



VIIRS SNOW COVER PRODUCTS: CURRENT STATUS AND PLANS

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- VIIRS Binary Snow Cover and Fractional Snow Cover
 - Definition, requirements
 - IDPS product performance
 - Enterprise products and performance
 - Further algorithm enhancements

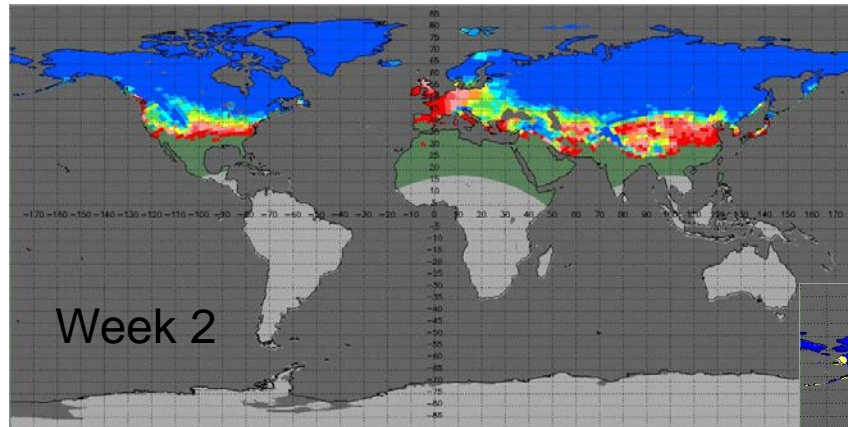
Cal/Val Team Members

Name	Organization	Roles and Responsibilities
Jeff Key	NOAA/NESDIS	Cryosphere Team Lead
Peter Romanov	CUNY/CREST	Snow Products Lead
Sean Helfrich	NOAA/NIC	User/Applications
Michael Ek	NOAA/NWS	User/Applications

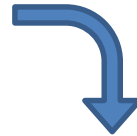
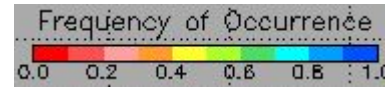
JPSS ESPC (JERD) Requirements

- Binary snow map:
 - Snow/no snow discrimination
 - 90% probability of correct typing
 - Over climatologically snow-affected areas
- Snow fraction:
 - “Viewable” snow fraction
 - 20% accuracy
- Both products are
 - Clear-sky daytime-only land products
 - Derived at 375 m resolution
- Both products depend on the accuracy of VIIRS cloud mask.

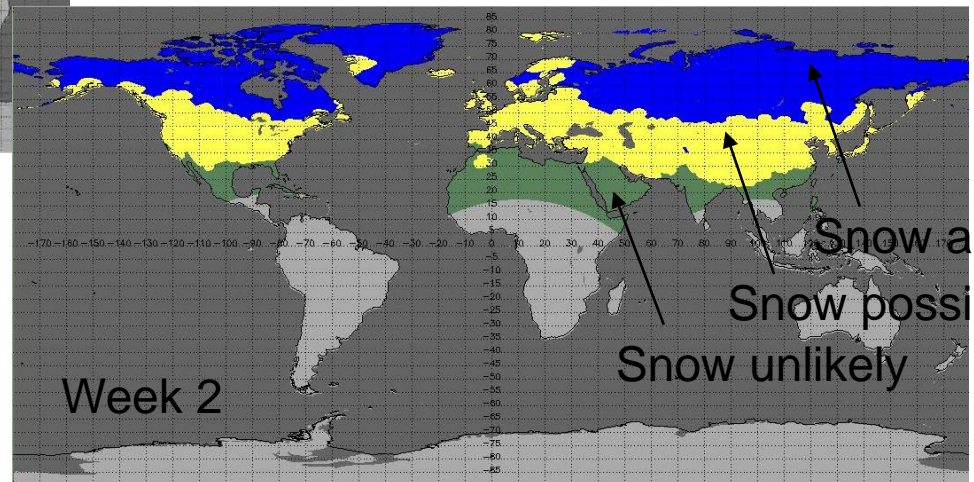
Climatologically snow-affected areas



Weekly climatic snow cover occurrence



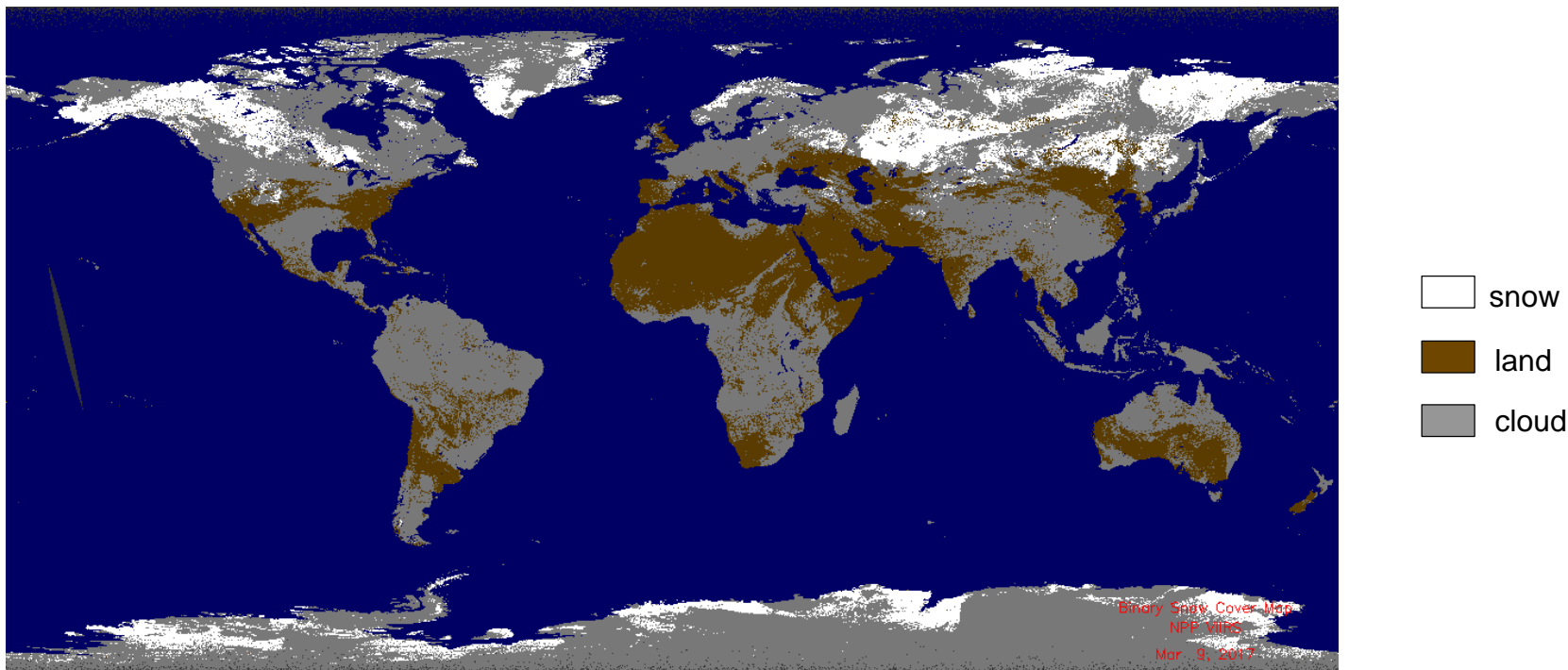
Snow cover occurrence categories



- Accuracy estimates are focused on the “snow possible” region (shown in yellow)

Binary Snow Cover

- Algorithm analogous to MODIS SnowMap
- Product locally gridded to 0.01 deg geographical projection
- Evaluation through : Visual examination, comparison with IMS and in situ data

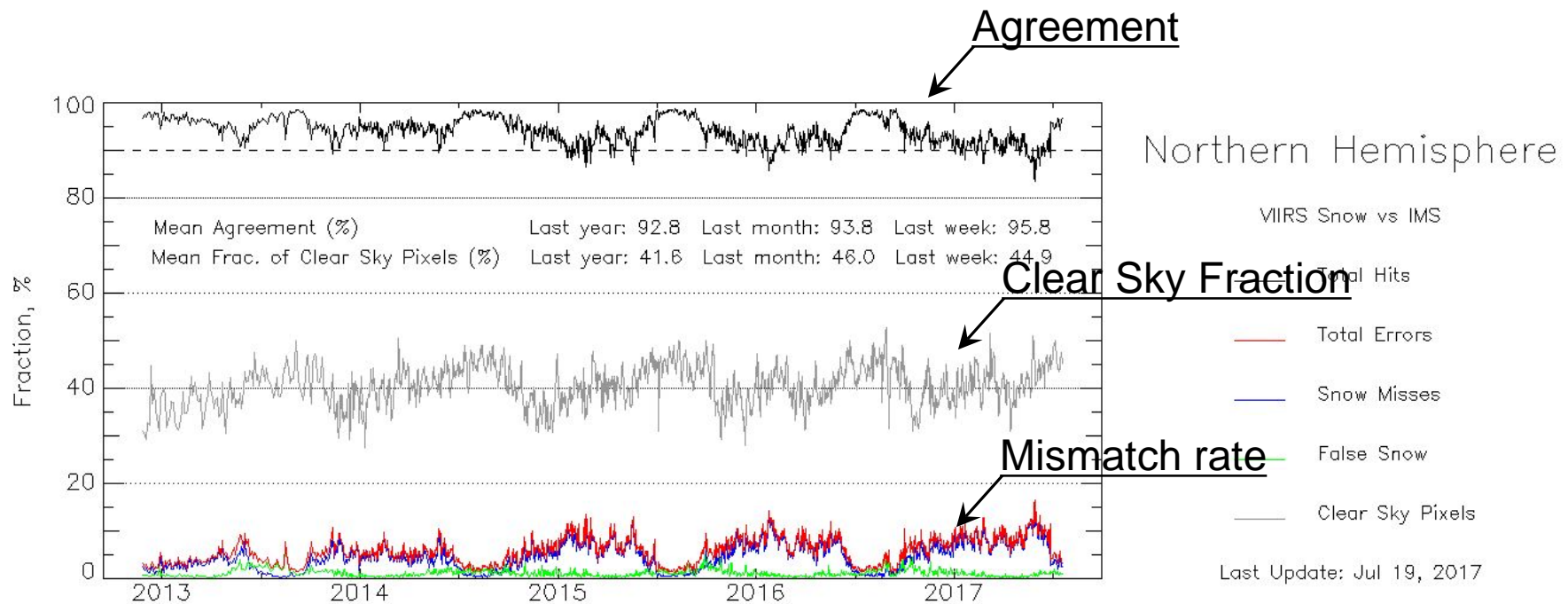


- On the Web (map updated daily)

<http://www.star.nesdis.noaa.gov/smcd/emb/snow/viirs/viirs-snow-fraction.html>

http://www.star.nesdis.noaa.gov/jpss/EDRs/products_snow.php

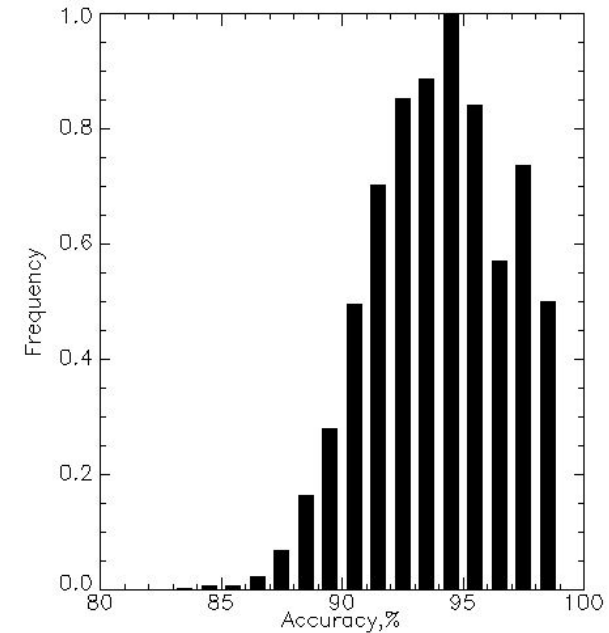
VIIRS binary snow map : Daily agreement to IMS



- Agreement rate: mostly over 90%
- IMS maps more snow than VIIRS
- VIIRS cloud fraction over land: ~ 60%

Daily rate of agreement of VIIRS IDPS snow maps

- To IMS (NH, over “snow possible” areas)
 - Mean: 93%,
 - Range: 85-99%
- To in situ reports (CONUS, November-April)
 - Mean: 92%
 - Range: 83-96%



VIIRS vs IMS daily rate of agreement statistics

Product	Requirement	Performance
Binary Snow	90% Correct Typing	Mean: 92-93% Range: 83-98%

Product generally satisfies current requirements

Enterprise Binary Snow Algorithm

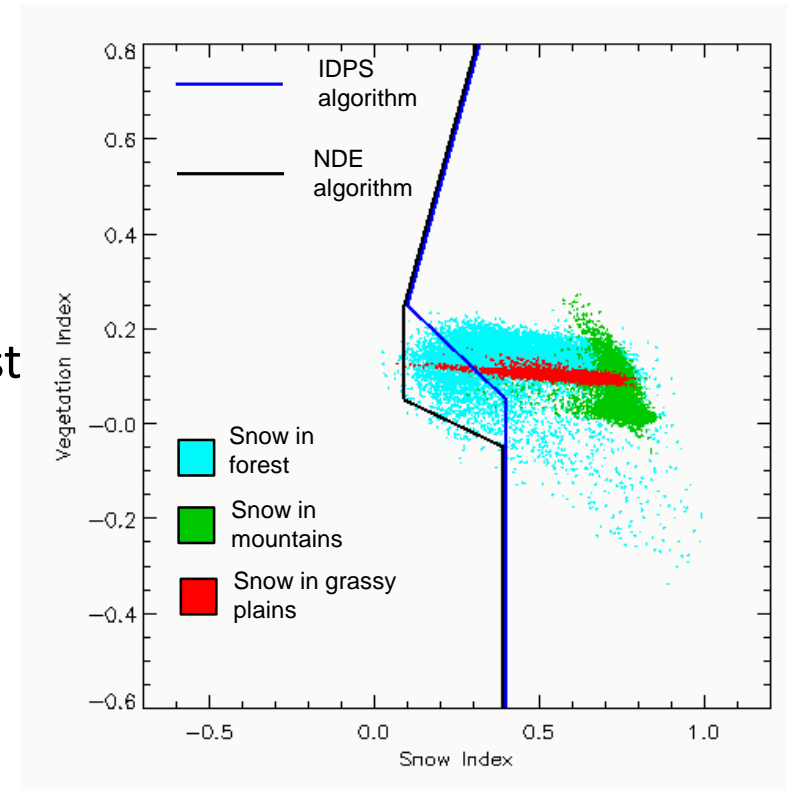
Intent: More efficient snow detection in forests
Reduce spurious (false) snow retrievals

Two-stage algorithm:

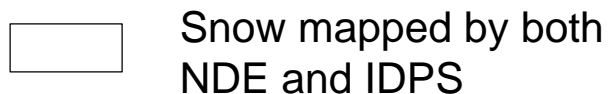
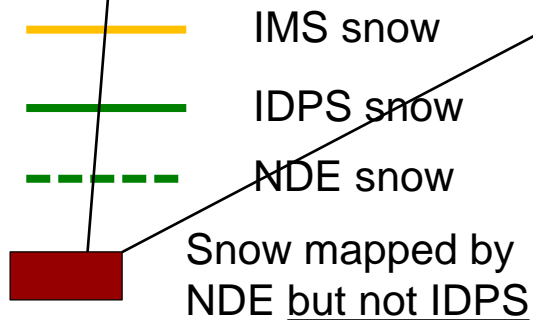
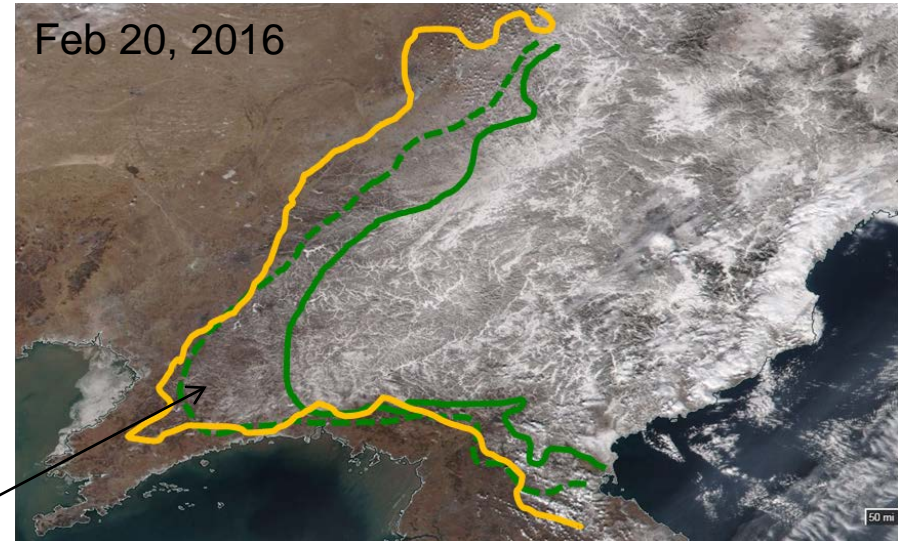
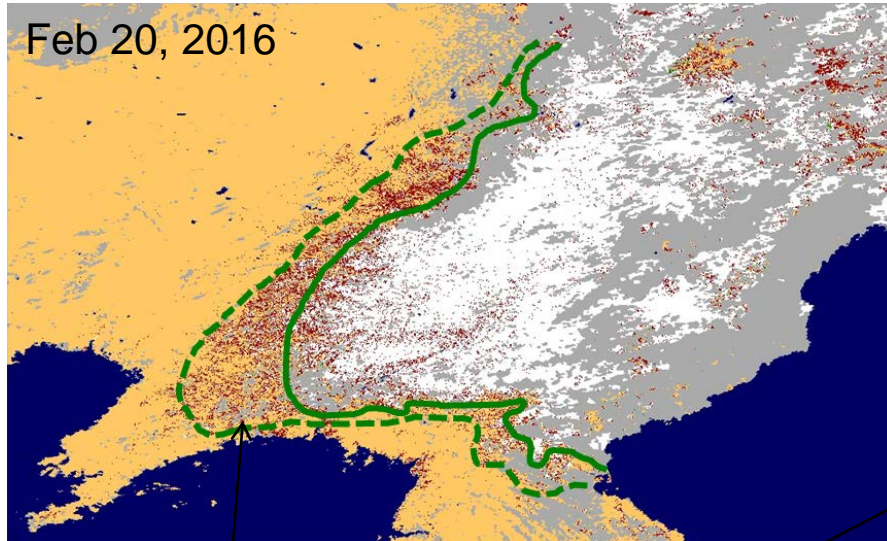
1. Spectral tests (bands I1, I2, I3, I5)
 - Improved snow identification in forest
2. Consistency tests
 - Eliminate spurious snow

Consistency tests (applied to “snow” pixels) :

- Snow climatology
- Surface temperature climatology
- Spatial consistency
- Temperature spatial uniformity



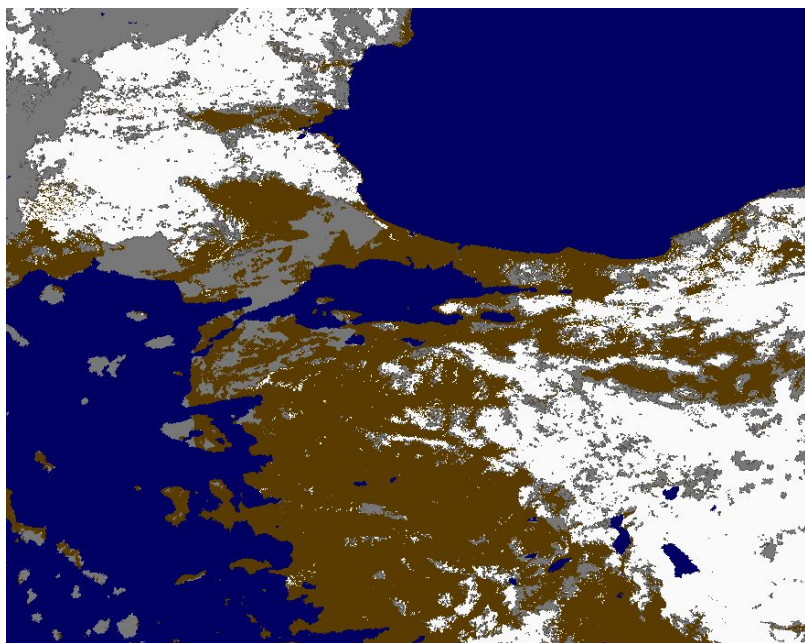
NDE vs IDPS Binary Snow Product



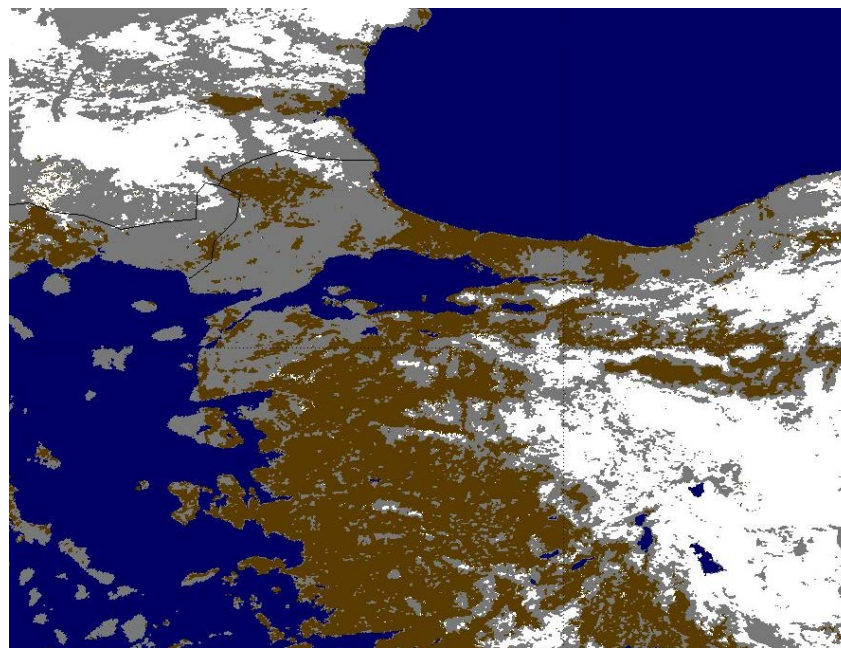
NDE algorithm maps more snow in the transition zone, better fits IMS

NDE vs IDPS Binary Snow Product

NDE: Better delineation of the snow cover boundary due to less conservative cloud masking in the snow/no-snow transition zone



NDE, Feb 2 2017

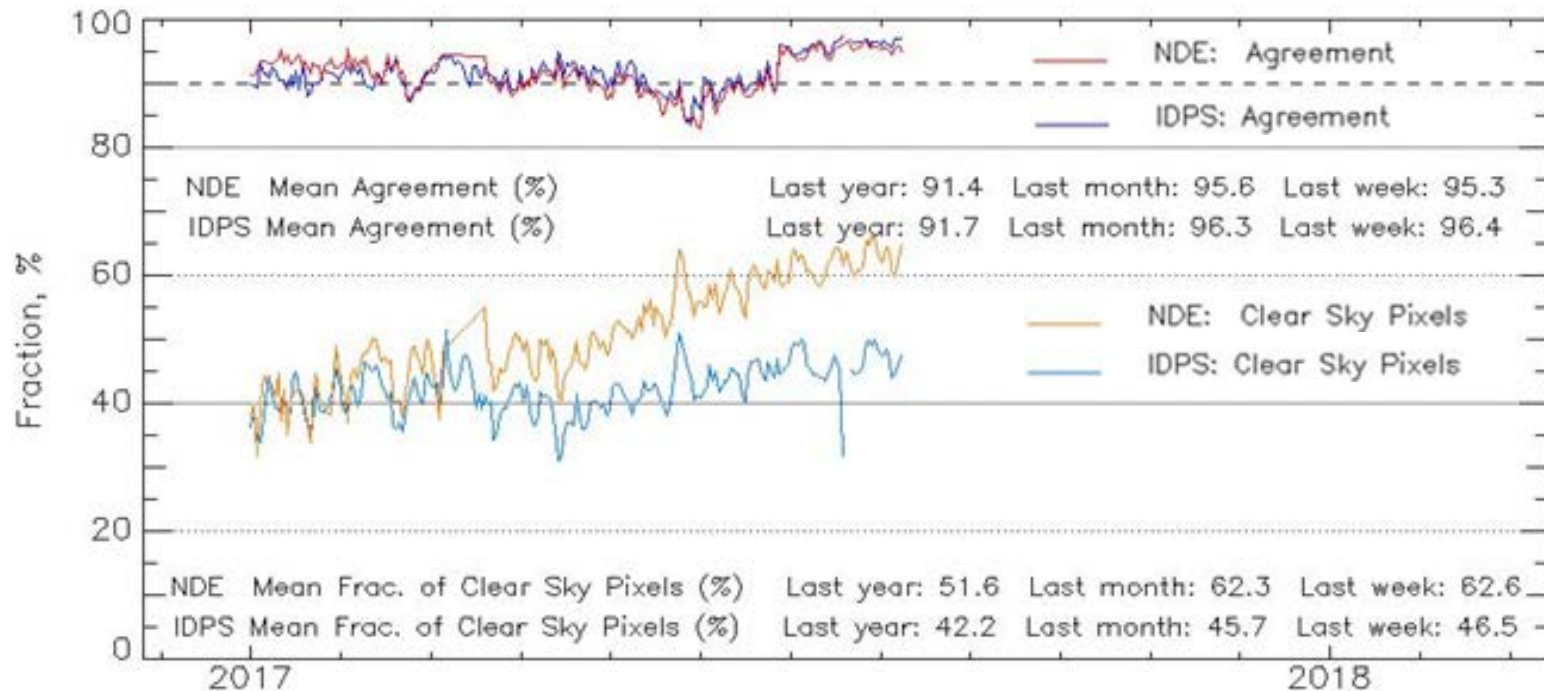


IDPS, Feb 2 2017

snow
 land
 cloud
 No data

NDE & IDPS: Binary Snow Accuracy

IDPS and NDE products vs IMS over N.Hemisphere



NDE vs IDPS

- Somewhat better (1-2%) accuracy in winter, similar accuracy in spring
- More clear sky views (less clouds), hence, better area coverage

NDE snow product satisfies requirements

Snow Fraction

NDE: Two algorithms implemented, replaced 2x2 aggregation approach in IDPS.

1. NDSI-based

$$\text{SnowFraction} = -0.01 + 1.45 * \text{NDSI}$$

- $\text{NDSI} = (R_{0.6} - R_{1.6}) / (R_{0.6} + R_{1.6})$
- MODIS heritage algorithm, used up to Collection 5 (not in Collection 6)

2. Visible reflectance-based

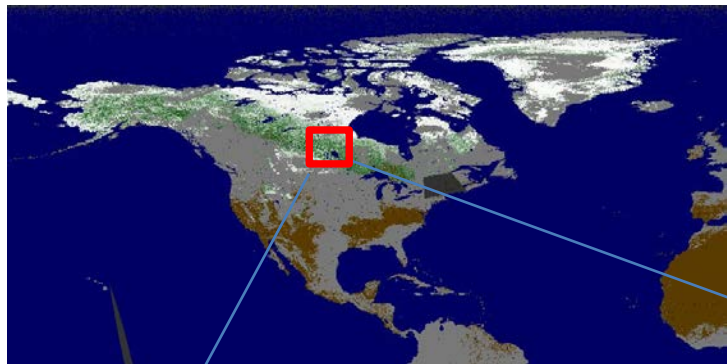
$$\text{SnowFraction} = (R - R_{\text{land}}) / (R_{\text{snow}} - R_{\text{land}})$$

- Uses VIIRS band I1 (0.6 μm) reflectance (R)
- Algorithm used with GOES Imager and AVHRR; Approach similar to GOES-R

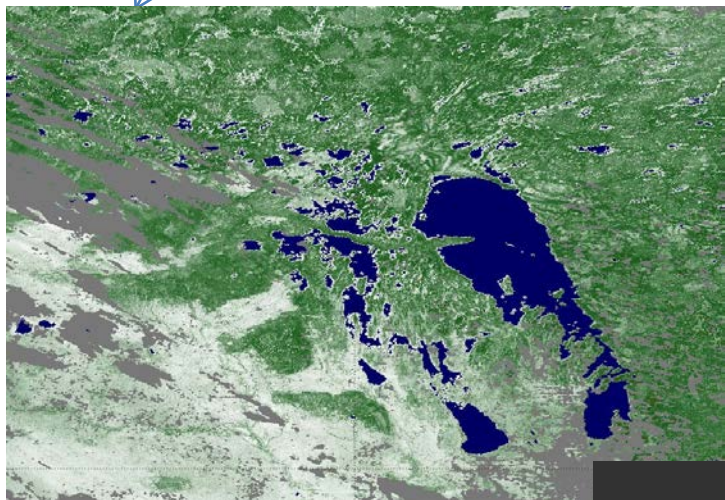
Snow Fraction: Two Algorithms

Reflectance-based Snow Fraction vs NDSI-based snow fraction

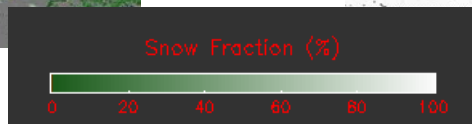
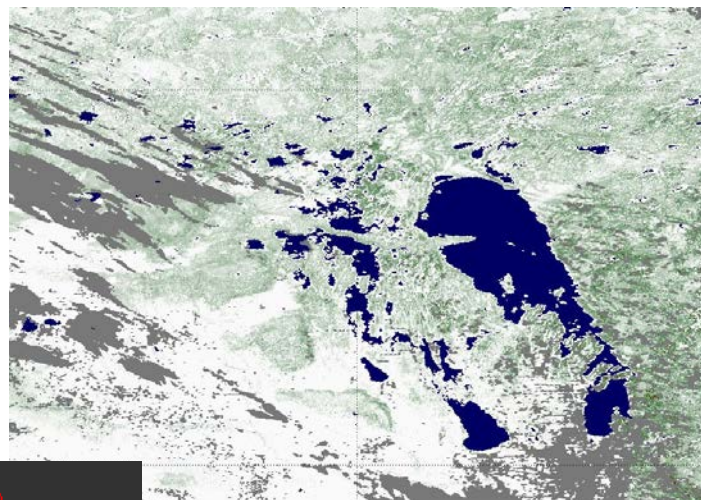
- Generally similar snow fraction patterns
- NDSI snow fraction is much larger in the forest



Reflectance-based snow fraction



NDSI-based snow fraction



Clouds are shown in gray

Theoretically estimated accuracy: 10-20%

vs Landsat: mean agreement ~ 17%, range: 5-25%

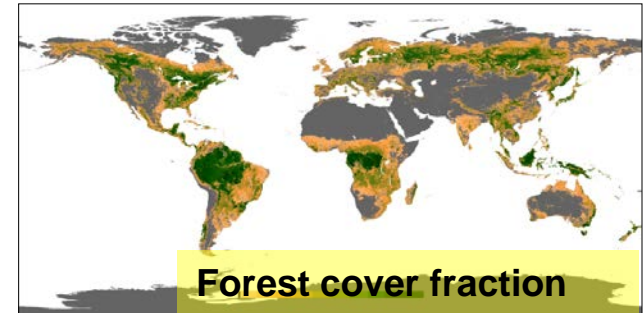
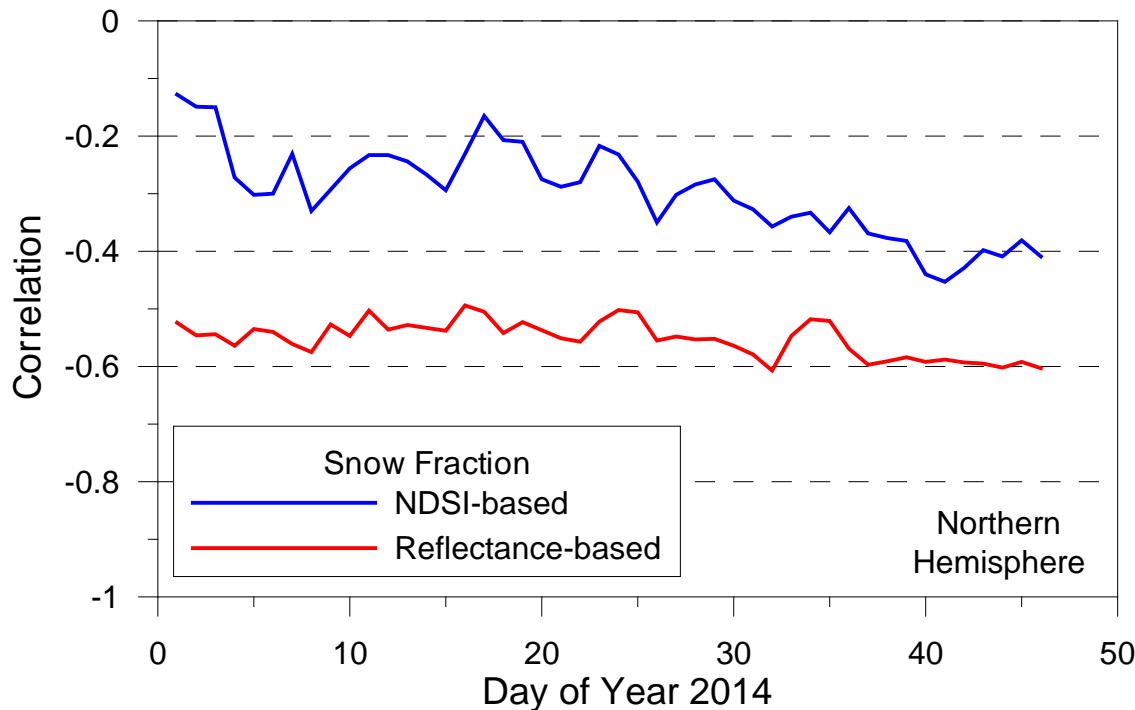
- Comparison over open areas
- Estimates are not independent, limited validity

Verification through consistency testing

- Day-to-day repeatability of spatial patterns
- Consistency with the forest cover distribution
- Consistency with in situ snow depth data over open flat areas.

Consistency with Forest Fraction

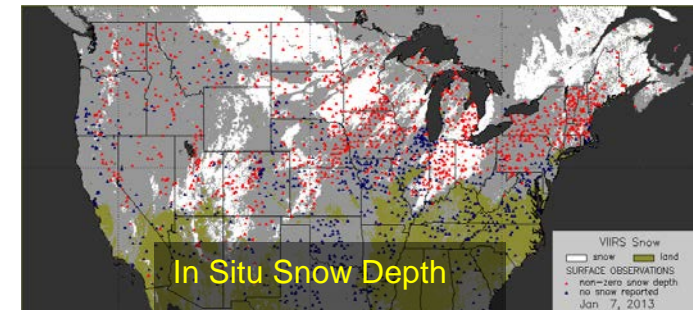
Snow fraction vs forest fraction correlation



- Stronger correlation ($-0.5 \div -0.6$), indicates better consistency of Reflectance-based snow fraction with the forest cover distribution

Consistency with Snow Depth

- VIIRS Snow Fraction vs matched In situ Snow Depth
- Correlation calculated over Great Plains
- Correlation is positive meaning that estimated snow fraction is consistent with the snow depth data



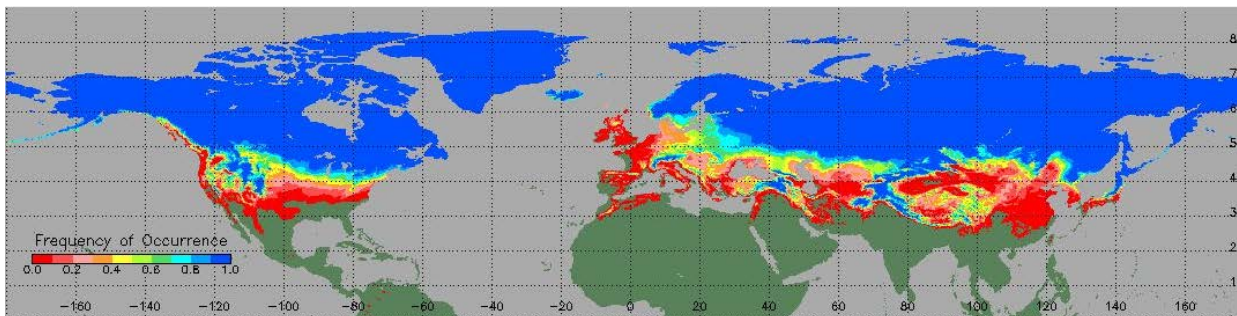
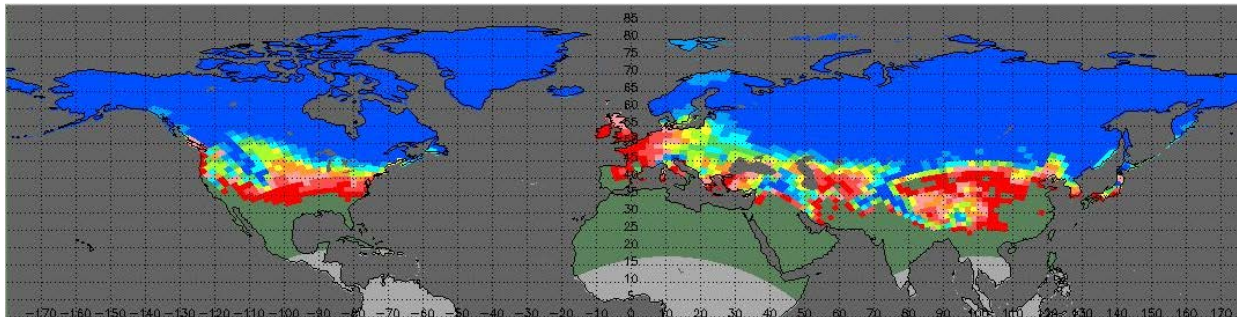
Snow Fraction vs Snow Depth Statistics

Date	Snow Depth Range, cm	Number of match-ups	Reflectance-based		NDSI-based	
			Mean SnFrac	Correlation	Mean SnFrac	Correlation
01/05/17	2 - 76	175	0.76	0.38	0.76	0.22
01/15/17	2 - 129	134	0.76	0.42	0.96	0.33
01/25/17	2 - 101	21	0.79	0.45	0.93	0.23
02/05/17	2 - 53	51	0.7	0.53	0.83	0.42
02/15/17	2 - 91	93	0.54	0.66	0.80	0.51
Mean (Jan-Mar 2017)			0.60	0.51	0.81	0.44

Planned Enhancements

Updated snow cover climatology

- Old: based on 200 km resolution IMS 1972-1998
- New: based on 4 km IMS 2014-2017



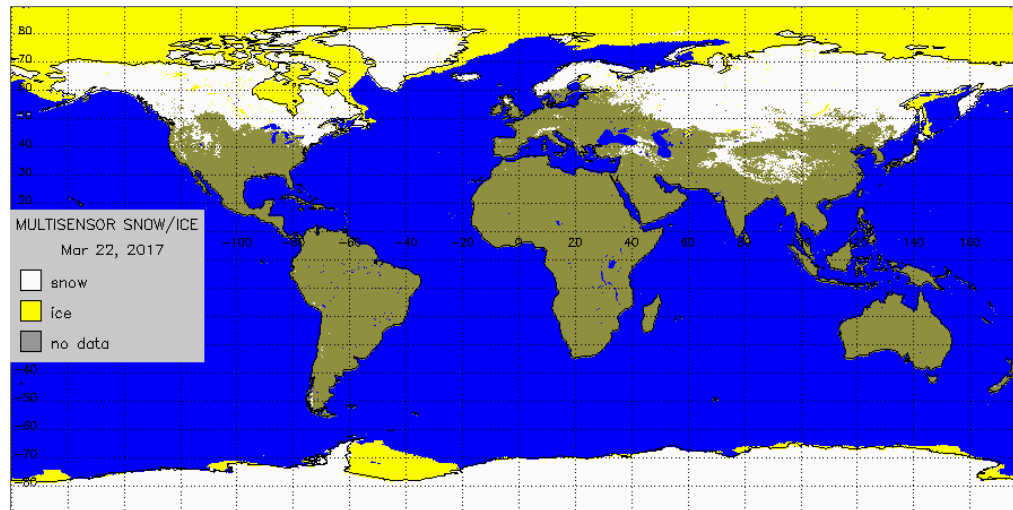
Canopy-corrected (“not viewable”) snow fraction

- Represents snow cover fraction on the ground
- Needed in hydrological applications
- Algorithm needs forest masking factor and derived “viewable snow fraction”:

$$F_{adj} = F_{viewable} / (1 - F_{masking})$$

Gap-free blended snow cover map (VIIRS + microwave)

- Involves GCOM AMSR2 or DMSP/SSMIS snow retrievals
- May use GMASI approach to merging vis/IR and MW data
- Effective spatial resolution:
 - 1 km clear sky
 - 5-10 km cloudy/polar night
- May add ice cover to the gridded product



IDPS Snow algorithms and products

- Demonstrate robust performance.
- Satisfy current accuracy requirements

Enterprise Snow algorithms and products

- Have been implemented in the NDE system.
- Evaluation and monitoring is conducted since Jan 2017
- Provide improved characterization of snow pack properties
- Ready for JPSS-1. Meet requirements.

Further improvements of both algorithms/products are planned