National Snow and Ice Data Center

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CIRES

Colorado
University of Colorado at Boulder

The Coldest Place on Earth:

-90°C and below from Landsat 8 and other satellite thermal sensors

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Funding Support:

NASA

USGS science for a changing world

What we did, and what we learned:

We used a series of satellite data sets measuring the *thermal emission temperature* of the Antarctic Ice Sheet surface;

We selected the coldest data over a 32 year period, 1982-2013;

We found that a region East Antarctic Plateau is always cloud-free during extreme cold events. The map of coldest temperatures is a map of the surface.

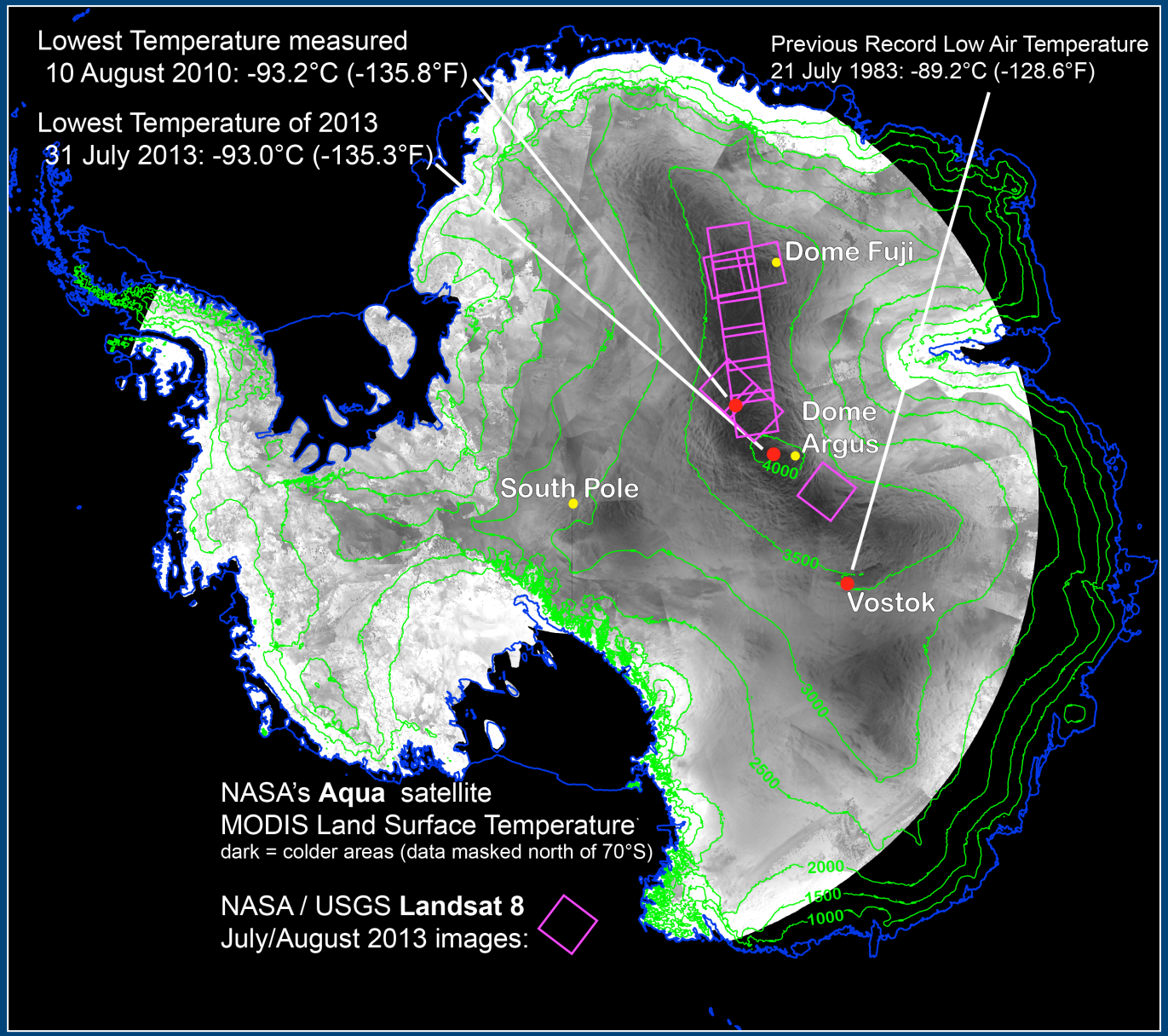
The map shows that ultra-low surface temperatures (-90°C and lower) occur in local topographic lows (pockets) just south of a long ice ridge. These areas routinely surpass the record temperature of the previous lowest temperature on record, at Vostok Station, Antarctica.

The lowest temperature in the data set* is -93.2°C, or -136°F, set on 10 August 2010. The record low Vostok air temperature is -89.2°C, or -128.6°F, set on 21 July 1983.

We used Landsat 8 to investigate and confirm the thermal structure of the pockets.

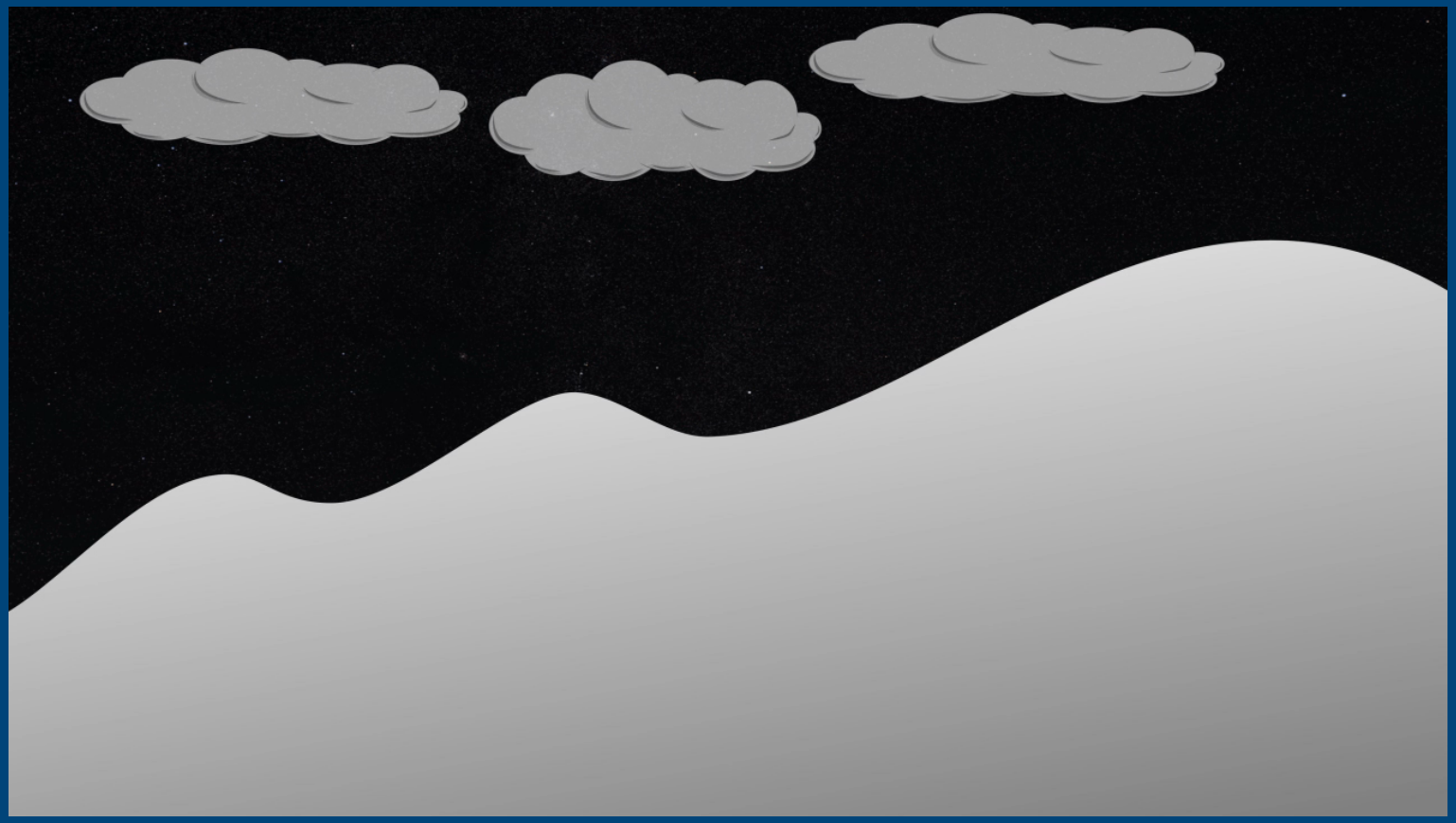
Science directions: What climate and weather conditions lead to the ultra-cold events?
Is there a physical limit to how cold it can get?

The Coldest Place On Earth



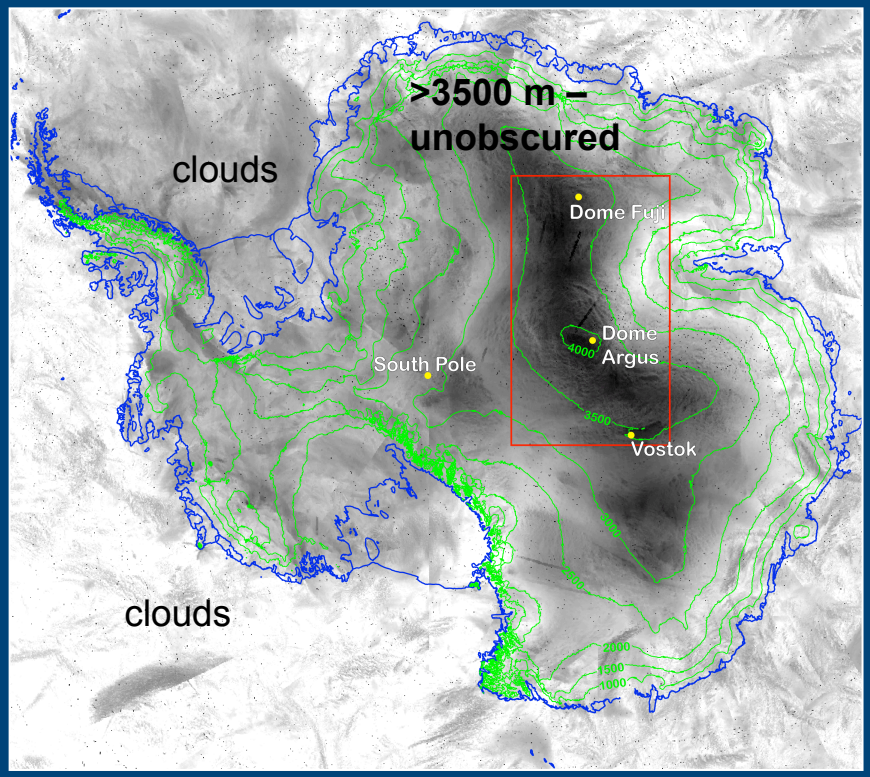
Visualization of Antarctic temperatures

Animation of how the temperatures get so cold



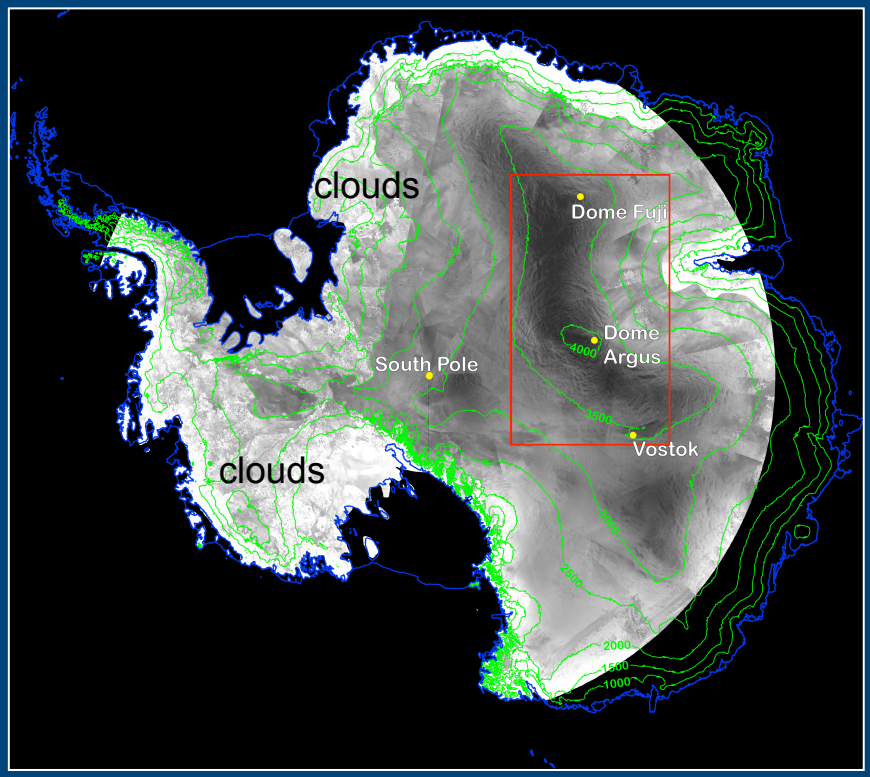
Thermal mapping of Antarctica in winter

Dark is colder, where data is mapped



NOAA's AVHRR sensor
Polar Pathfinder data set
5 km data grid; 1982-2000

Data has some noise, artifacts; data avail. to 2011

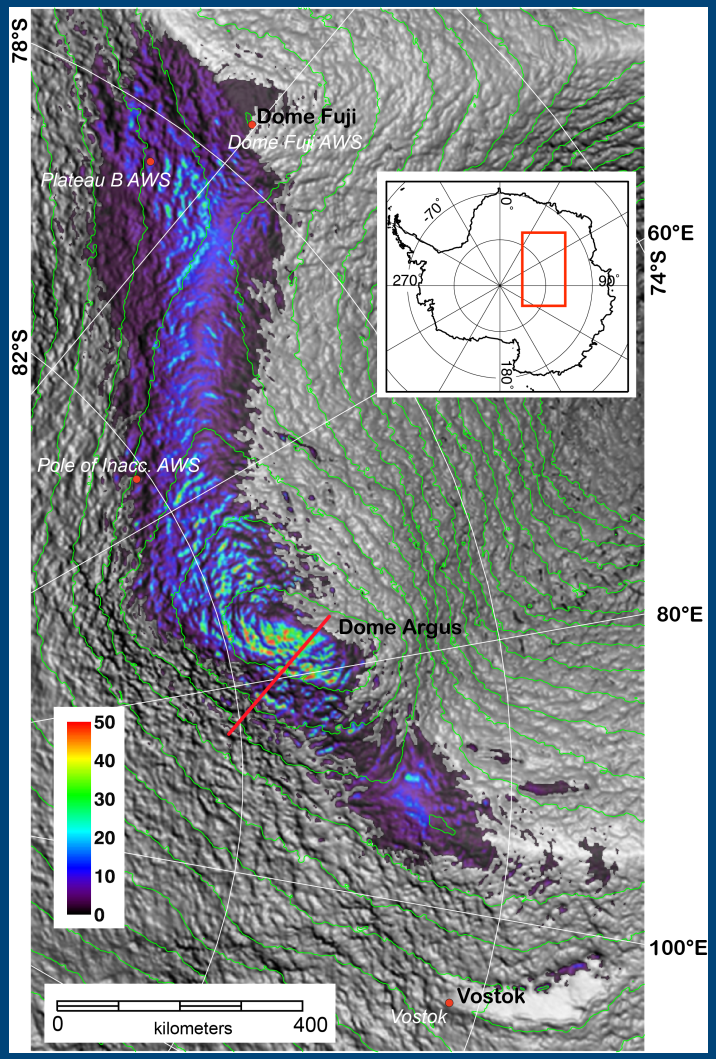


NASA's Aqua MODIS sensor
MYD11A1 data set, selected >70°S
1 km data grid; 2003-2013 July and August

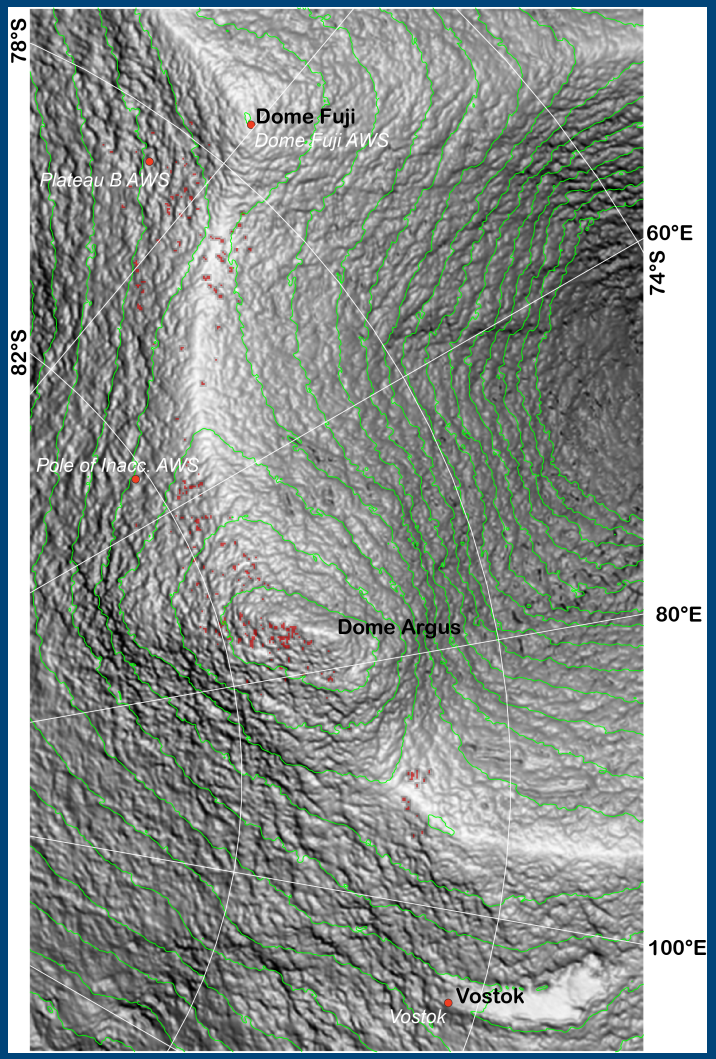
Less noise, better resolution and validation

Ultra-cold pockets (topographic lows) near the top of the ice sheet

Shaded relief of topography, central East Antarctic Plateau



Color: number of times surface temperature was below -88°C, July-August 2003 to 2013

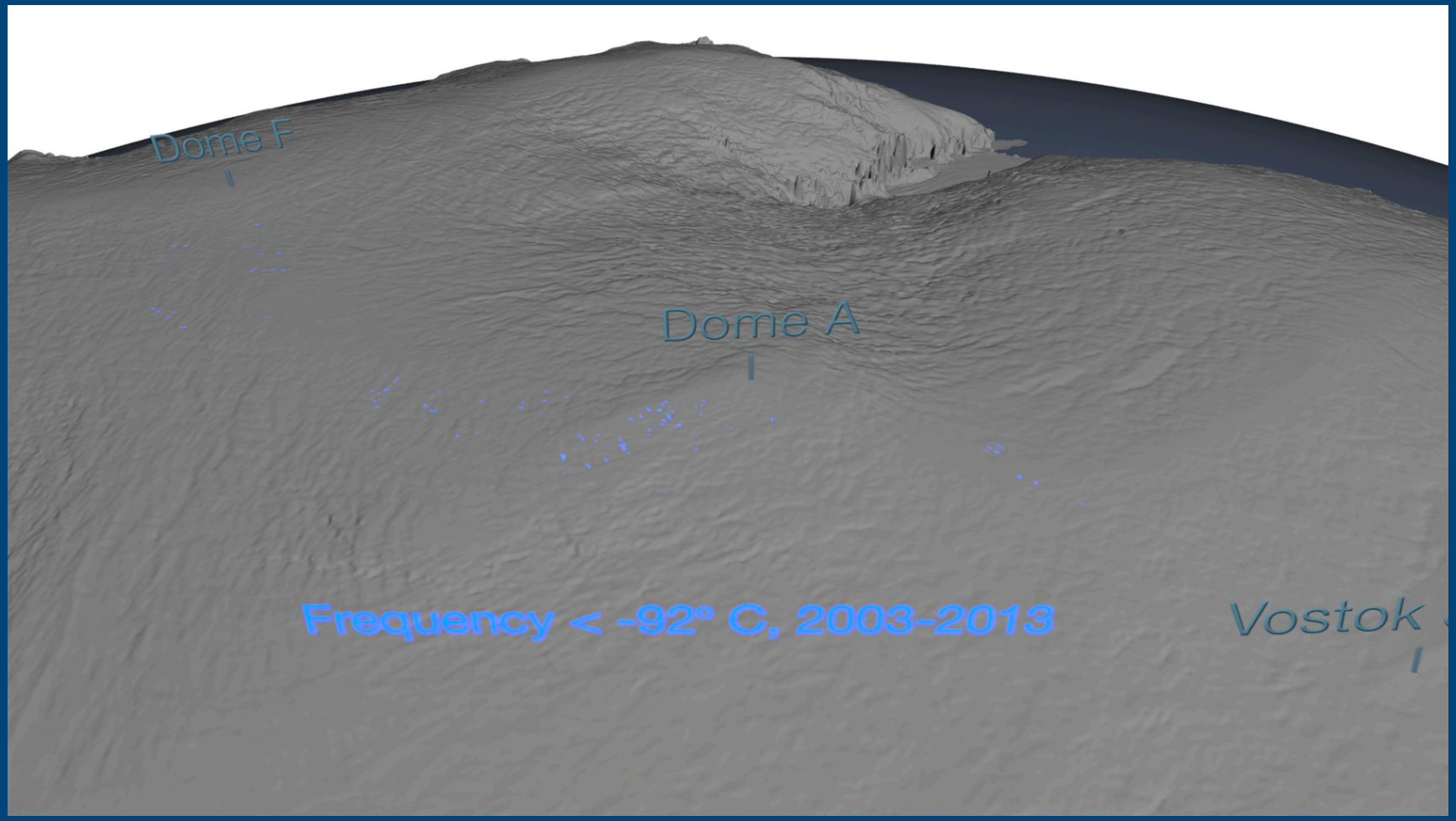


Red areas: regions where temperature was below -92°C, July-August 2003 to 2013

Ultra-cold pockets (topographic lows) near the top of the ice sheet

In the flat-lying topographic basins, the frequency of ultra-cold events increases, and the lowest measured temperature drops.

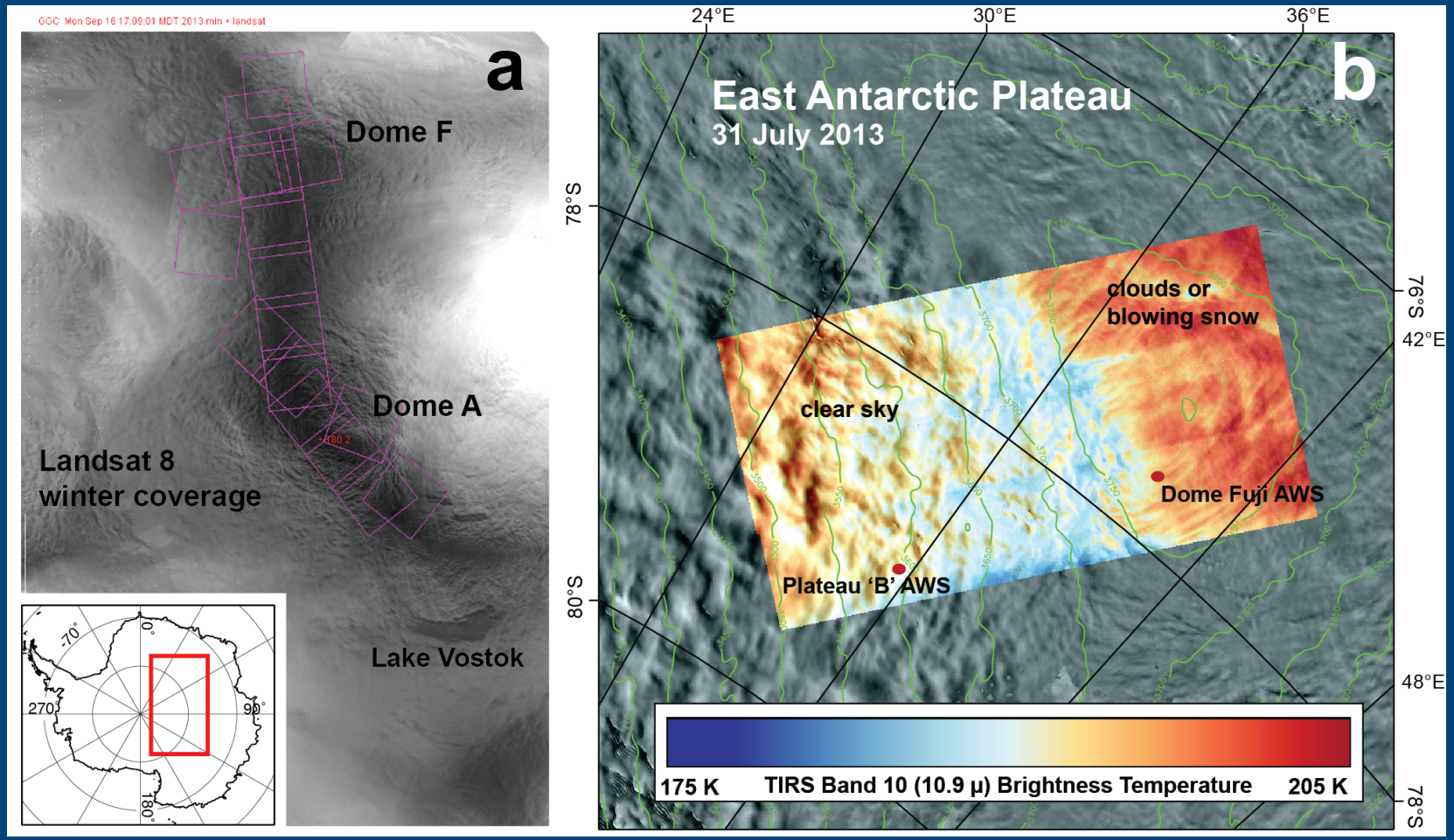
The coldest places – all in one region but widely distributed.



Thermal mapping of the East Antarctic interior in winter

MODIS LST minimum T, 2013

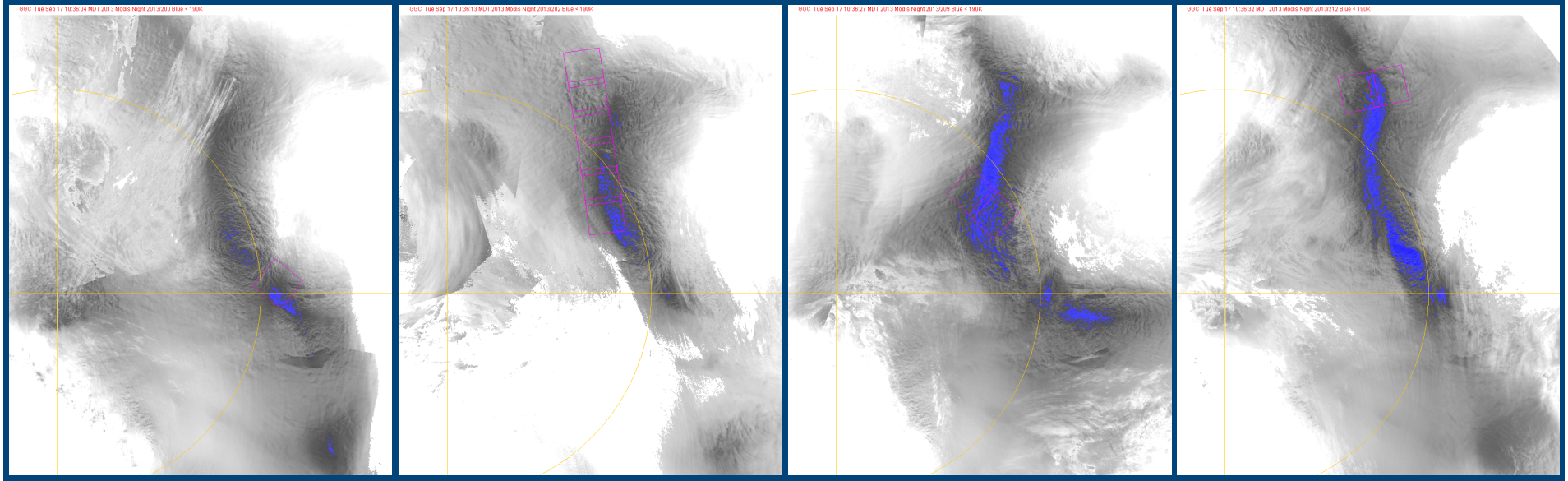
surface image with Landsat 8 B10 color scale BT



Purple outlines are all Landsat 8 acquisitions June-August 2013

Thermal mapping of the East Antarctic interior in winter 2013

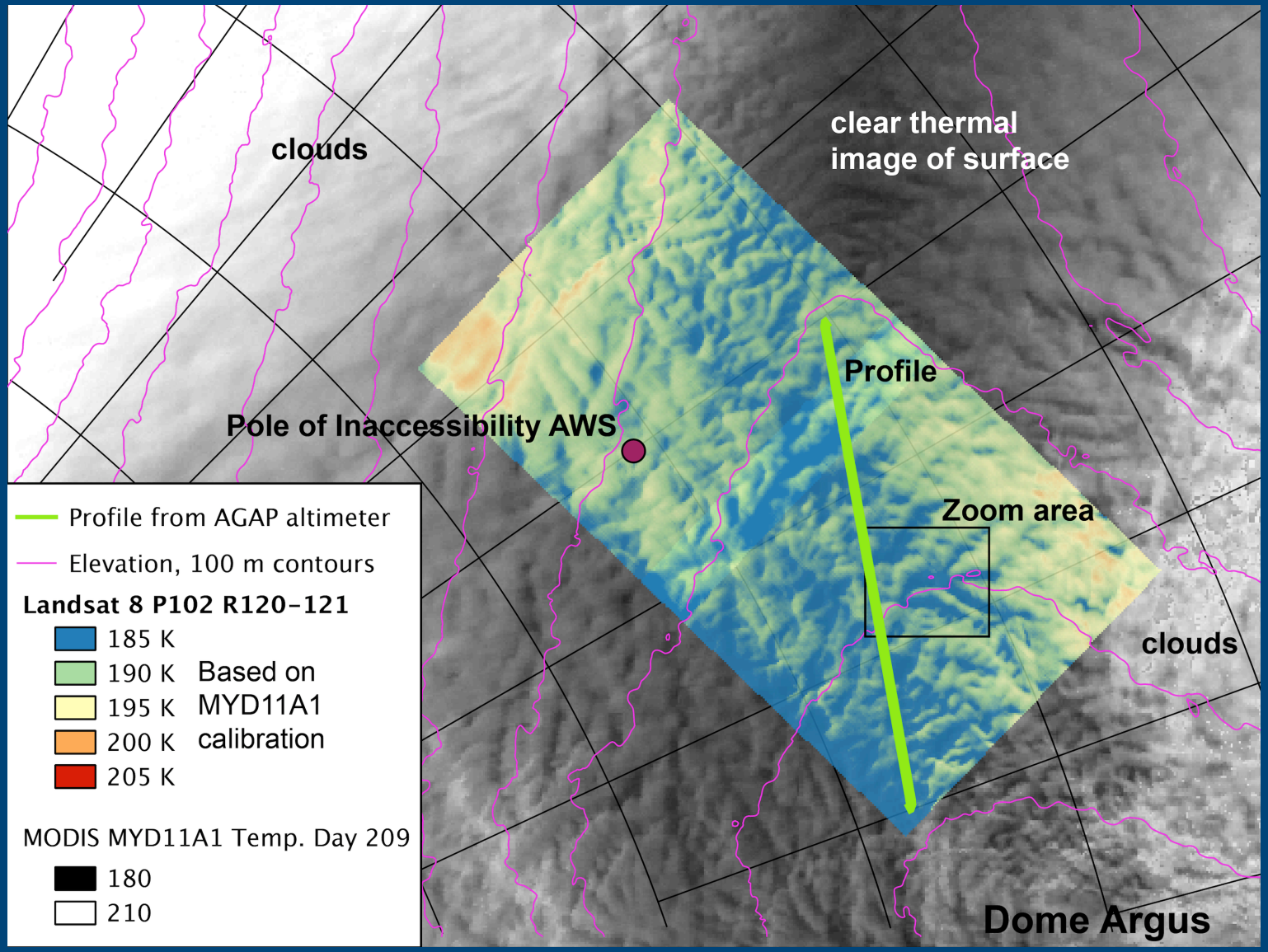
MODIS Aqua 'night' Land Surface Temperature (blue = < -83°C ; -117.4°F)



19 July 21 July 28 July 31 July

Purple outlines are Landsat 8 acquisitions on the same day

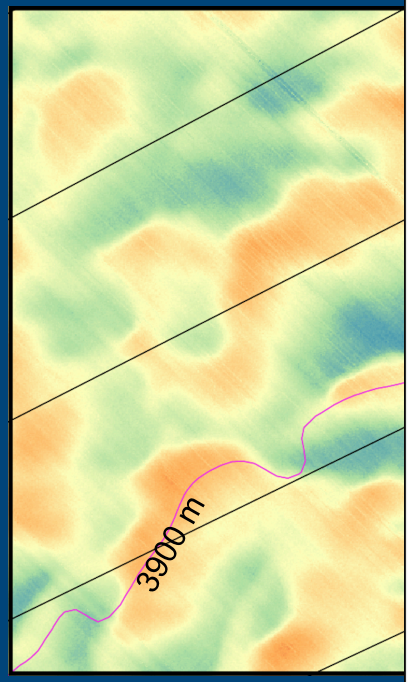
Landsat 8 TIRS (thermal mapper) 2013 winter images, Antarctica

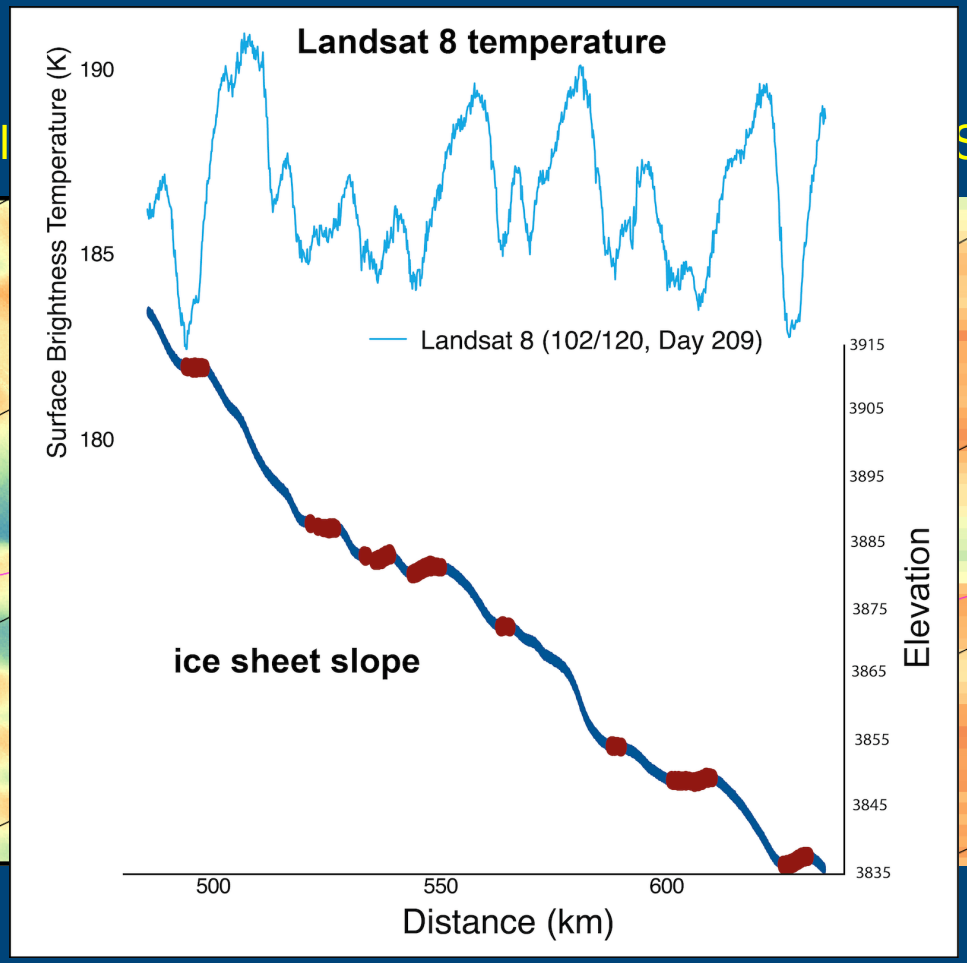


Aqua MODIS and Landsat 8, 28 July, 2013

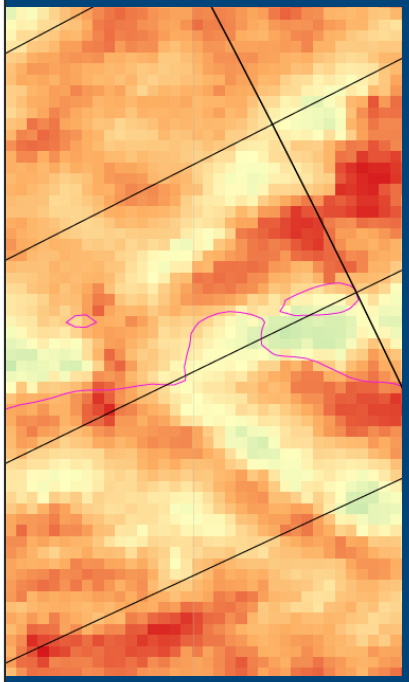
Landsat 8 TIRS (thermal mapper) 2013 winter images, Antarctica

Landsat 8, 28 Jul



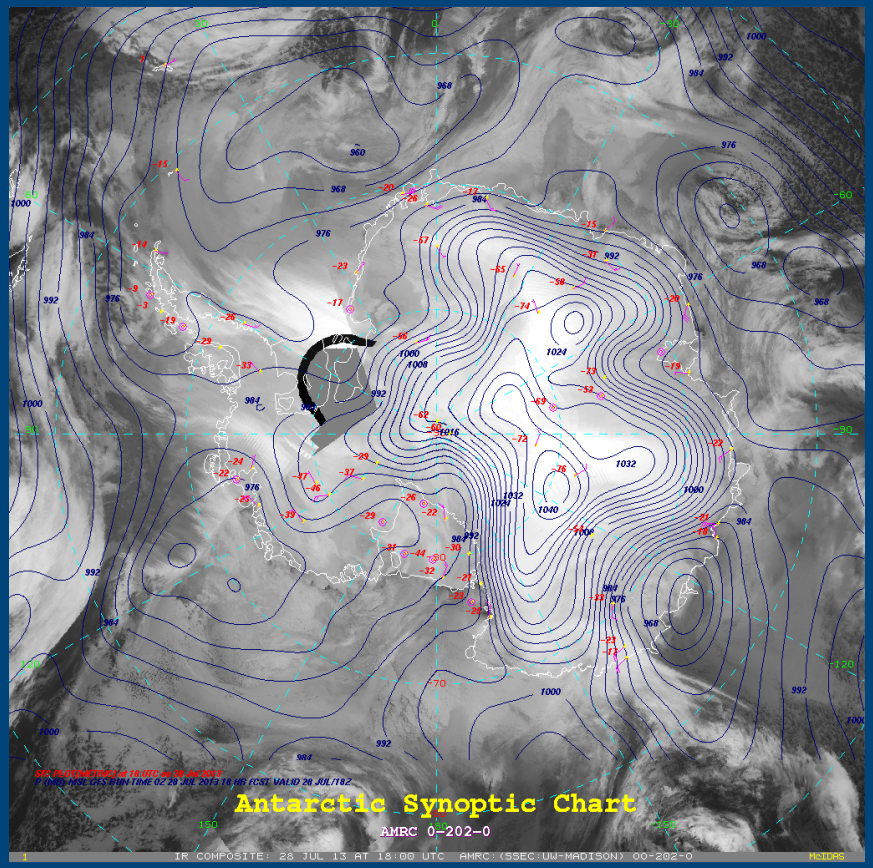


ST, 28 July, 2013

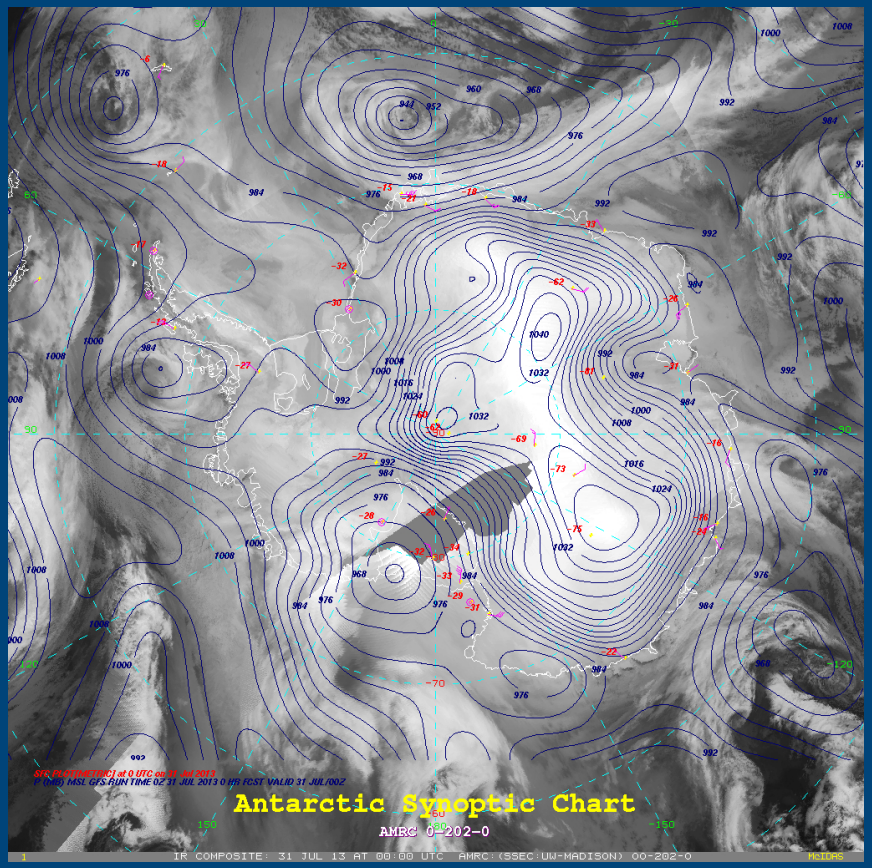


Weather plots for coldest days of 2013

Pressure gradients (and winds) that are light and/or oppose the gravity-driven flow of cold air



28 July, 2013



31 July, 2013

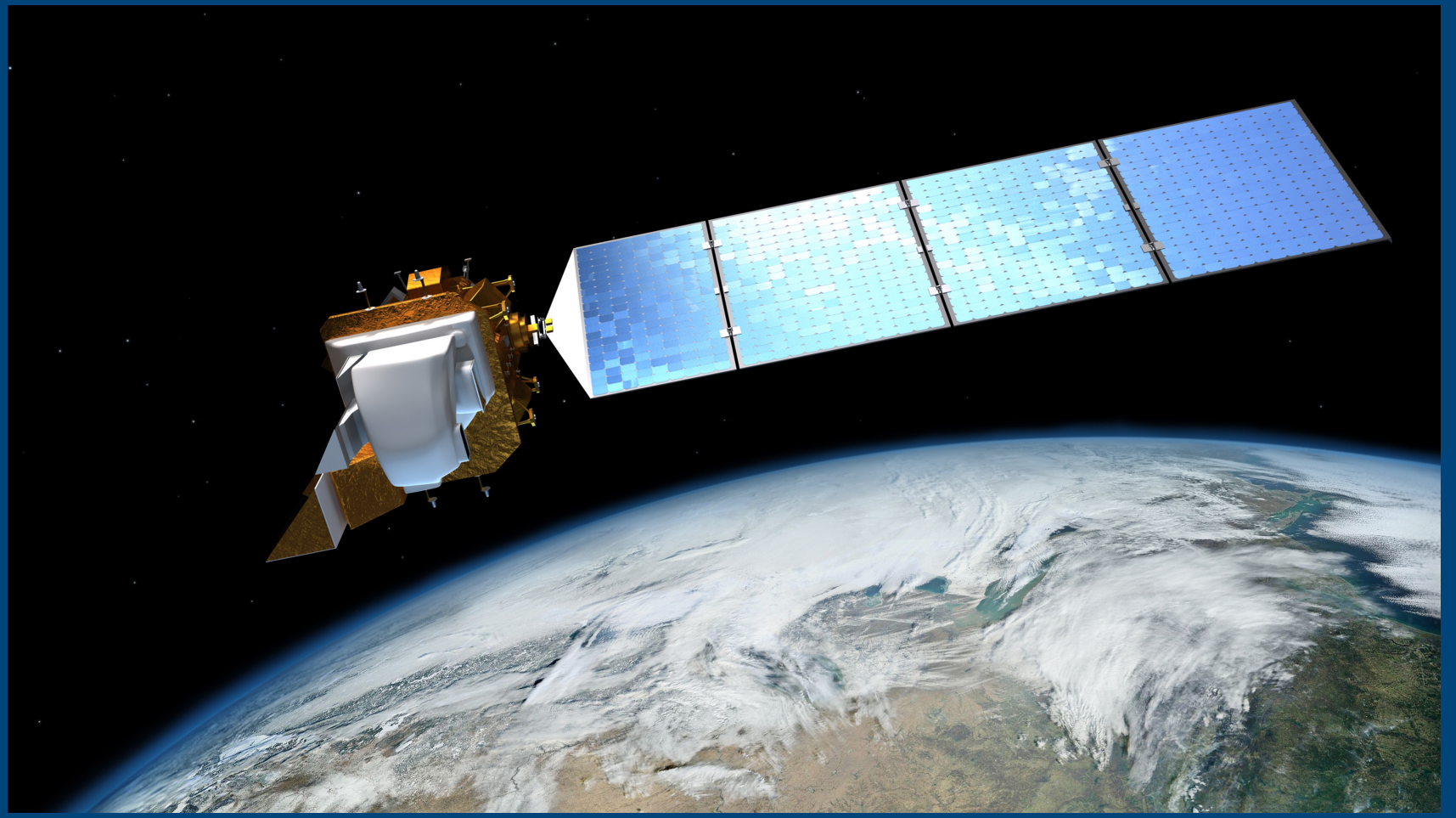
Can humans survive in these temperatures?

Yes, we can.

For about 3 minutes.

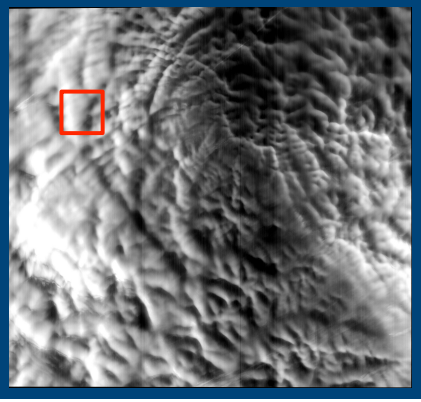
The ‘300 Club’.

Landsat 8 -- continuing a 40-year legacy of Earth observation



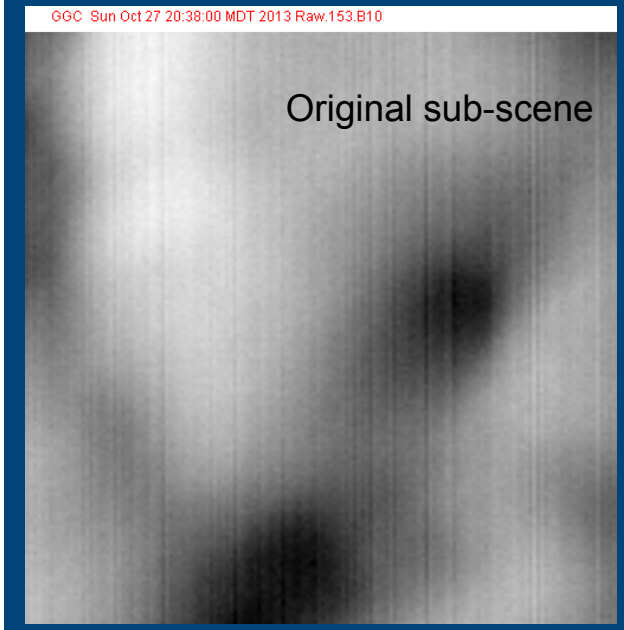
- Sensors: Operational Land Imager (OLI) and Thermal InfraRed Sensor (TIRS)
- 15 meter image resolution; 30 m spectral band resolution; 100 m thermal band resolution
- 12 – bit radiometric resolution in all bands
- Outstanding geo-location accuracy (~3 to 5 meters)

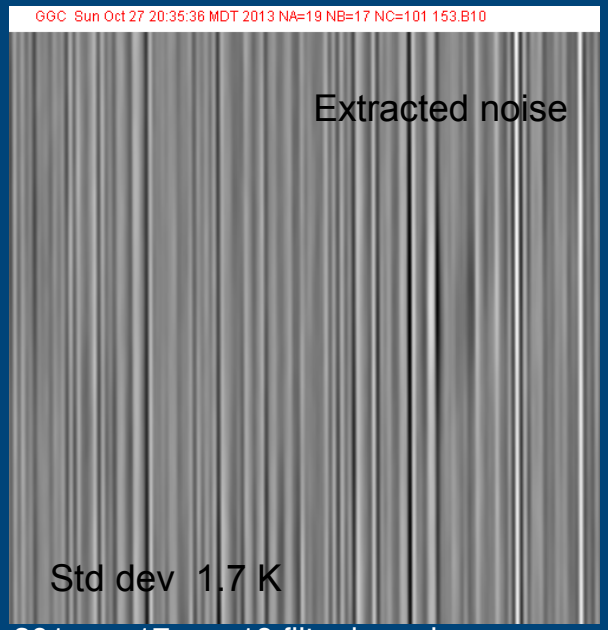
Landsat 8 TIRS (thermal mapper) 2013 winter images, Antarctica



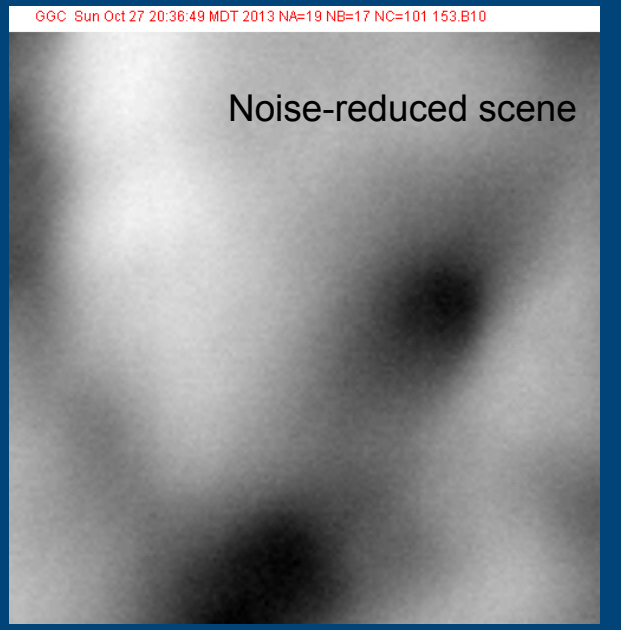
Pushbroom sensor noise in thermal channels at low T is significant;
Destriping filter scheme used to extract noise semi-quantitatively

Path 094, Row 120, 02 June 2013;
near Dome A, Kunlun Station, Antarctica





301 x 17 x 19 filter kernels



Crippen, PE&RS 1989 filtering (modified)