SYNERGY OF SATELLITE OPTICAL AND MICROWAVE OBSERVATIONS FOR BETTER SNOW COVER MONITORING

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OUTLINE

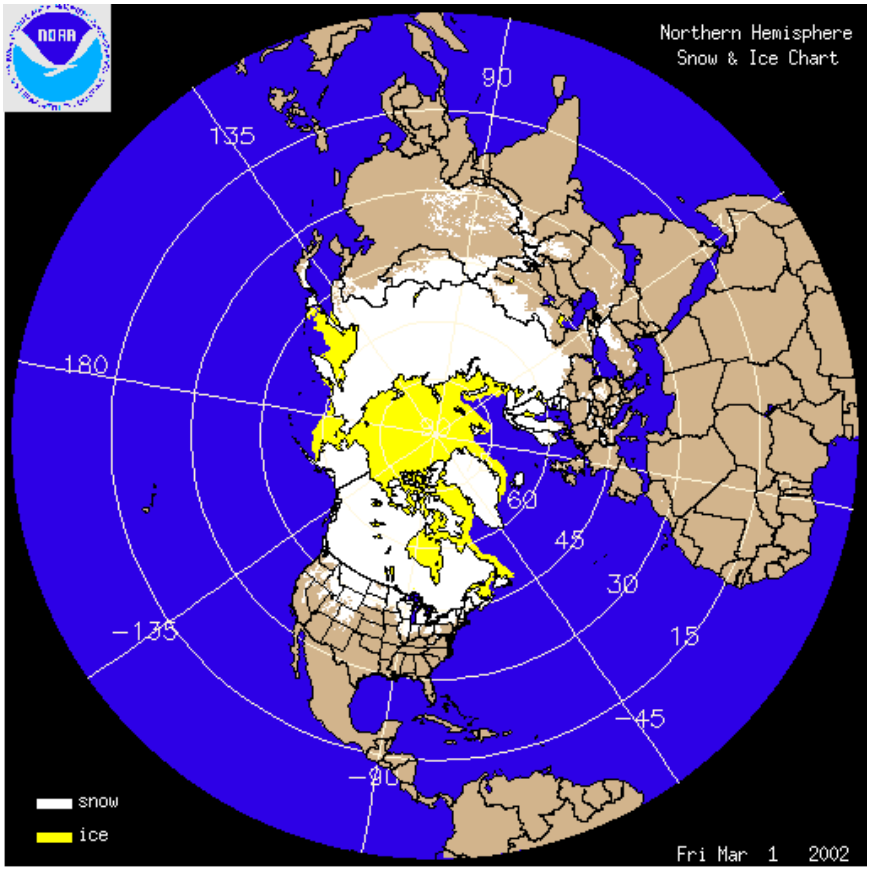
- Motivation
- Existing techniques and products
- NESDIS Multisensor Snow/Ice Mapping System
- Currents issues and plans

SNOW COVER: NCEP* MODELS NEEDS

- Continental to global scale coverage
- Spatial continuity (no gaps)
- Spatial resolution better than model grid size
  - < 8 km (target: 1 km)
- Daily updates (target: 2 times a day)
- Operational
- High accuracy, no biases

*NCEP: National Centers for Environmental Prediction of NWS

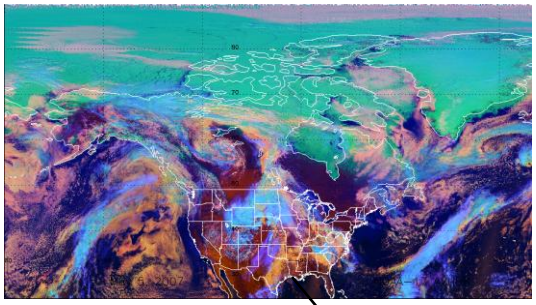
INTERACTIVE SNOW AND ICE MAPS (IMS)



- Routine operations since 1972
- Maps drawn by analysts
- Produced daily
- Northern Hemisphere coverage
- ~24km resolution since 1998
- ~4 km resolution since 2004
- “Snow” or “no snow”
- Used in all NOAA NWP models

On the Web: http://www.natice.noaa.gov/ims/

OPTICAL SNOW MAPPING

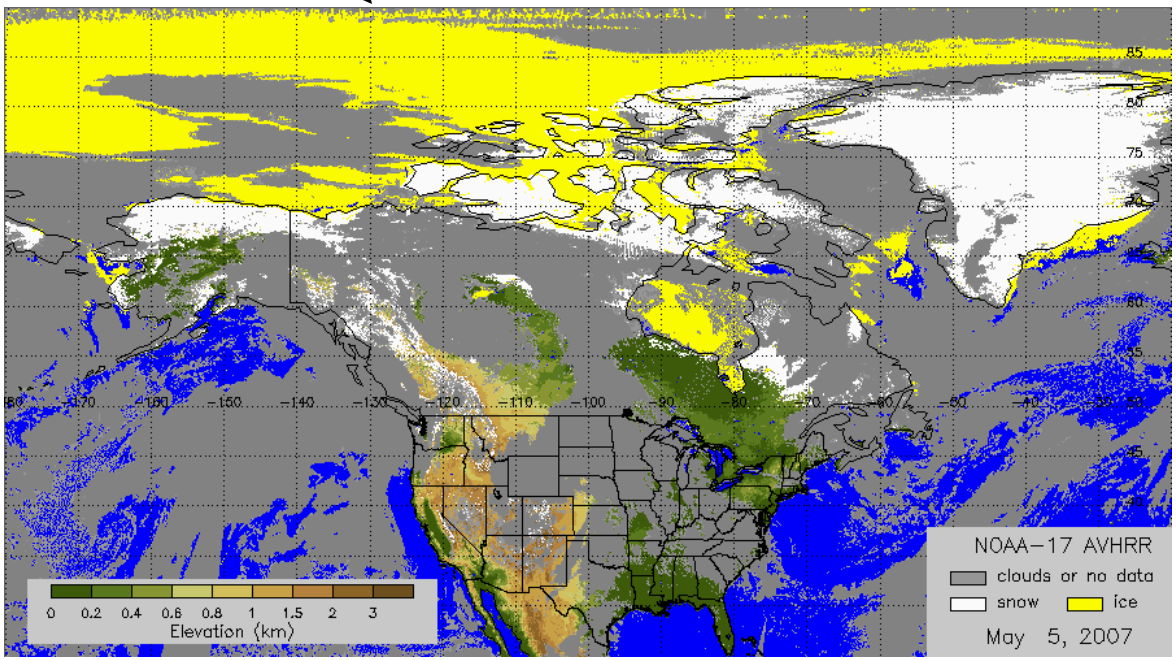


High spatial resolution (up to 0.5 km)

Gaps due to clouds (~40% of land area)

Needs daylight

Accuracy: ~90-95% in clear sky conditions



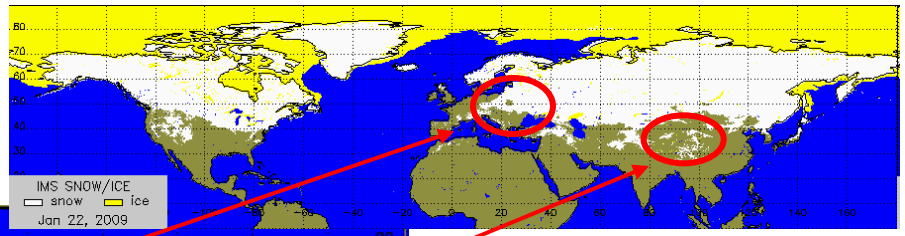
Geo vs polar satellites:

- Less cloud gaps but
- Limited area coverage

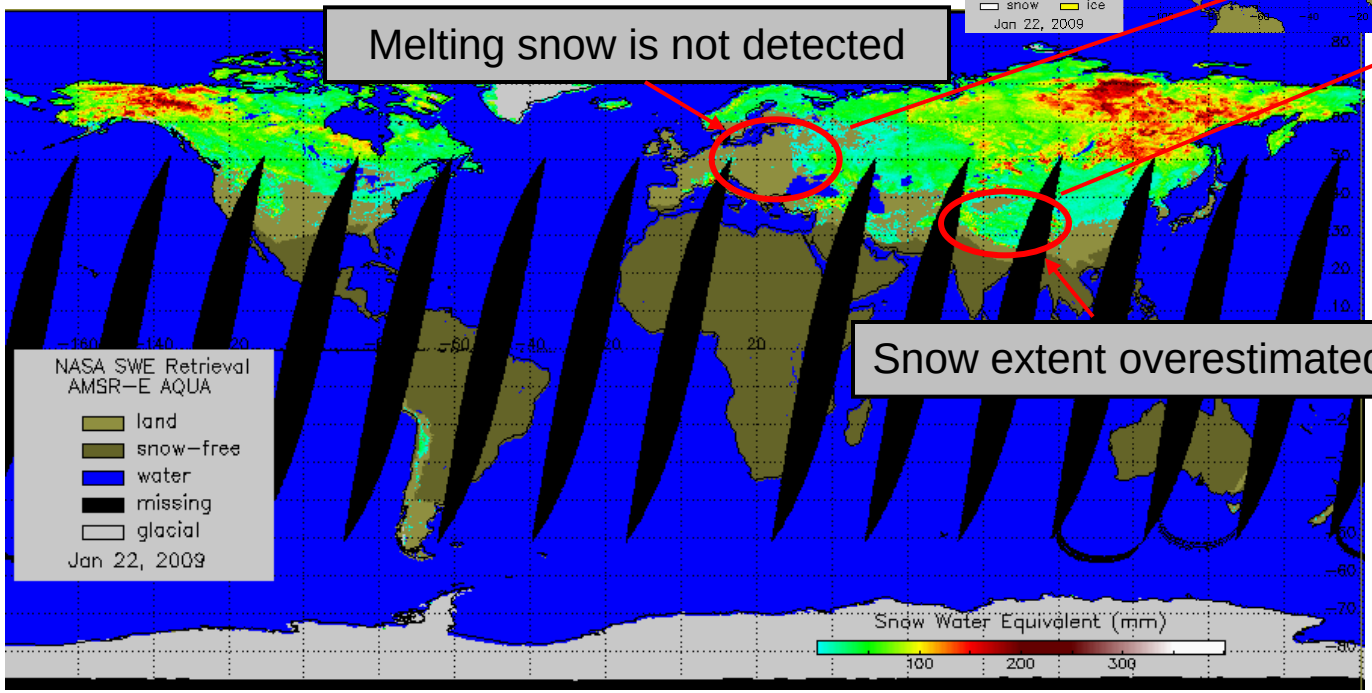
Daily AVHRR snow map (NOAA NESDIS)

SNOW MAPPING IN MICROWAVE

- All weather, day/night capability
- Coarse spatial resolution (~ 15…100 km)
- Underestimates snow in spring and fall
- Overestimates snow in the mountains
- Accuracy: ~75-80%



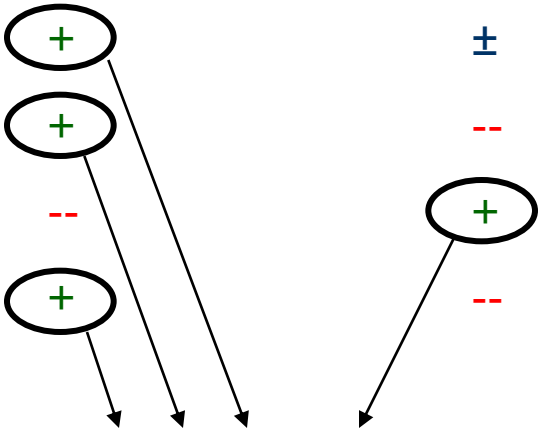
NOAA IMS (interactive)



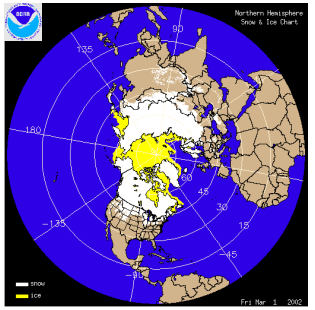
AMSR-E SWE

HOW TO COMBINE TWO PRODUCTS ?

NWP and climate model needs	*Snow cover products*	
	Optical	*Microwave*
High accuracy	+	±
No biases (regional or seasonal)	+	--
Daily update (continuity)	--	+
High spatial resolution	+	--



What is the optimal way to combine two techniques/products ?



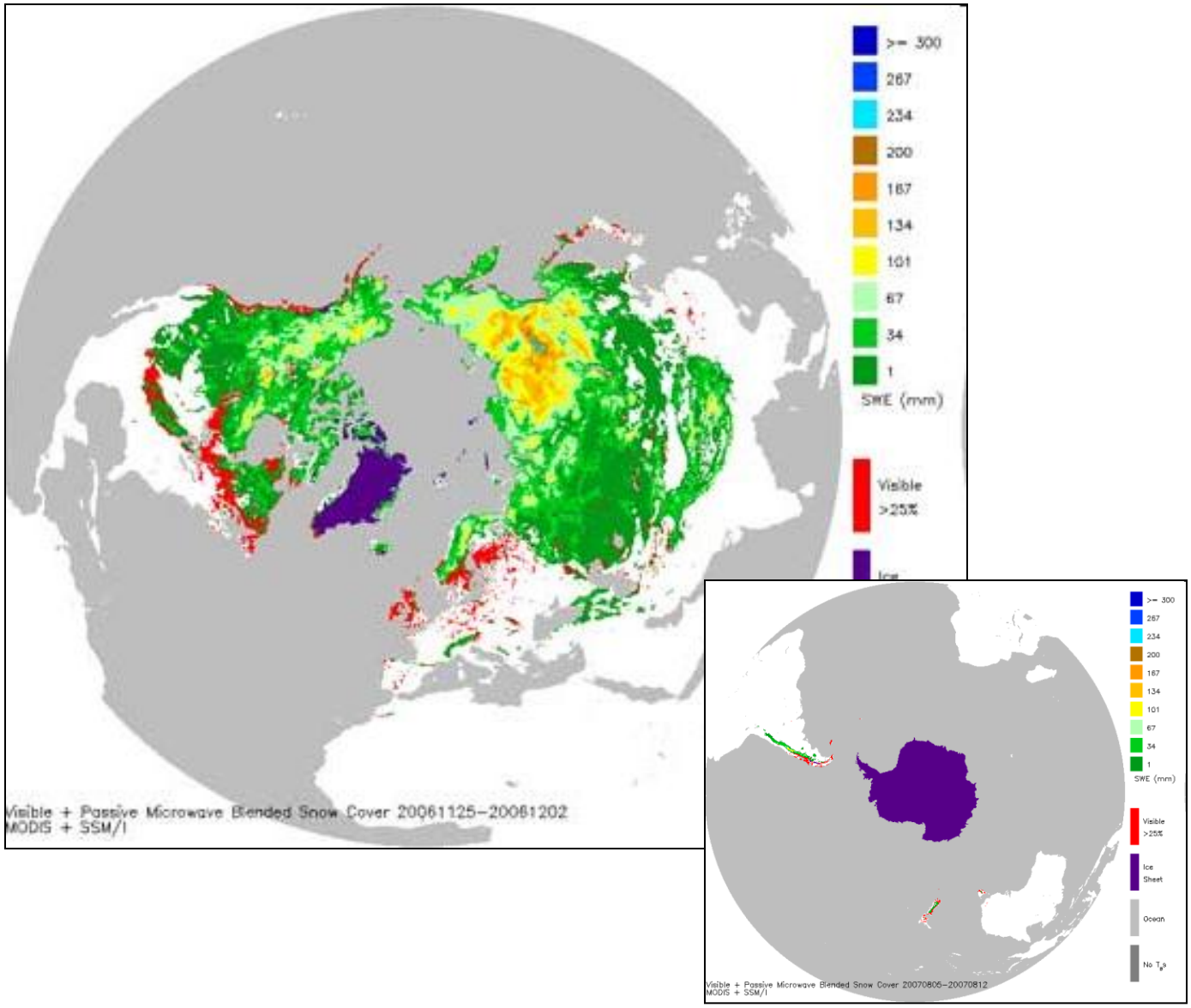
NSIDC BLENDED MAP (Armstrong et al.)

Features

25 km resolution

Weekly

SSMI+MODIS



NASA BLENDED MAP (Foster et al. 2007)

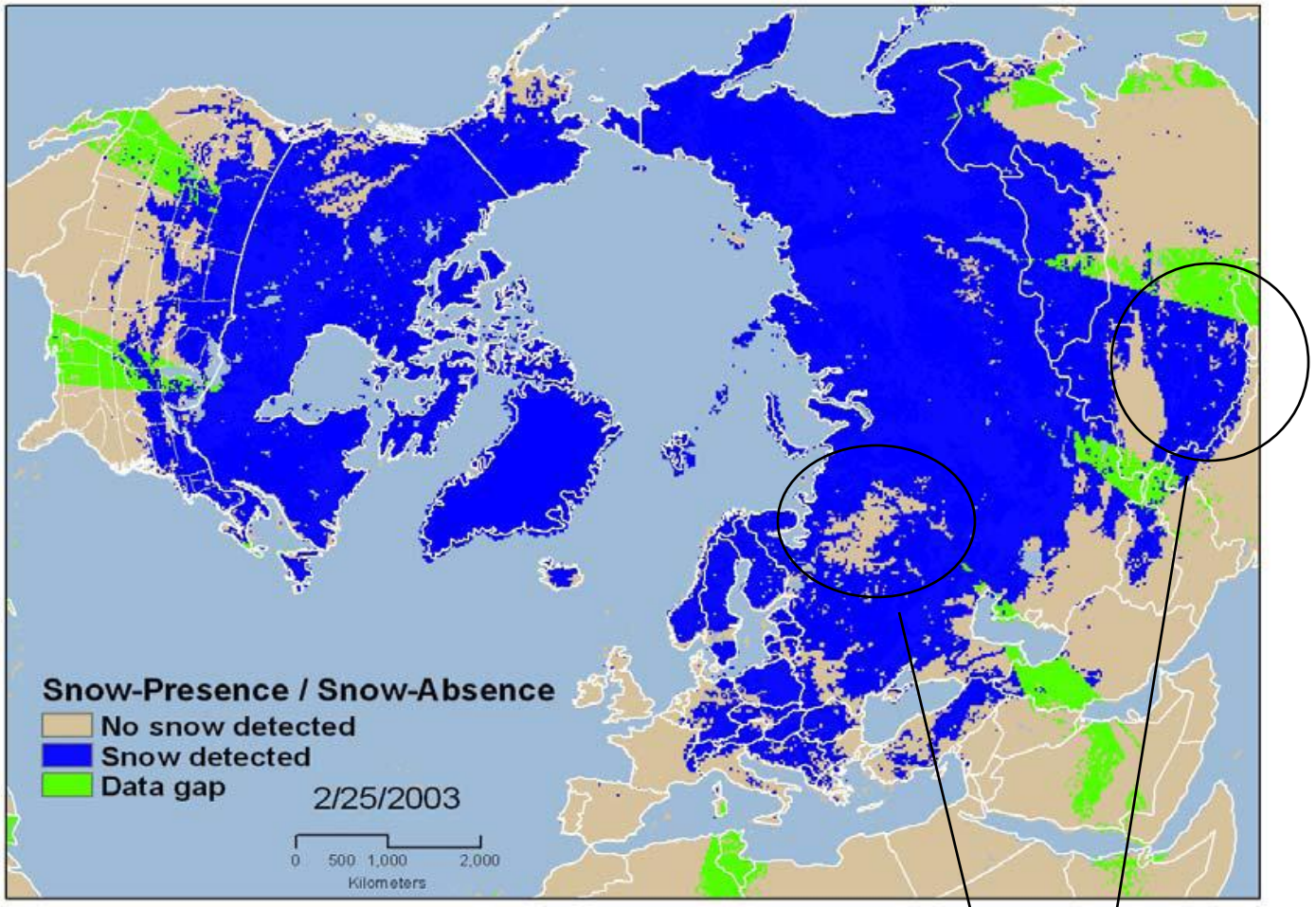
Features

Daily

Global

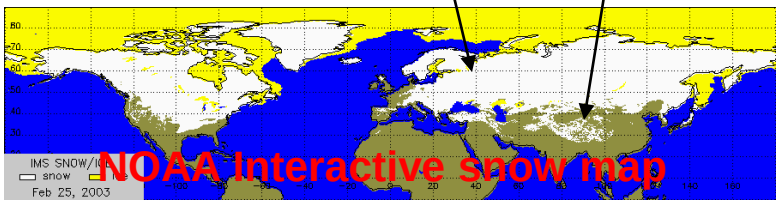
25 km resolution

MODIS+AMSR-E



- Heavily relies on MW retrievals

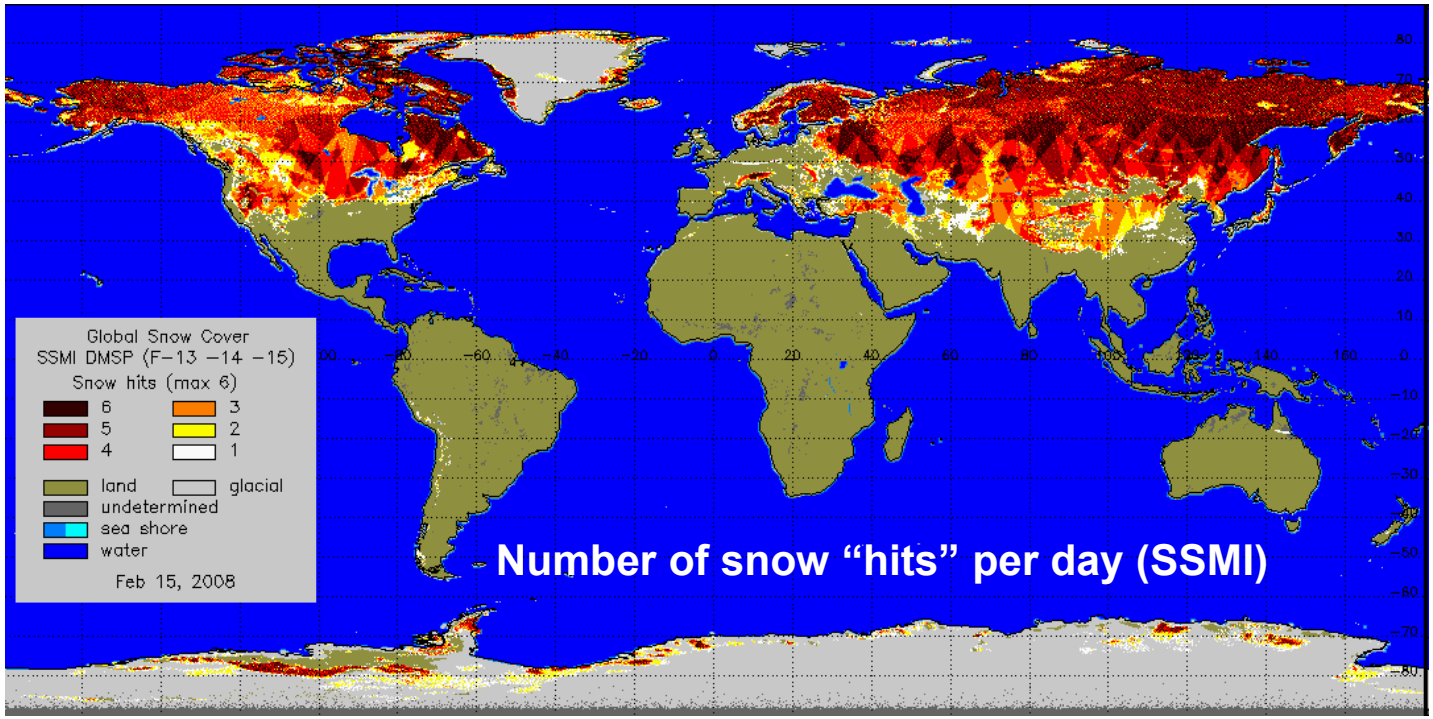
- MW errors propagate into the blended product



WHAT'S DIFFERENT IN NESDIS APPROACH ?

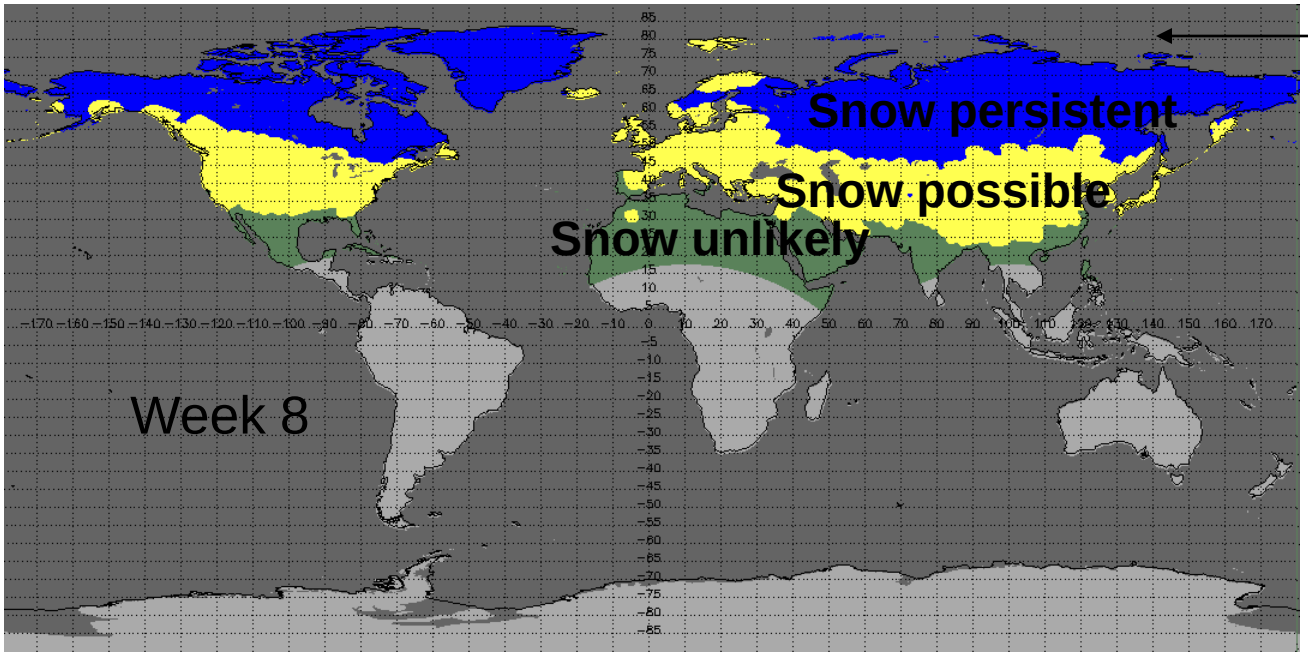
- Snow products from multiple sensors/platforms (polar, geo)
  - Allows for more conservative snow mapping from individual sensors
- More cautious approach to using microwave retrievals
- Extensive use of auxiliary data in the blending
  - Snow climatology
  - Terrain (mountains vs plains)
  - Vegetation cover (forest vs grasslands)
- Recurrent technique (inertial first guess)
  - "Day-1" product complements remaining gaps in current day product

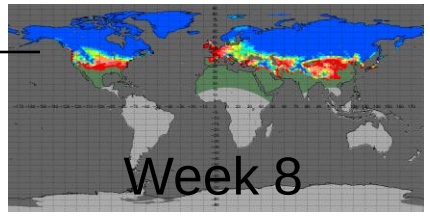
PROCESSING MICROWAVE DATA



- Snow retrievals from 3 satellites (6 overpasses per day)
- "Confirmed" snow: when snow is detected 3 or more times in a day
- Only "confirmed snow" over low elevation areas is further used
- Not used:
  - "No snow" identifications
  - Snow in mountains
  - Snow over mixed land/water scenes

USE OF SNOW COVER CLIMATOLOGY





Snow frequency of occurrence

Based on NOAA weekly snow charts 1972-1998

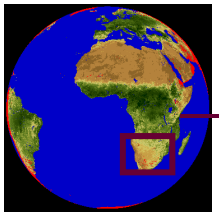
Merging Optical and MW snow

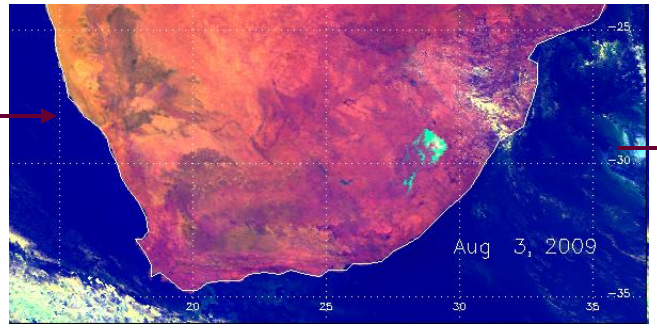
"Snow Persistent": Add snow from both optical and MW

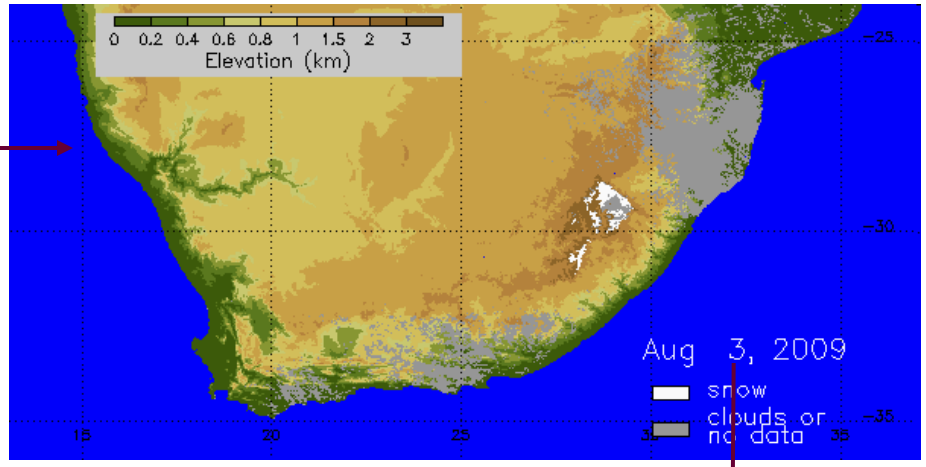
"Snow Possible": Optical snow when clear, MW when cloudy

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

SOUTHERN HEMISPHERE

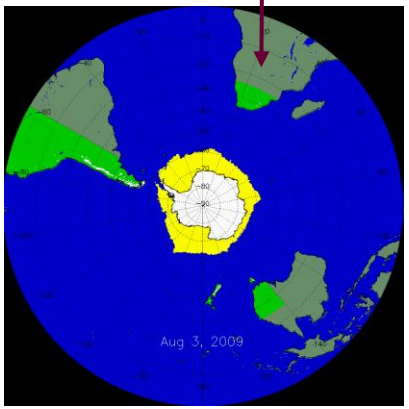






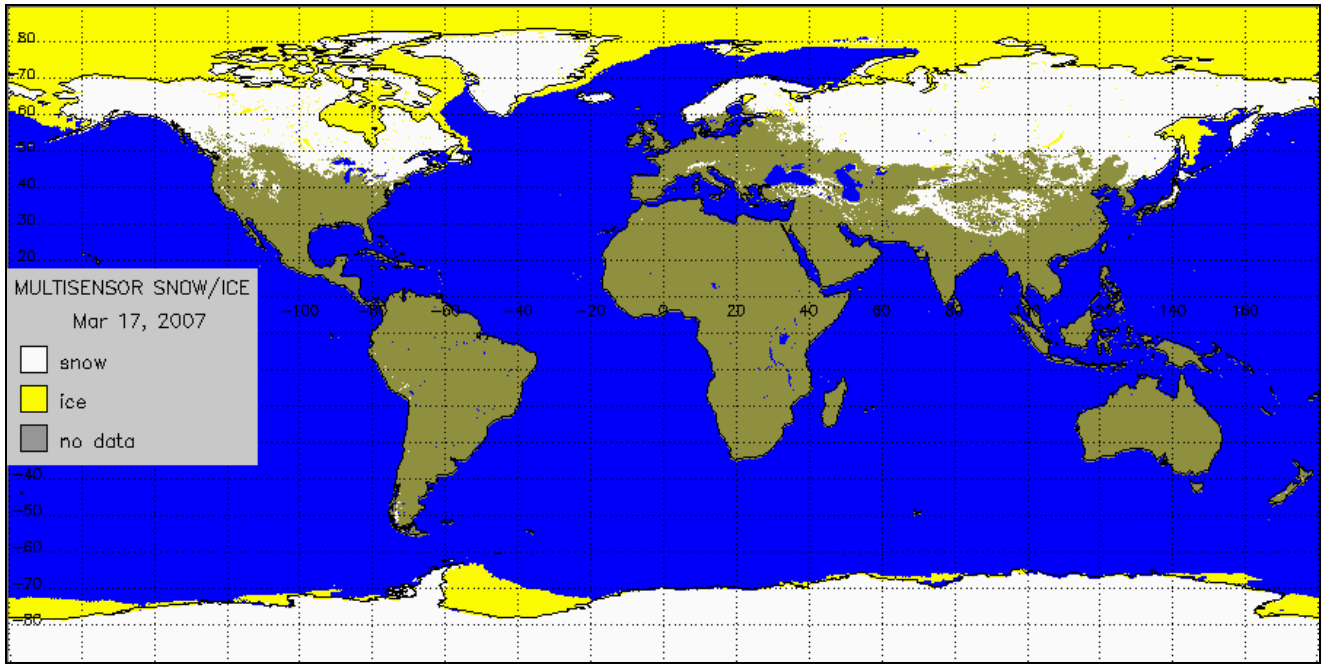
- Snow is mapped solely with optical data
  - NOAA AVHRR: South America, Australia, New Zealand
  - MSG SEVIRI: South Africa

- Antarctica is assumed snow covered



NESDIS MULTISENSOR SNOW/ICE MAPPING SYSTEM

North America: since 2000, Global: since 2006



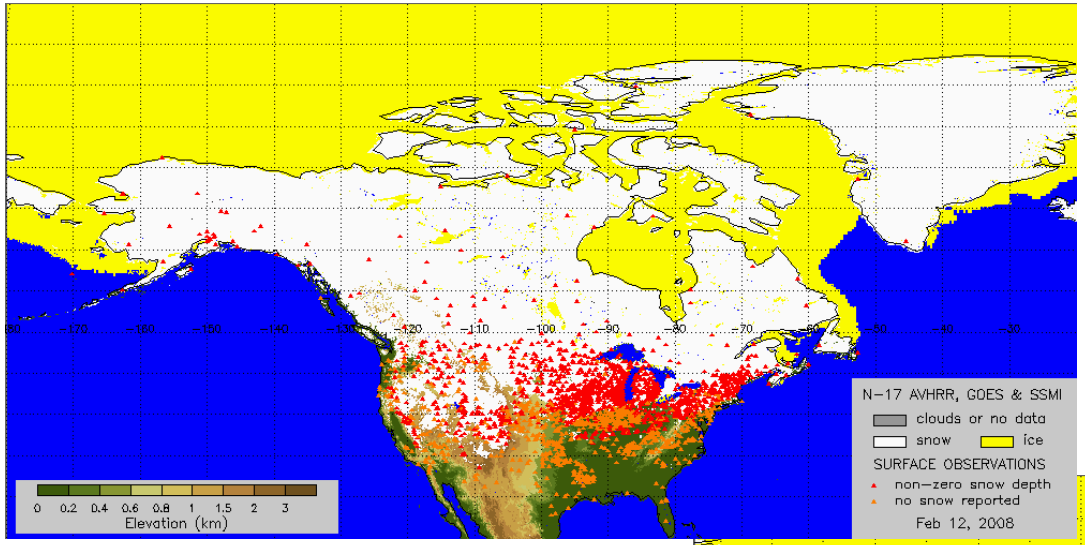
- Automated
- Daily
- Global
- 4 km resolution

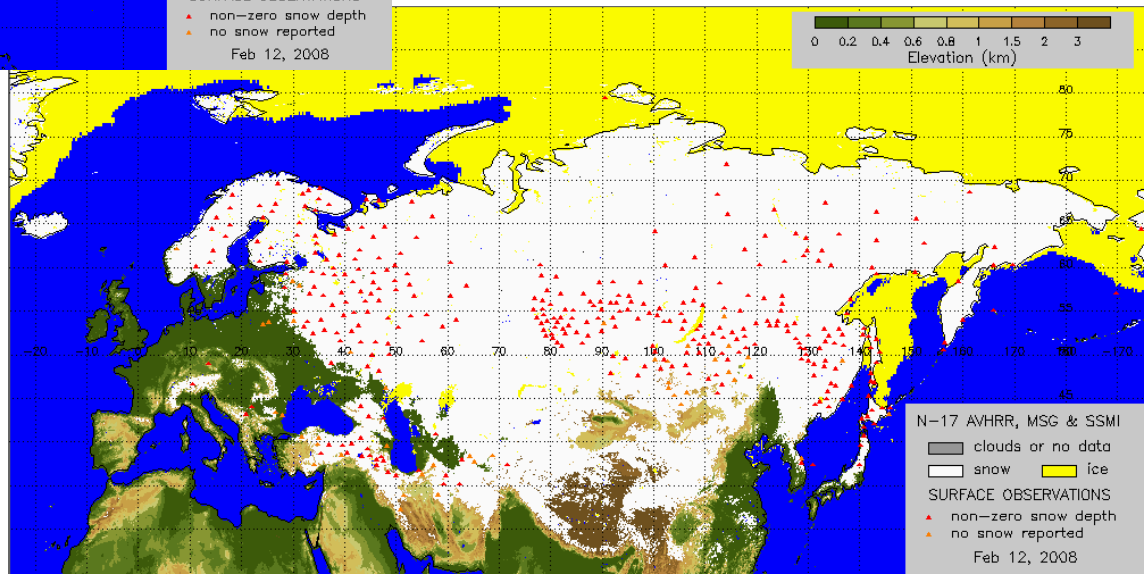
Current configuration: 8 satellite sensors

Imager/GOES-E and -W (geo)
SEVIRI/MSG (geo)

SSMI(S)/DMSP-15,16,17 (polar, microwave)
AVHRR/NOAA-17, 18 (polar, vis/IR)

VALIDATION AGAINST SURFACE OBS



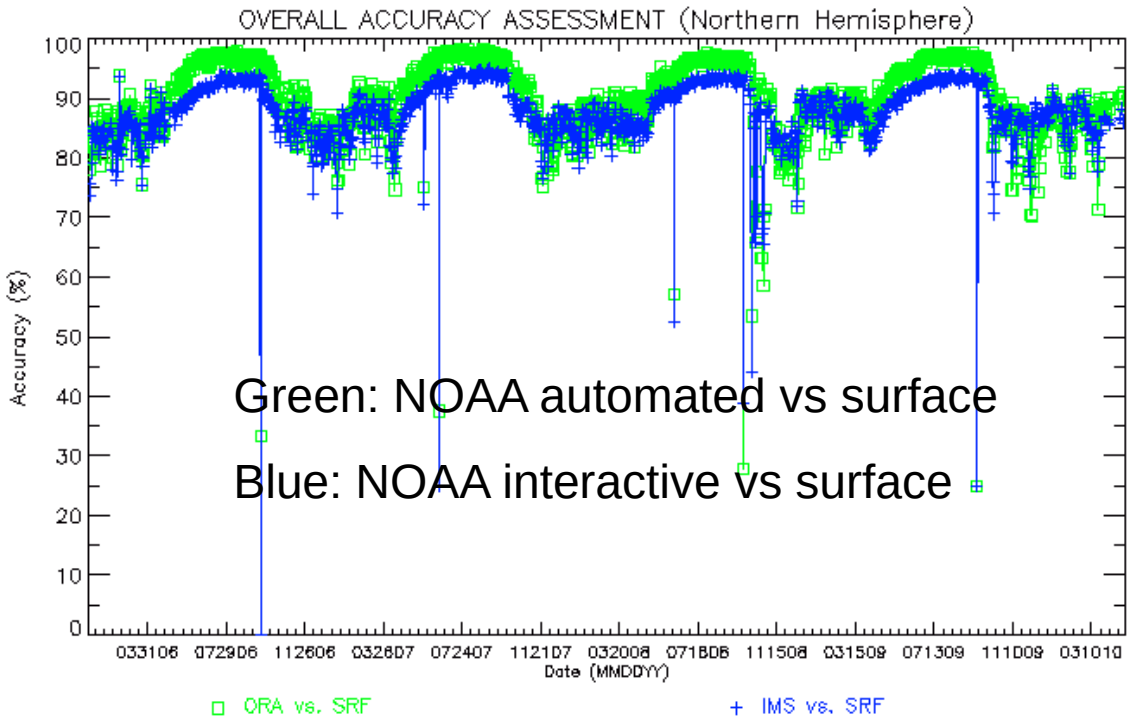


Comparison performed daily

Up to 2700 snow reports used

Most stations are in midlatitudes

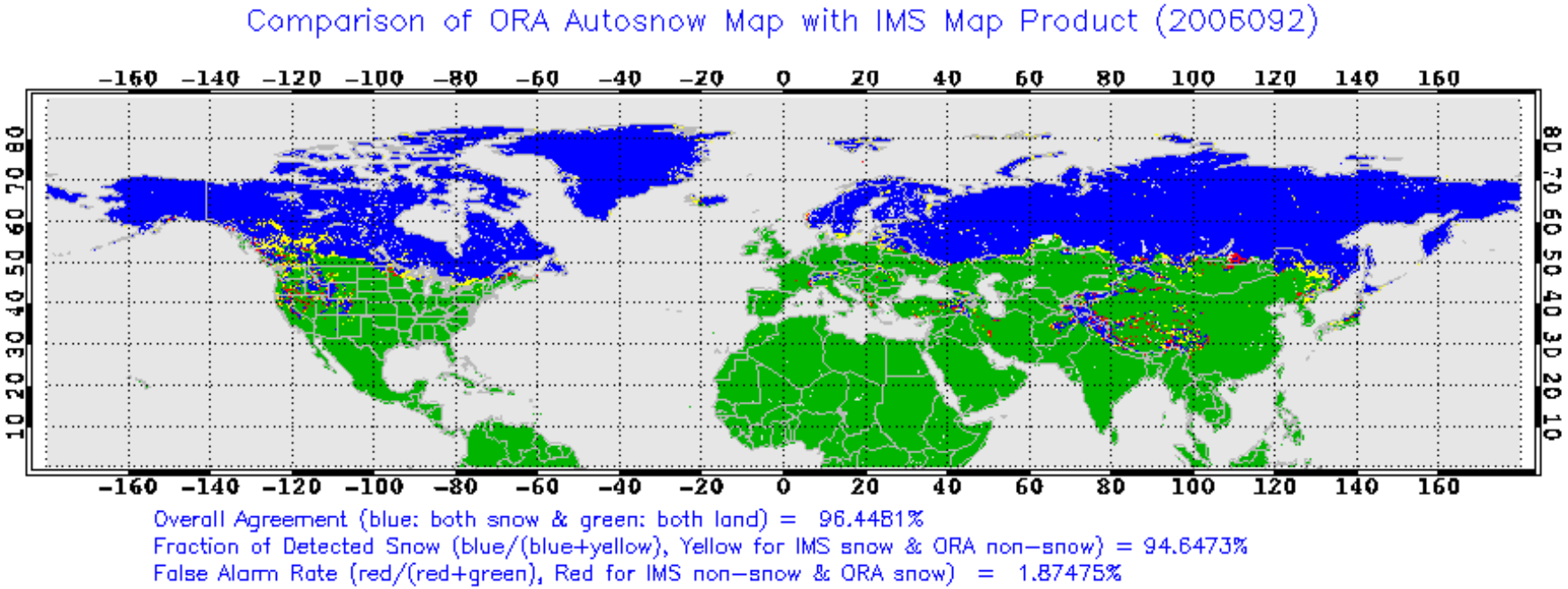
SATELLITE MAPS VS SURFACE OBSERVATIONS OF SNOW



Satellite and surface data agree in about 85% of cases in the middle of the snow season

Yearly average correspondence is about 90%

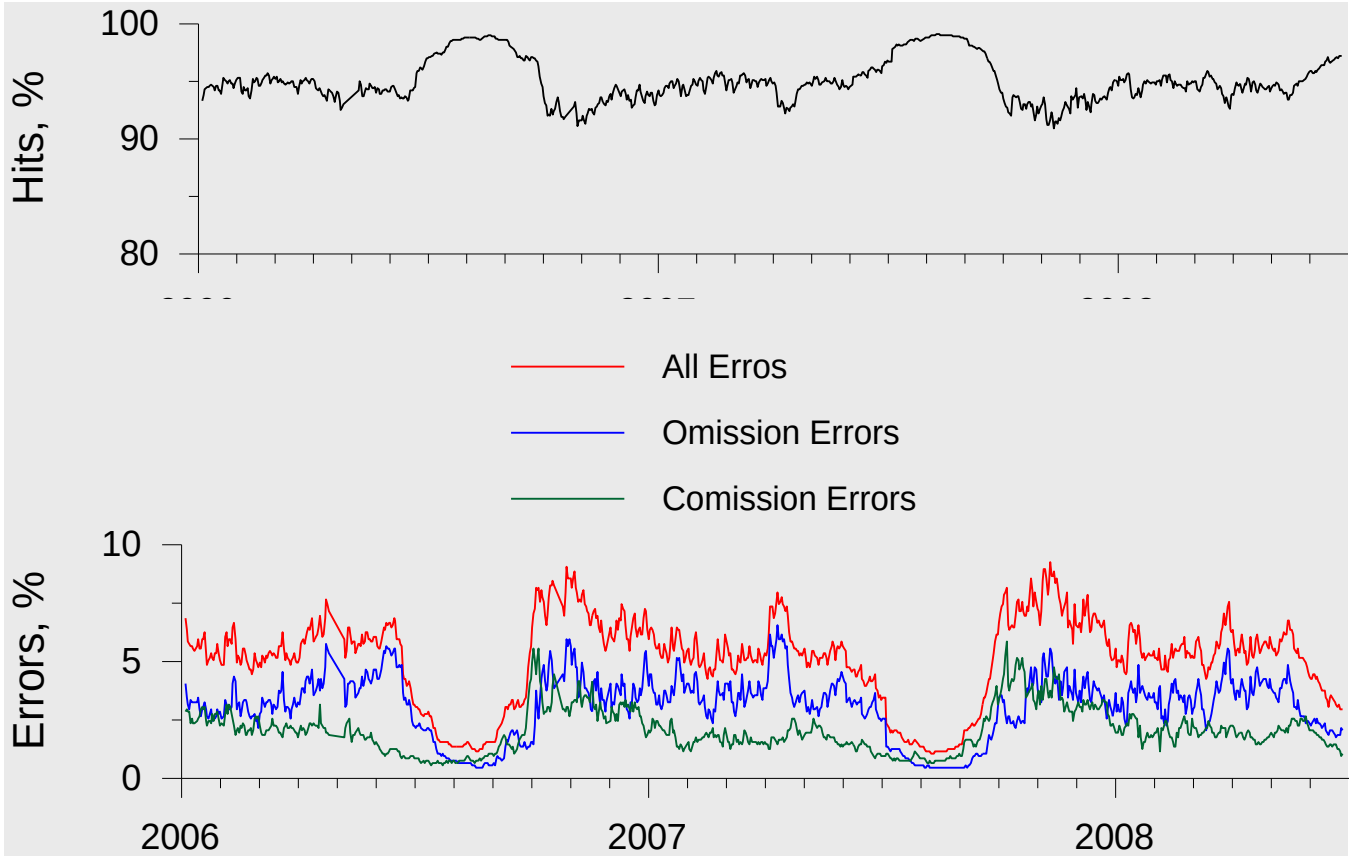
COMPARISON OF AUTOMATED AND INTERACTIVE MAPS



- Rate of agreement between automated and interactive maps: 93-98%
- Correspondence between microwave and interactive maps: 80-85%

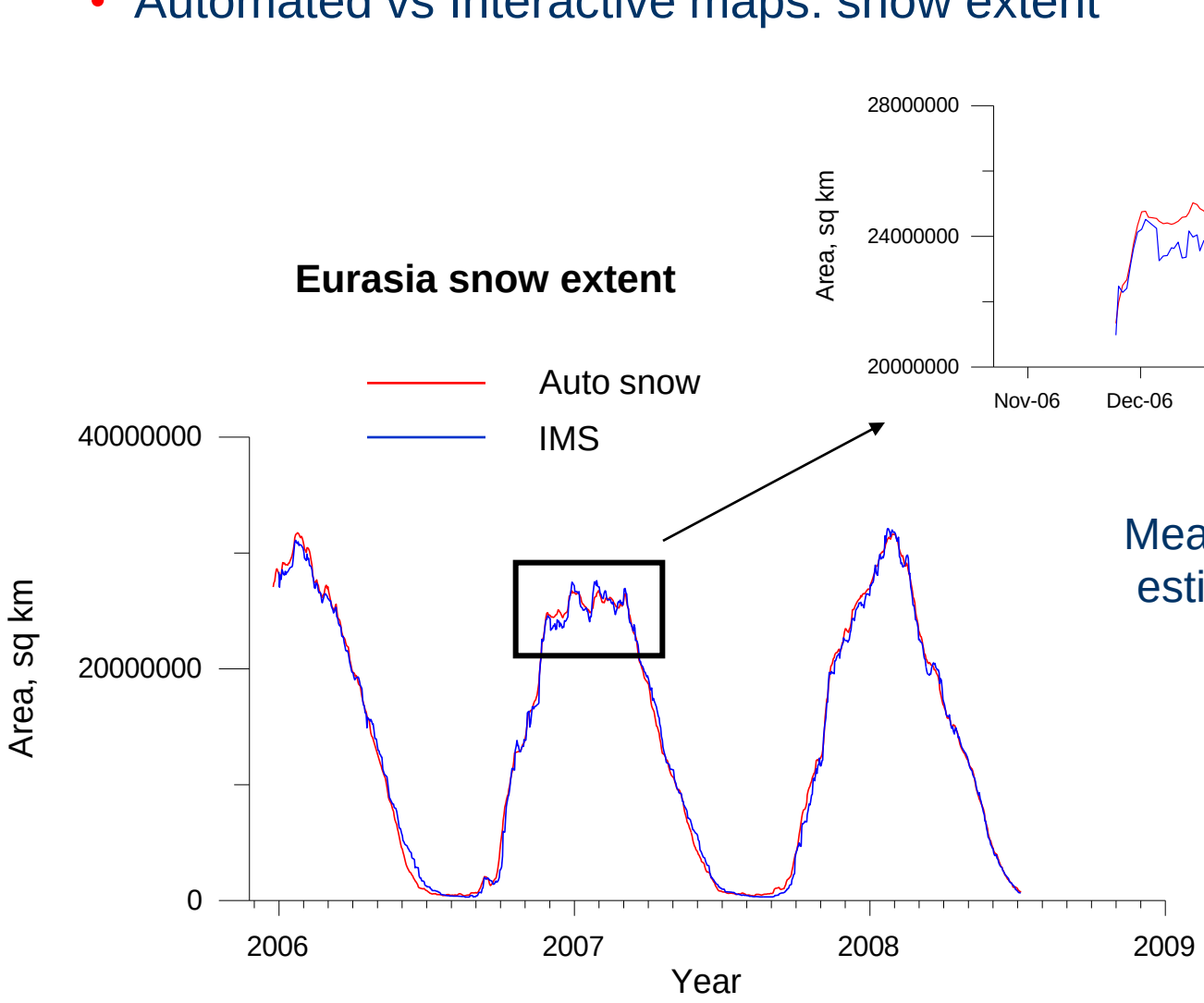
COMPARISON WITH INTERACTIVE SNOW MAPS

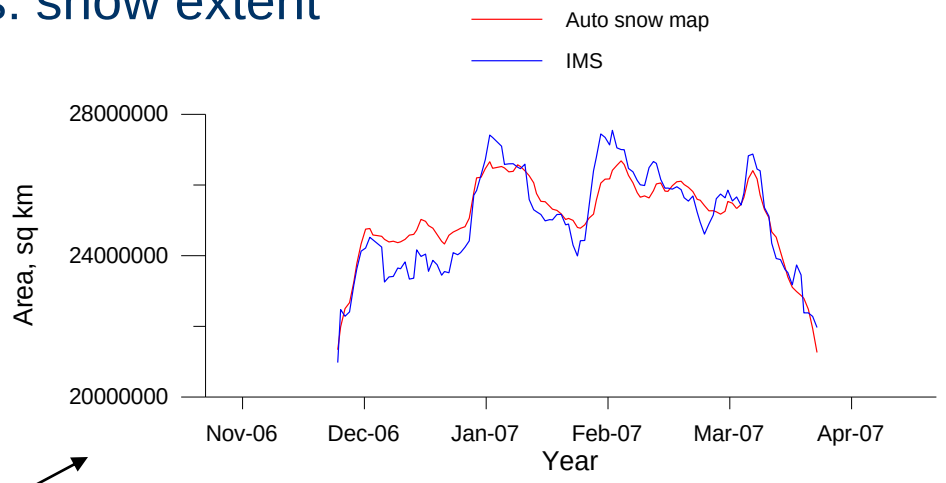
- Pixel by pixel comparison of mapped snow distribution
- Northern Hemisphere above 25 N, daily data



SNOW EXTENT

- Automated vs Interactive maps: snow extent





Mean absolute difference in estimated NH snow extent

Daily: ~4%

Monthly: ~1.5%

Mean bias: ~ -1%

ISSUES AND PLANS

Things to keep in mind

- Blending algorithm should be tailored to particular OPT and MW products
- Alternating use of optical and MW may cause spurious snow variations
- Inertial first guess: error propagation into next day product

What's next:

- METOP AVHRR
- 1 km resolution, SH in 2011, NH in 2013 (?)
- Reprocessing historical NOAA AVHRR and SSMI data

LINKS

NESDIS Automated snow remote sensing page:

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

NOAA Interactive snow charts:

http://www.natice.noaa.gov/ims/

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THANK YOU

BACKUP SLIDES

GENERAL STRATEGY TO COMBINING OPT/MW

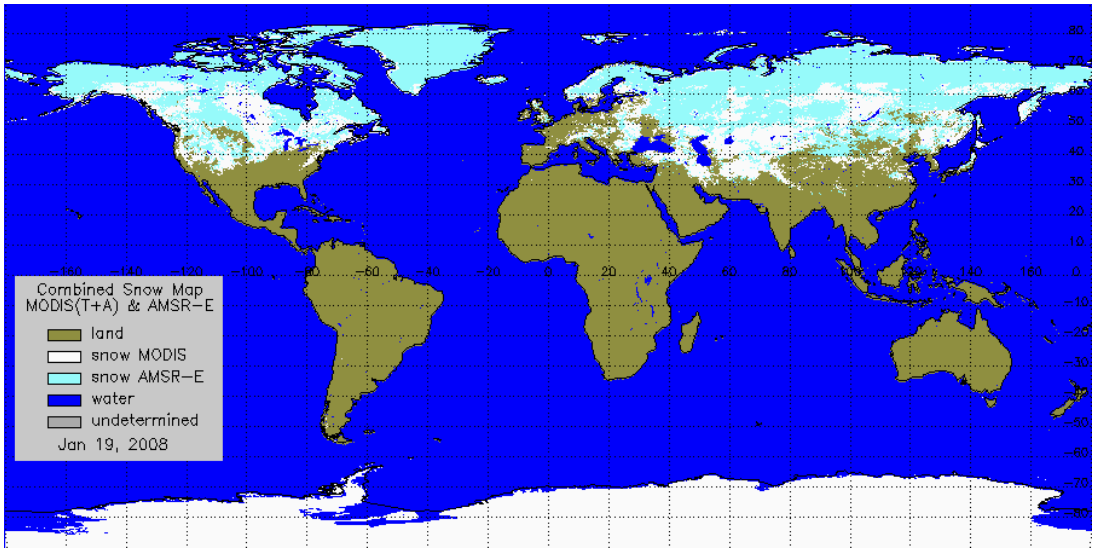
1. Utilize derived products (snow maps) rather than radiances
2. Use optical retrievals where possible
   - High spatial resolution
   - Better snow identification accuracy
3. Complement daily map with microwave retrievals
   - Coarser resolution, lower accuracy but provide continuity

SUMMARY

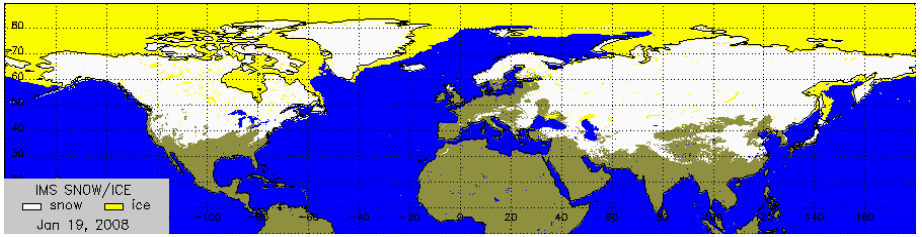
- Synergy of optical and MW:
  - Powerful approach, providing better snow cover product
  - Easy to implement if individual products are available
  - Part of improvement is due to the use of auxiliary datasets (snow climatology, vegetation cover type, elevation)

APPLICATION TO EOS DATA

- The same (slightly modified) approach have been used to combine MODIS and AMSR-E products into a blended snow map

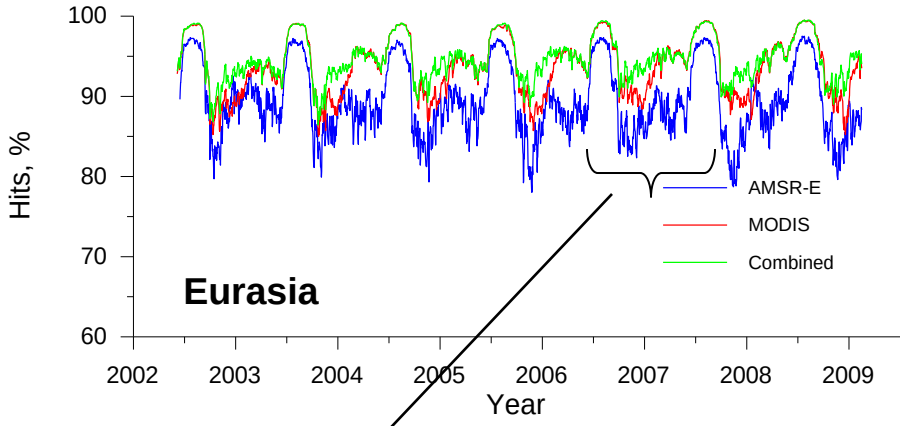


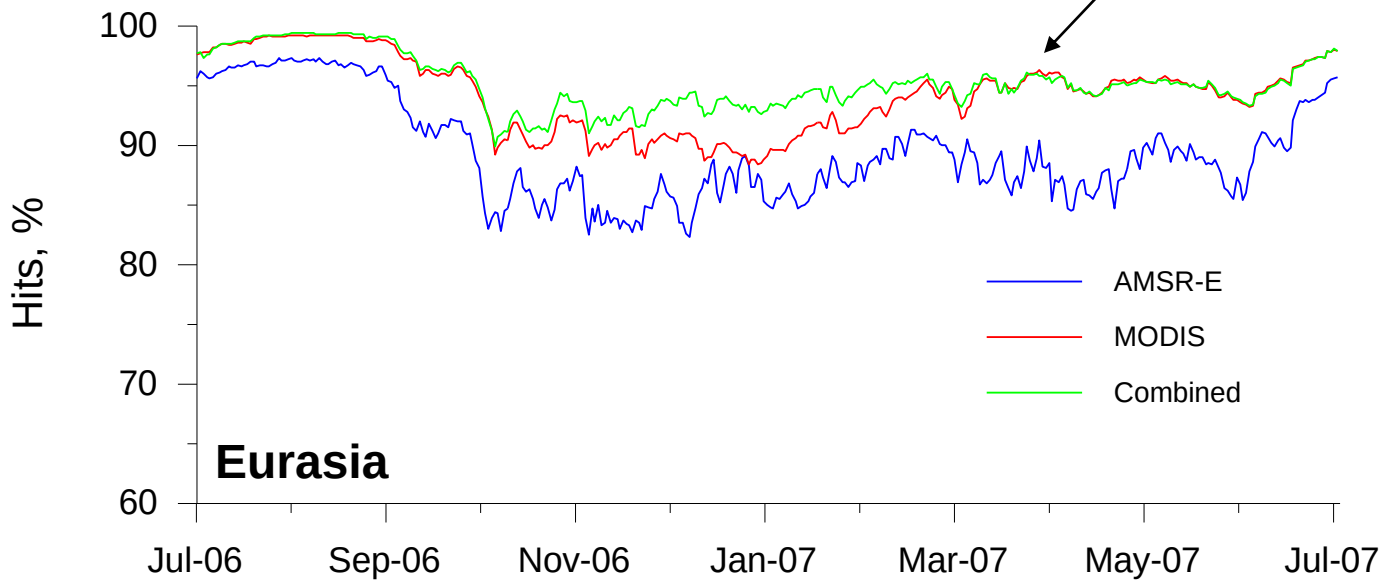
- Available since 2002
- Daily global maps
- 5 km nominal resolution
- Generated routinely



BLENDED EOS vs INTERACTIVE SNOW MAPS

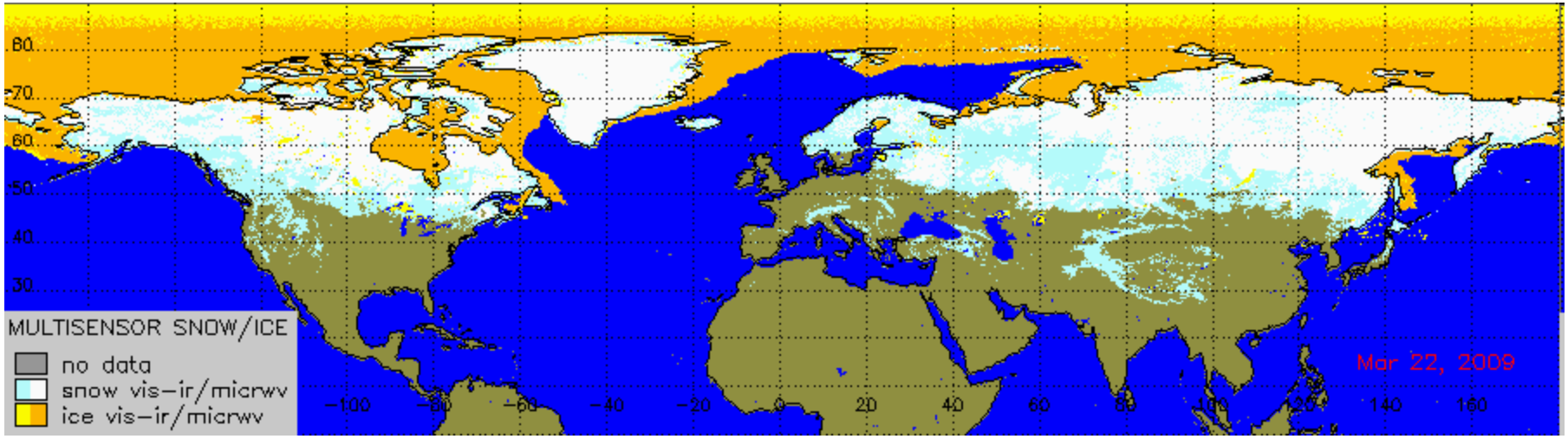
- Daily blended snow maps generated with
  - MODIS only
  - AMSR-E only
  - Combined MODIS and AMSR-E





Rate of agreement between EOS-based blended maps and NOAA interactive map

OPTICAL-MW CONTRIBUTION



Blue: optical sensor data used
White: MW sensor data used

- Microwave retrievals contribute most during snow advance (November-January)

- Optical retrievals contribute most in spring (snow retreat)

LINKS

NESDIS Automated snow remote sensing page:

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

NOAA Interactive snow charts:

http://www.natice.noaa.gov/ims/

Blended MODIS and AMSR-E daily maps at NESDIS

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

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