# VIIRS Binary Snow Cover: Current Status and Plans

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# Outline

- VIIRS Snow Cover products
- IDPS Binary Snow Map Product
  - Examples, Accuracy, Existing Problems
- NDE Algorithm
  - Modifications, Improvements, Examples
- Validation Plan
- Further Enhancements

# Current VIIRS IDPS Snow Cover Product

- Binary snow map:
  - Snow/no snow discrimination
  - Imagery (375m) resolution (better than MODIS @ 0.5 km)

- Snow fraction:
  - Aggregation of the binary snow within 2x2 pixel blocks
  - 750 m spatial resolution

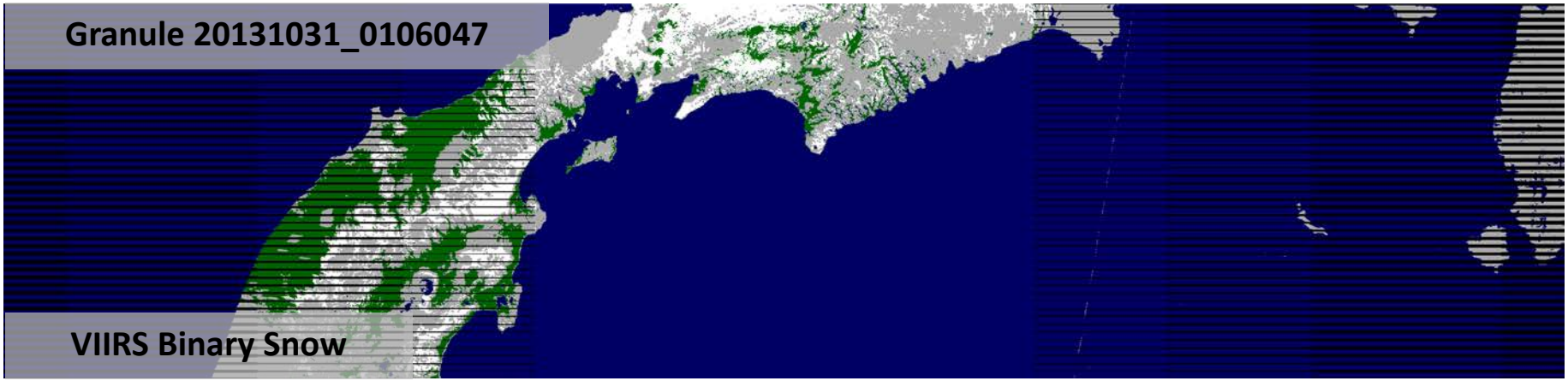
- <u>Both snow products are critically dependent on the accuracy of the VIIRS cloud mask which is an upstream product.</u>

# IDPS Binary Snow Cover Algorithm

- Similar to MODIS SnowMap algorithm (Hall et.al 2001)
- Decision-tree threshold-based classification approach
- Uses Normalized Difference Snow Index (NDSI), reflectance, thermal and NDVI thresholds
- Applied to cloud-clear pixels, requires daylight

# VIIRS Binary Snow Map at Granule Level

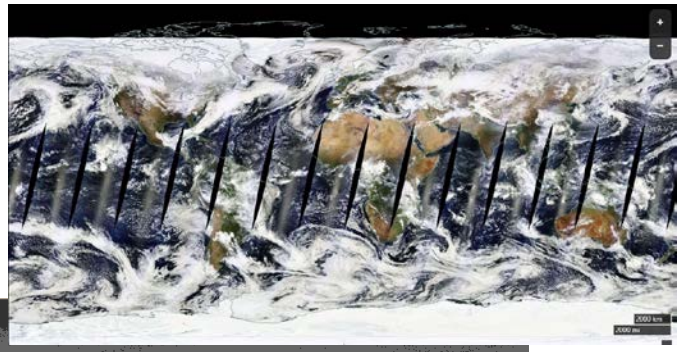


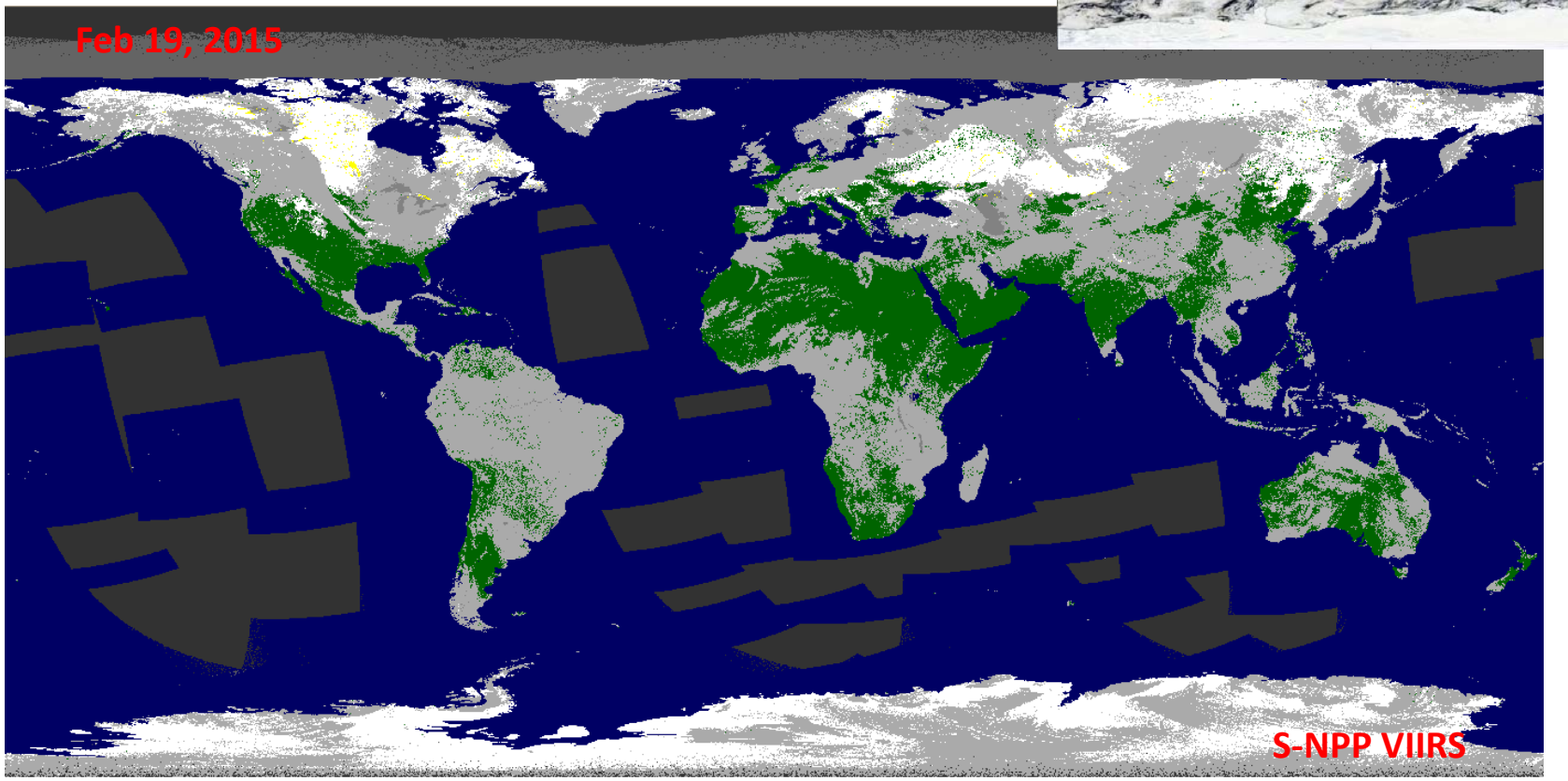




snow land cloud No data

# VIIRS Daily Gridded Snow Map

- Daily global gridded snow maps at 1 km resolution
- Have been produced since the beginning of 2013.
- Lat-lon projection is similar to NASA's CMG
- Granules with no land pixels are not processed





# Product Evaluation Approach

- Visual qualitative assessment of global images
- Quantitative comparison with in situ snow cover observations
  - Mostly over CONUS area
- Comparison with NOAA Interactive Snow/Ice product (IMS)
  - Only over Northern Hemisphere

# Accuracy Assessment

Daily rate of agreement of VIIRS IDPS binary snow maps

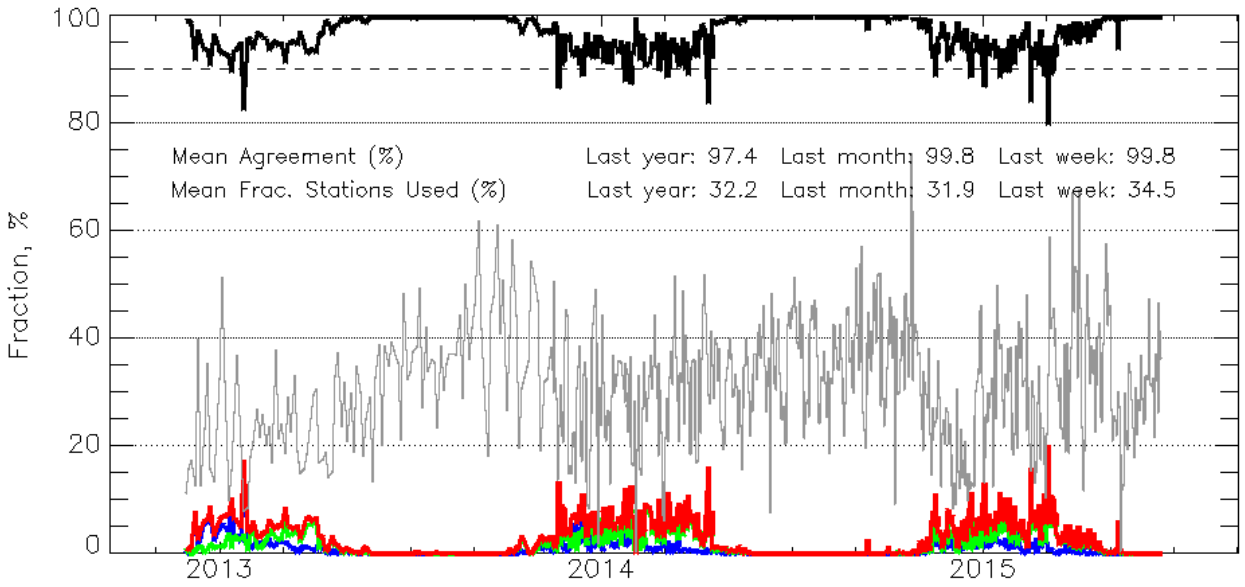
- To IMS, mean: 97%, range: 96-99%
- To in situ reports, mean: 92%, range: 85-96% (CONUS, November-April)
- 90% accuracy requirement is generally satisfied

Agreement decreases

- During transition seasons
- In forested areas
- At large solar/satellite zenith angles

# VIIRS Snow vs In Situ Data

## VIIRS vs In Situ Daily Comparison Statistics, 2013-2015




North America

VIIRS Snow vs Station Data

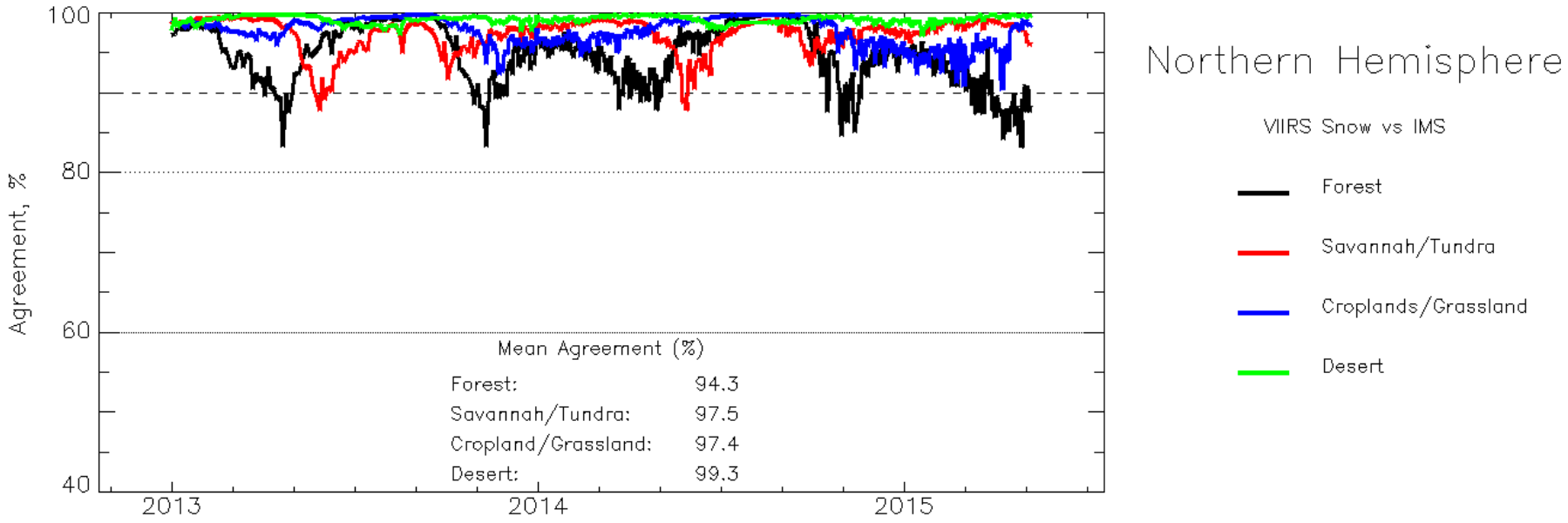
- Total Hits
- Total Errors
- Snow Misses
- False Snow
- Fraction of Stations Used

Last Update: Jun 21, 2015

Most stations are in the CONUS area
Most daily agreement estimates are within 90-95% range

# VIIRS Snow vs IMS

VIIRS daily agreement to IMS by surface cover type, 2013-2015




More frequent errors in forested areas
Some disagreement is due to finite accuracy of the IMS product

# VIIRS, AVHRR, MODIS Snow vs IMS

Mean agreement to IMS and cloud-clear fraction
of daily automated snow products in 2013
*Northern Hemisphere*

| | *Agreement to IMS (%)* | *Cloud-clear(%)** |
|---|---|---|
| **VIIRS** | **98.0** | **38.6** |
| MODIS (T) | 97.3 | 49.1 |
| MODIS(A) | 97.1 | 48.3 |
| AVHRR | 97.9 | 55.0 |

*Cloud-clear fraction is estimated in 25-60$^0$N latitude band

VIIRS: Better accuracy but smaller effective clear-sky coverage

2014-2015: VIIRS cloud-clear fraction increased to 40.7% while the rate of agreement to IMS dropped to 97.8%

# Uncertainty in Accuracy Estimates

**IDPS Snow Map agreement to IMS, Jan 7, 2015**

| | Agreement to IMS(%) |
|---|---|
| All Northern Hemisphere land | **98.4** |
| Snow climatologically possible | **95.3** |
| Within 200km of the snow cover boundary | **93.6** |
| Within 100km of the snow cover boundary | **91.0** |
| Within 50 km of the snow cover boundary | **87.2** |
| Within 20 km of the snow cover boundary | **81.3** |

Mean agreement between products decreases with the region of comparison narrowing down onto the snow cover boundary

When evaluating the accuracy it is important to know exactly how it was obtained

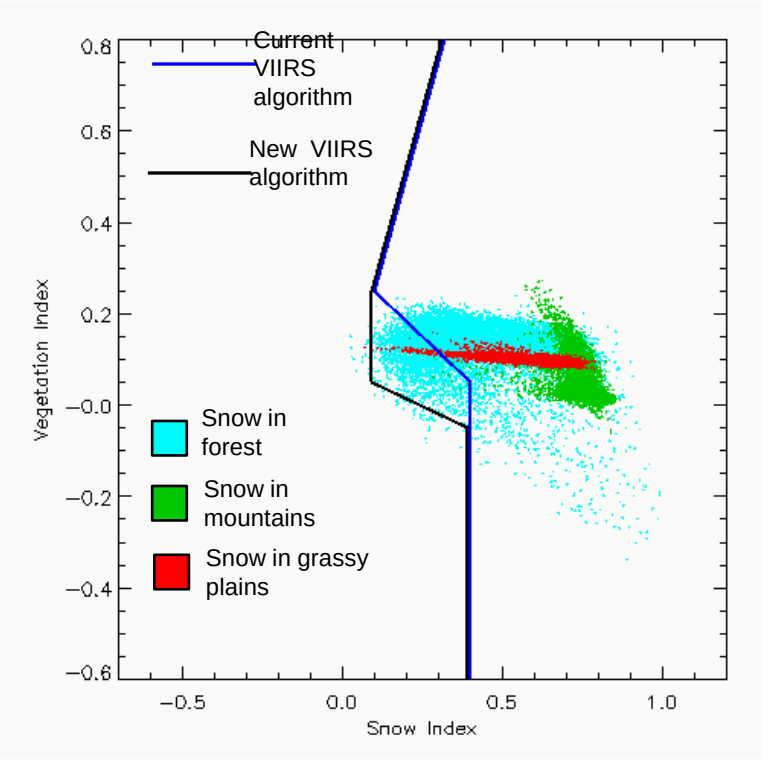
# NDE Snow Algorithm

## NDE Algorithm

- 2-stage procedure: spectral tests + consistency checks

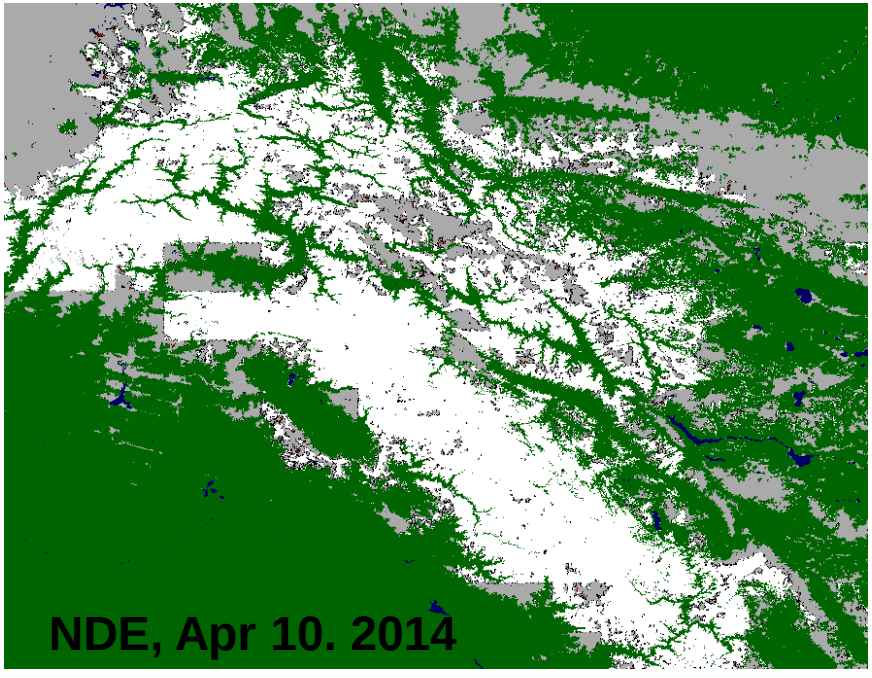
- Spectral tests: similar to IDPS but more relaxed
  - Intent: Improve snow identification in forests and in the transition zone

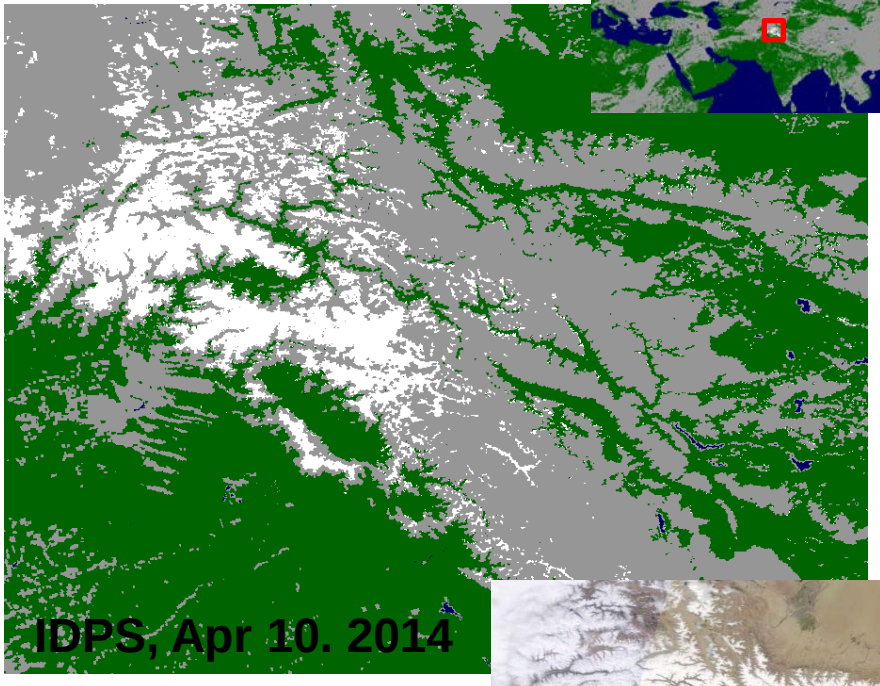
- Consistency tests (new, not in IDPS)
  - Snow climatology
  - Surface temperature climatology
  - Spatial consistency
  - Temperature spatial uniformity
  - Intent: Eliminate possible spurious snow

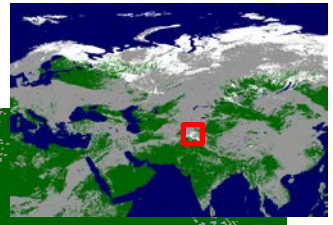


# NDE vs IDPS Binary Snow Product

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



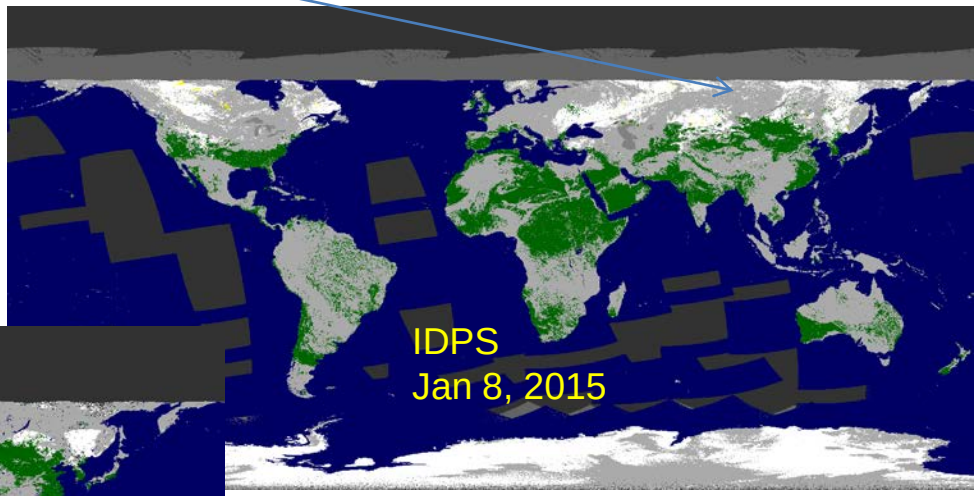
snow land cloud No data

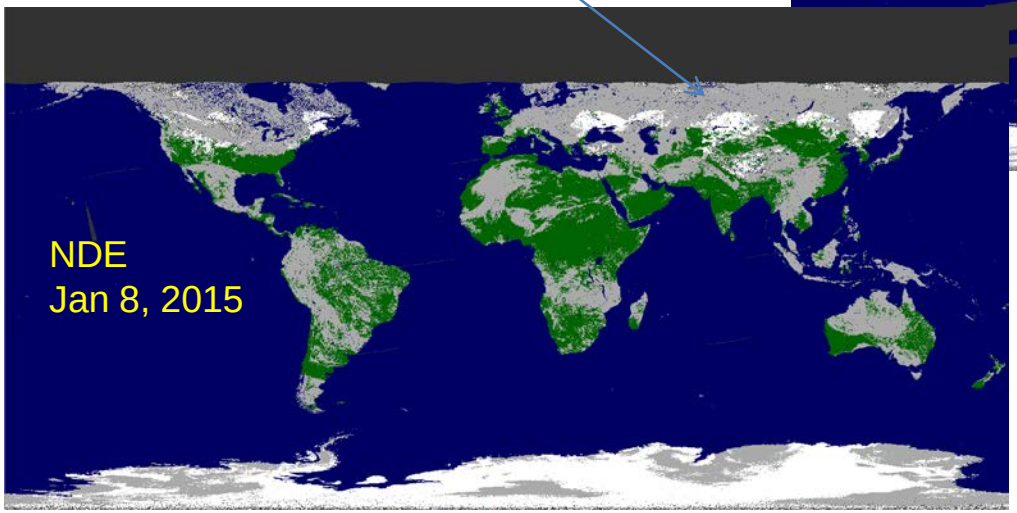
# NDE vs IDPS Binary Snow Product

**NDE: Less conservative cloud mask in low and midlatitudes, but much more conservative cloud mask at high solar zenith angles**

Some cloud-clear scenes in the IDPS product

Cloudy in the NDE product




snow land cloud No data

# NDE Binary Snow Accuracy

Limited dataset processed: January 2015, 10 days in April, July and Oct 2014

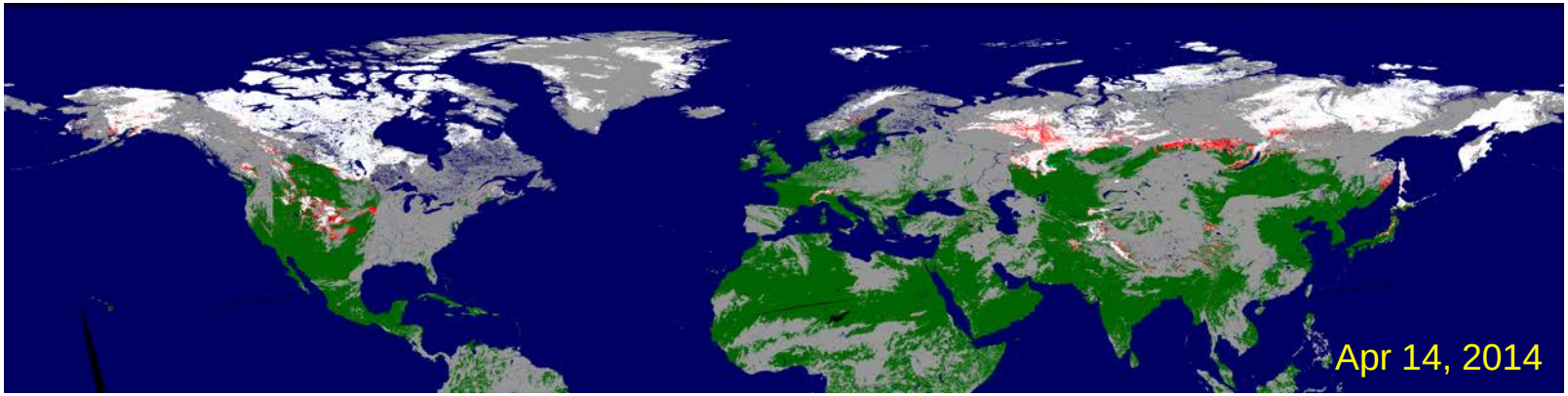
Daily rate of agreement,  January 2015

- To IMS: 96-99% (Northern Hemisphere)
- To in situ snow depth reports: 88-97%  (CONUS)

NDE Binary Snow accuracy is similar to the IDPS accuracy

# NDE Snow vs IMS

## VIIRS NDE Binary Snow with IMS data overlaid




Some VIIRS snow “omissions” may be due to overly aggressive snow mapping by IMS analysts

# Further Enhancements

- Location-dependent threshold values

- Improved snow cover climatology

- Add ice identification on rivers and lakes

- Daily gridded products

# NOAA vs NASA Approach

NASA:

- Discontinue producing binary snow maps
- Retain only Snow Fraction (NDSI-based)

NOAA:

- Binary Snow Cover is still needed. No plans to discontinue.

# Reprocessing, Long-Term Monitoring

No plans for reprocessing so far

NDE long term product monitoring will be similar to IDPS

- Global gridded snow maps
- Visual examination
- Routine comparison with IMS and in –situ data
- Daily accuracy estimates

# Summary

VIIRS Binary Snow validation approaches and tools

- Have been developed and are actively used

IDPS Binary Snow Cover product

- Provides consistent characterization of global snow cover
- Satisfies the 10% accuracy requirement but can be improved

New NDE algorithm will

- Improve snow detection/mapping in transition zones
- Reduce spurious snow identifications

Overall the quality of the new snow product is highly dependent on the performance of NDE cloud mask and its further improvement