

# **Entangling Snow/Snowmelt Screening and Smog AOT Retrievals in the VIIRS Aerosol Algorithm**

**Jingfeng Huang**

**UMD/ESSIC/CICS @ NOAA/NESDIS/STAR**

**Shobha Kondragunta, Istvan Laszlo, Hongqing Liu, Hai  
Zhang, Pubu Ciren, Lorraine A. Remer**

- Part 1: Towards a Better Snow/Snowmelt Screening in the IDPS VIIRS Aerosol Algorithm
- Part 2: The missing China Smog AOT Retrievals in the IDPS VIIRS AOT Product
- Part 3: Balance Snow/Snowmelt Screening and China Smog Detection in the EPS Aerosol Algorithm
- Summary



# The Two VIIRS Aerosol Algorithms



1. The Two S-NPP VIIRS AOT Algorithms
  - IDPS: Interface Data Processing Segment (Current Operational VIIRS Aerosol Algorithm)
  - EPS: Enterprise Processing System (Currently under testing and will replace IDPS in operation soon)
2. Improvements in EPS:
  1. Pixel screening procedures – *eliminate artifacts*
  2. New algorithm science – *provides enhanced spatial coverage*
3. EPS: Characterization of China Smog Events

# IDPS vs. EPS: Main Differences

- Detection, observation and quantification of global aerosol outbreaks is one of many important applications of the global satellite aerosol products

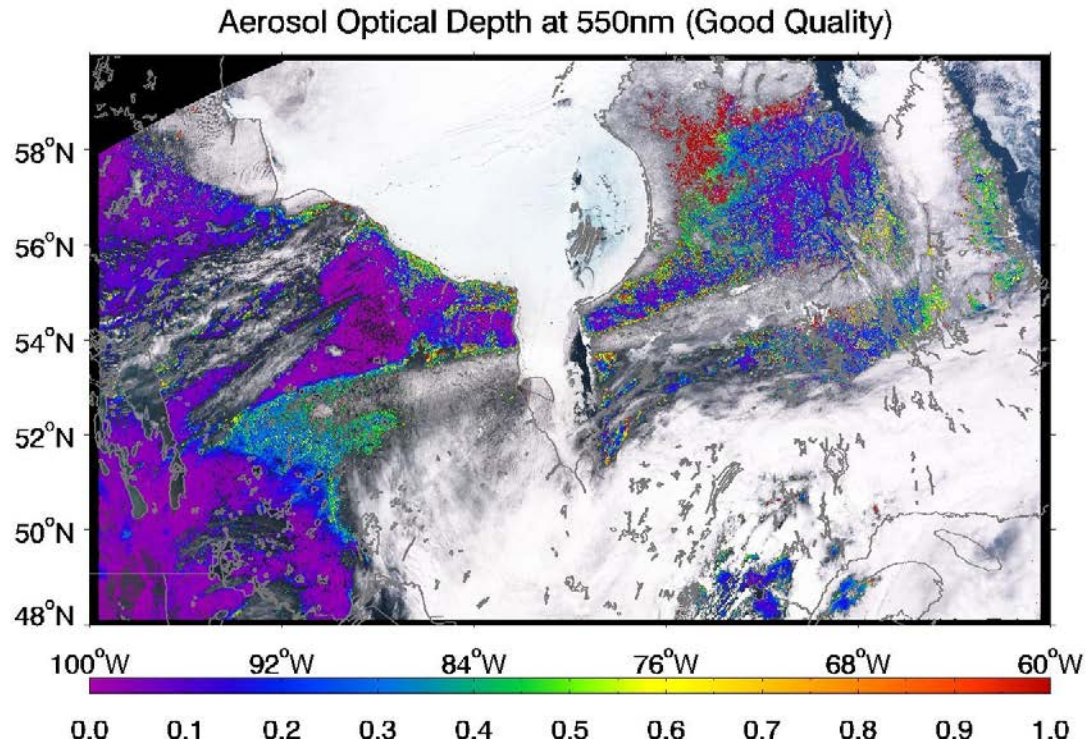
	IDPS Aerosol Algorithm (Current Operational)	EPS Aerosol Algorithm (Upcoming Operational)
AOT range	[0, 2.0]	[-0.05, 5.0]
Retrieval surfaces over land	Dark surface only	Both dark and bright surfaces
Cloud overscreening	Heavy aerosol mis-identified as clouds in some pixels	internal heavy aerosol callback test
Internal snow test over land	Smog mis-identified as snow in some pixels	Improved snow test
Internal Ephemeral Water Test	Aerosol mis-identified as ephemeral water in some pixels	Improved ephemeral water test

# PART 1:

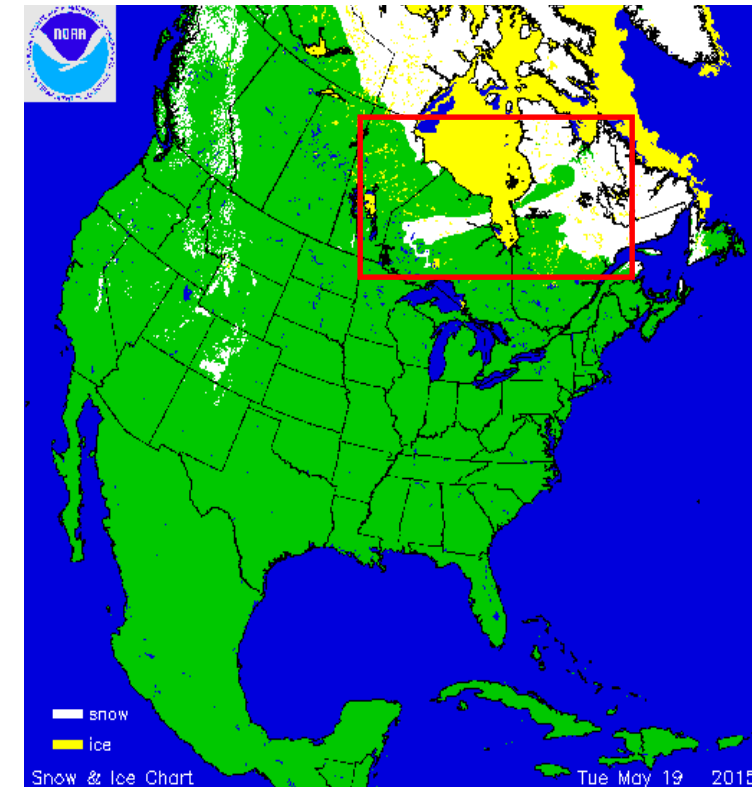
## **TOWARDS A BETTER SNOW/SNOWMELT SCREENING IN THE IDPS VIIRS AEROSOL ALGORITHM**

# Problem: Snow/Snowmelt Underscreening (regional)

**May 19, 2015**



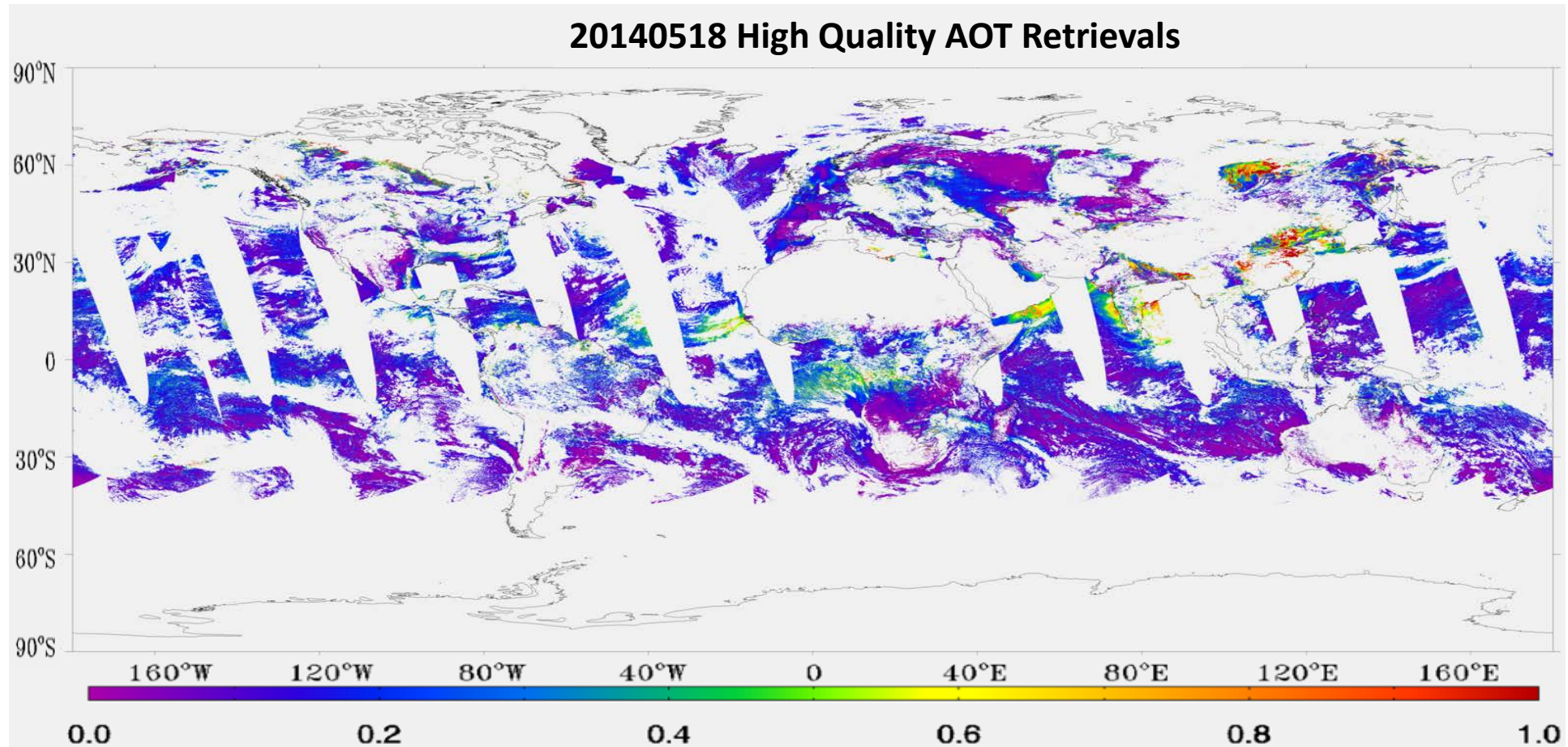
**IDPS VIIRS 'Good' quality AOT retrievals on  
May 19, 2015**



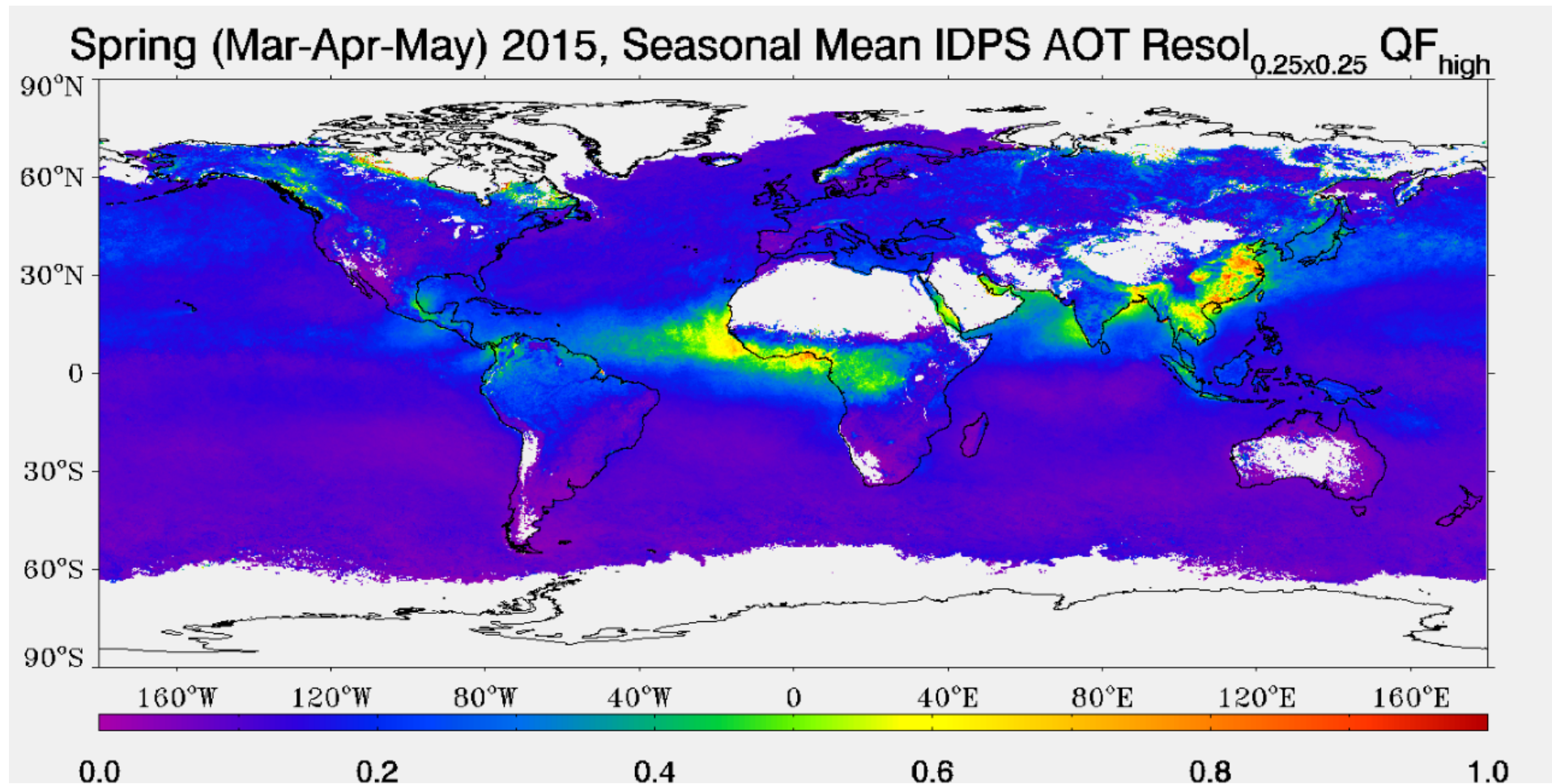
the snow cover map produced by NOAA National Centers for Environmental Information (NCEI)  
(<https://www.ncdc.noaa.gov/snow-and-ice/snow-cover/us/20150519>).



# Problem: Snow/Snowmelt Underscreening (Global, Daily)



# Problem: Snow/Snowmelt Underscreening (Global, Seasonal)



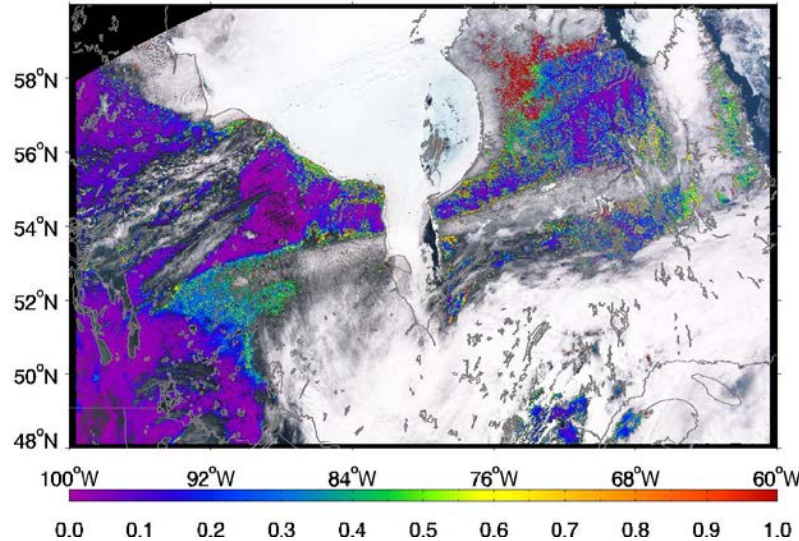


# New NDSI and BT11 based Snow Test

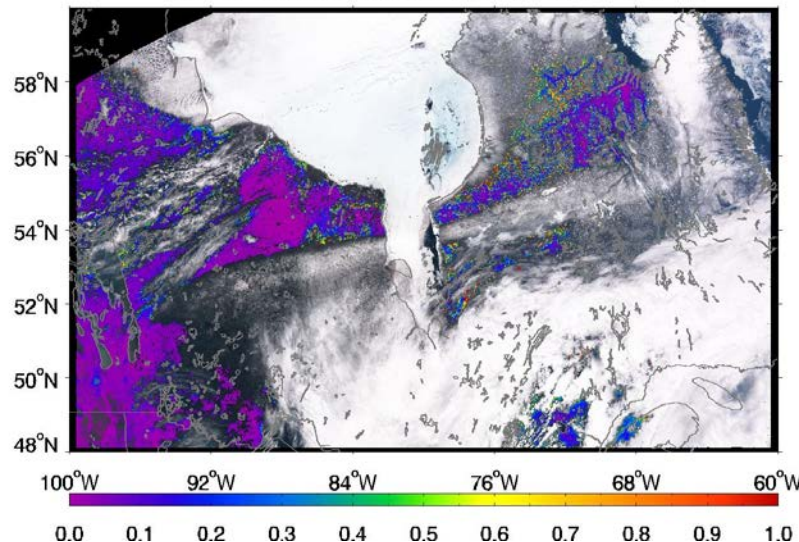
Tests	Old VRA Based Test	New NDSI Based Snow Test	Snow Adjacency Test	Spatial Filter
Criteria	<ol style="list-style-type: none"> <li>1. <math>VRA &gt; 0.02</math>;</li> <li>2. <math>rM8/rM7 &lt; 0.9</math>;</li> <li>3. Surface Temperature (ST) <math>&lt; 278\text{ K}</math></li> </ol>	<ol style="list-style-type: none"> <li>1. <math>NDSI &gt; C</math>;</li> <li>2. <math>BT_{10.76\text{ }\mu\text{m}} &lt; 285\text{ K}</math></li> </ol>	If any of 7x7 surrounding pixels is snow	If the standard deviation of 3x3 M1 is higher than 0.05
Quality	Not Produced	Not Produced	Degraded to Medium	Degraded to Medium
Notes	<ol style="list-style-type: none"> <li>1. <math>VRA = crM3 - 0.5 * crM5</math>;</li> <li>2. ST derived from <math>BT_{10.76\text{ }\mu\text{m}}</math> and <math>BT_{12.01\text{ }\mu\text{m}}</math></li> </ol>	<ol style="list-style-type: none"> <li>1. <math>NDSI = (rM7 - rM8) / (rM7 + rM8)</math>;</li> <li>2. <math>C = 0.01</math> for IDPS;</li> <li>3. <math>C = 0.10</math> for EPS</li> </ol>	Check high quality AOT retrievals at central pixel only	Check high quality AOT retrievals at central pixel only

# Better Snow/Snowmelt Screening

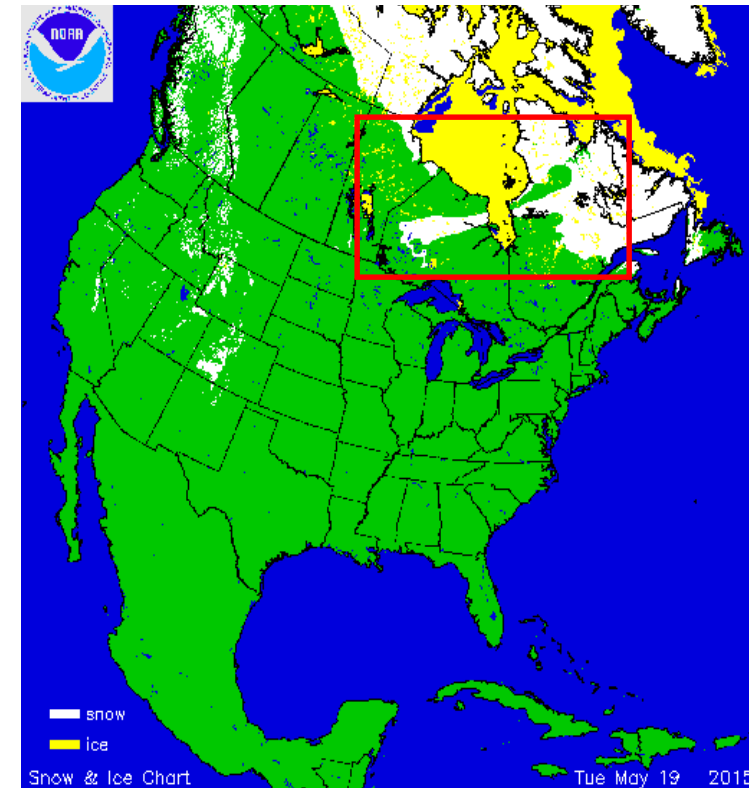
Aerosol Optical Depth at 550nm (Good Quality)



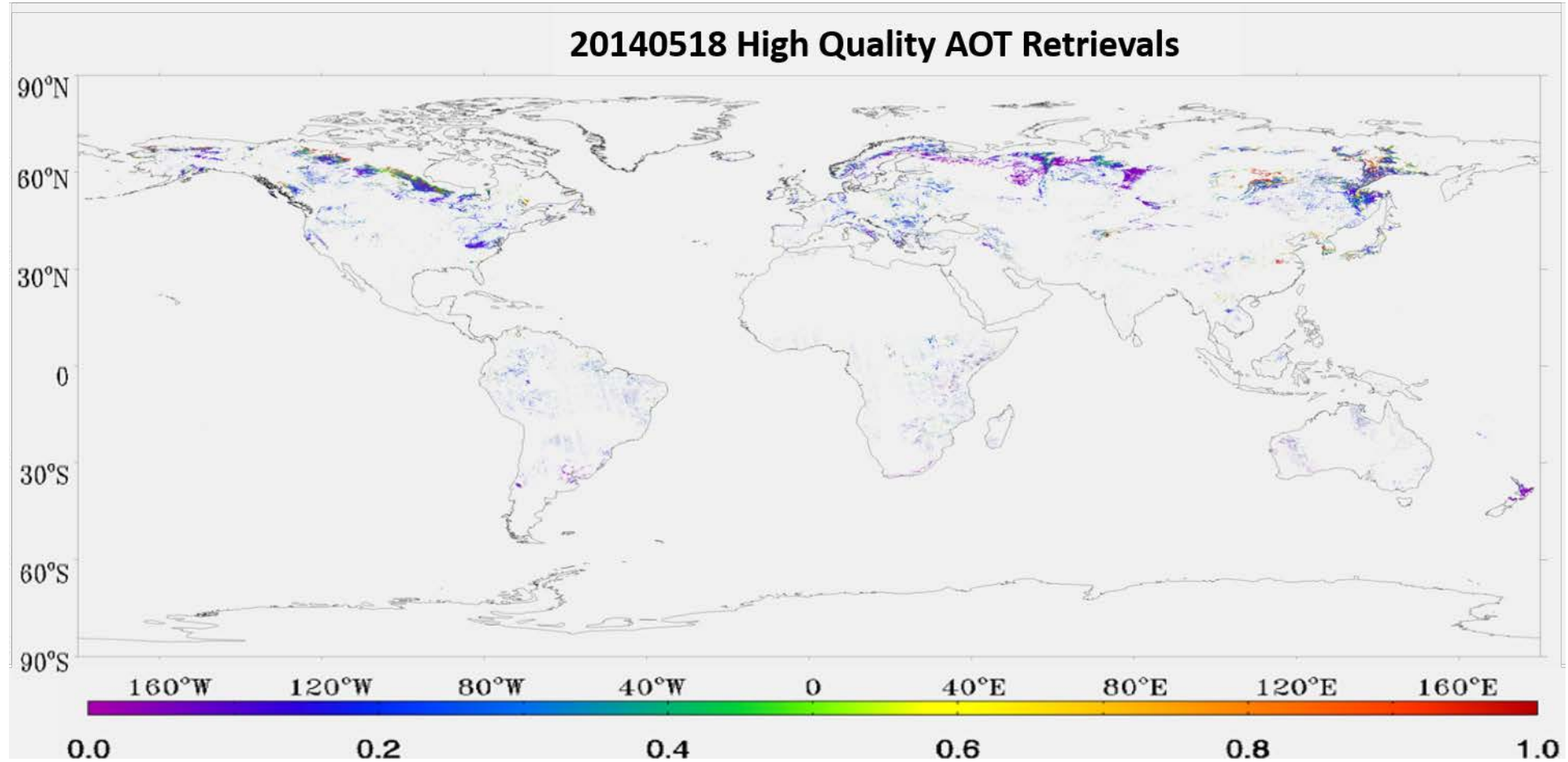
Aerosol Optical Depth at 550nm (Good Quality)



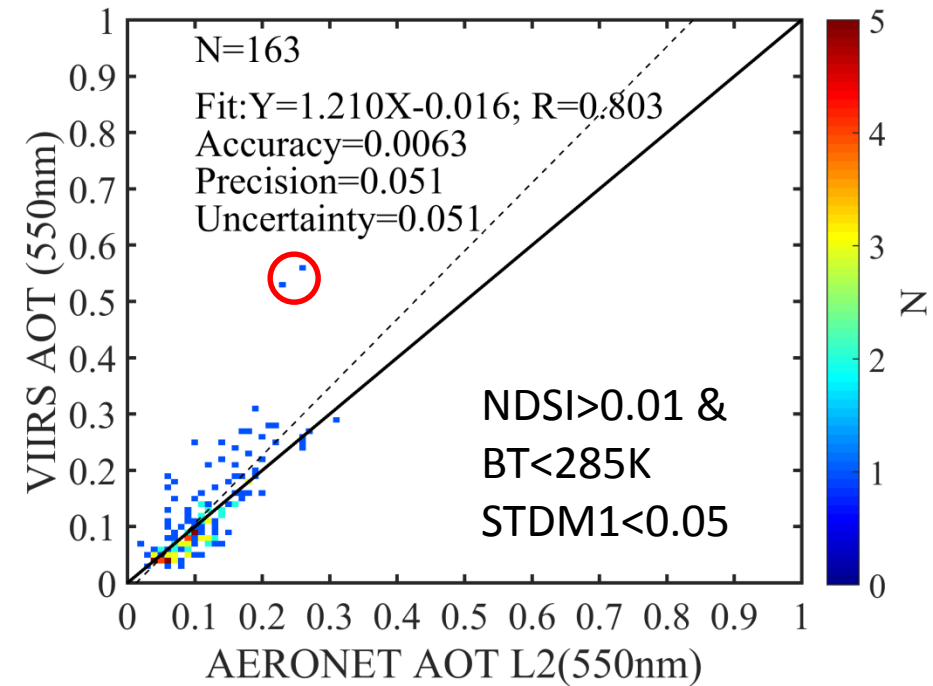
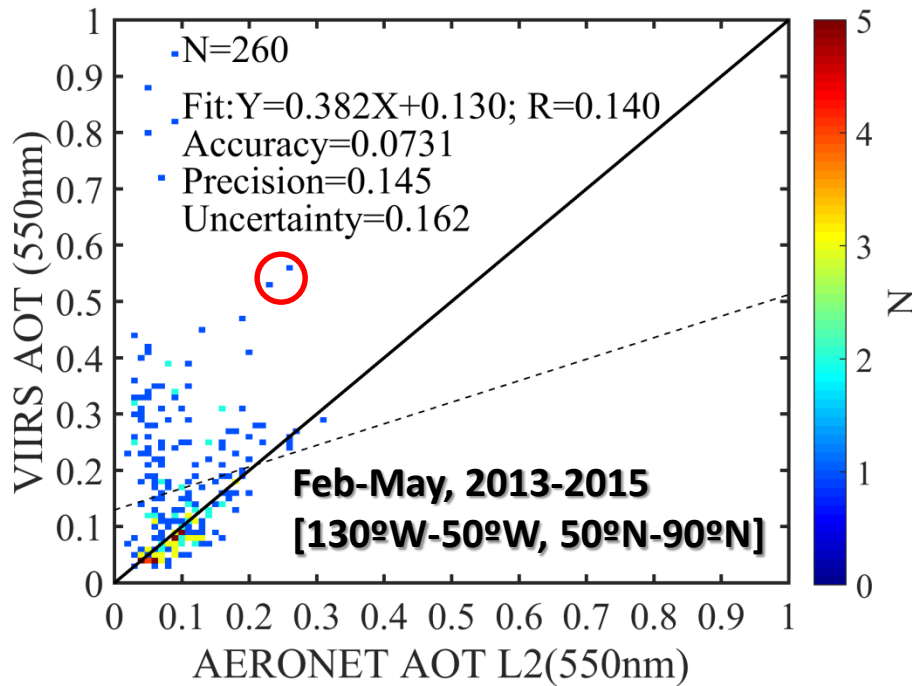
**'Good' quality AOT retrievals on May 19, 2015**



# Better Snow Screening



# Better Snow/Snowmelt Screening



	N	Snow	SnowAdj	SpaFil	N'
Case1	260	43	94	0	163

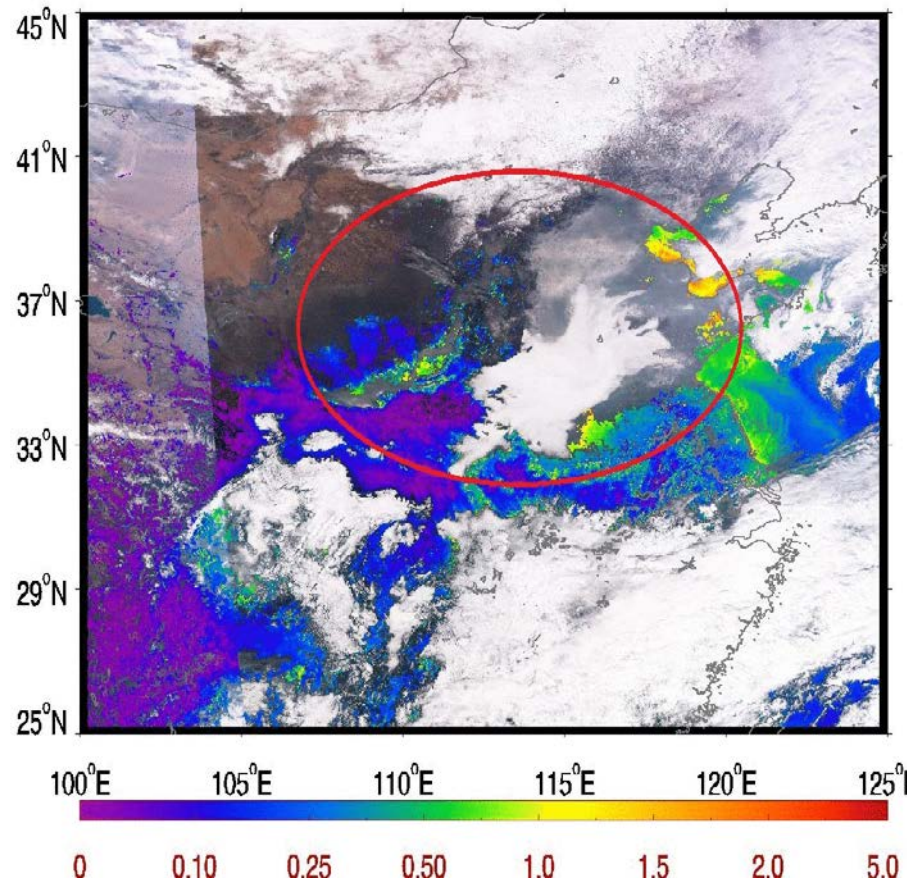


## PART 2:

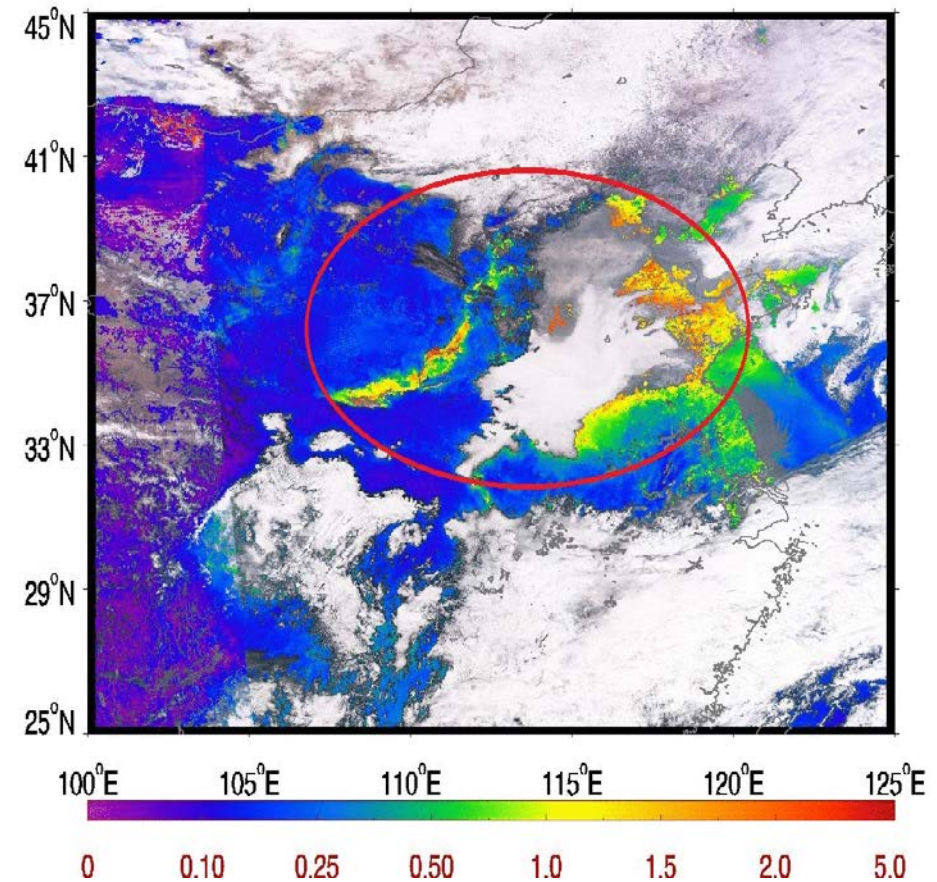
# **THE MISSING CHINA SMOG AOT RETRIEVALS IN THE IDPS VIIRS AOT PRODUCT**

# IDPS vs. EPS: Best Quality AOT Animation

IP Aerosol Optical Depth at 550nm (High Quality), 20151129



EPS Aerosol Optical Depth at 550nm (High Quality), 20151129



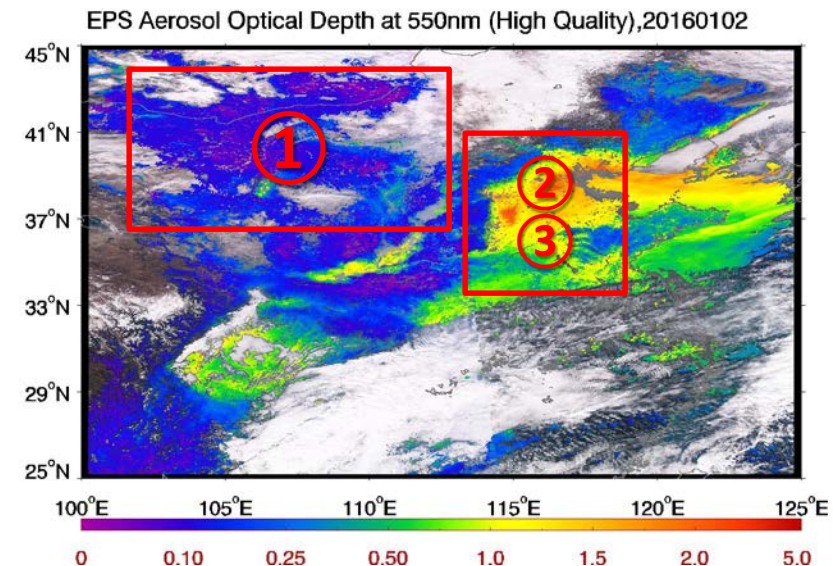
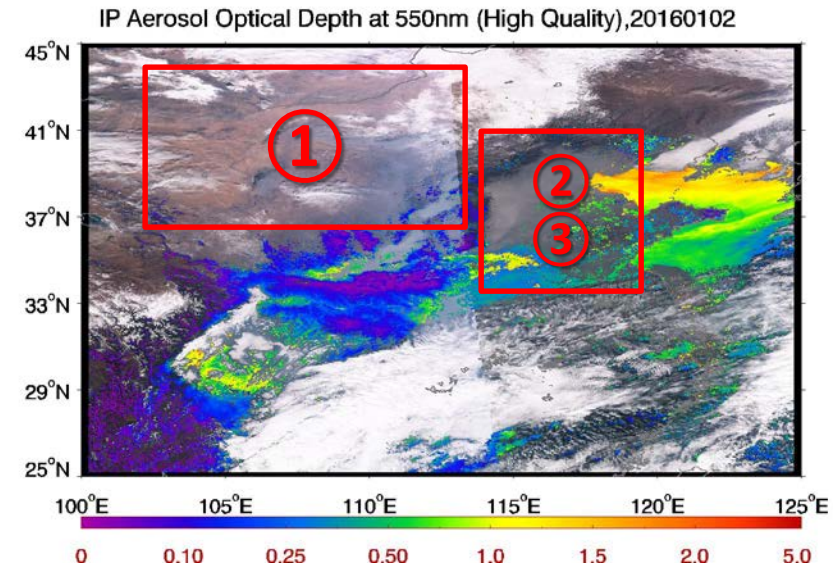


# IDPS vs. EPS Best Quality AOT, 2016-01-02

① IDPS only has dark surface retrieval over land; EPS has both dark and bright surface retrievals over land.

② IDPS had AOT retrieval up to 2.0; EPS had AOT retrieval higher than 2.0 and up to 5.0

③ Main Focus: IDPS missed heavy smog AOT retrievals; EPS regained these retrievals.



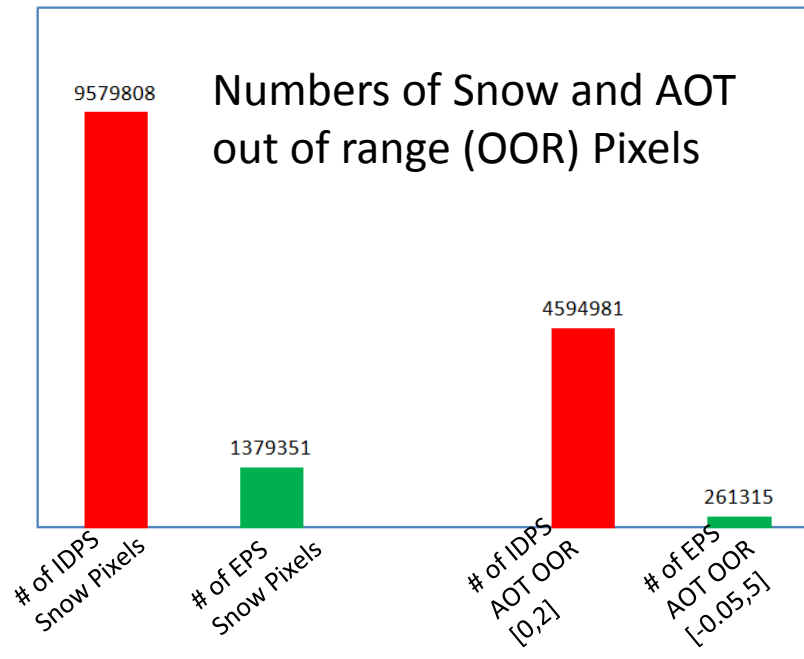
# Why did IDPS miss the smog AOT retrievals?

## Data Collection:

- ✓ 13 smog events ([25-45N, 100-125E], Winter 2015-2016)
- ✓ IDPS AOT with QF not produced or excluded
- ✓ EPS AOT (Best Quality) > 0.5
- ✓ 448881 Pixels In Total

## Statistical Results:

- ✓ **49.7% had smog mis-identified as snow**
- ✓ **43.7% had IDPS AOT retrievals out of range [0.0, 2.0]**

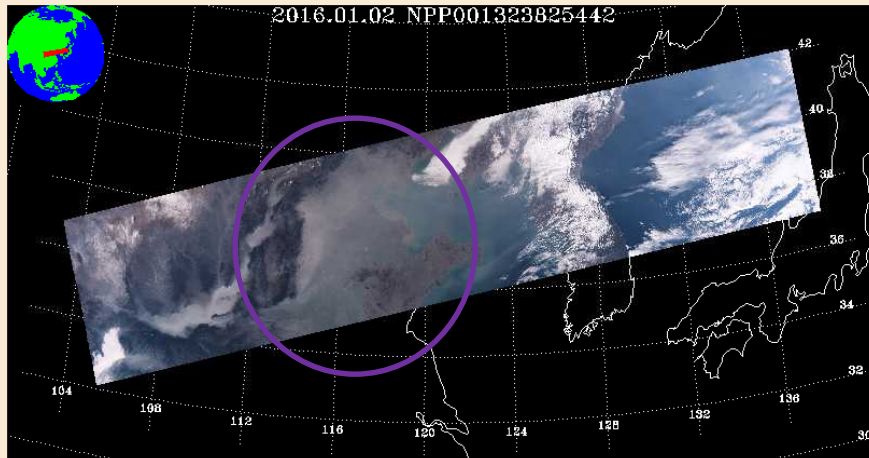


- Internal Snow Over Screening and AOT Out Of Range (OOR) were identified as the Top Two factors that prevented IDPS best quality AOT retrievals over smog pixels;
  - EPS /IDPS Snow Pixels: 14.4%
  - EPS/IDPS AOT OOR pixels: 5.7%
- (Note: EPS has larger AOT range than IDPS)



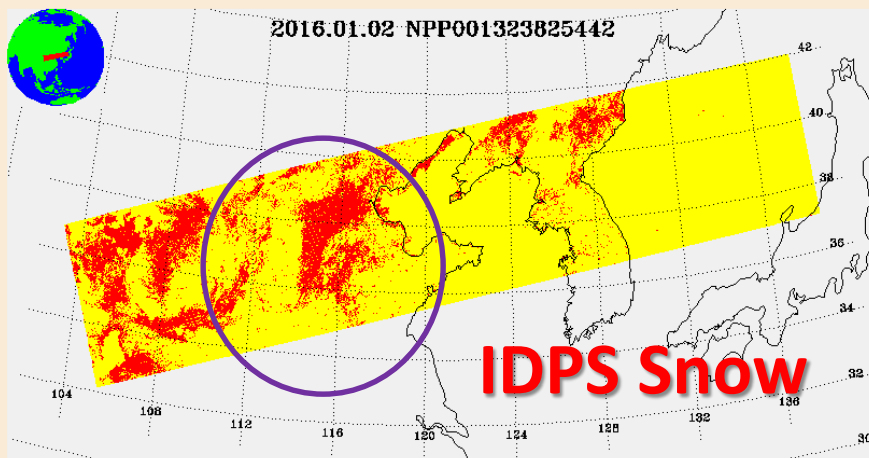
# IDPS vs. EPS: Internal Snow Test

RGB Image [R=M5 (672 nm), G=M4 (555 nm), B=M3 (488 nm)]



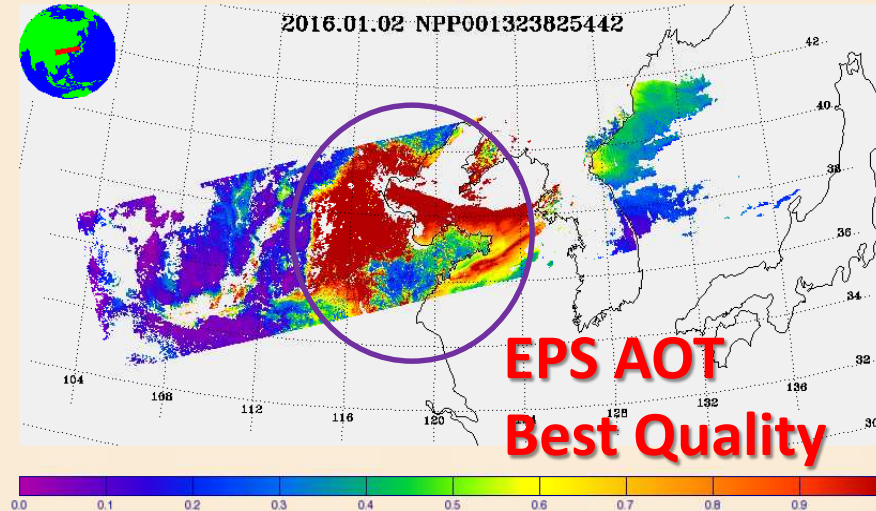
VAOT\_npp\_d20160102\_t0455425\_e0457066\_b21662\_c20160524141400638713\_noaa\_ops.h5

IP Snow/Ice

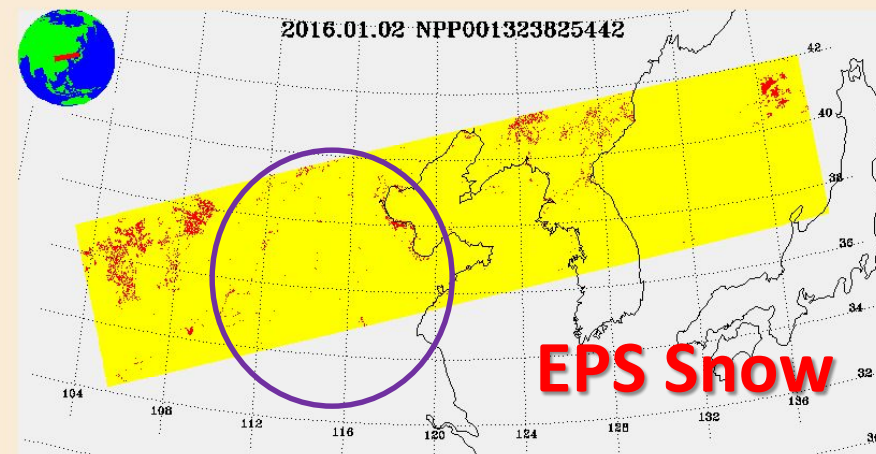


2016002\_t0455425.h5

AOT at 550nm  
Overall Quality Flag=High



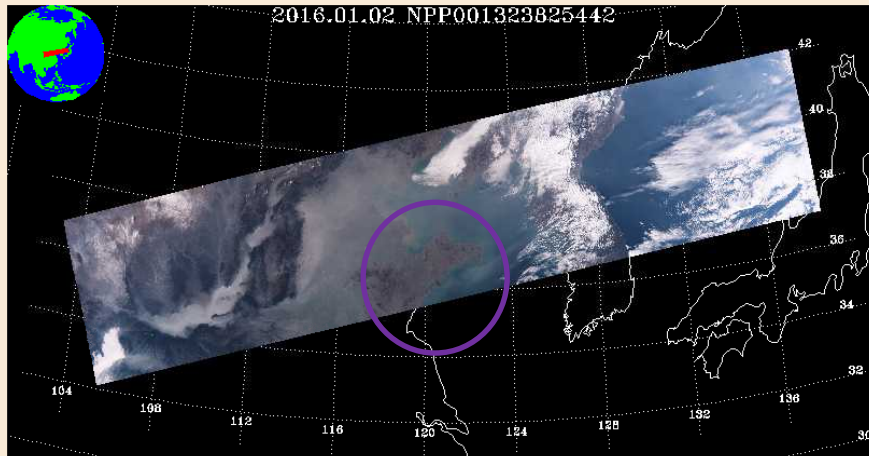
SnowIce (Internal Test)



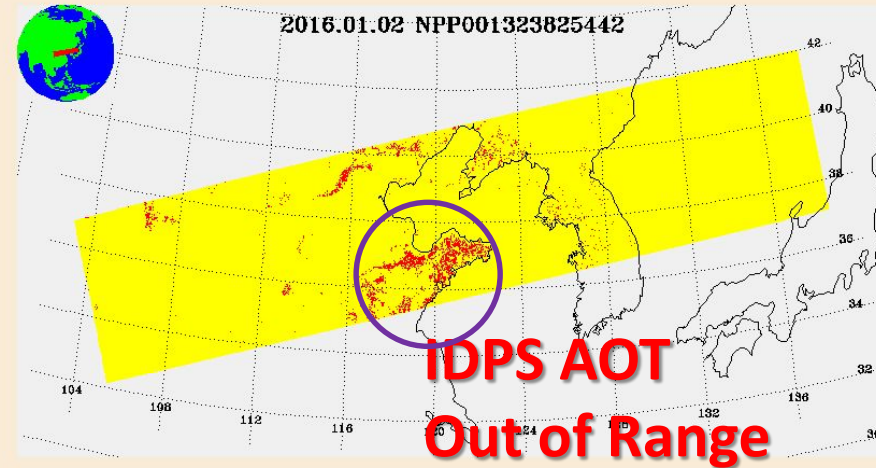
# IDPS vs. EPS: AOT Out Of Range (OOR)

IVAOT\_npp\_d20160102\_t0455425\_e0457066\_b21662\_c20160524141400638713\_noaa\_ops.h5

RGB Image [R=M5 (672 nm), G=M4 (555 nm), B=M3 (488 nm)]

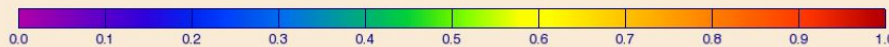
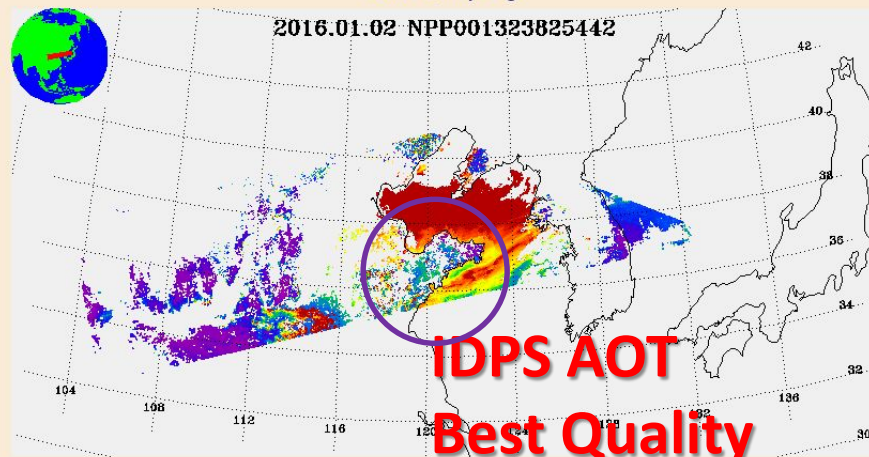


IP AOT Out of Spec Range



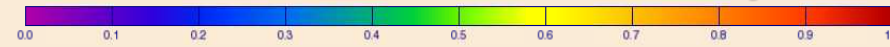
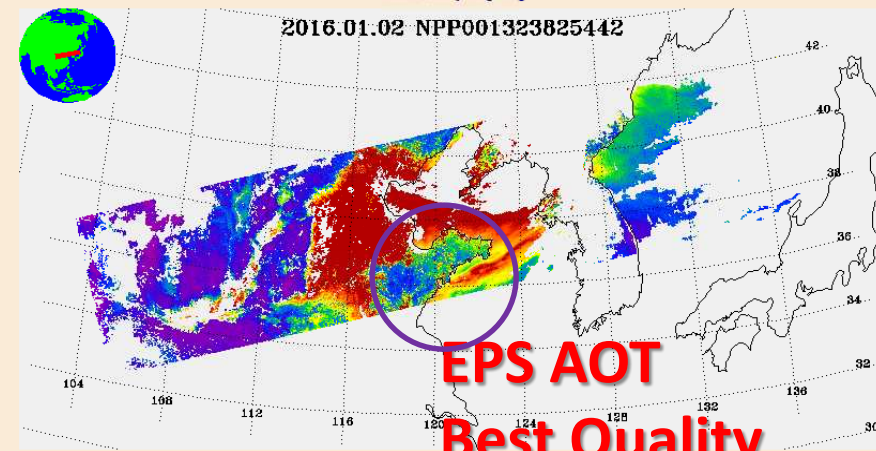
IVAOT\_npp\_d20160102\_t0455425\_e0457066\_b21662\_c20160524141400638713\_noaa\_ops.h5

Aerosol Optical Thickness (IP) at 550nm  
IP AOT Quality=High

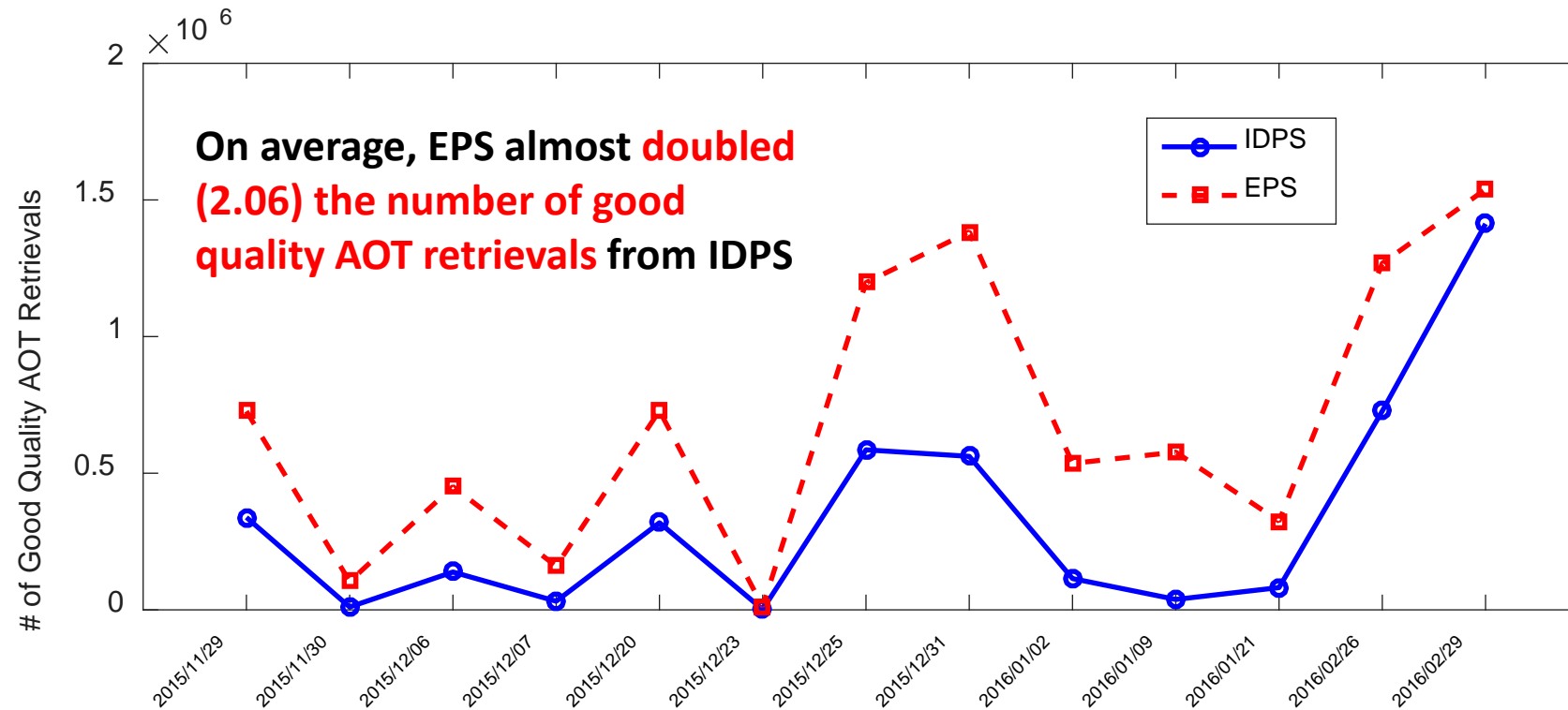


False True

AOT at 550nm  
Overall Quality Flag=High



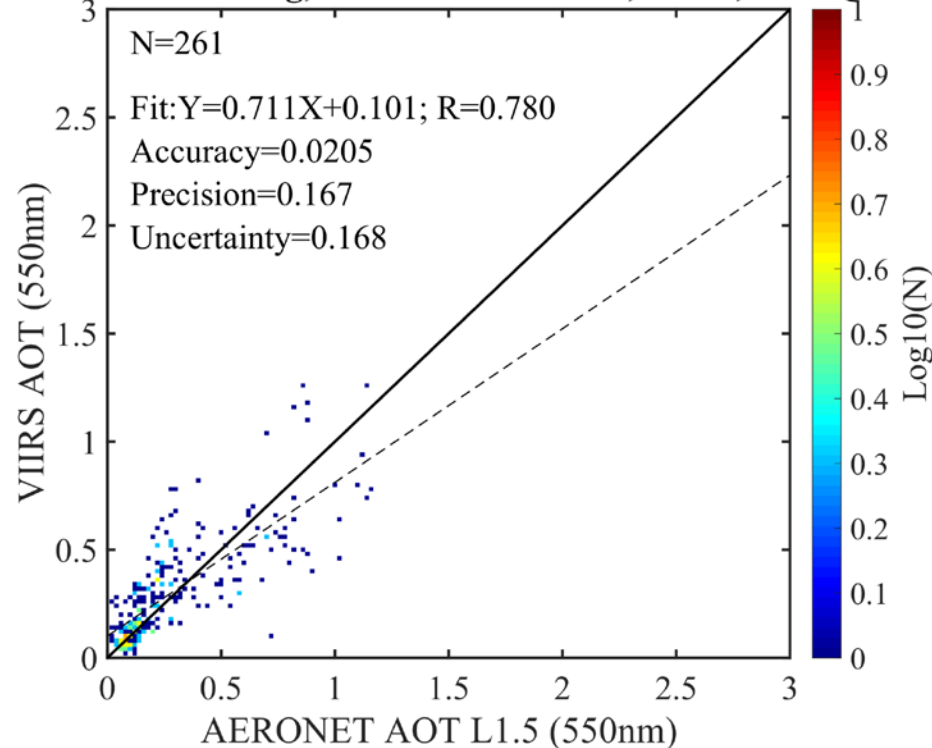
# IDPS vs. EPS: Number of Good Quality AOT





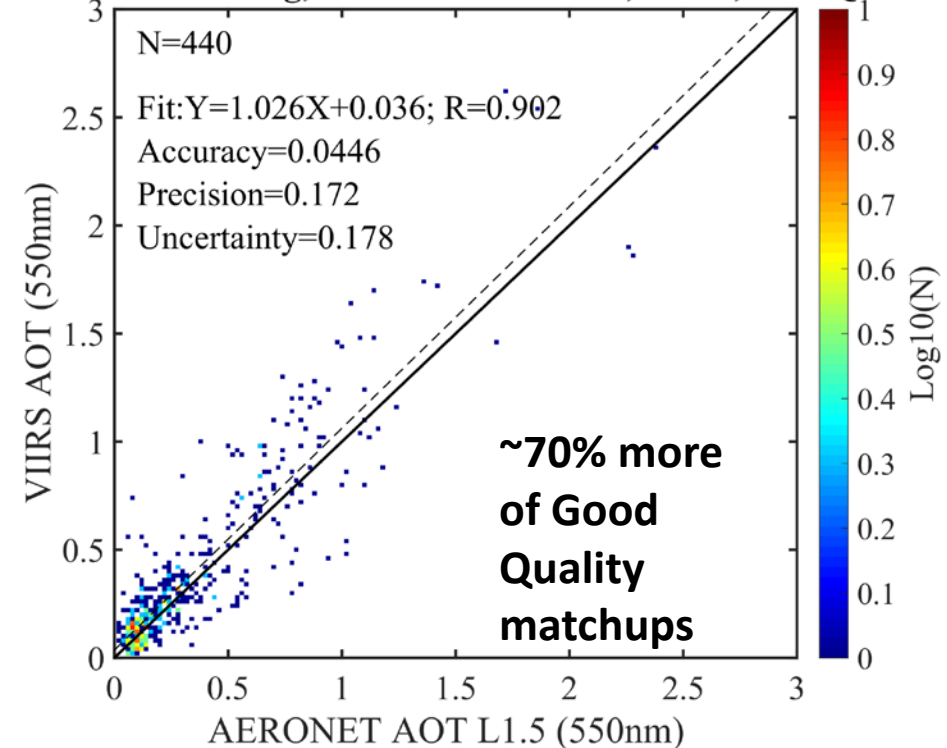
# IDPS vs. EPS: Comparison to AERONET

**IDPS: China Smog, 2015 Nov-2016 Feb, M2M, Best QA**



## IDPS vs. AERONET L1.5

**EPS: China Smog, 2015 Nov-2016 Feb, M2M, Best QA**

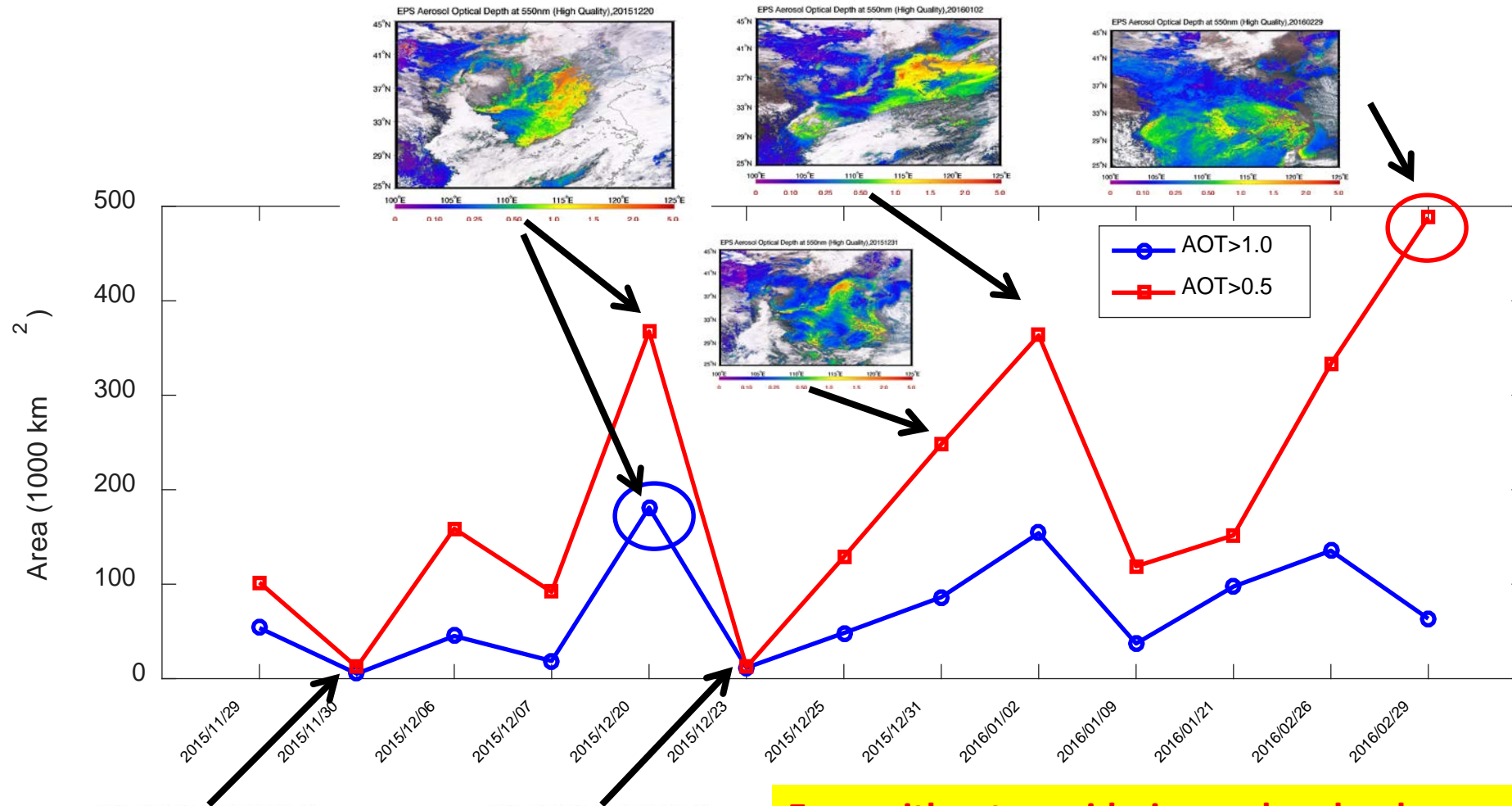


## EPS vs. AERONET L1.5

**In the matchup with AERONET L1.5, EPS VIIRS Aerosol Algorithm increased best quality AOT matchups by ~70% more than IDPS**



# EPS evaluated Smog Spatial Coverage



**Even without considering under-cloud smog:**

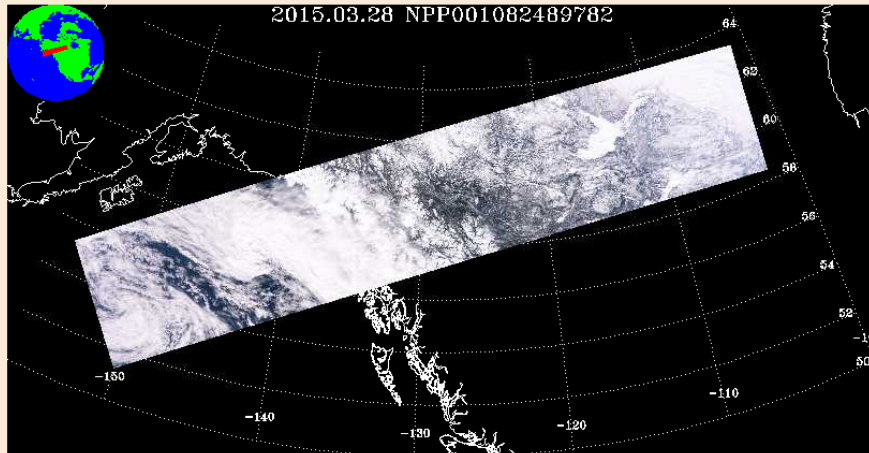
➤ AOT > 1.0: can be as large as 200,000 km<sup>2</sup>

➤ AOT > 0.5: can be as large as 500,000 km<sup>2</sup>

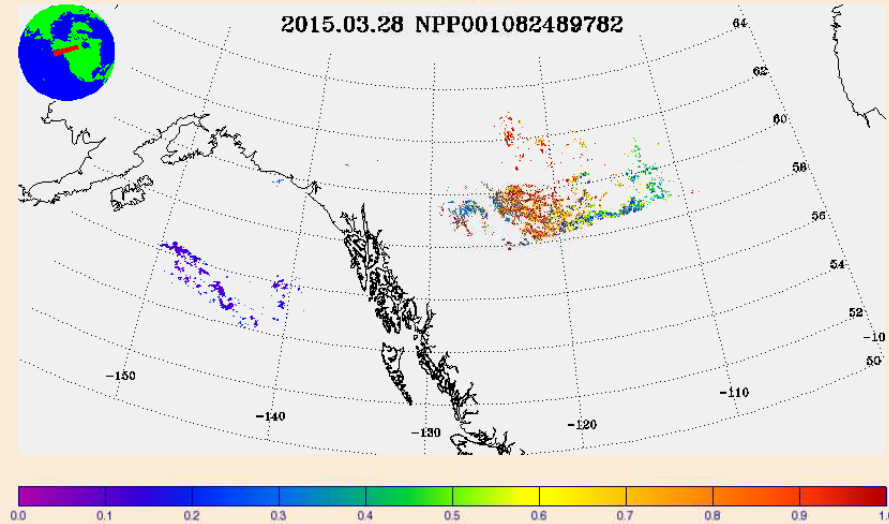
# Fine Tuned Spatial Filter in EPS

IVAOT\_npp\_d20150328\_t2109372\_e2111014\_b17699\_c20150328230603123444\_noaa\_ops.h5

RGB Image [R=M5 (672 nm), G=M4 (555 nm), B=M3 (488 nm)]

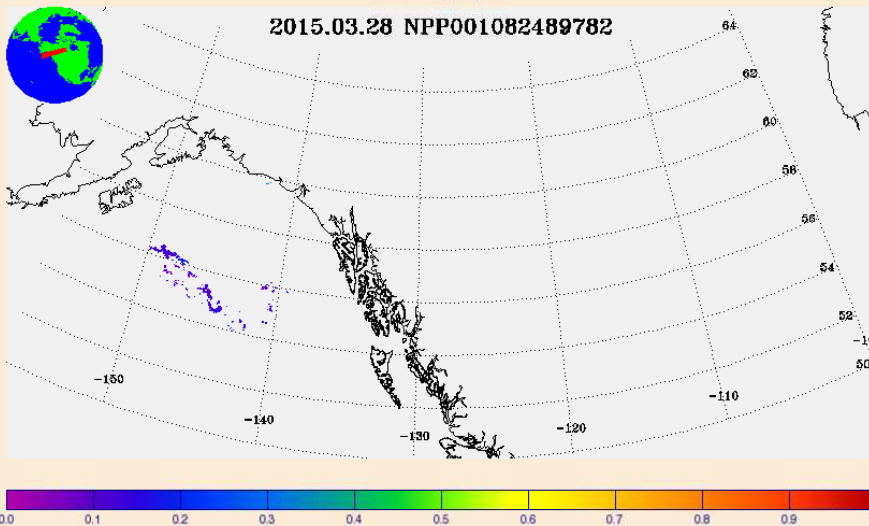


Aerosol Optical Thickness (IP) at 550nm  
IP AOT Quality=High



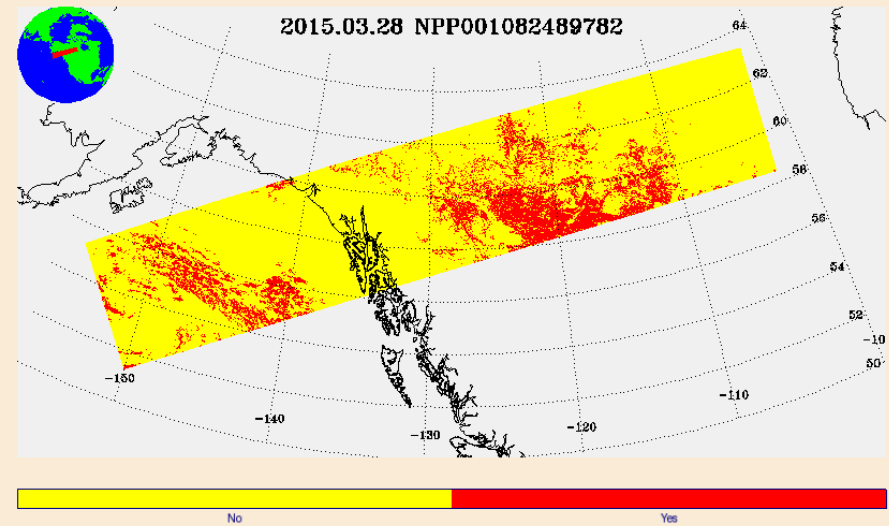
2015087\_t2109372.h5

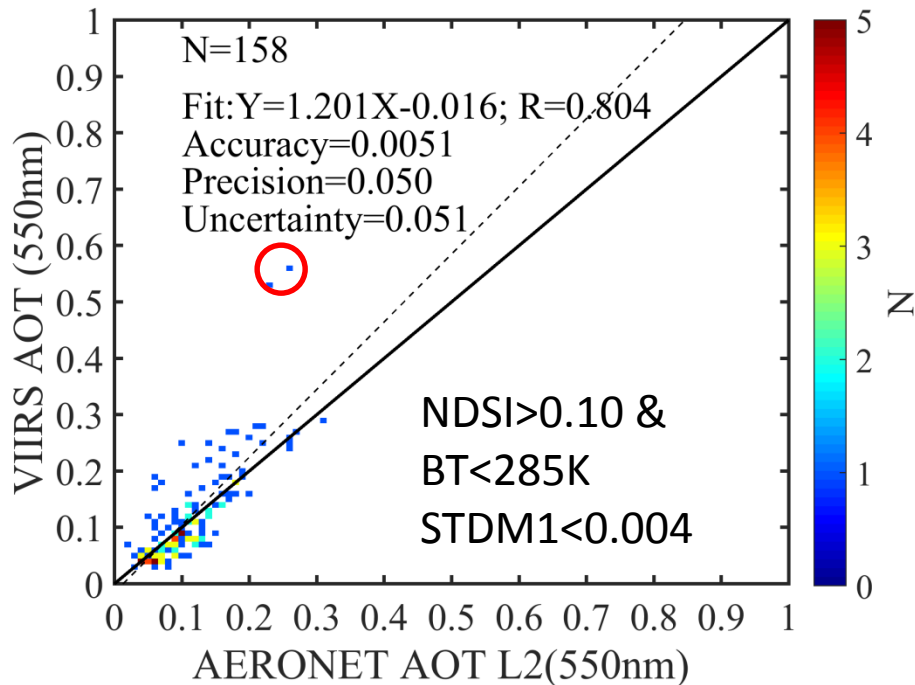
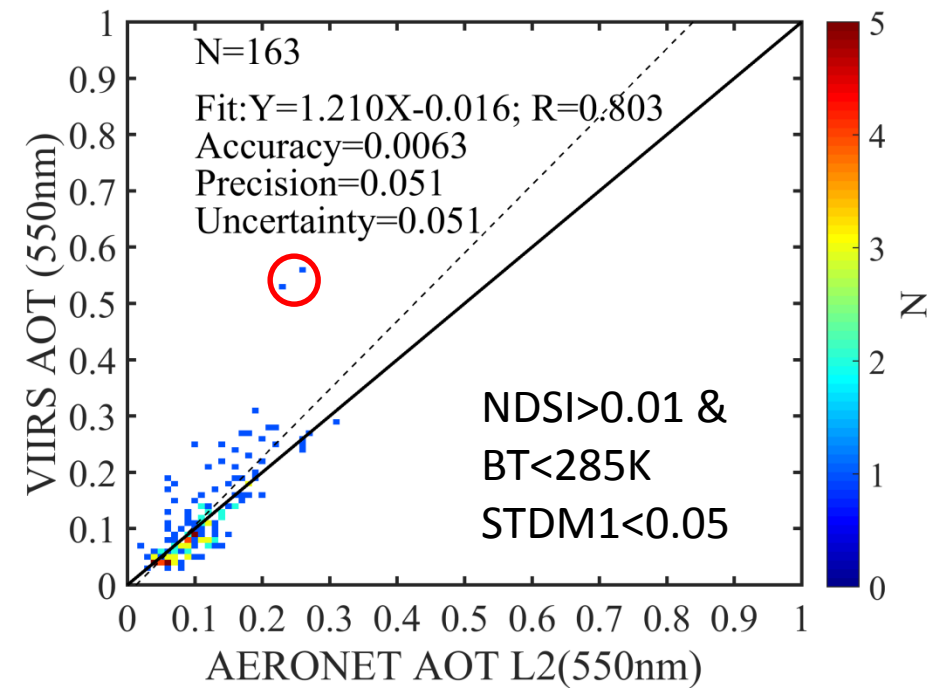
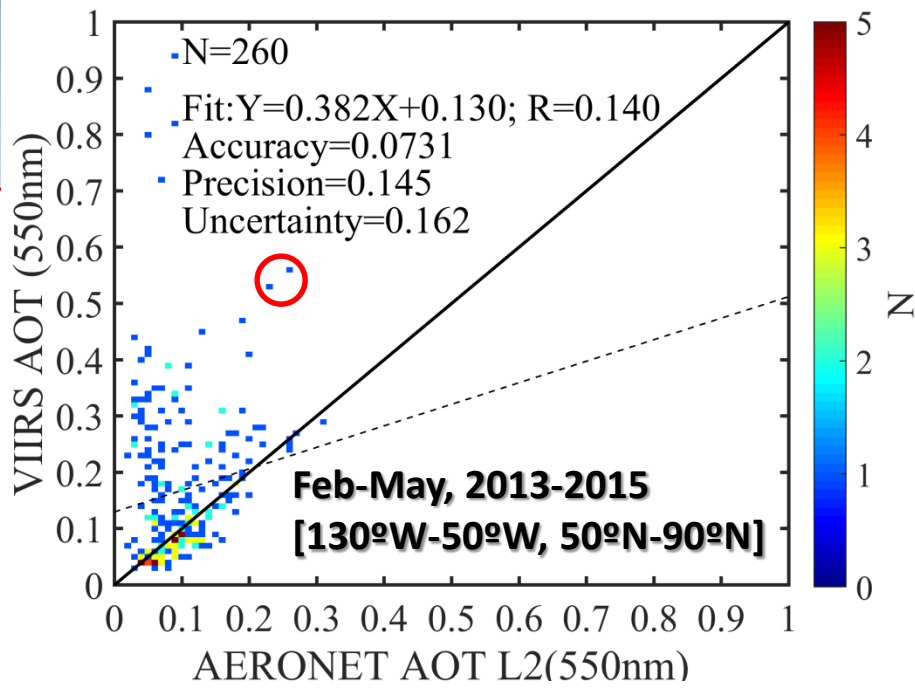
AOT at 550nm  
Overall Quality Flag=High



2015087\_t2109372.h5

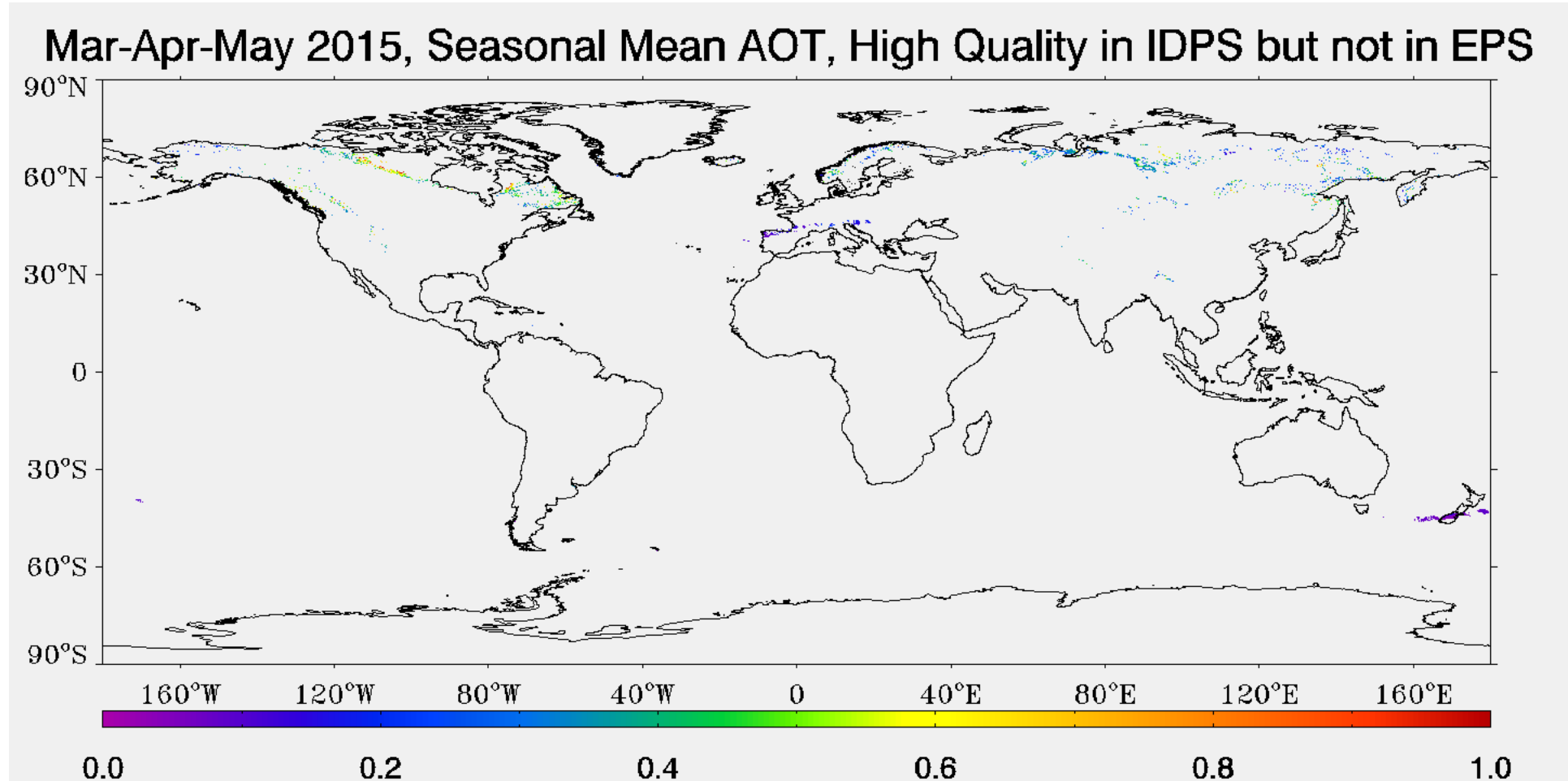
Inhomogeneity (Internal Test)





	Initial N	Snow	SnowAdj	SpaFil	New N
IDPS Thresholds	260	43	94	0	163
EPS Thresholds	260	30	94	81	158

# IDPS vs. EPS: Boreal Spring AOT





# Summary

- The NDSI and BT11 based snow test, combining with the complement snow adjacency test and spatial filter, improves the snow/snowmelt screening in the IDPS VIIRS aerosol products;
- However, AOT retrievals in heavy China Smog events were found missing in the IDPS aerosol product;
- The main reason for the missing smog AOT retrievals is snow over screening, followed by AOT out of range;
- The snow test and spatial filter were fine tuned to regain the missing China Smog AOT retrievals and to keep the same level of snow/snowmelt screening;
- With the new tests, EPS VIIRS Aerosol Algorithm has much more smog AOT retrievals than IDPS; and with more retrievals, EPS AOT also demonstrated better correlation with AERONET than IDPS; and yet, the high biases in the snow/snowmelt region remain screened.
- The EPS VIIRS aerosol algorithm will replace the IDPS algorithm and become operational in 2017