Arctic Land-Surface Temperatures Increasing From 2000 Through 2012 Derived By MODIS Sensors On NASA Earth Observing Satellites[1]

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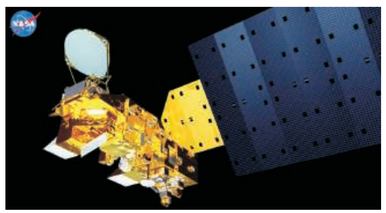
ABSTRACT

Heating of land surfaces by solar irradiance is a fundamental parameter of environment and climate. Across the Arctic changes in active layer, melting of glaciers and ground ice, thawing of permafrost and sequestration changes of carbon storage are driven in part by variations of land surface heat absorption and conduction. In permafrost regions taliks are important for water movement and heat advection into the ground. We investigate land-surface temperature changes and regional variations derived by the MODIS sensors (Terra EOS-AM and Aqua EOS-PM) at the spatial and temporal resolutions of 1-km and daily across the Arctic from March 2000 through July 2012. Since 2000 the number of days with daytime Land-surface temperatures above 0 °C increases by fourteen. On average Arctic land-surface daytime temperature increase is 2.1 ± 0.2 °C with a P-Value of 0.01 and R-Square of 0.97. Regional increases are 1.7 ± 0.3 °C for Northern Eurasia, 1.9 ± 0.2 °C for Northern Far East Russia-Western North America and 2.5 ± 0.3 °C for Eastern North America-Greenland-Northwestern Europe with significant P-Value and R-Square. Coordination of terrestrial measurement network stations with satellite-based measurement systems is required for assessment, evaluation and prognoses of impacts of land-surface temperature changes to the Arctic environment, communities and infrastructures.

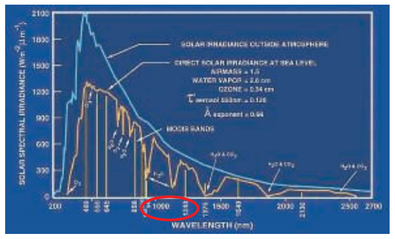
The Satellites and Sensors

NASA-Terra Satellite (EOS AM, MODIS Proto-Flight Model)



NASA-Aqua Satellite (EOS PM, MODIS Flight Model 1)

(Images from NASA)



Spectral channels 31 and 32 are used for land-surface temperature retrieval by the v.5 algorithm (image from Wikipedia).

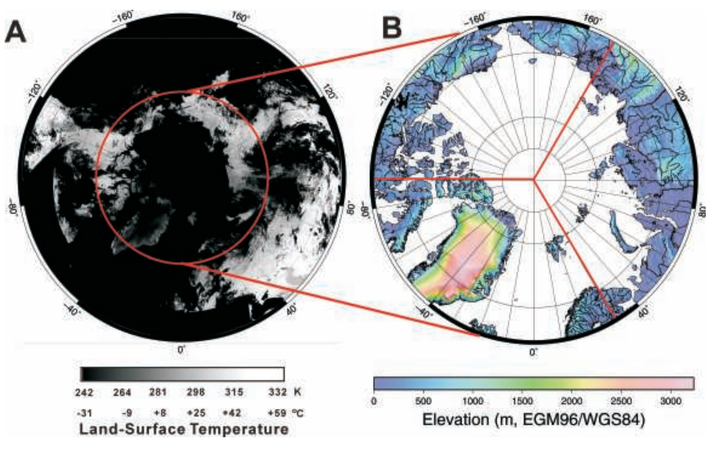


Figure 1. MODIS land-surface temperature on the northern hemisphere and our regions of interest for mathematical analysis. A) 22 July 2004, 10:30 equator crossing time, NASA Terra satellite with temperature scales in Kelvin and Celsius. B) Regions of interest, the Arctic and 120 degree sectors. The digital elevation model is the Altimetry Corrected Elevation 2 Digital Elevation Model. Data files are produced in 5x5 degree tiles. Our processing takes 81 tiles covering the northern hemisphere, mosaic (in sinusoidal projection) and reproject to WGS with WGS-84 reference ellipsoid, consistent with the International Terrestrial Reference Frame.

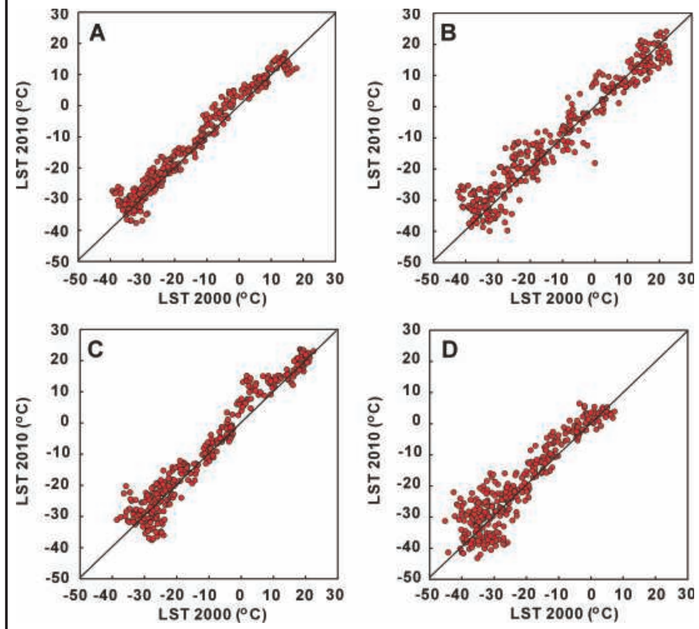


Figure 2. Comparison of co-located MODIS-Terra land-surface temperatures in regions of interest: year 2000 through 2010, A) 65° N, B) Eurasia, C) Western North America and D) Eastern North America and Western Europe.

Table 1. Arctic MODIS-Derived Decadal Land-Surface Temperature Change Trends

Regions	MODIS-Terra 10:30 2000-2010		
	Δ°C	PV	R^2
(A) Arctic	+2.1 ± 0.2	0.01	0.95
120° Arctic Sectors			
(B) Eurasia	+1.7 ± 0.3	0.01	0.93
(C) Western NA	+1.9 ± 0.2	0.01	0.95
(D) Eastern NA-WE	+2.5 ± 0.3	0.01	0.85

Table 1. Arctic MODIS-Derived Decadal Land-Surface Temperature Change Trends

Regions	MODIS-Aqua 13:30 2002-2012		
	Δ°C	PV	R^2
(A) Arctic	+0.1 ± 0.2	0.01	0.95
120° Arctic Sectors			
(B) Eurasia	+2.8 ± 0.3	0.01	0.93
(C) Western NA	-1.5 ± 0.2	0.01	0.95
(D) Eastern NA-WE	-1.5 ± 0.3	0.01	0.87

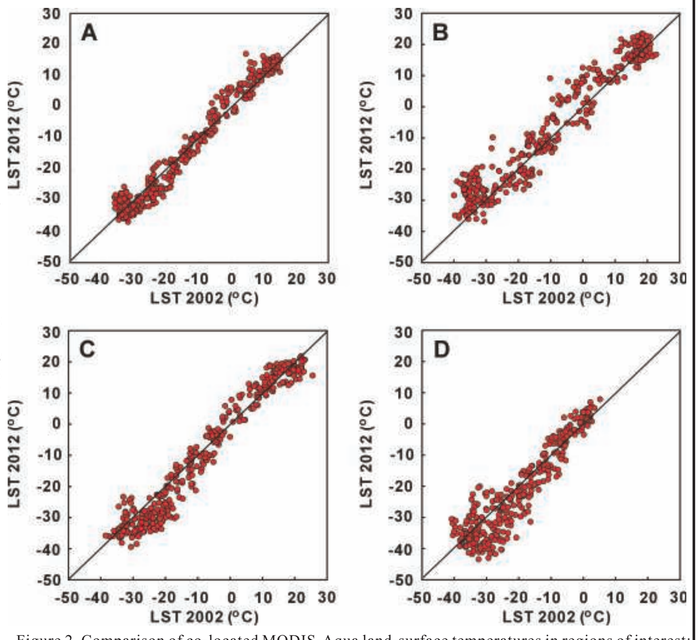


Figure 2. Comparison of co-located MODIS-Aqua land-surface temperatures in regions of interest: year 2000 through 2010, A) 65° N, B) Eurasia, C) Western North America and D) Eastern North America and Western Europe.

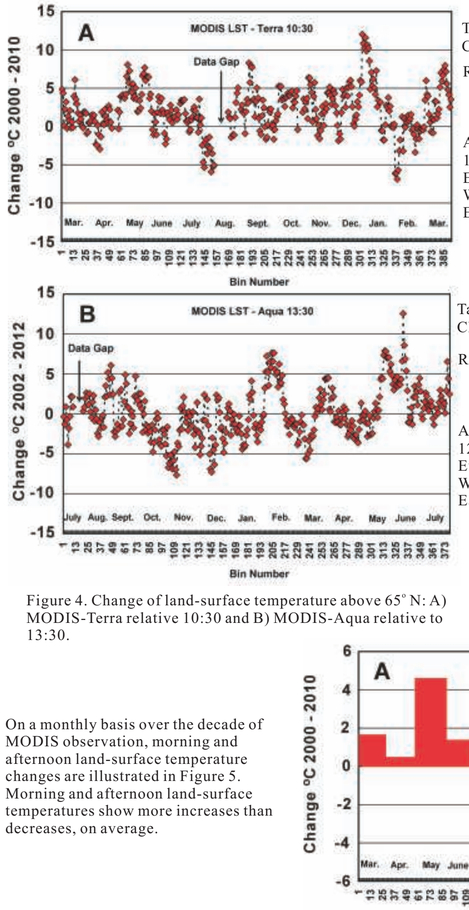


Figure 4. Change of land-surface temperature above 65° N: A) MODIS-Terra relative 10:30 and B) MODIS-Aqua relative to 13:30.

Table 3. Arctic MODIS-Derived Decadal Change of Days Above 0°C.

Regions	MODIS-Terra 10:30 2000-2010 Δ Days Above 0°C
Arctic	+14
120° Arctic Sectors	
Eurasia	+0
Western NA	+13
Eastern NA-WE	+31

Table 4. Arctic MODIS-Derived Decadal Change of Days Above 0°C.

Regions	MODIS-Aqua 13:30 2002-2012 Δ Days Above 0°C
Arctic	+14
120° Arctic Sectors	
Eurasia	+20
Western NA	+8
Eastern NA-WE	+23

On a monthly basis over the decade of MODIS observation, morning and afternoon land-surface temperature changes are illustrated in Figure 5. Morning and afternoon land-surface temperatures show more increases than decreases, on average.

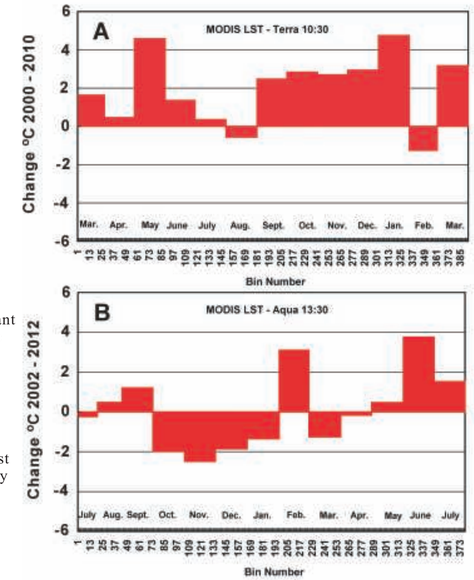


Figure 5. Change of land-surface monthly temparatures above 65° N: A) MODIS-Terra and B) MODIS-Aqua relative to their equator crossing time of 10:30 and 13:30, respectively.

Conclusions

In conclusion we are detecting significant increasing trends in Arctic land-surface temperature during the first decade of MODIS NASA-Aqua and -Terra observations. In particular we detect increases in the days of land-surface temperature above 0°C. This is an important constraint on physical processes affecting snow-ice-permafrost vulnerability, ecosystems and hydrology of the Arctic.

ACKNOWLEDGEMENTS

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REFERENCE

[1] Reginald R. Muskett (2012 in press). MODIS-Derived Land-Surface Temperature Changes and Trends. Atmospheric and Climate Science 3 (1) 2013. At http://www.scirp.org/journals/acs/