

MODIS Global Snow and Sea Ice Cover Maps, and Validation Status

Dorothy K. Hall¹

George A. Riggs²

Vincent V. Salomonson¹

¹NASA/Goddard Space Flight Center

²SSAI

December 18, 2001



Other team members and recent collaborators:

- Igor Appel
- Jon Barton
- Klaus Bayr
- Carl Benson
- Kimberly Casey
- Al Chang
- Janet Chien
- Nick DiGiromalo
- Jim Foster
- Richard Kelly
- Andrew Klein
- Shusun Li
- Glen Liston
- Anne Nolin
- Hugh Powell
- J.C. Shi

Outline

- **Product availability**
- **Improving the snow algorithm using thermal mask and various cloud-mask tests**
- **Direct-readout snow maps**
- **Validation status of products**
- **Outreach**

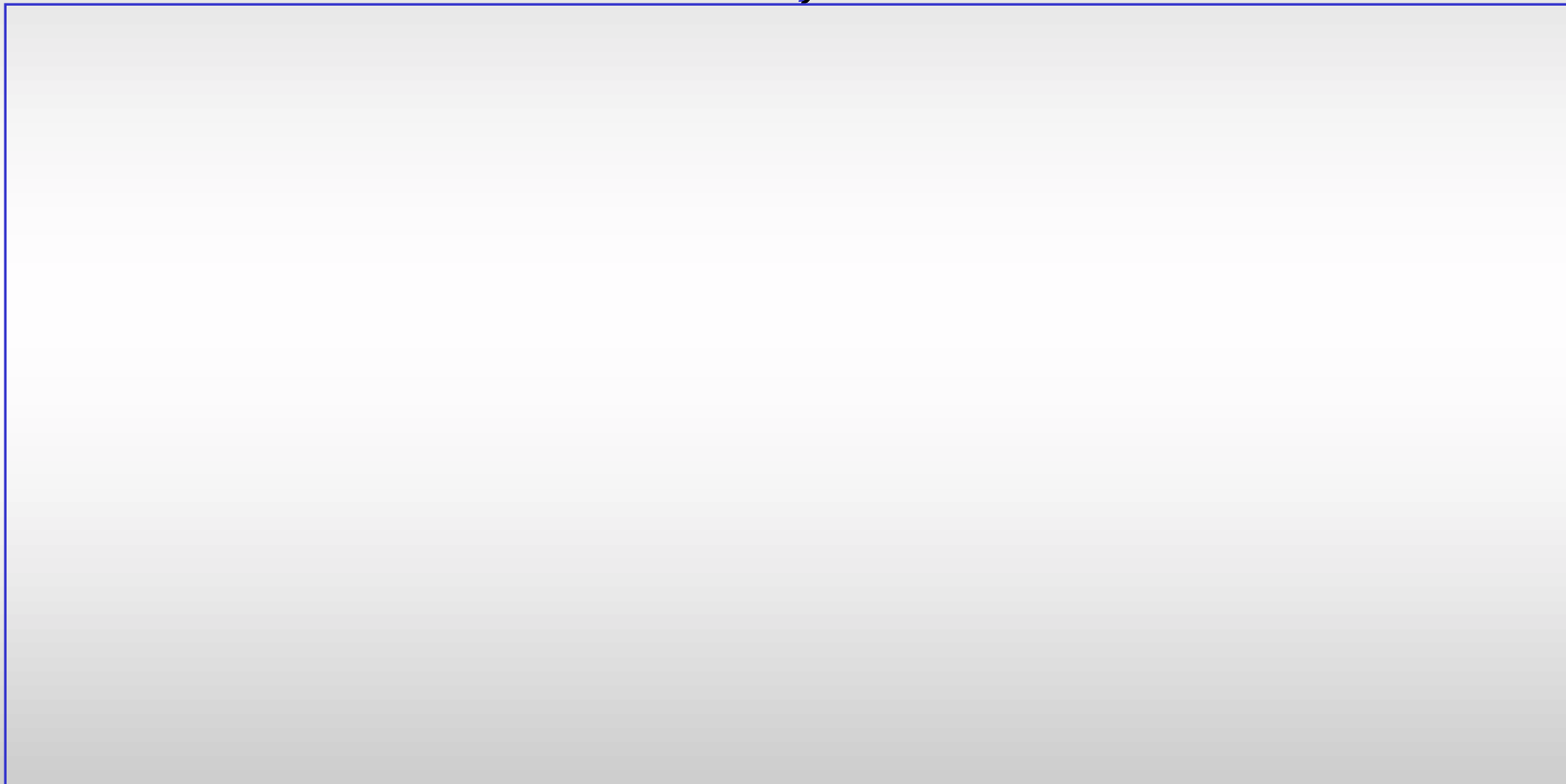
MODIS Snow Data Products (available through NSIDC)

- **Global, daily and 8-day composite 500-m resolution snow maps**
- **Global 8-day composite Climate-Modeling Grid (CMG) products at 5-km resolution in production**
- **Global daily CMG will be available soon**
- **Snow albedo (spring 2002)**
- **Level 2 and Level 3 sea ice products available (includes IST)**

***Eight-Day Composite Global Climate Modeling Grid Snow
Map (5.6-km resolution, 1/20°)***

***With Fractional Snow Cover 40-100%
16 - 23, 2000***

November



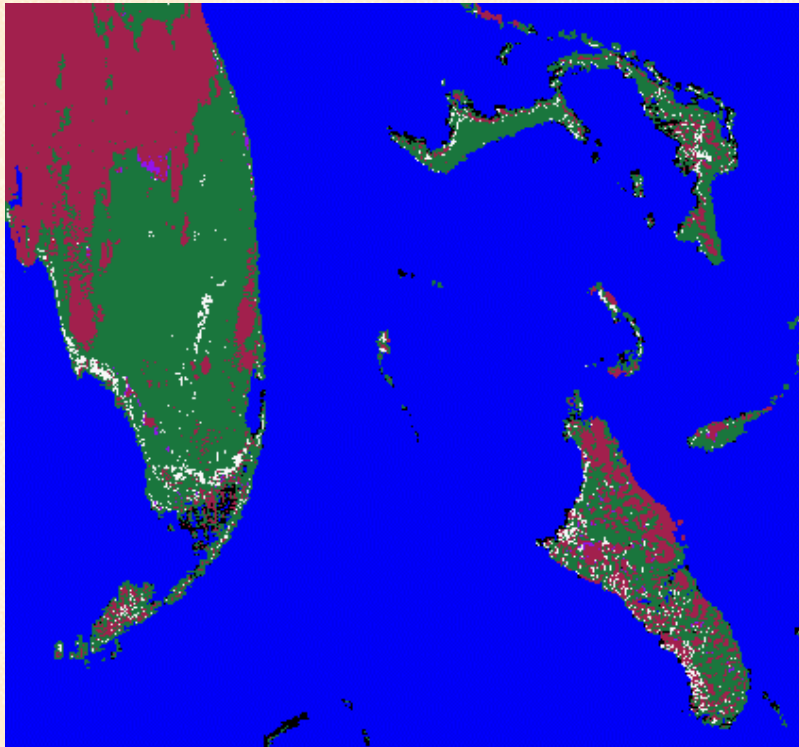
Can be downloaded from: http://snowmelt.gsfc.nasa.gov/MODIS_Snow/modis.html

Algorithm Enhancements

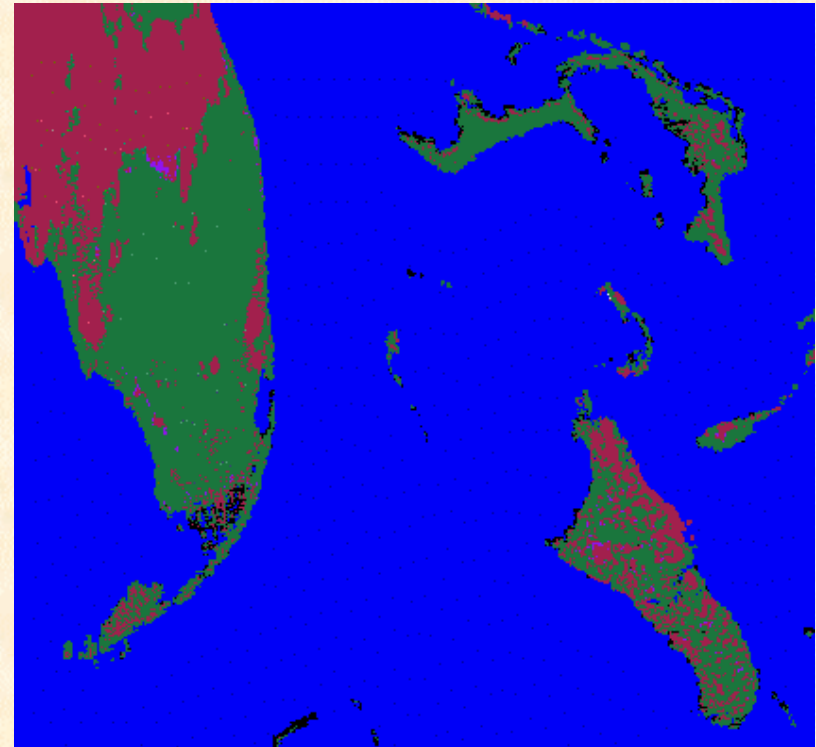
- **Thermal mask - done**
- **Cloud tests – in progress**

14 November 2000 16:00 MODIS L2 Snow Product
Detail of Southern Florida and the Bahamas

Before Thermal Mask

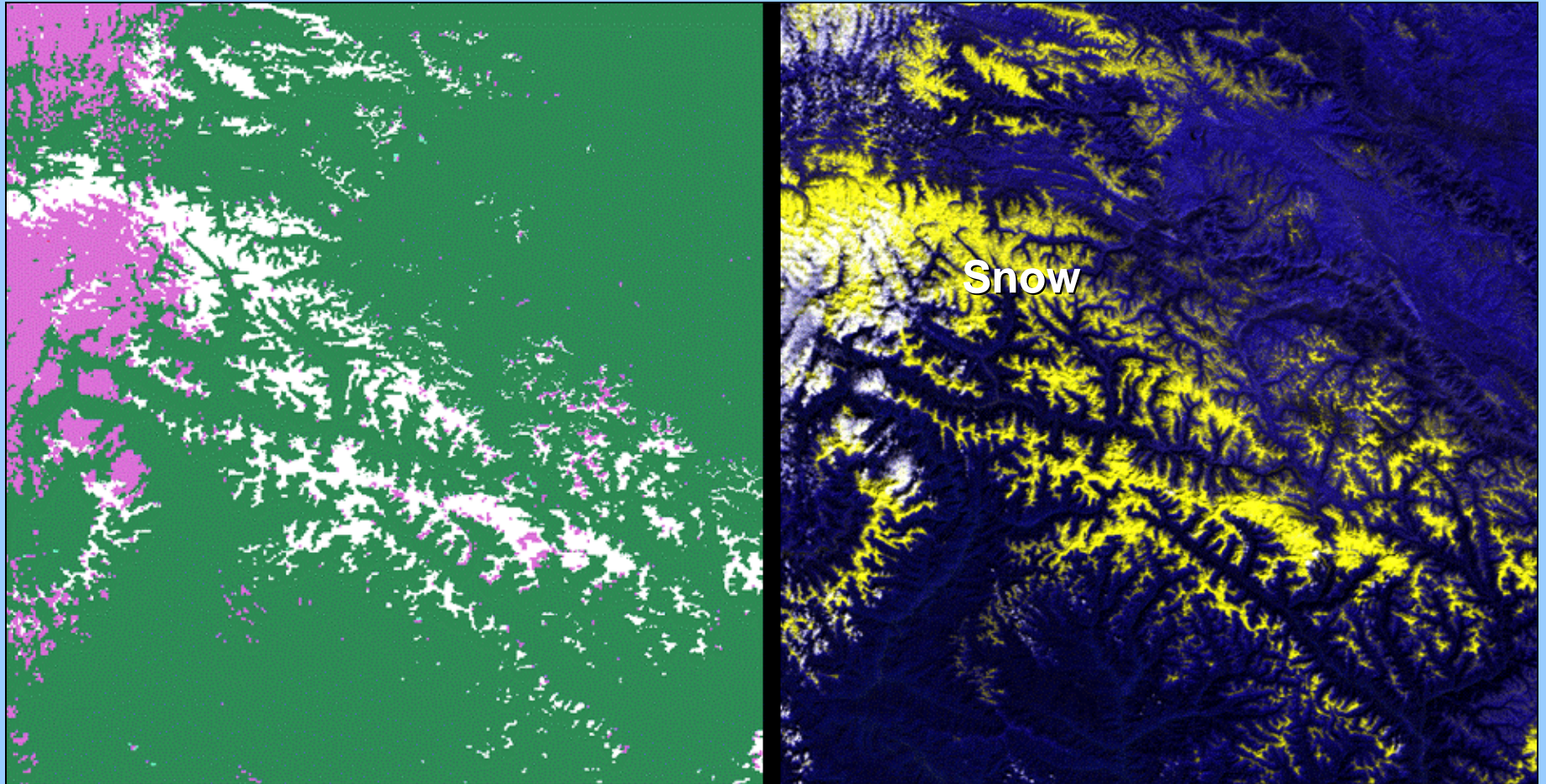


After Thermal Mask



Errors of commission are now very low, e.g., $<0.05\%$ in non-snow-covered areas such as Australia in the summer

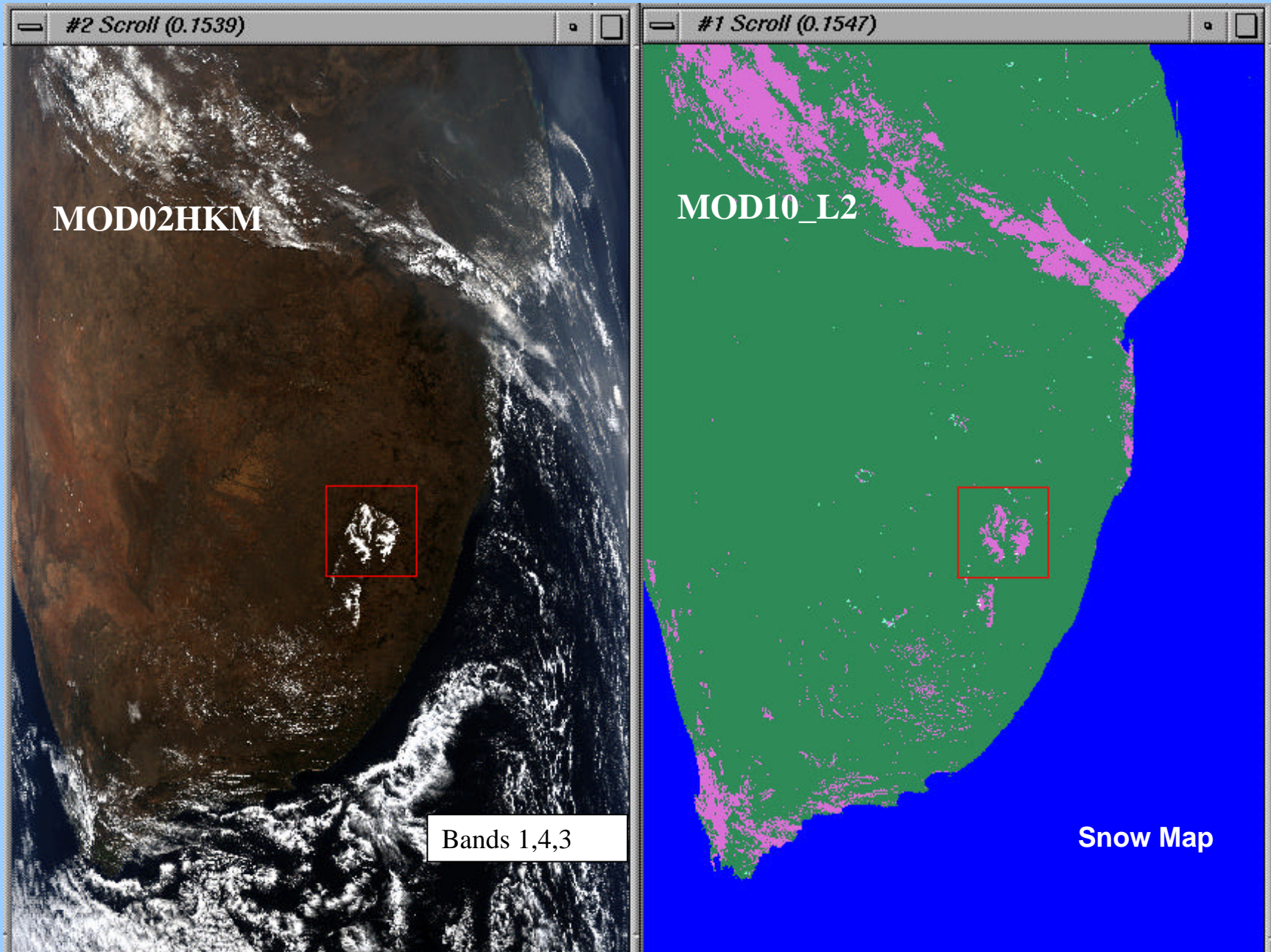
Eastern Himalayas, October 23, 2001



MOD10_L2

MOD02HKM (bands 1,4,6)

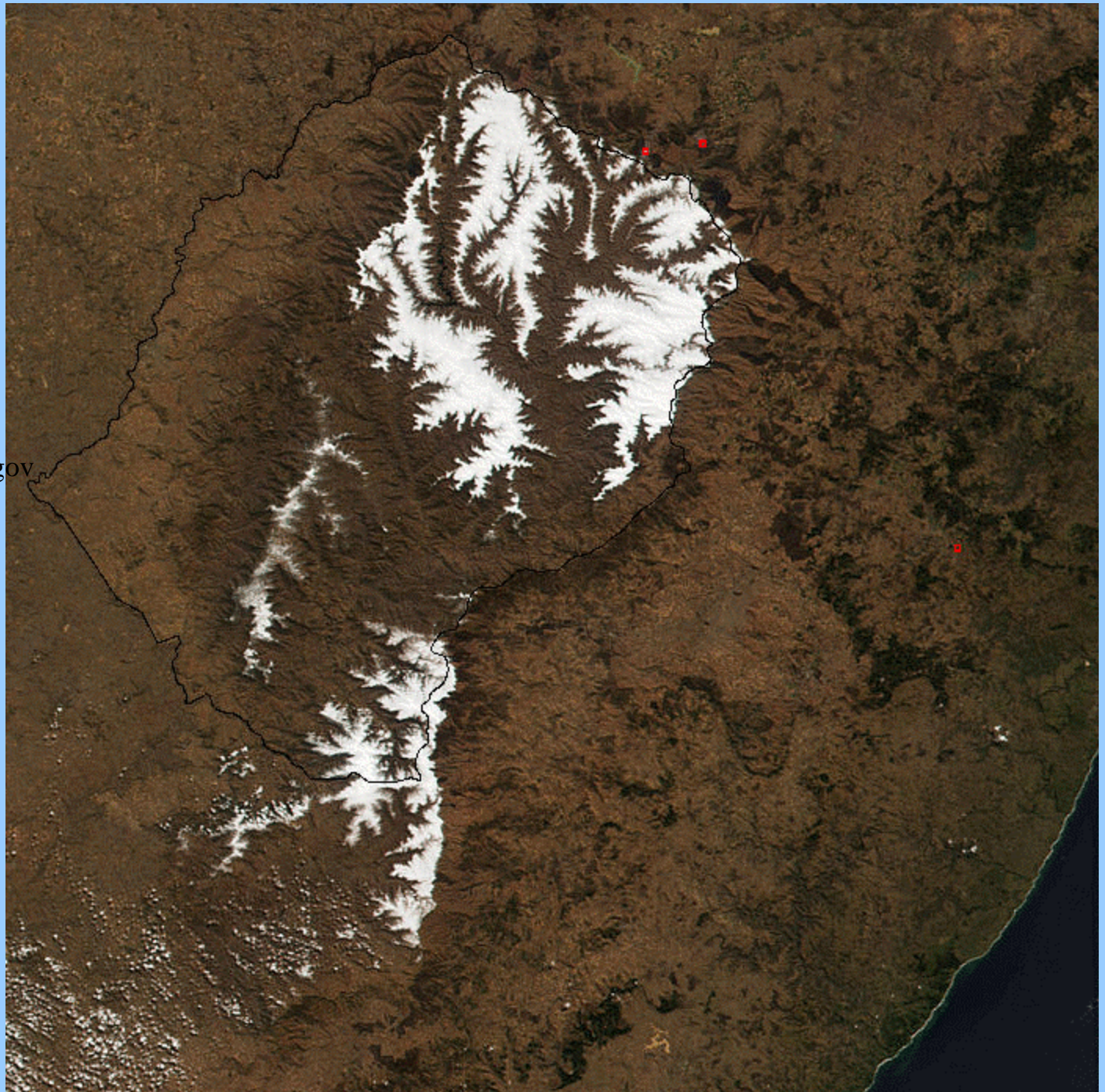
Lesotho (southern Africa) September 1, 2001



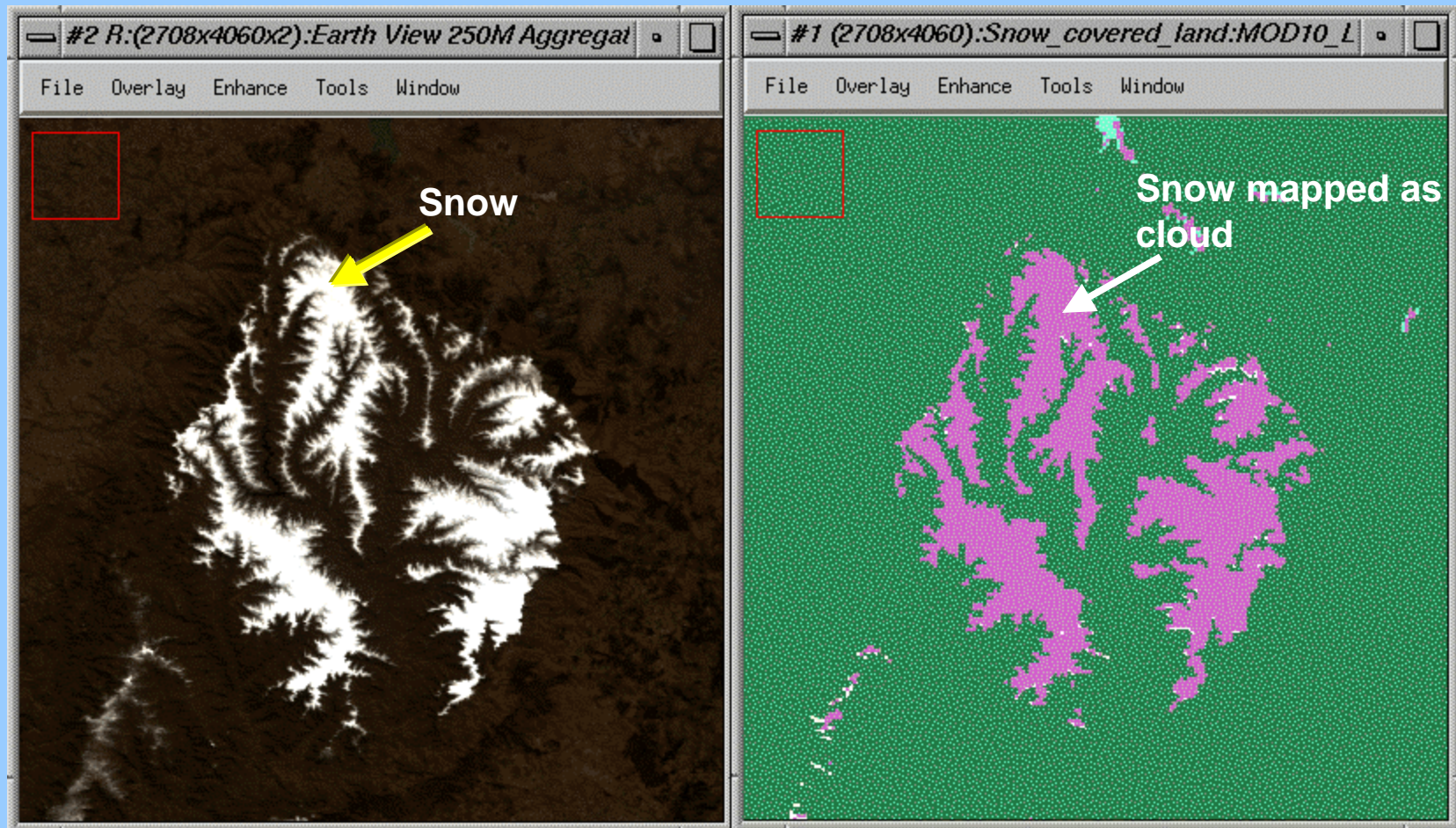
Snow in Lesotho

Sept 01, 2001
08:25 UTC

Image courtesy of
<http://rapidfire.sci.gsfc.nasa.gov>

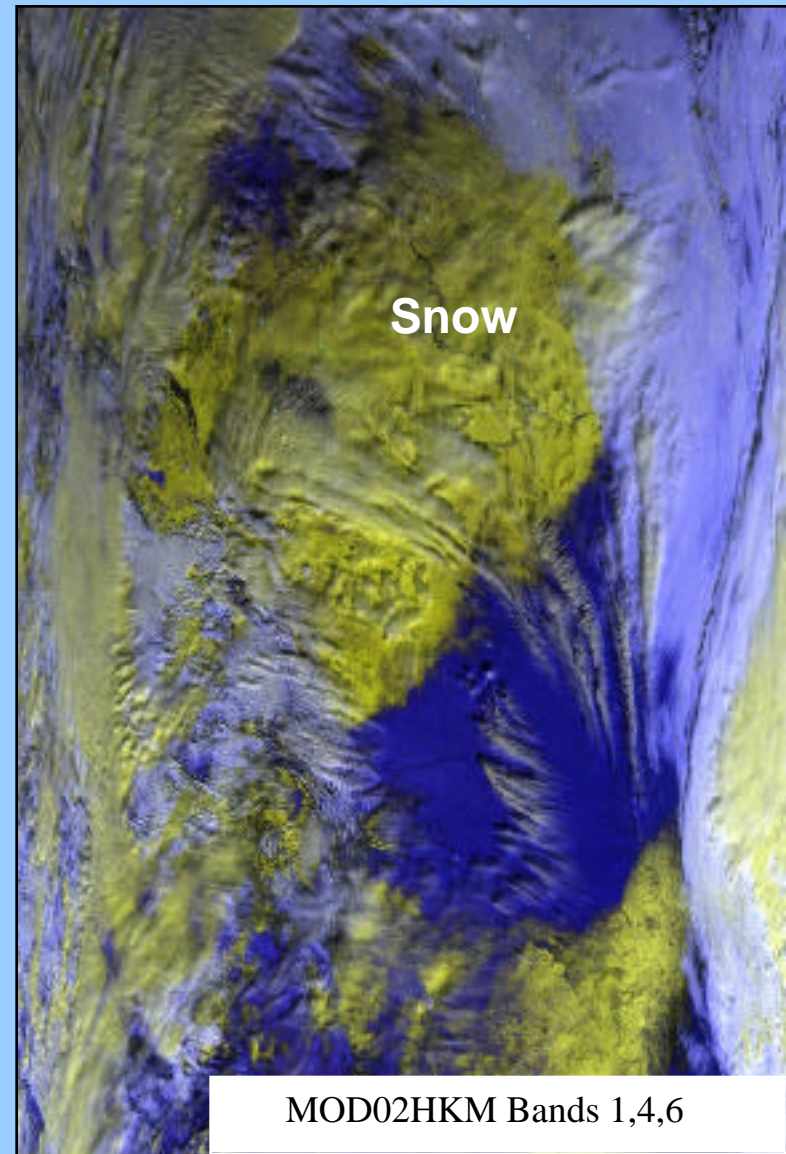
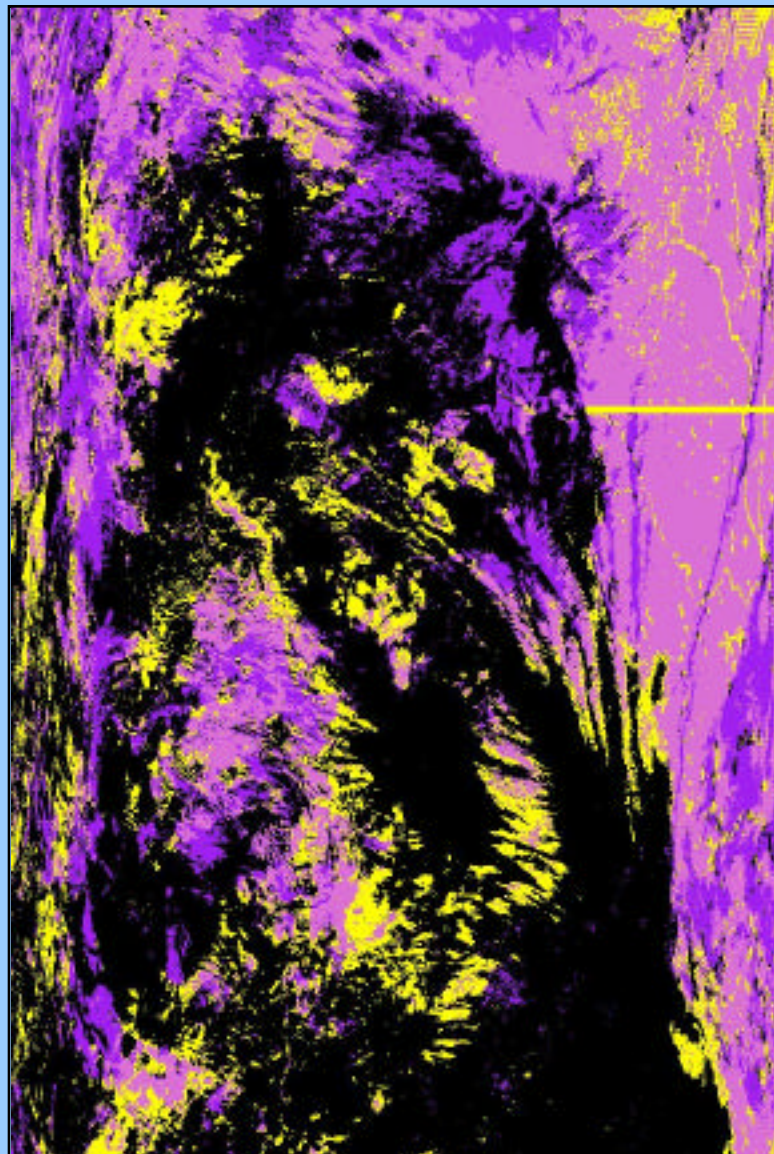


Zoom showing natural-color image on left and MODIS snow map on right



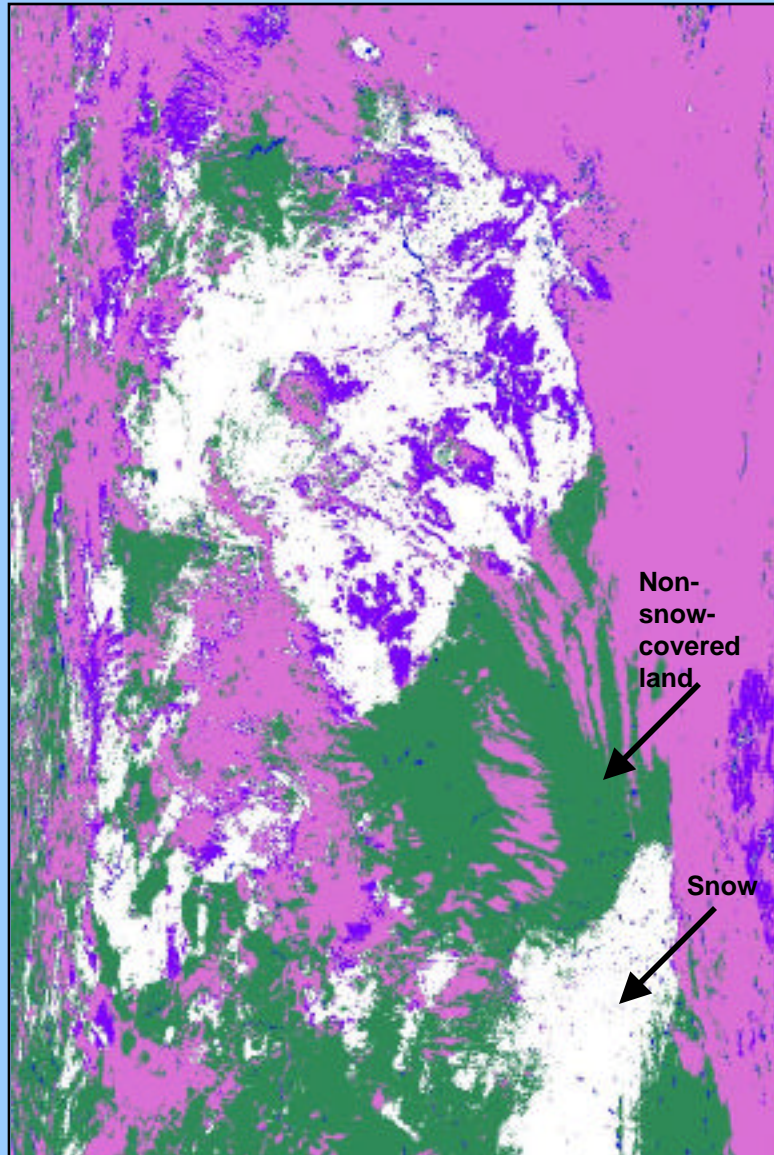
Snow in the central U.S. and southern Canada – November 27-28, 2001

Left - MOD35_L2 cloud spectral tests of bit19 (pink) [BT11 - BT3.7] and bit21 (purple) [R0.87/R0.66], cloud in both (yellow). Black is snow or non-snow-covered land. Right – MODIS false-color image.



MOD02HKM Bands 1,4,6

SNOW MAPPING IS IMPROVED BY SELECTIVE USE OF MOD35_L2 DATA



Snow algorithm with cloud mask composed of MOD35_L2 bits 19 (pink) and 21 (light purple).

Pixels changed from snow in cloudless run to cloud in this run are shown in dark purple. 25% of snow pixels were changed (correctly) to cloud.

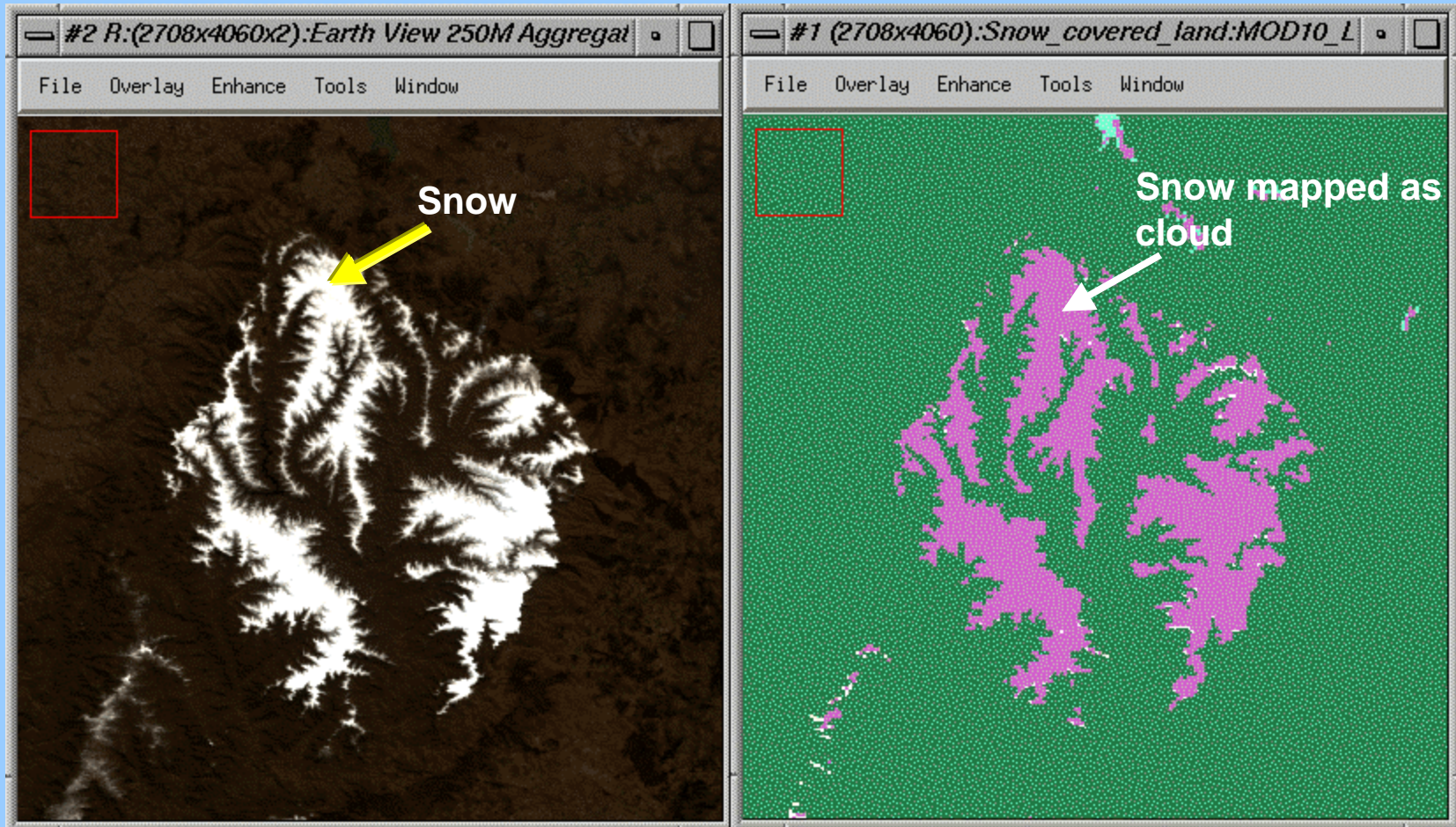
Compared to MOD10_L2 this snow map has:

- 45% more snow cover

- 35% less cloud obscuration

Very small error of false snow on clouds remains.

Zoom showing natural-color image on left and MODIS snow map on right



Cloud spectral test (bit 21) is causing snow to be mapped as cloud (right).

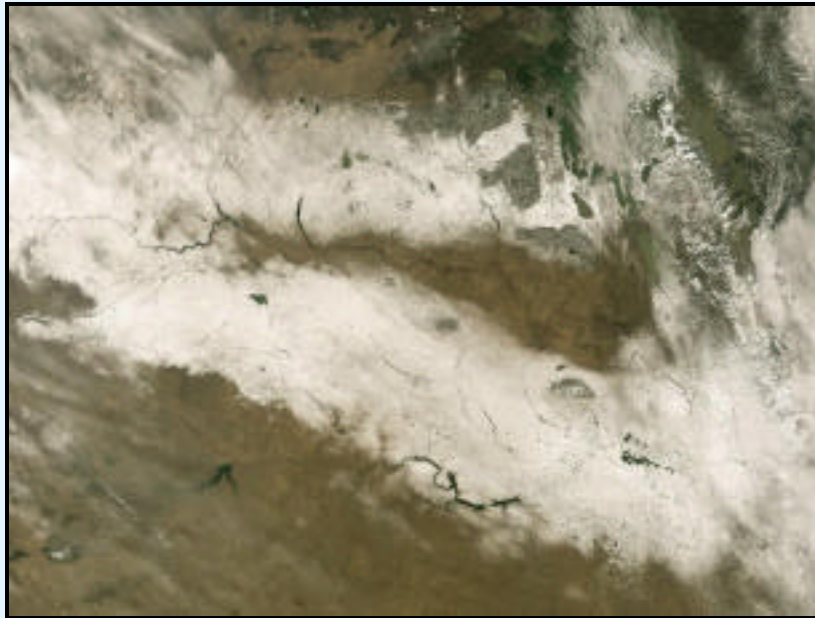


Direct Readout

**Space Science and Engineering Center,
(SSEC) University of Wisconsin-Madison**

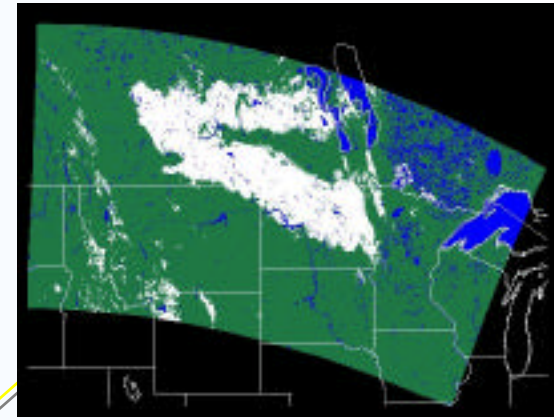
NOAA/NESDIS - “Rapid Response”

MODIS 250-m resolution image (below) and 500-m resolution snow map (right) derived from MODIS direct-readout data showing result of major snowstorm in southern Canada and North Dakota that occurred on October 24, 2001



**University of Wisconsin - Madison Space Science
and Engineering Center
October 26, 2001**

Snow map

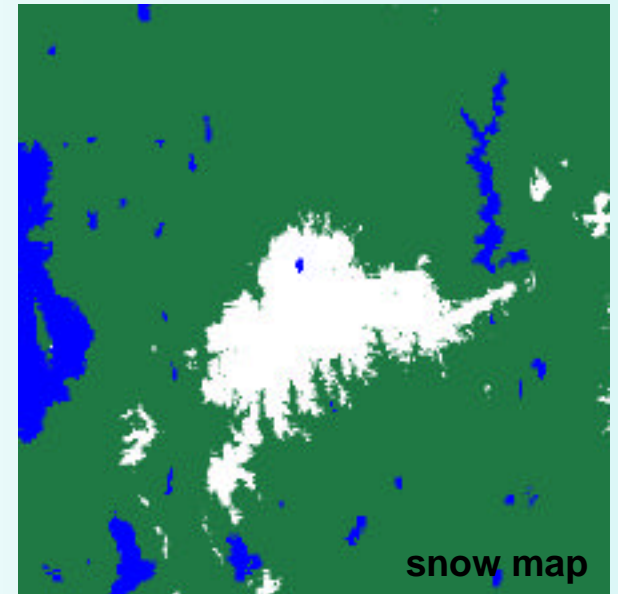
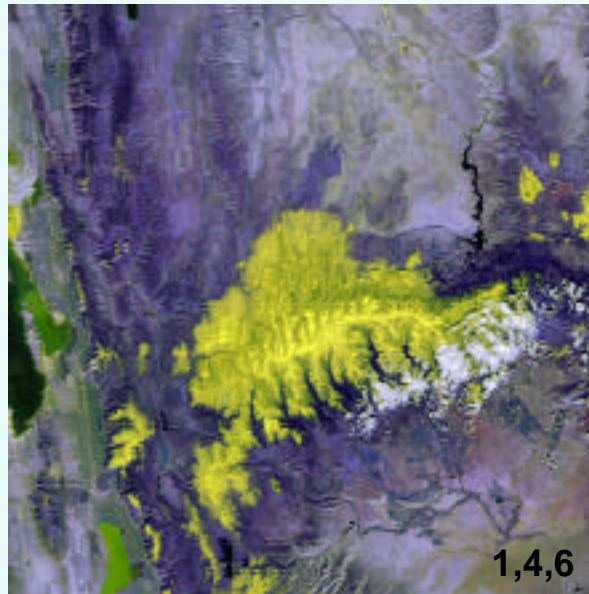
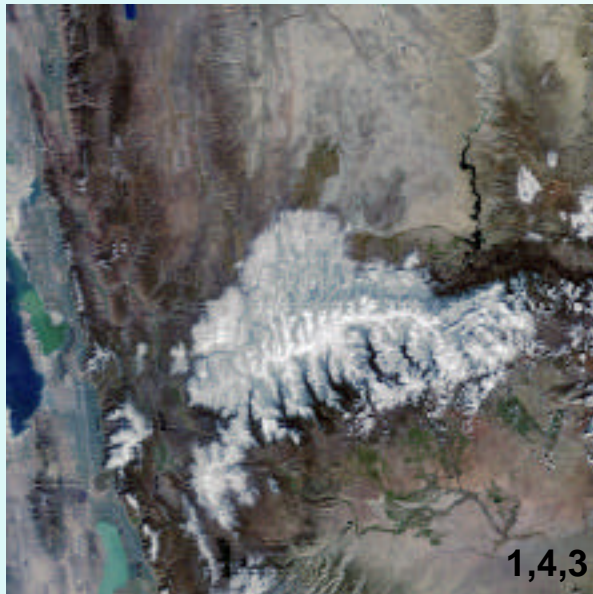


Grand Forks, ND



Uinta Mountains (northeastern Utah)

October 10, 2001



Sub images from the SSEC direct broadcast station

Ad-Hoc Advisory Committee on the MODIS Snow and Ice Products

October 31, 2001

Committee Members:

- **Don Cline/NOHRSC**
- **Jeff Key/NOAA – University of Wisconsin**
- **Bruce Ramsay/NOAA**
- **Dave Robinson/Rutgers University, CHAIR**
- **Greg Scharfen/NSIDC**
- **Marc Stieglitz/Columbia University**

Ad-Hoc Advisory Committee on the MODIS Snow and Ice Products

October 31, 2001

Some recommendations:

- **Complete evaluation of snow products so that they can be considered to be validated**
- **Validate sea ice products**
- **Work with cloud mask tests to identify optimum tests for use with the snow and sea ice maps**
- **Provide daily CMG snow maps at ~5-km resolution**
- **Provide a fractional snow-cover algorithm for the 500-m resolution snow products**
- **Release snow albedo product for beta testing**
- **Integrate passive-MW and MODIS algorithms in the Aqua era to improve snow mapping in cloudy areas**

In-House Validation Activities

Snow

North America - 2000-01 winter time series

MODIS snow maps compare well, but show more snow cover than do the NOAA operational snow maps (maximum snow cover)

Comparisons with Landsat ETM+ data indicate that we are mapping snow cover that other maps often miss because of the more frequent coverage of the MODIS sensor

Sea Ice

IST results are reasonable (Li and Key) but serious cloud mask issues over sea ice remain (Key)

2001-02 winter

Validation efforts will concentrate on CMG product in N.A. and Europe (Scandinavia with J.-G. Winther and R. Solberg)

Sea ice maps will be compared with NOAA maps and Landsat images

Snow-covered area in millions km² for each 8-day composite snow-cover map, exclusive of cloud cover from MODIS and NOHRSC maps. Numbers in red refer to the 8-day periods**

	1	2	3	4	5	6	7	8
MODIS	0.24	0.92	2.13	2.32	1.56	1.79	1.98	2.99
NOHRSC	0.04	0.53	1.76	1.98	1.38	1.57	1.99	2.78
Difference (MODIS-NOHRSC)	0.20	0.39	0.37	0.34	0.18	0.22	(0.01)	0.21

*Period 1: October 23-30, 2000; period 2: October 31-November 7, 2000; period 3: November 8-15, 2000; period 4: November 16-23, 2000; period 5: November 24-December 1, 2000; period 6: December 2-9, 2000; period 7: December 10-17, 2000; and period 8: December 18-25, 2000.

+Exact numbers would change slightly if watershed boundaries were removed from the NOHRSC maps.

When will the snow and ice products be validated?

Snow maps - May 2002 – two papers on this topic will be completed before summer: ESC and PIERS; ESC paper will show errors in different vegetation types in N.A. and Scandinavia

Sea ice maps – July 2002

A photograph of a snowy forest. The ground is covered in a thick layer of snow, and the trees are dark against the white background. The sun is shining, creating shadows on the snow.

Education and Outreach

- Snow video entitled, “Observations of Global Snow Cover from the Ground and Space”
- New educational Web site based on the snow video
- Ten Web-based activities that focus on EOS data
- Numerous presentations to students and teachers
- Posters