TEMPO aerosol workshop, Sep 11th,2017

Aerosol algorithm for GEMS, and observation capabilities from geostationary satellites in GEOKOMPSAT-2

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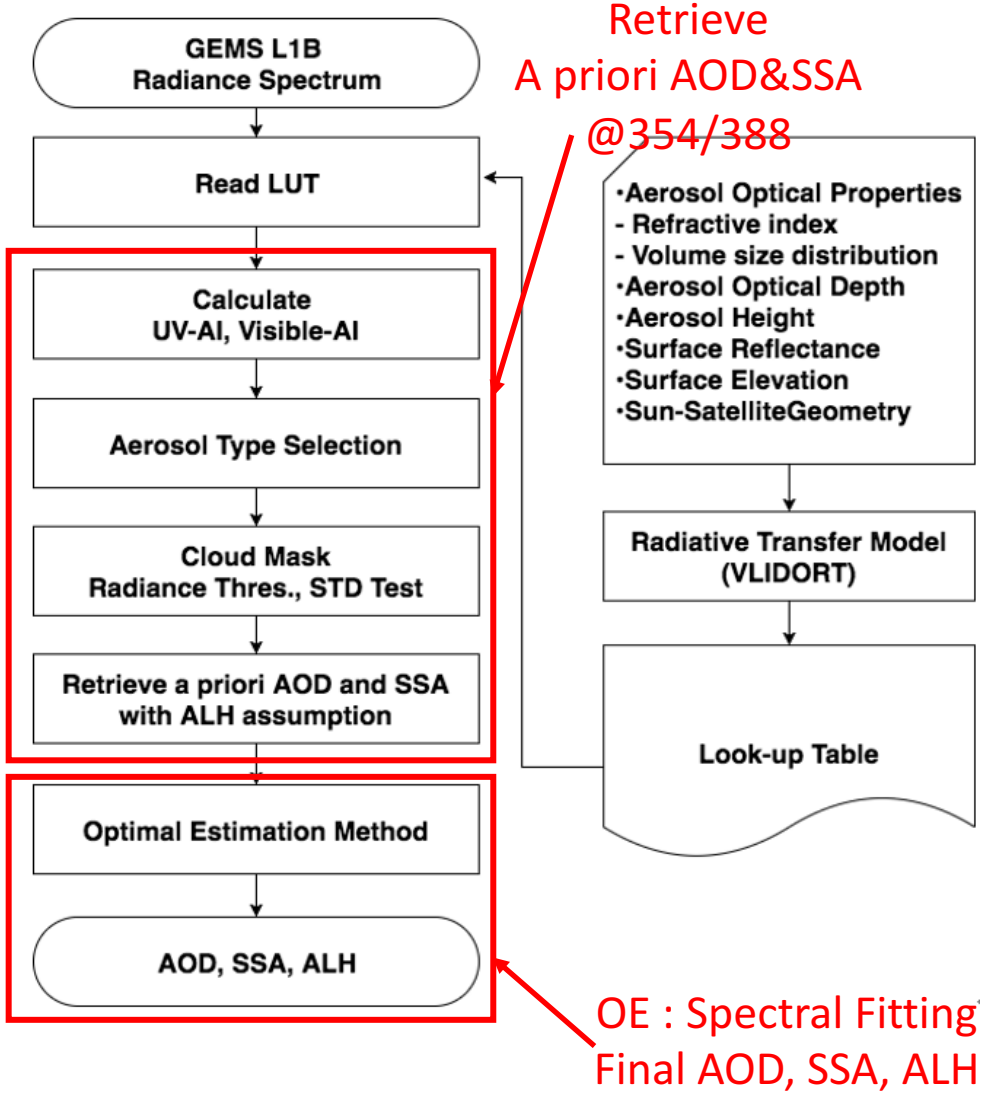
Outline:

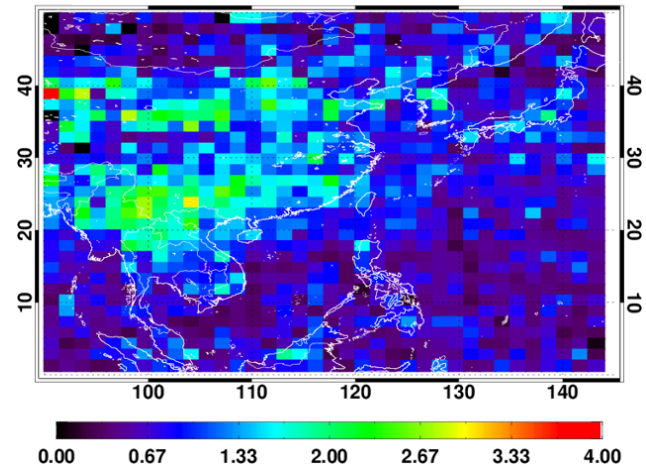
- ***GEMS Stand alone aerosol algorithm***
- ***Recent research on dust non-spherical particles***
- ***[Research version] OE-based Online Retrieval Algorithm***
- ***AOD fusion technique for GEOKOMPSAT-2***

GEMS Standard Aerosol Retrieval Algorithm

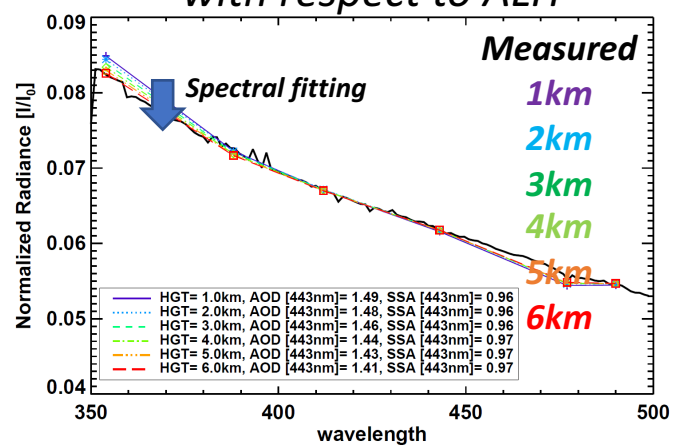
Aerosol Algorithm Flowchart



A priori ALH
(CALIOP Climatology)



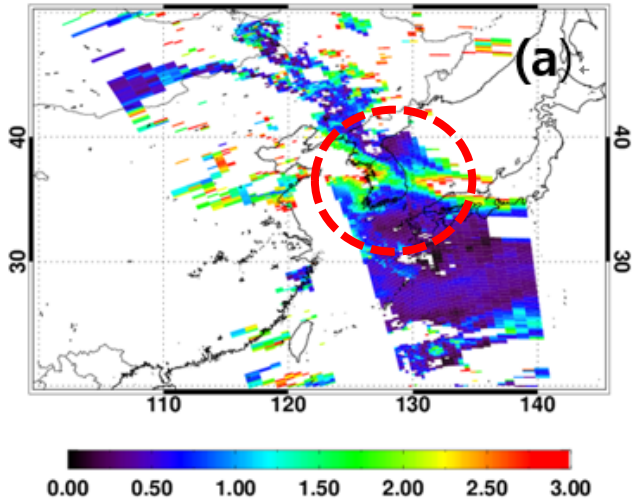
A priori spectrums
with respect to ALH



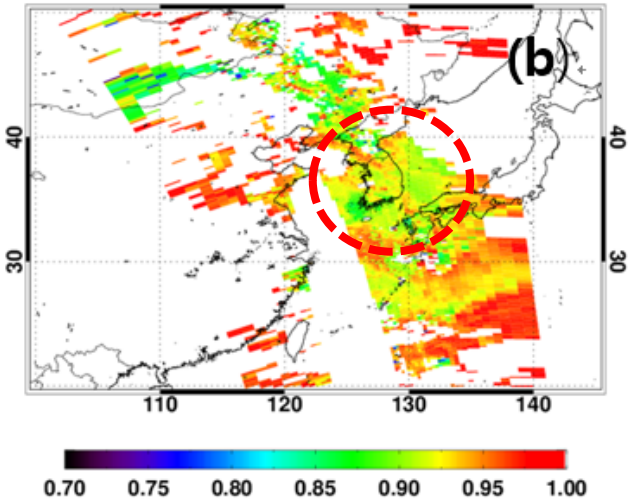
GEMS Aerosol Algorithm are being tested with OMI L1B measurement data

Standard GEMS Aerosol Products

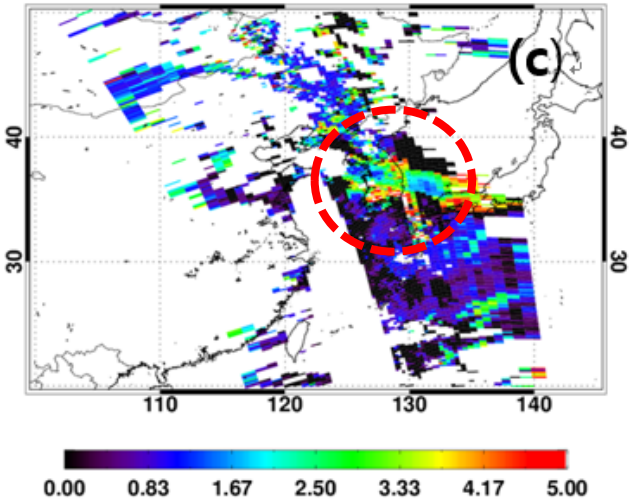
GEMS AOD 443nm



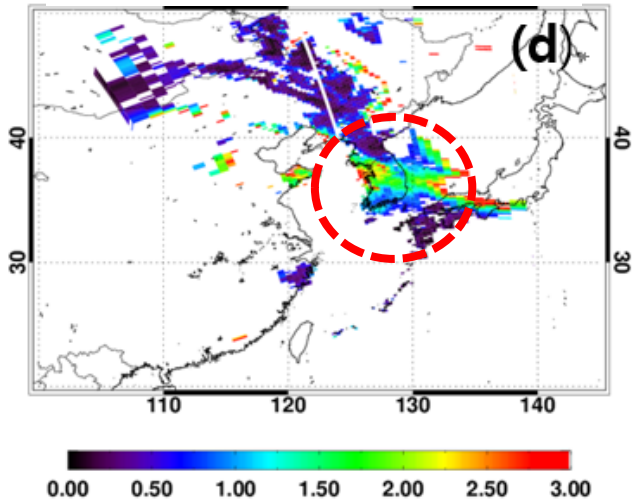
GEMS SSA 443nm



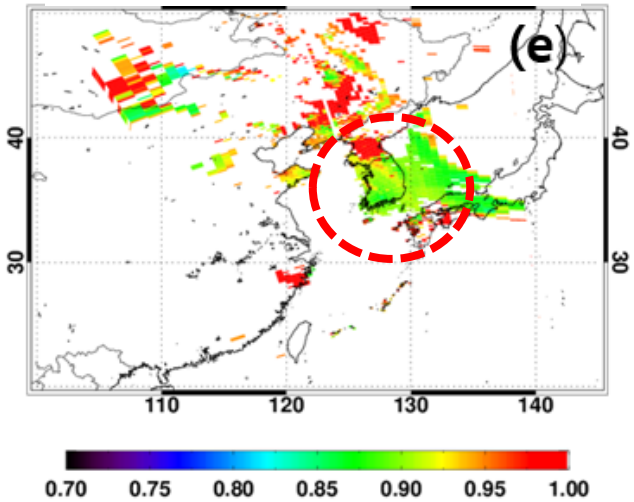
GEMS ALH



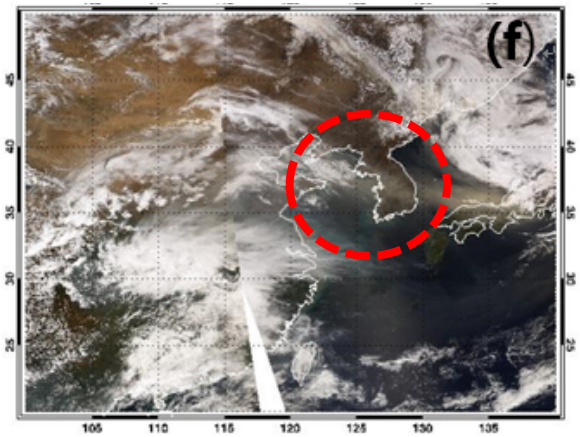
OMI AOD 388nm



OMI SSA 388nm

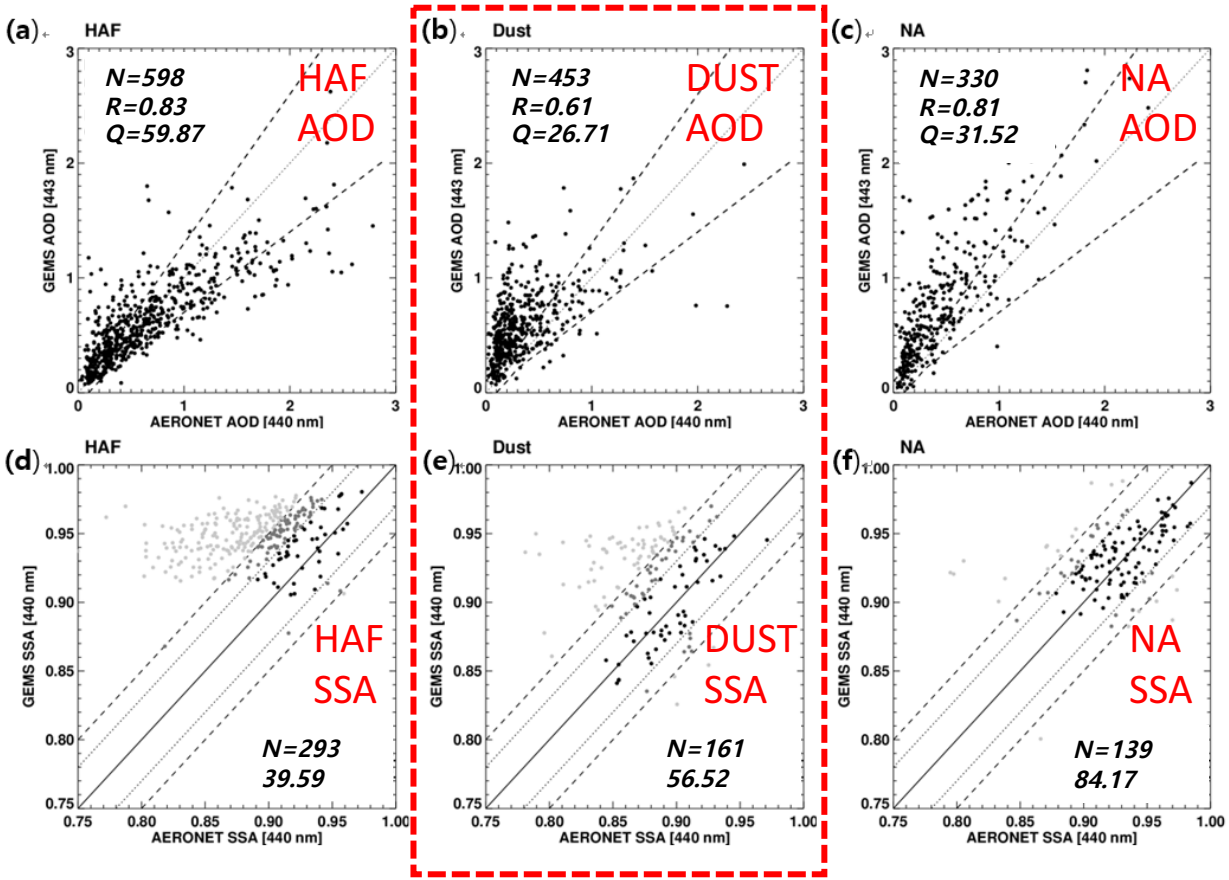


MODIS RGB

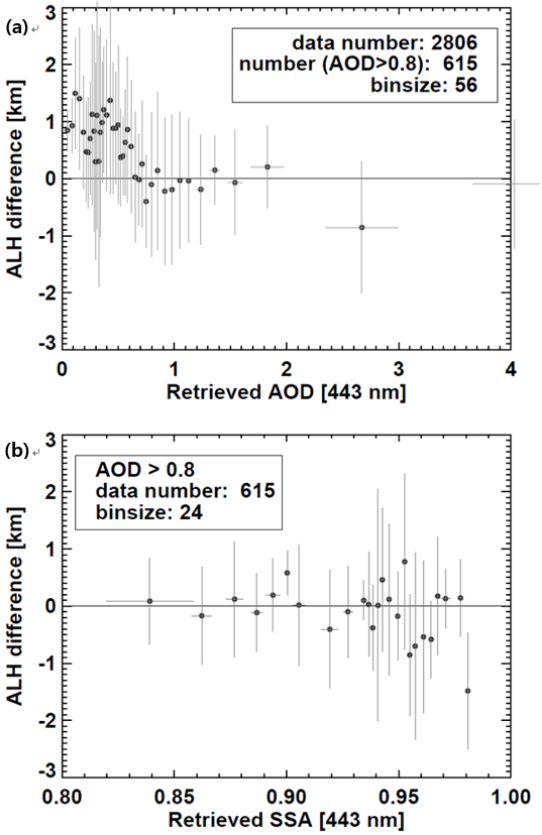


Validation of GEMS Aerosol Products

AOD, SSA validation with AERONET over East Asia



Height Error w.r.t AOD, SSA (validation with CALIOP)

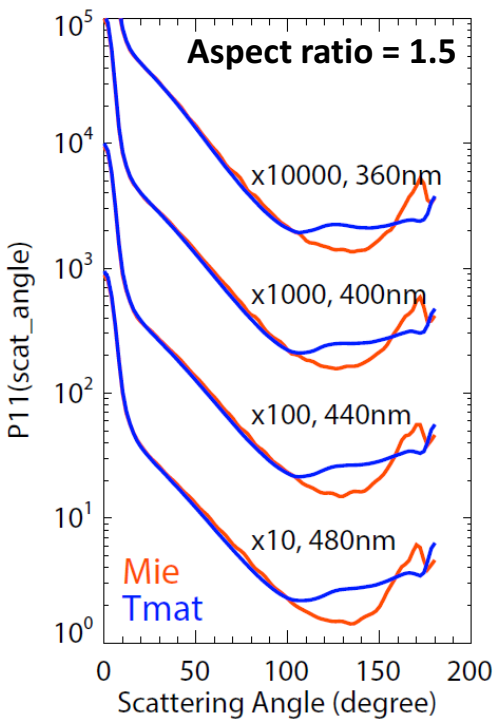


Dust detected pixels, retrieved with Mie LUT, cause error on AOD, SSA, and ALH

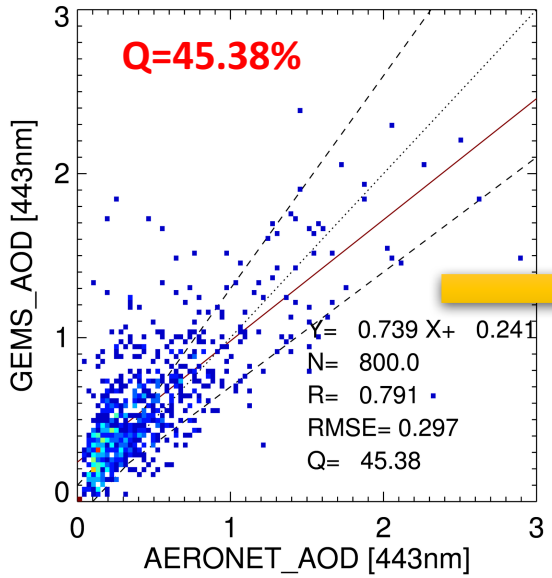
GEMS dust detected AOD retrieved with non-spherical particles

✓ ***Validation Only for Dust detected type***

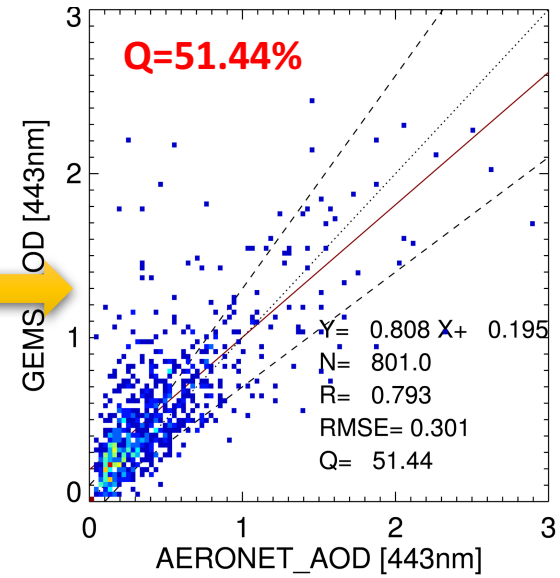
Phase Function simulated with VLIDORT



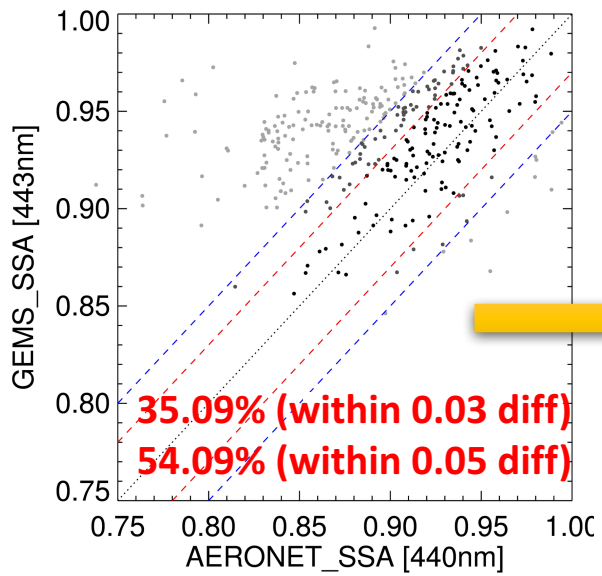
Dust type AOD w/Mie



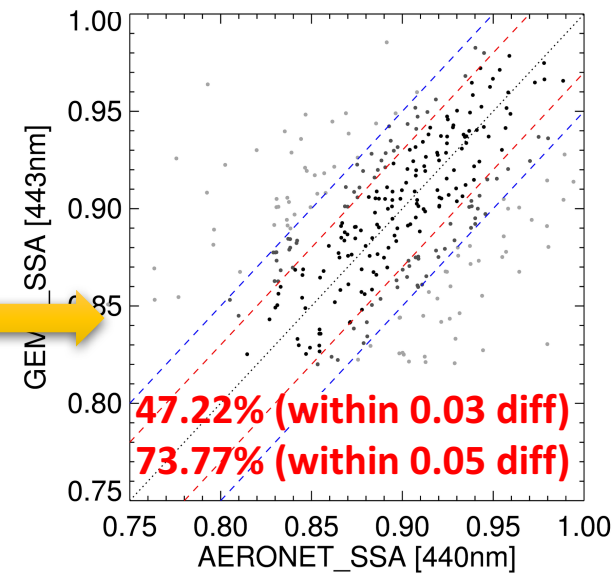
Dust type AOD w/T-matrix



Dust type SSA w/Mie



Dust type SSA w/T-matrix



Flowchart of the OE-based OMAERUV algorithm

[Jeong et al., ACP 2016]

Normalized radiance
@ 354 and 388 nm from OMI
TOMS surface reflectances

↓

Calculation of the UVAI

↓

Cloud masking &
algorithm flag (AF)

AF >1 → No retrieval

AF = 0 ↓

Aerosol type classification
(AIRS CO data & UVAI thresholds)

↓

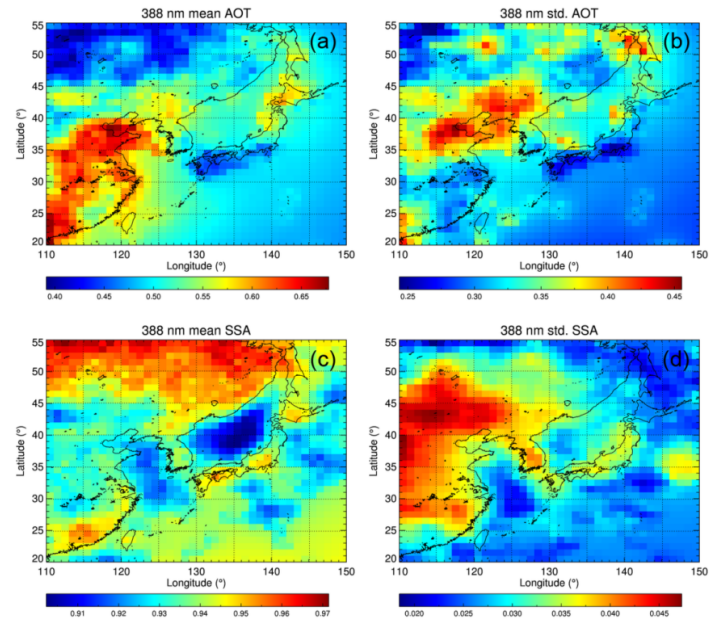
Aerosol peak height estimation
(Caliop climatology)

↓

A priori database of AOD and SSA
10-year OMAERUV records

↓

Optimal Estimation retrievals of AOD and SSA
Coincident estimation of errors in each retrievals
(Apply logarithmic transformation for AOD)



- 10-year OMAERUV AOT and SSA in spring (May to March) from 2005 to 2014

- But the *a priori* constraints has been loosen

→ To increase the degrees of freedom

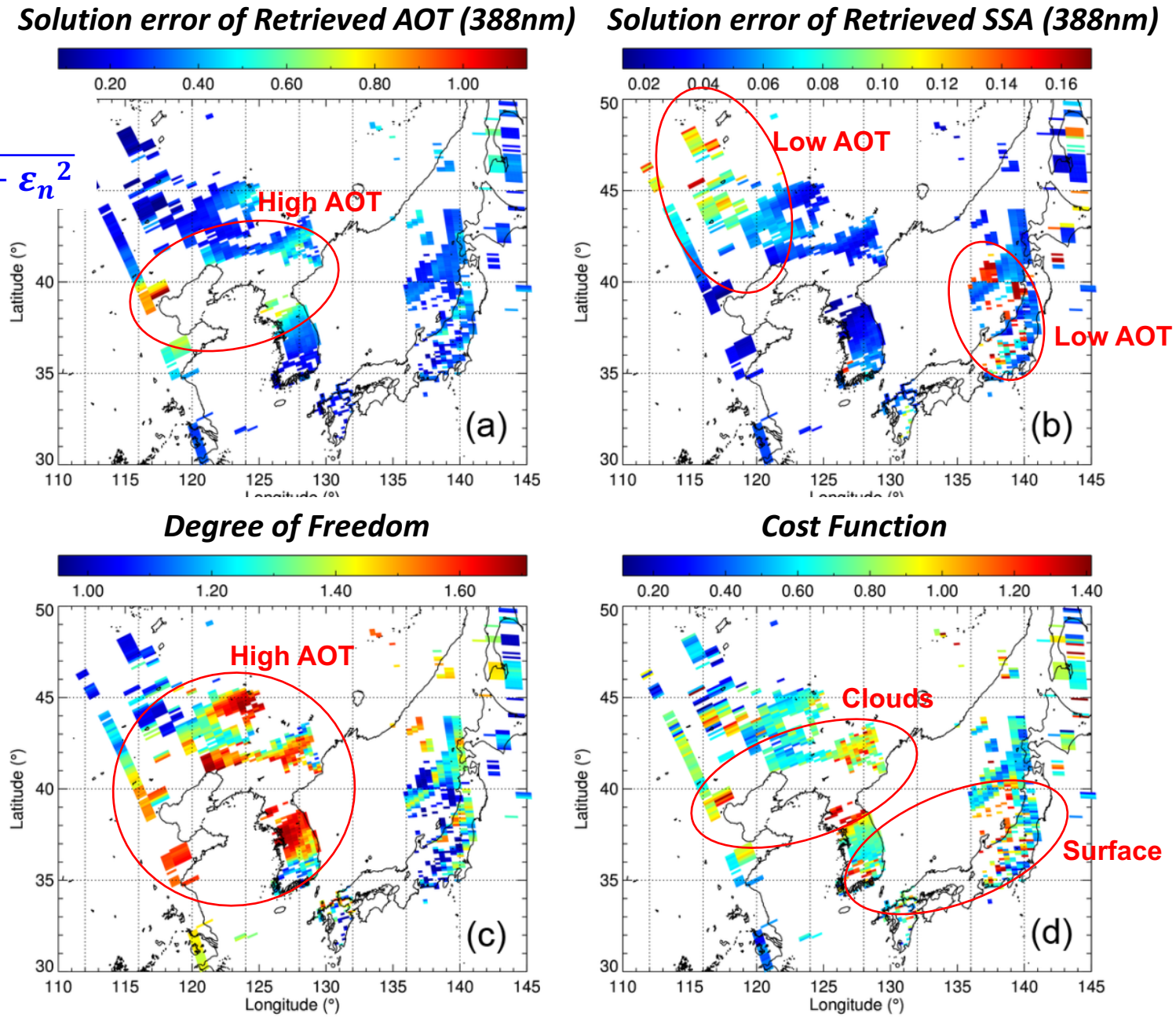
→ To avoid the *a priori* biases in OMAERUV algorithm

<u>Online retrieval methods</u> can reduce errors from the interpolation and are numerically efficient particularly for the smaller number of target retrievals

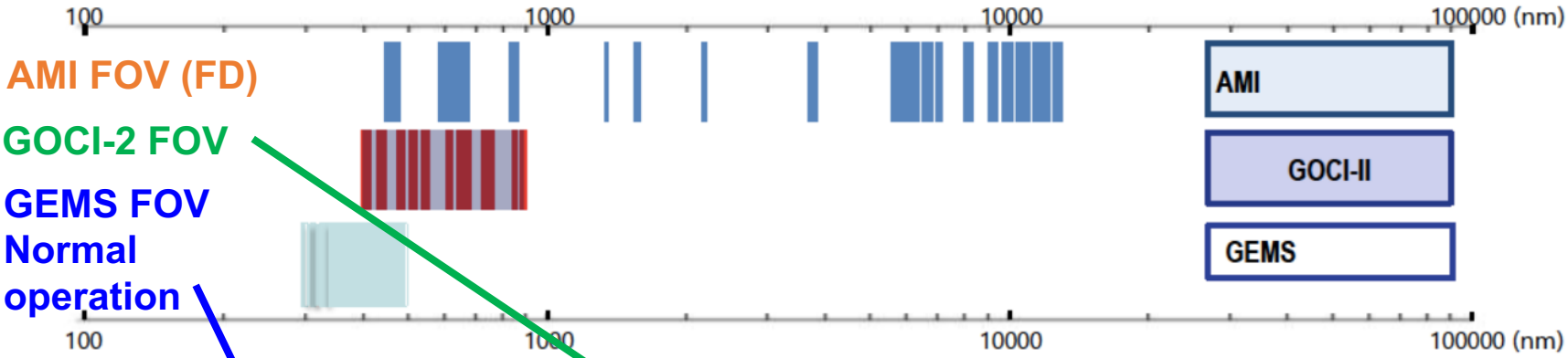
[Jeong et al., ACP 2016]

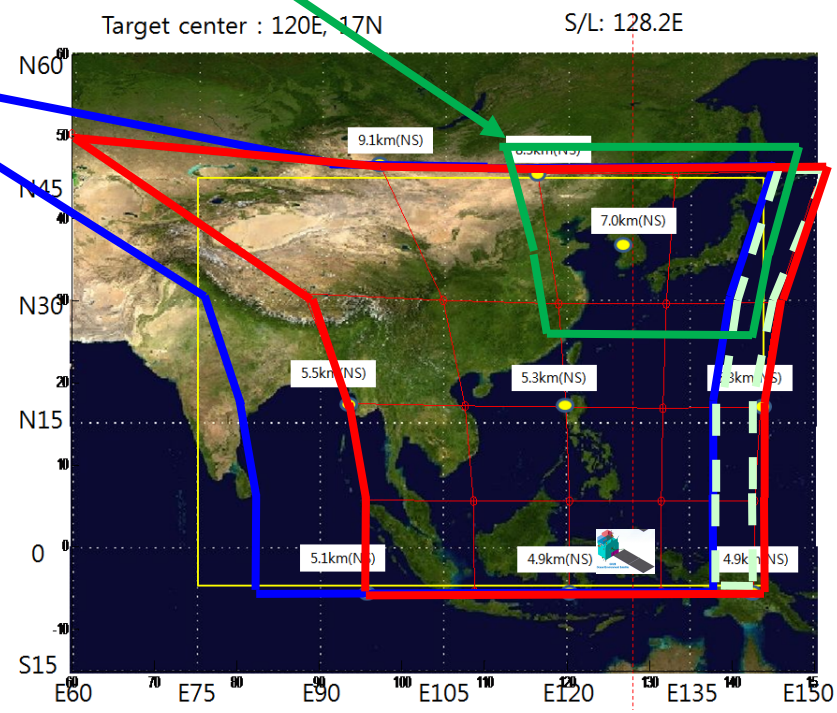
Estimated Solution Error from OE-based algorithm

$$\varepsilon_{sn} = \sqrt{\varepsilon_{sm}^2 + \varepsilon_n^2}$$



GK-2A/2B Satellite instruments FOV





Projected FOV

Region of interest

GEMS
For clear sector method

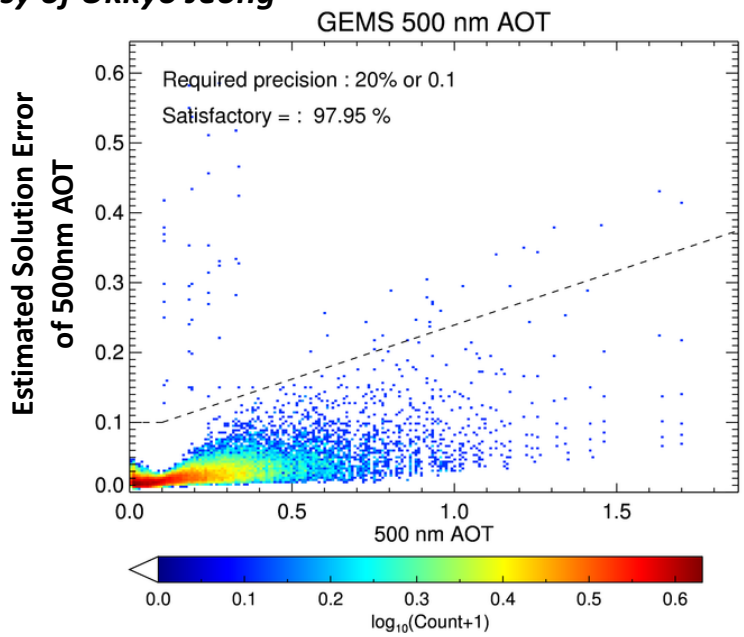
(Courtesy, KARI)

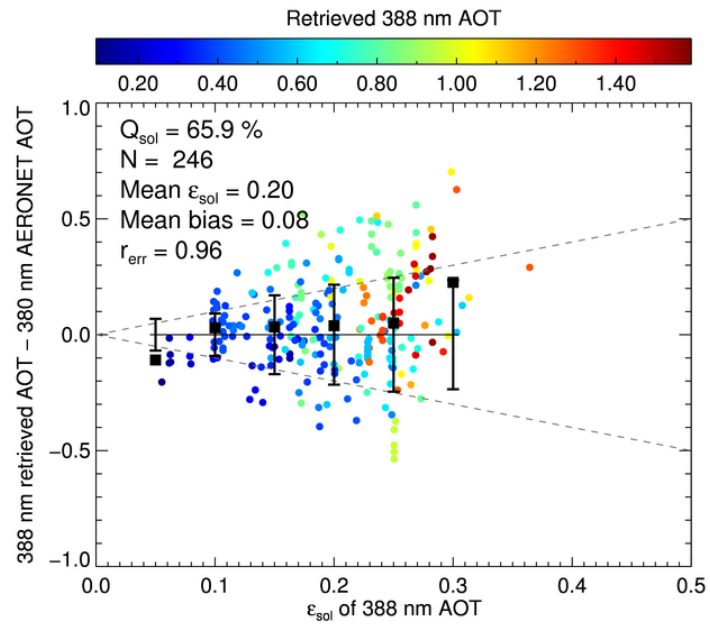
GK-2A/2B Satellite instruments specification

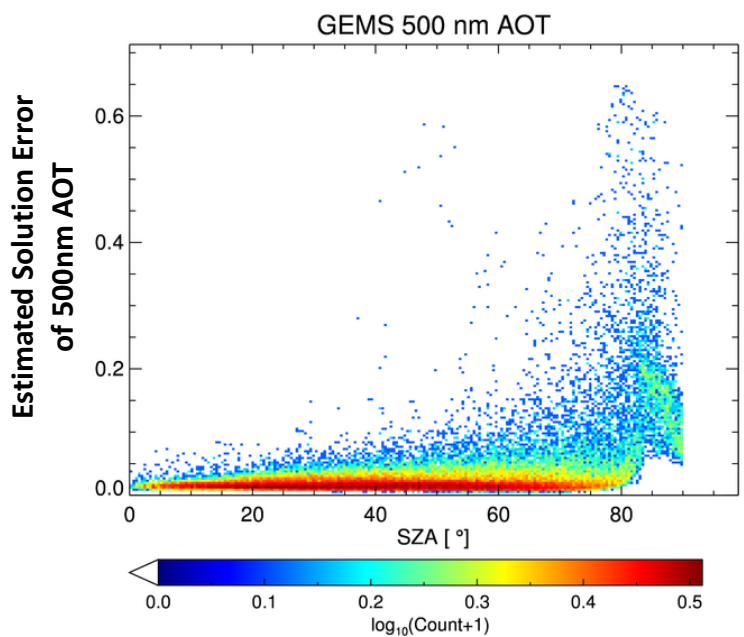
Satellite in Orbit	GEO-KOMPSAT-2A	GEO-KOMPSAT-2B	
Payload	**AMI (~ABI)**	**GEMS(~TEMPO)**	**GOCI-2**
Channels (㎛)	*16 channels (0.47~13.31)*	*1000 channels (0.3~0.5) Scanning UV-VIS Spectrometer*	*12 channels + 1 wideband (0.380~0.865) VIS, NIR*
Temporal resolution	within 10 min (FD) ← **5 min Diff** →	1 hour (8 times/day) (30min imaging + 30min rest) ← **30 min Diff** →	1 hour (10 times/day (Local) + 1 times (FD))
Spatial resolution	1km (<0.856㎛, VIS) 0.5km (=0.64㎛, VIS) 2km (>1.38㎛, IR)	Gas : 7(NS)x8(EW) km Aerosol : 3.5(NS)x8(EW) km	250m (@130°E) 1km (FD)
Spectral resolution	-	<0.6nm (3 samples) (spectral sampling < 0.2nm)	12 narrow bands (10 ~ 40 nm)
Field of regard (FOR)	**Full Disk**	5,000km(N/S) × 5,000km(E/W) N/S: 45°N～5°S, E/W: 75°E～145°E (E/W, Selectable)	2,500km(N/S) × 2,500km(E/W)
Baseline products	- Scene & Surface Analysis - Cloud & Precipitation - *Aerosol* & Radiation *: (AOD, Asian Dust detection, Particle Size)* - Atmospheric condition & Aviation	O_3 (Column, Profile), NO_2, SO_2, HCHO, *Aerosols (AOD, SSA, ALH),* UVI, CHOCHO	- Water quality variable - Marine Environmental products - *Atmospheric Properties* *: AOD, dust detection, aerosol type..* - Land variable

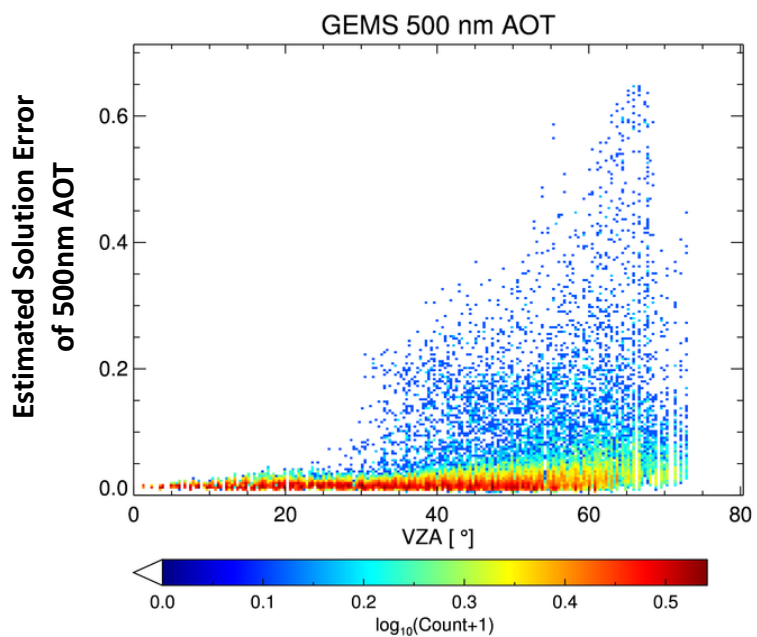
Performance prediction of GEMS AOD

Courtesy of Ukkyo Jeong









Previous Research about AOD fusion technique

When valid AOD exist at least one or more.

- Cressman [Cressman, 1959]
- Optimum Interpolation [Xue et al., 2012, 2014; Yu et al., 2003, Singh et al., 2017]
- The Empirical Orthogonal Functions [Liu et al., 2005]
- The linear or second-order polynomial functions [Mélin et al., 2007]
- The arithmetic and weighted average [Gupta et al., 2008]
- The least squares estimation [Guo et al., 2013]
- The maximum likelihood estimate [Nirala, 2008; Xu et al., 2015]

Geostatistical methods : Data assimilation

<spatial only>

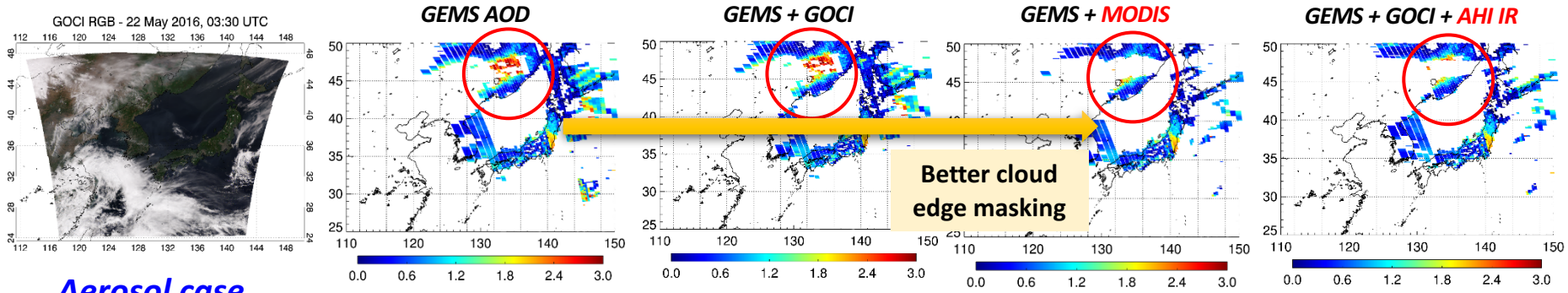
- The universal kriging method [Chatterjee et al., 2010; Li et al., 2014]
- The geostatistical inverse modeling [Wang et al., 2013]
- The spatial statistical data fusion (SSDF) method [Nguyen et al., 2012; Puttaswamy et al., 2013]
  (SSDF : variant of kriging method, multi-sensor AOD fusion)

<spatio-temporal>

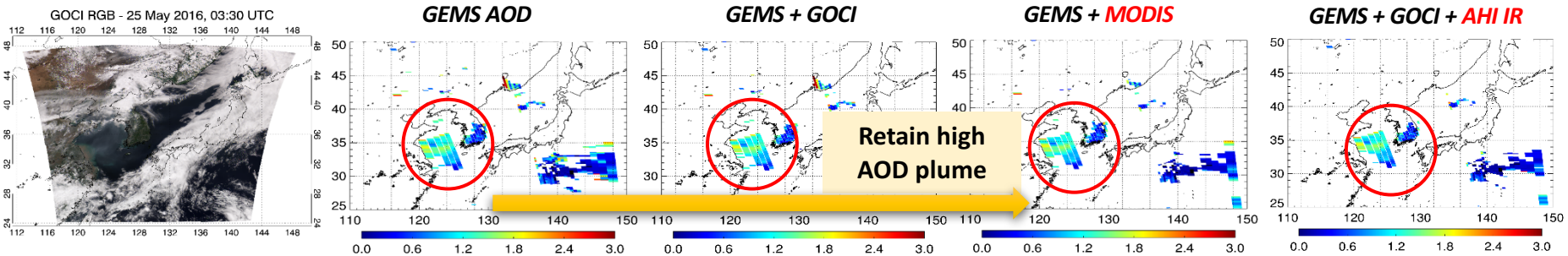
- Bayesian Maximum Entropy (BME) [Tang et al., 2016]
  (temporal autocorrelation + uncertainty of the observation)
- Spatio-Temporal Kriging

GEMS-AMI (~OMI-MODIS) synergies : cloud masking

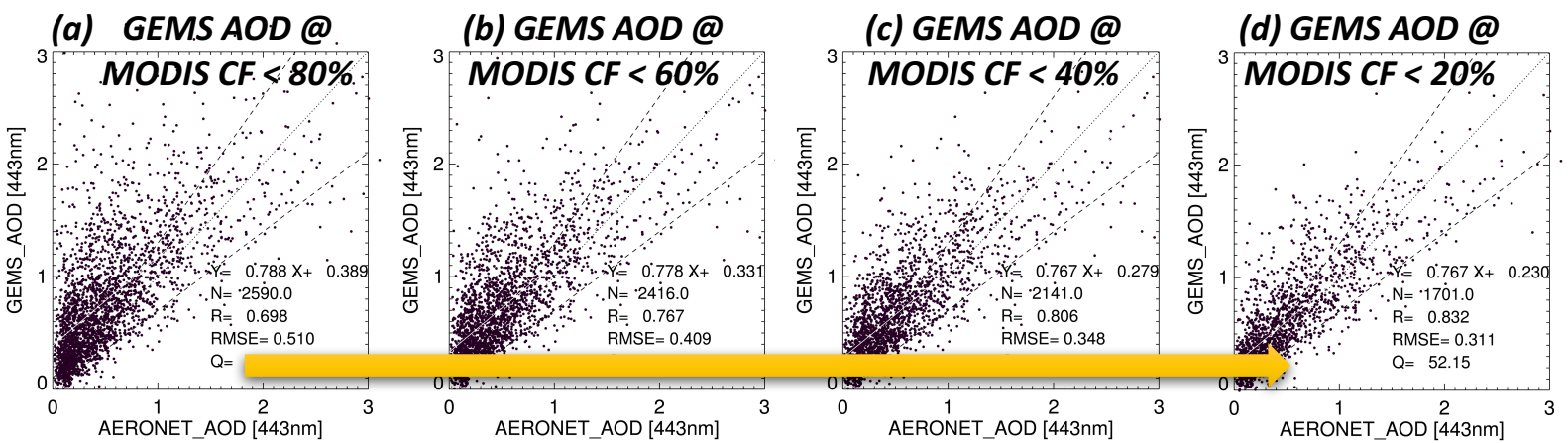
Cirrus case



Aerosol case



3yr validation



(a)	(b)	(c)	(d)
R=0.70	R=0.77	R=0.81	R=0.83
RMSE=0.51	RMSE=0.41	RMSE=0.35	RMSE=0.31
Q=38.69	Q=42.59	Q=47.31	Q=52.15

Consistent AOD dataset of OMI & MODIS (~GEMS & AMI)

Maximum Likelihood Estimation (MLE)

$$R_{i,k} = \sqrt{\frac{\sum_{i=1}^{M}(s_{i,k} - g_i)^2}{M}}$$

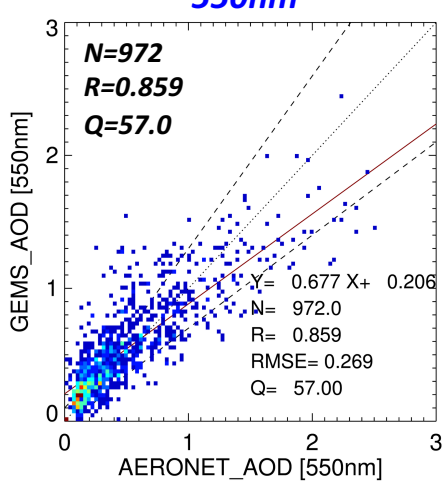
$$\tau_i^{MLE} = \sum_{k=1}^{N} \frac{R_{i,k}^{-2}}{\sum_{k=1}^{N} R_{i,k}^{-2}} \tau_{i,k}$$

Surface albedo is a an important source of the uncertainties in AOD retrieval
AOD amount is also a key parameter related to the error in the retrieved satellite AOD [Xu et al., 2015]

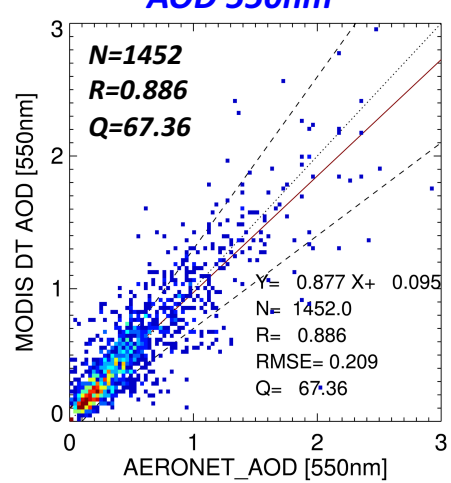
Weight matrices for original satellite AOD products for four albedo (MCD43) ranges (0-5%, 5-8%, 8-11%, 11-25%) and four AOD ranges (0.0-0.25, 0.25-0.5, 0.5-0.8, 0.8-5.0) are calculated and used for AOD merging.

3yr validation

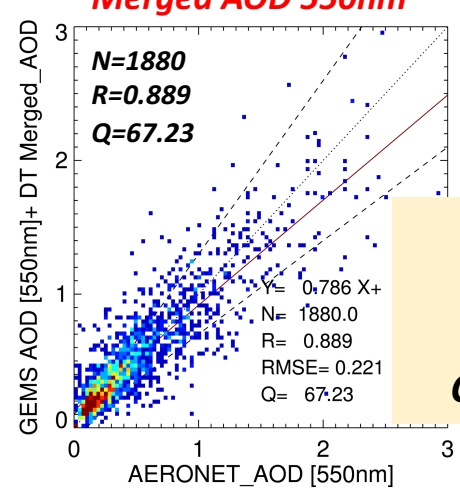
(a) GEMS AOD 550nm



(b) MODIS DT AOD 550nm



(c) GEMS + MODIS Merged AOD 550nm



Maintain Accuracy Spatial Coverage ↑

Thank you for your attention ☺