Two New Snow Products: NASA MEaSUREs and MODIS Collection-6 Snow Cover

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New Products

- NASA MEaSUREs Terrestrial Snow 25km EASE-Grid 2.0 merged product

- Collection-6 standard MODIS snow-cover product

Climate Data Record Attributes

- Length
- Consistency
- Continuity
- Documentation

Northern Hemisphere Snow and Ice Earth System Data Records

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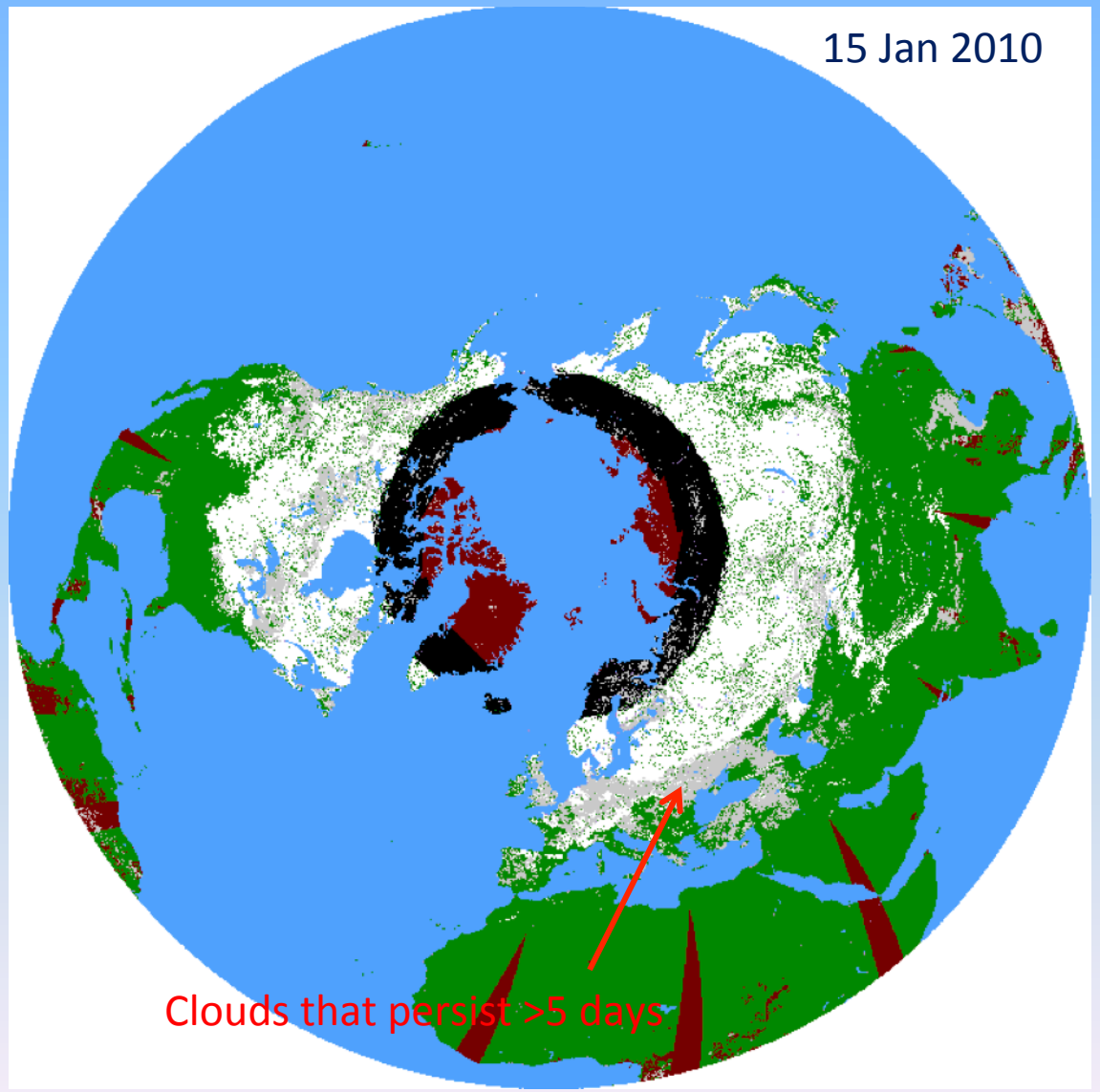
MEaSUREs Project Goals for Northern Hemisphere Snow Cover

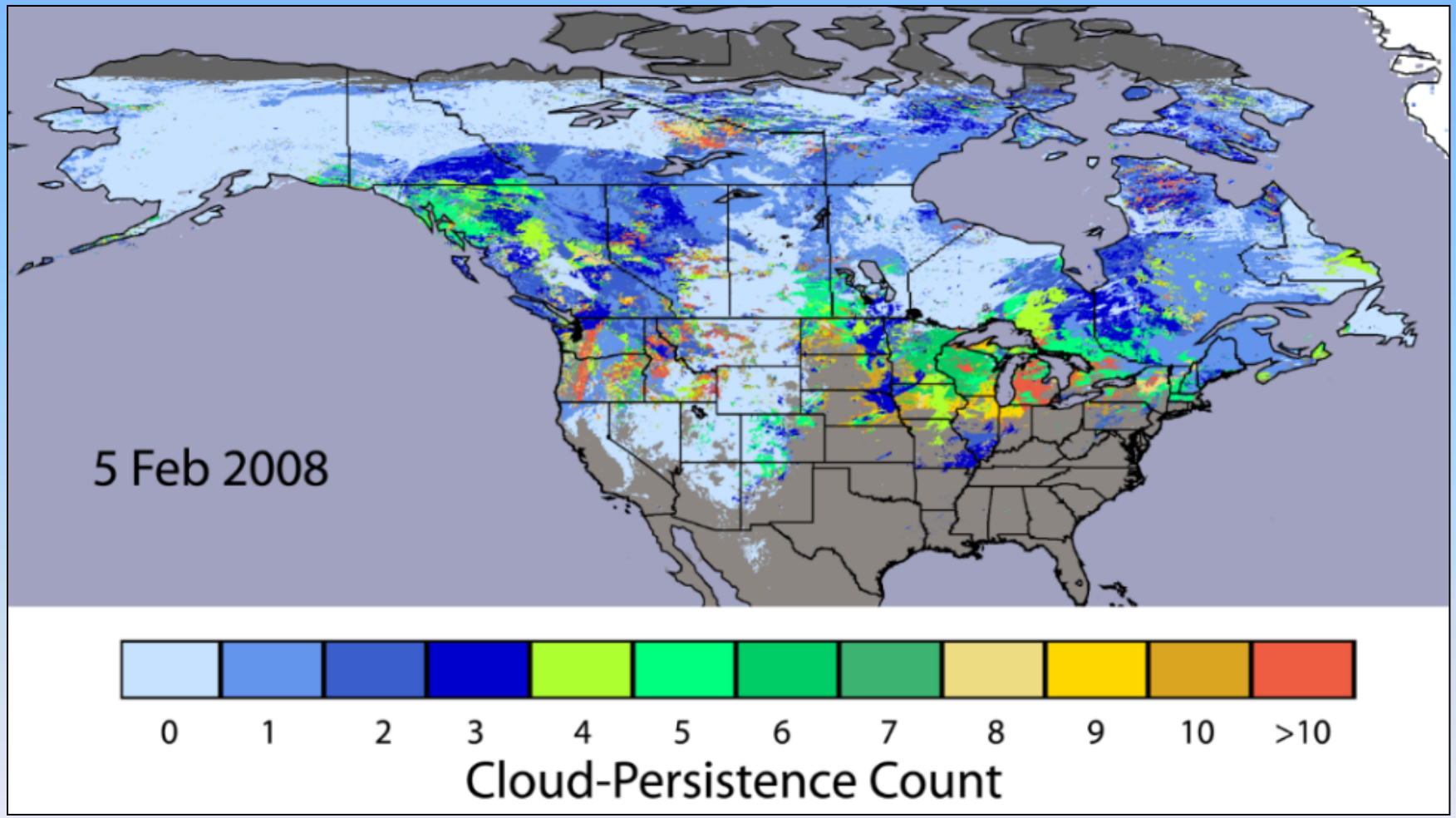
- Fuse existing data records to develop enhanced Earth System Data Records (ESDRs) of NH snow conditions
  - MODIS Collection 5 cloud-gap filled (CGF) daily fractional snow-cover maps;
  - NOAA IMS daily snow-cover maps;
  - Passive microwave (SSM/I) daily snow-cover maps.
- Make the ESDRs and associated products available to the user community via the NASA Distributed Active Archive Center (DAAC) at NSIDC;
  - 1999 – 2012, daily 25-km resolution & weekly 100-km resolution
  - netCDF file format.

MODIS Cloud-Gap-Filled (CGF) Fractional Snow-Cover Map

- Gridded to EASE-Grid 2.0, 25-km resolution



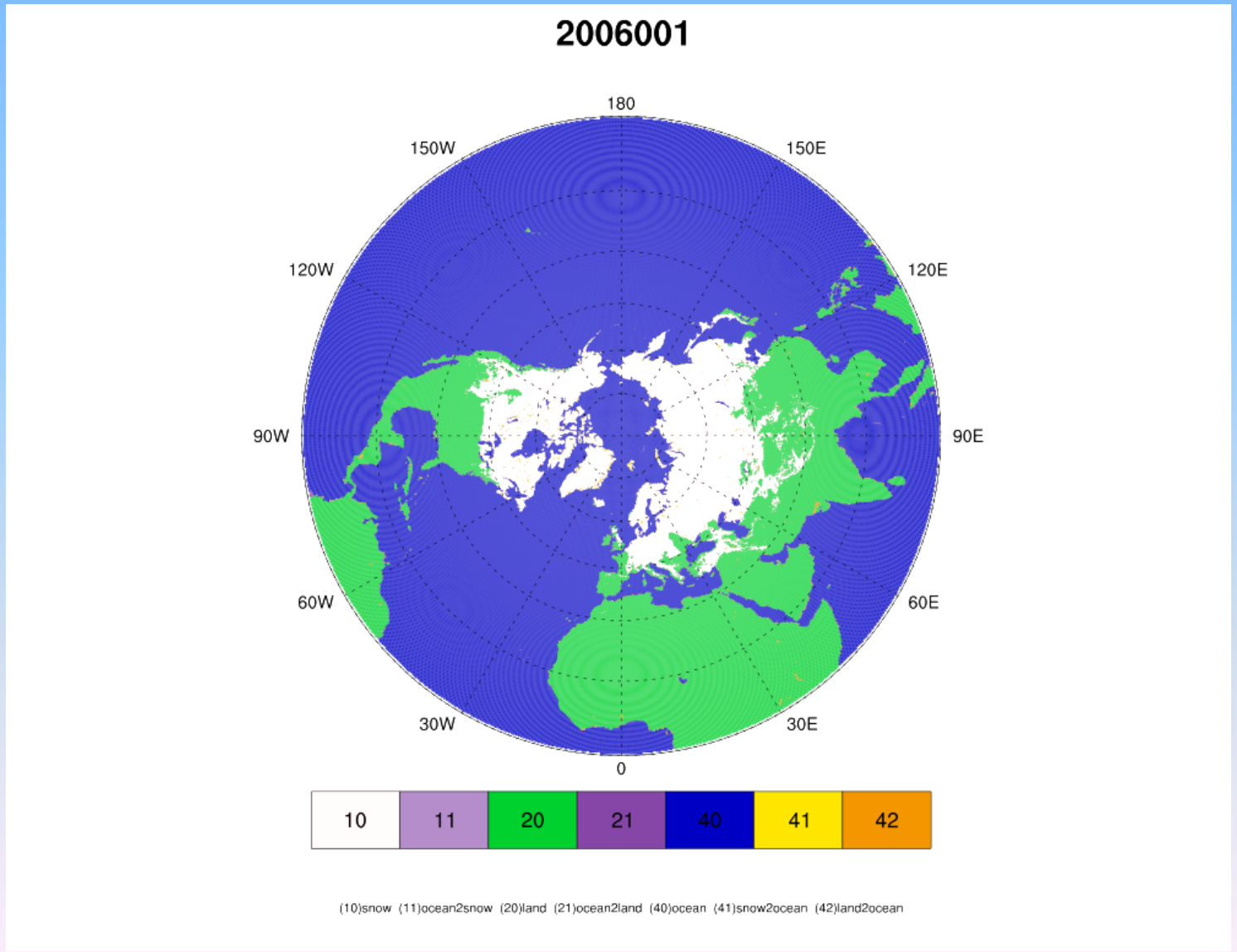
500 m cloud-gap-filled (CGF) daily snow cover



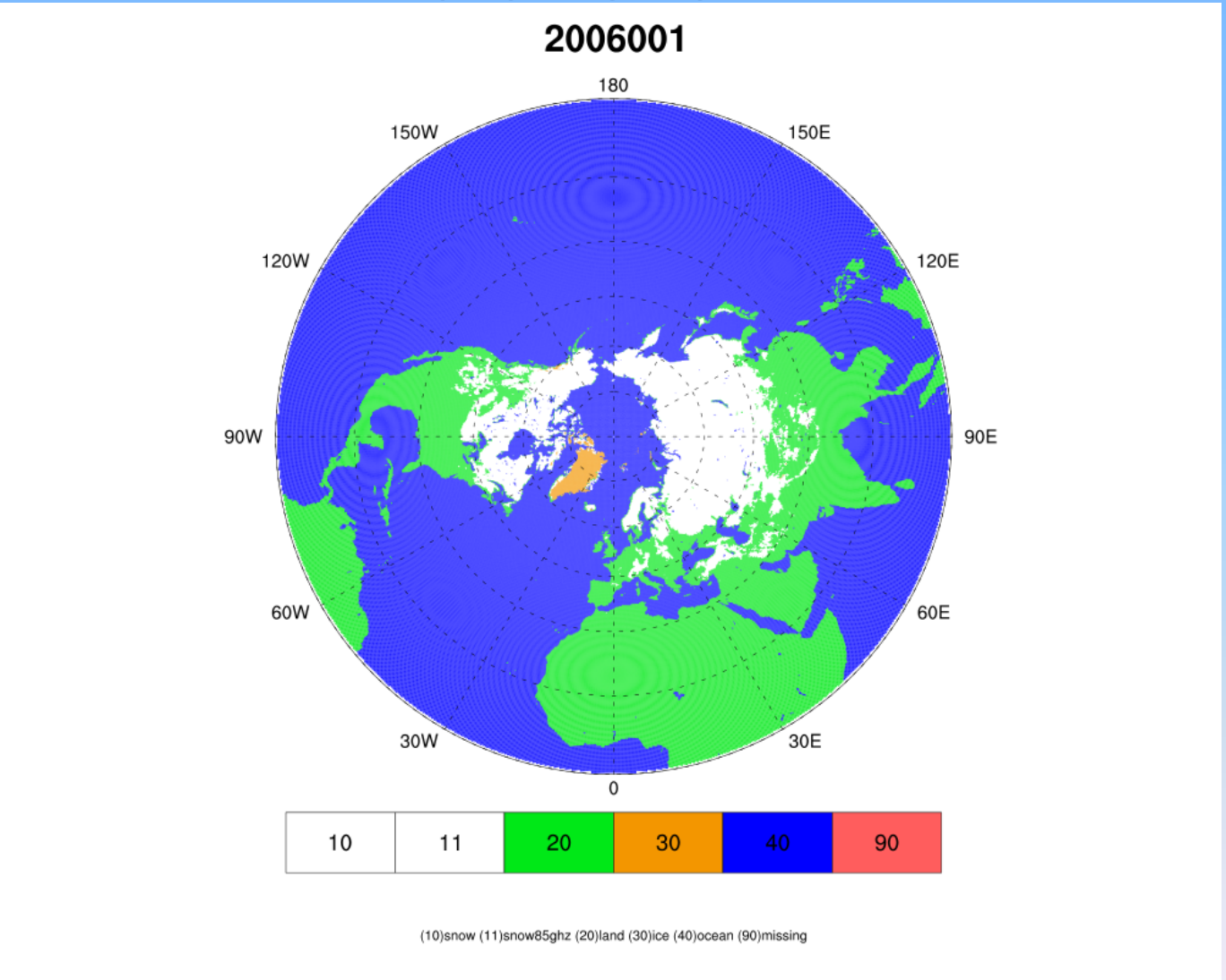
Cloud-gap filled (CGF) cloud-persistence count (CPC) snow-cover map. The CPC informs the user how "old" the snow decision is, in each pixel or cell.

Hall et al., 2010

NOAA Daily 25km EASE-Grid 2.0 IMS snow extent

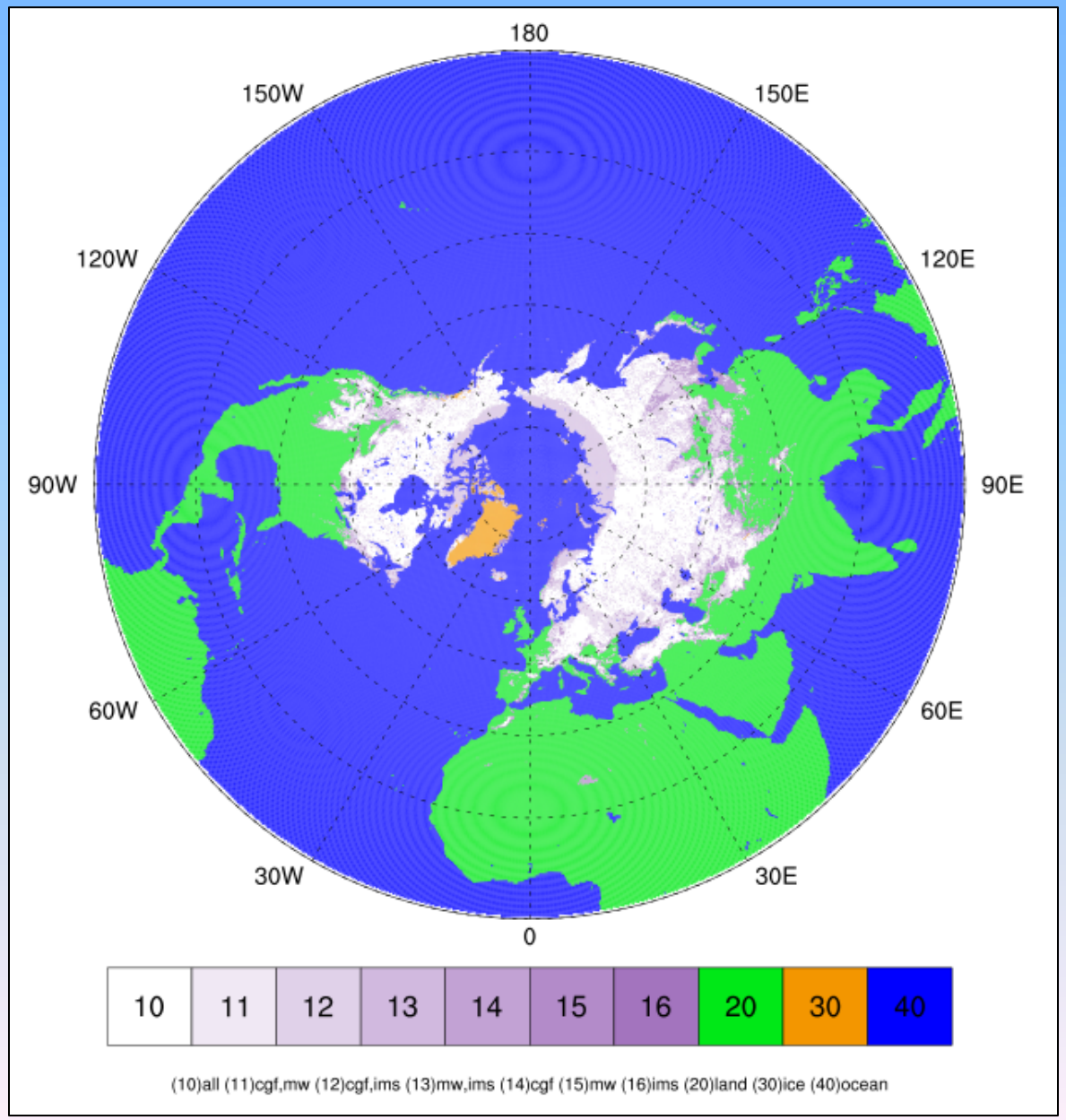


SSM/I Daily 25km EASE-Grid 2.0 Passive Microwave snow extent



1 January 2006

Terrestrial Snow 25km EASE-Grid 2.0 merged product, 1 February 2006



Sources:

1) Interactive Multisensor Snow and Ice Mapping System (IMS)

2) MODIS Cloud Gap Filled imagery (CGF)

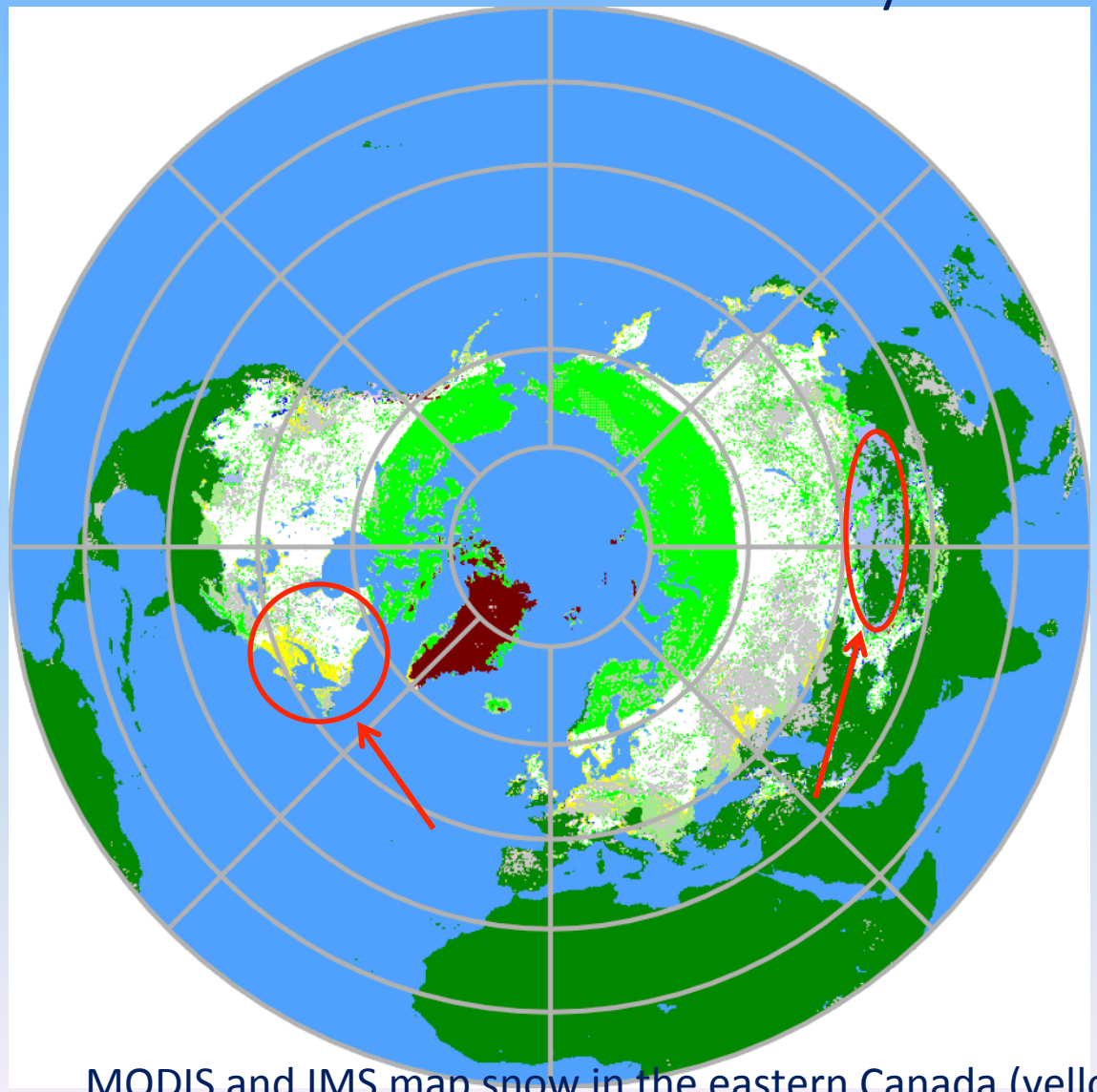
3) Passive Microwave snow extent (PM) from SSM/I

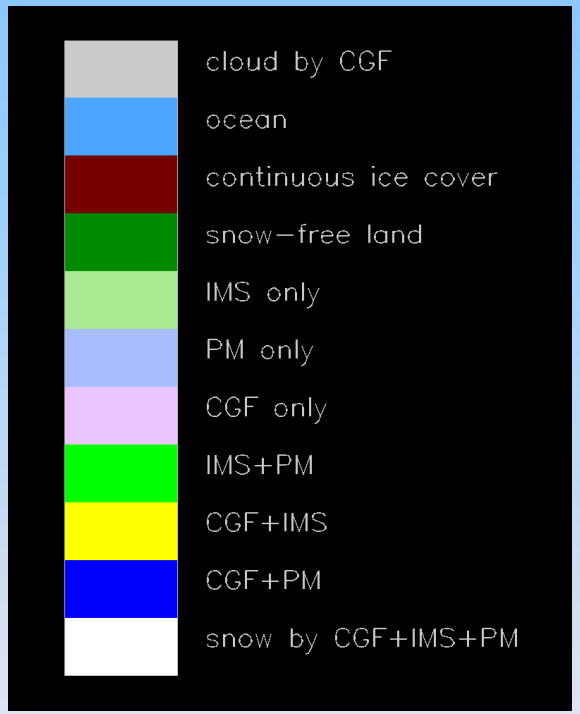
User community:

- Weather and hydrologic forecasting modelers;
- Climate scientists;
- Planning and Monitoring officials (i.e., commerce, engineering, agriculture, etc.)

MEaSUREs Northern Hemisphere Terrestrial Snow Daily, 25 km

3 January 2010

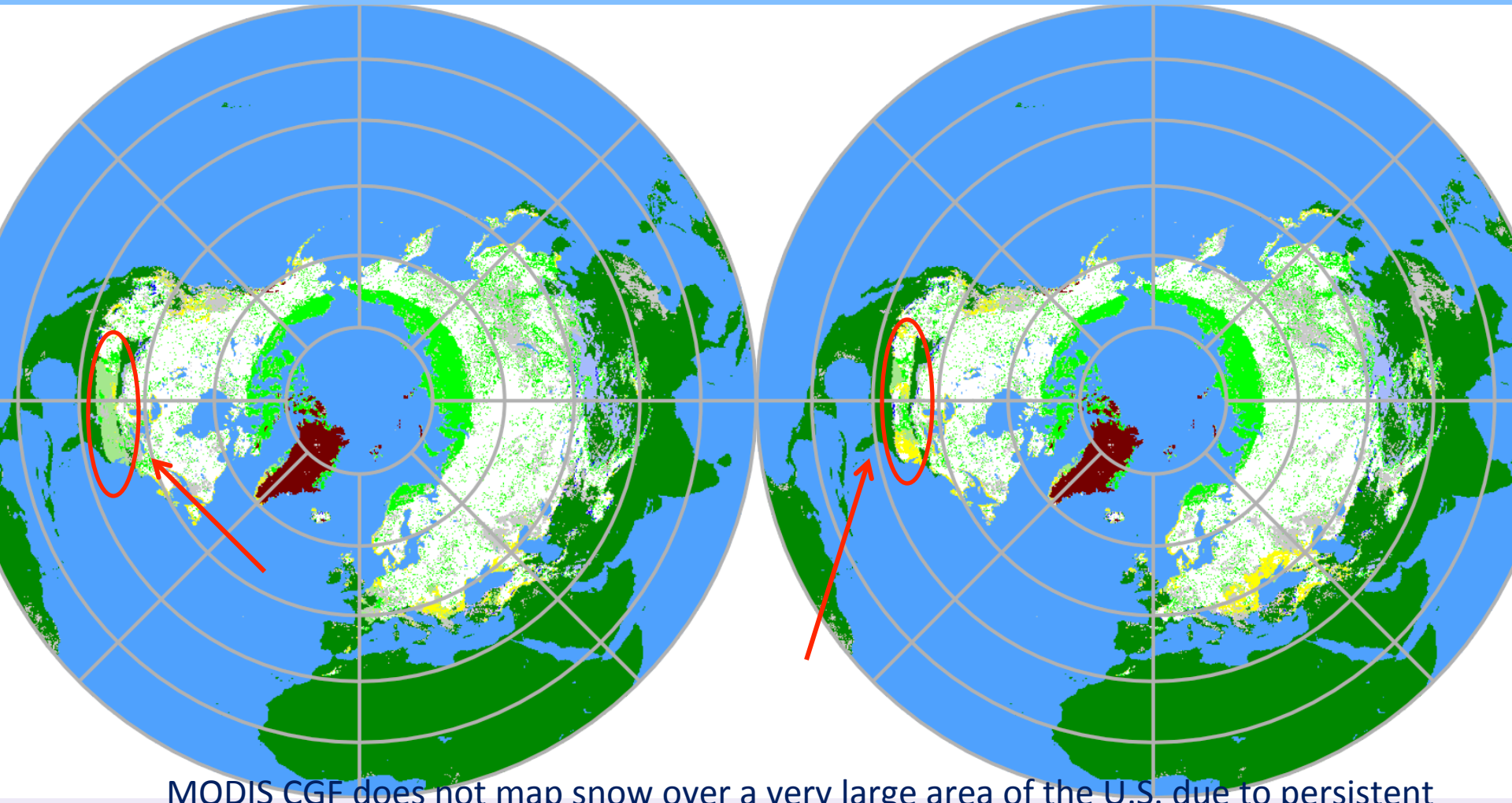




MODIS and IMS map snow in the eastern Canada (yellow area at left), but PM does not; PM maps snow erroneously over the Tibet Plateau(right).

MEaSUREs Northern Hemisphere Terrestrial Snow Daily, 25 km

30 & 31 January 2010



MODIS CGF does not map snow over a very large area of the U.S. due to persistent clouds on and before 30 January (see light green at left), but as clouds clear more snow is mapped by MODIS on 31 January (see yellow at right).

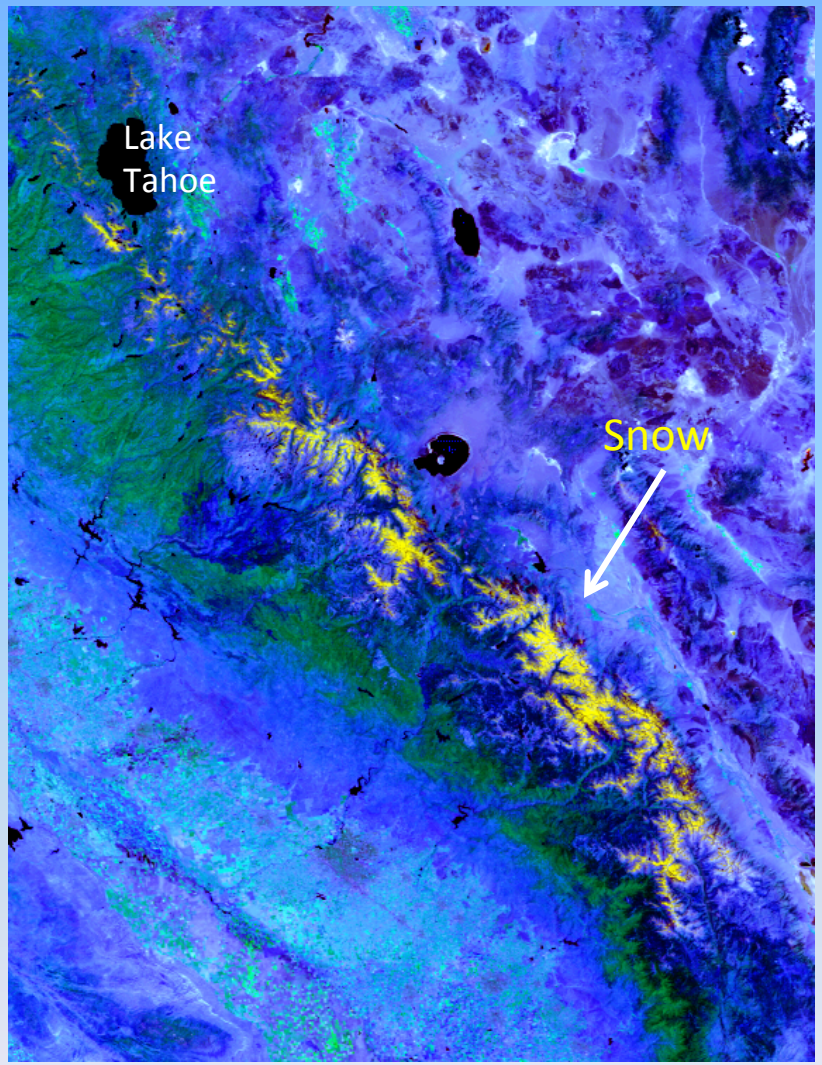
Specification of snow product:

Product Name	MEaSUREs Northern Hemisphere Terrestrial Snow Cover Extent Daily 25km EASE-Grid 2.0
Sensor and applied spectral bands	MODIS, AMSR-E, AVHRR, VIIRS, SSMI, SSMIS, VISSR, AMSU-B and VAS
Temporal characteristics	
Period (Start – End)	1/1/1999 – 12/31/2012
Temporal resolution (1 day, 1 week, etc.)	Daily
Spatial characteristics	
Spatial resolution / pixel size	25 km
Spatial coverage	Northern Hemisphere
Map projection / datum	EASE-Grid2.0
If applicable: cloud screening	
Algorithm	MOD35 for MODIS CGF product
If applicable: valid / non-valid areas	
Invalid / masked areas	
Product format	netCDF
Products accessible at	http://nsidc.org
Contact person Name: David Robinson Email: drobins@rci.rutgers.edu	Project website: http://climate.rutgers.edu/measures/snowice/

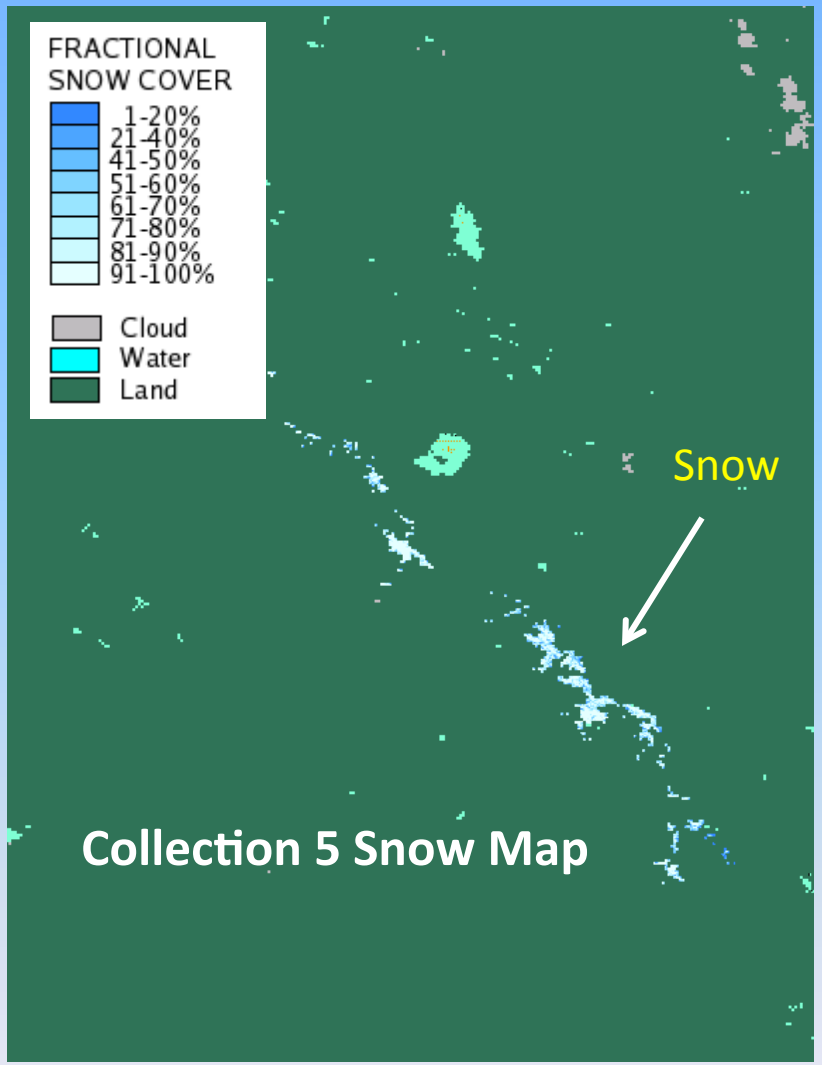
MODIS 500-m Fractional Snow Cover Daily Product, Collection 6 (C6)

- Improvements relative to C5:
  - Accurate mapping of spring and summer snow cover in mountainous areas achieved by removing the surface temperature screen;
  - Developed new screens to reduce snow commission errors to compensate for removal of the temperature screen;
  - Increased quality assessment (QA) information content relevant to interpretation/understanding of the snow cover product;
  - Cloud-gap-filled (CGF) maps potentially allowing cloud-free snow images.

Sierra Nevada Mountain Range, 31 May 2014

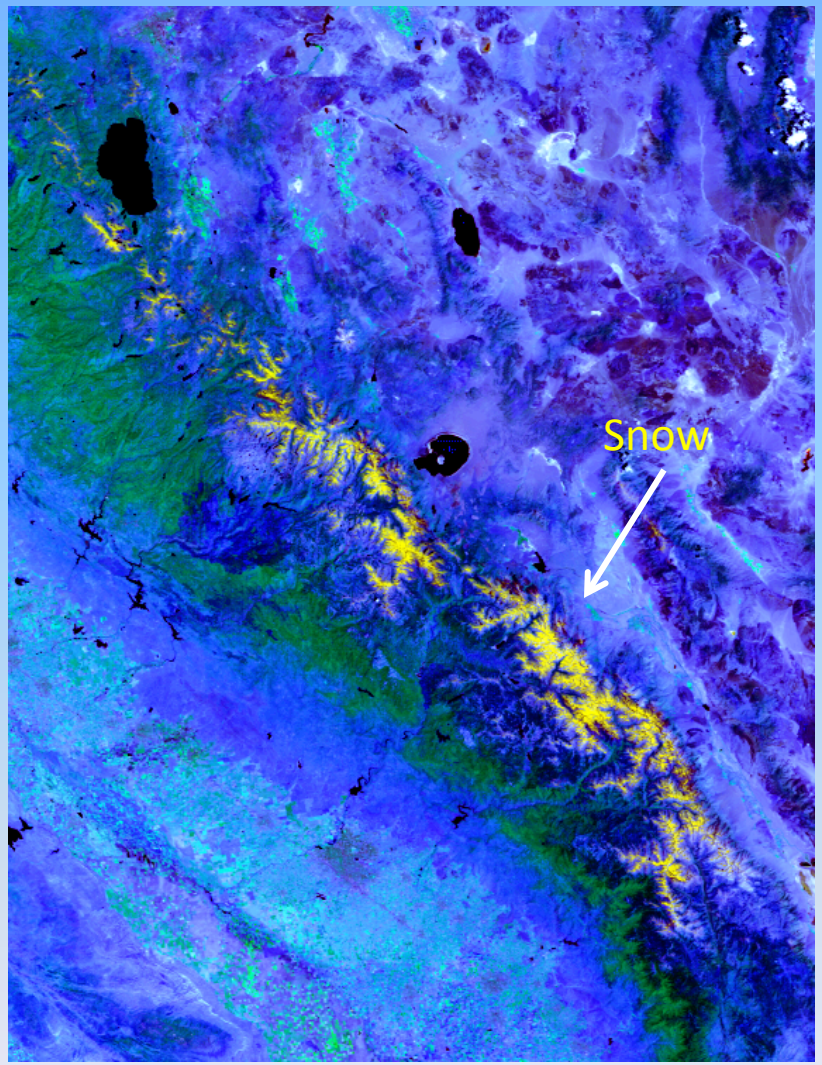


MOD02HKM TOA reflectance, bands 1,2,6 color image 31 May 2014, 1850 UTC.

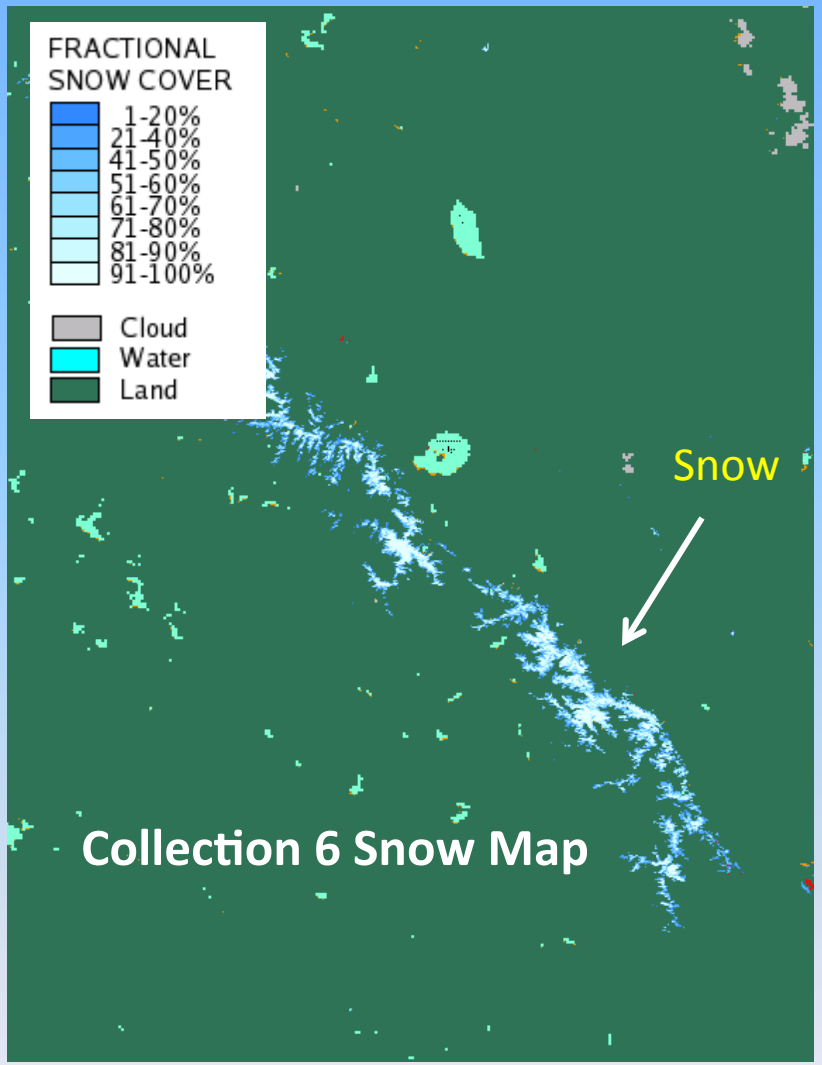


MOD10_L2 FSC map – surface temperature screen causes significant snow omission error, about 32% of snow cover extent was screened out in C5 but not in C6.

Sierra Nevada Mountain Range, 31 May 2014

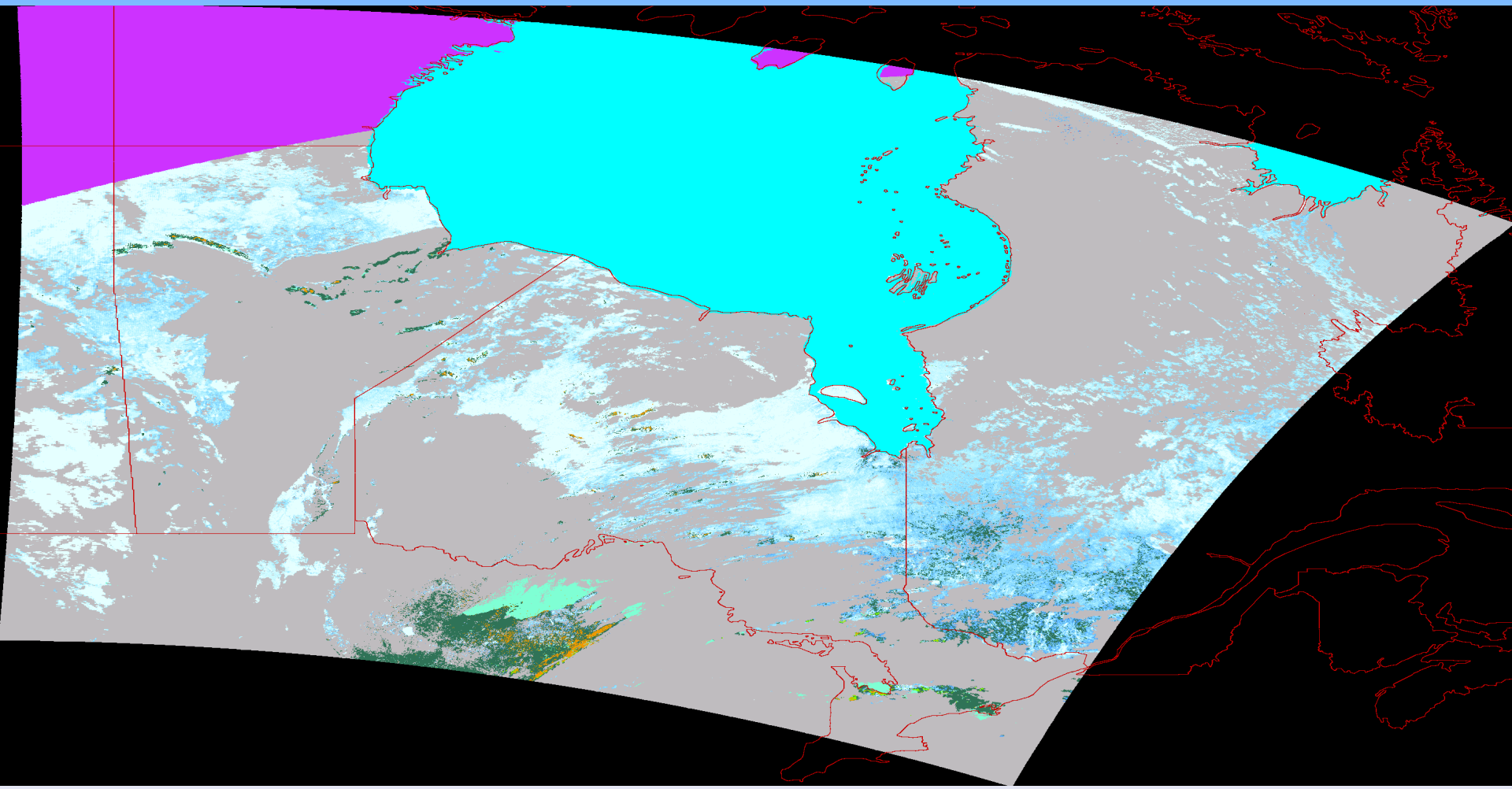


MOD02HKM TOA reflectance, bands 1,2,6 color image 31 May 2014, 1850 UTC.



MOD10_L2 FSC map – surface temperature screen causes significant snow omission error, about 32% of snow cover extent was screened out in C5 but not in C6.

FSC Level-2 swath, on geographic projection.

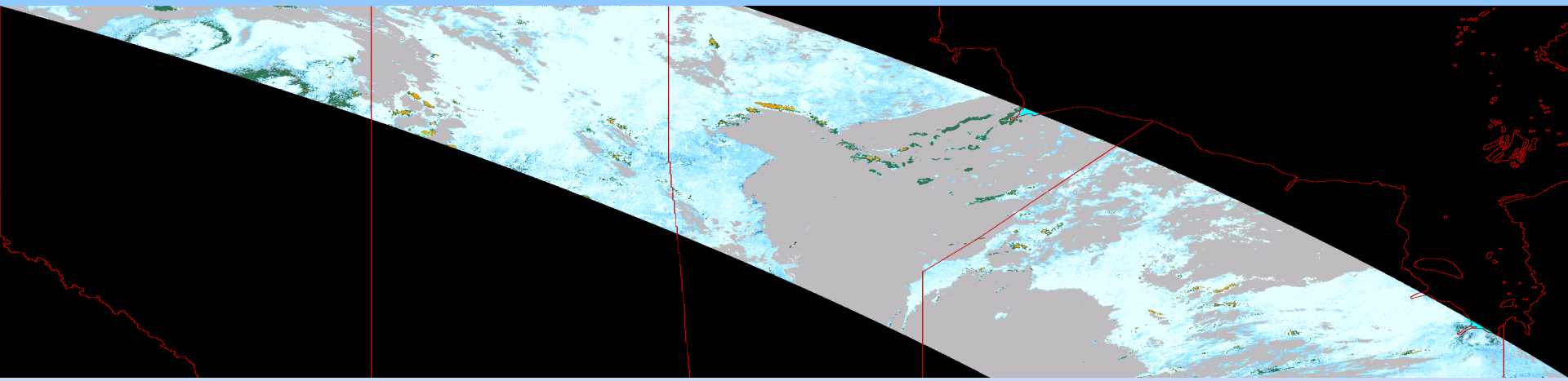


MOD10_L2.A2003002.1700.006.*.hdf

Specification of snow product:

Product Name	MOD10_L2 MODIS/Terra Snow Cover 5-Min L2 Swath 500m MYD10_L2 MODIS/Aqua Snow Cover 5-Min L2 Swath 500m
Sensor and applied spectral bands	MODIS bands 1,2,4,6
Temporal characteristics	
Period (Start – End)	Terra: 24 February 2000 – present Aqua: 4 July 2007 -- present
Temporal resolution (1 day, 1 week, etc.)	1 day: 5 min along track swath
Spatial characteristics	
Spatial resolution / pixel size	~500 m
Spatial coverage	global
Map projection / datum	Latitude, longitude
If applicable: cloud screening	
Algorithm	MODIS cloud mask data product MOD35_L2
If applicable: valid / non-valid areas	
Invalid / masked areas	darkness
Product format	HDF-EOS
Products accessible at	http:// reverb.echo.nasa.gov/reverb
Contact person Name: Dorothy Hall / George Riggs Email: dorothy.k.hall@nasa.gov; george.a.riggs@nasa.gov	http://modis-snow-ice.gsfc.nasa.gov/ http://nsidc.org/data/modis/index.html

MOD10A1.A2003002.h12v03.006.*.hdf
FSC Level-2 daily tile from the sinusoidal projection,
reprojected onto geographic projection

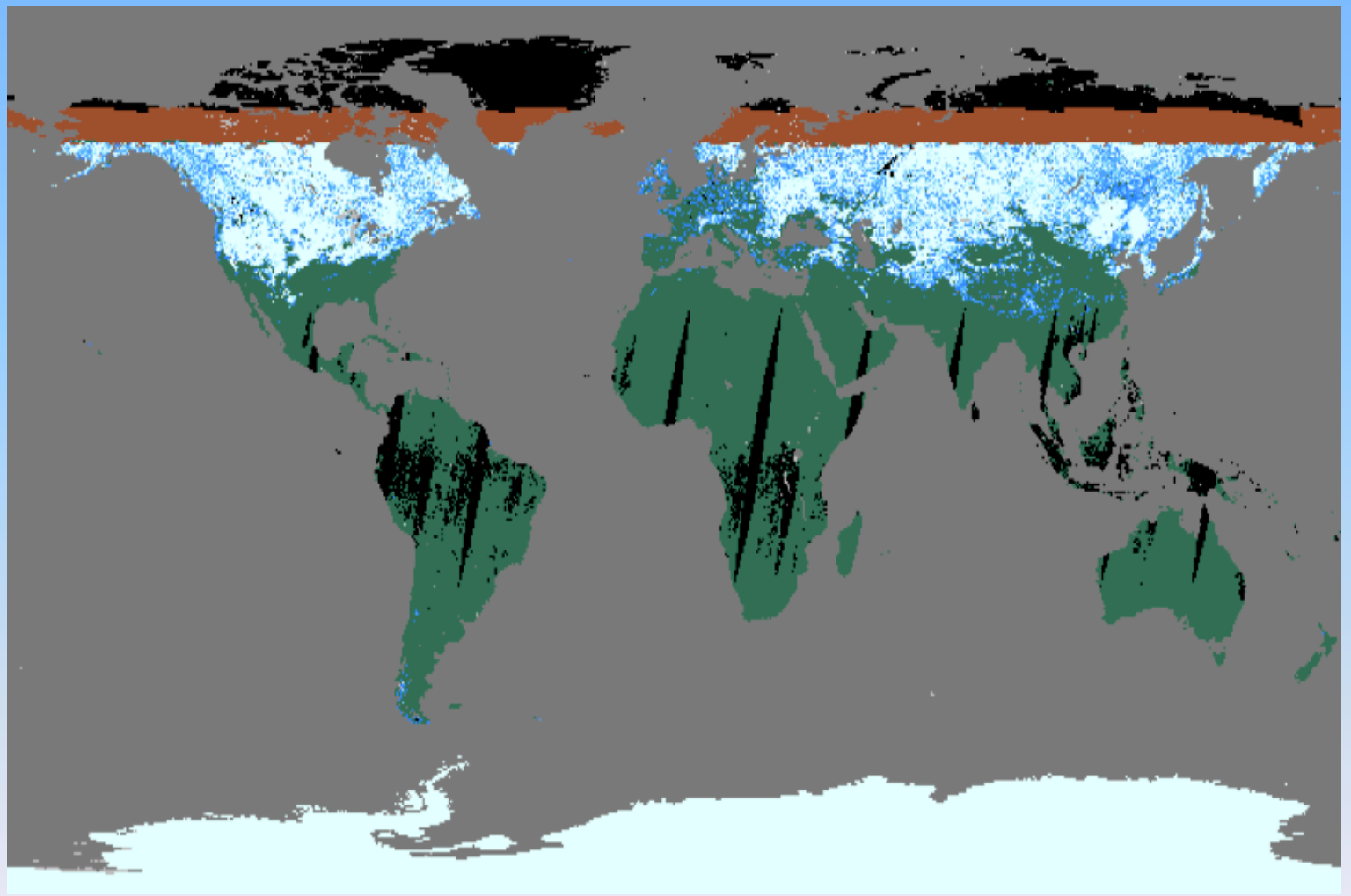


MOD10A1.A2003002.h12v03.006.*.hdf

Specification of snow product:

Product Name	MOD10A1 MODIS/Terra Snow Cover Daily L3 Global 500m Grid MYD10A1 MODIS/Aqua Snow Cover Daily L3 Global 500m Grid
Sensor and applied spectral bands	MOD10_L2, MYD10_L2
Temporal characteristics	
Period (Start – End)	Terra: 24 February 2000 – present Aqua: 4 July 2007 -- present
Temporal resolution (1 day, 1 week, etc.)	1 day
Spatial characteristics	
Spatial resolution / pixel size	~500 m
Spatial coverage	Global
Map projection / datum	Sinusoidal projection, tiles of global grid
If applicable: cloud screening	
Algorithm	
If applicable: valid / non-valid areas	
Invalid / masked areas	darkness
Product format	HDF-EOS
Products accessible at	http:// reverb.echo.nasa.gov/reverb
Contact person Name: Dorothy Hall / George Riggs Email: dorothy.k.hall@nasa.gov; george.a.riggs@nasa.gov	http://modis-snow-ice.gsfc.nasa.gov/ http://nsidc.org/data/modis/index.html

MODIS Fractional Snow Cover Level-3 daily global Climate Modeling Grid (CMG)



MOD10C1.A2003002.006.*.hdf

5 Jan 2013

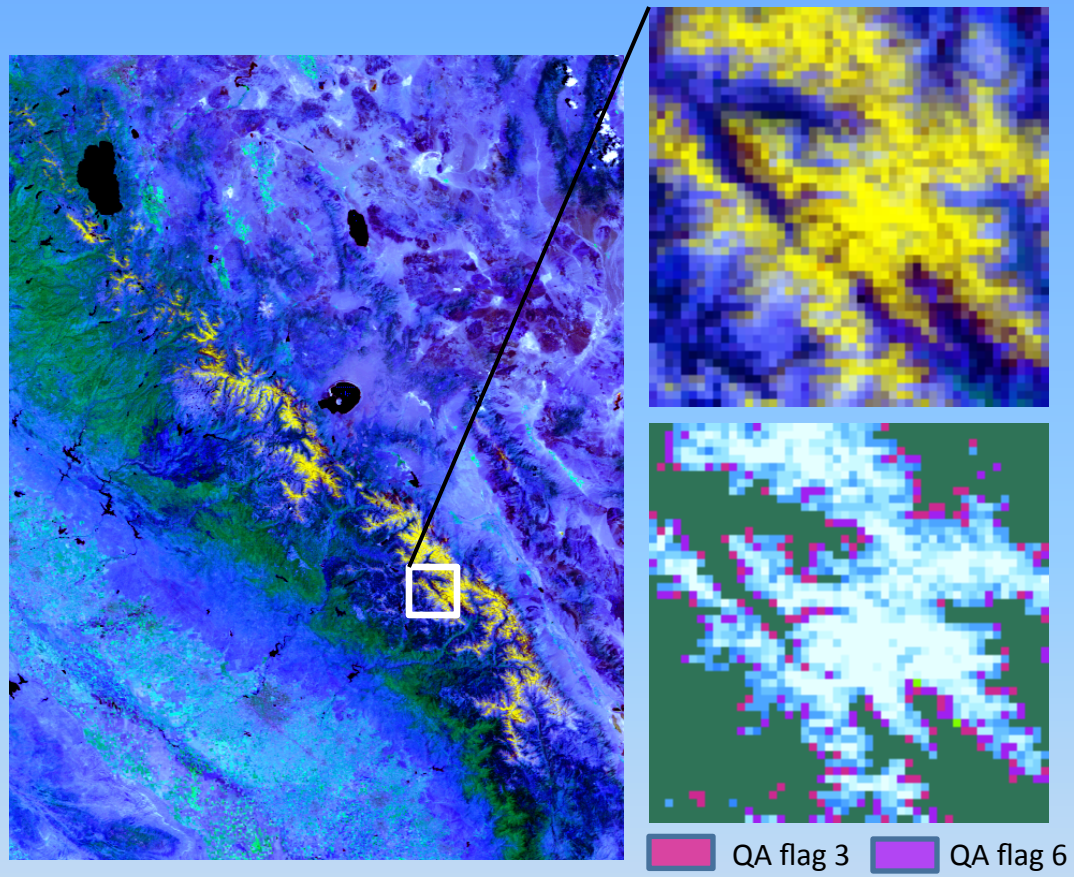
Specification of snow product:

Product Name	MOD10C1 MODIS/Terra Snow Cover Daily L3 Global 0.05Deg CMG MYD10C1 MODIS/Aqua Snow Cover Daily L3 Global 0.05Deg CMG
Sensor and applied spectral bands	MOD10A1, MYD10A1
Temporal characteristics	
Period (Start – End)	Terra: 24 February 2000 – present Aqua: 4 July 2007 -- present
Temporal resolution (1 day, 1 week, etc.)	1 day
Spatial characteristics	
Spatial resolution / pixel size	0.05 degrees
Spatial coverage	Global
Map projection / datum	Geographic, Climate Modeling Grid (CMG)
If applicable: cloud screening	
Algorithm	
If applicable: valid / non-valid areas	
Invalid / masked areas	darkness
Product format	HDF-EOS
Products accessible at	http://reverb.echo.nasa.gov/reverb
Contact person Name: Dorothy Hall / George Riggs Email: dorothy.k.hall@nasa.gov; george.a.riggs@nasa.gov	http://modis-snow-ice.gsfc.nasa.gov/ http://nsidc.org/data/modis/index.html

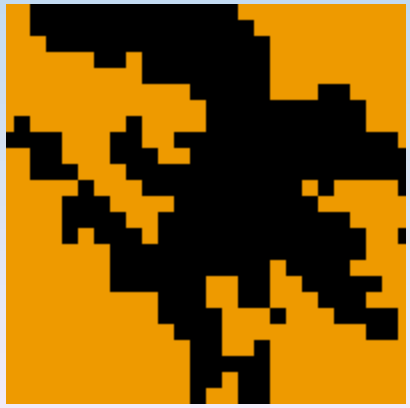
Conclusions

- Two new snow products:
  - MEaSUREs Terrestrial Snow 25km EASE-Grid 2.0 merged product, and
  - MODIS 500-m daily fractional snow-cover standard product in Collection 6 (C6).
- MEaSUREs:
  - Allows detailed comparisons to assess errors and limitations of the three input products;
- MODIS Collection 6:
  - Represents an important improvement relative to Collection 5 in springtime mid-latitude mountainous regions.
- Data product continuity, length of record (IMS only) and documentation are consistent with Climate Data Record standards.
- By adhering to these standards a researcher can go back in time and get consistent results; if an error is found, the entire dataset can be reprocessed (e.g., MODIS C5 reprocessed in C6).

Backup



QA flag 3 QA flag 6



MOD10_L2 C6 FSC map – with algorithm specific QA flags 3 and 6 set showing snow cover detection reversals to no snow. These flags indicate pixels with reflectance characteristics weakly indicative of snow. Pixels are not mapped as FSC but could be interpreted as a snow detection by a user of the QA flags.

Surface temperature can be useful in some situations to block snow commission error on some surfaces, e.g., mineral surfaces or tropical forests. A surface temperature flag is in the QA flags for users to use; it is not applied in the snow algorithm. If the estimate surface temperature is >= 288 K the flag is set on (orange).