NESDIS Global Automated Satellite Snow Product: Current Status and Recent Results

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Outline

- Overview of the system/product
- Examples of product
- Performance in 2013-2014
- Planned Improvements

Global Multisensor Automated Snow/Ice (GMASI-Autosnow) Mapping System: Overview

Objective: Generate snow/ice cover product for use in NWP models and other operational applications.

Approach:

Synergy of optical and microwave retrievals to achieve continuity of snow maps.

Application of auxiliary environmental datasets and consistency tests to improve characterization of the snow cover

Product:

Global continuous (gap-free) maps of snow cover distribution generated daily at 4 km nominal spatial resolution

Algorithm Details

- Decision-tree threshold-based classification schemes
- Repeated daily observations used whenever available
- Climatology-based consistency checks/filters
- Optical snow retrievals are complemented with microwave data (blending)
- Blending strategy accounts for weaknesses of individual techniques
- Recurrent gap-filling (uses previous day snow map as the "first guess")
- Exclusion regions
  - Low elevation (<1km) regions in tropics (25N-25S) [assumed snow-free]
  - Antarctica [assumed always snow]
- Other datasets used by algorithms
  - Climatological snow occurrence (IMS-based, weekly)
  - Climatological surface temperature (ISCCP, monthly)
  - Surface elevation

For full details see ATBD at http://www.star.nesdis.noaa.gov/smcd/emb/snow/documents/Global_Auto_Snow-Ice_4km_ATBD_February_2014.pdf

Technical Specifications

Product Name	**GMASI-Autosnow 4 km**
Sensor(s) and applied spectral bands	METOP-A[B] AVHRR, bands 1,2,3a,4 DMSP –F16,17,18 SSMIS, 19vh, 22v,37v,85v MSG SEVIRI bands 1,2,3,6 GOES- E, W Imager bands 1,2,4
Temporal Characteristics	
Period (Start – End)	2006-current
Temporal resolution	Daily
Spatial Characteristics	
Spatial resolution / Pixel size	0.04^0 (~4km)
Spatial Coverage	Global
Map Projection	Plate Carrée
Product Format	Flat binary, geotiff, grb
Product accessible at	Operational: http://satepsanone.nesdis.noaa.gov/ southern_hemisphere_multisensor.html http://satepsanone.nesdis.noaa.gov/ northern_hemisphere_multisensor.html Quasi-operational: http://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/ multisensor_global_snow_ice.html
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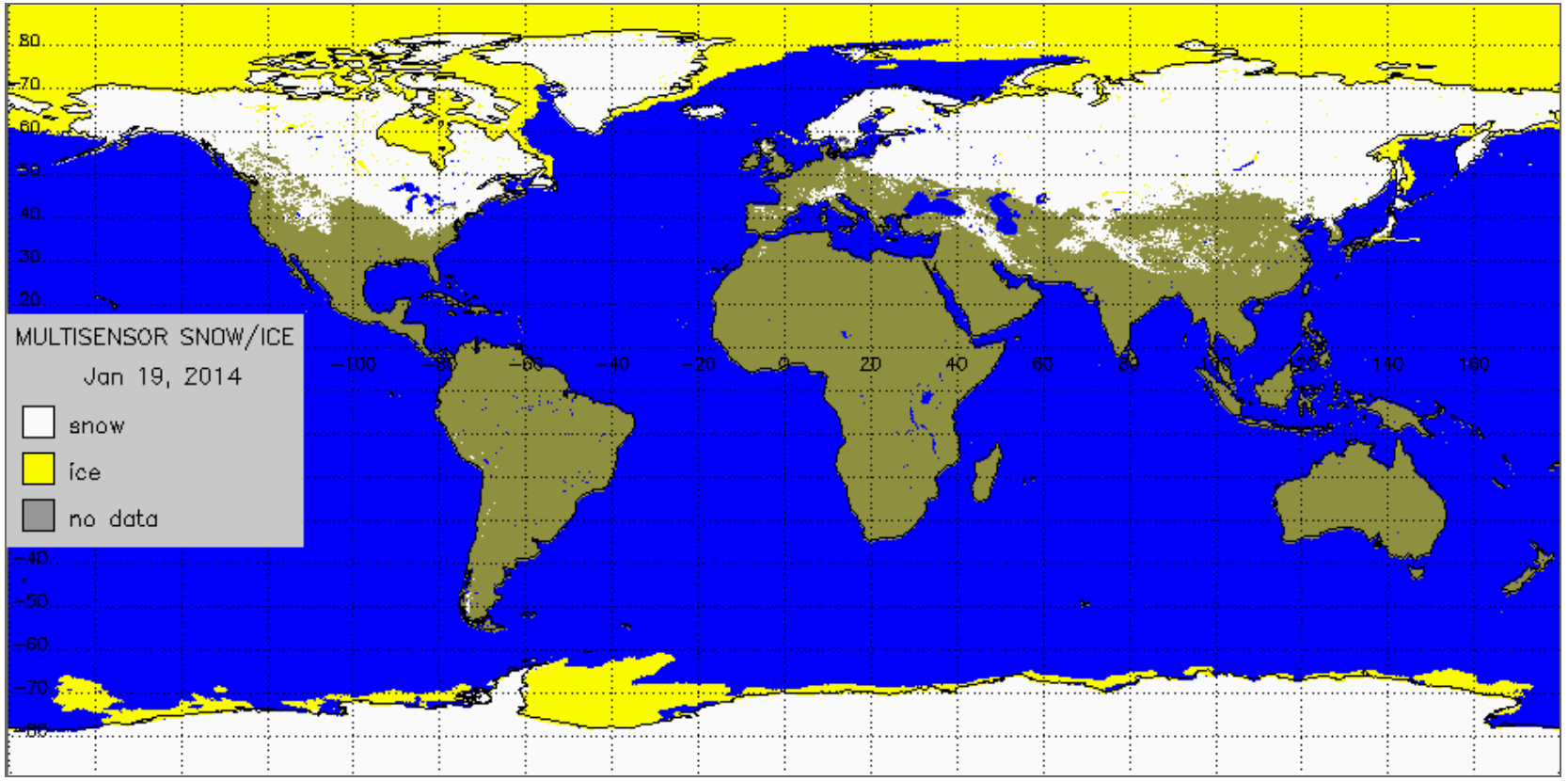
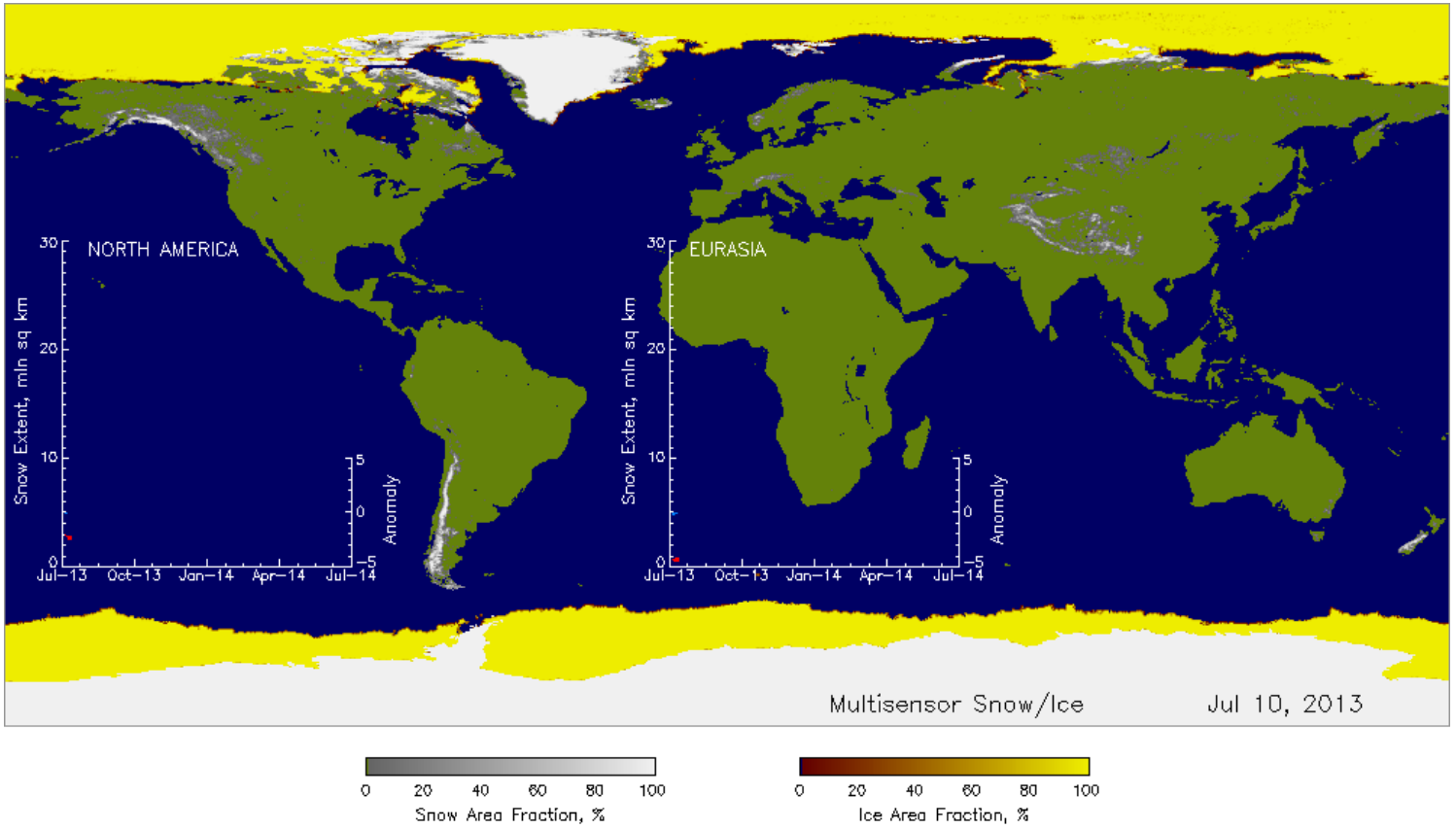
Daily Snow/Ice Map



Current day snow/ice map becomes available at ~10AM UTC the next day

On the Web: http://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/multisensor_global_snow_ice.html

2013-2014 Season



Snow and ice fraction is obtained by aggregating 4 km retrievals within 10x10 grid cell boxes

Validation Approach

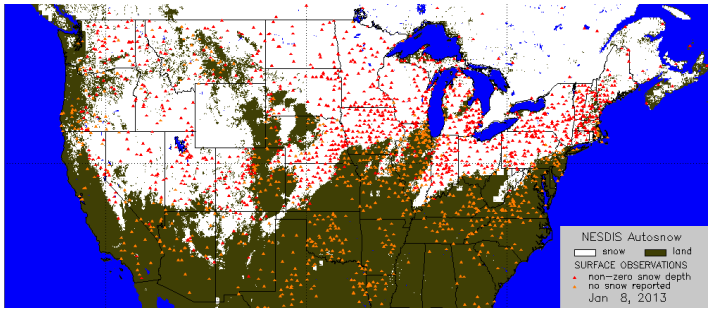
- Validation data sources
  - In situ snow depth observation data
    - WMO
    - US Coop (subsetted by NOAA CPC)
  - IMS analysis

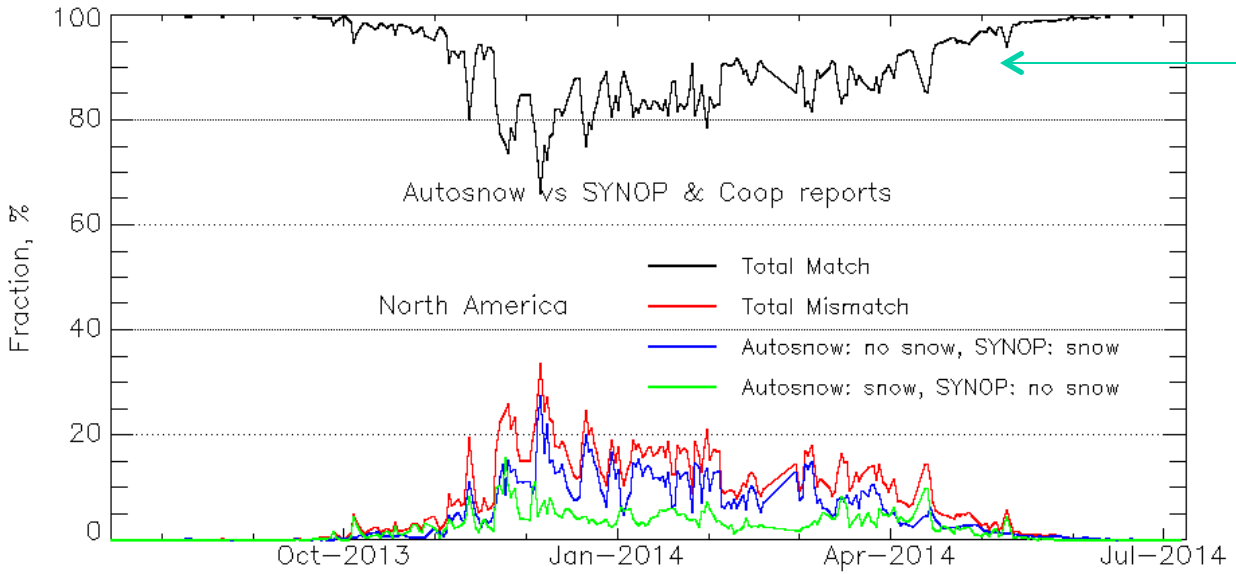
- Parameters we validate/compare
  - Binary snow extent (IMS, station data)
  - Snow area extent (IMS)
  - Snow cover duration (IMS, station data)

- Validation schedule
  - Daily (binary extent, area extent)
  - Yearly (duration)

Autosnow vs SYNOP & Coop

- Daily point-to grid comparison
- Agreement:
  - 80-90% in winter
  - over 90% yearly average
- Most stations are in the CONUS region





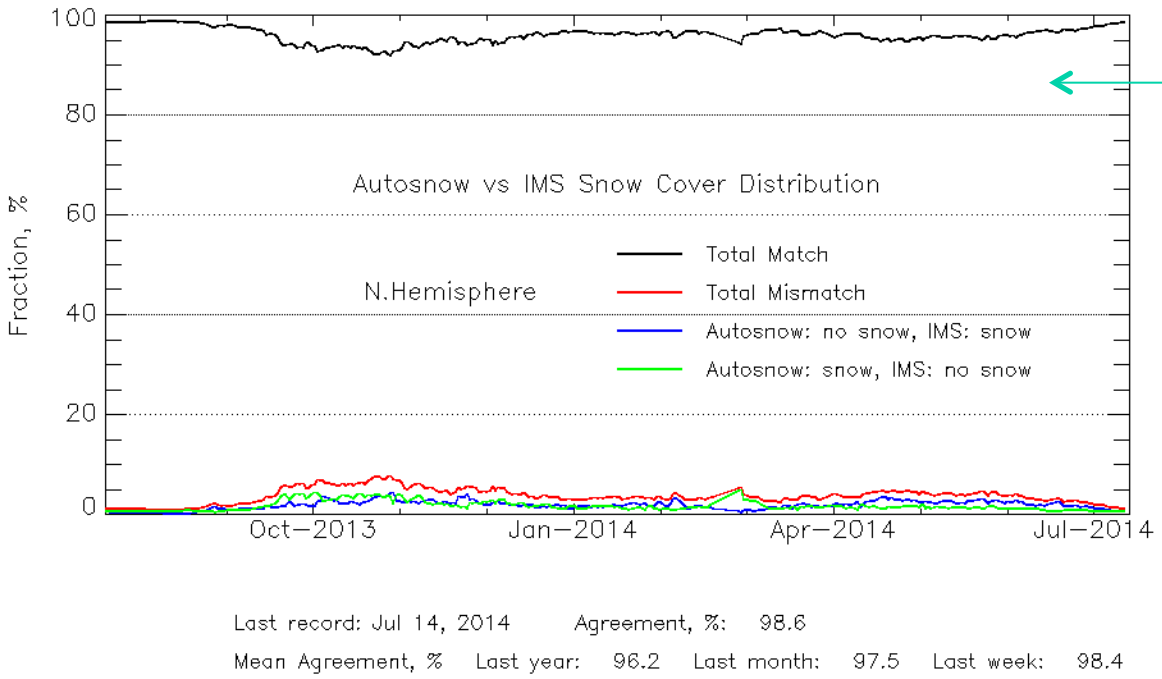
Percent of correct "snow" and correct "no-snow" identifications

Station data are not quality controlled

Last record: Jul 9, 2014 Agreement, %: 99.9

Mean Agreement, % Last year: 93.6 Last month: 99.9 Last week: 99.9

Binary Snow Cover: Autosnow vs IMS compared daily

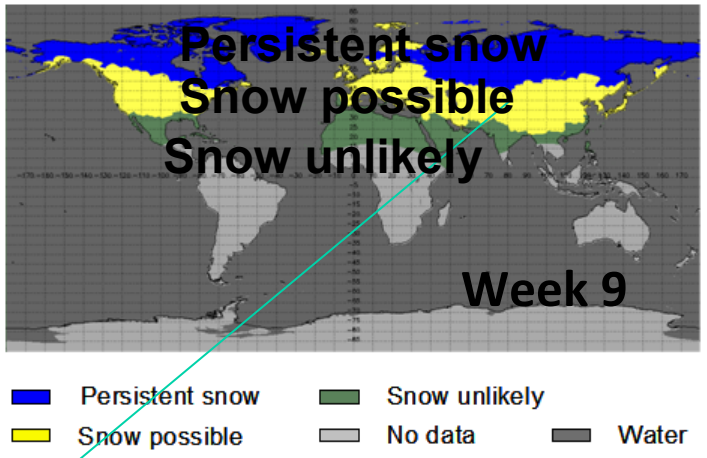


Percent of correct "snow" and correct "no-snow" identifications

- IMS resampled to Plate Carre projection
- Grid-to-grid match-ups over N.Hemisphere, N.America, Eurasia
- Agreement , continental-scale
  - 90-95% in winter
  - over 95% yearly average (96.2% in the last year)

Autosnow vs IMS Comparison: Consider Climatic Snow Occurrence

Climatological Snow Occurrence

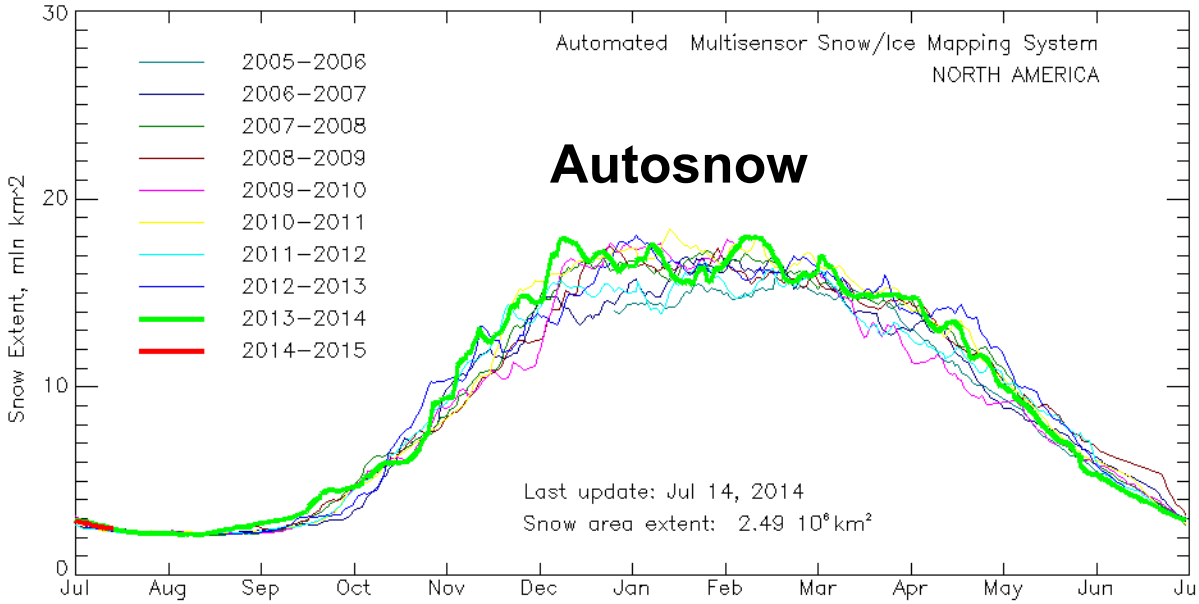


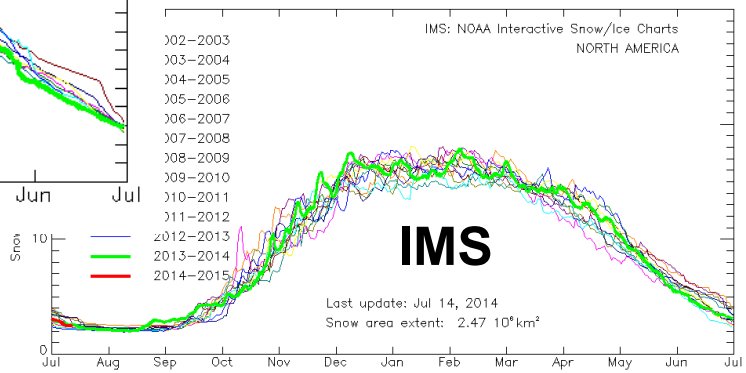
Autosnow-IMS Mean Agreement (2013-2014)

Region	Agreement, %	
	All Land Area	***"Snow Possible"***
Northern Hemisphere	96.2	90.9
Eurasia	96.5	91.6
North America	95.6	90.0

Agreement drops by ~5% if the comparison is reduced to the region where snow may or may not exists at the time of observation ("snow possible").

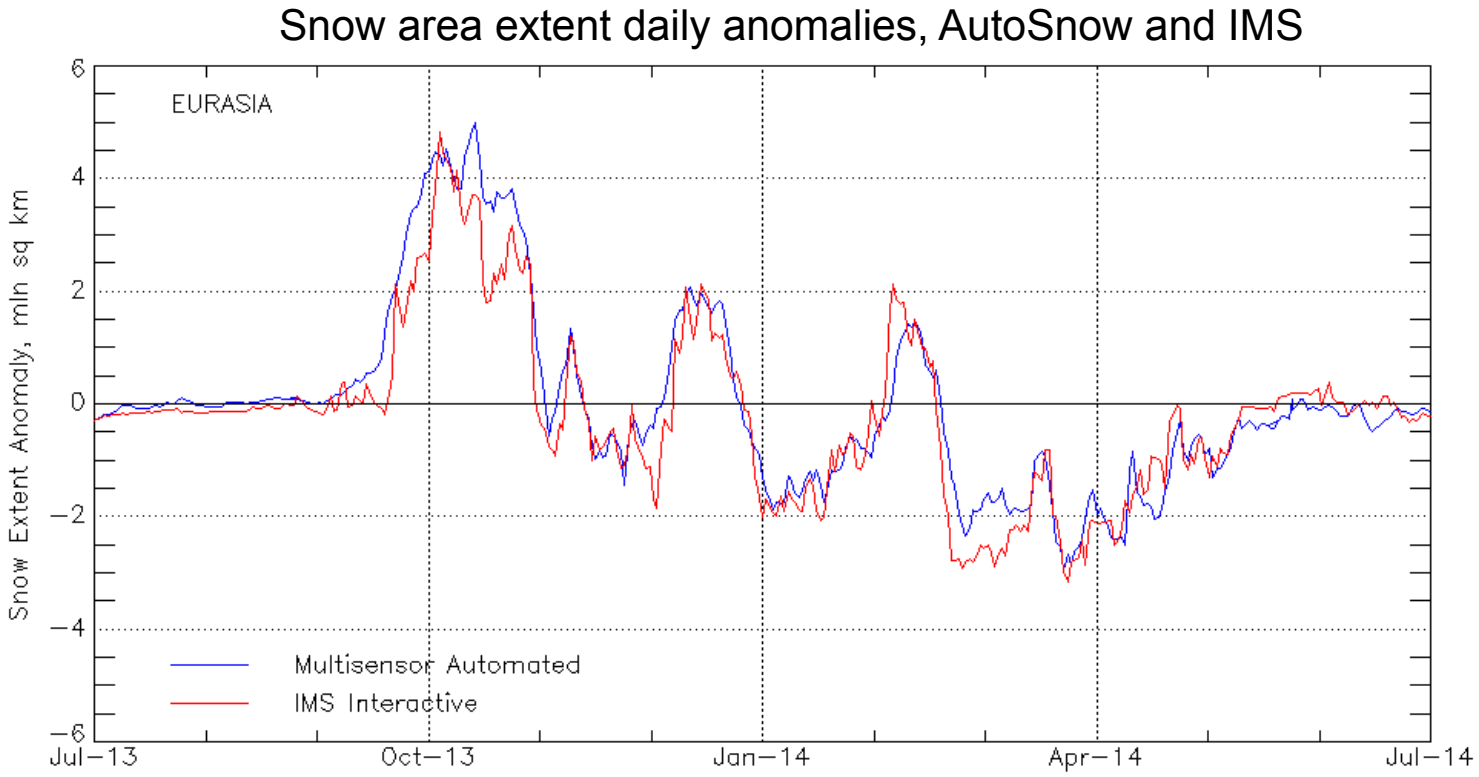
Snow Extent Monitor





- Less short-term variations in the Autosnow time series as compared to IMS
- Land-water masks are different. This may affect the agreement.
- Autosnow vs IMS Northern Hemisphere snow extent mean abs. difference:
  - Daily: 3.3% (October-March)
  - Yearly: 1.5%

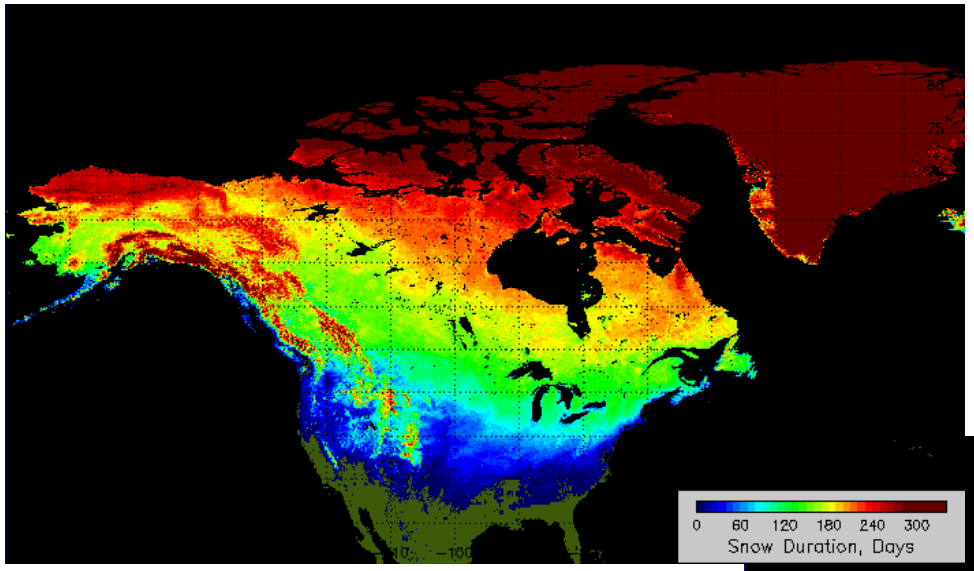
Snow Extent Anomalies



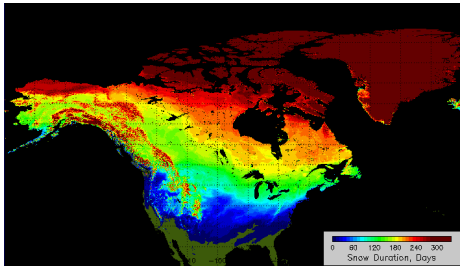
Correlation of daily snow extent anomalies, Autosnow vs IMS:

- 0.85 in North America
- 0.94 in Eurasia

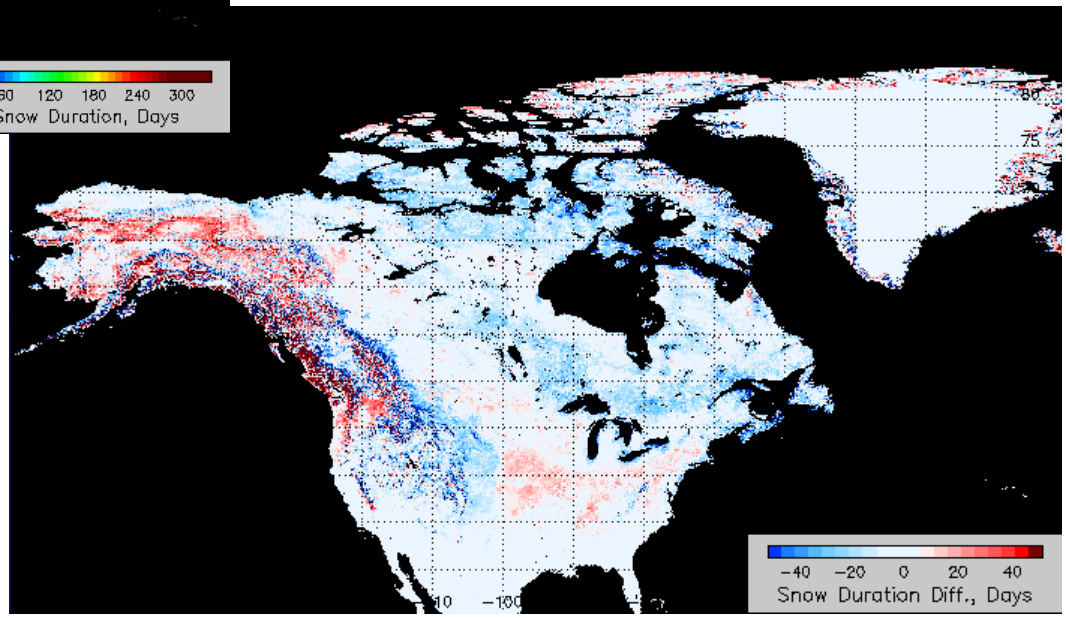
Snow Cover Duration



Snow Duration 2013-2014, Autosnow



Snow Duration, IMS



Autosnow-IMS Snow Duration Difference
2013-2014 winter season

<u>Autosnow vs IMS Duration, NH</u>

Mean bias : -1.1 days
Mean abs difference: 11.2 days

Largest differences are in the mountains. Some disagreement may be caused by resampling.

Autosnow: Problems

- Shallow snow, snow in forests, misinterpretation of clouds, topographic/ vegetation/cloud shadowing.
- None of the sensors can “see” through precipitating clouds
  - Delayed reproduction of changes in the snow cover distribution/extent
  - Short-term snow on-off events are often missed
- Alternating use of optical and MW observations may cause spurious variation in the mapped snow cover
- Snow mapping errors may affect the blended product for several following days.
- No true validation possible in the Southern Hemisphere (SH).

Further Plans

- Improve resolution to 1-2 km globally (2 km SH snow map has been implemented operationally in 2013)
- Add AMSR2/GCOM-W1: improved spatial resolution
- Replace AVHRR with VIIRS: improved spatial resolution, potentially better cloud detection
- Reprocess historical data, fill in existing data gaps

Summary, Recommendations

- Autosnow provides adequate and accurate characterization of the global snow cover. Autosnow demonstrates better agreement to IMS than to in situ data.
- Disagreement between snow cover datasets increases with narrowing of the comparison region around the snow cover boundary.
- Snow cover climatology has to be accounted for when evaluating the binary snow cover products.
- When comparing the estimated snow area extent difference in the land/ water mask should be addressed.

THANK YOU

Links

NESDIS STAR Automated snow remote sensing page:

http://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow.htm

NESDIS OSDPD Operational Automated Snow Maps:

http://satepsanone.nesdis.noaa.gov/northern_hemisphere_multisensor.html

http://satepsanone.nesdis.noaa.gov/southern_hemisphere_multisensor.html

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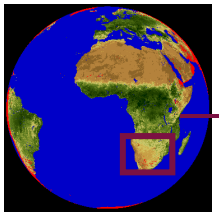
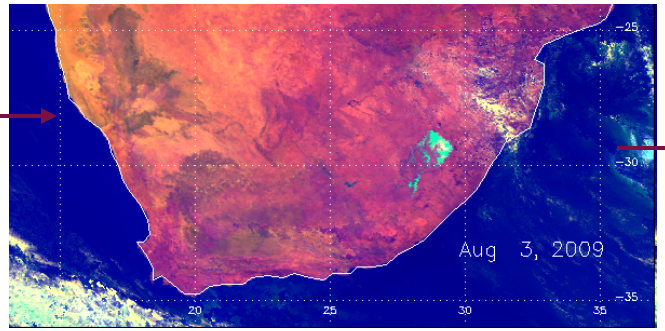
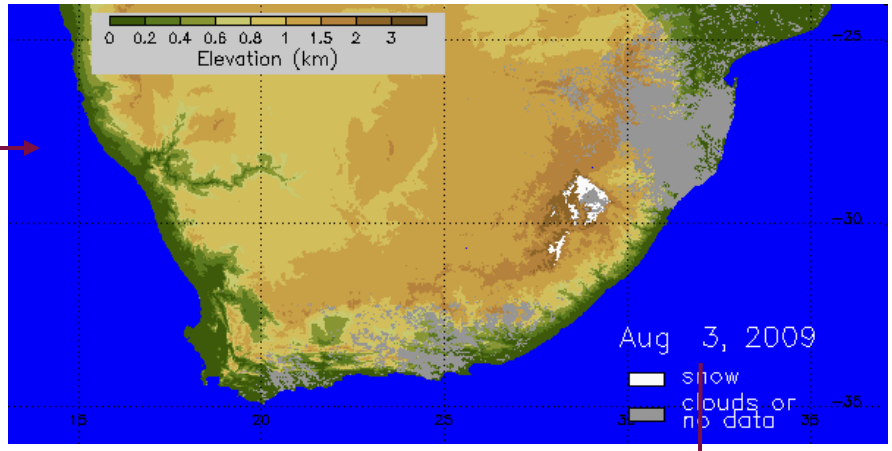
BACKUP SLIDES

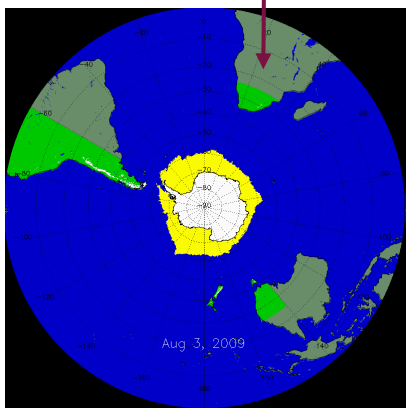
Southern Hemisphere



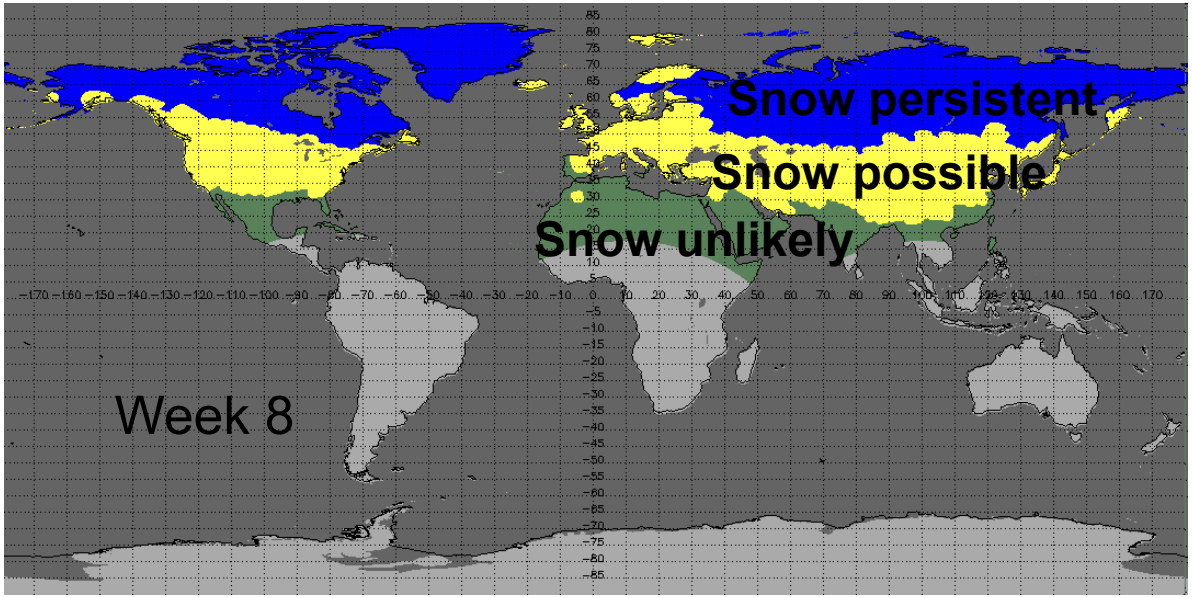




- Snow is mapped solely with optical data
  - METOP AVHRR: South America, Australia, New Zealand
  - MSG SEVIRI: Southern Africa
- Ice is mapped solely with microwave data
- Antarctica is assumed always snow covered



Merging optical and MW snow



Weekly Climatic Three-Category Map of Snow Occurrence

Strategy depends upon snow occurrence probability and elevation

"Snow Persistent": Use snow from both optical and MW

"Snow Possible": Use optical snow when clear, MW when cloudy

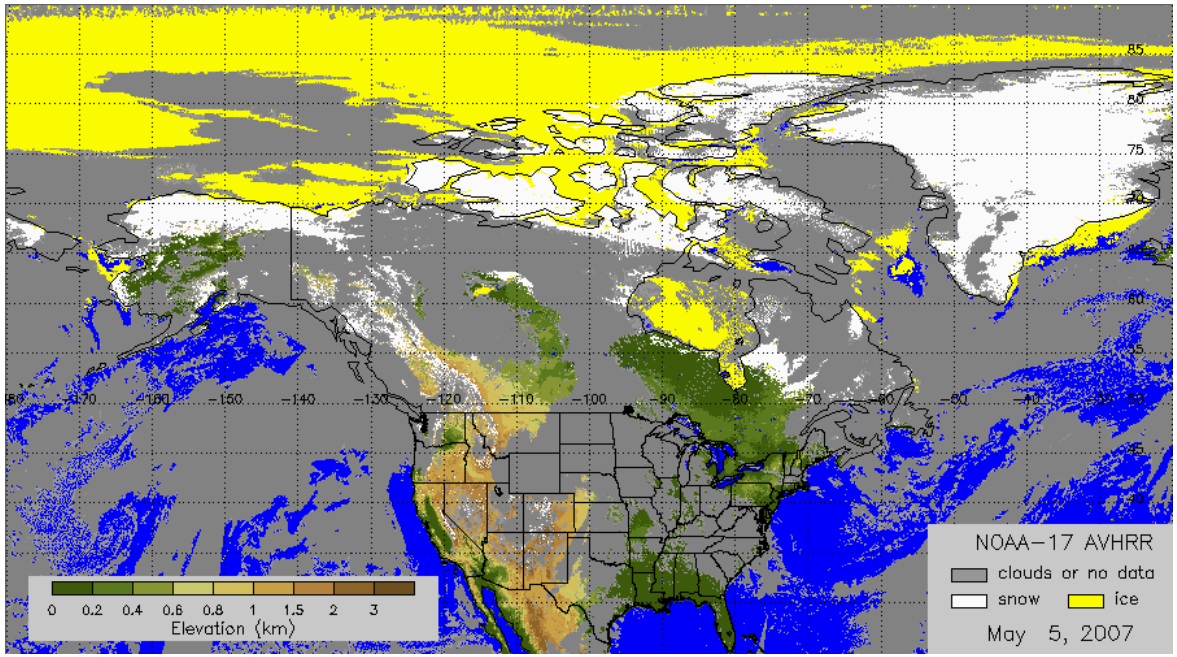
"Snow Unlikely": Use optical only, only elevated areas (H > 1 km)

Optical snow mapping

Snow identification: Decision-tree threshold-based technique

Temporal consistency test used with geo satellite data for better snow/cloud discrimination

Gaps due to clouds (40-60% of land area)



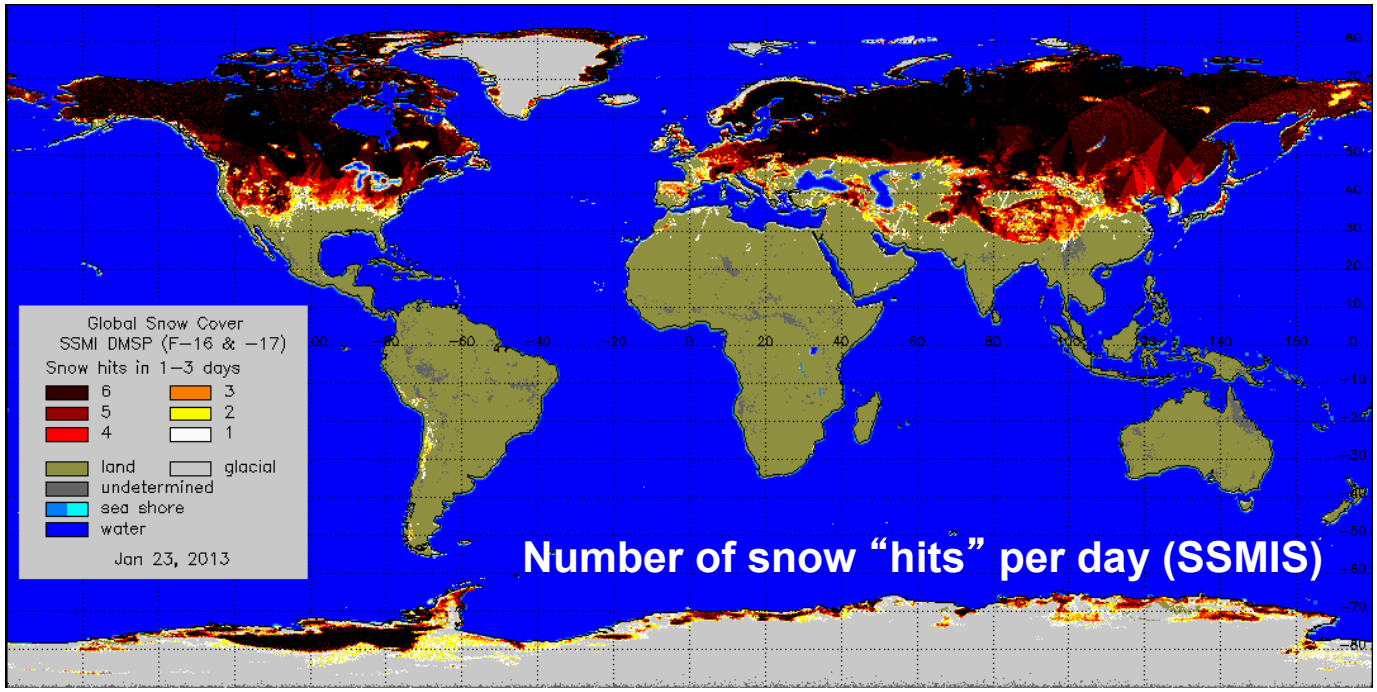
Daily AVHRR snow map (NOAA NESDIS)

Routine snow retrievals are performed with

- METOP AVHRR
- GOES-E, -W Imager
- Meteosat SEVIRI

Microwave snow mapping

DMSP SSMIS: Spectral identification + Temporal consistency test



- Snow retrievals from 3 DMSP satellites (6 overpasses per day)
- "Confirmed" snow: snow detected 3 or more times during a day
- Only "confirmed snow" over plain areas is used in the blended map