GOES-R AWG Cryosphere Team Snow Depth Product

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Cryosphere-SD Team

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- Validation Approach
- Validation Results
- Summary

Executive Summary

- The GOES-R Snow Depth is an Option 2 product. It is generated from Option 1 Snow Cover Fraction product
- Software Version 3 was delivered in February. ATBD (80%) and test datasets will be delivered in June 2010
- Algorithm uses an empirical relationship between Snow Depth and Snow Fraction
- The algorithm has been developed and tested using GOES Imager data and in situ snow depth observations
- The algorithm was tested with snow fraction data derived from MODIS
- Validation studies indicate specs compliance

Requirements – Snow Depth

Product	*Observational Requirement*	*Measurement Range*	*Accuracy*	*Refresh Rate*	*Horizontal Resolution*
Snow Depth	Full Disk	0-27 cm	9 cm	60 min	2 km

Algorithm Description

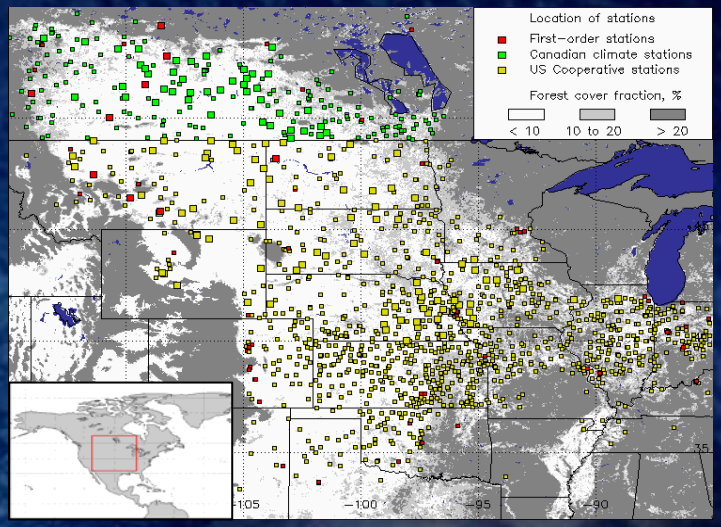
Snow Fraction – Snow Depth Relationship Background

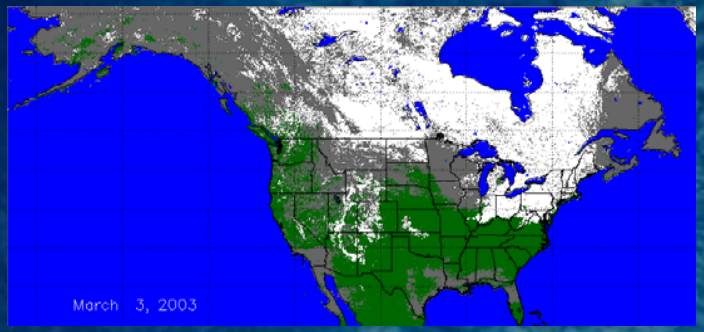
- Due to vegetation and surface roughness, increasing snow depth (SD) causes gradual increase of the snow fraction (SF)
- SD-SF relationship is most pronounced over non-forested (grassy) plain areas
- When snow pack covers all low-level vegetation, SF is no longer sensitive to SD (saturation)
- SF-SD relationship is used in land models to predict SF from SD
- The developed techniques uses SF to estimate SD

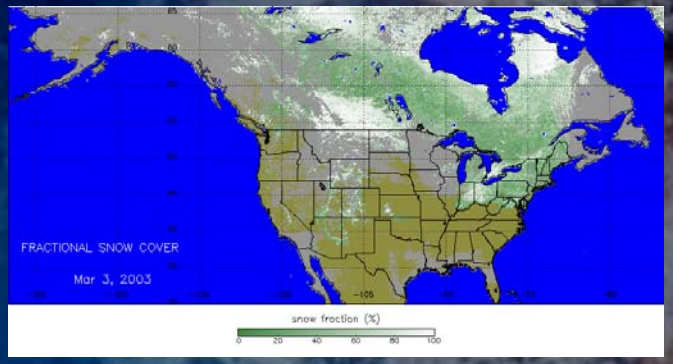
Establishing SD-SF Relationship

- Over 10,000 cloud-clear observations from GOES Imager matched with synchronous surface snow depth measurements over Great Plains have been collected

- Snow fraction was derived from GOES Imager observations in the visible spectral band.







Establishing SD-SF Relationship (Cont'd)

- SD-SF relationship was approximated with exponential function

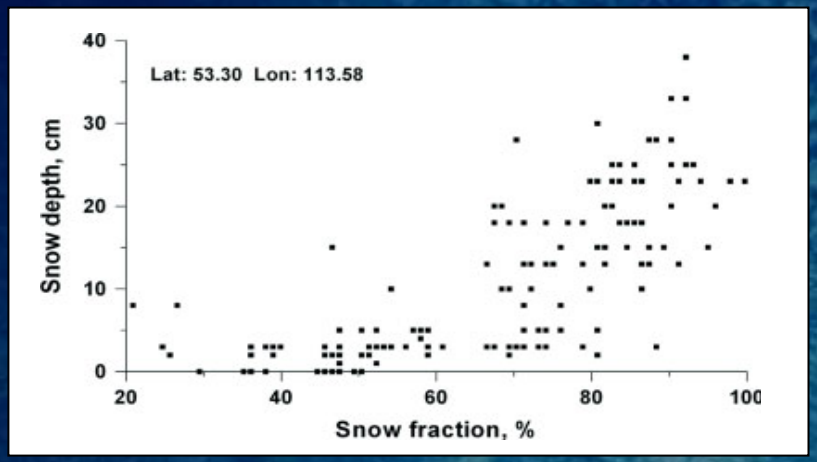
$$D = \exp(a * SF) - 1$$

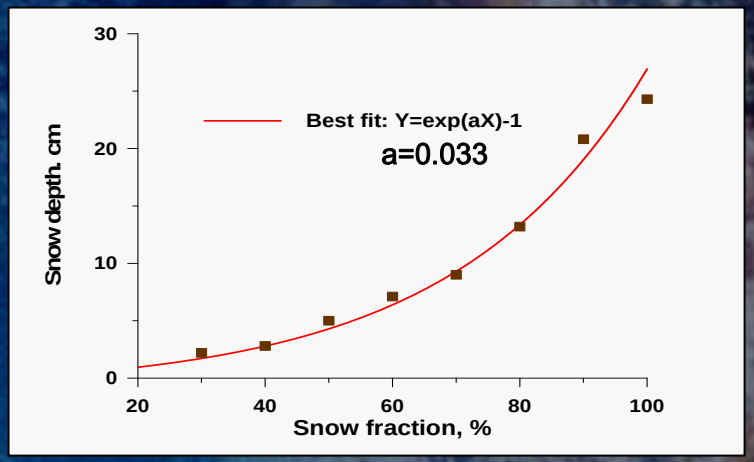
a=0.0333

D: snow depth in cm

SF: snow fraction (1-100%)

- 100% snow fraction is reached at about 27cm of snow depth





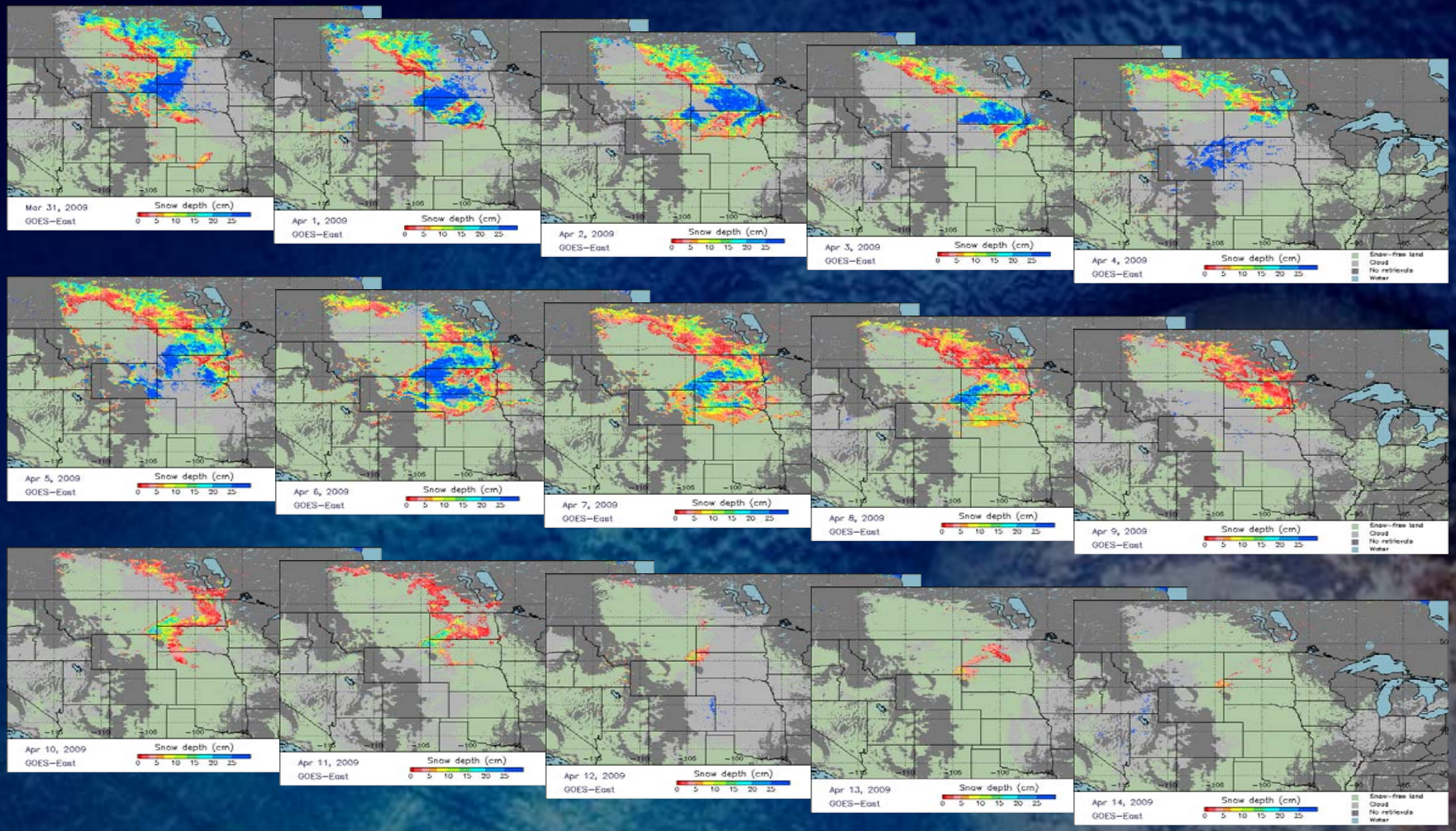
Algorithm Summary

- Snow depth retrieval technique is based on an empirical relationship between snow depth and snow cover fraction
- Snow depth – snow fraction relationship has been established empirically from GOES Imager-based estimates of snow fraction collocated with synchronous in-situ snow depth measurements
- Over grassy plain areas the snow fraction “saturates” on the average at about 30 cm of snow depth. This is the maximum retrievable snow depth.
- Retrievals are limited to grassy plain areas and to clear-sky conditions.

Examples of Product Output

Daily Maps of Snow Depth from GOES Imager Data

April 1-14, 2009, GOES-East data



Validation Approach

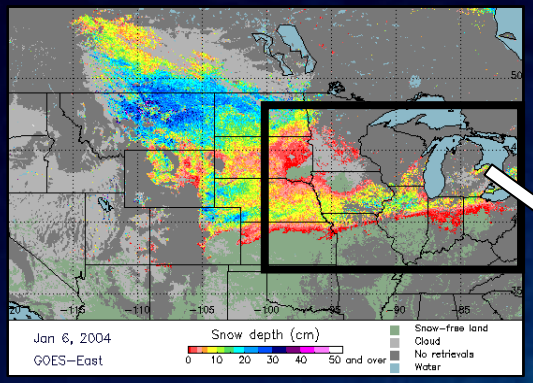
Validation Approach

- Direct comparison of snow depth retrievals with in situ snow depth observations.
- Validation sites: Non-forested areas in US Great Plains and Canadian Prairies
- Compare observations with SD below 30 cm
- Over 20,000 matched pairs over the US Great Plains
- Additional source for validation: NOHRSC SD product

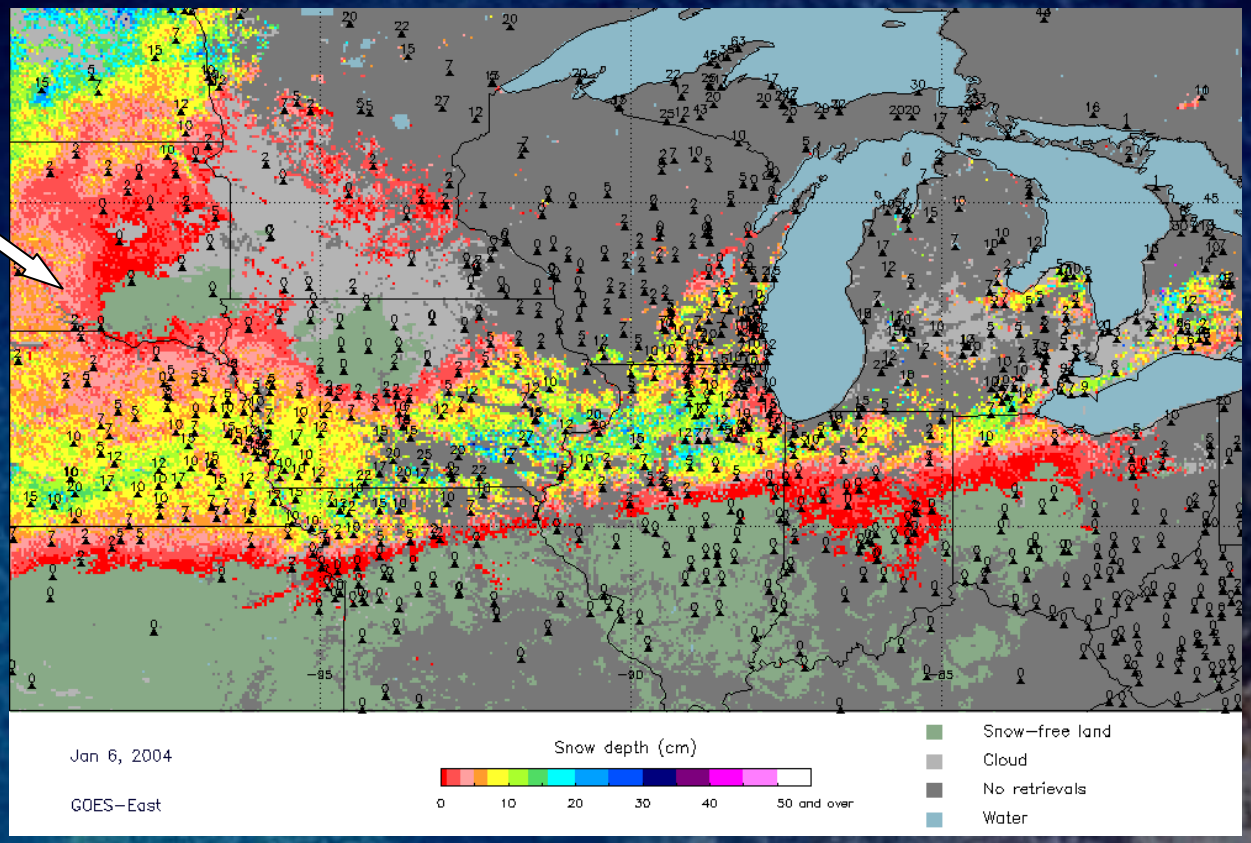
Validation Results

Validation of GOES-Based Snow Depth

Comparison of GOES snow depth with in situ data



GOES snow depth map

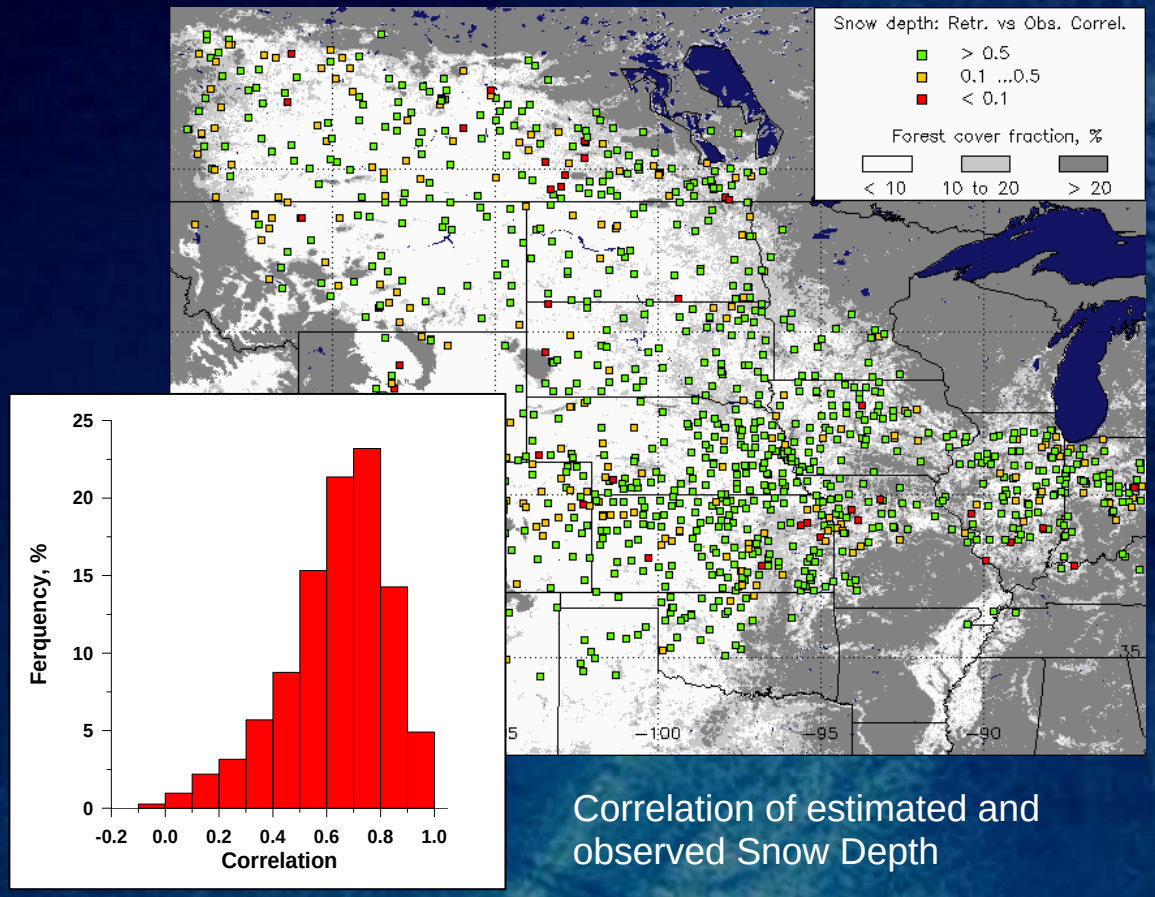


GOES snow map with surface observations overlaid

GOES-based snow depth distribution demonstrates good qualitative agreement to surface data

Validation of GOES-Based Snow Depth (cont'd)

Station-by-station Snow Depth Retrieval statistics: correlation

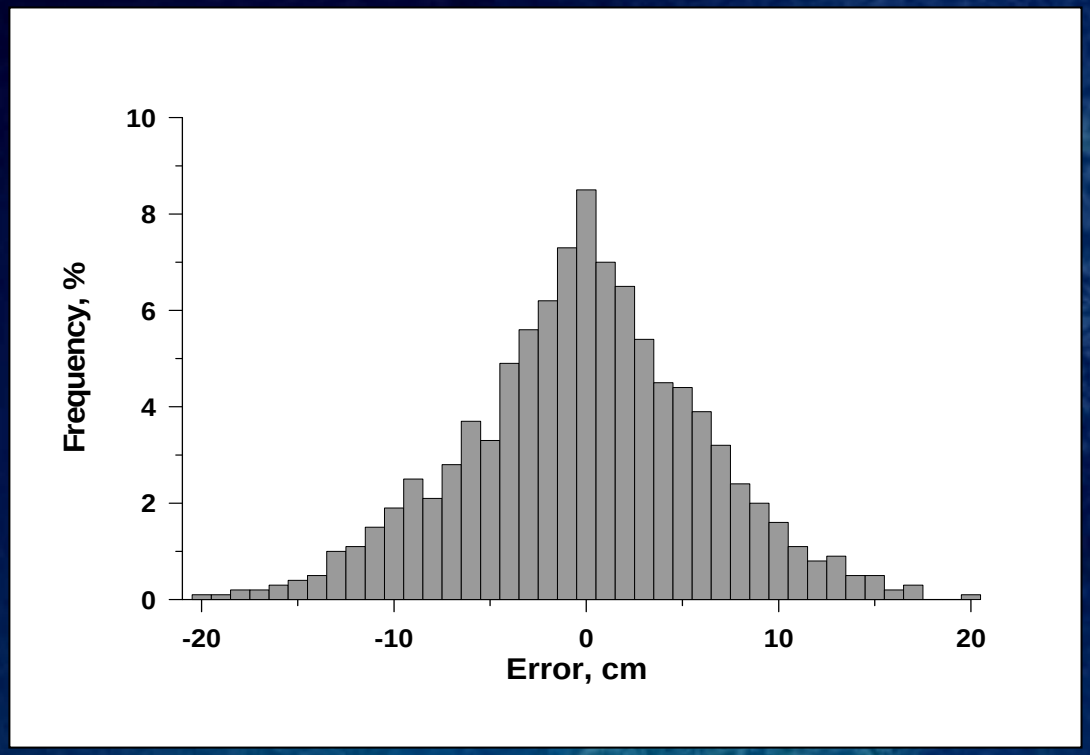


Correlation of estimated and observed Snow Depth

For over 75% stations in the Great Plains area correlation between observed and derived snow depth exceeds 0.5

Test data with the current GOES Imager

Validation of GOES-Based Snow Depth (cont'd)



Retrievals are made with GOES East Imager data

Errors below 5 cm: in ~60% of retrievals

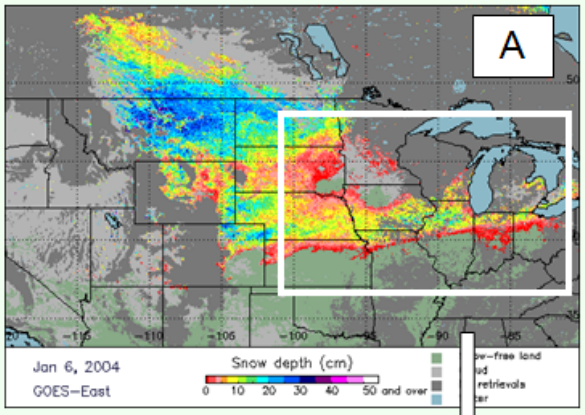
Errors below 10cm: in ~85% of retrievals

MRSE = 8.6 cm

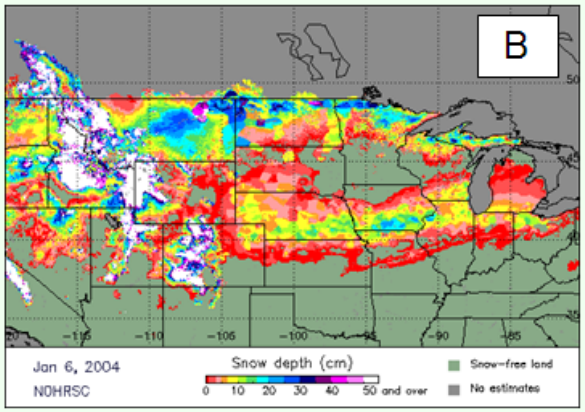
Errors increase with increasing snow depth

Error frequency distribution over Great Plains and Canadian Prairies 2006-2007 winter season

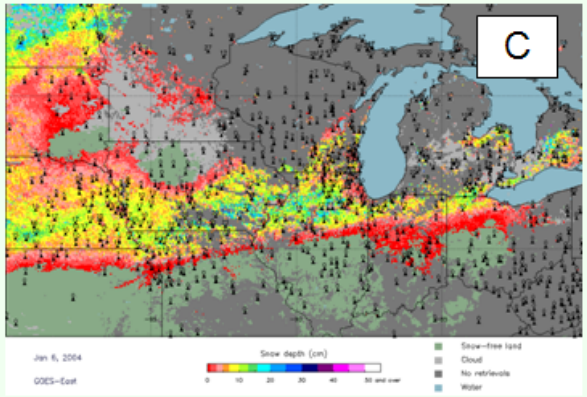
GOES SD vs NOHRSC SD



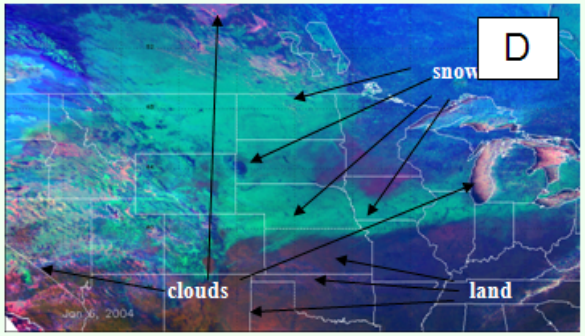
GOES snow map



NOHRSC snow map



GOES snow map with surface observations overlaid



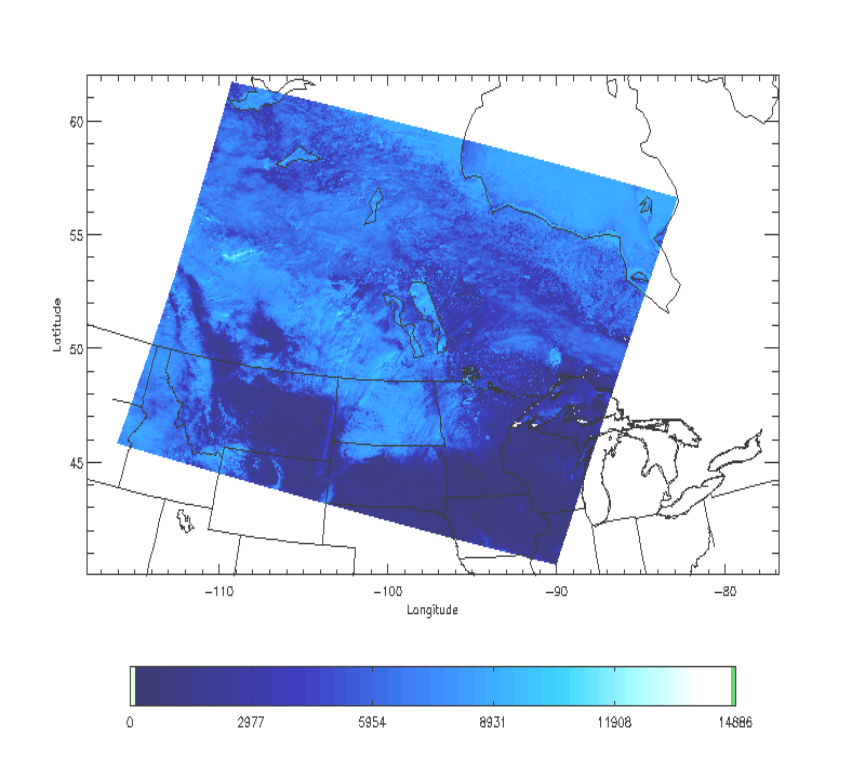
GOES RGB false color image

- Good qualitative agreement of derived snow depth

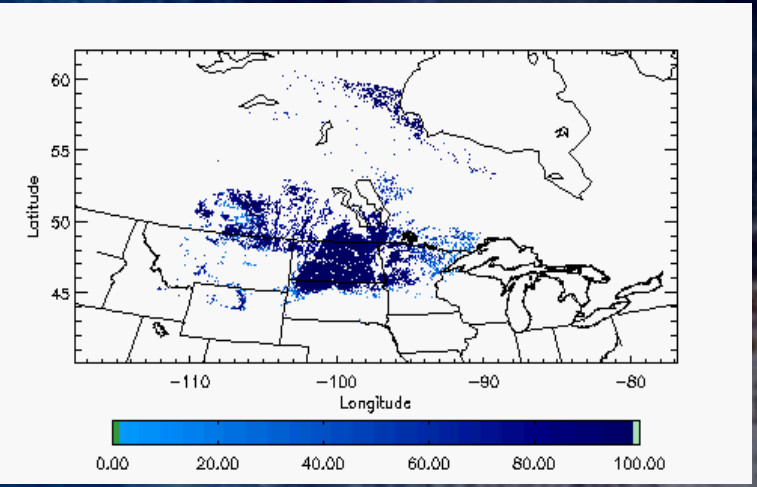
Application to MODIS-Based Snow Fraction

Terra MODIS data at 1750Z on 20090315

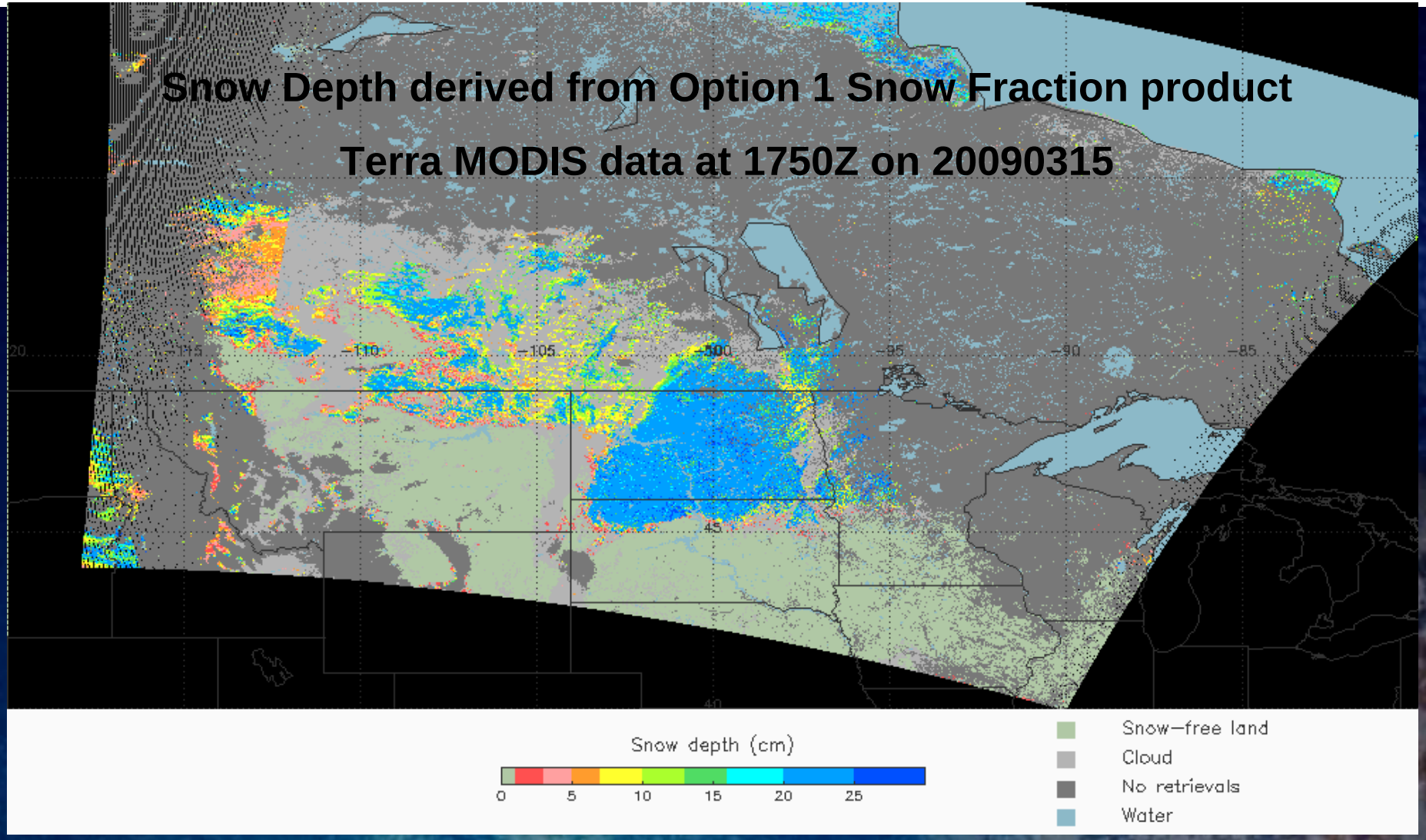
Surface Reflectance Band 1



Snow Fraction (%)

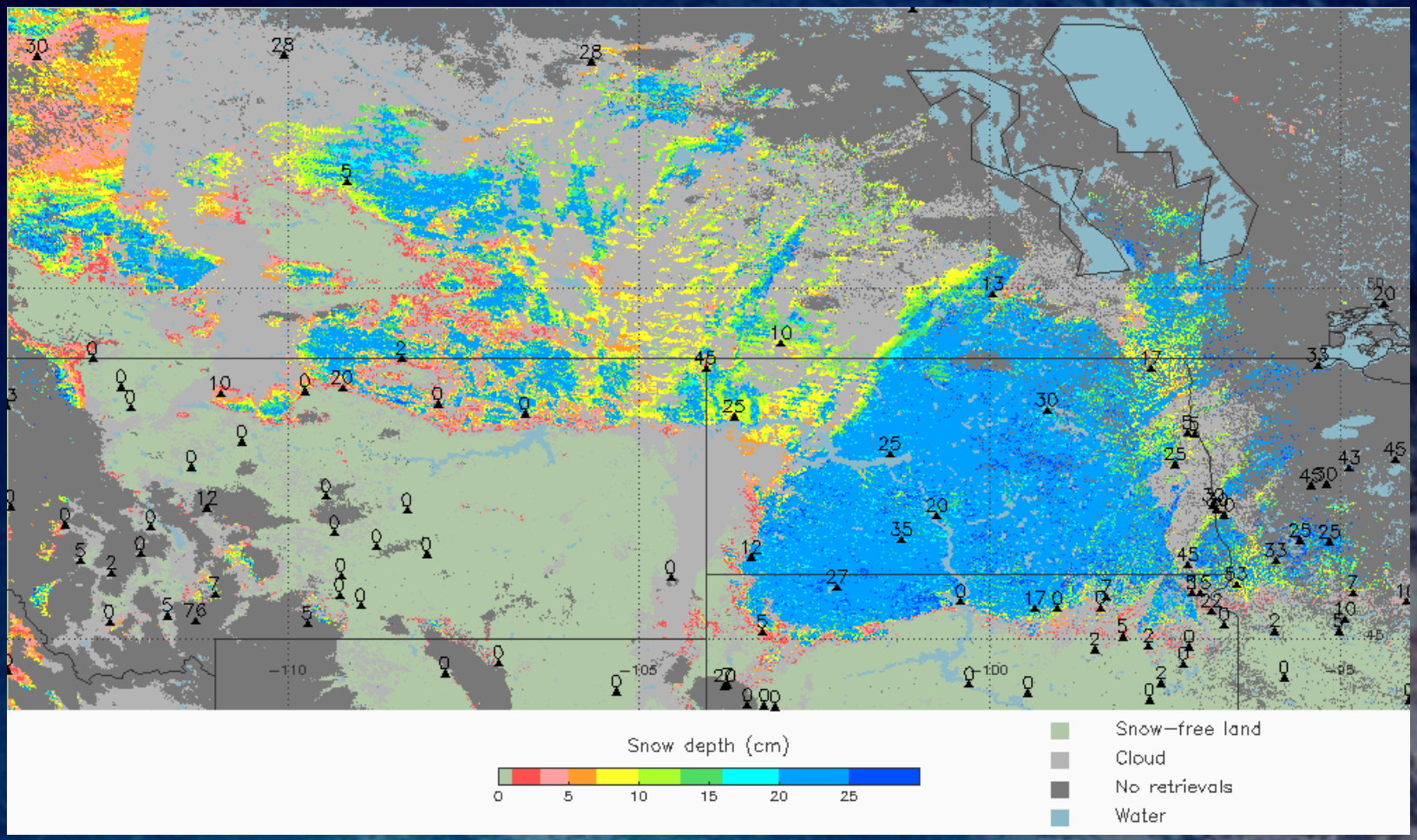


Application to MODIS-Based Snow Fraction (cont'd)



Application to MODIS-Based Snow Fraction (cont'd)

MODIS-based snow depth map with station snow depth overlaid



Next Steps to Reach 100%

- Extensive validation with common data set
- Addition of QC flags
- Addition of metadata output
- Scheduled delivery is in September 2011

Summary

- The GOES-R ABI Snow Depth Algorithm is based on an empirically derived snow fraction – snow depth relationship
- The relationship is valid over relatively flat and non-forested areas and for snow covers less than 25-30 cm deep.
- The Snow Depth algorithm has been extensively tested using GOES Imager data. Results show accuracy better than 10cm about 85% of retrievals and MSRE below 9 cm.
- Snow Depth algorithm was applied to snow fraction derived from Terra MODIS.