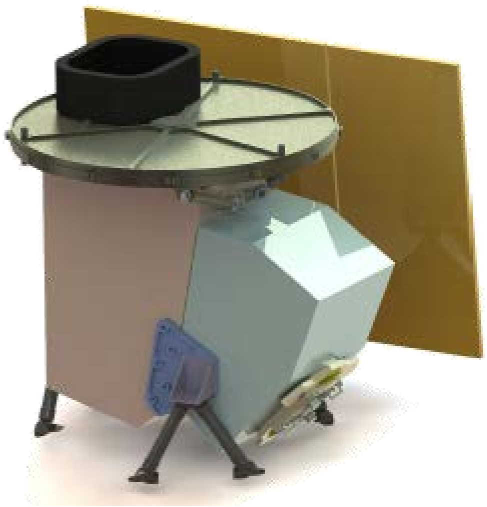
2018 GEMS Science Team Meeting



Status of GEMS Surface Reflectance Algorithm

Kwoh-Ho Lee

Gangneung-Wonju National University(GWNU)

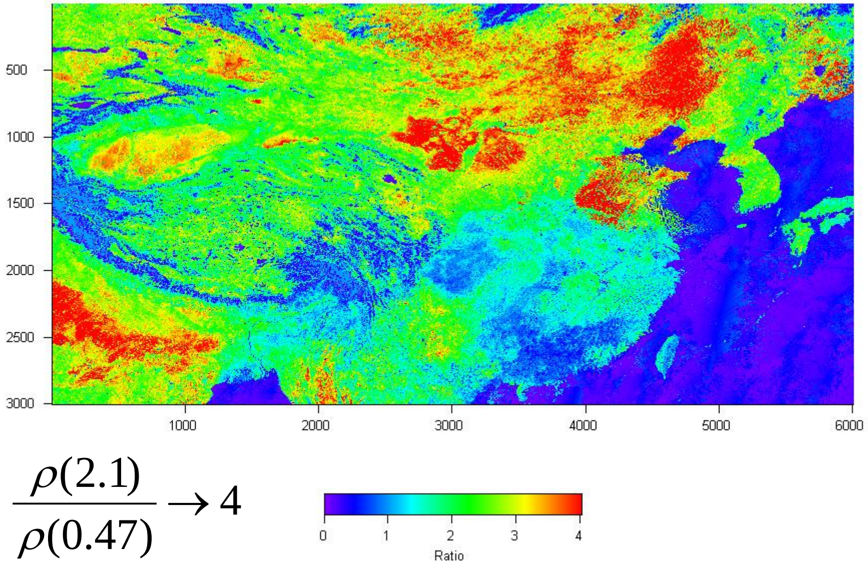
Outline

The status of the operational algorithm development for the GEMS surface reflectance products(SRP):

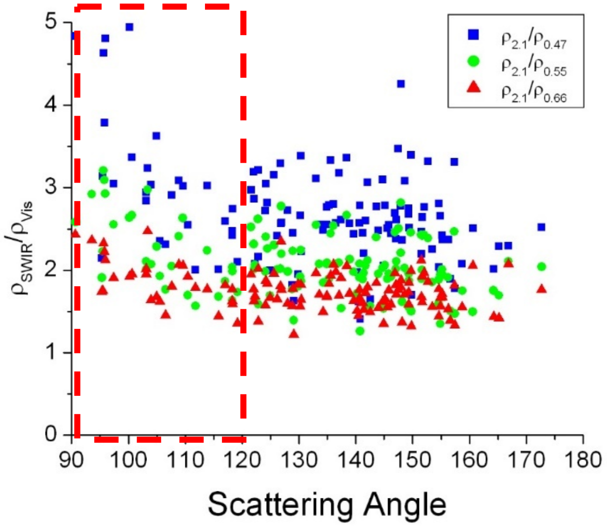
- SRP algorithm requirements definition based on ATBD
- Review of the current methods and selection of the candidate approach
- Algorithm description and validation analyses.

MODIS Min. Reflectance Map (Apr 2015)

$$\rho_{TOA}(SWIR) = c \cdot \rho_{Surf}(Vis)$$



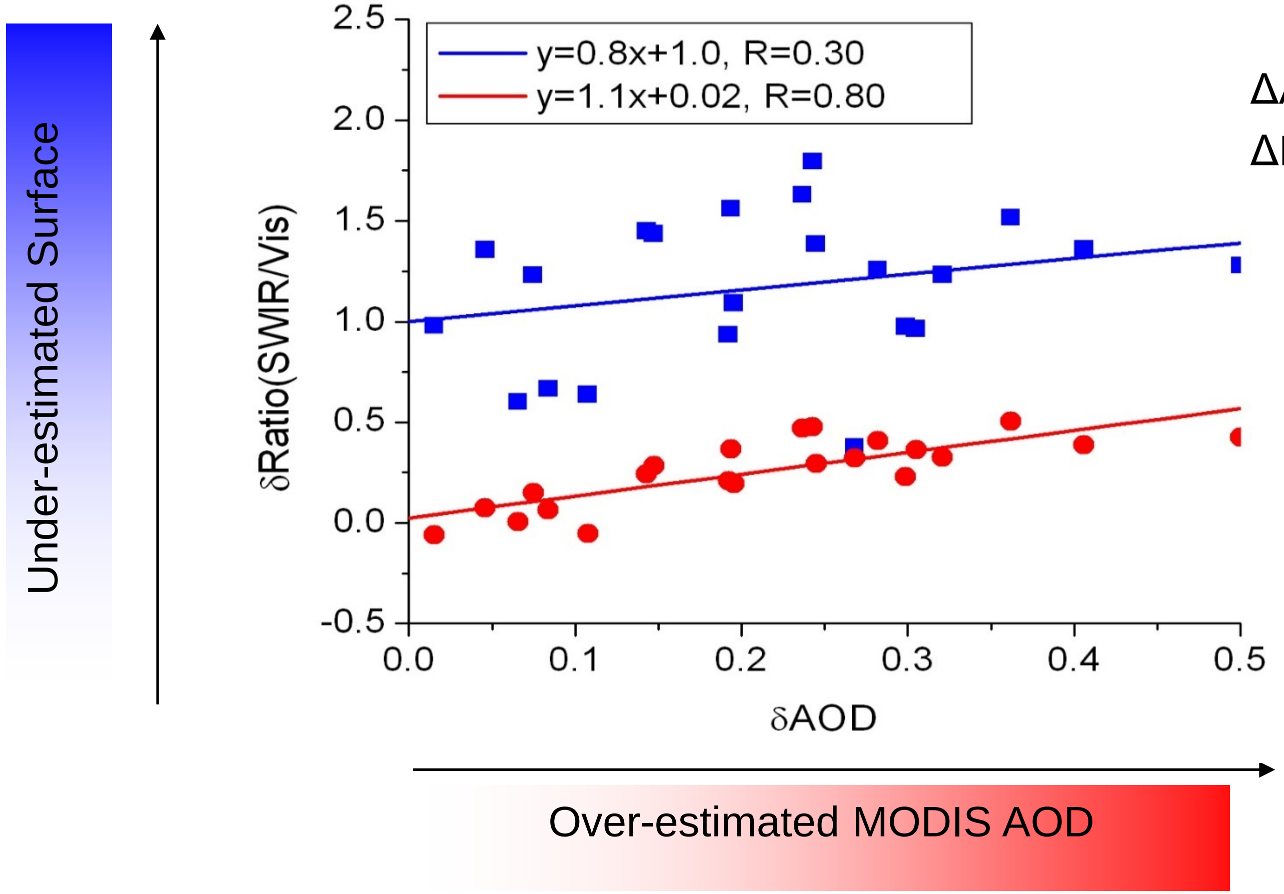
$$\frac{\rho(2.1)}{\rho(0.47)} \rightarrow 4$$



- Vis/SWIR ratio has been widely used for surface reflectance estimation [Kaufman et al., 1997; etc.]
- Those fixed ratios between SWIR and Vis can not represent real surface cover !!

- Karnielli et al., (2001) : 4.35 over Brazil
- Lee et al., (2006) : 2.86 over Korea
- Levy et al., (2006) : 6.67 over Wallops, US

Importance of SRP

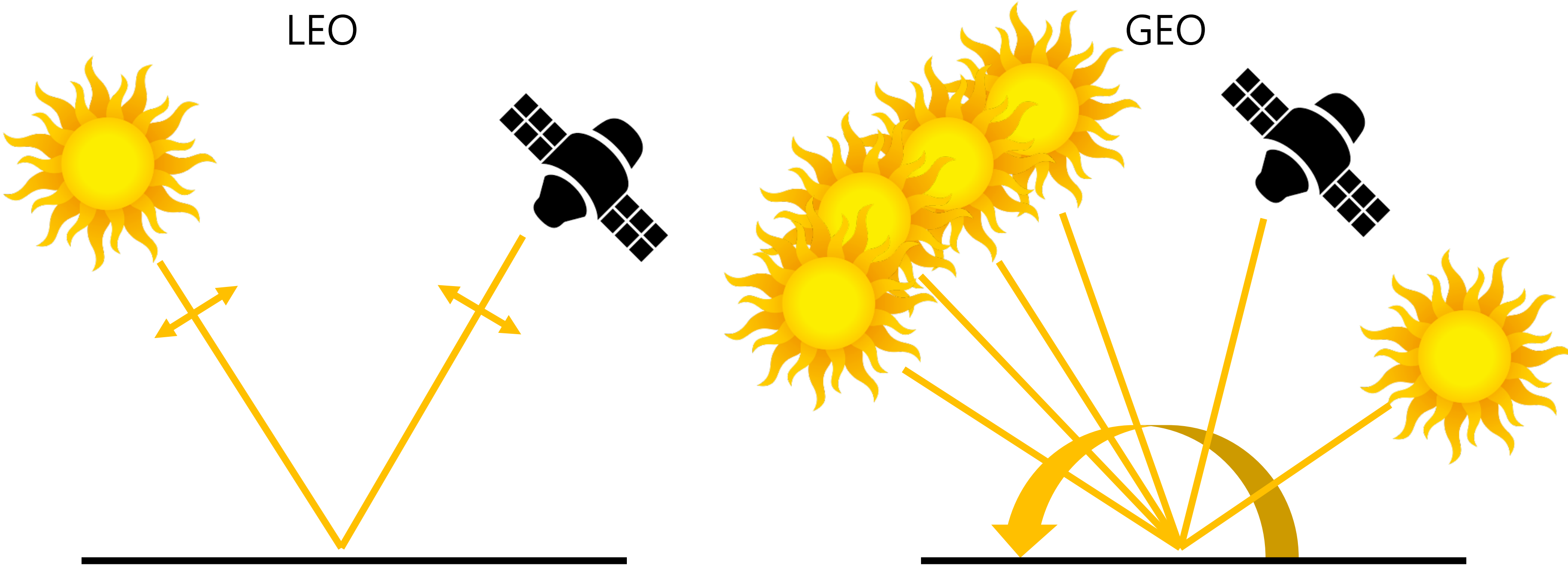


ΔAOD=MOD04-Ground

ΔRatio=Fixed Ratio-Real ratio

- Smaller then SWIR/Vis ratio → Under-estimated surface reflectance → Over-estimated AOD !!

How BRDF from the Geostationary Observation?



Pros
- Minimize Latitudal difference

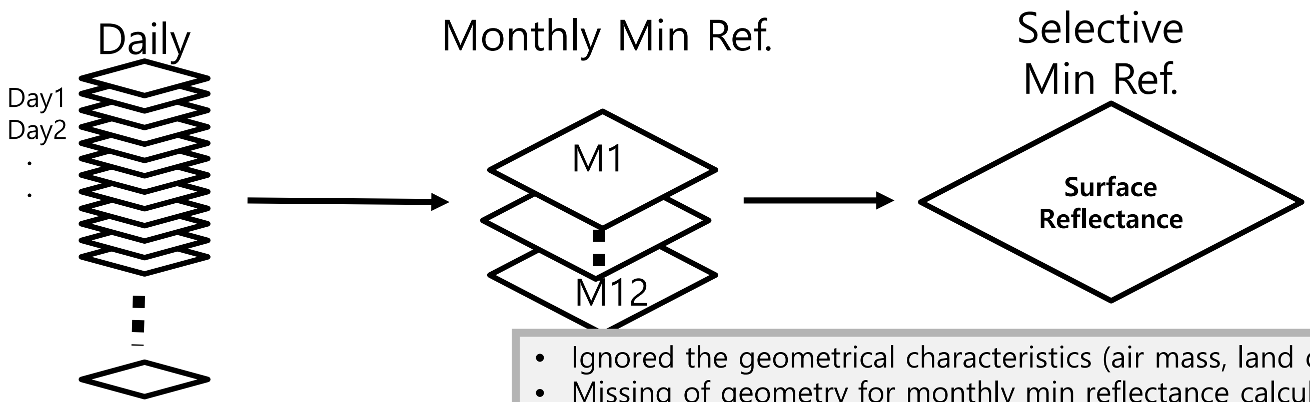
Cons
- Limited sun-sensor geometry
- 1 or 2 observation of VZA, SZA / day (require longer period observation)

Pros
- Wide ranges of SZA

Cons
- Latitudal difference of VZA

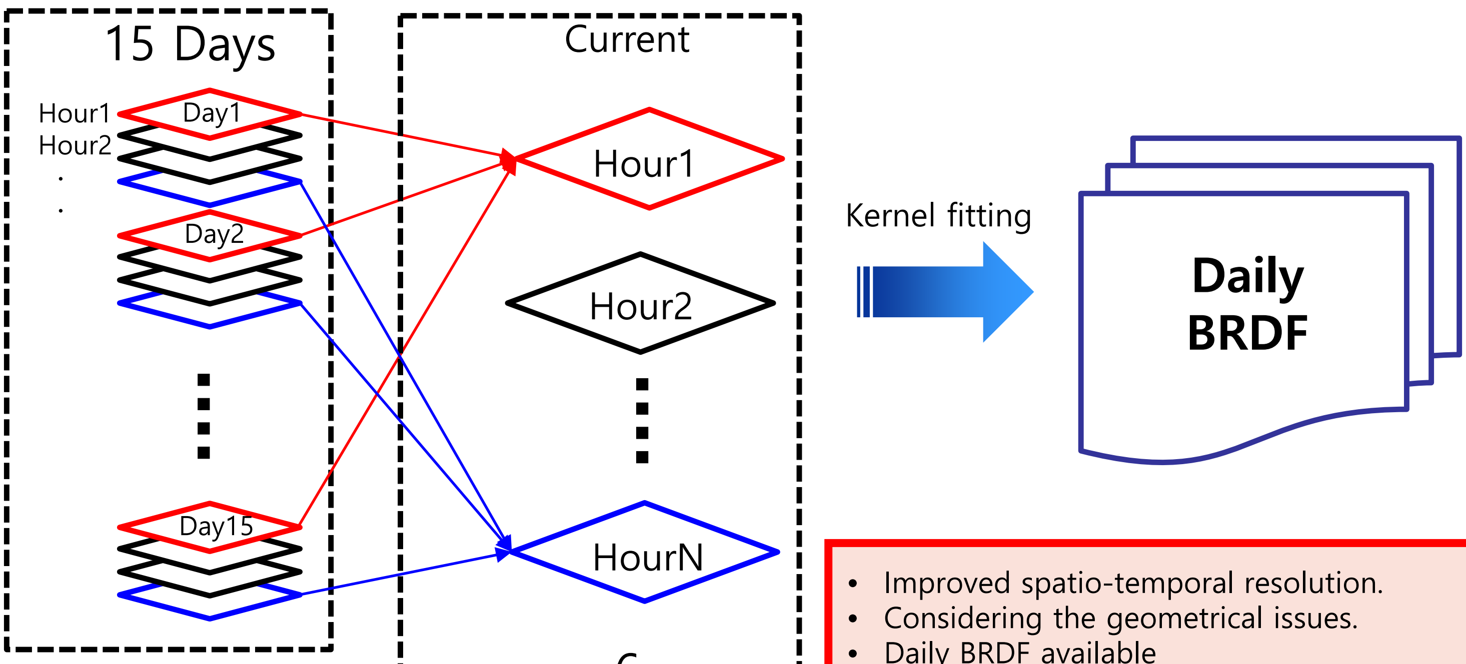
GEMS Surface Reflectance Retrieval Strategy

Past



- Ignored the geometrical characteristics (air mass, land cover, pixel size)
- Missing of geometry for monthly min reflectance calculation.
- BRDF not possible

Present



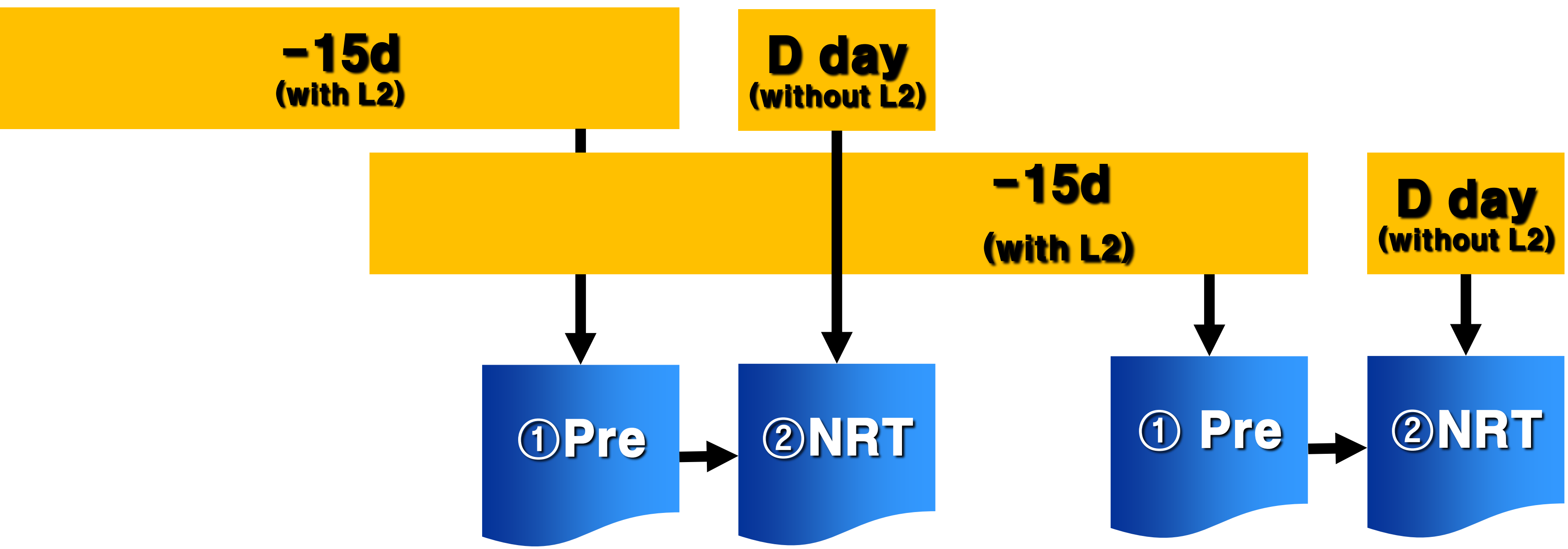
- Improved spatio-temporal resolution.
- Considering the geometrical issues.
- Daily BRDF available

Data accumulation and product generation

Current algorithm consists of 2 parts.

① Pre-process: Min reflectance data composited (moving window) during the last 15 days with L2 products (cloud, gas, aerosols).

② NRT process: Simple comparison of the atmospherically corrected data with ① at a given time.



Physical Basis

Atmospheric reflectance

Ground reflectance

$$\rho_{TOA}(\theta_S,\theta_V,\varphi) = \rho_{ATM}(\theta_S,\theta_V,\varphi) + T_{ATM}(\theta_S,\theta_V)\frac{\rho_{SFC}(\theta_S,\theta_V,\varphi)}{1-\rho_{SFC}(\theta_S,\theta_V,\varphi)S}$$

Atmospheric Transmissions

Atmosphere spherical albedo

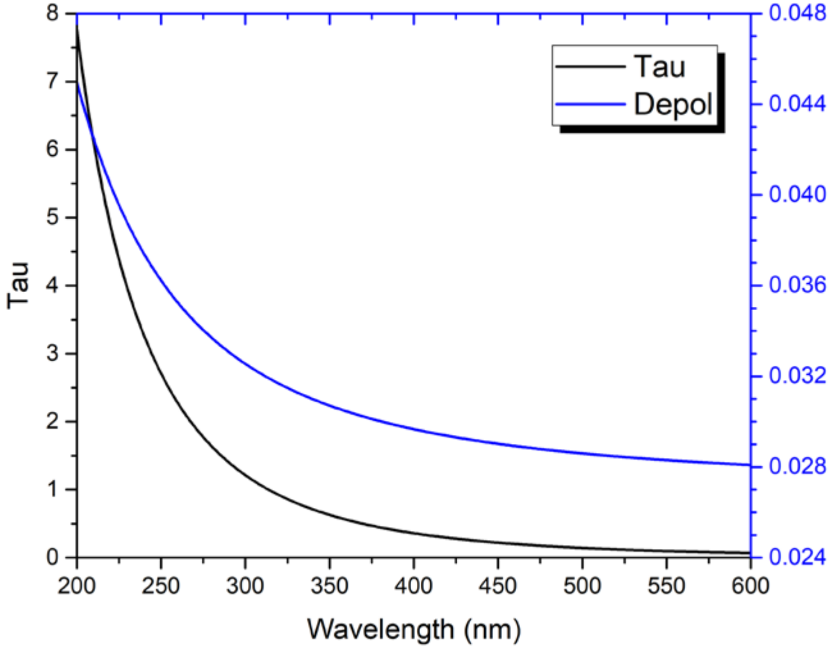
Apparent reflectance at satellite level

$$\rho_{SFC}(\theta_S,\theta_V,\varphi) = \frac{\rho_{TOA}(\theta_S,\theta_V,\varphi)-\rho_{ATM}(\theta_S,\theta_V,\varphi)}{T_{ATM}(\theta_S,\theta_V)+\left(\rho_{TOA}(\theta_S,\theta_V,\varphi)-\rho_{ATM}(\theta_S,\theta_V,\varphi)\right)S}$$

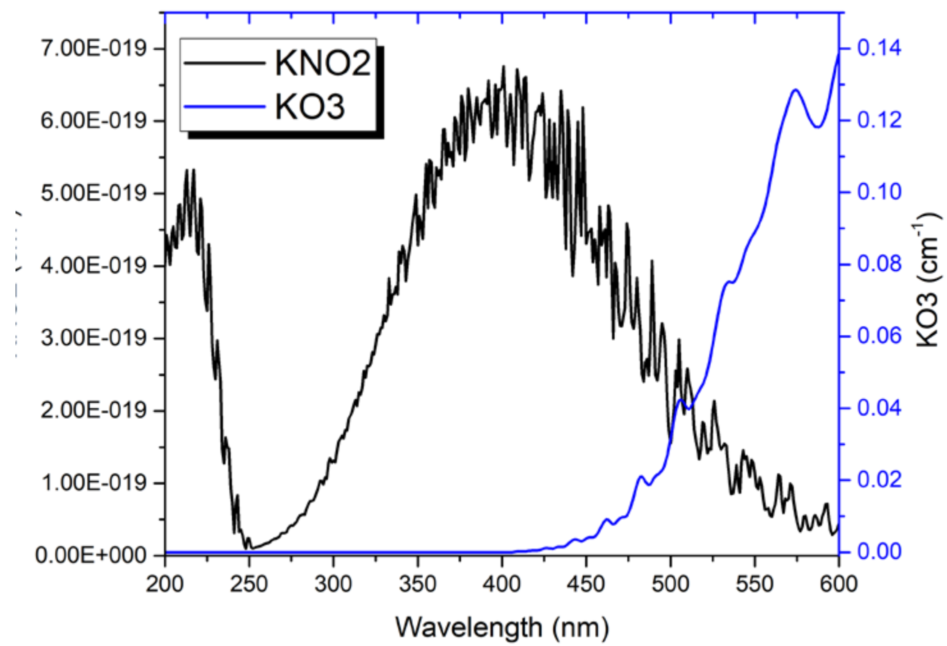
Scattering ↑	↓ $\rho_{SFC}(\theta_S,\theta_V,\varphi)$
Absorption ↑	↑ $\rho_{SFC}(\theta_S,\theta_V,\varphi)$

Atmospheric Transmittance

Rayleigh scattering



Absorption cross section



Total Atmospheric Transmissions = absorbing gases(NO2, O3, H2O)

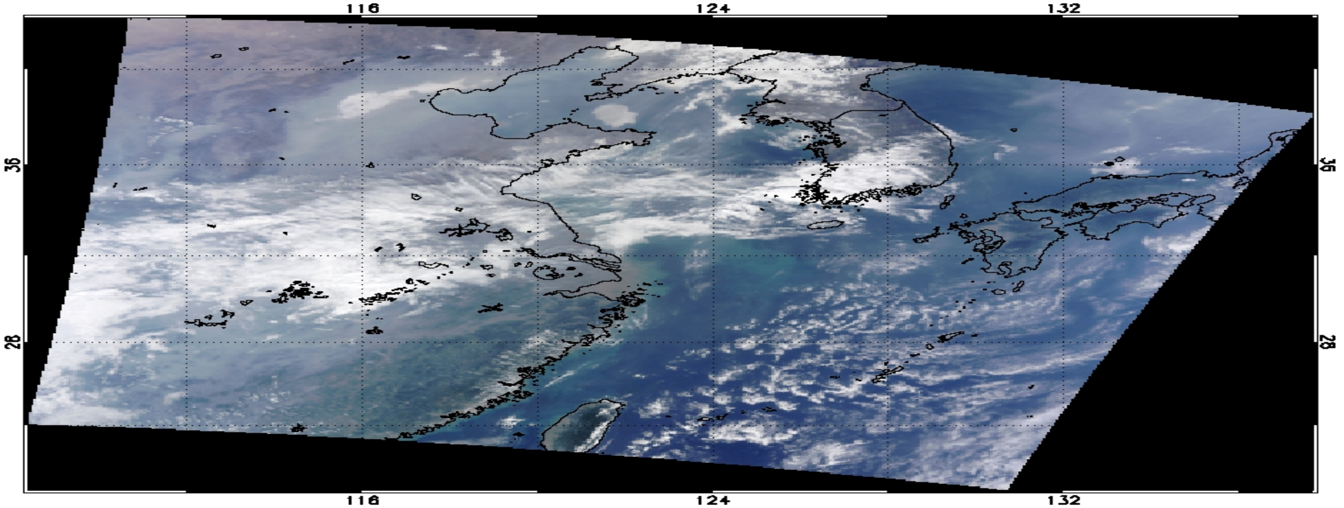
$$T_{ATM}(\theta_S, \theta_V) = \prod T_{Gas}(\theta_S, \theta_V)$$

$$= T_{NO2}(\theta_S) \cdot T_{NO2}\ (\theta_V) \cdot T_{O3}(\theta_S) \cdot T_{O3}(\theta_V) \cdot T_{H2O}(\theta_S) \cdot T_{H2O}(\theta_V)$$

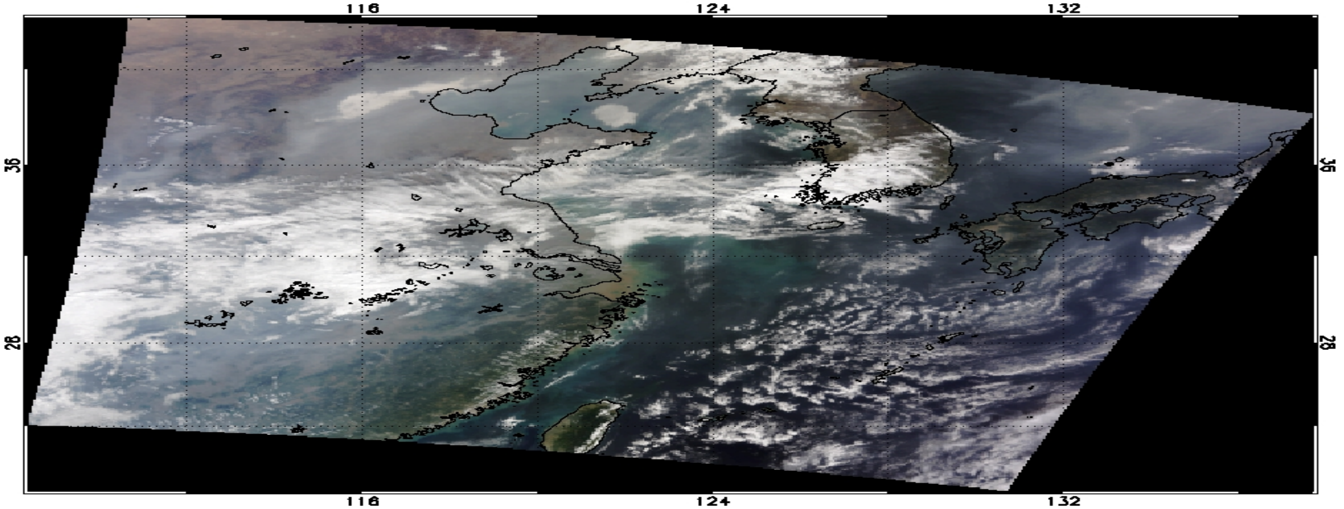
Atmospheric Correction

MODIS RGB [10/29/2009]

Before



After



Selected Retrieval Wavelengths

- **GEMS Aerosol - 354,388,412,443,477,490nm**
- **Cloud - 477nm**
- **HCHO - 340nm**
- **CHOCHO - 448nm**
- **SO2 - 317nm**
- **NO2 - 440nm**
- **R: 474-494 nm, G: 410-430 nm, B: 350-370 nm**

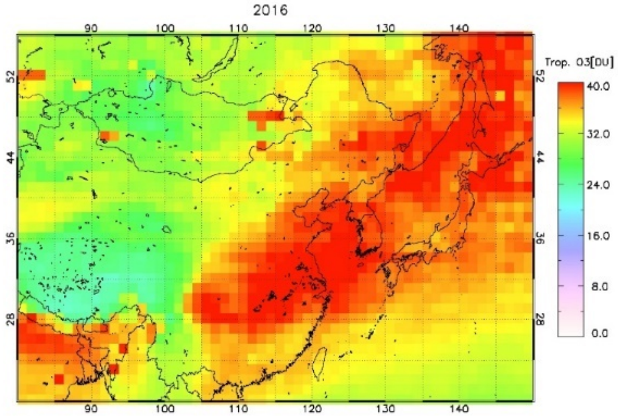
[requested by GEMS ST]

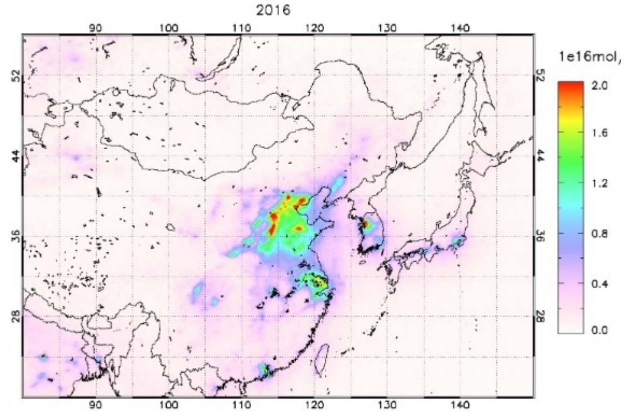
OMI based algorithm

- OMI L1b data: 2004~present
- Ancillary data: OMI L3 NO2, O3, NCEP PWV

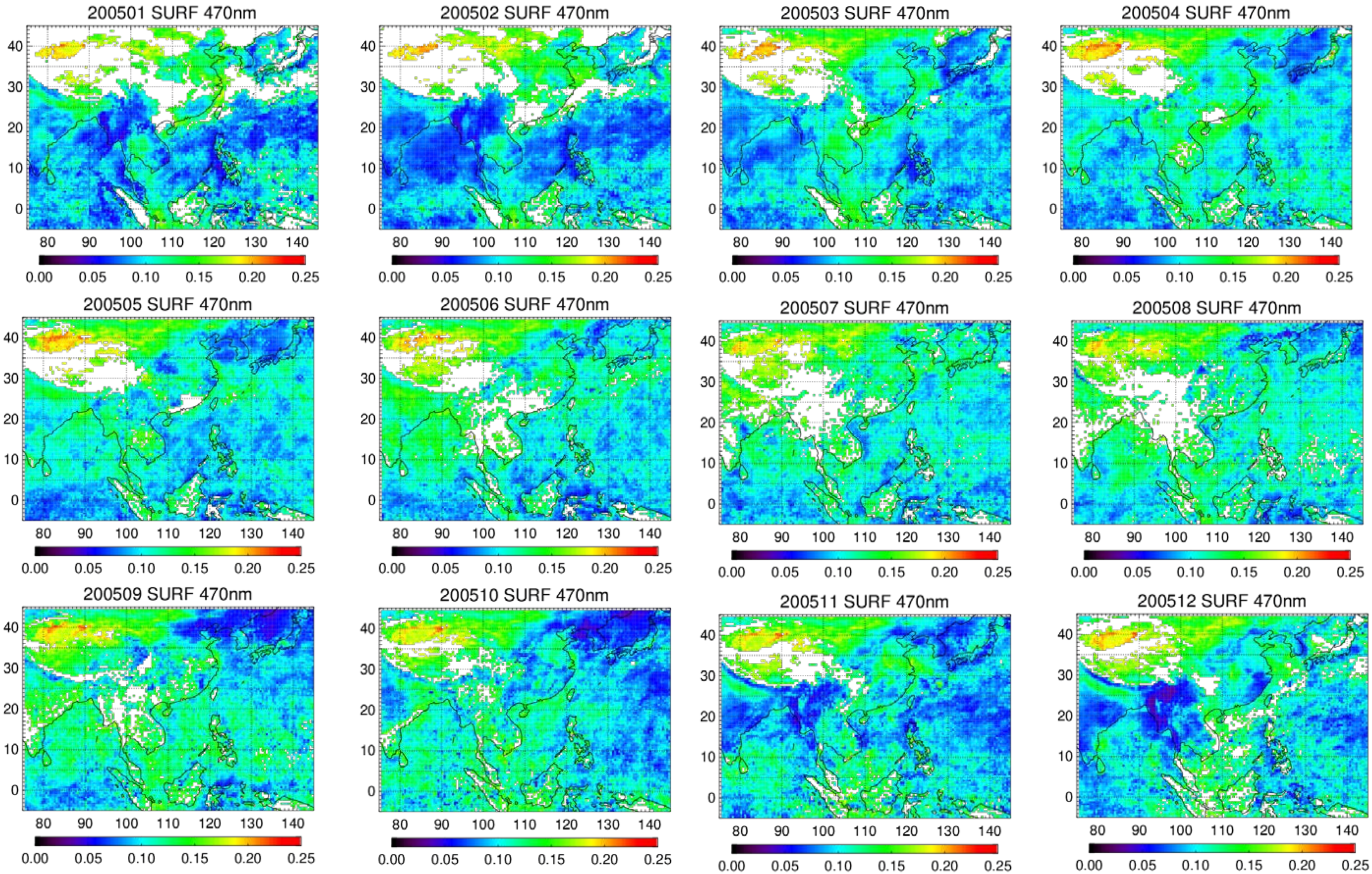
  Rayleigh scattering LUT
- Additional input data: MOD43 BRDF (for geometry corrected reflectance)
- Output: Daily LER (OMI only)

  Daily Geo-SRP (OMI+MODIS)

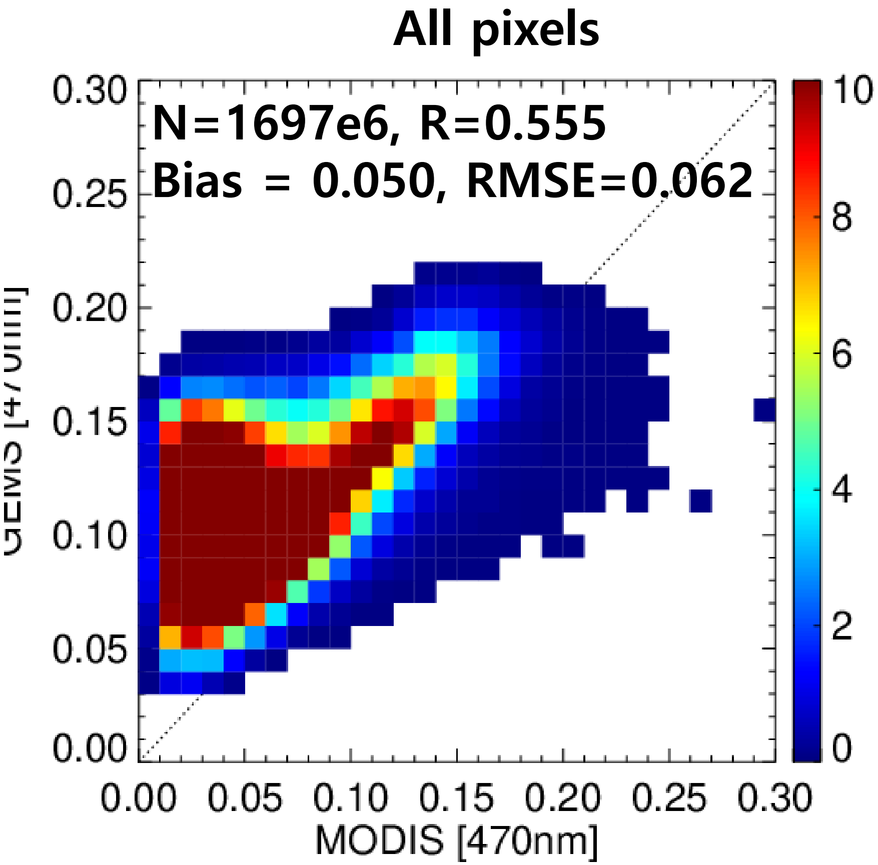


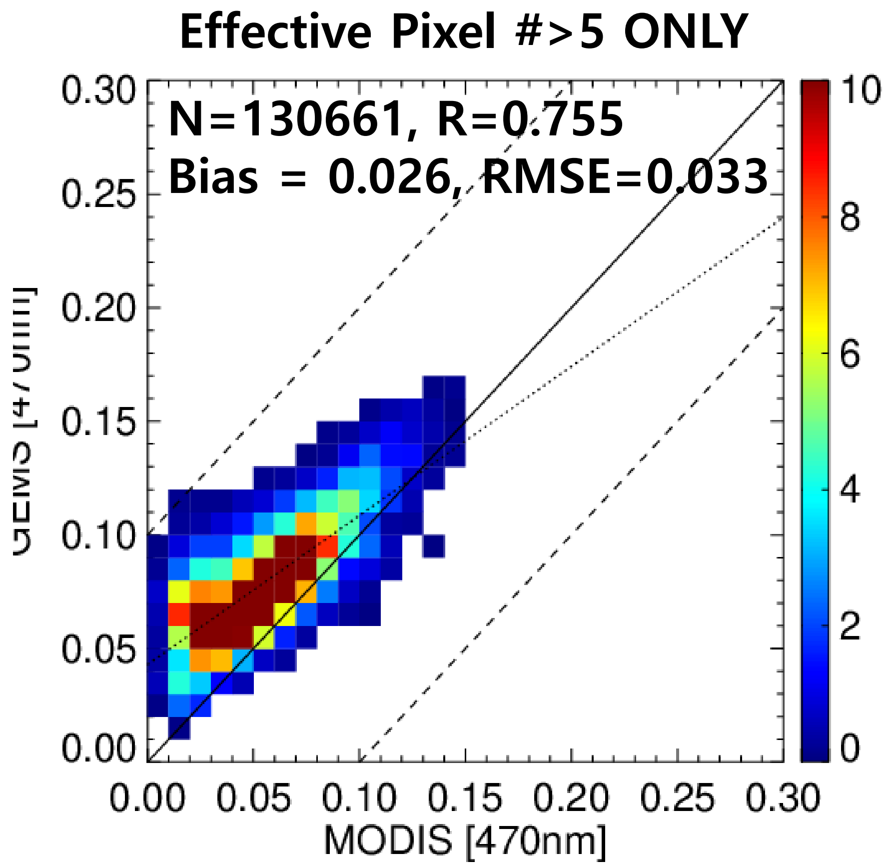


OMI Monthly SRP @ 470nm



GEMS(by OMI) vs MODIS





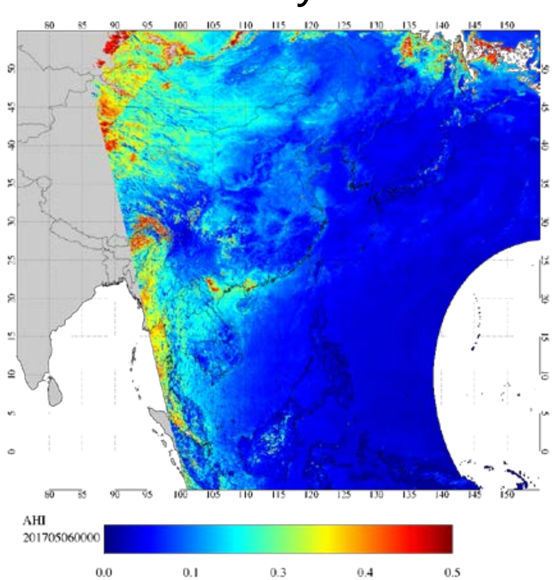
Bias in lower reflectance ?
- MODIS error,
- Cloud
- Overestimation of atmospheric transmission

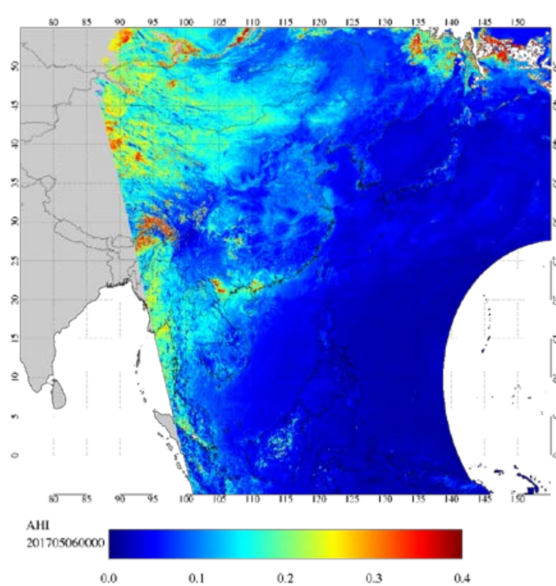
Himawari based algorithm

- **AHI L1b data: 2015~Present**
- **Ancillary data: OMI L3 NO2, O3, NCEP PWV**

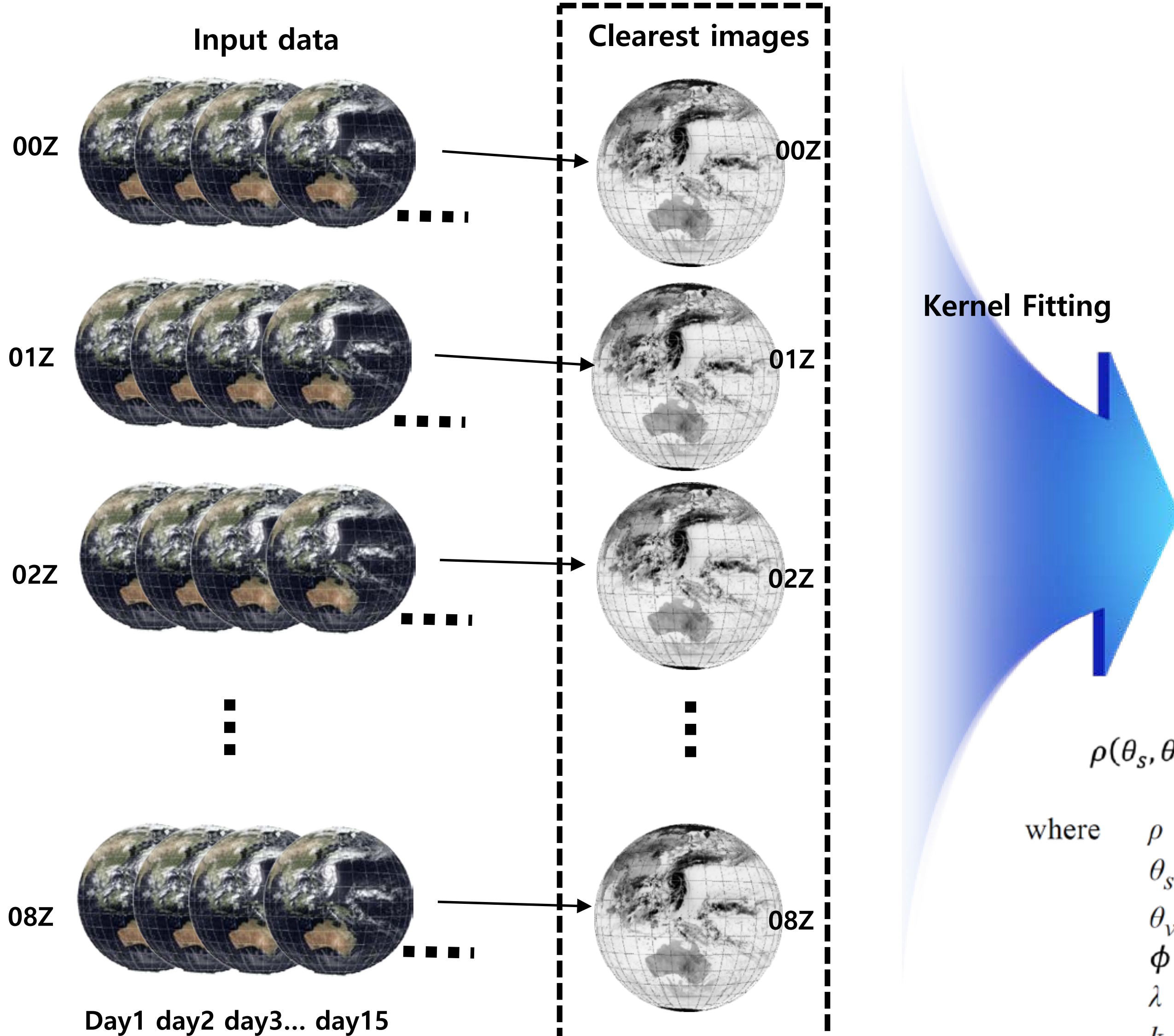
  Rayleigh scattering LUT
- **Output: Hourly LER, Daily BRDF**

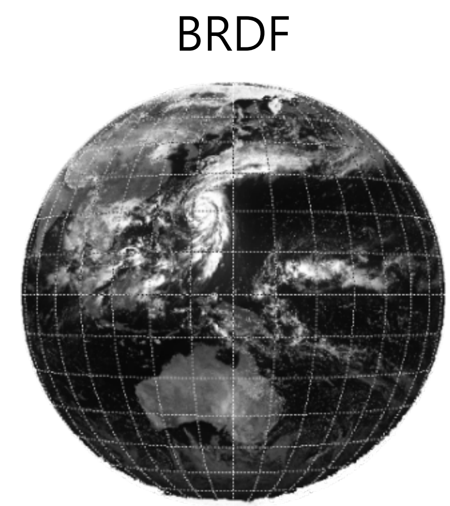
Timely LER





BRDF estimation



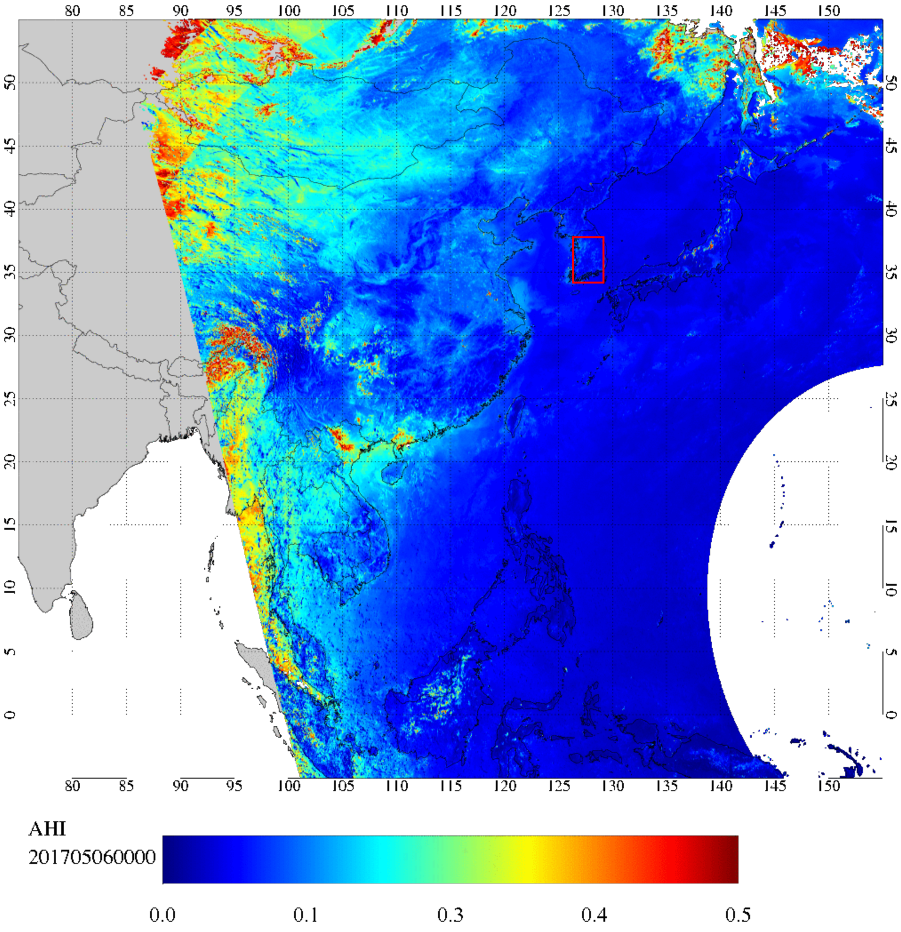


$$\rho(\theta_s, \theta_v, \phi, \lambda) = f_{iso} + f_{vol}k_{vol} + f_{geo}k_{geo}$$

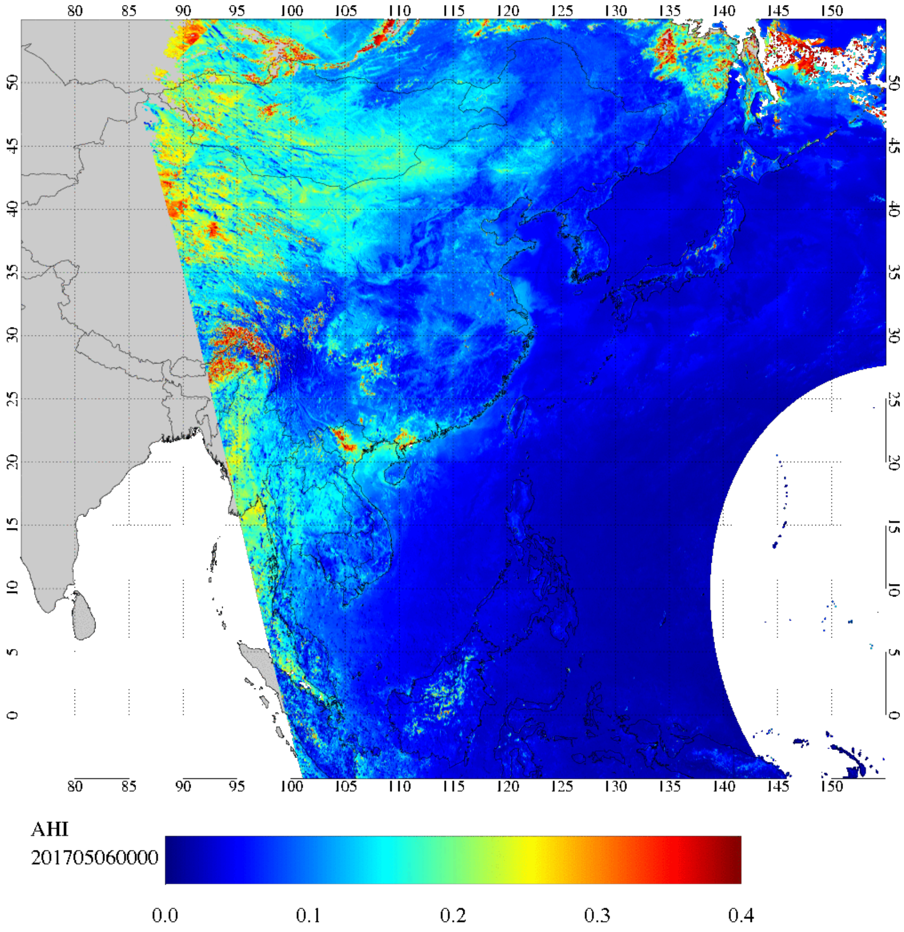
where
- ρ = spectral reflectance
- θ_s = solar zenith angle
- θ_v = view zenith angle
- ϕ = relative azimuth angle
- λ = spectral wavelength
- k_{vol}, k_{geo} = volume and geometric kernel
- $f_{iso}, f_{vol}, f_{geo}$ = kernel model parameters

Proxy data: Himawari-8/AHI 0.47um

- **Min reflectance (2017/05/06 00Z-09Z)**



AHI Band 1(470nm)



AHI Band 2(510nm)

BRDF Kernel Parameters

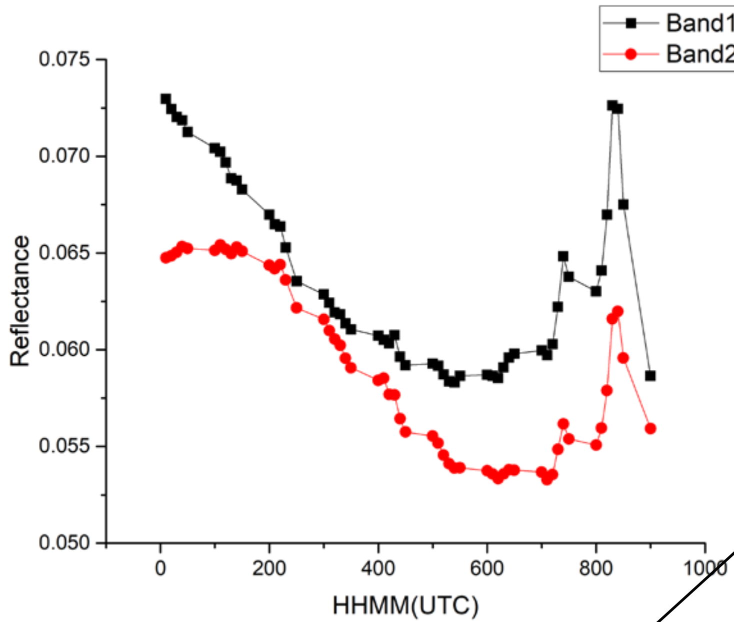
- **Used a Kernel-driven BRDF model [Lucht et al., 2000; Roujean et al., 1992; etc]**

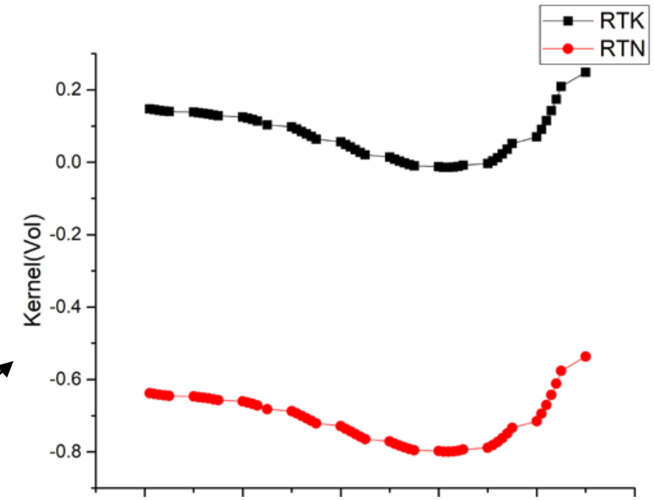
$$R_{TOA}(\theta_0, \theta_v, \varphi, \lambda) = Fiso + FvolKvol + FgeoKgeo$$

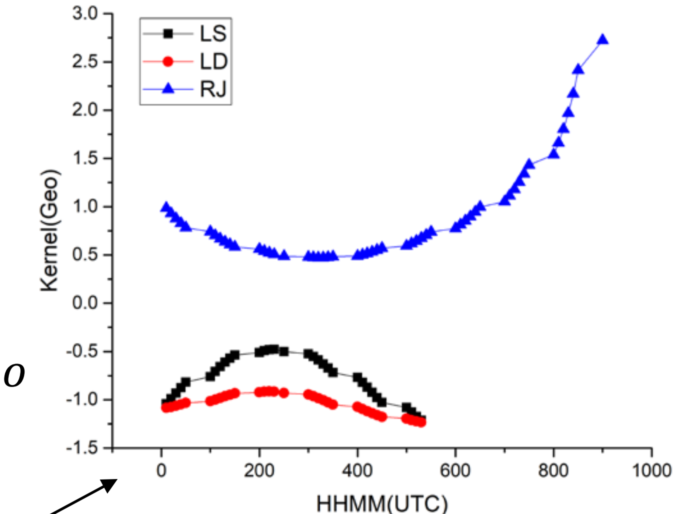
- **Volume and geometrical kernels (Kvol & Kgeo) can be derived by widely used geometrical formulas [Pokrovsky et al., 2000; Tang et al., 1999].**

- **Best combination between two Kernels by Ross-Thick [RTK], Ross-Thin[RTN], Li-Sparse [LS], Li-Dense [LD], Roujean [RJ] kernels has been estimated.**

Temporal Variations in Reflectances







Volumetric

$$R_{TOA}(\theta_0, \theta_v, \varphi, \lambda) = Fiso + FvolKvol + FgeoKgeo$$

Does not changeable

Geometric

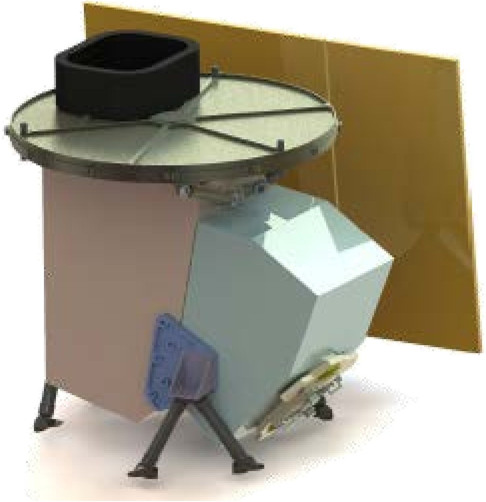
Kernel Combinations

Vol. Kernels	Geo. Kernels	R(@Band1)
RTK	LS	0.828
RTK	LD	0.898
RTK	RJ	0.844
RTN	LS	0.736
RTN	LD	0.712
RTN	RJ	0.864

Best results can be selected by the user.

Summary

- GEMS has advantages of both spectral and temporal resolution data that can be used to derive the directional land surface with high temporal frequency.
- The geostationary observation at the various sun-sensor geometry enable to derive both atmospherically corrected reflectance and a kernel-driven bidirectional reflectance distribution function (BRDF).
- Using the proxy data (i.e. OMI, Himawari-8/AHI), the effects of directional surface reflection on the remote sensing and significant parameters in radiative transfer process has been estimated.
- Estimated errors due to the use of the different kernel models and atmospheric transmissions are substantial. Large differences in BRDF were found in use of different kernel functions.



Thank You !