

MODIS Collection-6 Standard Snow-Cover Product Suite

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Outline

- **New C6 products**
- C6 improvements
- Northern Hemisphere snow cover time series from MODIS

MODIS Collection-6 Standard Snow-Cover Products*

- 500-m resolution daily snow cover at the swath level, M*D10_L2
- 500-m daily snow-cover tile products – gridded to sinusoidal projection, M*D10A1
- 5-km daily climate-modeling grid (CMG) snow cover, M*D10C1
- 500-m 8-day composite snow-cover tile products – gridded to sinusoidal projection, M*D10A2
- 5-km 8-day composite climate-modeling grid (CMG) snow cover, M*D10C2
- 5-km monthly snow cover, M*D10CM

New!

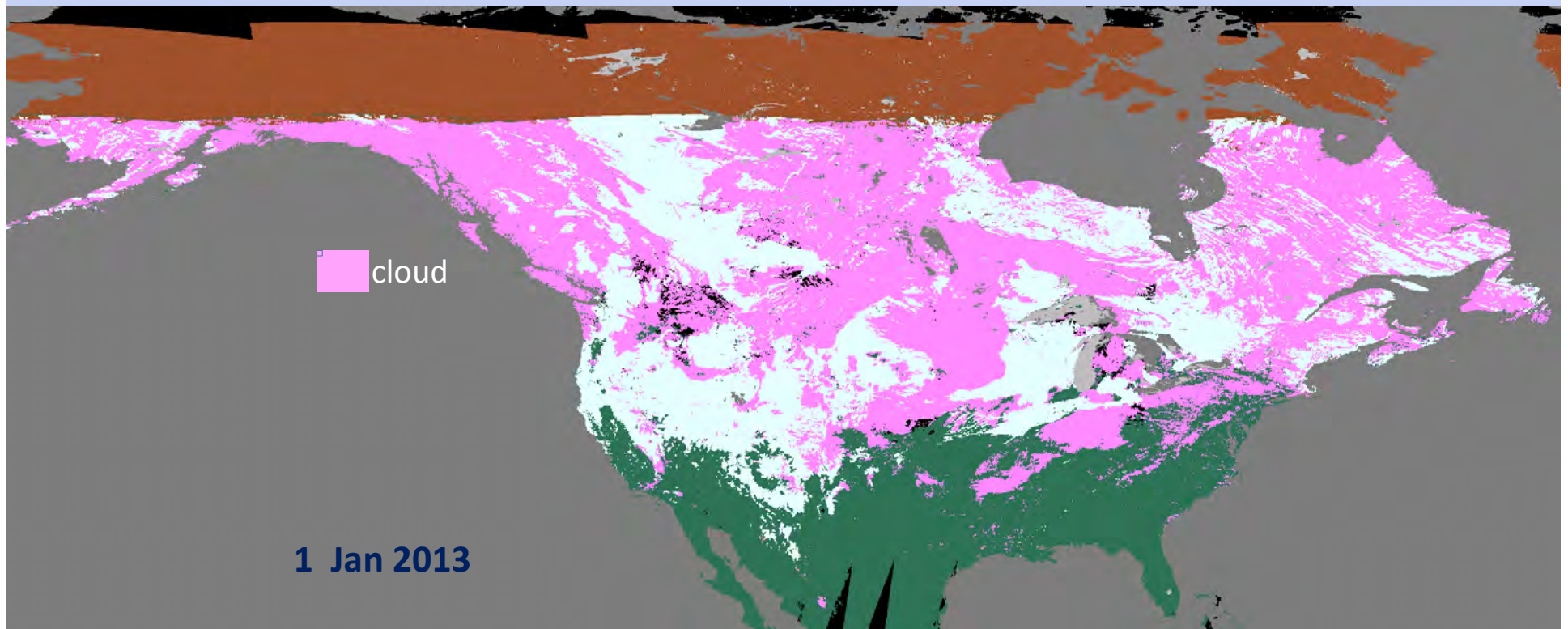
- 500 m cloud-gap-filled (CGF) daily snow cover, M*D10A1F
- 5 km cloud-gap-filled (CGF) daily snow cover, M*D10C1F
- 500 m snow cover extent using surface reflectance input, MOD10A1S (Terra MODIS only for now)

*No significant changes to sea ice algorithms

Sequence of MODIS Snow Maps (CGF)

1

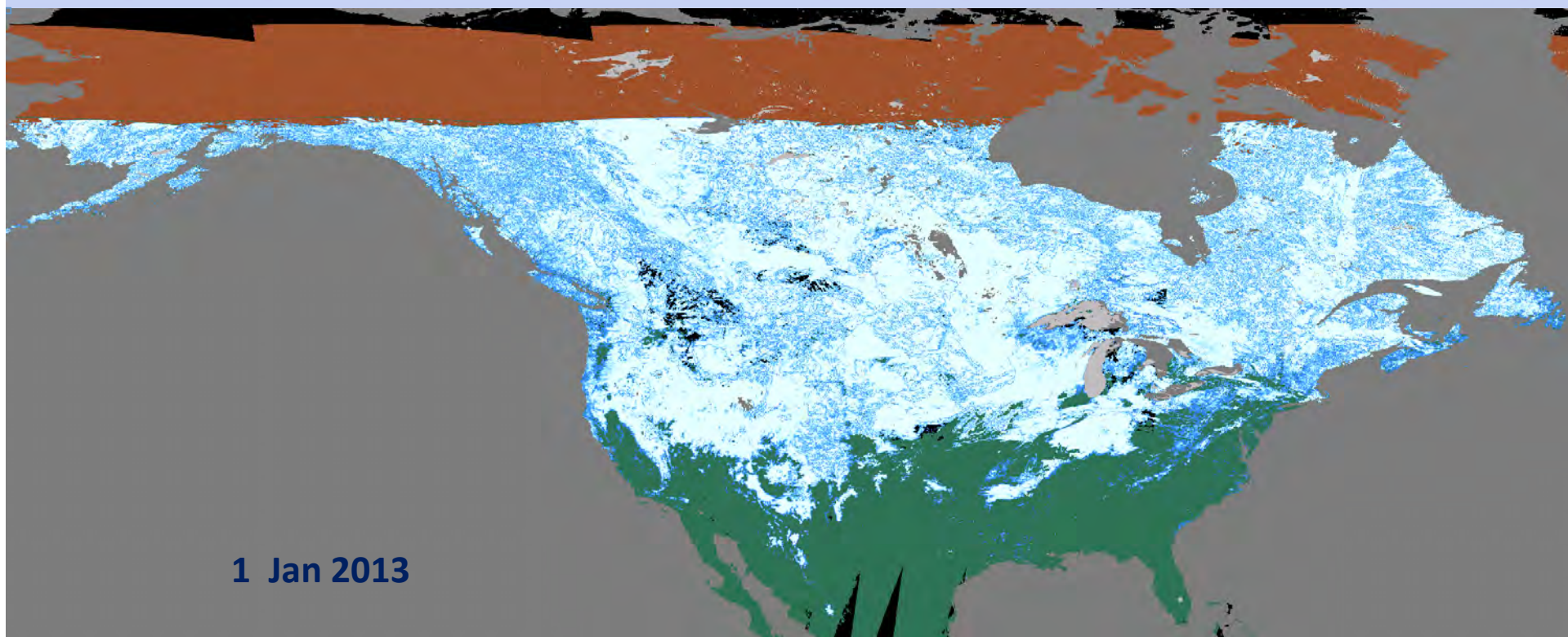
– 6 January 2013



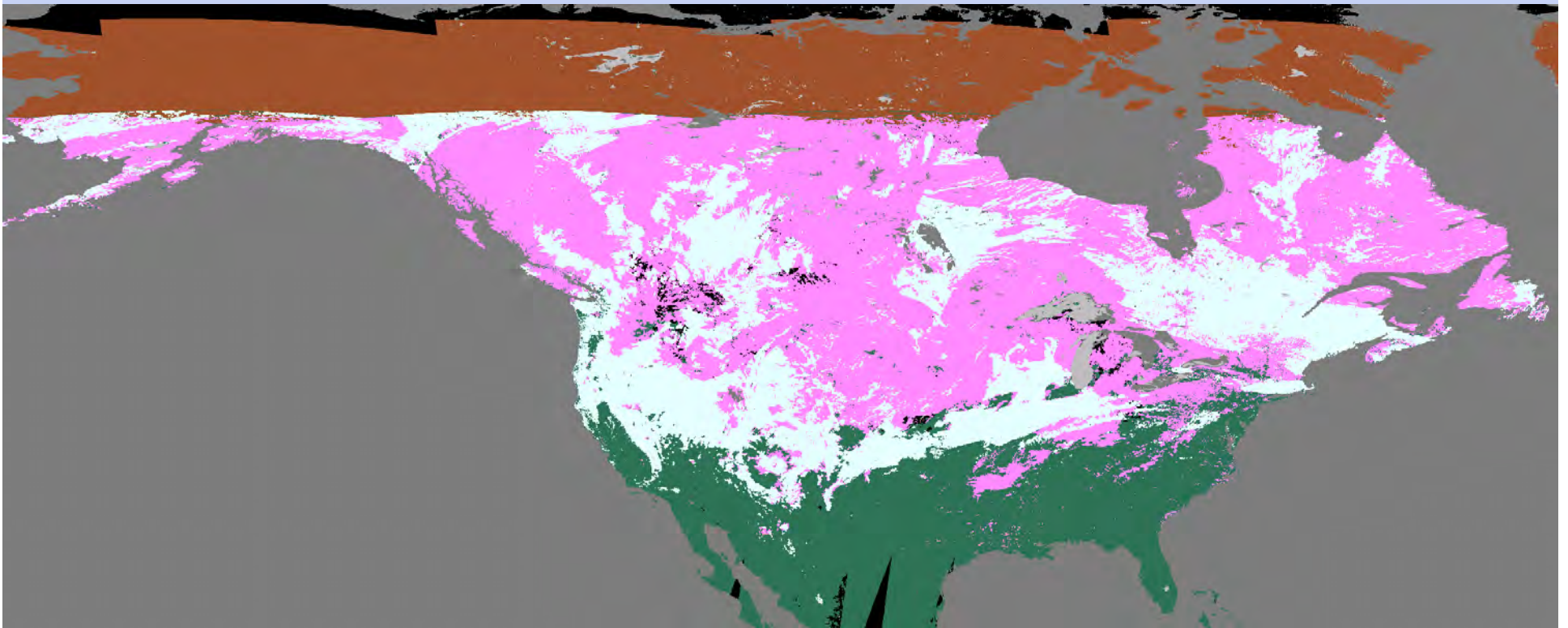
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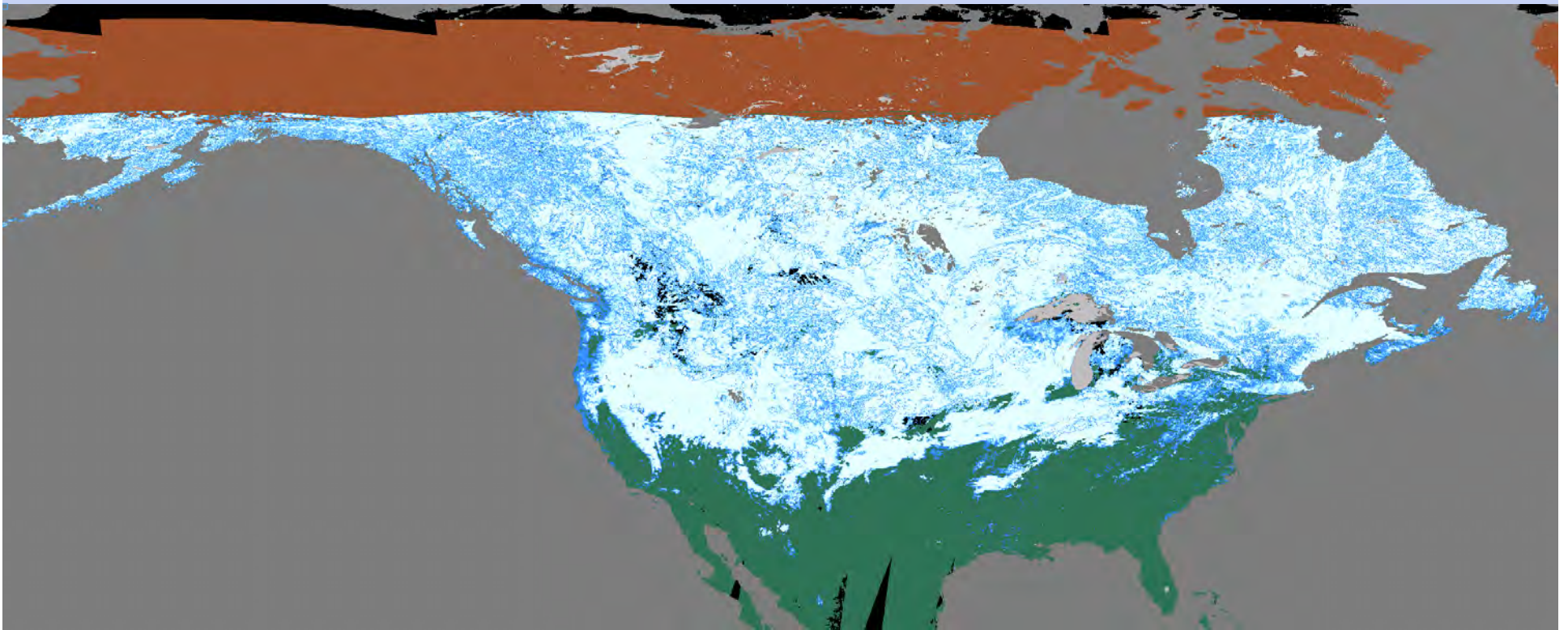
– 6 January 2013



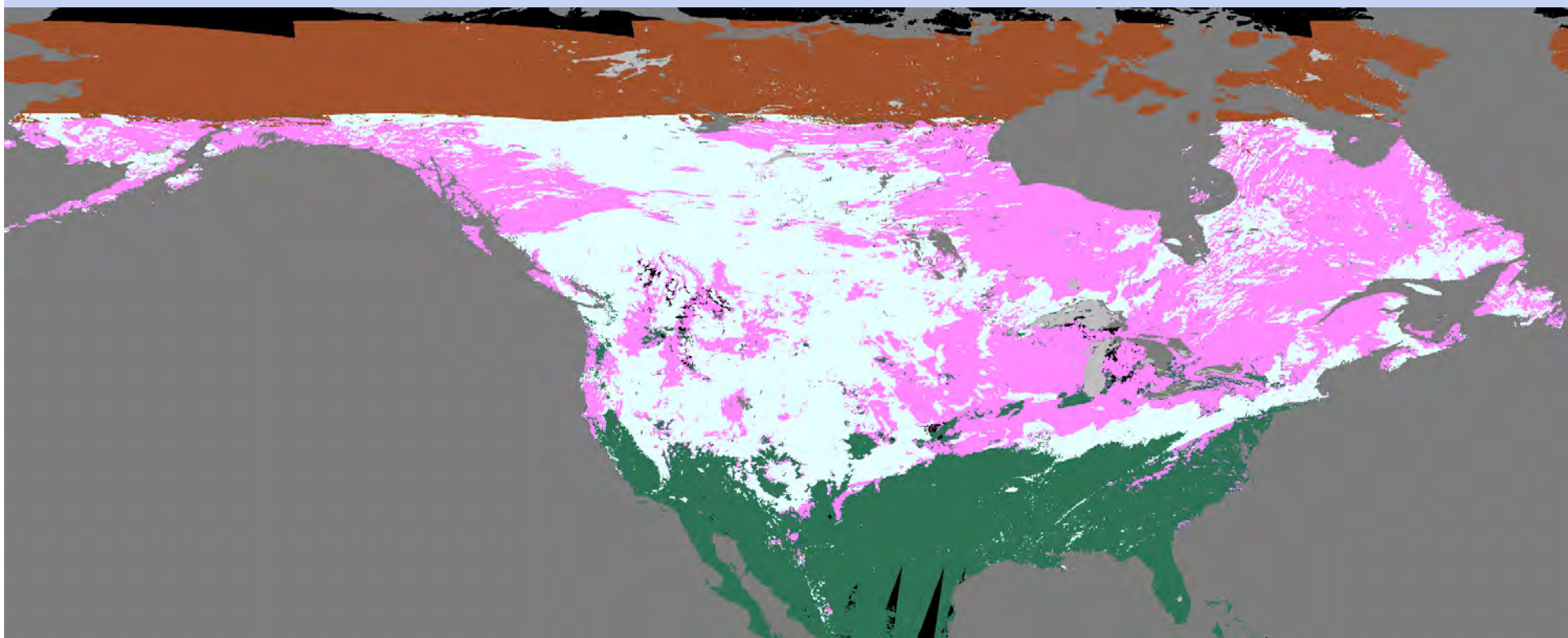
2 Jan 2013



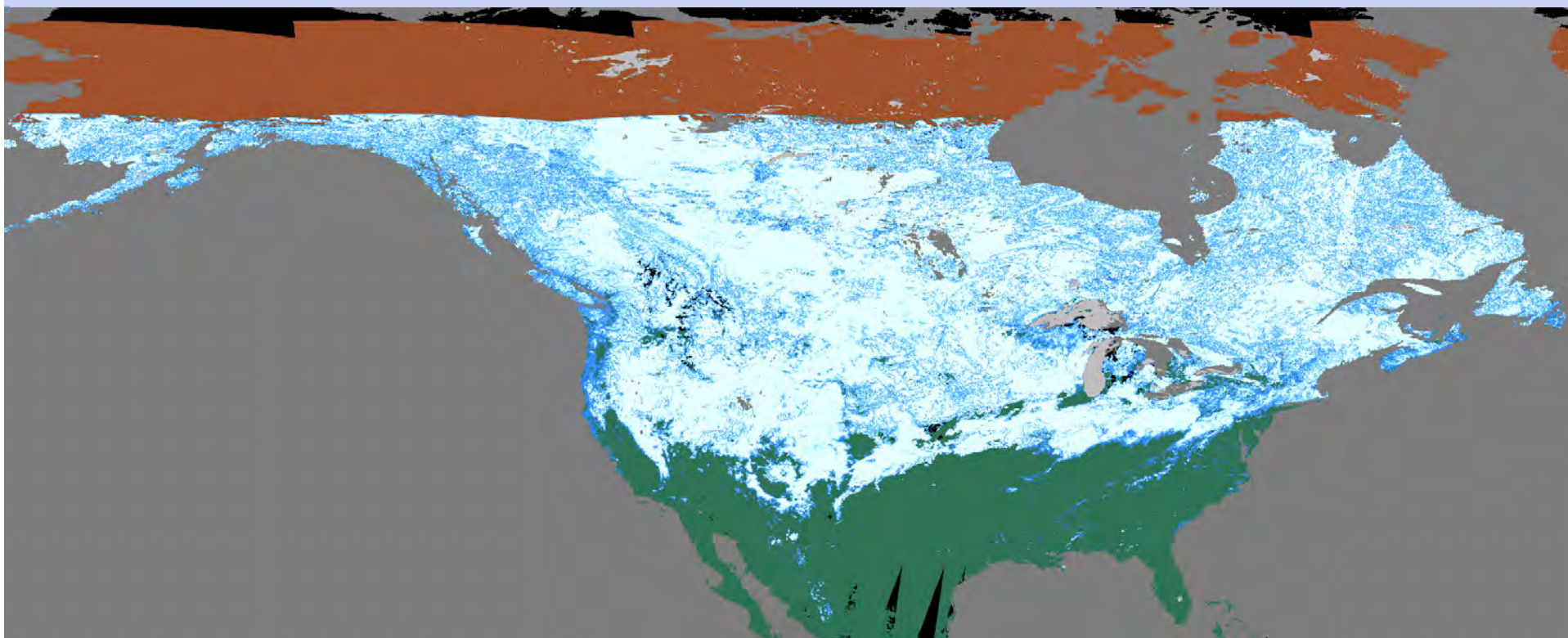
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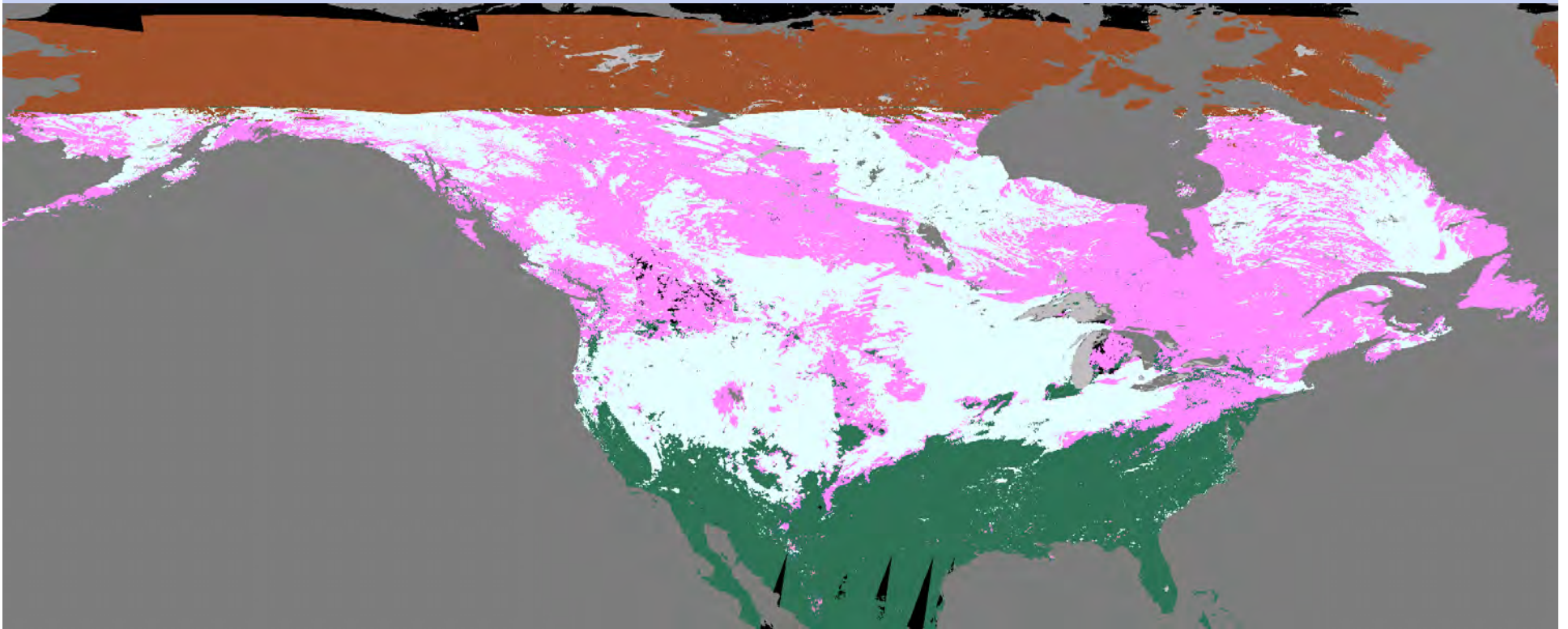
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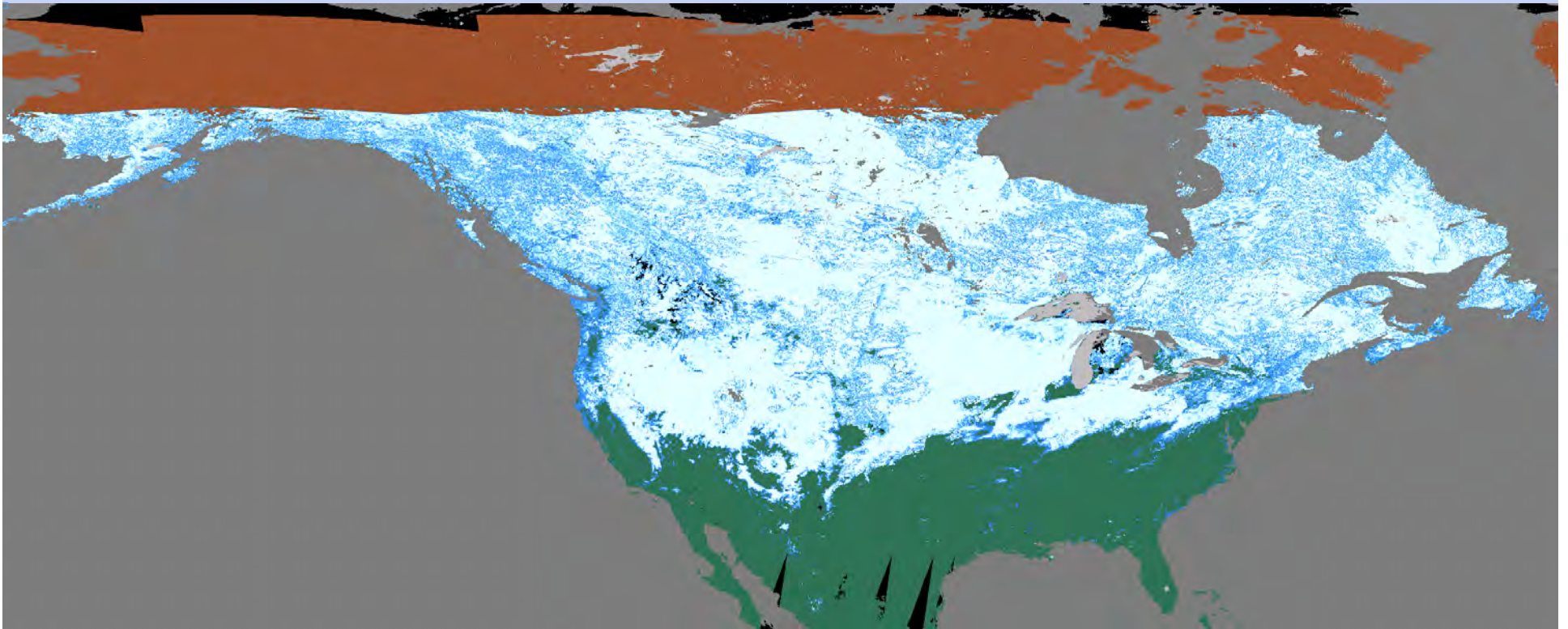
3 Jan 2013



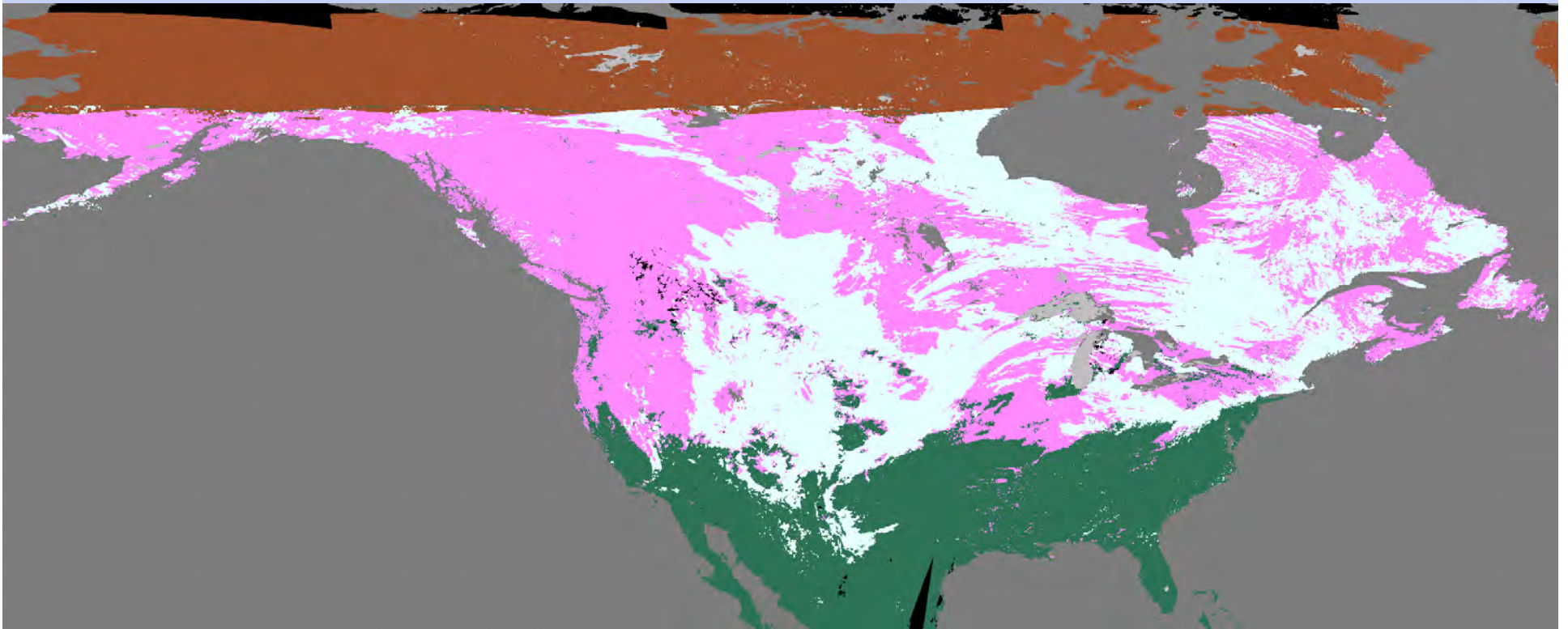
4 Jan 2013



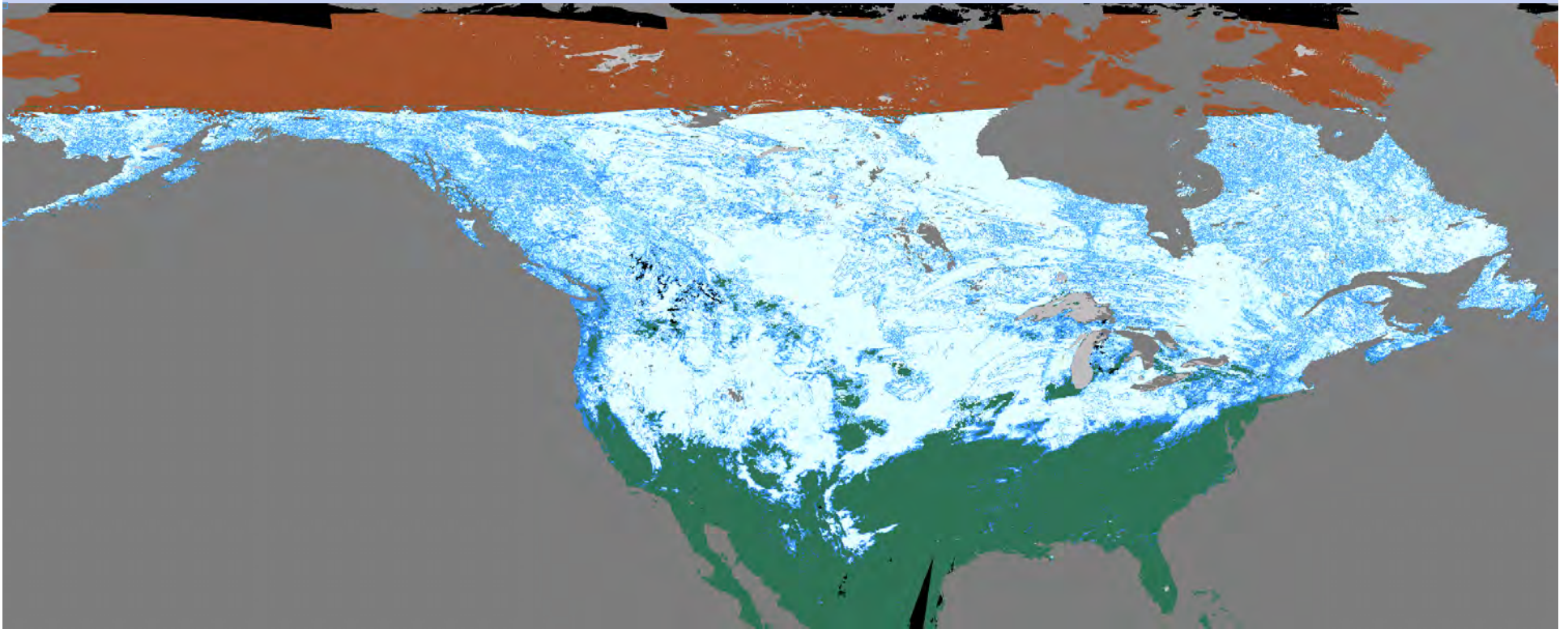
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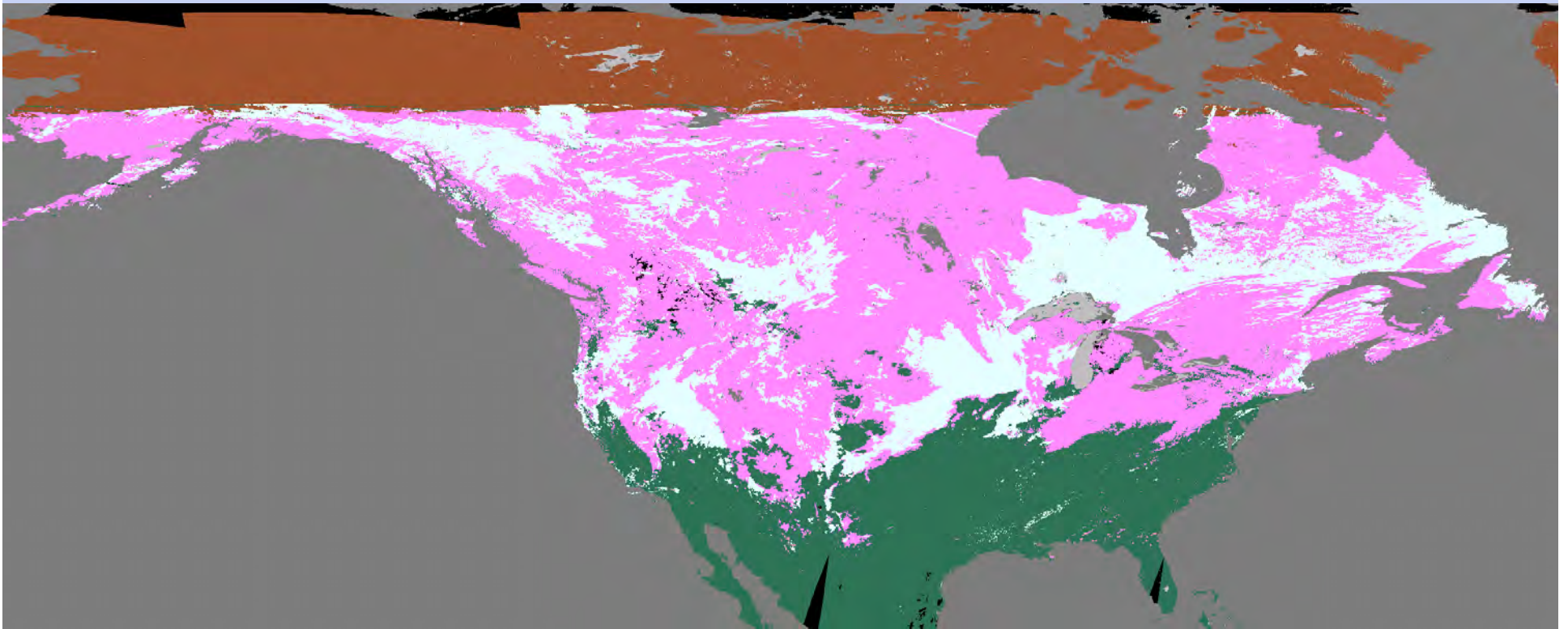
5 Jan 2013



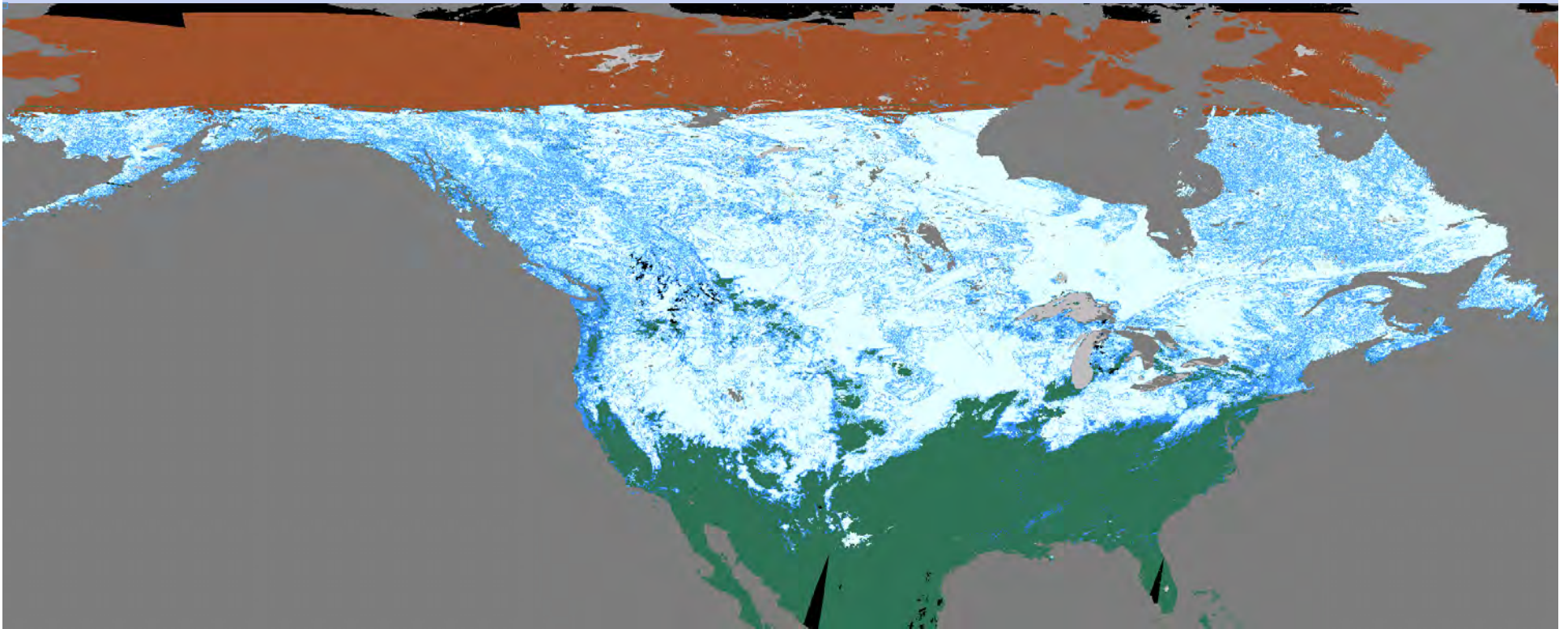
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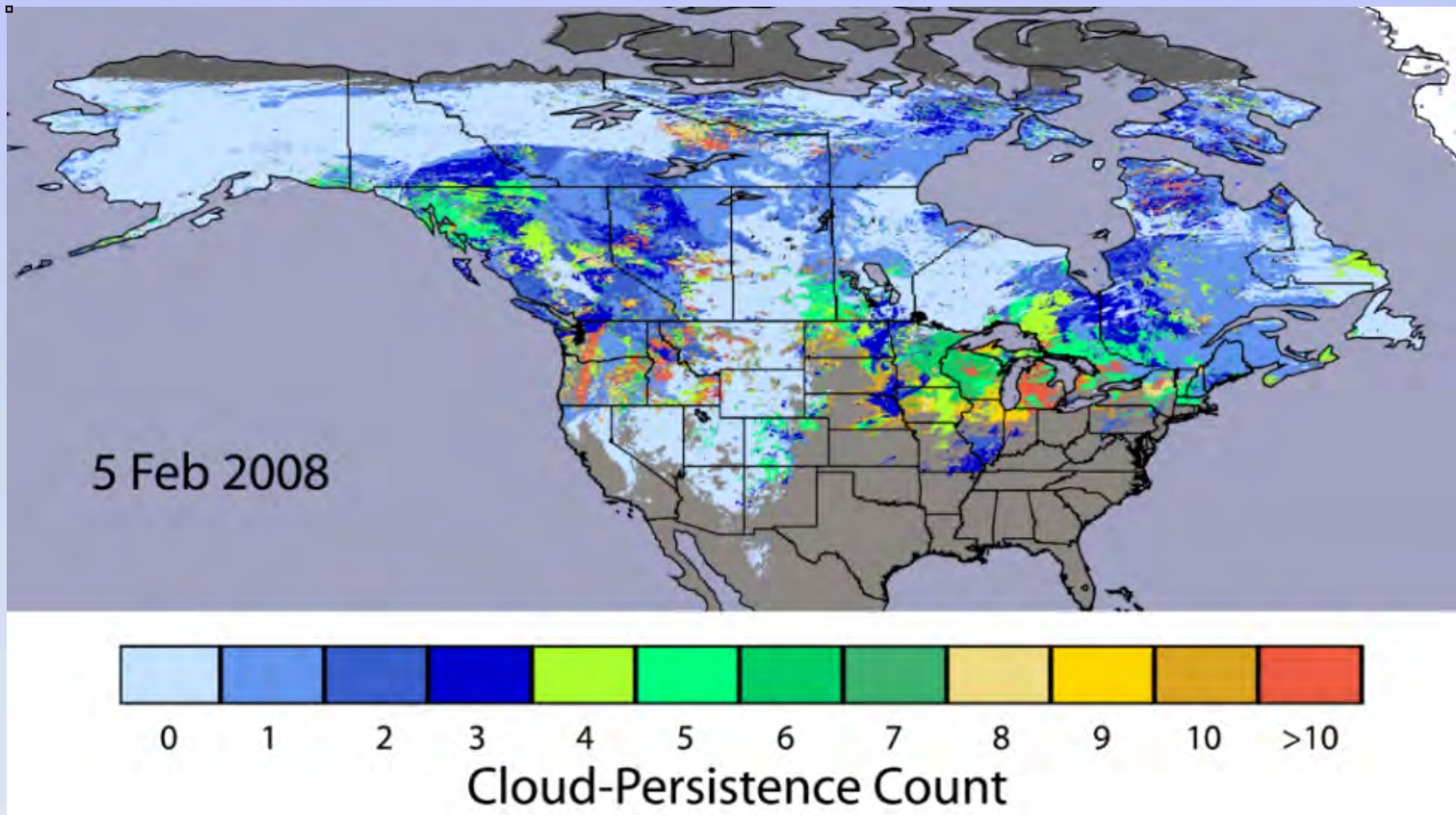
6 Jan 2013



6 Jan 2013



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



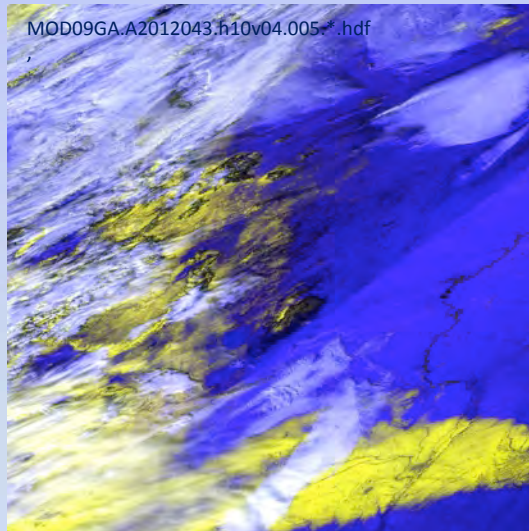
Cloud-gap filled (CGF) cloud-persistence count (CPC) snow-cover map. The CPC provides quality assurance (QA) information in each pixel or cell.

Surface Reflectance vs. TOA

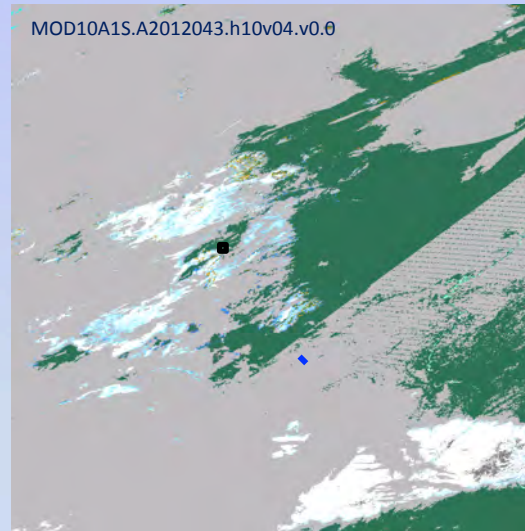
New snow-cover products will use MOD09 surface reflectance instead of TOA reflectance as input;

- This change results in a small improvement in mapping snow cover in some areas, especially under less-than-ideal viewing conditions.

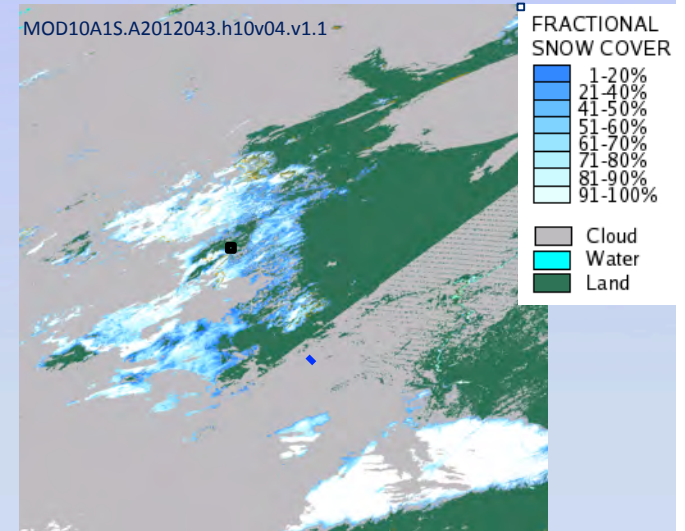
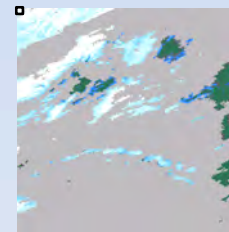
Combined use of the M*D09+ and M*D35 cloud masks can reduce cloud/snow confusion in some situations MOD09GA



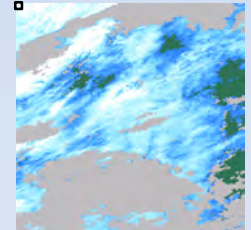
MOD09GA -- RGB bands 1,4,6. Snow appears in hues of yellow.



Fractional snow map, using only MOD35_L2 cloud mask.



Fractional snow map, using combination of MOD35_L2 and MOD09GA land mask flags alleviate some snow/cloud confusion.



+ Based on M*D35

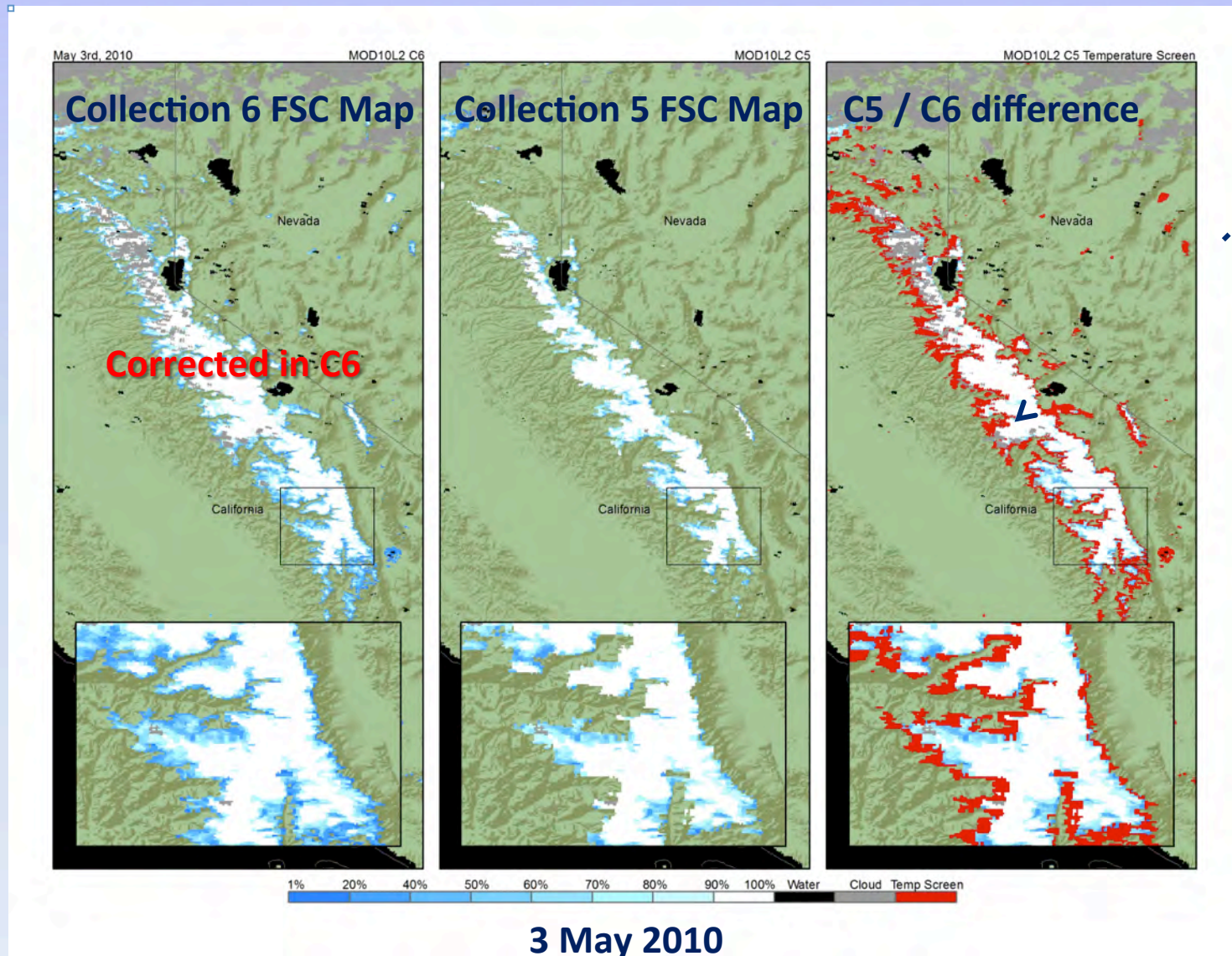
Outline

- New C6 products
- **C6 improvements**
- Northern Hemisphere snow cover time series from MODIS

Collection-6 (C6) Algorithm Improvements

- **Dropped the surface temperature screen that erroneously reversed snow detection on some mountains during spring and summer in C5;**
- For Aqua products, we are in the process of implementing the QIR (Gladkova et al.) to improve snow mapping using Aqua MODIS (with non-functional B6 detectors);
- Dropped the binary snow product in C5 –only fractional snow algorithm will be provided using the full range of NDSI from 0.0 – 1.0; no binary product will be distributed;
- Added new screens to alleviate snow commission errors;
- Increased data information content in the QA data to enable better evaluation of the snow cover; QA flags set for screens applied.

Deleterious Effect of the C5 Surface-Temperature Screen on Spring Snow-Cover Mapping in the Sierra Nevada Mts., USA



Collection-6 (C6) Algorithm Improvements

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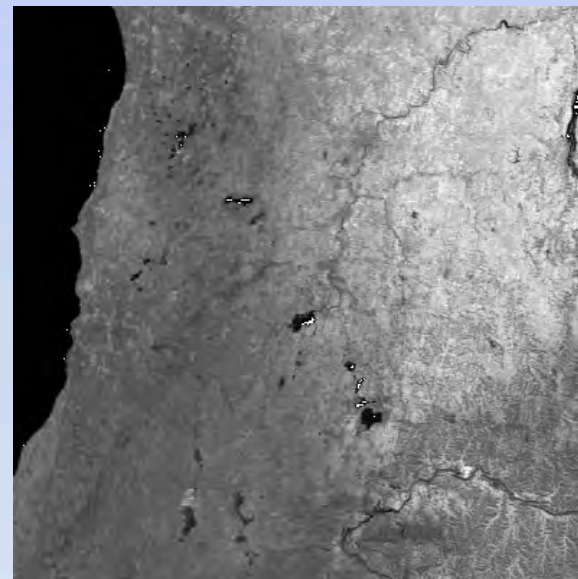
Quantitative Image Restoration (QIR) applied to Aqua Band 6

To enable the same snow algorithm to be used with both Terra and Aqua

Technique is based on multilinear regression over both spatial and spectral windows using Bands 1 – 5 and 7, to estimate value in Band 6



MYD02HKM C6 band6 has fill value for non-functional detectors. A sub image from MYD02HKM.A. 2012043.1845.006*.hdf shown above.



MYD10_L2 with Quantitative Image Restoration (QIR) applied to MODIS Aqua band 6 data. QIR band6 restored shown above.

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Snow-Cover Trends in the Northern Hemisphere

- 13 winters of MODIS snow-cover maps are available to study short-term trends in snow-cover extent (SCE)
 - Northern Hemisphere (North America & Eurasia separately)
 - Regional studies
- MODIS Terra maps of total SCE compare well with Rutgers University Climate Lab (RUCL) CDR maps, but MODIS maps have better spatial resolution (and other differences)

Average Maximum Snowline from MODIS, 2001 – 2012

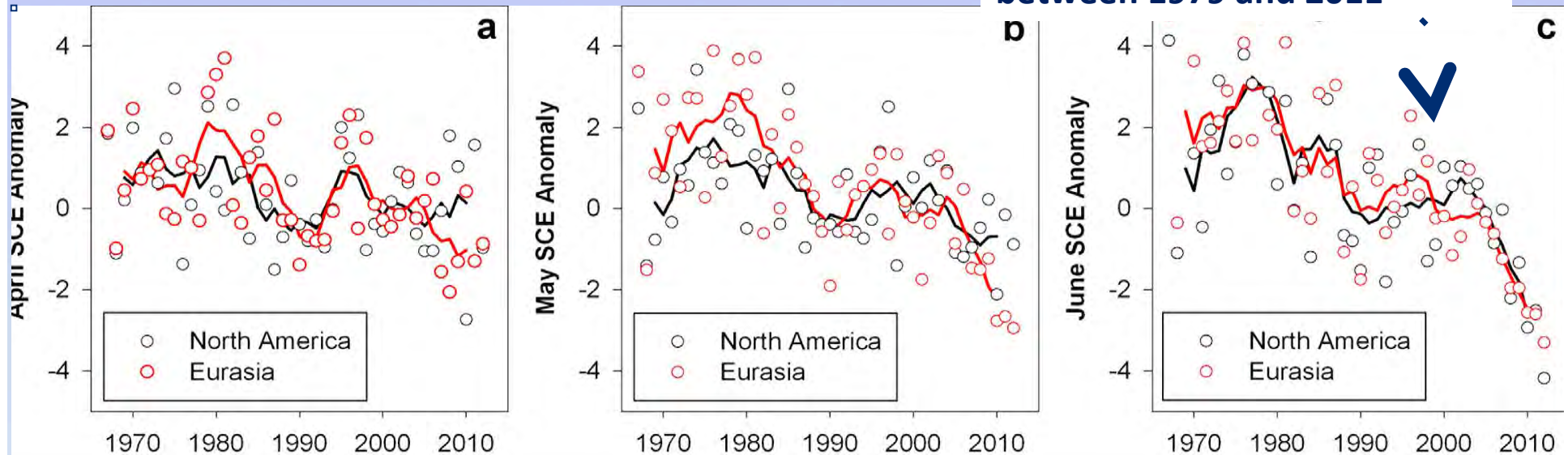
Derived from MOD10CM standard data products



Derived from MOD10CM standard data products

Snow Cover in Northern Hemisphere Declines in Springtime

June snow-cover reductions at a rate of -17.8% / decade between 1979 and 2011

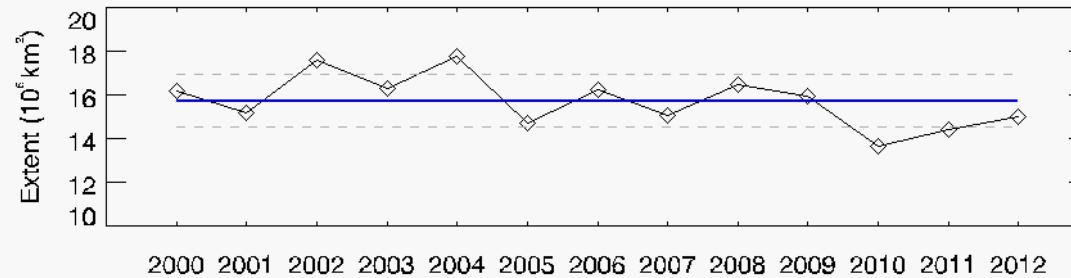


(Derksen and Brown, 2012, *GRL*)

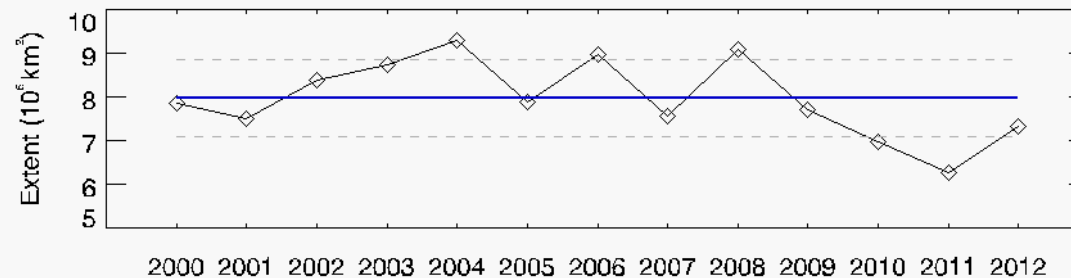
(a) snow-cover extent (SCE) anomaly time series from the NOAA snow chart CDR for (a) April, (b) May, and (c) June. Solid line denotes 5-yr running mean.

MODIS Monthly Data

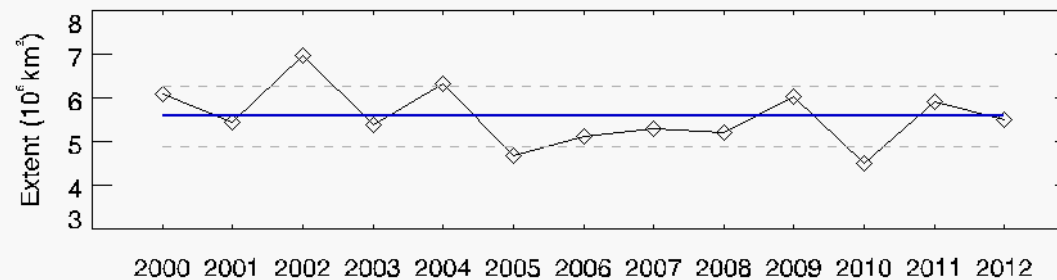
Northern Hemisphere May Snow Extent



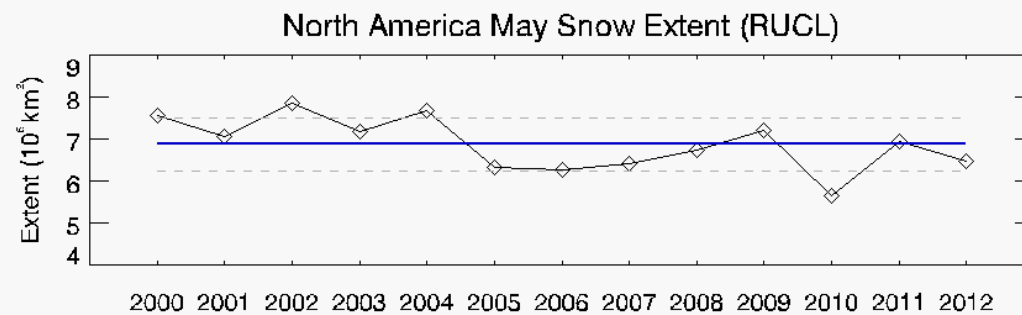
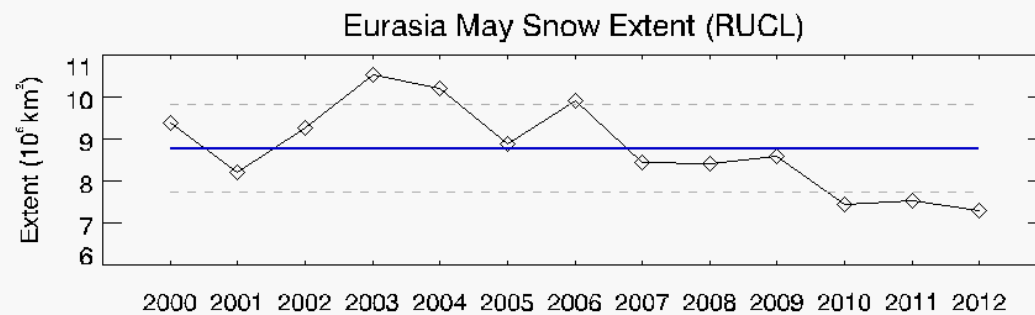
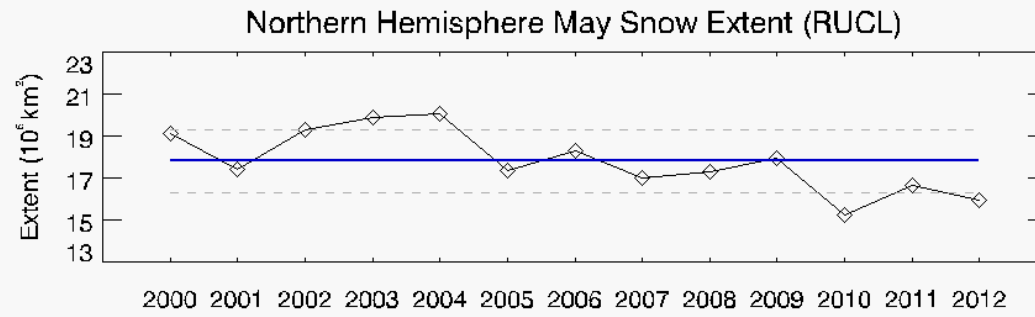
Eurasia May Snow Extent



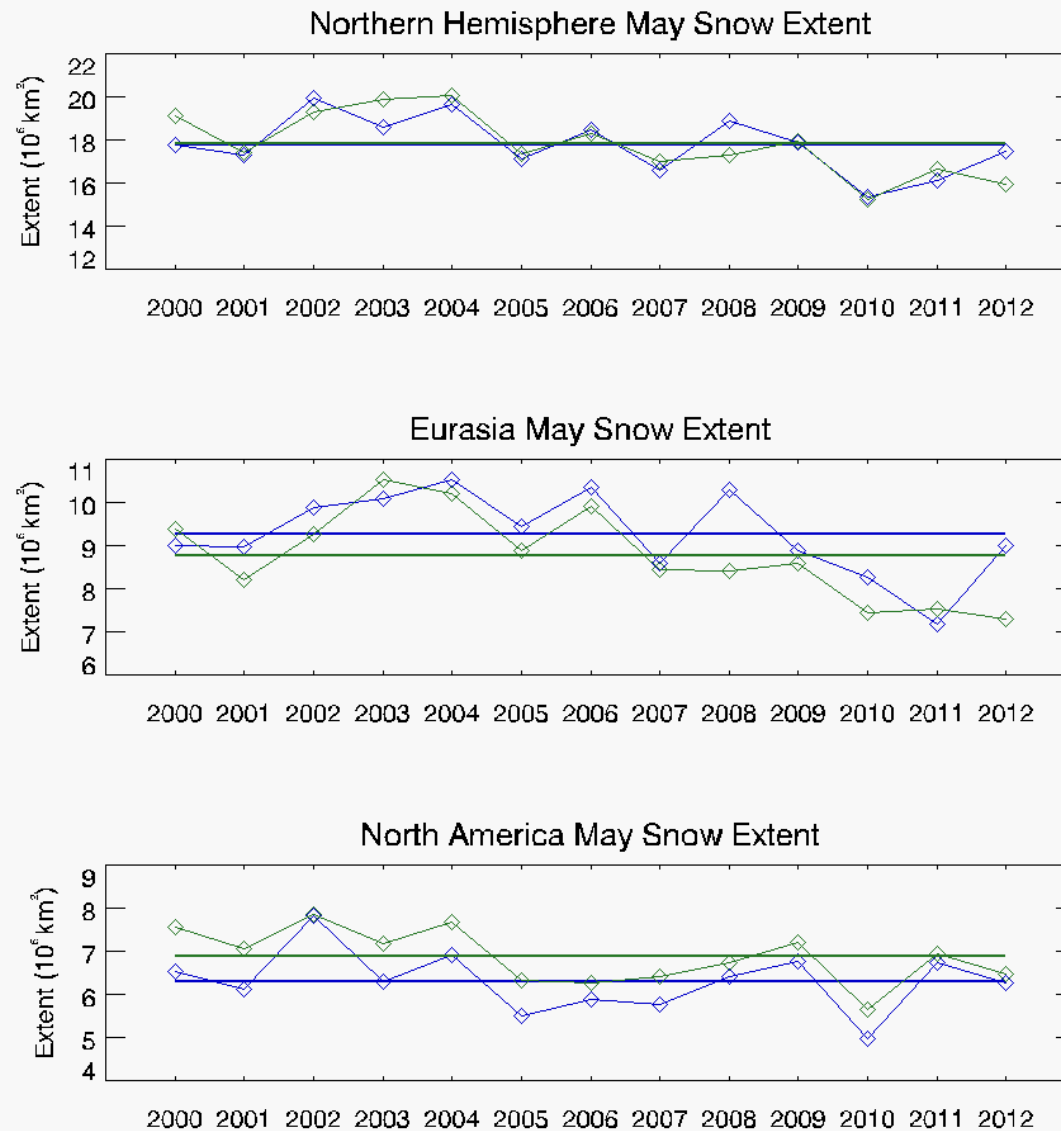
North America May Snow Extent



Rutgers (RUCL) Monthly Data



Comparison of MODIS & RUCL



Key:
Modis
RUCL

Conclusions

- **Snow cover and sea ice algorithms were mature in C5, but improvements have been made;**
- **New products will be added to C6:**
 - Cloud-gap filled snow maps;
 - Maps based on surface reflectance (instead of TOA).
- **Standard snow product improvements:**
 - Removed surface temperature screen;
 - Added screens to reduce snow commission errors.
- **13-yr time series is especially useful for regional and snow-cover global studies and creation of a CDR which can be continued in the VIIRS era.**