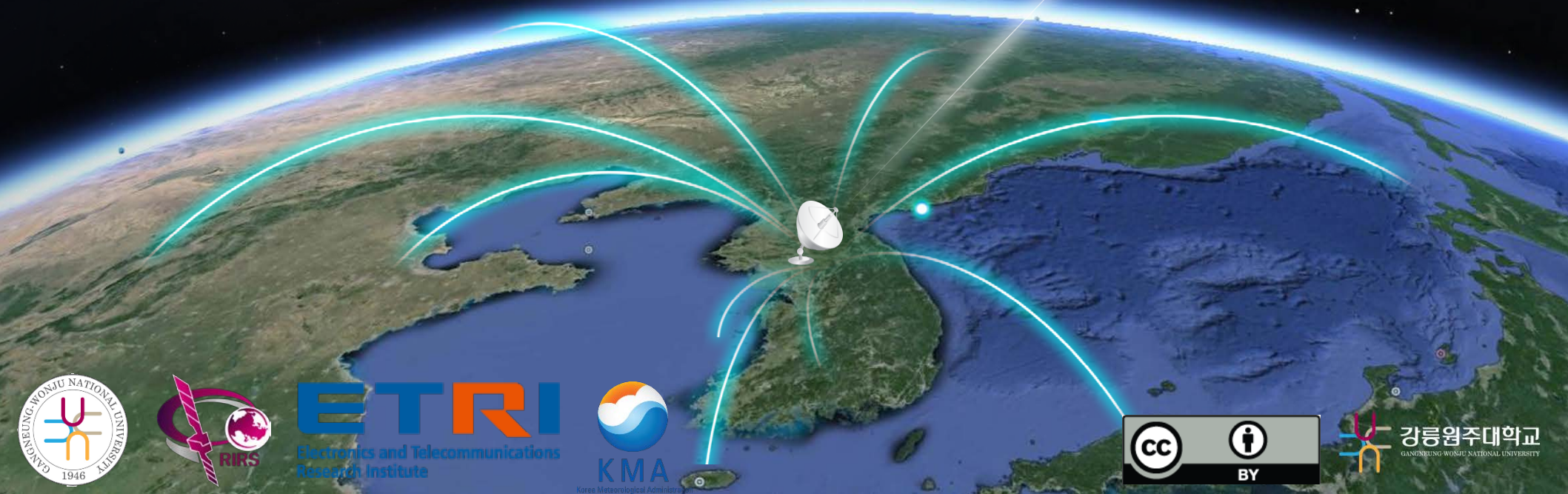
EGU General Assembly 2016

An algorithm for estimating aerosol optical depth from HIMAWARI-8 data over Ocean (Sub title: Development of Aerosol retrieval algorithm for GK-2A satellite)

Kwon-Ho Lee, Myung-Jae Jeong, Kyu-Tae Lee
Dept. of Atmospheric Environmental Sciences,
Research Institute for Radiation & Satellite(RIRS),
Gangneung-Wonju National University(GWNU)

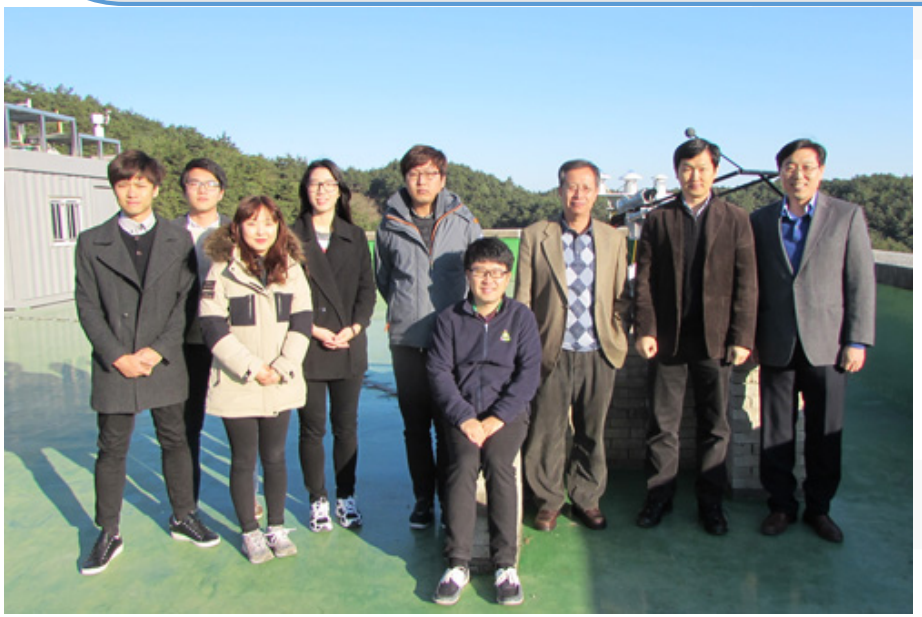


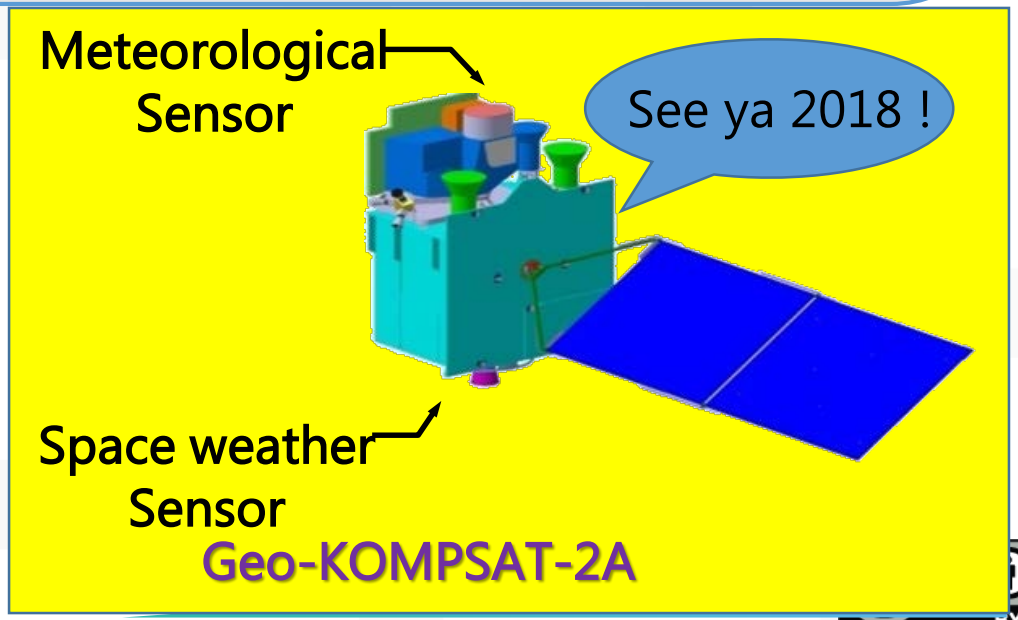
Contents

1. Background

○ GeoKOMPSAT-2A(GK-2A) :
- Advanced Meteorological Imager (AMI)
- 16 Bands, 0.5-2km spatial resolution, 52 operational products.

○ Radiation/Aerosol Algorithm Development Team :
- Aerosol Detection(Ash/dust/smoke/etc),
  Aerosol Optical Depth, Angstrom exponent
  (by K.H. Lee & M.J. Jeong)
- Radiative transfer model, Radiation products (by K.T. Lee)





Official products

Name	explanations	dimension
Aerosol Detection Product (ADP)	Pixel mask for Ash, dust, smoke, etc. type aerosols (separated algorithm for ocean & land) Ash & Dust detectIon for day & night	grid(lon, lat)
Aerosol Optical Depth(AOD)	wavelength:550nm, range: 0.0 – 5.0 (day)	grid(lon, lat)
Dust Aerosol Optical Depth(DAOD)	wavelength:11㎛, range: 0.0 – 3.0 (day, night)	grid(lon, lat)
volcanic ash product (VAP)	Height, optical depth (11㎛, range: 0.0 – 3.0; day & night), effective radius, mass	List(lon, lat, attribute)
Angstrom Exponent (AEP)	Range: 0~3 (day)	grid(lon, lat)

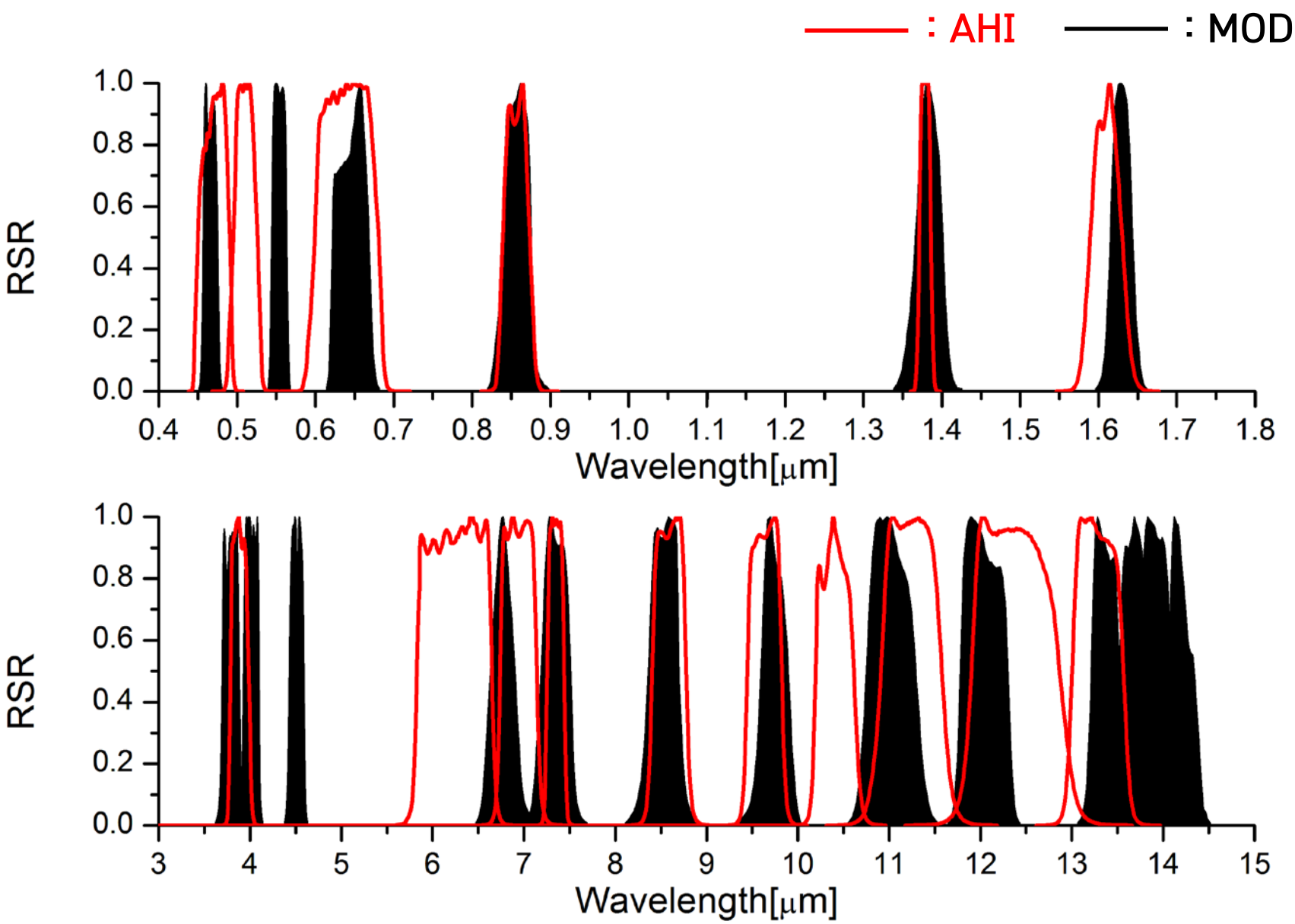
GK-2A mission requirements for Aerosol algorithm

Year	Research Plan	Product accuracy
2014	• Algorithm development plan • Design core algorithm	• Aerosol detection product(ADP): Ocean: 50%, Land: 40% • Aerosol optical depth(AOD): Ocean: 0.25±0.45τ, Land: 0.30±0.50τ
2015	• Independent algorithms for main products • Testbed with proxy data (MODIS)	• ADP: Ocean: 60%, Land: 50% • AOD: Ocean: 0.20±0.40τ, Land: 0.25±0.45τ
2016	• **Integration of algorithms** • **Validation of products** • **Transfer to the testbed (using AHI)**	• **ADP: Ocean: 65%, Land: 55%** • **AOD: Ocean: 0.15±0.35τ, Land: 0.20±0.40τ**
2017	• **Revision & Improvement of the algorithm** • **Provide the operational algorithm**	• **ADP: Ocean: 70%, Land: 60%** • **AOD: Ocean: 0.10±0.30τ, Land: 0.15±0.35τ**
2018	• **GK-2A based operation support**	• **ADP: Ocean: 80%, Land: 70%** • **AOD: Ocean: 0.05±0.20τ, Land: 0.10±0.30τ**

2. Data

Channels	Center Wavelengths(㎛)				
	AMI	ABI	AHI	MI	MODIS
1(VIS) blue	0.470	0.470	0.46		0.466 (B03)
2(VIS) green	0.511		0.51		0.554 (B04)
3(VIS) red	0.640	0.640	0.64	0.675	0.647 (B01)
4(VIS)	0.856	0.865	0.86		0.857 (B02)
5(NIR)	1.380	1.378			1.382 (B26)
6(NIR)	1.610(2)	1.610(1)	1.6(2)		1.629 (B06)
NIR		2.250	2.3		2.114 (B07)
7(IR)	3.830	3.90	3.9	3.75	3.788 (B20)
8(WV)	6.241	6.185	6.2		6.765 (B27)
9(WV)	6.952	6.95	7.0	6.75	6.765 (B27)
10(WV)	7.344	7.34	7.3		7.337 (B28)
11(IR)	8.592	8.50	8.6		8.529 (B29)
12(IR)	9.625	9.61	9.6		9.734 (B30)
13(IR)	10.403	10.35	10.4	10.8	B30+B31
14(IR)	11.212	11.20	11.2		11.019 (B31)
15(IR)	12.364	12.30	12.3	12.0	12.032 (B32)
16(IR)	13.31	13.30	13.3		13.365 (B33)

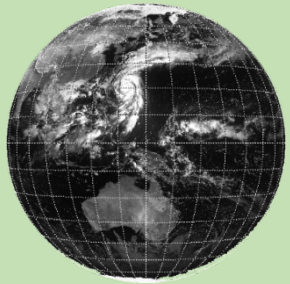
Band response functions



New Generation Geostationary Satellites

Current

COMS/MI, MTSAT



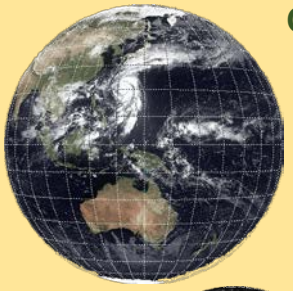
1 Visible: 1km, 30min

4 IR: 4km

5 bands

Future

Himawari/AHI, GK-2A/AMI, GOES-R/ABI

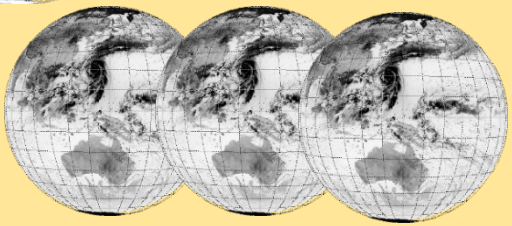


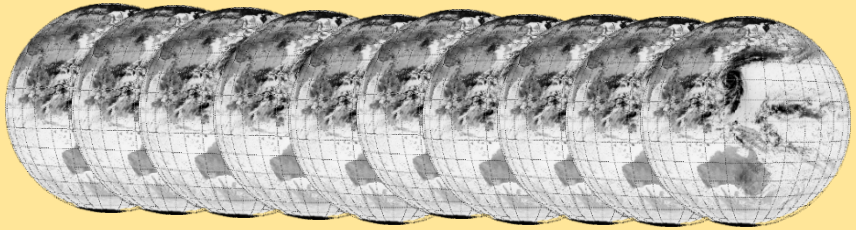
3 Visible:

~0.5km, 10min

3NIR:

2km

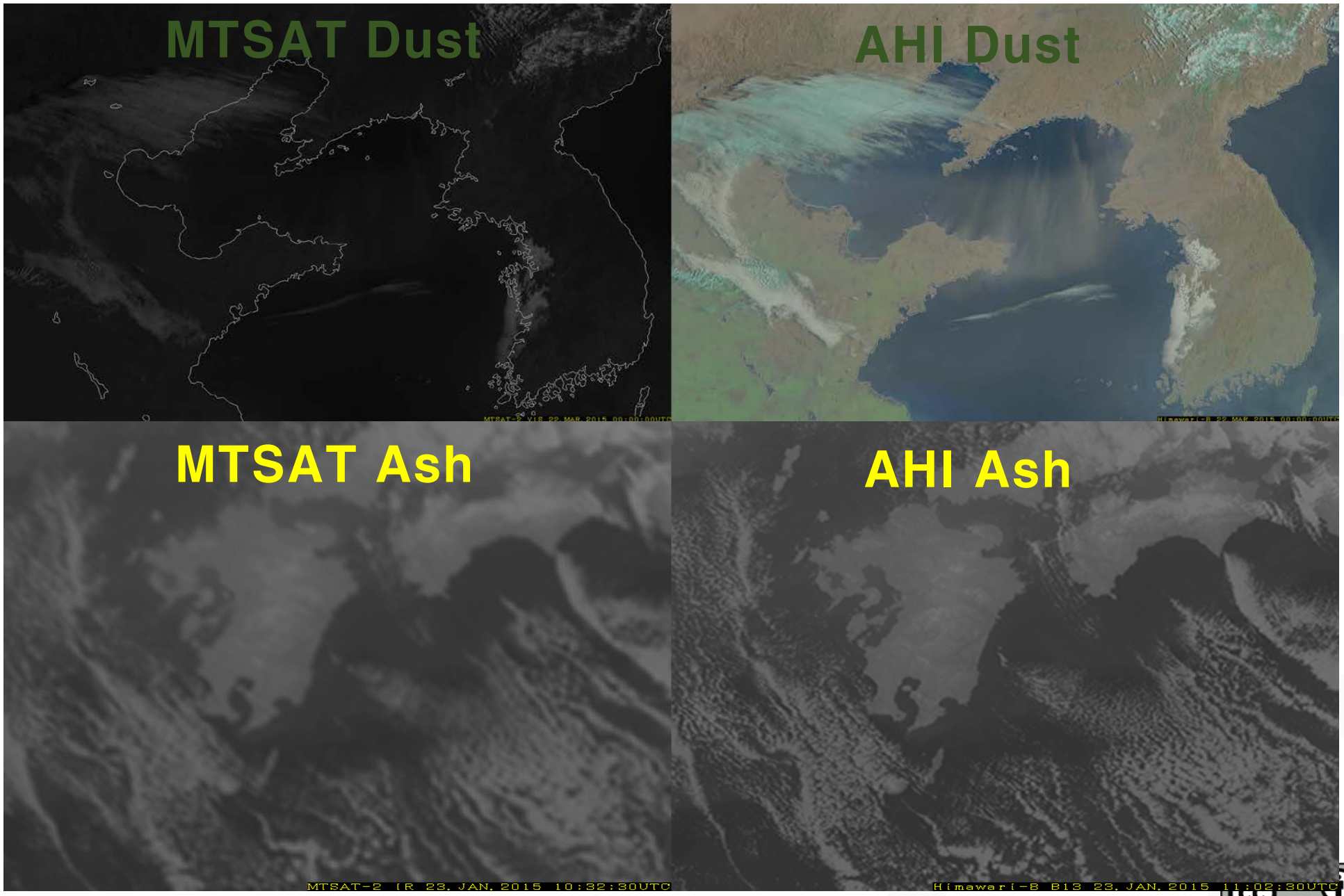




10 IR:2km

16 bands

MTSAT vs. AHI



[images from JMA]

Methodology

Base Algorithm

1) Proxy data: MODIS
- 16 bands, geo-data
- 10km resolution
- LUTs based retrieval

1) Code: IDL 8.x+Fortran 90
- independent
- For research

3) Aerosol algorithm
- Land/Ocean ADP
- Land/Ocean AOD(day/visible)
- Land/Ocean DOD(IR)
- VAP(IR)

4) Verification
- Case study based

Core Algorithm

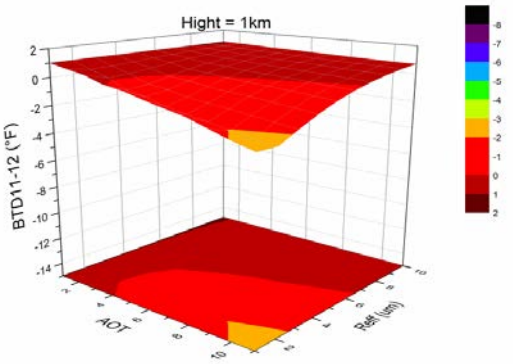
1) Proxy data: Himawari L1
- 16 bands, lon-lat data
- 2km resolution
- Calculate sun-sat geometry
- Re-construction LUTs

2) code: Fortran 90
- Integration
- standard protocol for testbed

3) Aerosol algorithm
- ADP+AOD+AEP
- DOD
- VAP

4) Validation tools
- ADP
- DOD
- VAP

Design for satellite data processing



L1B data

Data quality check

Cloud, Wind Snow/ice

Clear sky test: Cloud, glint, snow/ice

n

No process

y

Aerosol Type (ash, dust, smoke, generic)

ash

Ash retrieval (height, effective radius, mass)

NWP, Ash LUT

dust

dust retrieval (height, effective radius, mass)

NWP, Dust LUT

Visible channel AOD retrieval

Atmospheric correction (Gas absorption Rayleigh scattering)

BRDF correction (glint, white foam, CDOM)

NWP, LUT

ADP

AOD

DOD

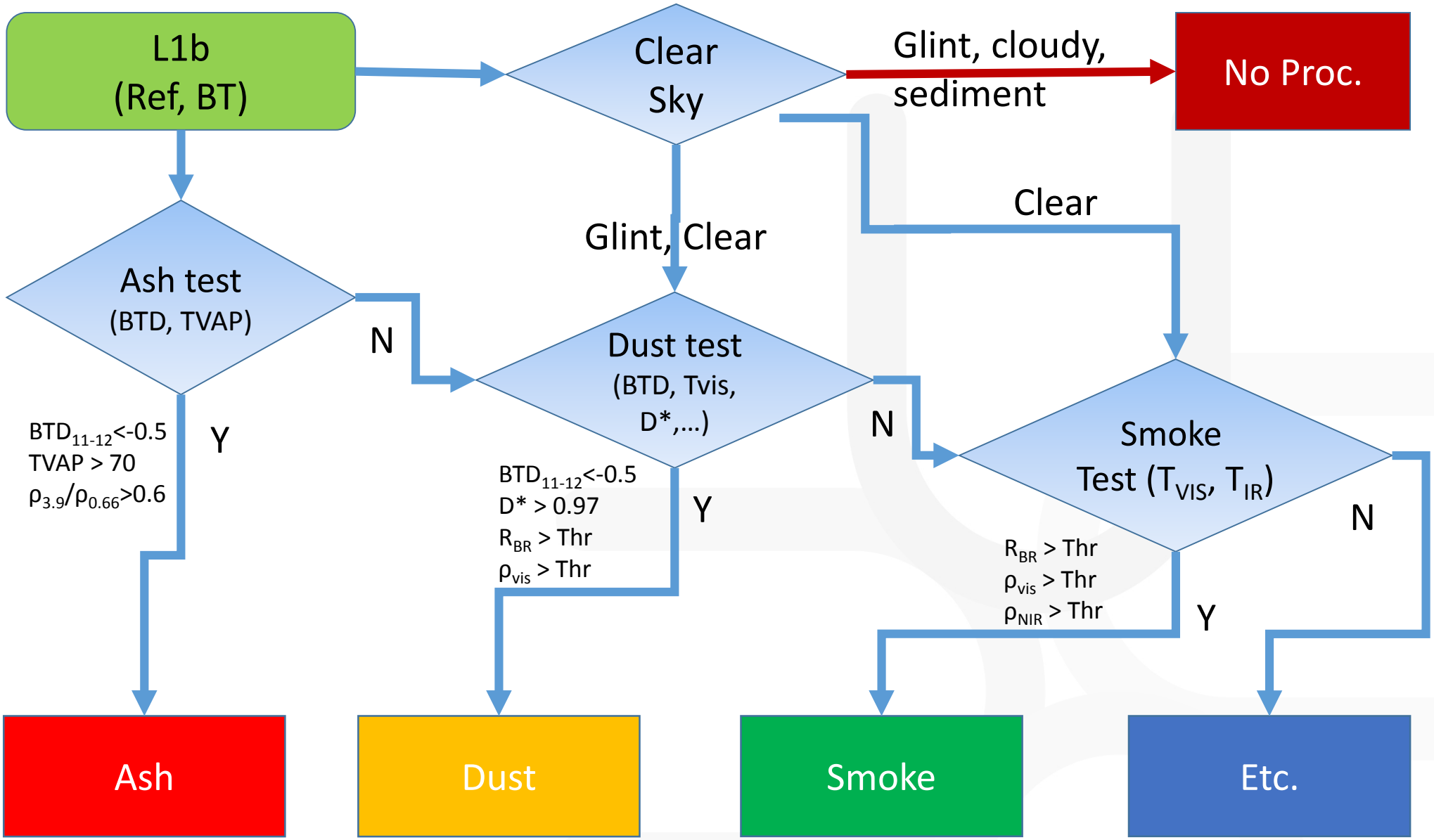
VAP

Size information (Angstrom, FMF)

AEP

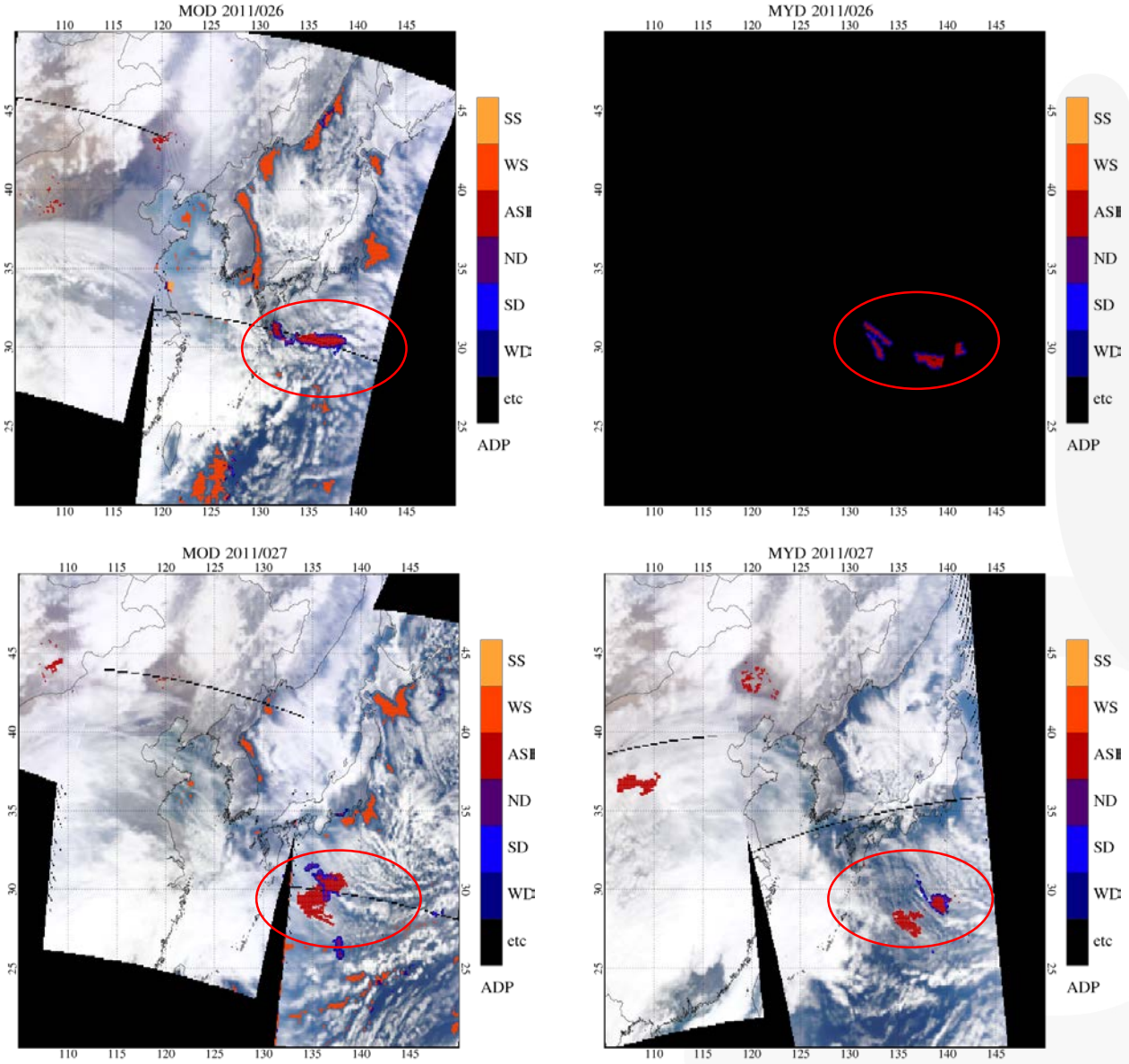
L2 data (ADP, AOD, AEP, DOD, VAP)

ADP algorithm



Detail information on ash detection is found from Lee et al (RSE, 2016)
on D* for dust detection is from Hansell et al(GRL, 2007)

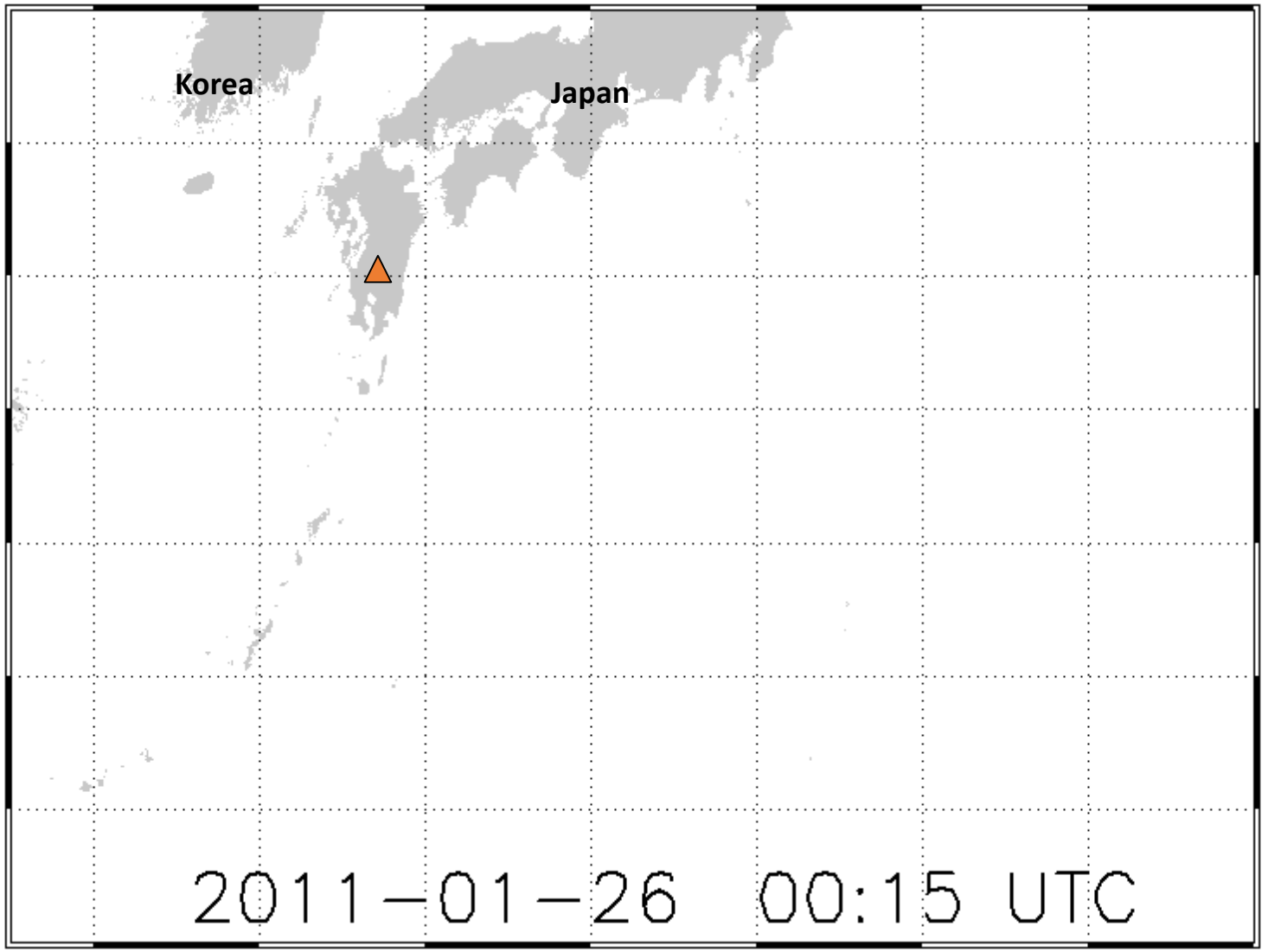
3. Case study (Volcanic ash)

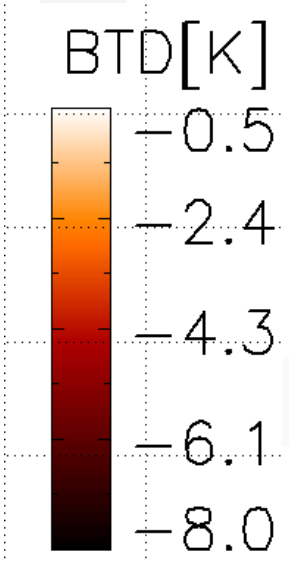


Mt. Shinmoedake eruption, Japan (26 Jan 2011)

MODIS

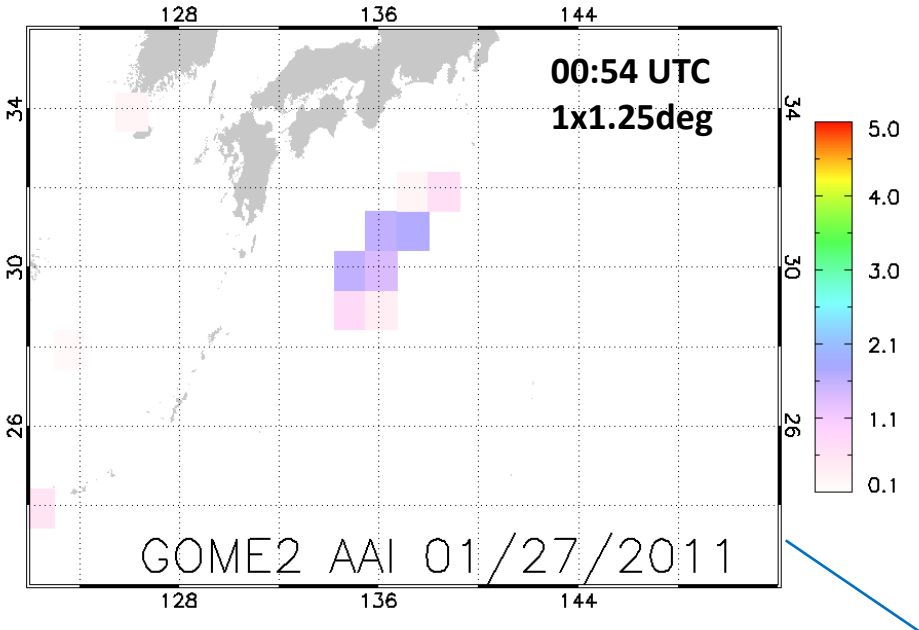
Case study (Volcanic ash)

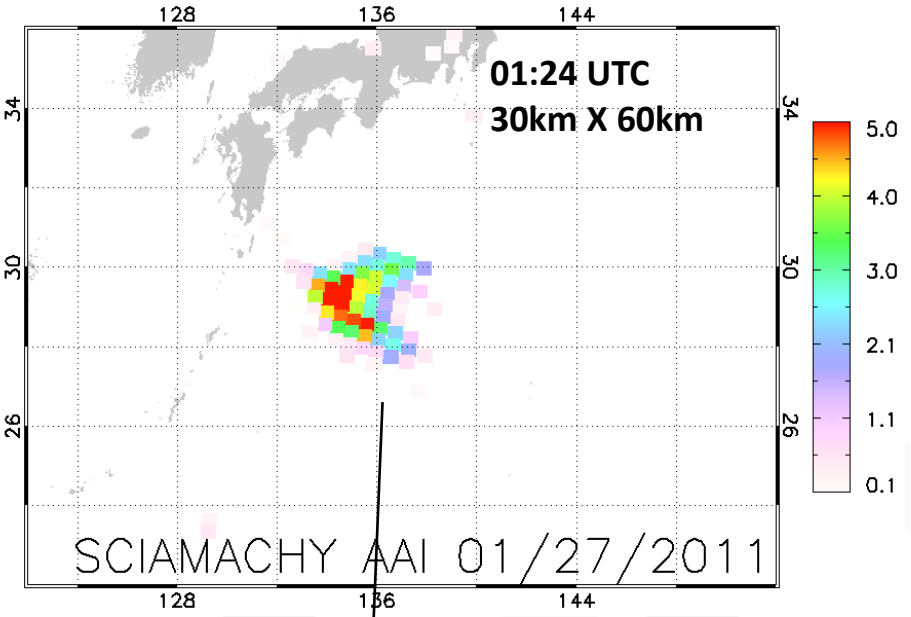


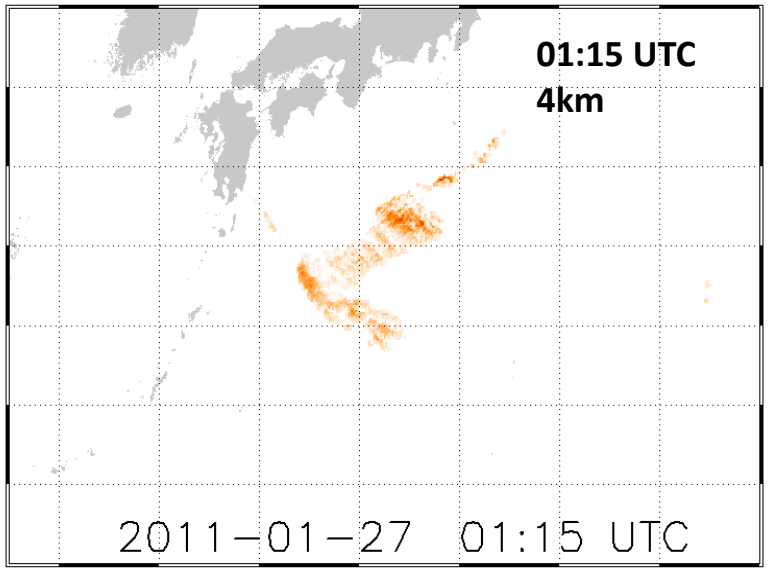


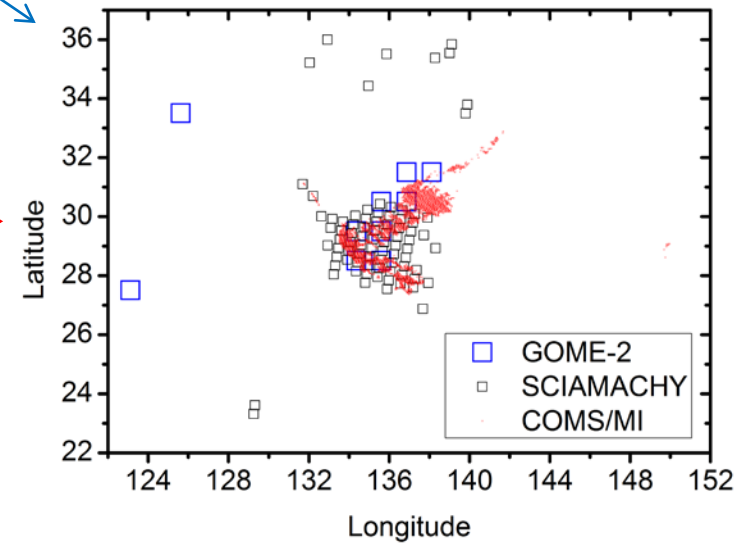
Mt. Shinmoedake eruption, Japan (26 Jan 2011)
COMS MI

Comparisons with other satellite products



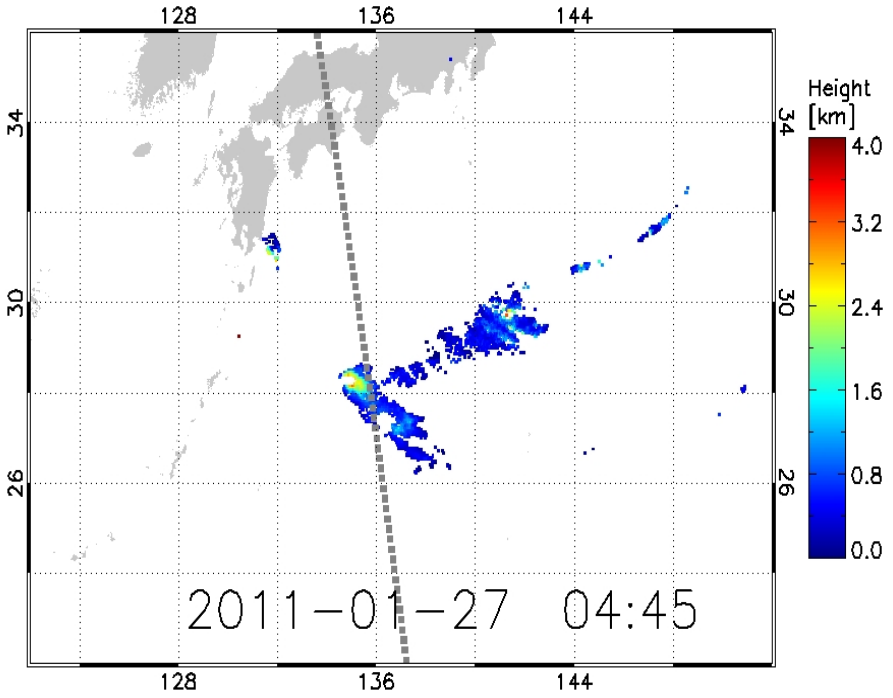


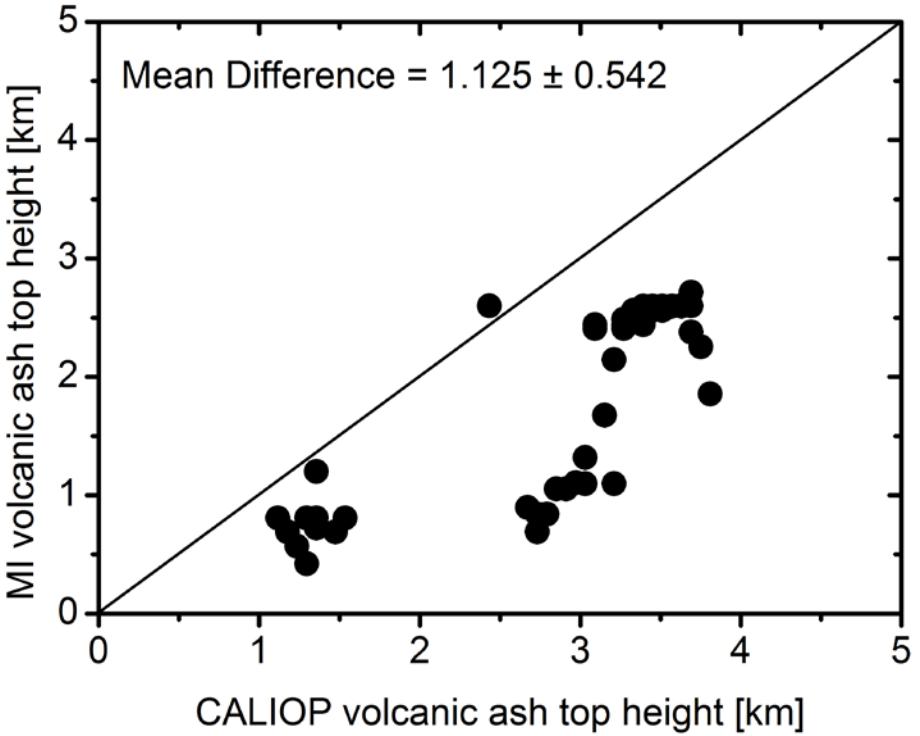


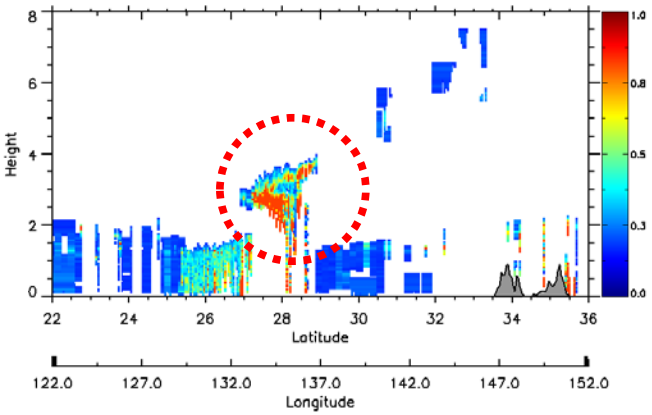


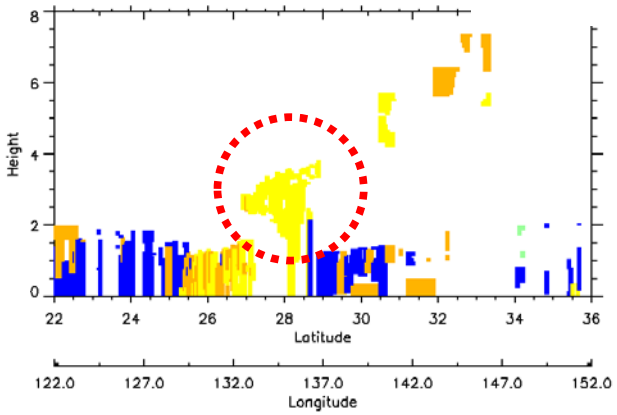
Lee et al (RSE 2016)

Comparisons with other satellite products



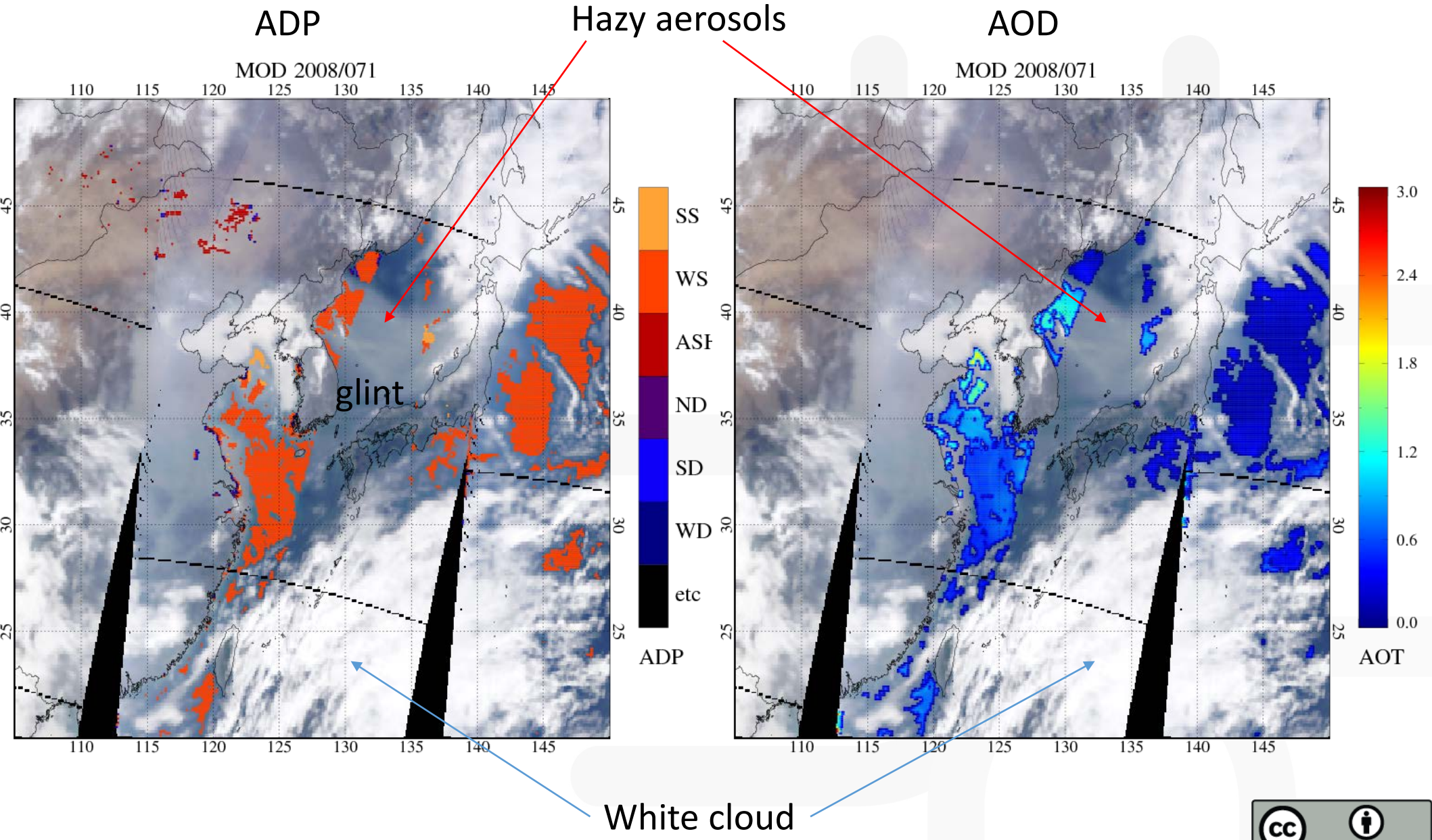




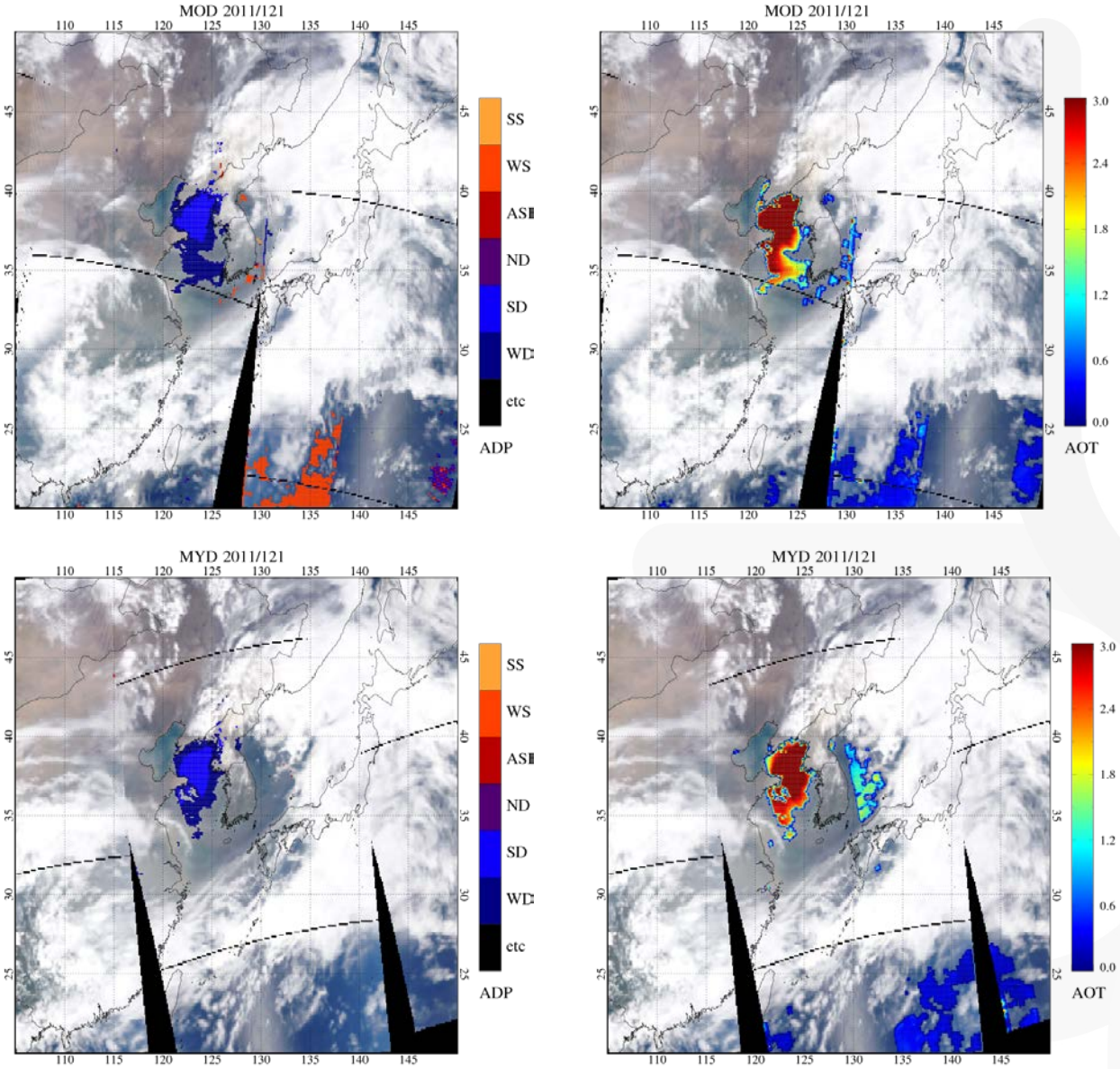


Lee et al (RSE, 2016)

3. Case study (Smoke)

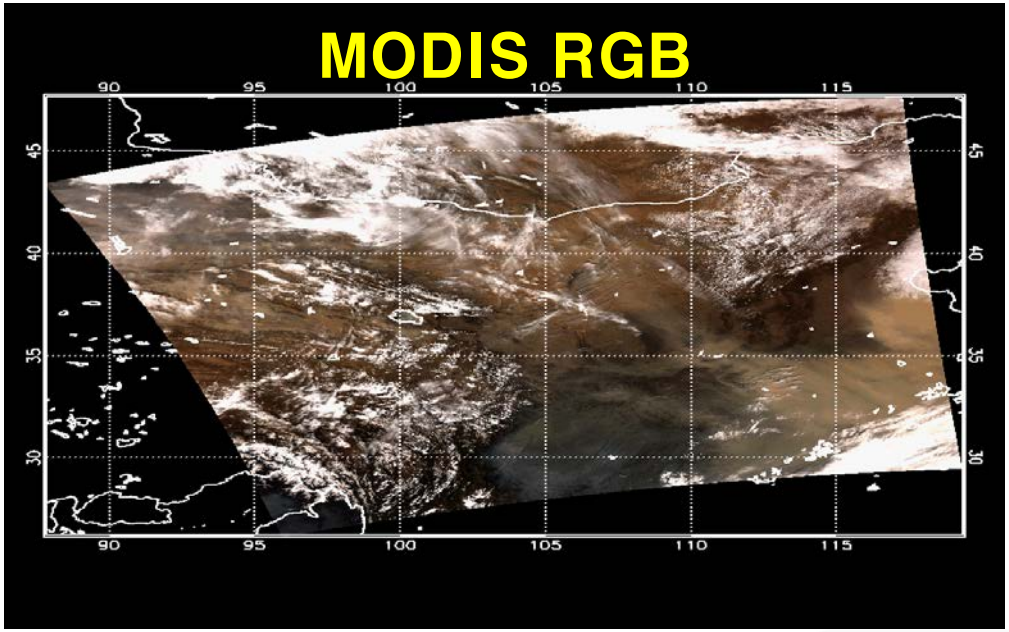


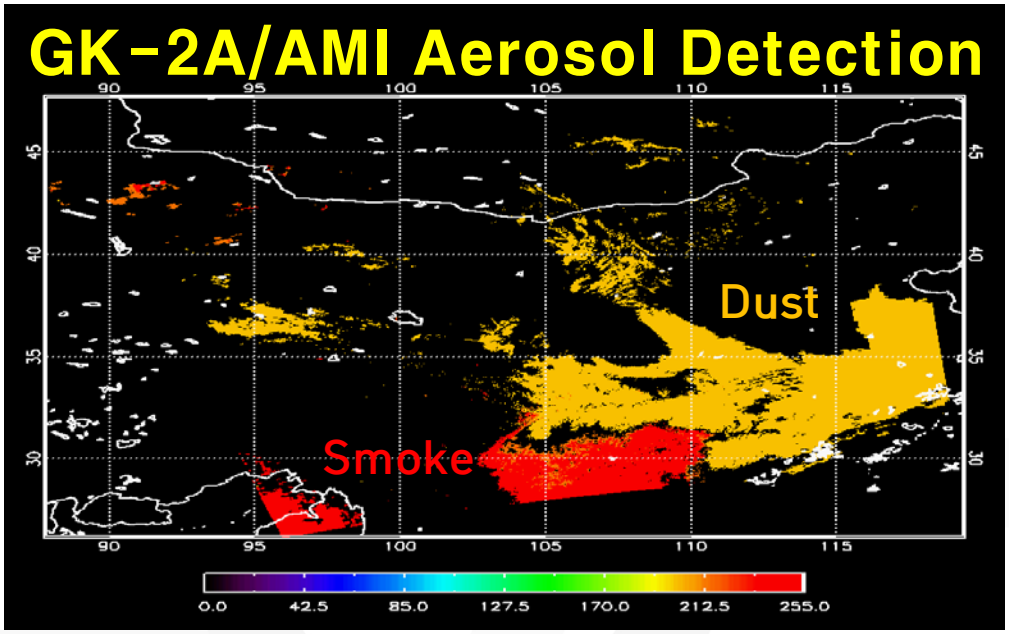
3. Case study (Smoke)

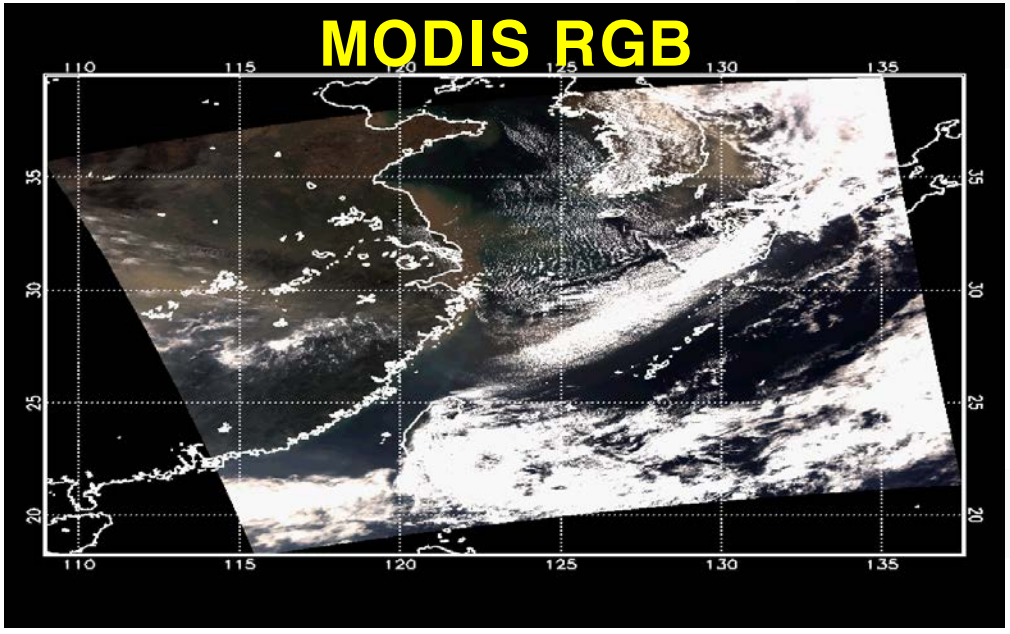


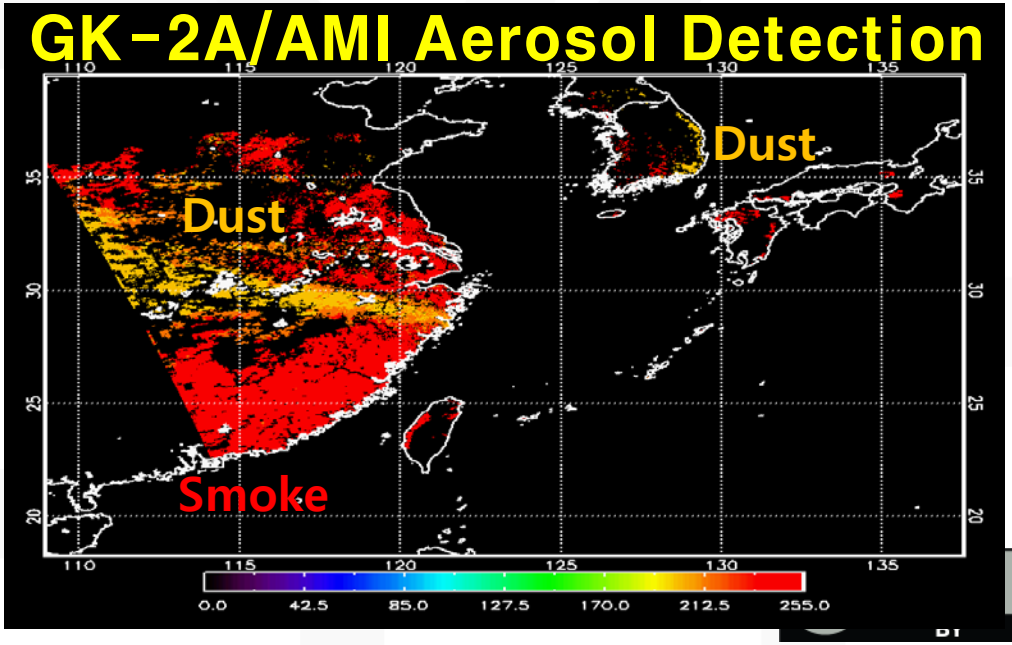
Asian Dust plume over Yellow Sea (1 May 2011)

3. Case study (Smoke and Dust over Land)

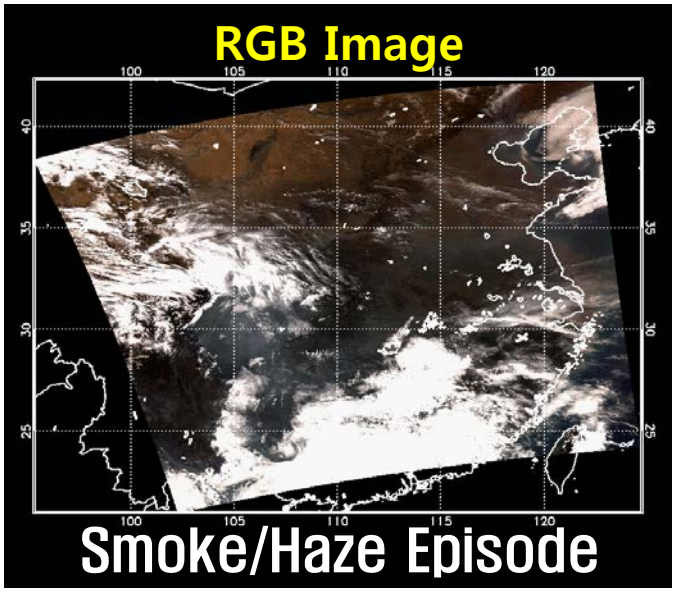


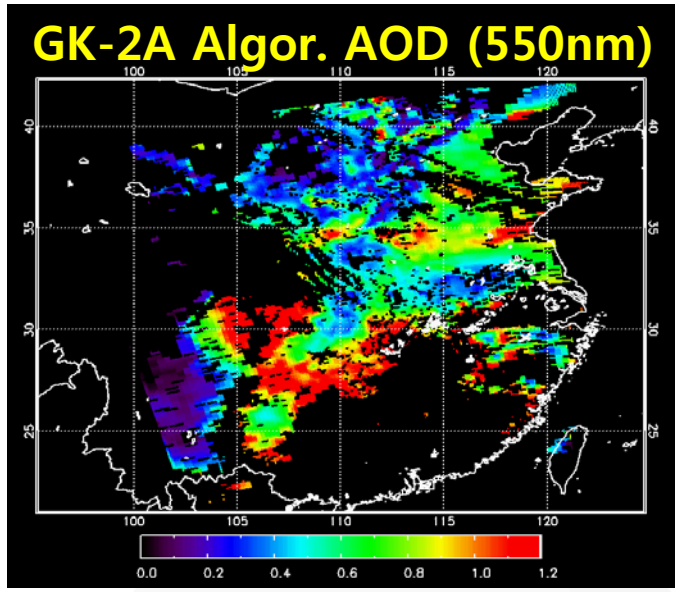


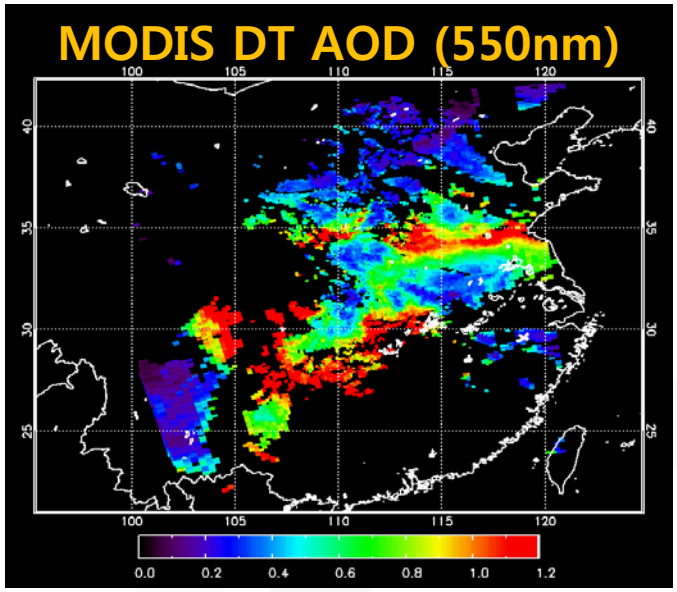


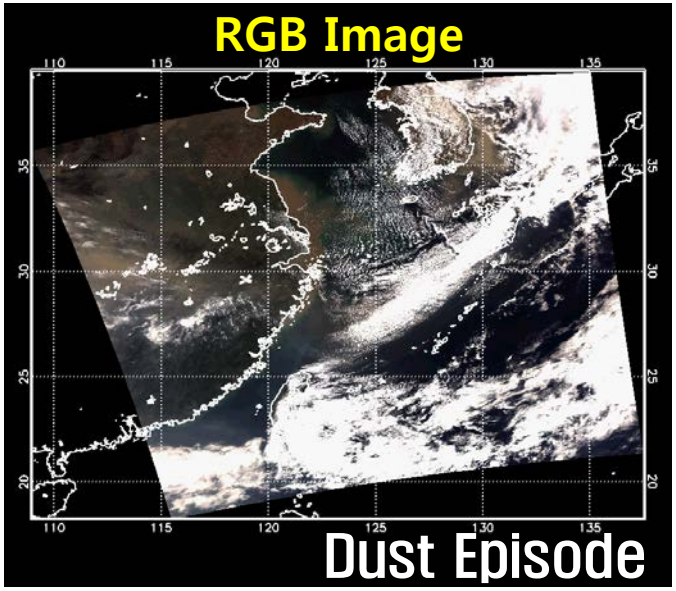


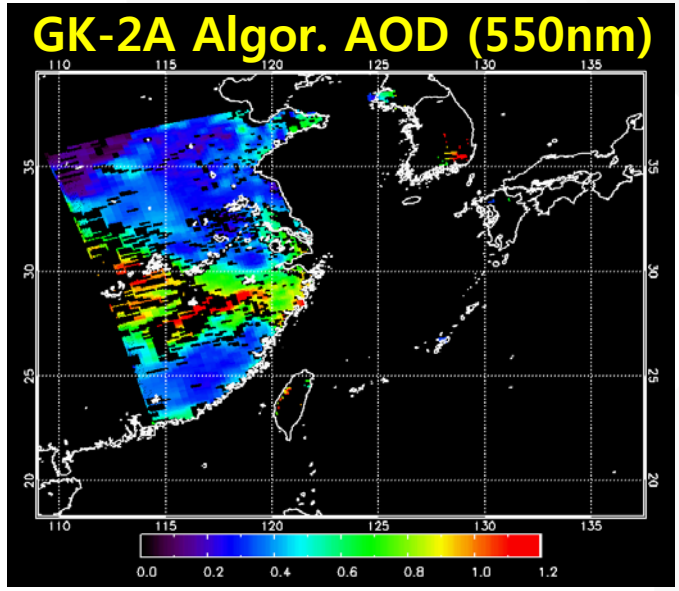
3. Case study (Smoke and Dust over Land)

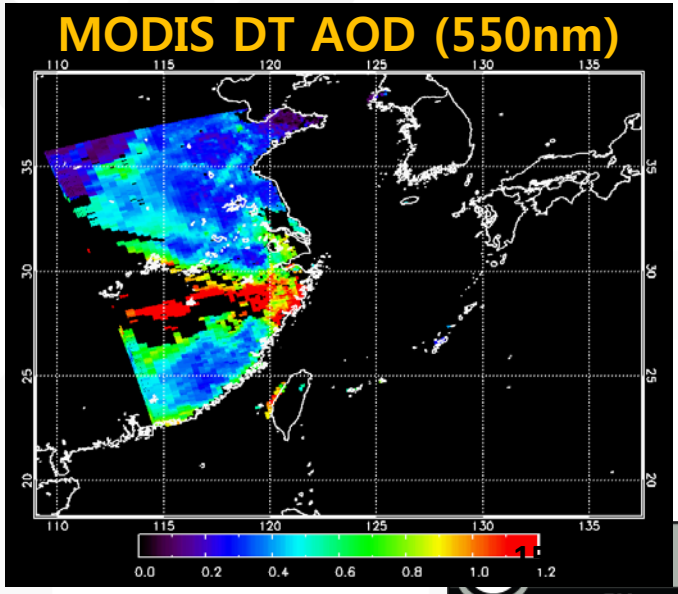




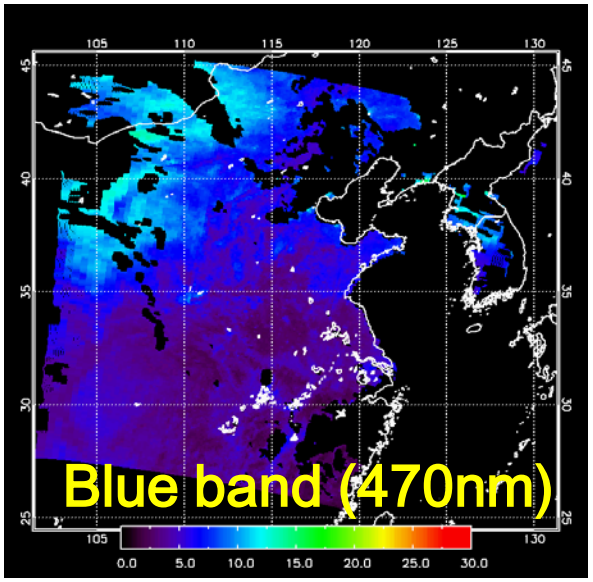


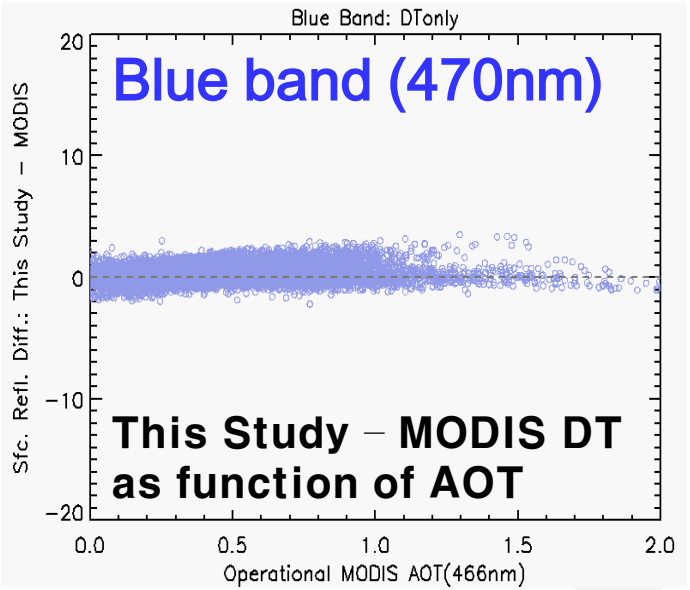


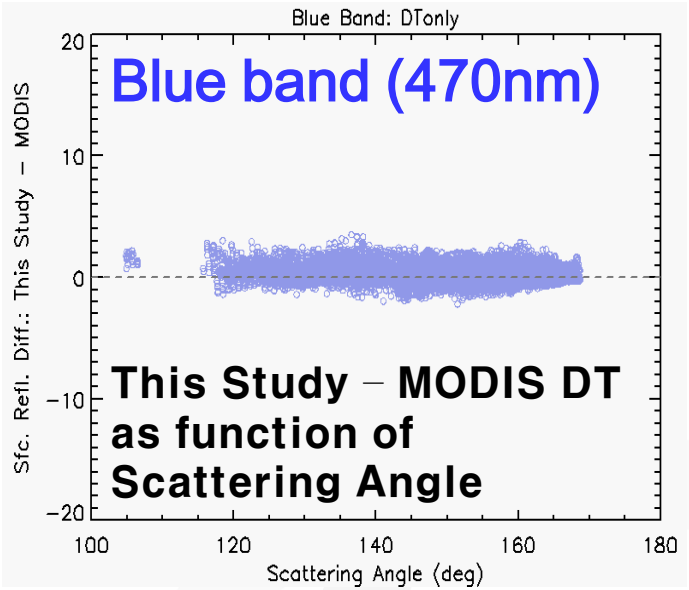


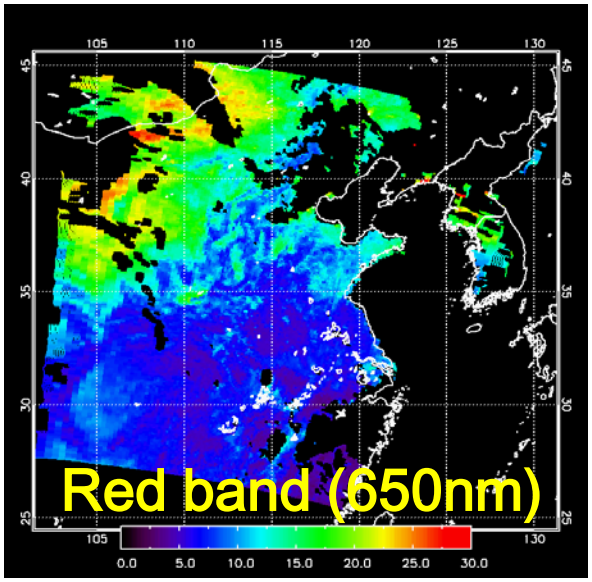


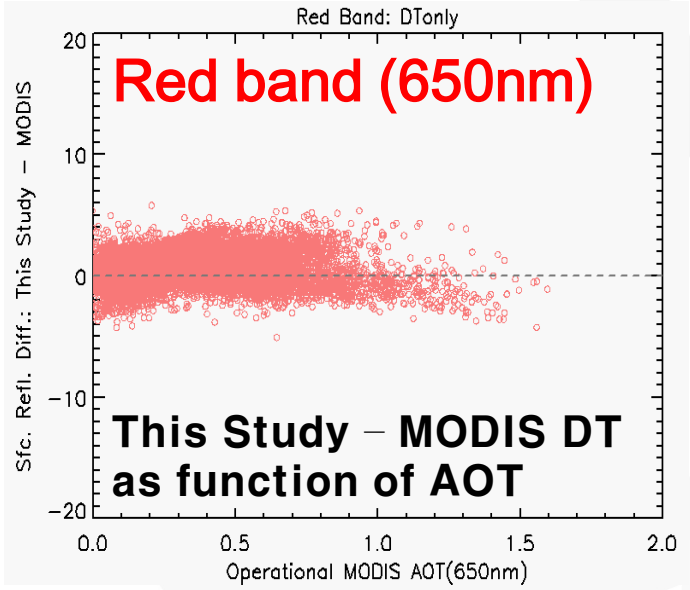
Improvement: Land surface estimation

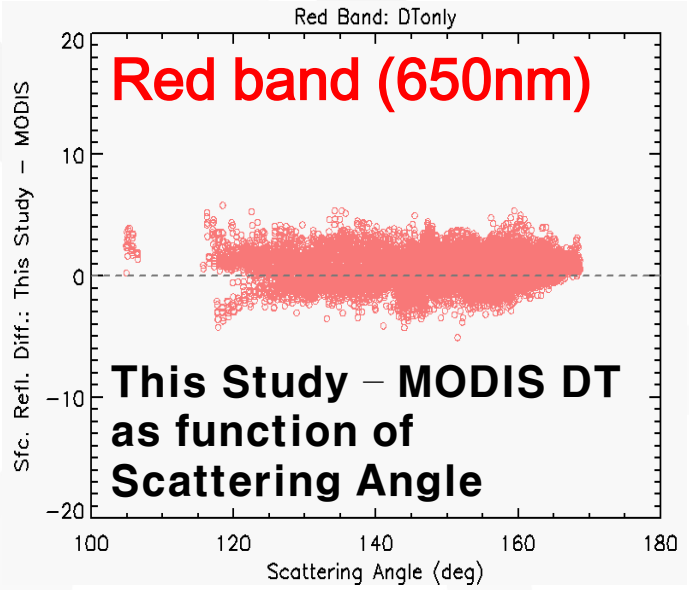








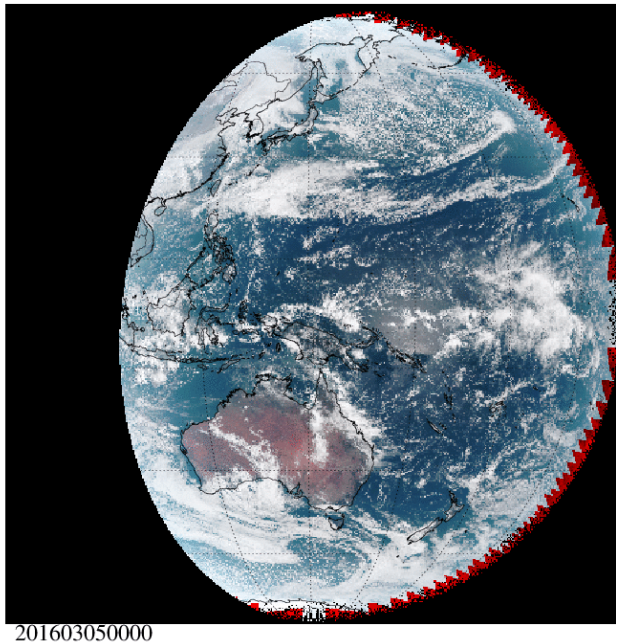




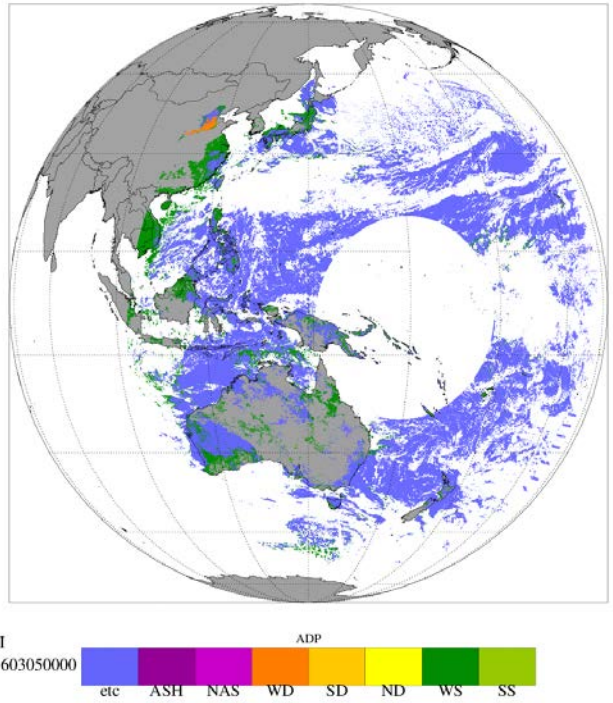
Proposed Method: $R_{sfc}(VIS) = R_{toa}(NIR)*(a*NDVI + b) + c$

New era for Aerosol detection using AHI

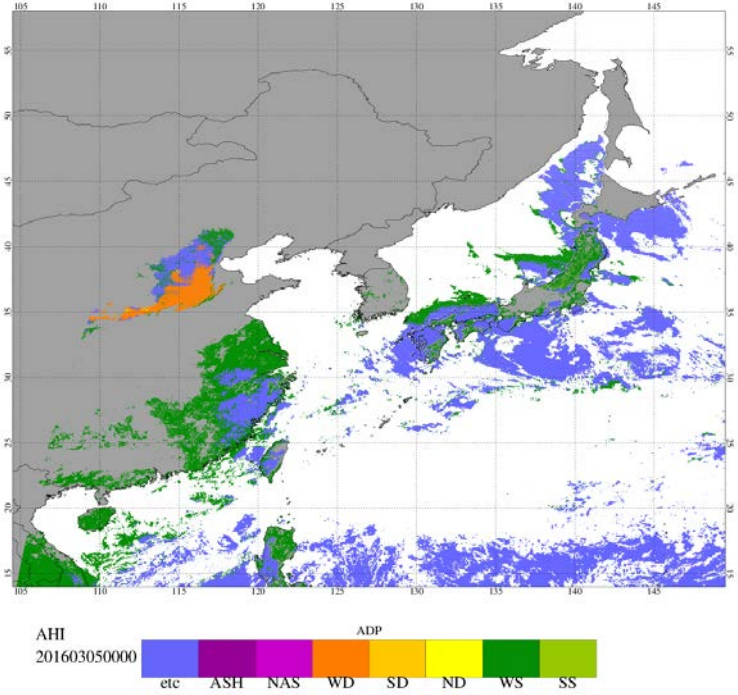
RGB



Full Disk

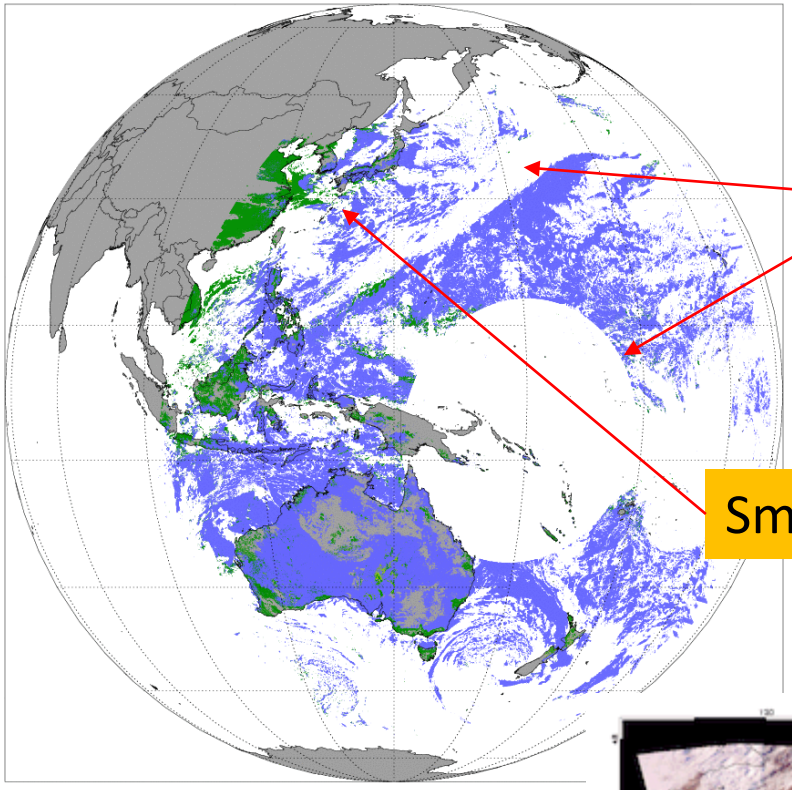


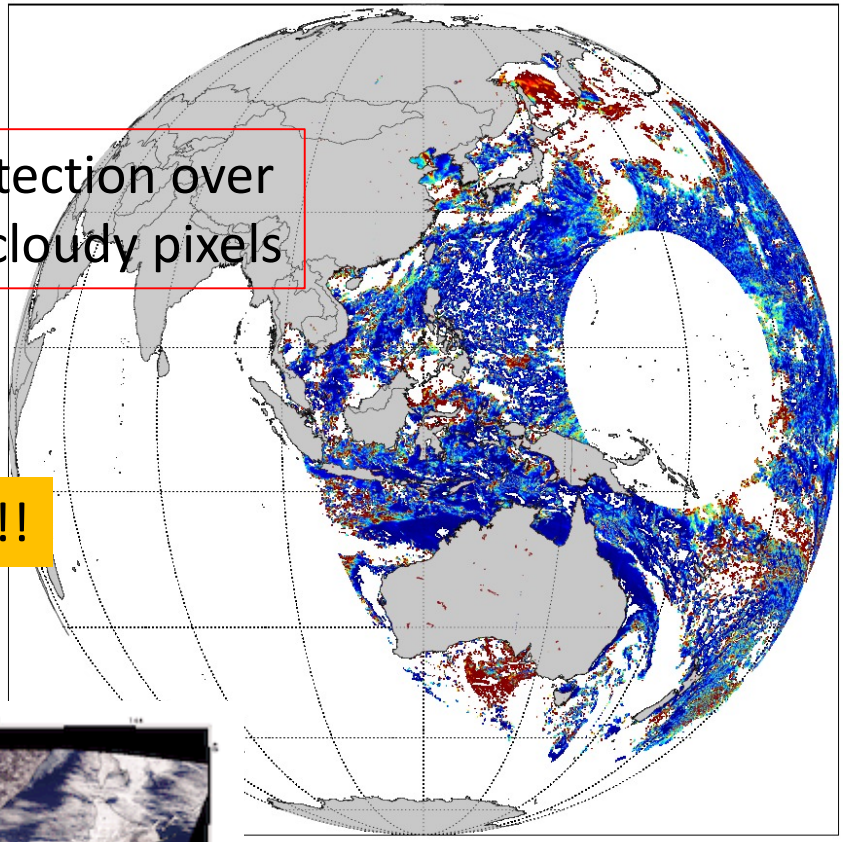
North Asia



- ✓ **HIMAWARI-8 L1B (2km) RGB and ADP products**
- ✓ **Asian dust storm has been well detected during Mar 5, 2016.**
- ✓ **Nighttime detection using two IR bands has noisy pixels.**

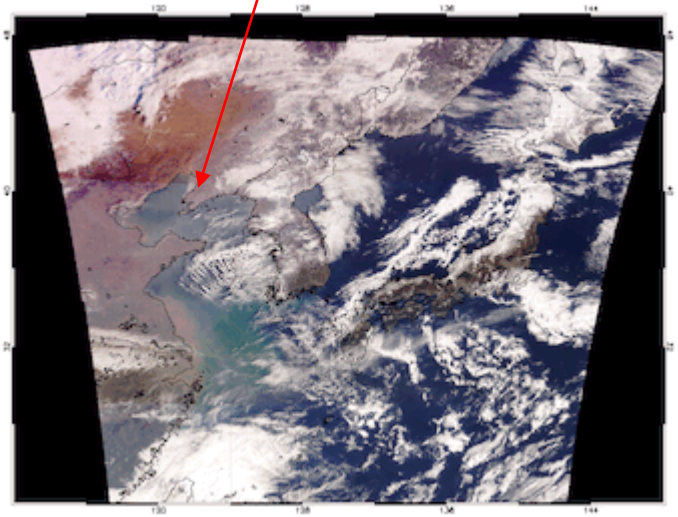
New era for Aerosol retrieval using AHI

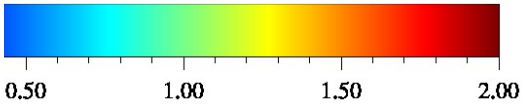




No detection over
Glint, cloudy pixels

Smoke plume !!

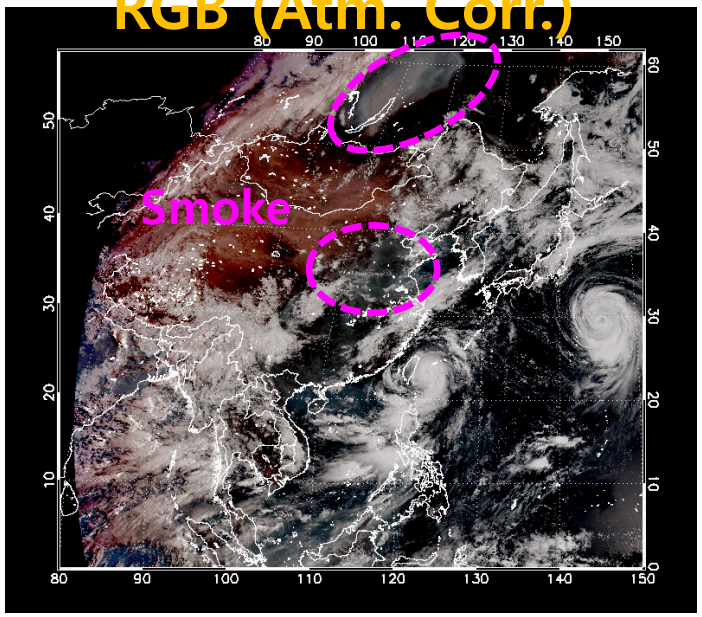




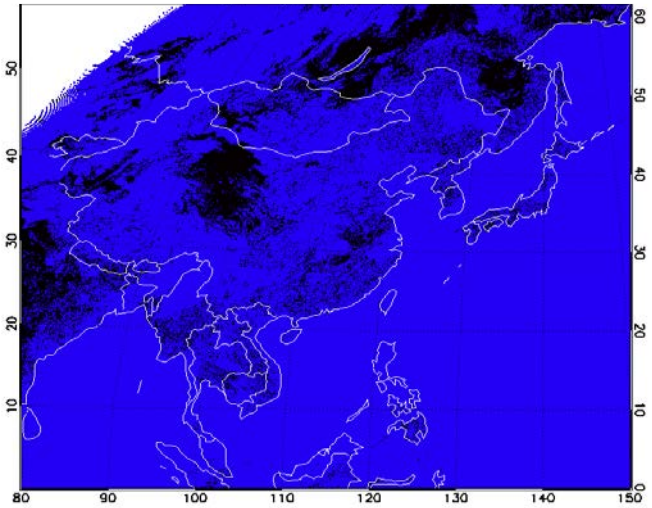
GOCI image

Aerosol products from AHI

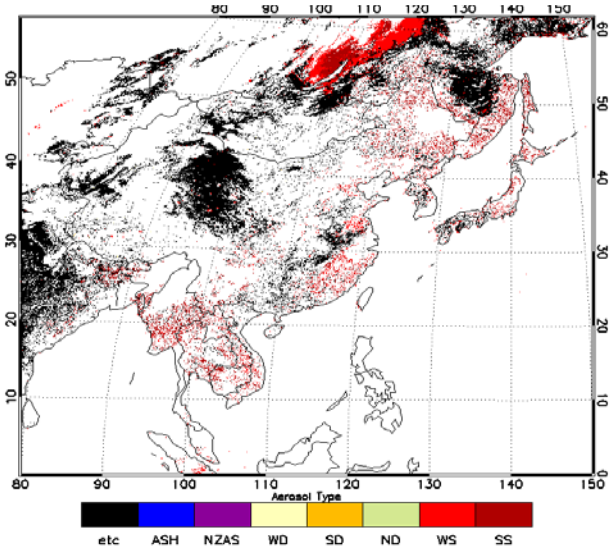
RGB (Atm. Corr.)



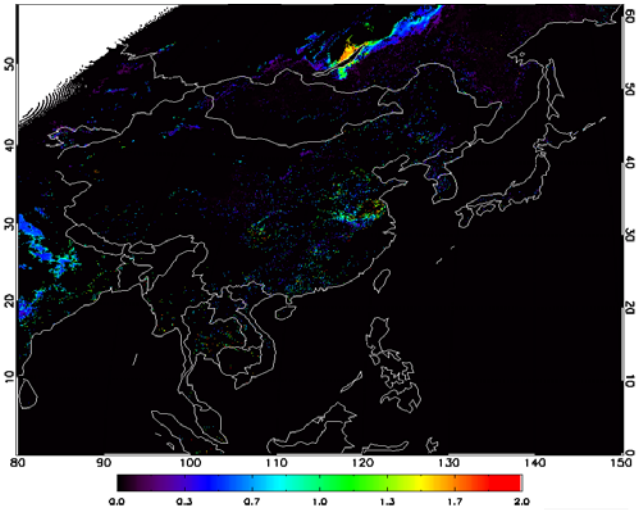
Cloud Mask



ADP



AOD at 550nm

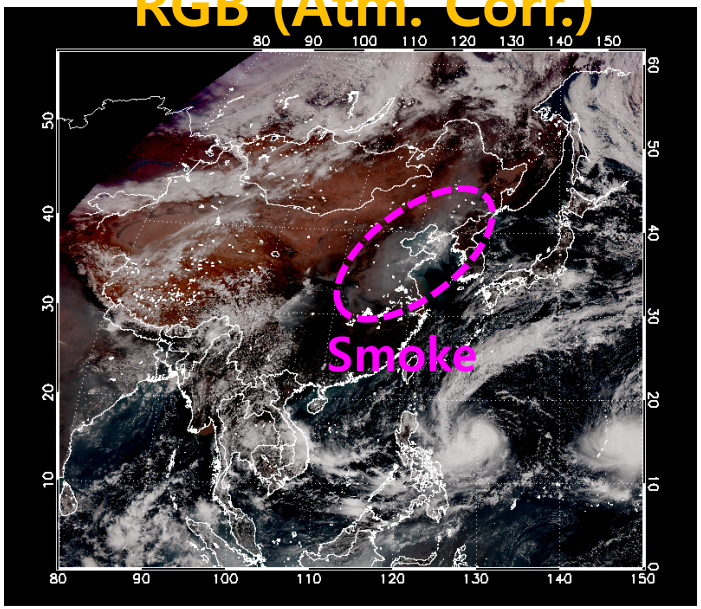


2015/08/23 05:00Z

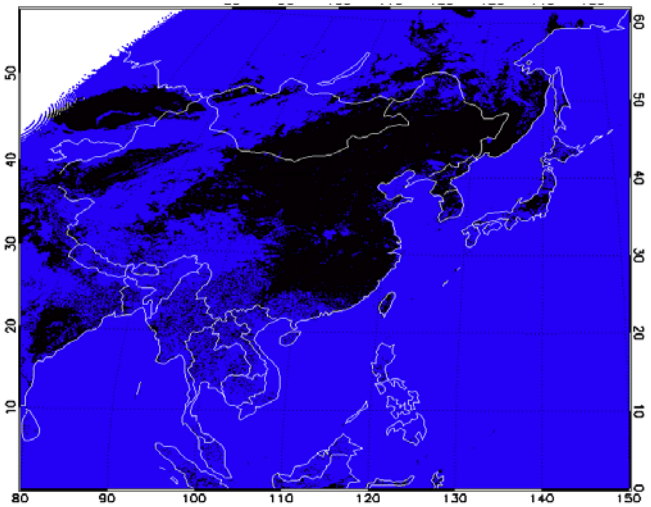
✓ **HIMAWARI-8 (2km) (Modify threshold values and Surface reflectance)**

Aerosol products from AHI

RGB (Atm. Corr.)

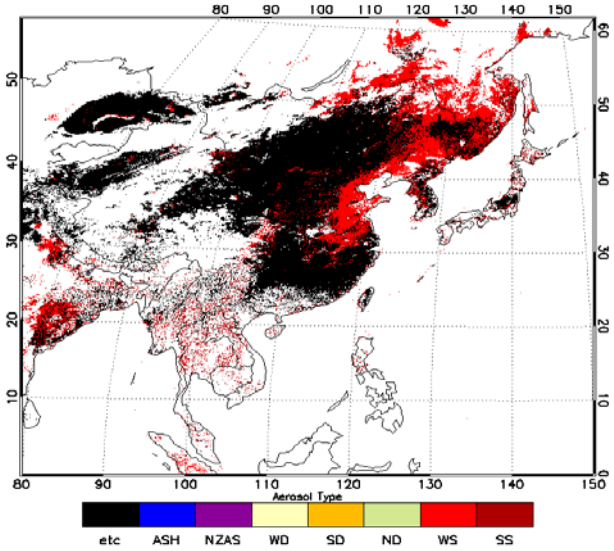


Cloud Mask

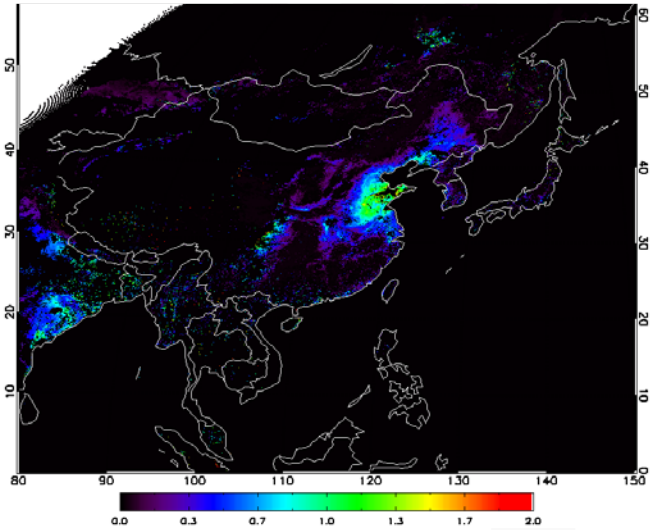


2015/10/15
0500Z

Aerosol Mask



AOD at 550nm



4. Validation plan

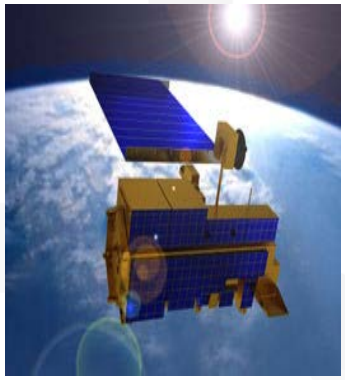
- **Area:** Full Disk
- **Period: 2015.8 ~ present**
- **Datasets**

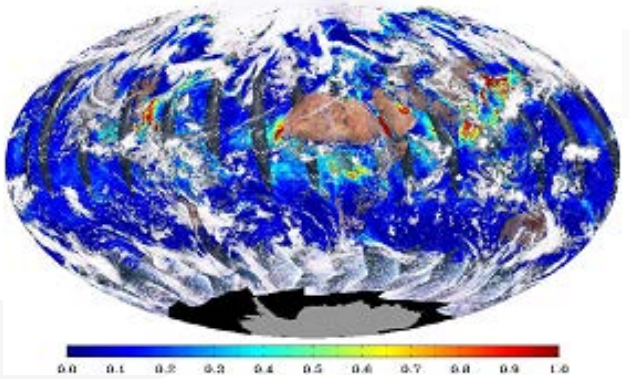
➢ **AERONET, Microtops II**
  - ✓ Ground-based AOD,
  - ✓ Angstrom exponent

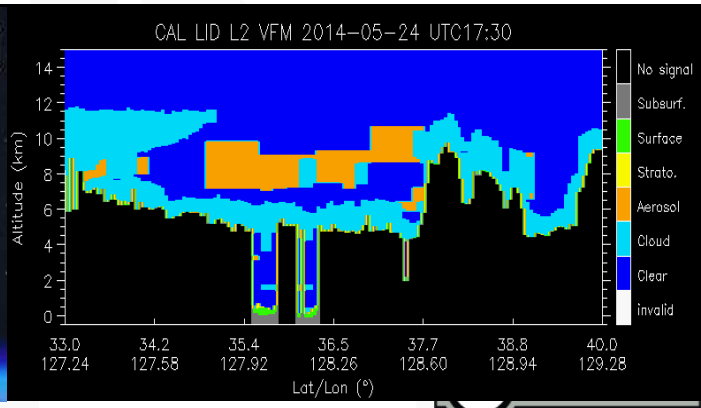
➢ **Lidar Network**
  - ✓ AD-net, KALION

➢ **MODIS, VIIRS, OMI**
  - ✓ Satellite-based AOD
  - ✓ Angstrom exponent

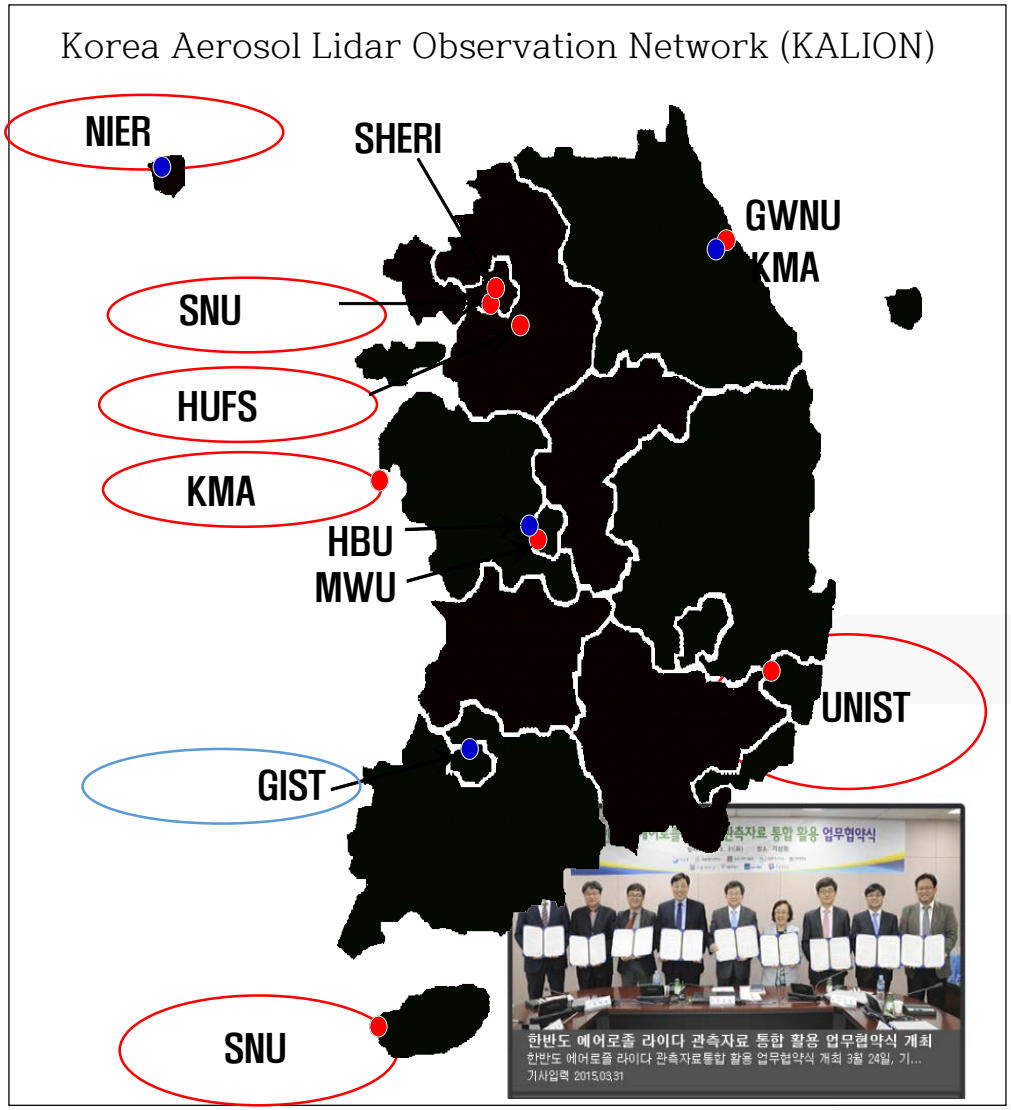
➢ **CALIPSO**
  - ✓ VFM(Aerosol type)
  - ✓ AOD

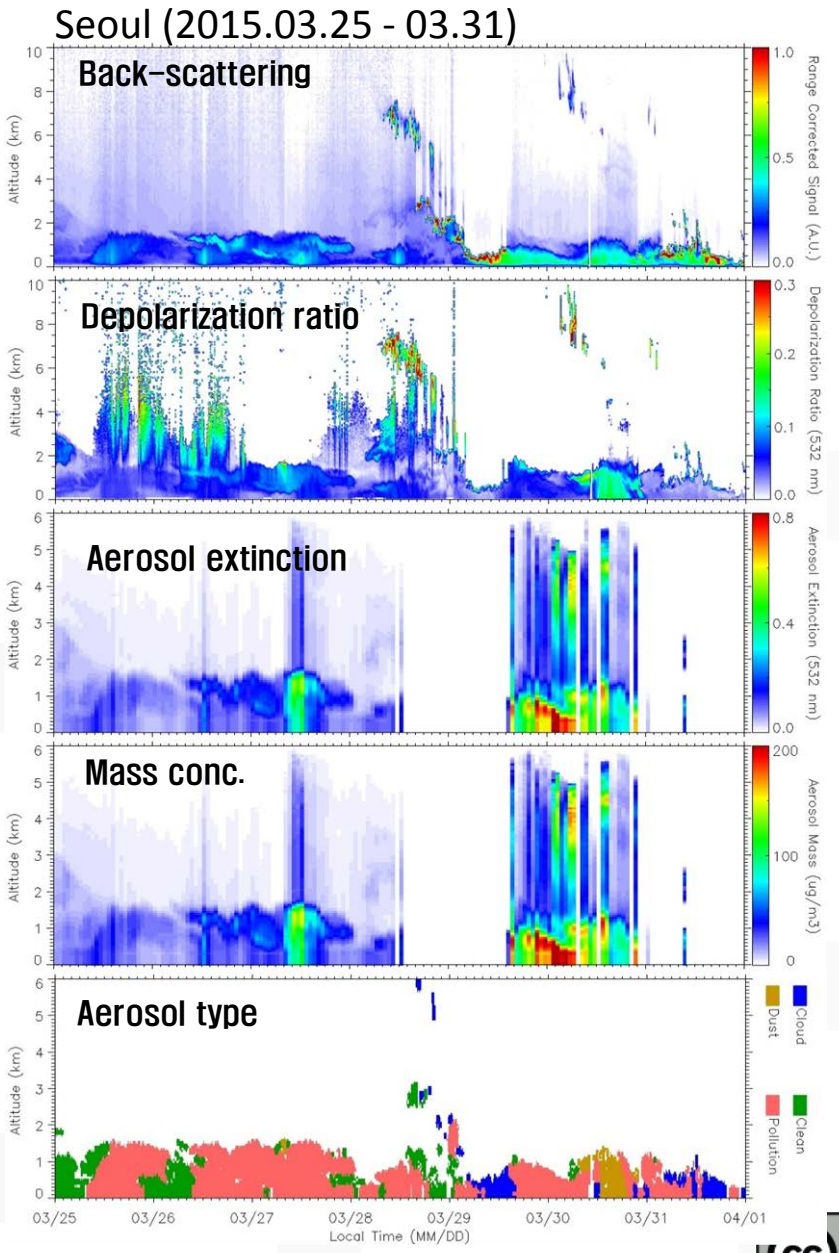






Korea Aerosol Lidar Observation Network(KALION)

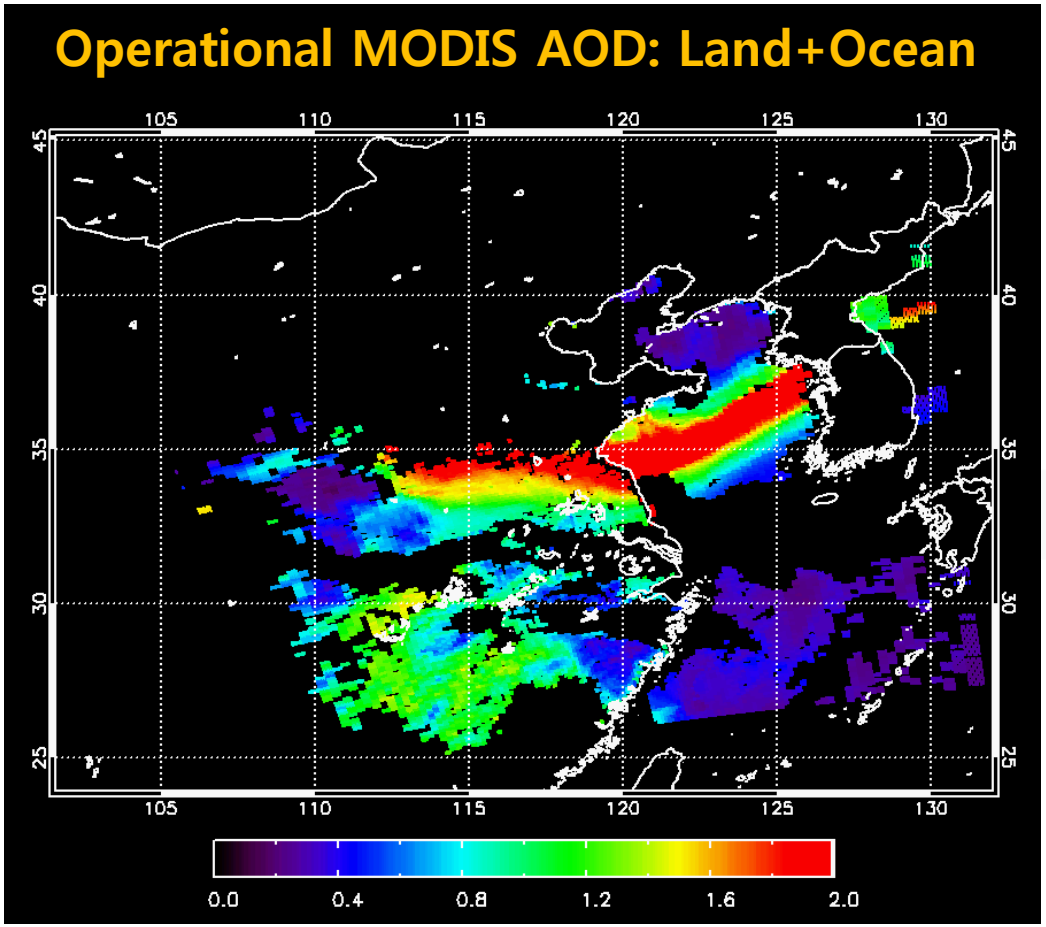


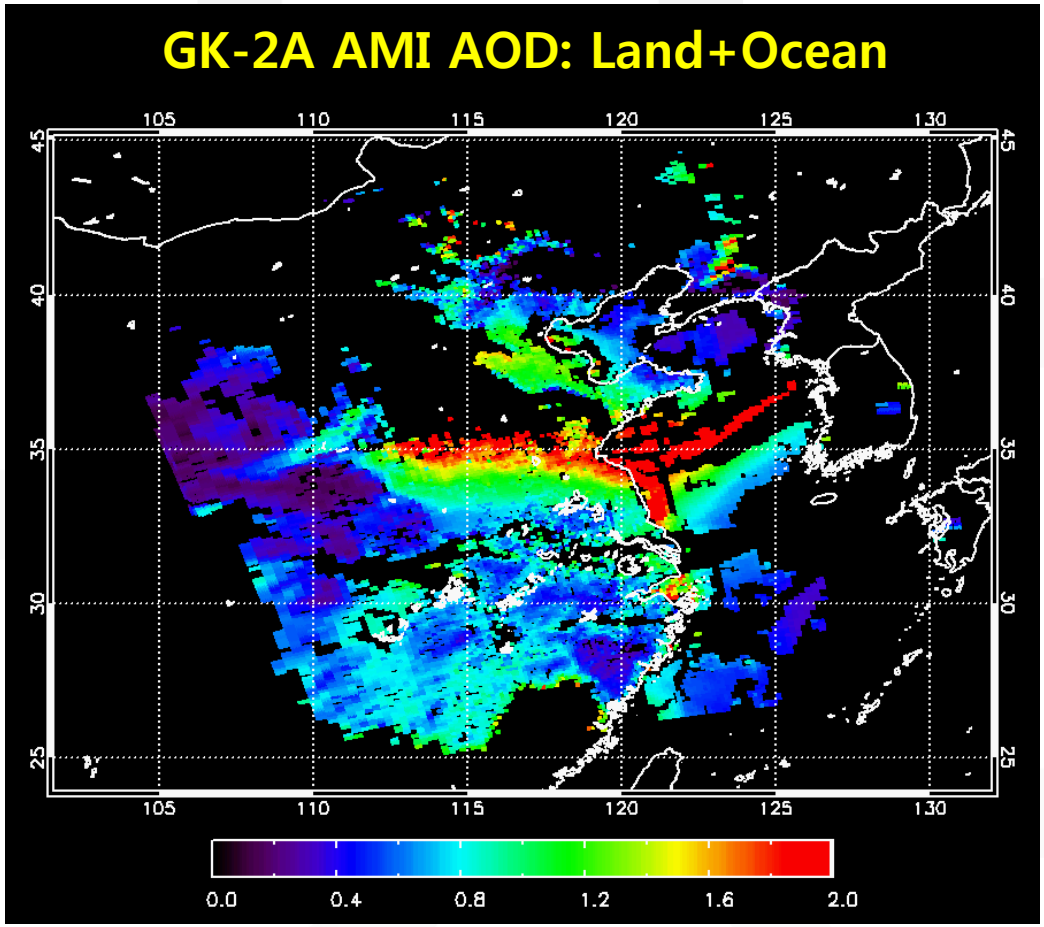


http://www.kalion.kr/Main.do

4. Compare different satellite products

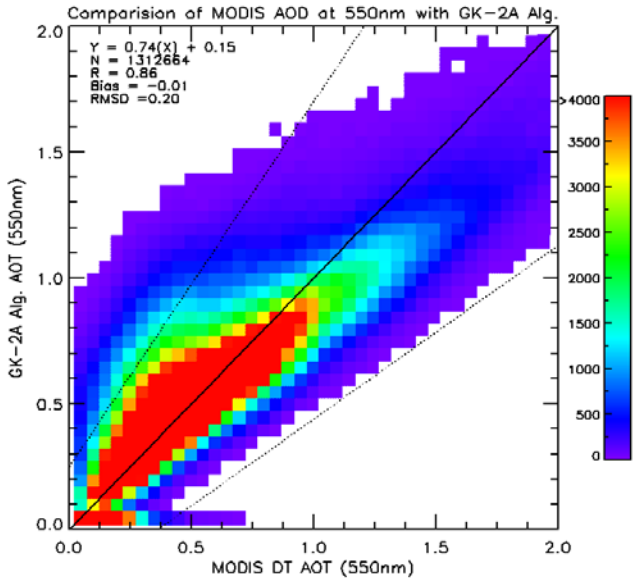
Dust case

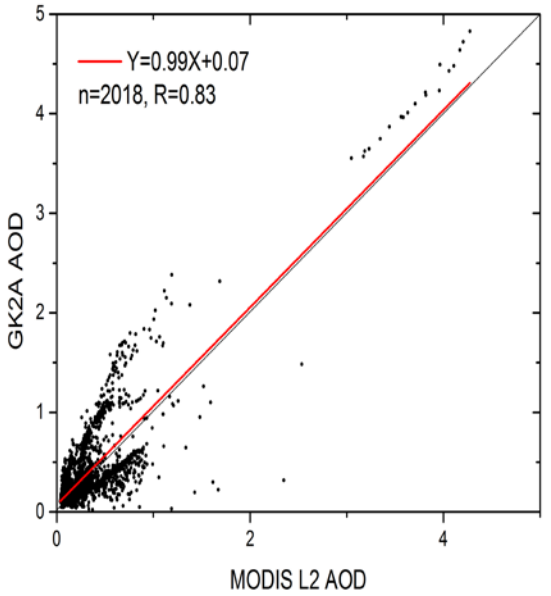




4. Validation

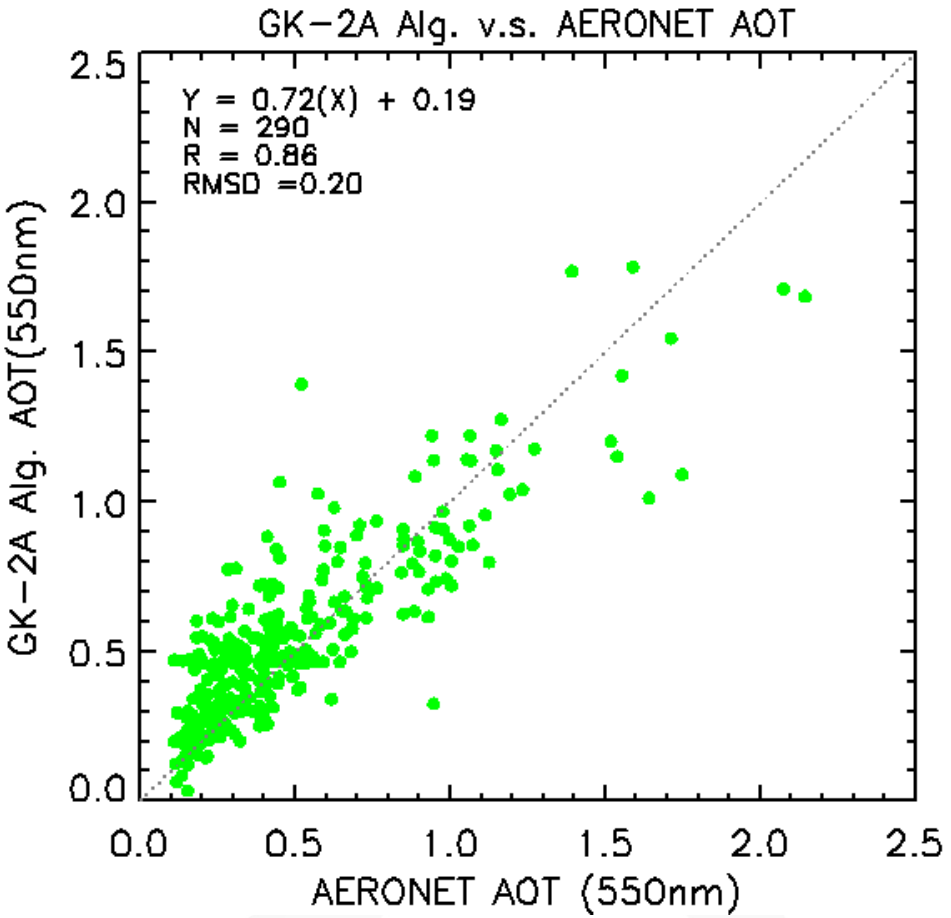
GK-2A v.s. MODIS





Mar-May 2012, East Asian Region

GK-2A v.s. AERONET



5. Summary

- Integrated aerosol retrieval algorithm for the new generation geostationary satellite (Himawari-8, GK-2A) data has been developed.
- The results showed that the derived aerosol detection and optical depth can effectively produce aerosol products by using the proxy data.
- Time-and-space distribution of the aerosol pixels is in good agreement with the data pertaining to operational aerosol products.
- This algorithm is expected to provide a fine spatial and temporal resolution of aerosol products from GK-2A satellite observation data.

Q&A

Interdisciplinary Study on
Integrated Diagnosis and Environmental Assessment

강릉원주대학교
GANGNEUNG-WONJU NATIONAL UNIVERSITY

This work was supported by “Development of Geostationary Meteorological Satellite Ground Segment(NMSC-2014-01)” program funded by NMSC (National Meteorological Satellite Centre) of KMA(Korea Meteorological Administration).