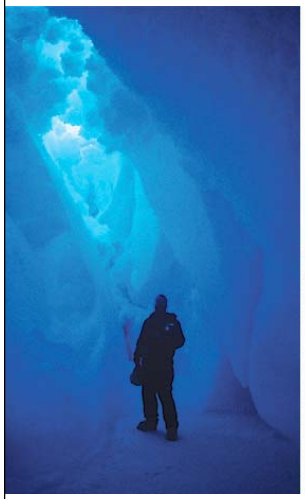
National Snow and Ice Data Center

Supporting Cryospheric Research Since 1976



MODIS in the Land Ice and Snow Community

Ted Scambos *Terry Haran, Julienne Stroeve, Tom Painter, Ruth Duerr*

National Snow and Ice Data Center, CIRES

University of Colorado, Boulder

Overview

MODIS product development and cal/val at NSIDC:

- mapping and monitoring of the ice sheets
- albedo mapping of ice sheet snow and seasonal snow cover
- mixed-pixel snow cover and snow albedo for western (and other) watersheds
- thermal (skin temperature) cal-val and AVHRR-MODIS comparison over sea ice and ice sheets
- photoclinometry ('shape from shading') for ice sheet DEMs; 'image differencing' for elevation change detection

MODIS data use by the cryospheric community is increasing;

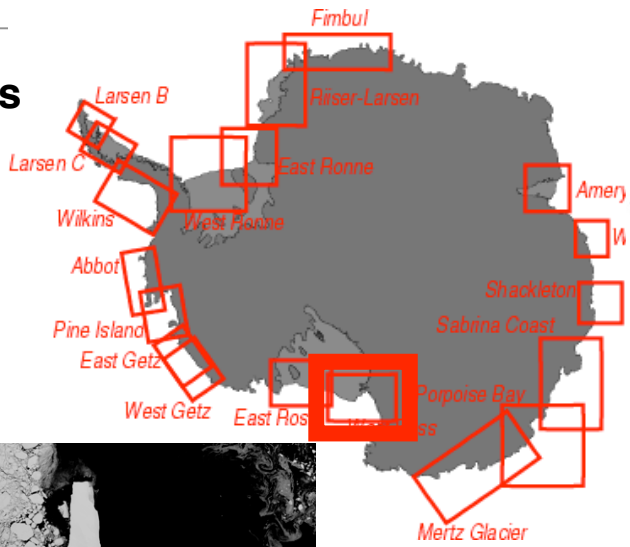
Interest in **time-series of MODIS data** for the poles and snow catchments will cause a huge continued increase

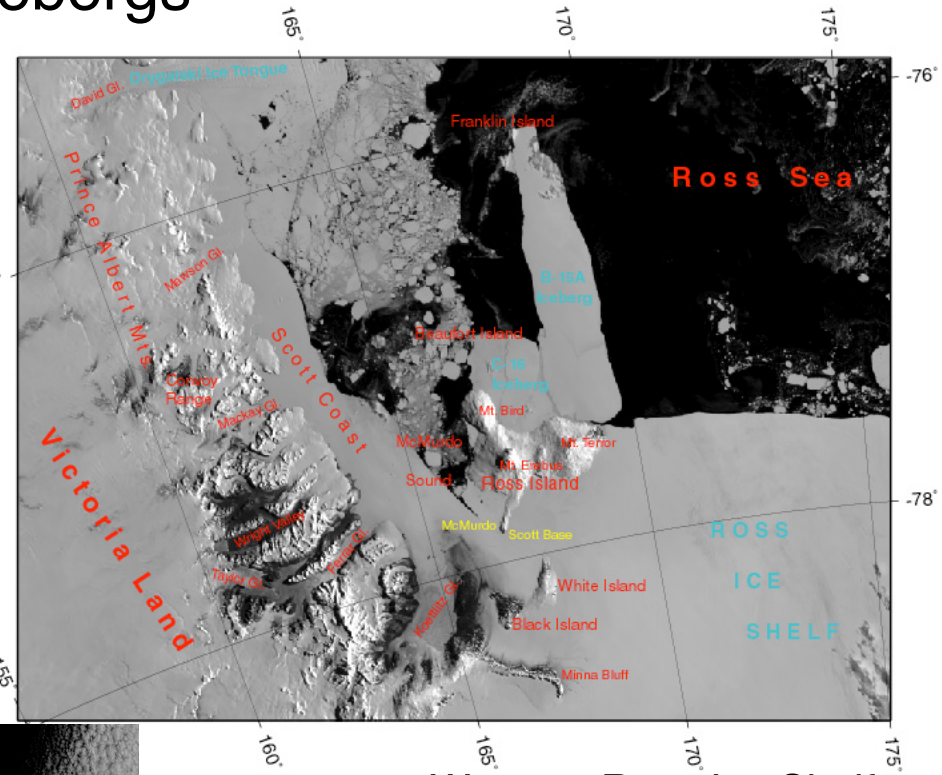
Monitoring of ice shelves and icebergs

http://nsidc.org/agdc/iceshelves_images

20 shelf areas Monitored

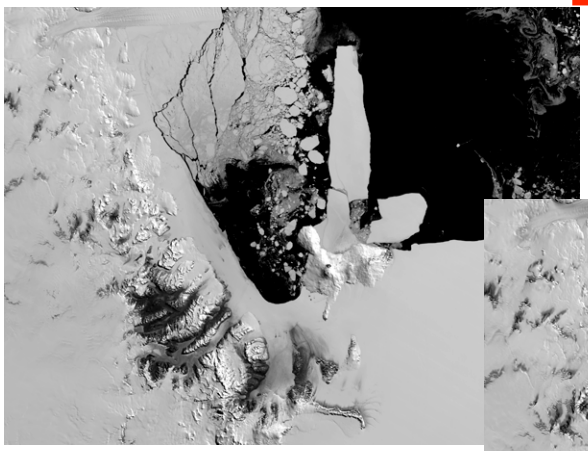
Band 1 or Band 31



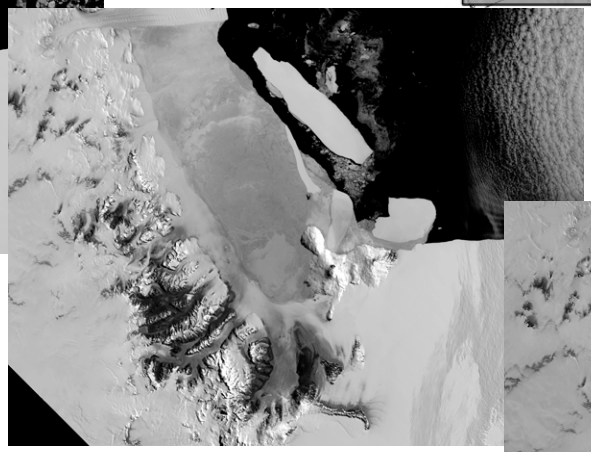


Western Ross Ice Shelf

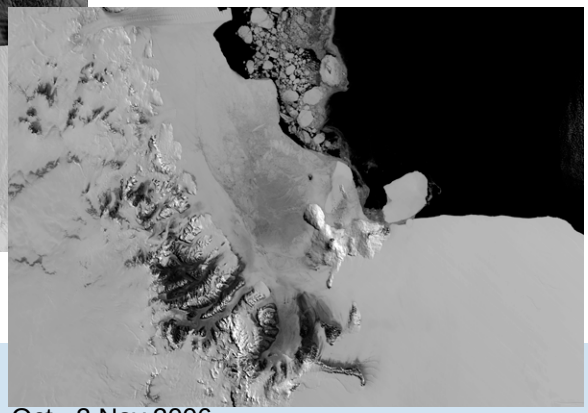
2003



2004



2005



AVHRR and MODIS
1989 - present
~20 images/shelf/year

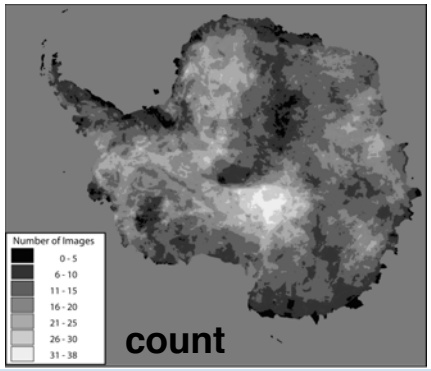
MODIS Mosaic of Antarctica (MOA) and Greenland (MOG)

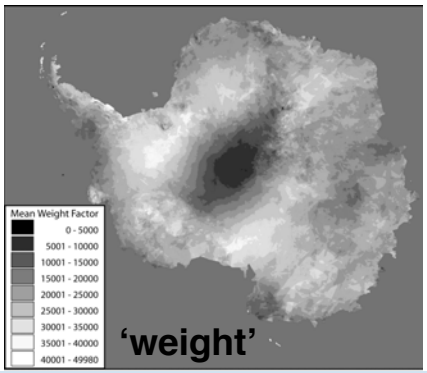
http://nsidc.org/data/moa

Continent-wide (or island-wide)
digital image maps

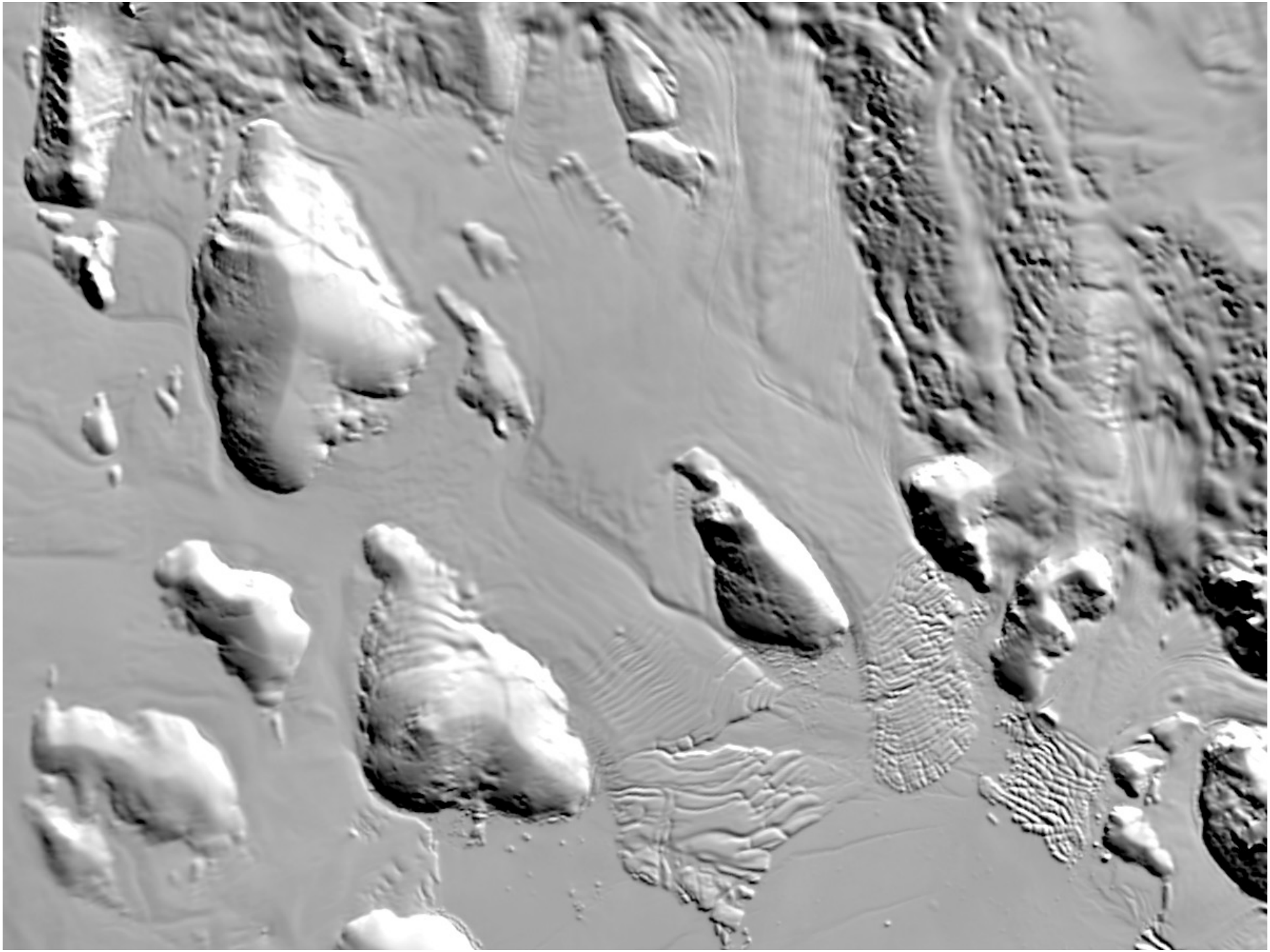
• enhanced resolution, radiometry
•accurate geolocation
•optical snow grain size
•coastline and 'grounding line'

- Multiple images
- 'Stacked' into 125m grid
- Manually cloud-cleared
- Antarctica: 260 scenes;
  Greenland: 95 scenes
- Constrained illumination azim.





MOA IHS image

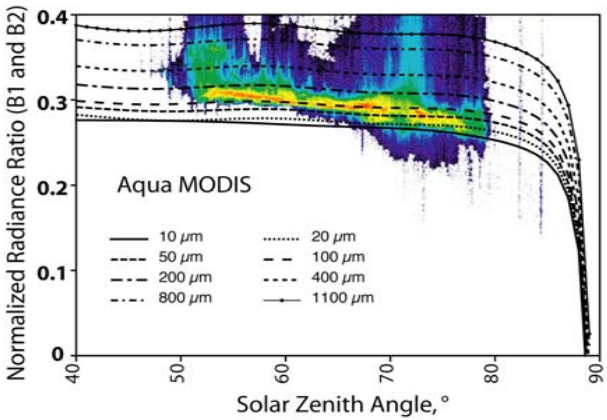


MOA
Snow Grain Size

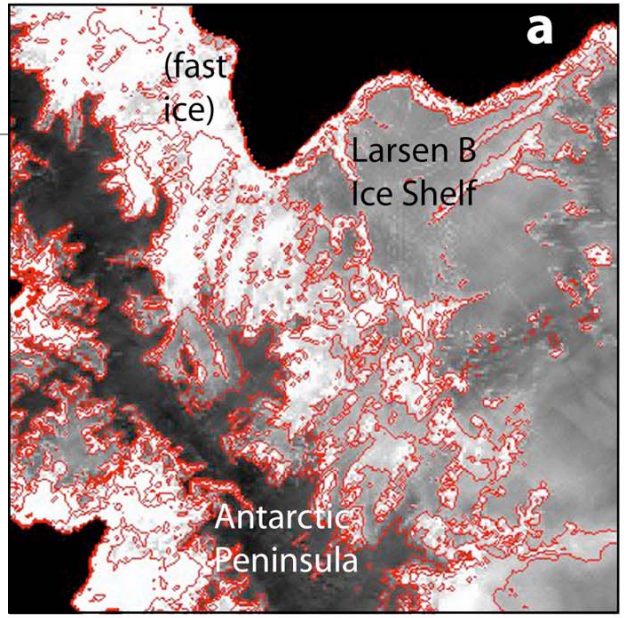
- Band1/Band2 ratio

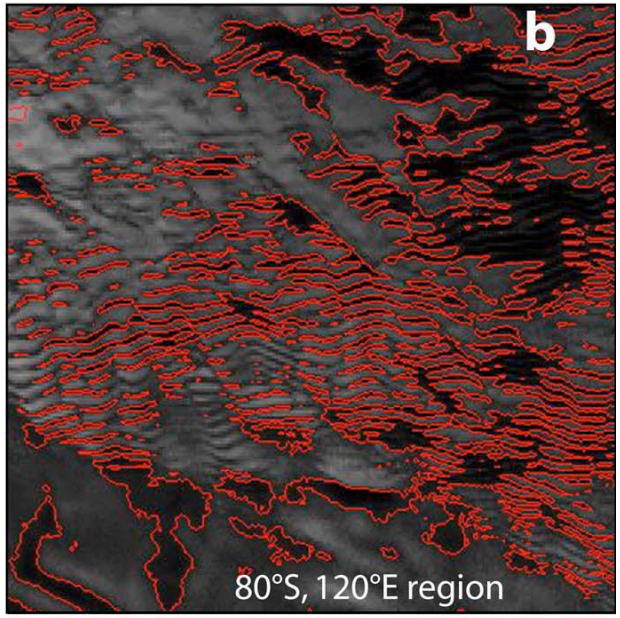
- Look-up table

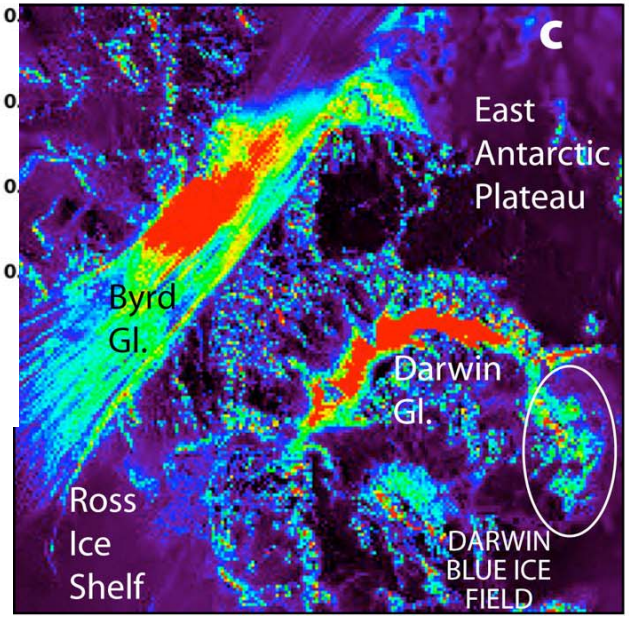
using Atm. Transfer model, Snow BRDF model, snow grain spectra

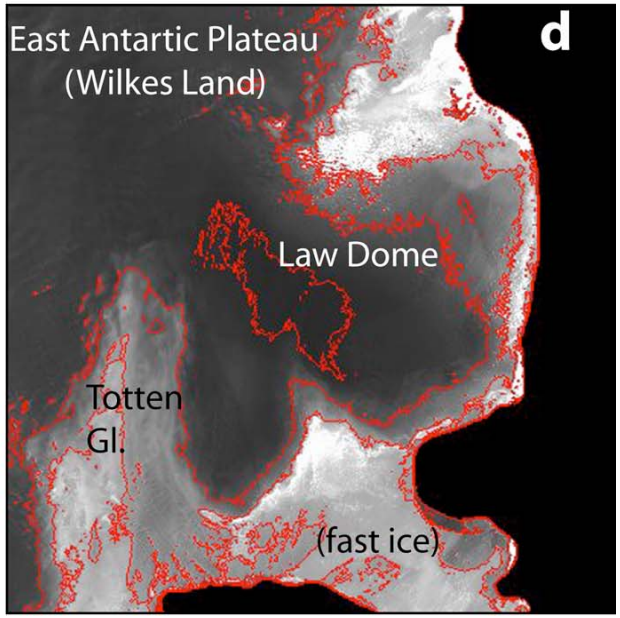


- Climate, melting, blue ice



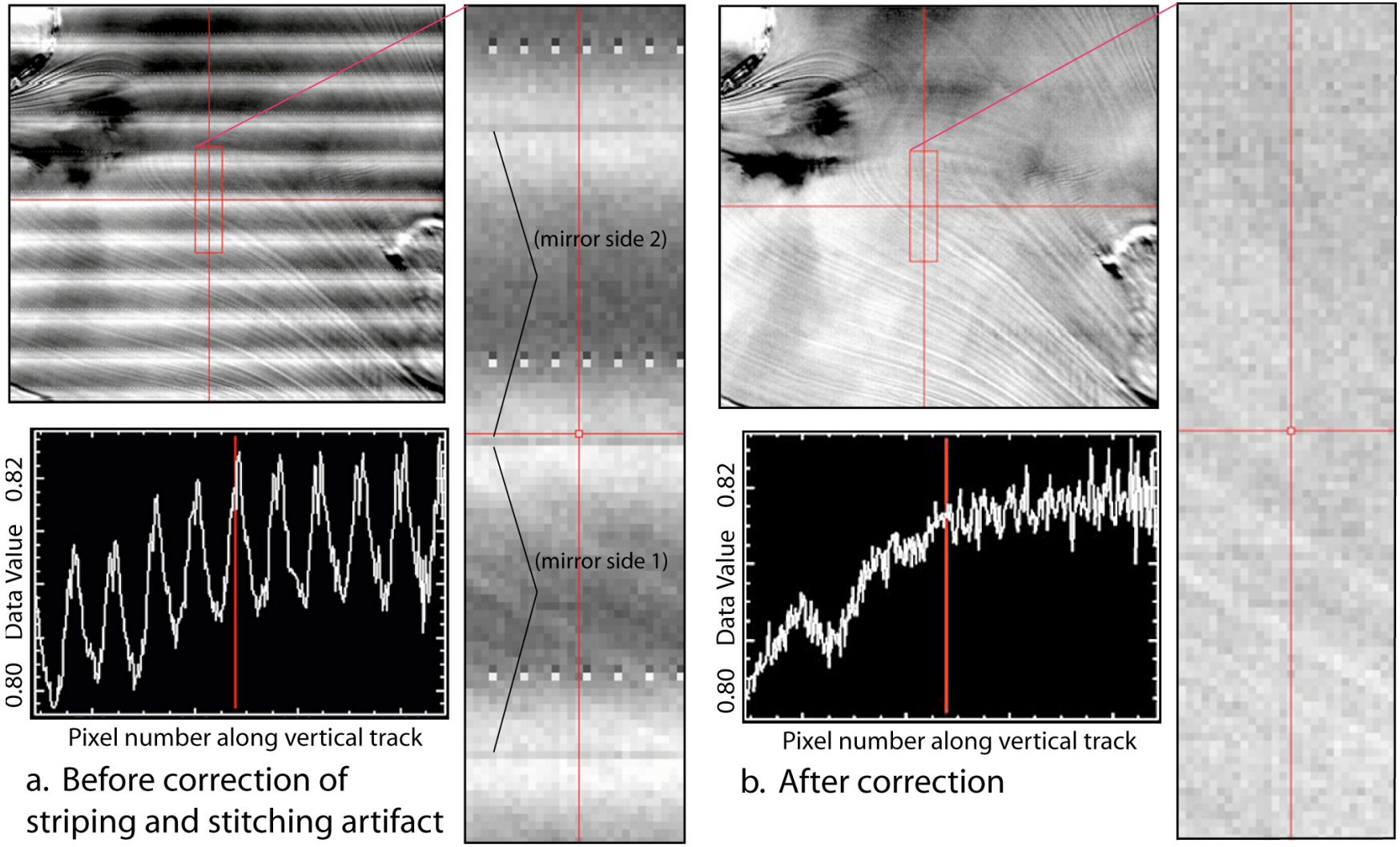






MODIS De-Striping Algorithm for 250m Bands

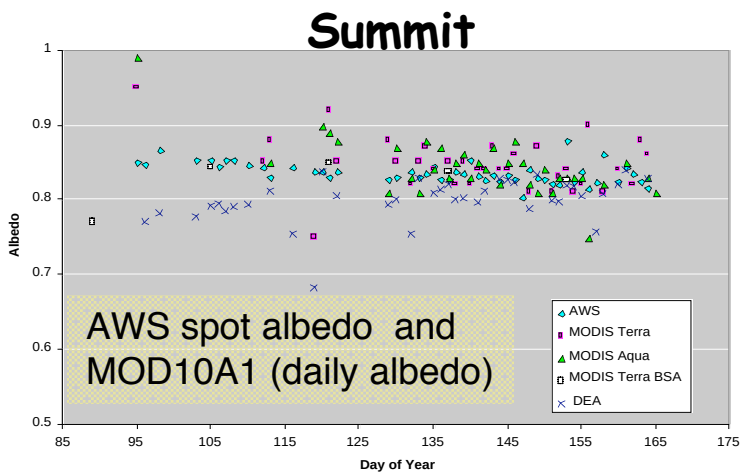
See the Poster : Land "1c"



a. Before correction of striping and stitching artifact

b. After correction

Validation of data and identification of error sources in MODIS snow albedo of ice sheets using MODIS (J. Stroeve)



Validation of the the daily snow albedo data (MOD10A1 and MYD10A1) set by comparison to AWS data

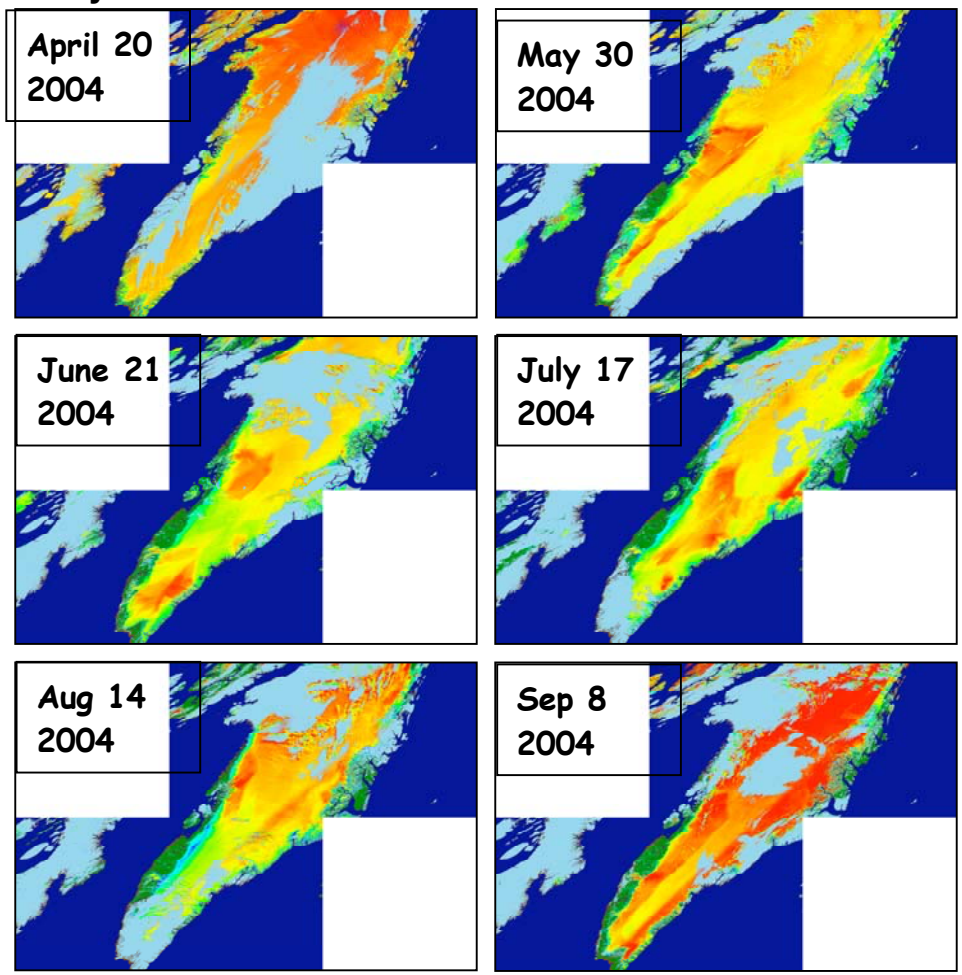
- would it improve with a better BRDF (HDRF) model for snow?

Goals:

- **better tracking of albedo variations during the melt season**
- **more detailed input for surface energy balance studies**
- **monitoring changes in melt onset date, snow-off date**

Daily Albedo

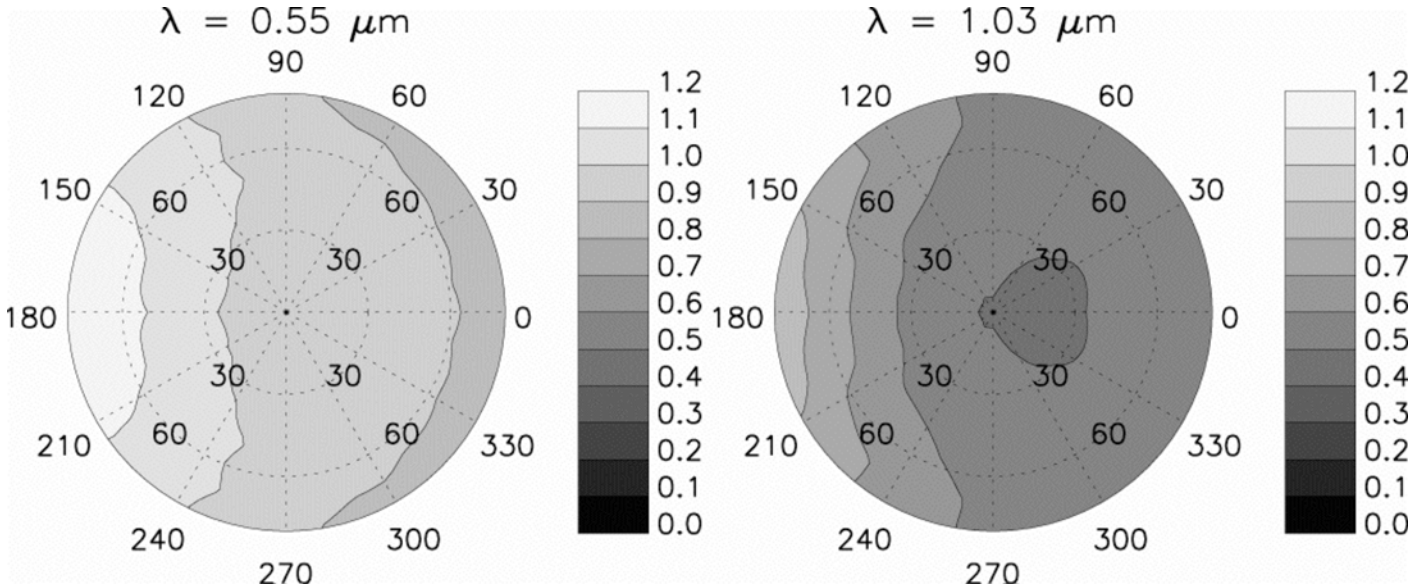
See the Poster : Land "1b"



Blue=low, Red=high albedo

Validation of data and identification of error sources in MODIS snow albedo of ice sheets using MODIS (J. Stroeve)

New BRDF (HDRF) Data Sets for better snow albedo algorithms



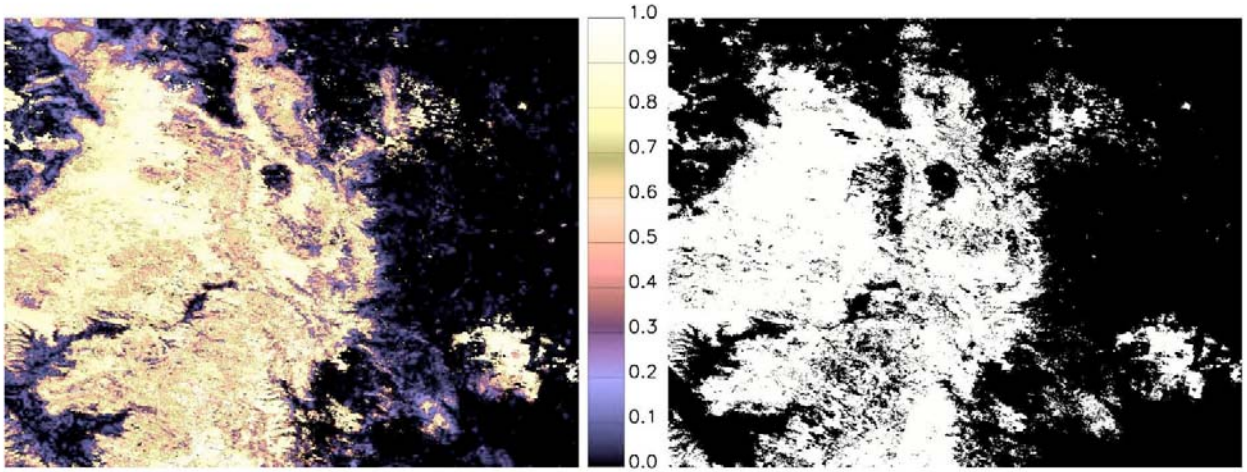
Hemispherical-directional reflectance factor measurements of snow at 0.55 mm and 1.03 mm made with Automated Spectro-Goniometer (ASG) [*Painter and Dozier*, 2004]. SZA was 49°, snow grain radius was 284 mm.

Multi-resolution snow products for the hydrologic sciences

(T. Painter, J. Dozier, et al.)

Motivation and goals:

-more accurate assessment of snow cover in mountainous areas
-quantification of snow water resources at the global, regional, and local scale
-accurate sub-pixel resolution mapping
-multi-sensor fusion; multi-end member spectral mixture analysis (r,v,s: gs + alb)



Fractional

Binary – MOD10A1

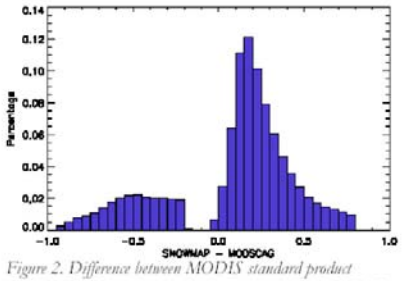


Figure 2. Difference between MODIS standard product (SNOWMAP) and spectral mixing method (MODSCAG)

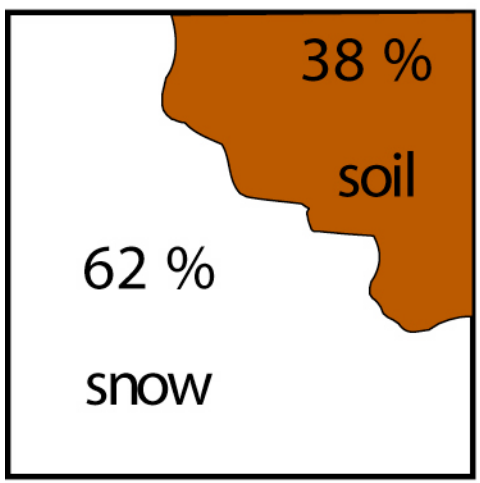
CLPX, Rocky Mountains, 2/15/2002

Multi-resolution snow products for the hydrologic sciences

(T. Painter, J. Dozier, et al.)

MODSCAG

- MODIS Snow Covered Area and Grain size
- Final Products:
  - Fractional SCA, fractional grain size, fractional albedo
- Based on MEMSCAG (Multiple Endmember Snow-Covered Area and Grain Size)
  - Painter, Dozier, et al. 2003 RSE
  - 4% SCA accuracy, 50 *micron* grain size accuracy
- Coupling of snow directional reflectance from DISORT RT modeling and field/lab non-snow spectra



MOD101a →

100% SCA
(38% overestimate)

$\alpha_{snow} = 0.4\text{-}0.5$

(~ 0.30 underestimate because it is a composite albedo)

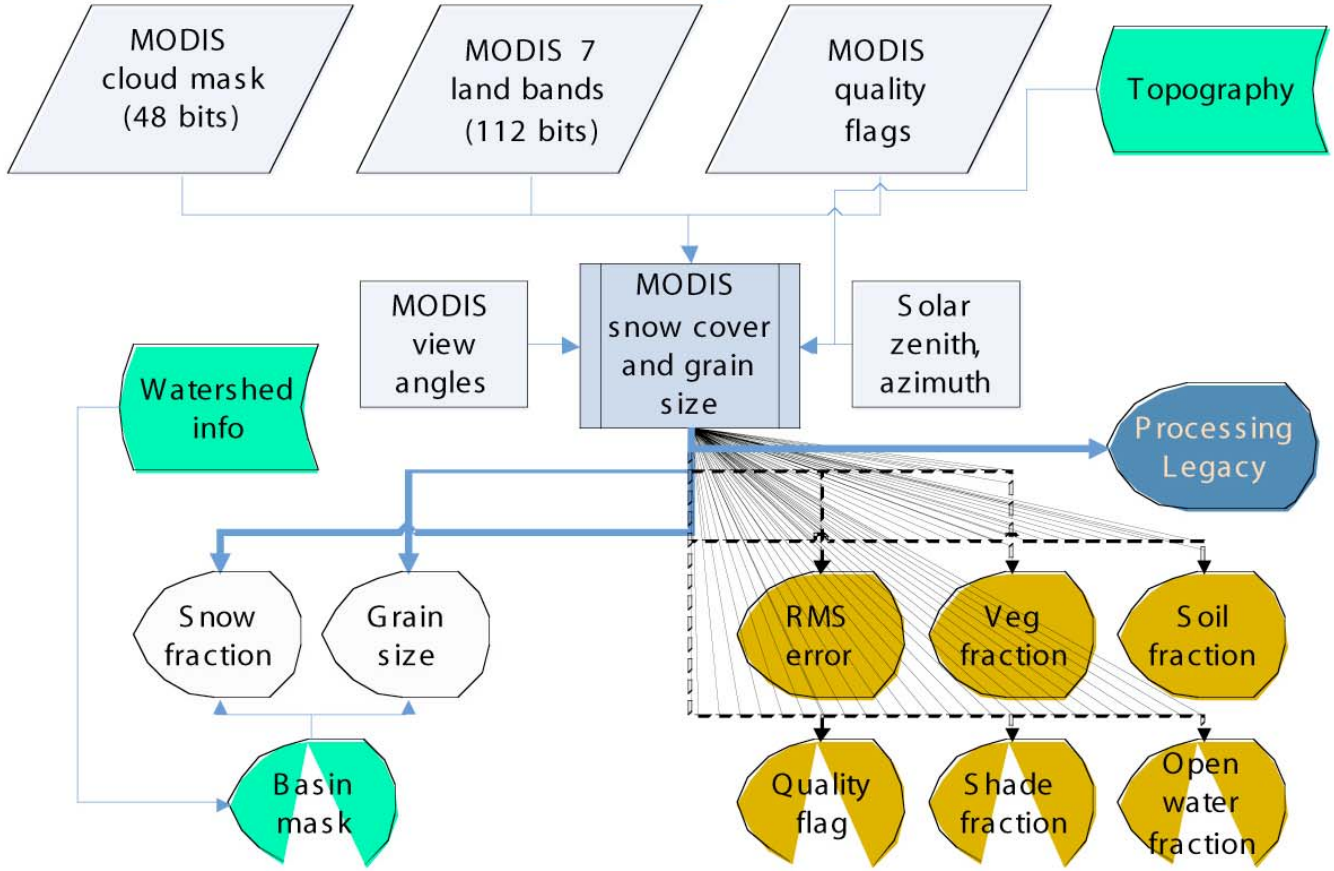
MODSCAG →

$62 \pm 5\%$ SCA

$\alpha_{snow} = 0.8 \pm 0.05$

(specific to snow because it is a fractional albedo)

Model structure for MODIS snow-covered area and grain size



Next-generation DEMs: Image-enhanced

After DEM Enhancement with 11 images

Photoclinometry: Elevation maps of Greenland from images

Using multiple AVHRR images with different

The Photofunction Eqn.,
for Lambertian surfaces:

Advantages of photoclinometry:

- improved spatial resolution -
  - DEMs and slope maps at the scale of pixels, rather than active-sensor spots
  - Full representation of the dynamically-generated topography
- extending sparse elevation data to a full grid
- improved local accuracy of elevation

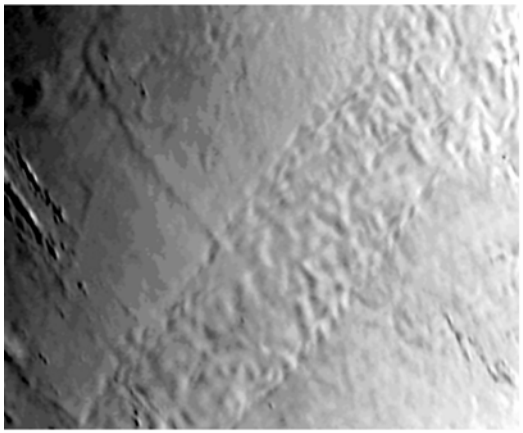
Challenges of photoclinometry:

- clouds
- image noise
- surface albedo variations

Multiple MODIS Images and Satellite Radar Altimetry

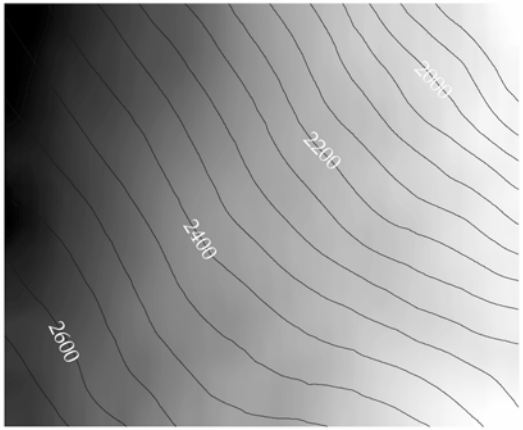
AVHRR (one of ~8)

a.



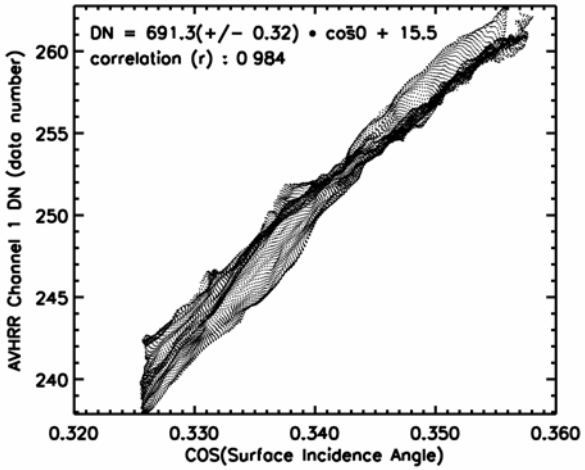
Smoothed Image and DEM-based contours

b.



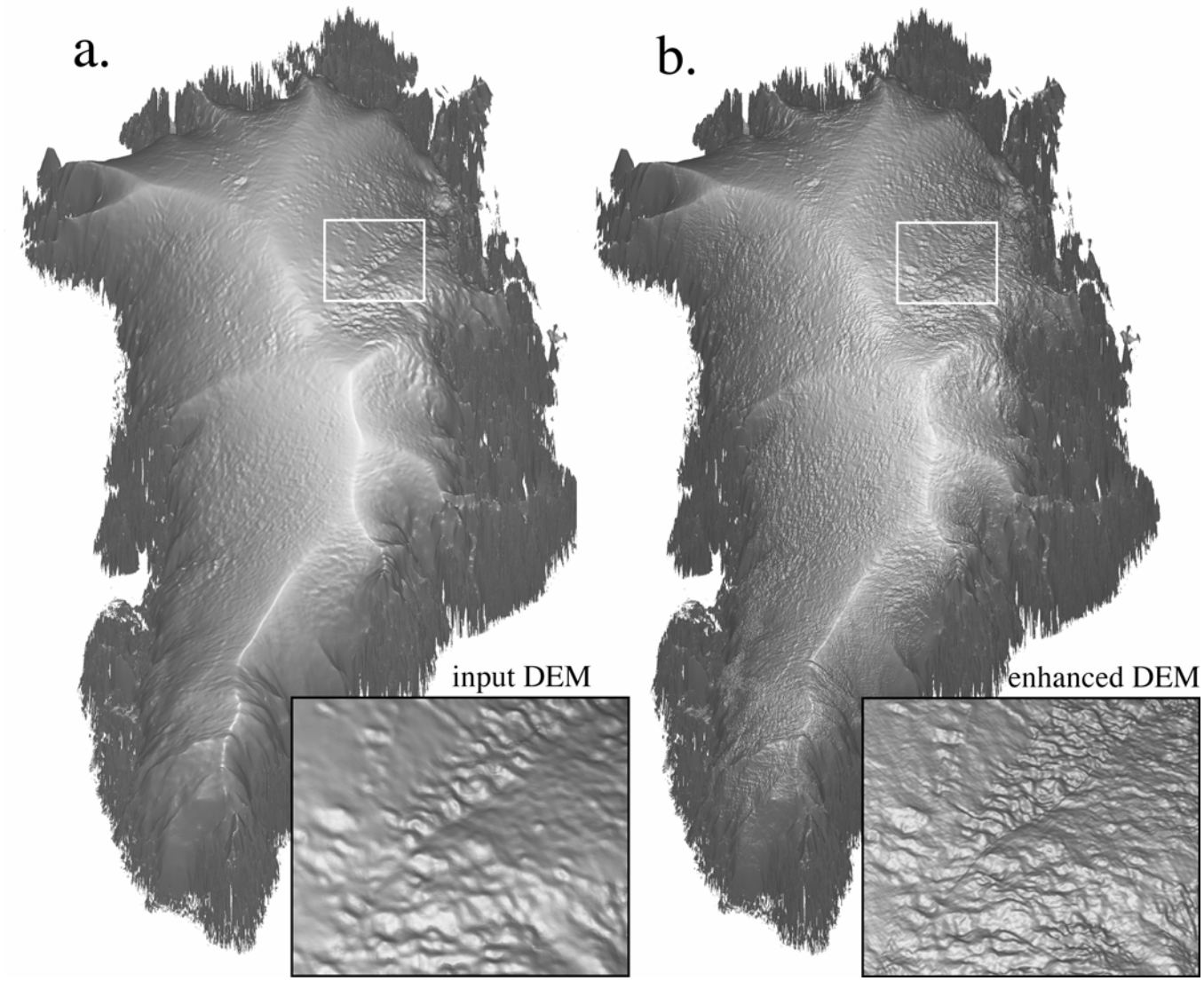
Smoothed Image DNs versus DEM-derived slopes

c.

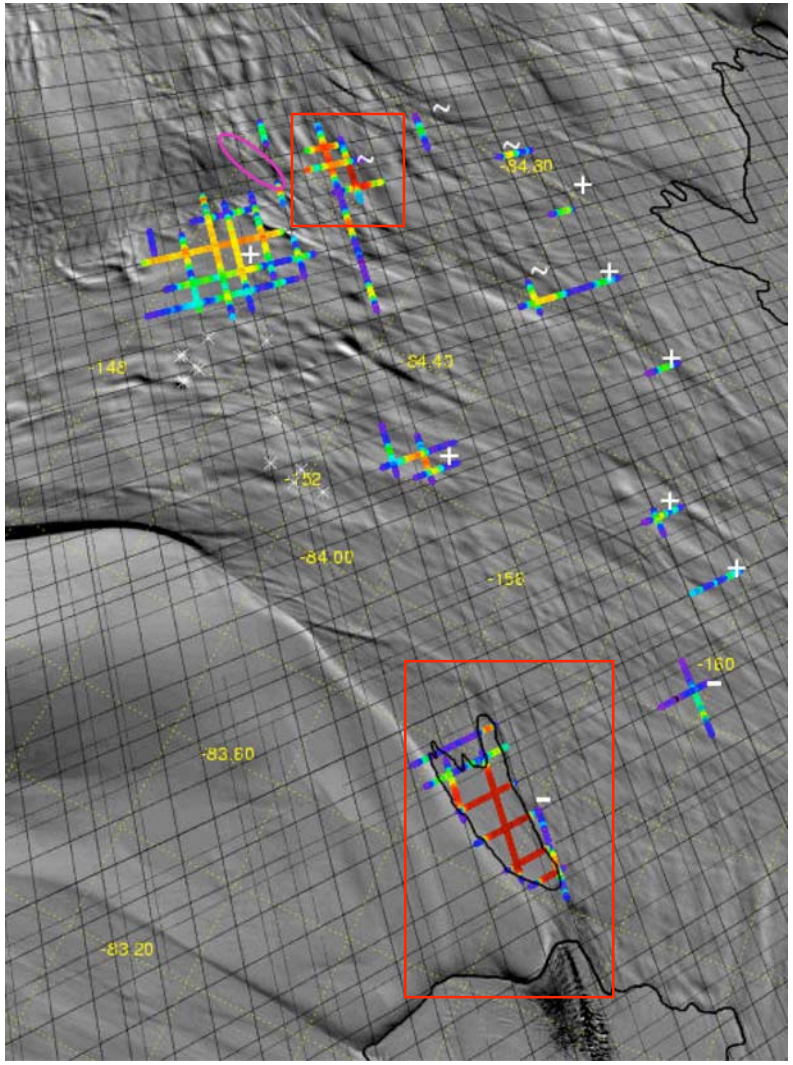


We establish the pixel brightness - to - slope relationship using filtered images and filtered DEM data - then apply the derived equation to the full-resolution image data. Several images (with several sun directions) are merged.

Input Radar Altimetry DEM and Image-enhanced DEM comparison

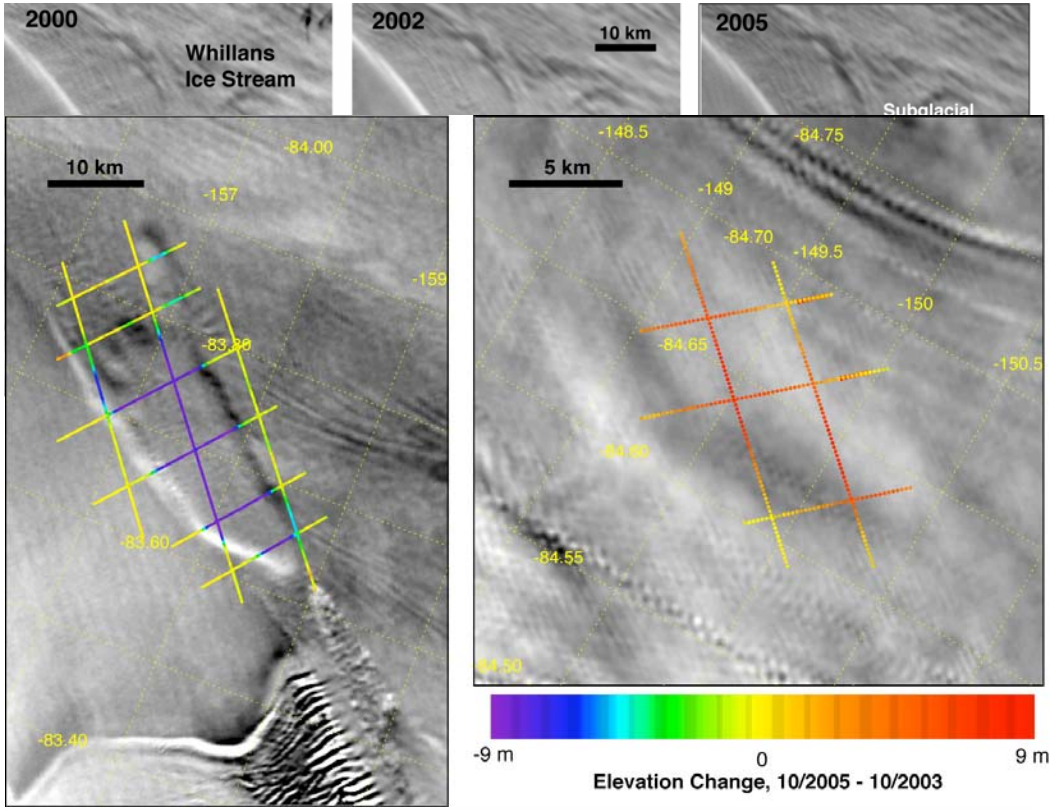


MODIS Image Differencing for Detection of Vertical Elevation Change



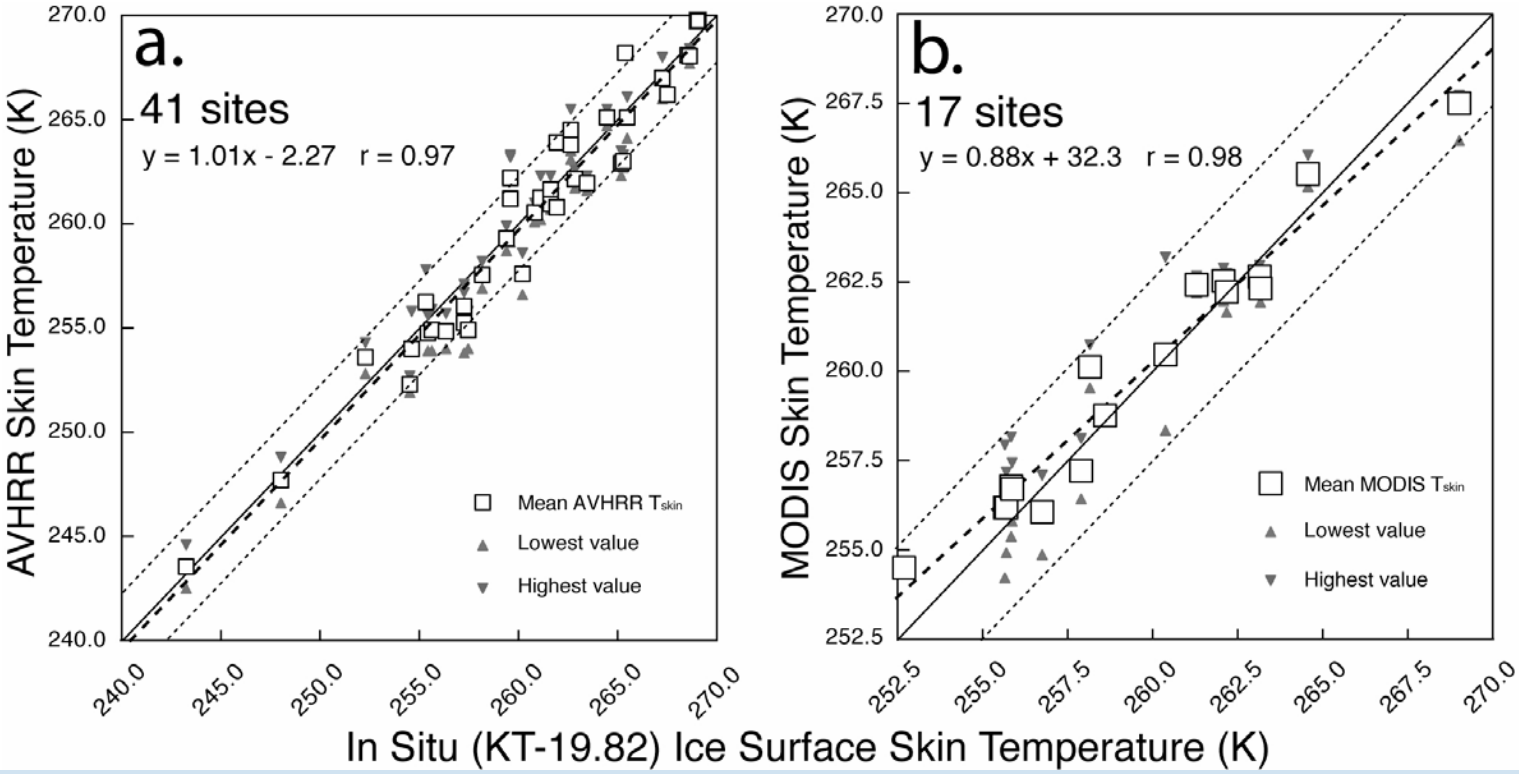
The “Lake District” of the Ross Embayment Ice Streams

Image subtraction under near-identical lighting conditions



Thermal Skin Temperature Cal-Val for AVHRR and MODIS

In-situ skin temperature measurement over Sea ice (from ship's rail and helicopter) to Validate both Pathfinder AVHRR and MODIS Ice Surface Temperature algorithms



Thank you

Work supported by NASA and NSF grants