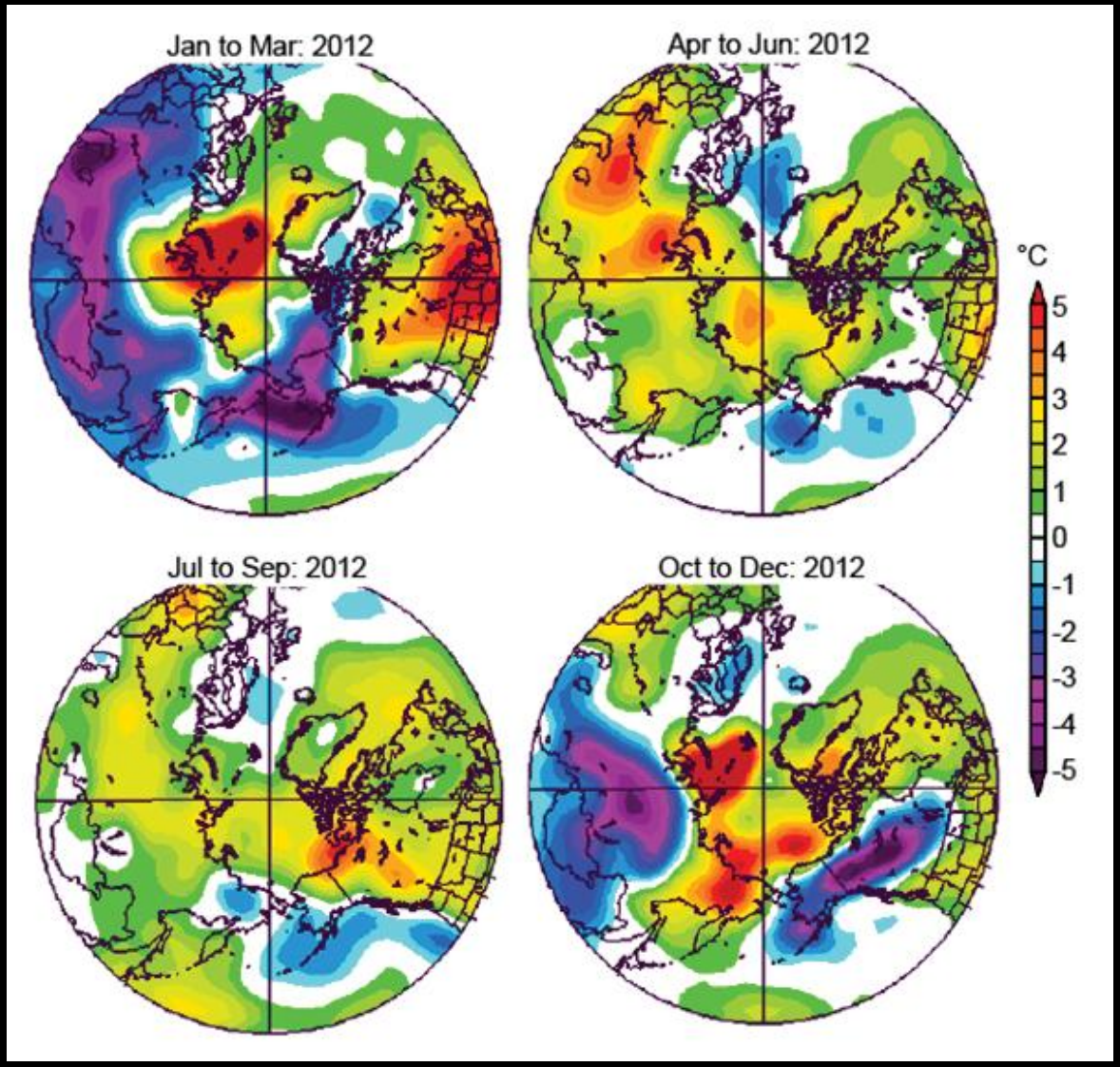
Arctic Climate: Recent Variations



Seasonal surface air temperature anomalies

2005-2009 relative to 1951-2000 mean

Source: NASA Goddard Institute for Space Studies (http://data.giss.nasa.gov/gistemp)



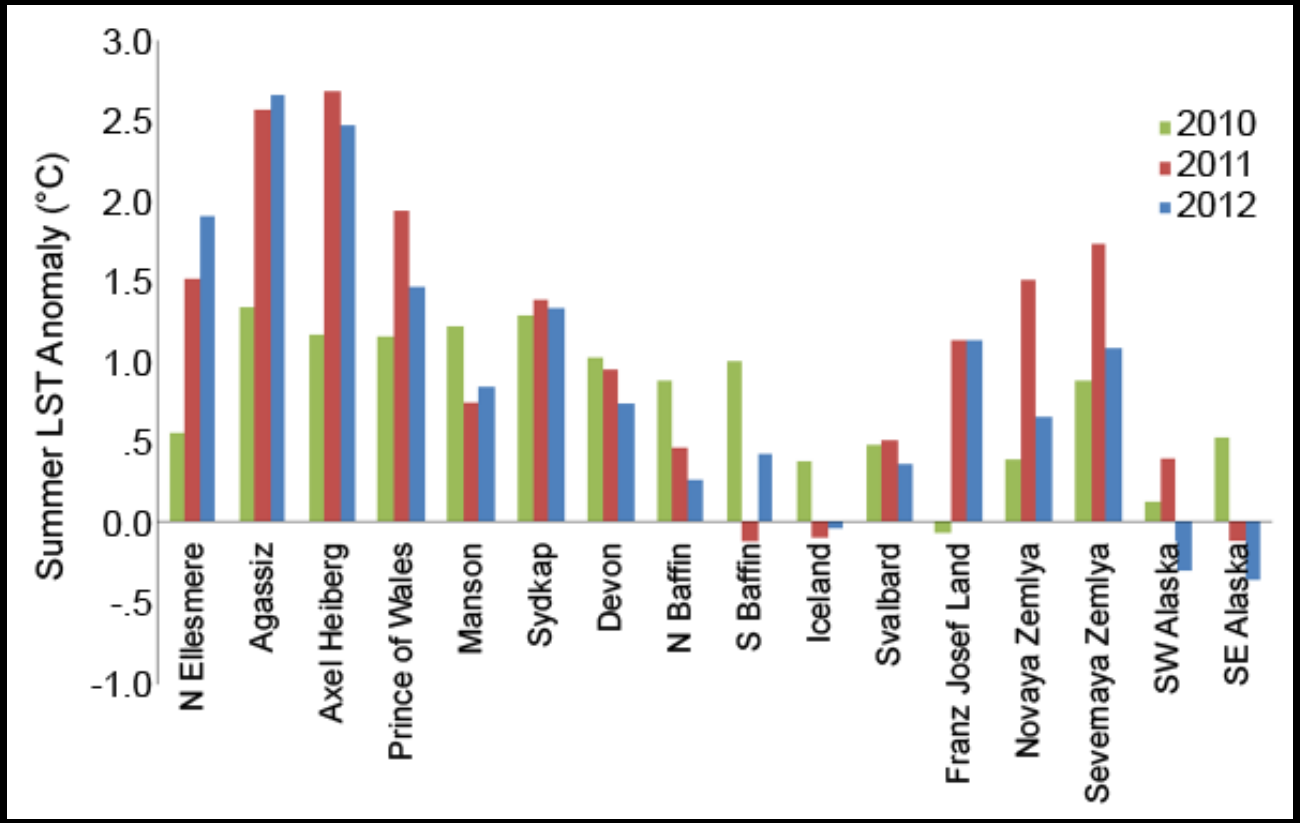
Seasonal anomaly patterns for near-surface air temperatures

2012 relative to the reference period 1981-2010

Data (NCEP/NCAR Reanalysis) are from NOAA/ESRL, Boulder, CO: http://www.esrl.noaa.gov/psd/

Overland *et al.*, 2013

Comparison of 2010, 2011 and 2012 summer (JJA) mean LST anomalies (relative to 2000 to 2010) for 16 glaciated regions of the Arctic based on the MODIS (Terra) MOD11A2 LST product



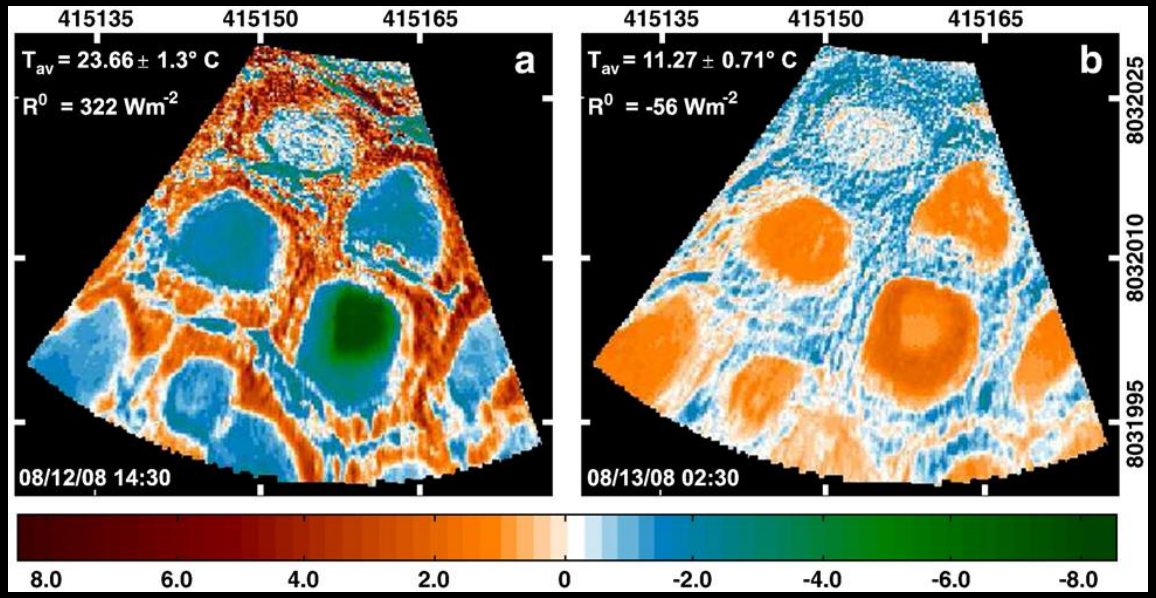
Wolken *et al.*, 2013

Greenland Ice Sheet

Ice sheet-wide JJA surface temperature from MODIS increased 3.4ºC between 2000 and 2012, from an average value of -9ºC in 2000 to -5.6ºC in 2012

Tedesco *et al.*, 2013

Arctic LST from satellite observations: validation/comparison

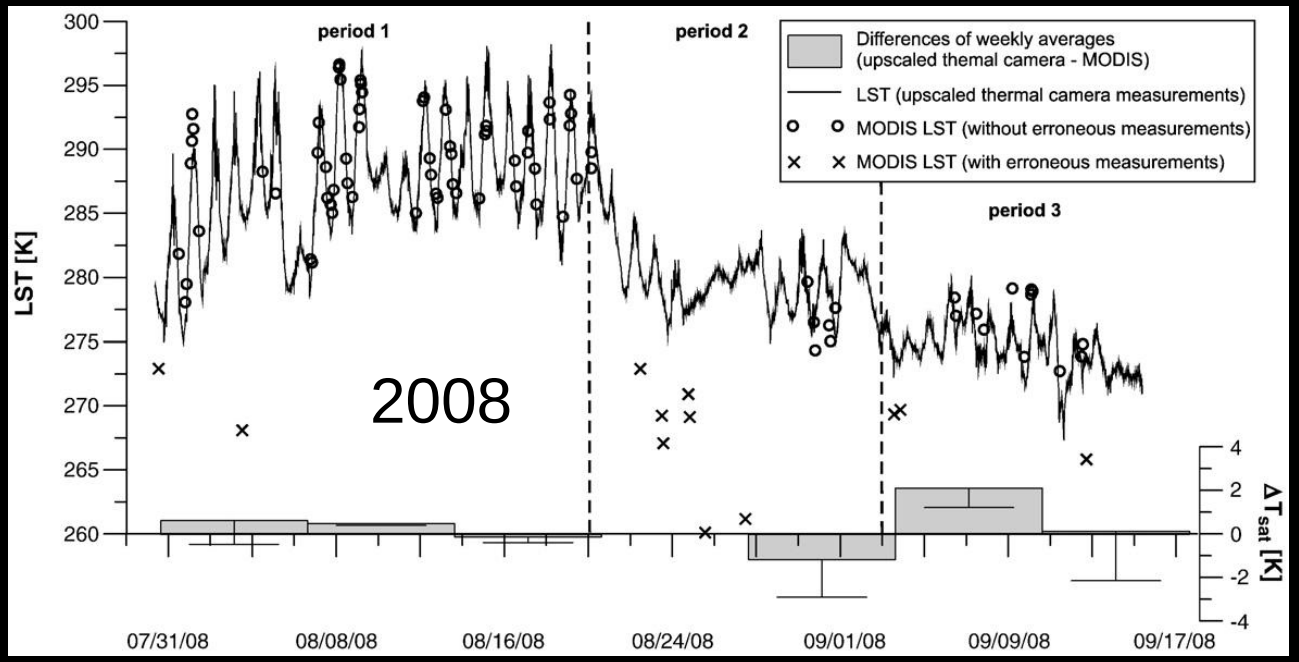


Langer *et al.*, 2010

MODIS L2 (collection 5) LST products (MOD11L2.5 and MYD11L2.5) obtained by the satellites Terra and Aqua

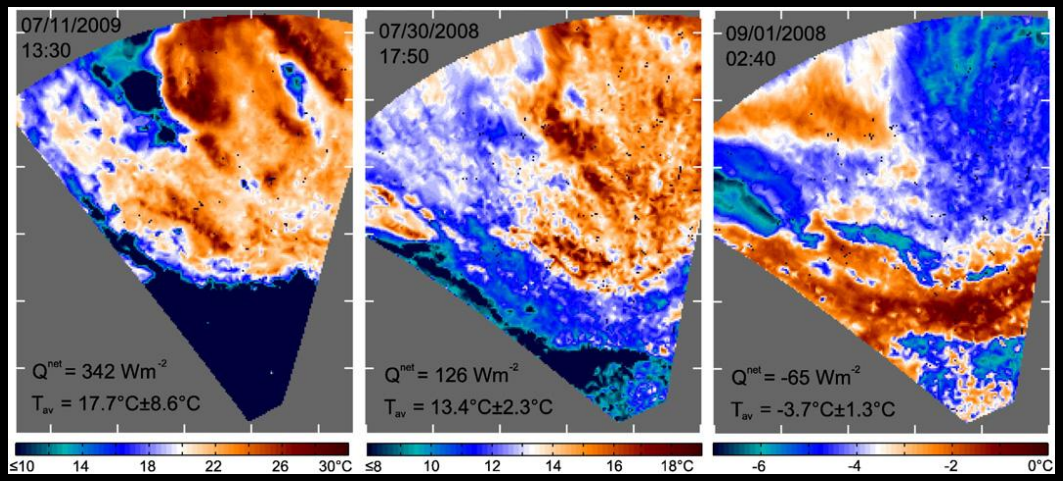
Thermal camera* installed on Samoylov Island, Lena River Delta

Good correspondence, but misses in cloud cover detection result in MODIS LST 5 to 15 K colder than that inferred from the thermal camera



* VARIOCAM HRTM, Infratec GmbH, Dresden, Germany)

Arctic LST from satellite observations: validation/comparison

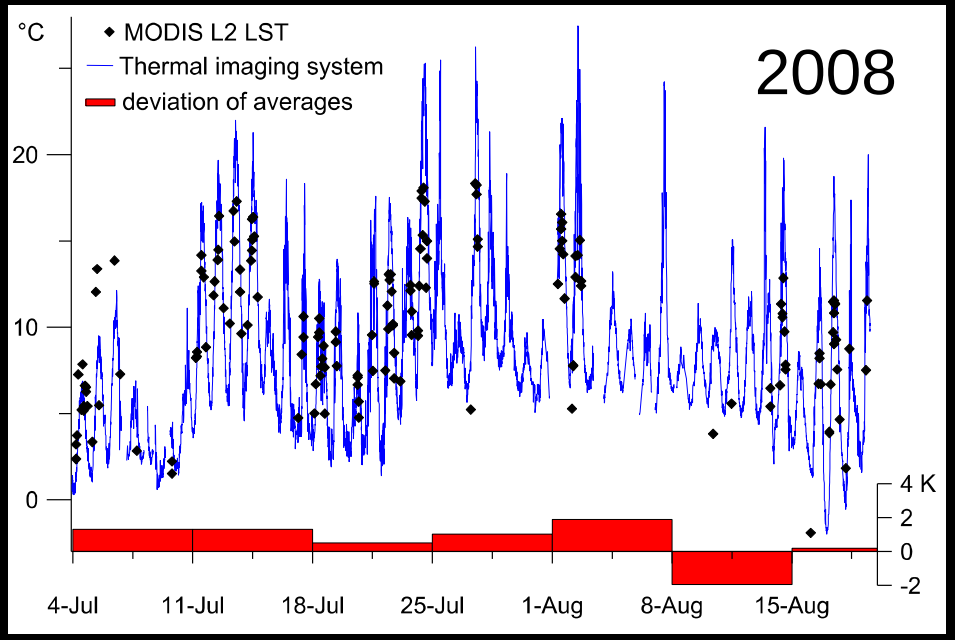


Westermann *et al.*, 2011

MODIS L2 (collection 5) LST products (MOD11L2.5 and MYD11L2.5) obtained by the satellites Terra and Aqua

Thermal camera installed on the Brøgger Peninsula in NW Svalbard

Weekly averages calculated from the thermal imaging system and from MODIS LST agree within less than 2 K (larger for cases with undetected clouds)

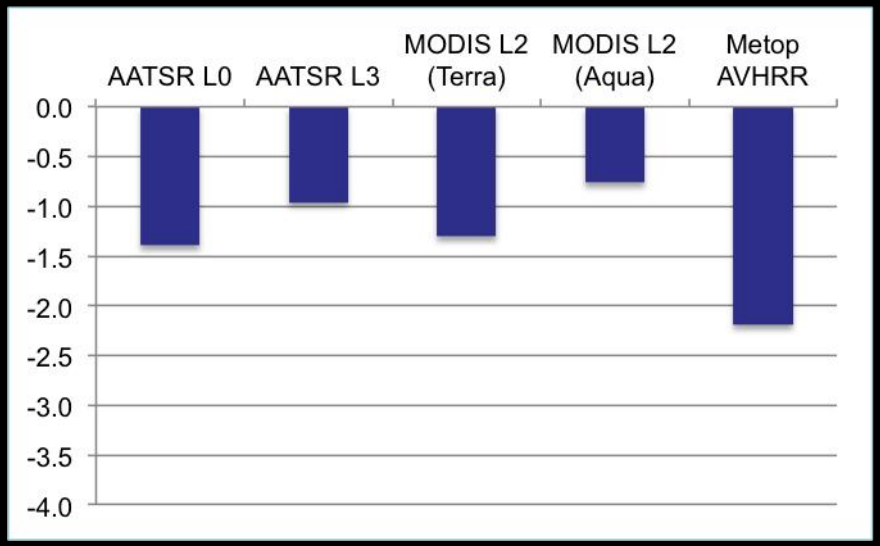


* VARIOCAM HRTM, Infratec GmbH, Dresden, Germany)

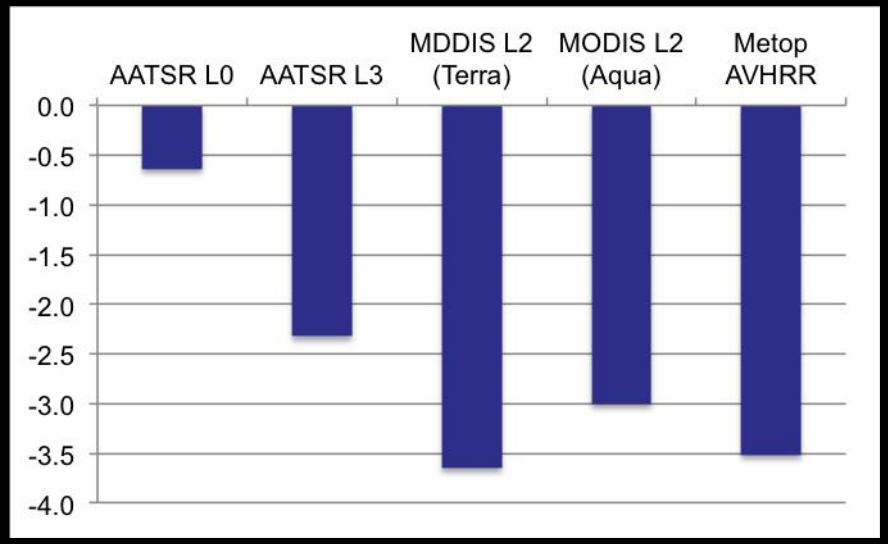
Arctic Case Study: Matchup Database

Barrow ARM site, Alaska, 1 January - 31 March 2012

LST satellite minus *in situ*



LST satellite minus 2-m air temp.

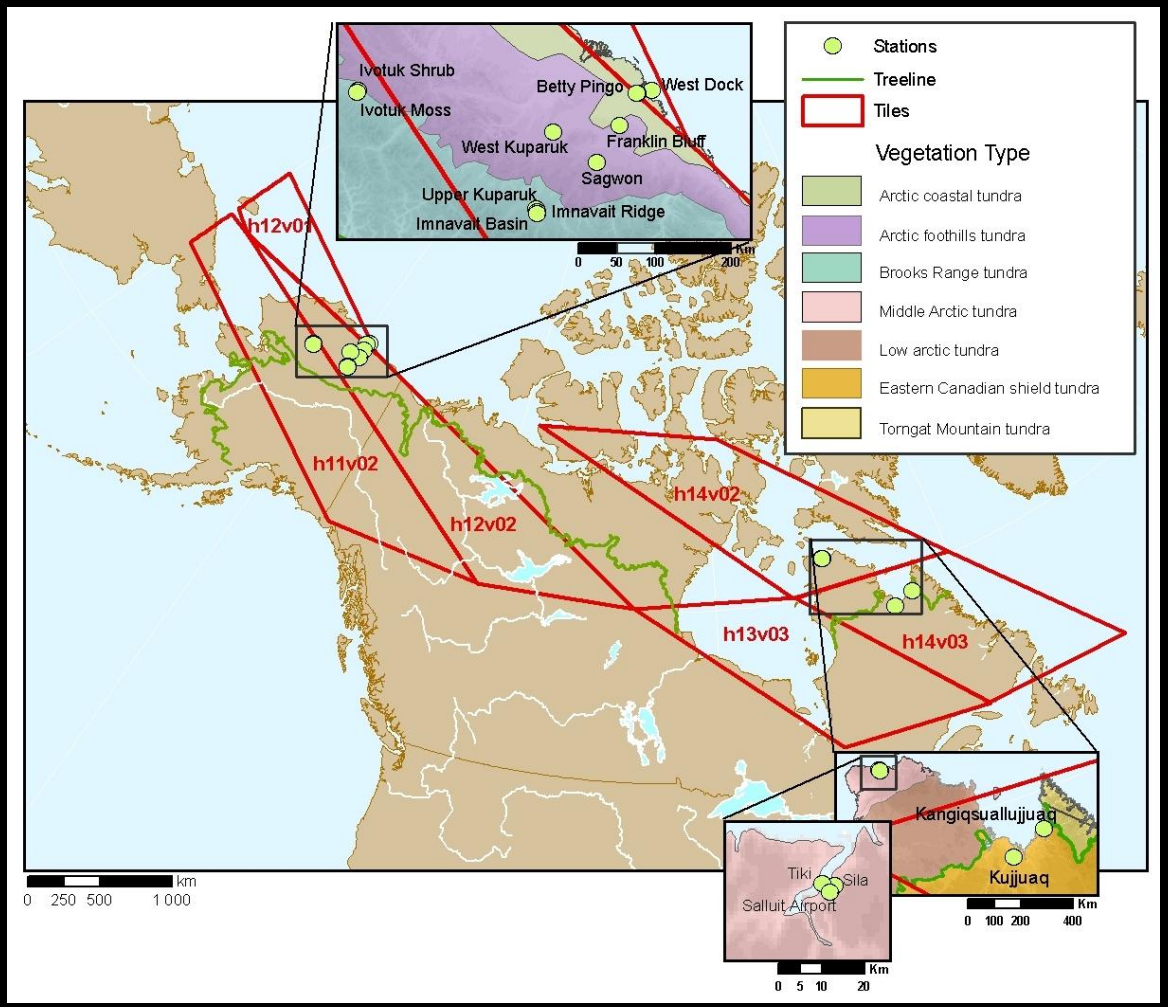


Mean bias

Data produced by Darren Ghent, U. Leceister

Arctic LST from satellite observations: validation/comparison

MOD11A1 (Terra) and MYD11AI (Aqua) Level-3 Version 5 (1 km) (2000-2008 period)



Comparison of LST day, night and day/night average with air temperature at 11 sites.

Combining Aqua and Terra LST-day and LST-night acquisitions into a mean daily value a better overall agreement with Tair.

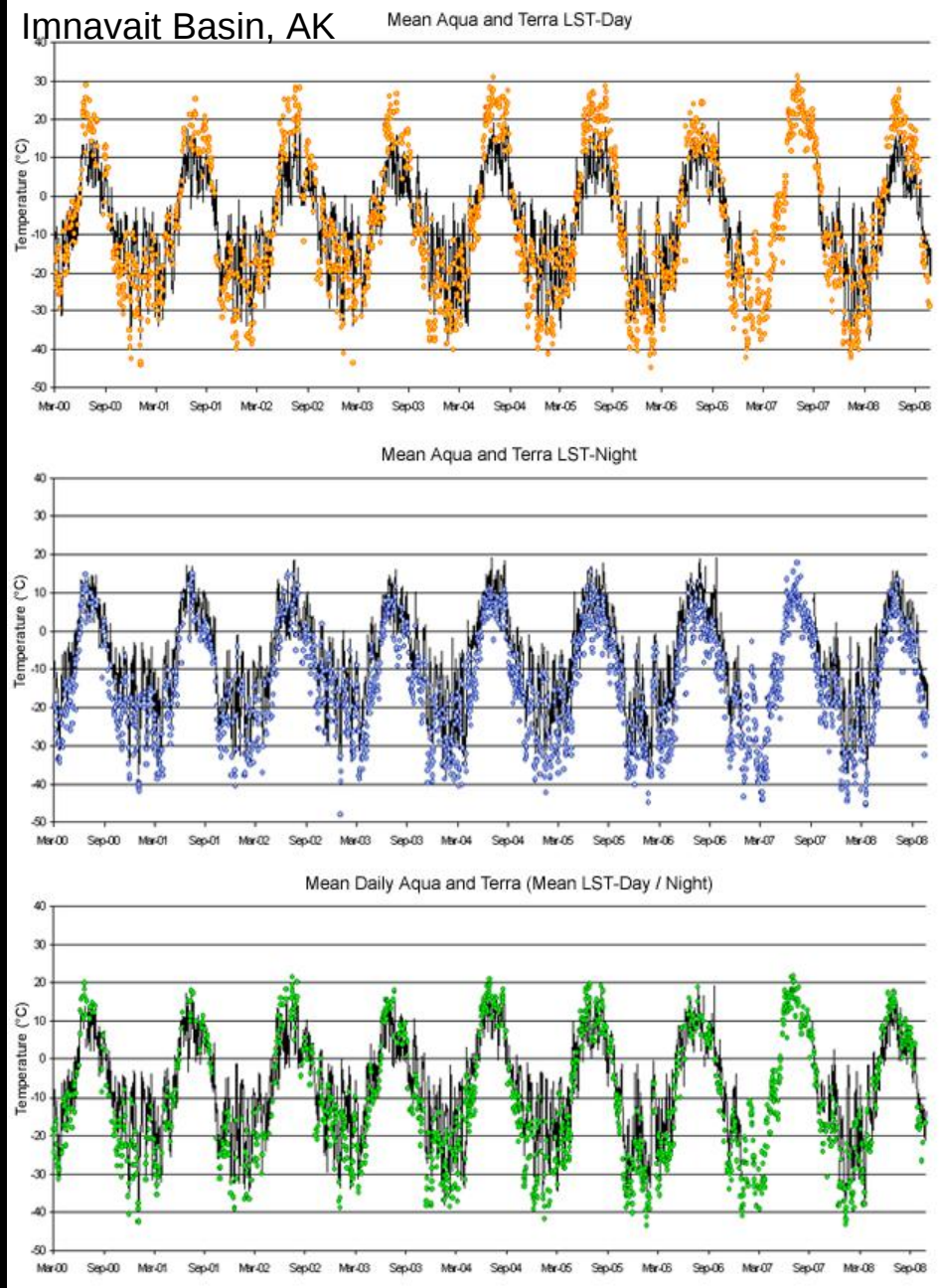
R = 0.97; mean difference (MD) = 1.8 ◦C; and standard deviation of MD (SD) = 4.0◦C

Hachem *et al*., 2012

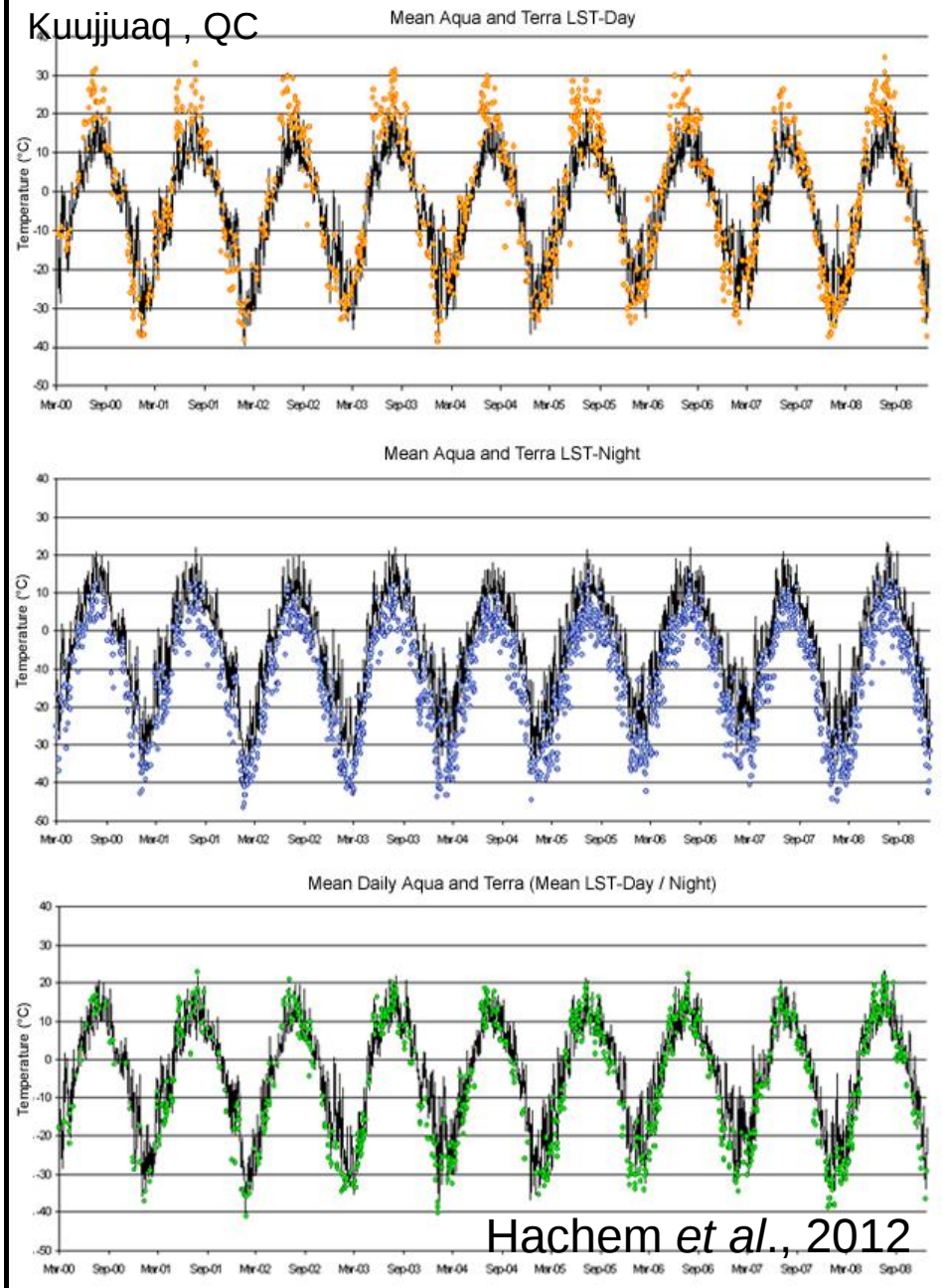
LST vs air temp.

Arctic LST from satellite observations: validation/comparison

Imnavait Basin, AK

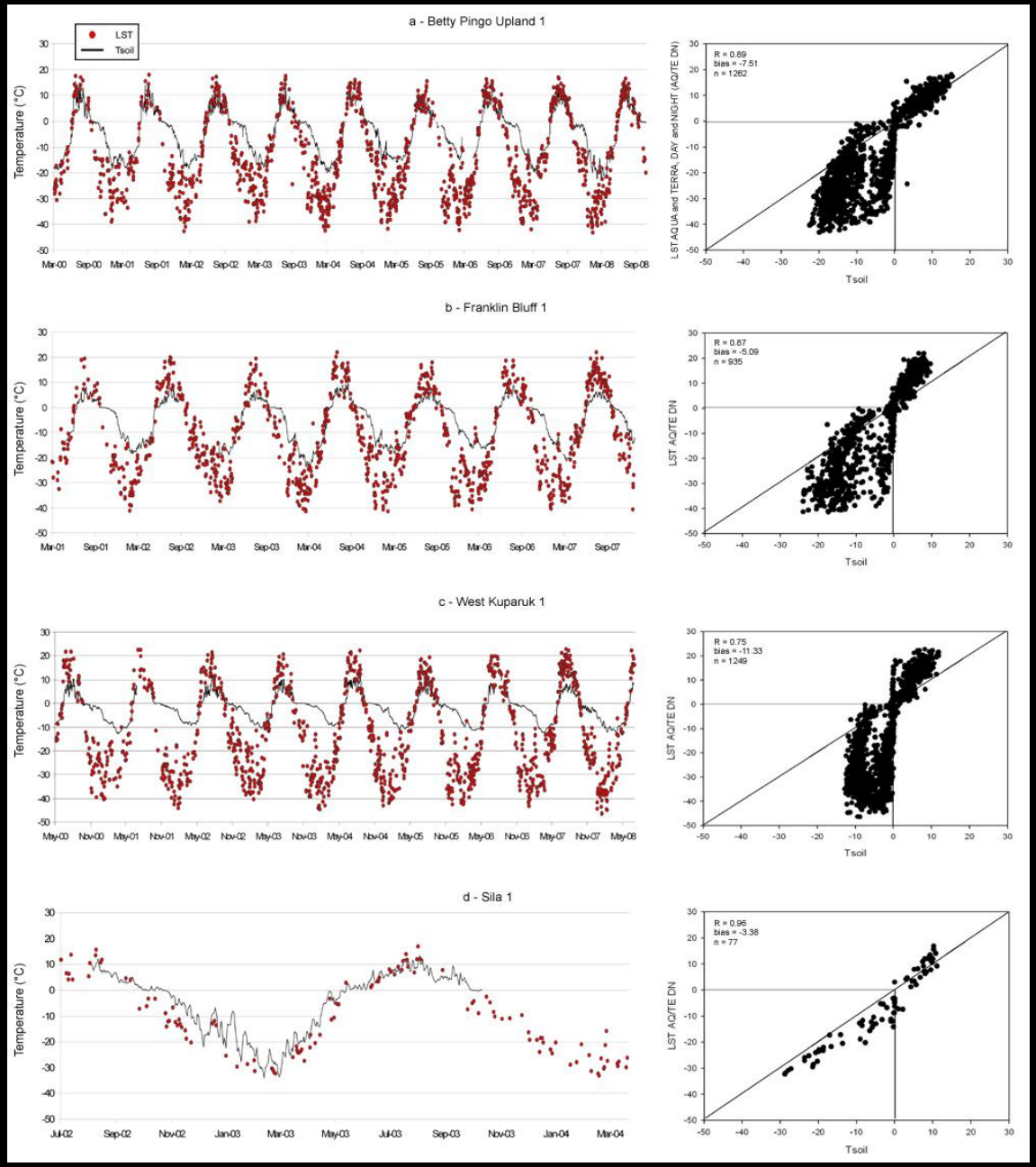


Kuujjuaq , QC



Hachem *et al.*, 2012

Arctic LST from satellite observations: validation/comparison

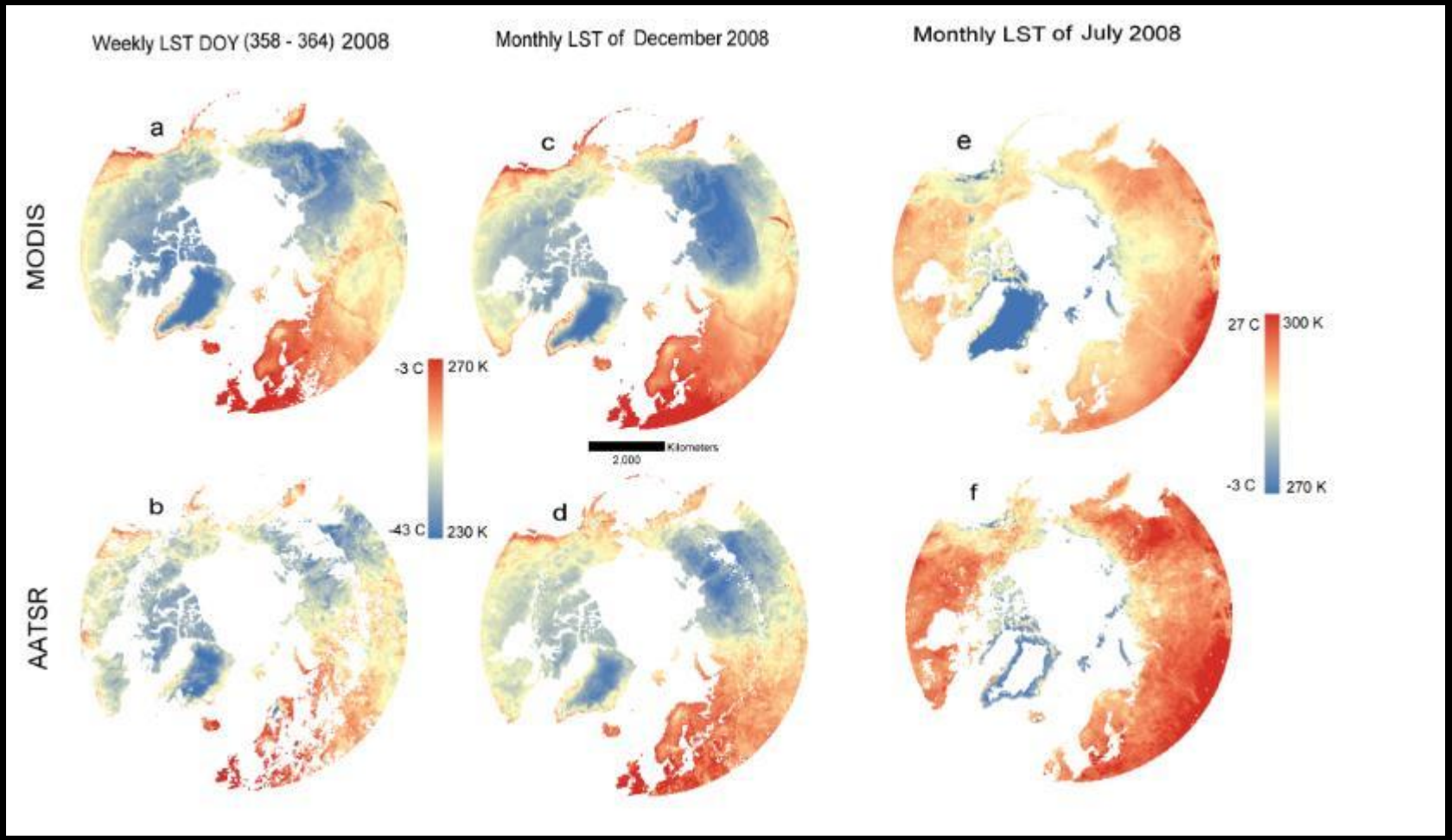


LST vs ground temp. (3-5 cm below the surface)

Hachem *et al*., 2012

Arctic LST from satellite observations: intercomparison

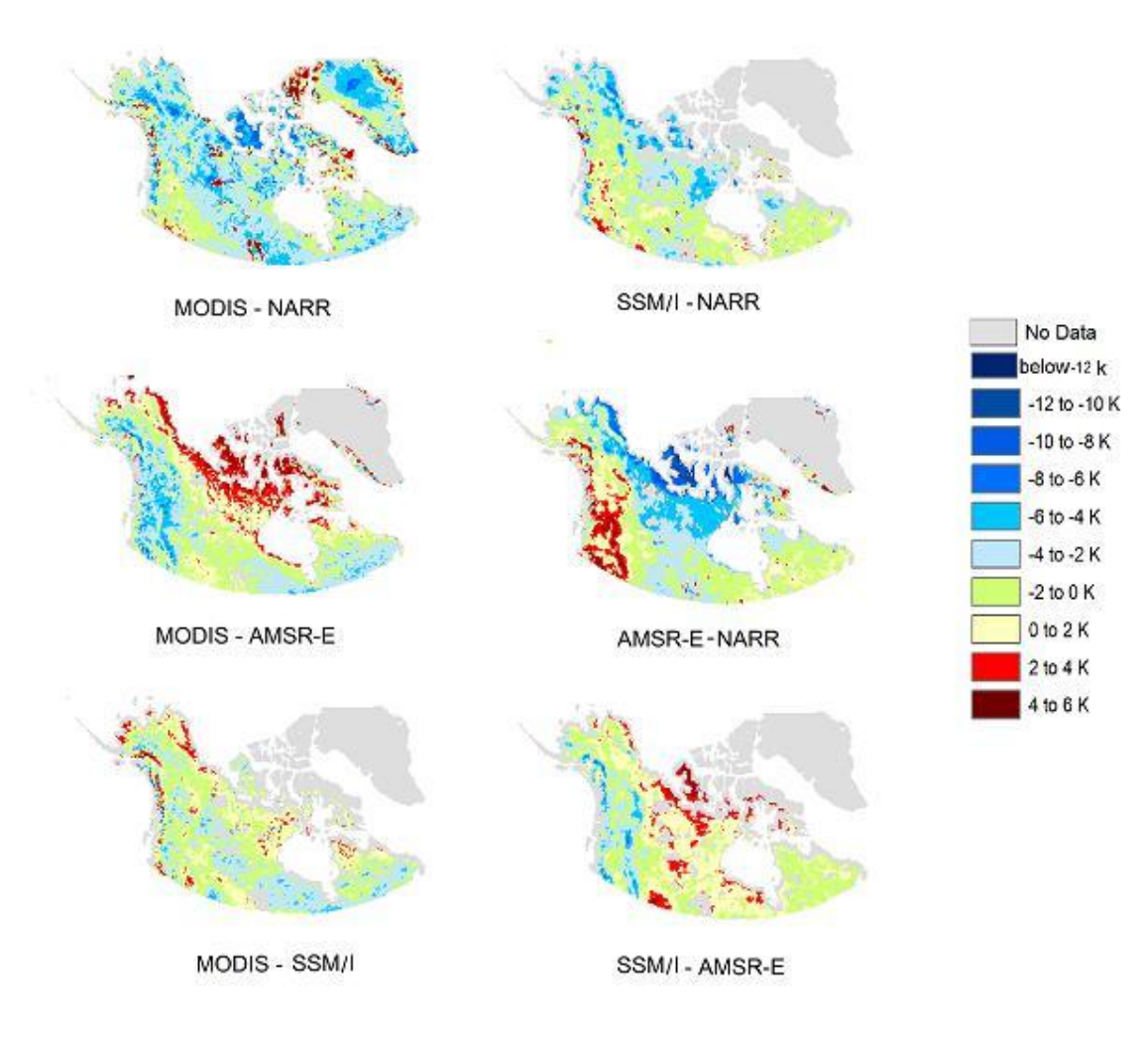
UW-L3 LST weekly and monthly (1-25 km) products derived from combination of Terra and Aqua L2 data (top)



25 km x 25 km grid cells

Soliman *et al.*, 2012

UW-L3 LST monthly product intercomparison



Monthly MODIS (Terra and Aqua combined) and clear-sky monthly average of NARR and SSM/I LST, and AMSR-E screen-height air temperature for July 2007.

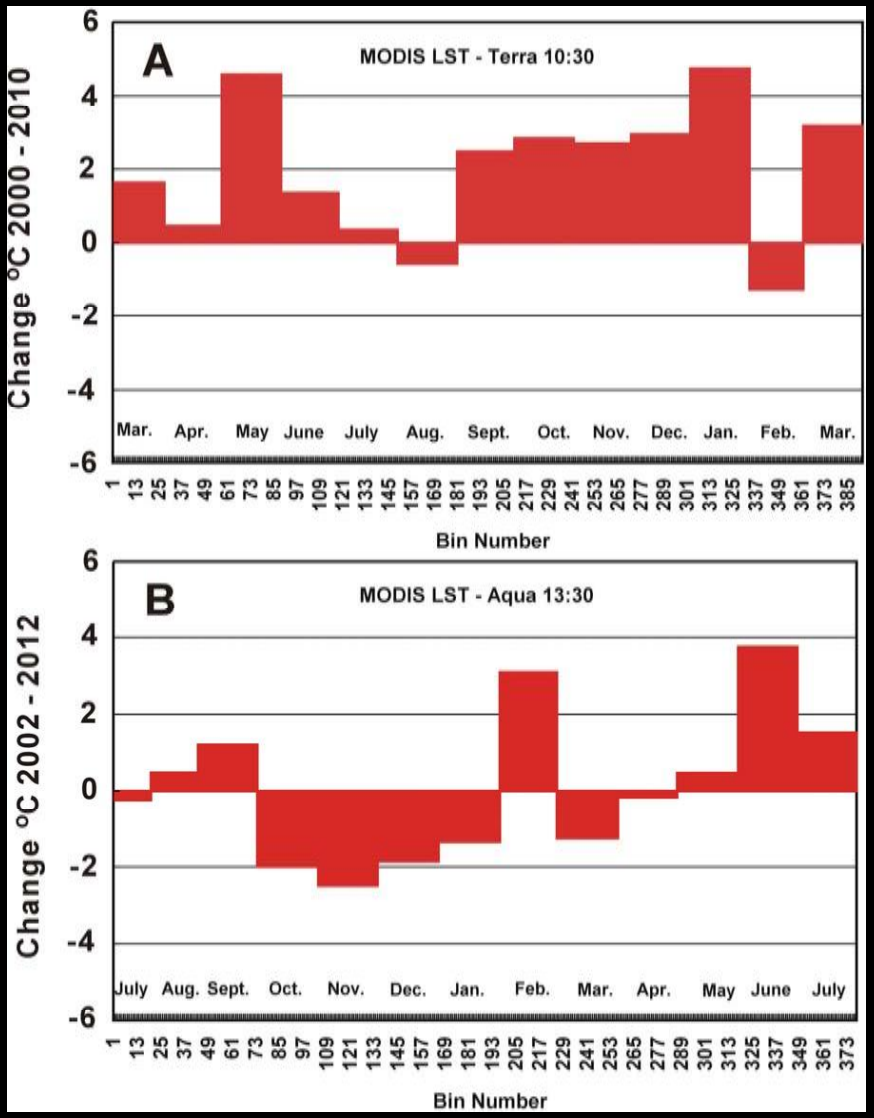
Mean difference in the order of 1-2 K between MODIS and other products during snow-free conditions.

SSM/I: Royer and Poirier, 2010
AMSR-E: Jones et al., 2010

25 km x 25 km grid cells

Soliman *et al*., 2012

Recent variations observed by MODIS (2000-2012)



Muskett, 2013

"Decadal Changes"

MOD11A1 (Terra) and MYD11AI (Aqua) Level-3 Version 5 from March 2000 through July 2012

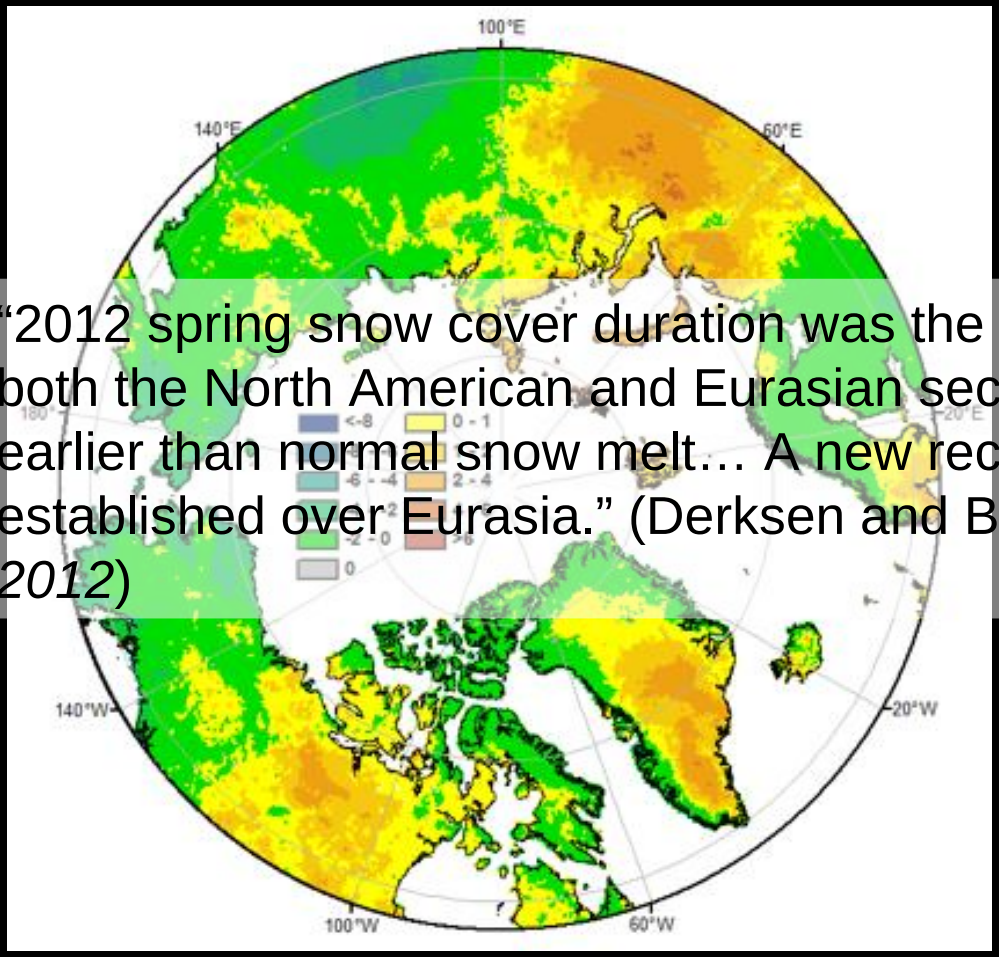
Change of land-surface monthly temperatures above 65° N:
(A)MODIS-Terra relative 10:30 and
(B)MODIS- Aqua relative 13:30 local equator crossing times.

Table 1. Arctic MODIS-derived decadal land-surface temperature change trends.

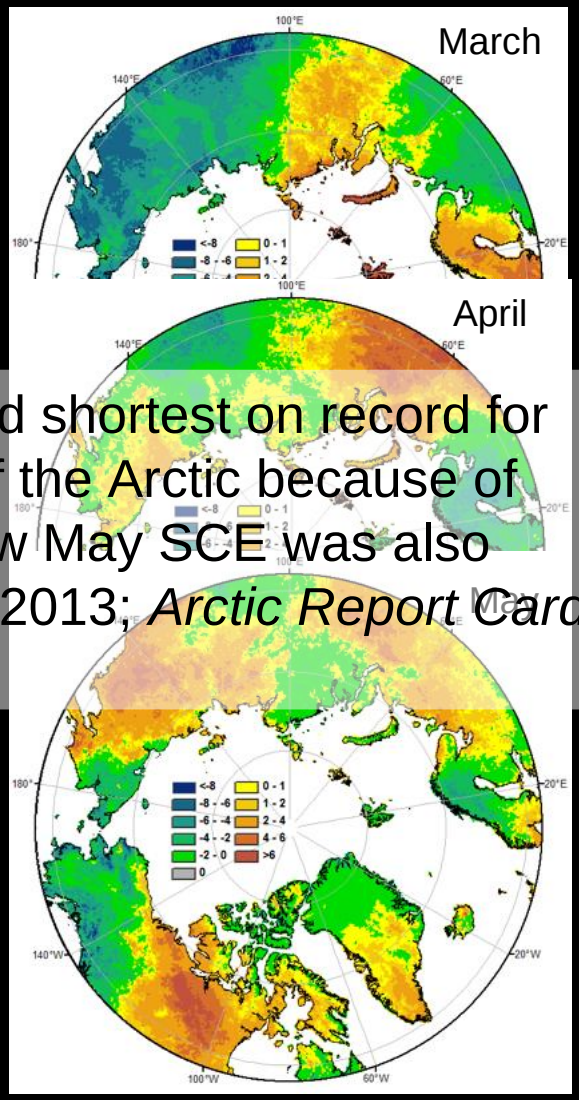
Regions	MODIS-Terra	MODIS-Aqua
	10:30	13:30
	2000-2010	2002-2012
	D°C PV R^2	D°C PV R^2
Arctic	+2.1 ± 0.20.01 0.95	+0.1 ± 0.2 0.01 0.95
*Eurasia	+1.7 ± 0.30.01 0.93	+2.8 ± 0.3 0.01 0.93
*Western NA	+1.9 ± 0.2 0.01 0.95	−1.5 ± 0.2 0.01 0.95
*Eastern NA-WE	+2.5 ± 0.3 0.01 0.85	−1.5 ± 0.3 0.01 0.87

*120° azimuth sectors of the Arctic. PV = P-Value (ANOVA).

Spring (MAM) anomaly (2012 vs mean 2002-2011)

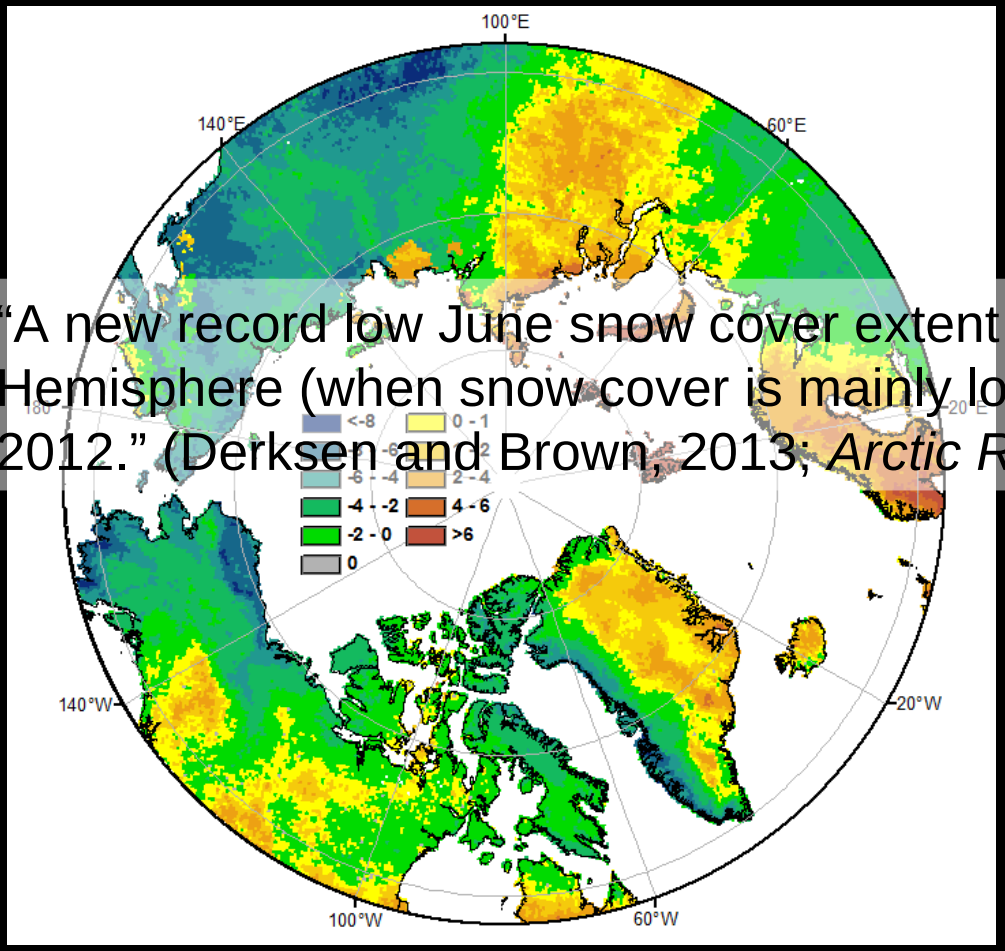


Derived from UW-L3 LST (25 km x 25 km)

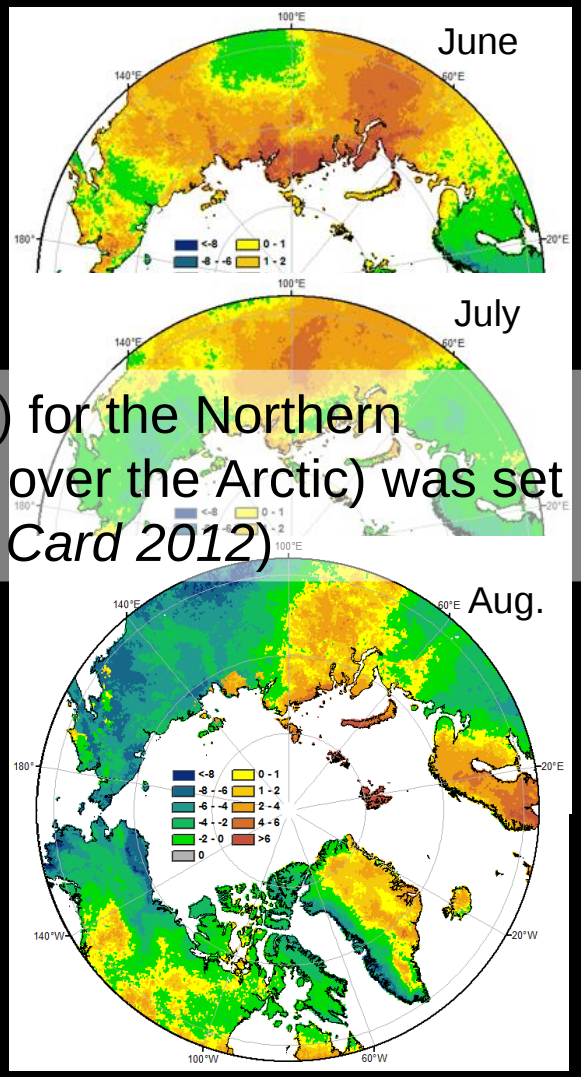


"2012 spring snow cover duration was the second shortest on record for both the North American and Eurasian sectors of the Arctic because of earlier than normal snow melt… A new record low May SCE was also established over Eurasia." (Derksen and Brown, 2013; *Arctic Report Card 2012*)

Summer (JJA) anomaly (2012 vs mean 2002-2011)

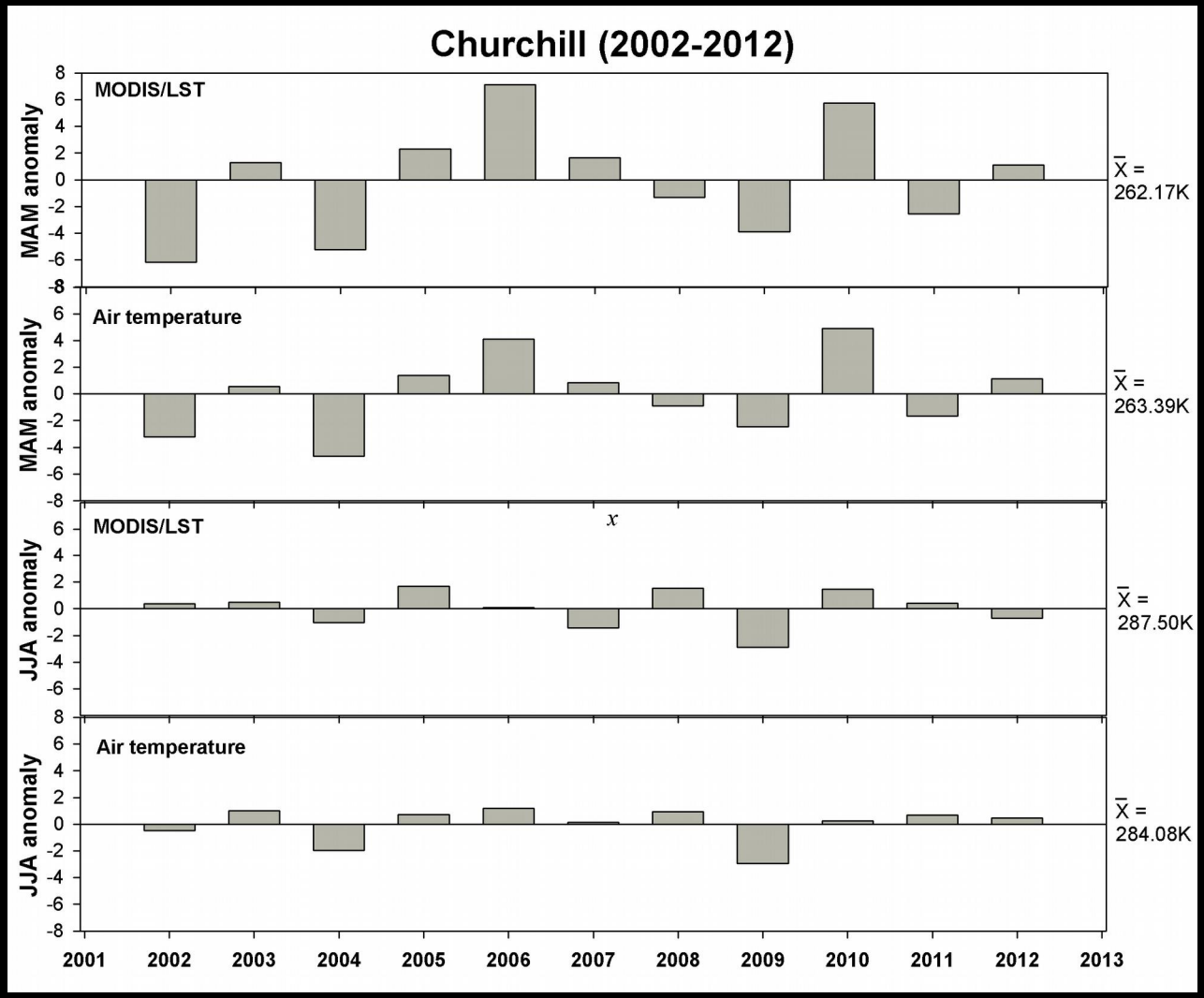


Derived from UW-L3 LST (25 km x 25 km)



"A new record low June snow cover extent (SCE) for the Northern Hemisphere (when snow cover is mainly located over the Arctic) was set in 2012." (Derksen and Brown, 2013; *Arctic Report Card 2012*)

Spring and summer LST and 2-m air temperature anomalies (Churchill, Canada)



Derived from UW-L3 LST (25 km x 25 km)

Concluding remarks

- LST and surface air temperature do not represent the same thing. They are complementary observations.

- Differences are in the order of 1-2 K between LST *in situ* (radiometric) and satellite-derived observations.

- Average differences are in the order of 1-2 K between various satellite and other gridded products (e.g., reanalysis) during snow-free conditions. Greater differences are observed spatially and in other periods of the year. The source(s) of these differences need to be more fully investigated.

- MODIS Level 2 (Aqua/Terra) and derived products (e.g., UW-L3) allow for the examination of monthly and seasonal anomalies, and changes over the last decade (although the historical record is too short to draw any strong conclusion regarding any trends).


Questions?