2025 Cloud and Environment

Week 3: Introduction of True Color image & RGB composite product

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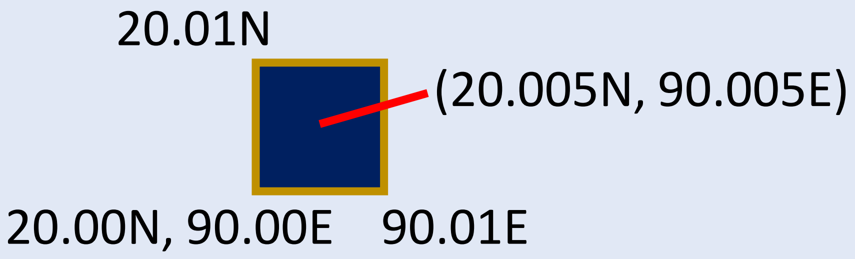
Recap

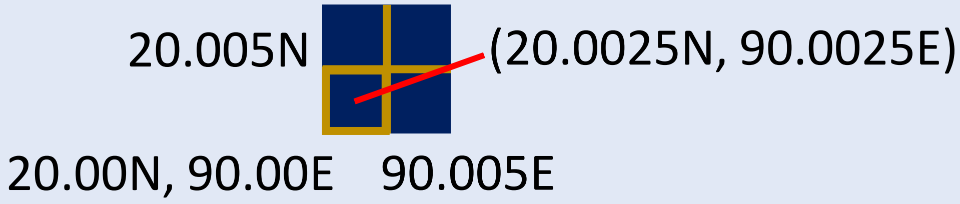
1. Set download time period – method 2
   - Time period and time delta
2. himawari.check_exist_sub_domain_file()
3. himawari.read_binary():
   - Given binary type (geoss, bin, dat) & band type (ext, vis…), file naming rule can be ignored
4. **himawari.pre_process(ftp_path_file_list,remove_list_flag=True)**
   - Combine check_exist_sub_domain_file() to generate_nc()

5. grid and resolution

Resolution: 1km

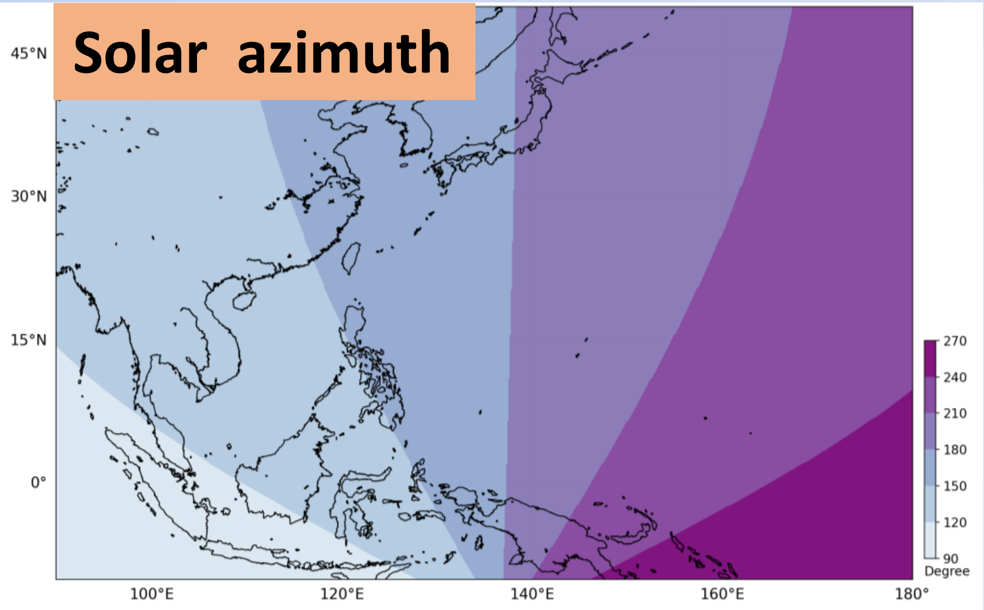


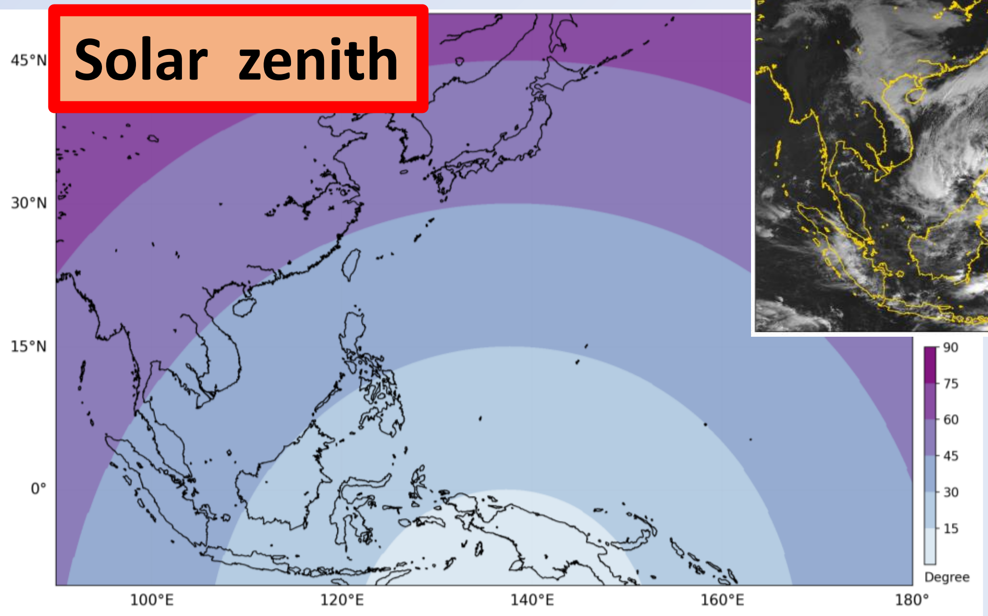
Resolution: 0.5km

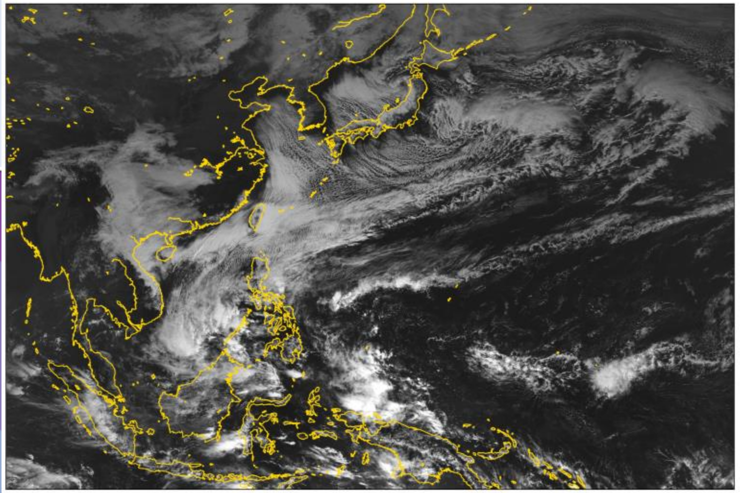


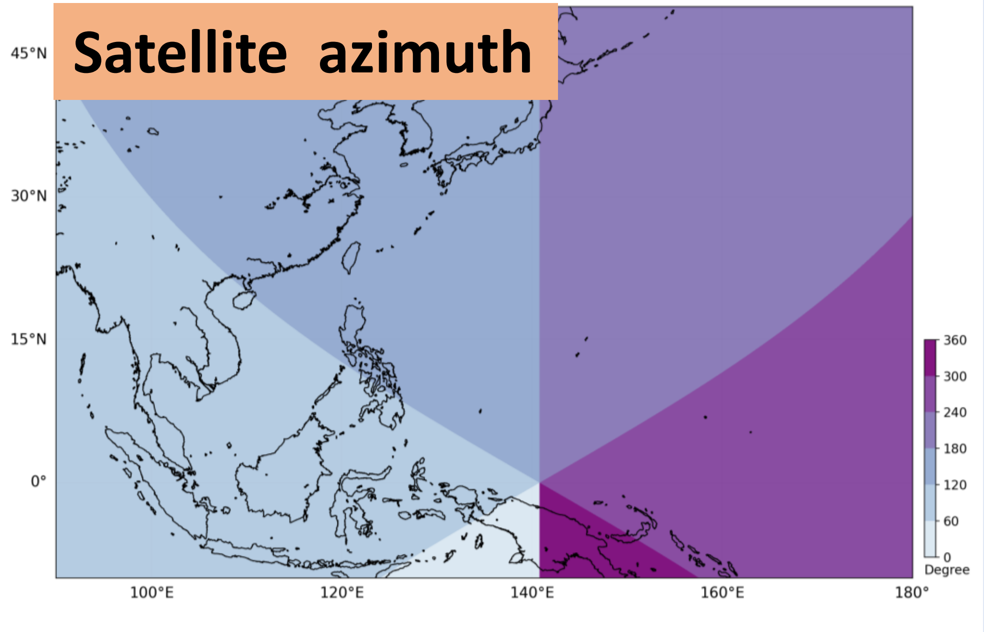
6. geometries data
   - Solar azimuth & zenith angle
   - Satellite azimuth & zenith angle

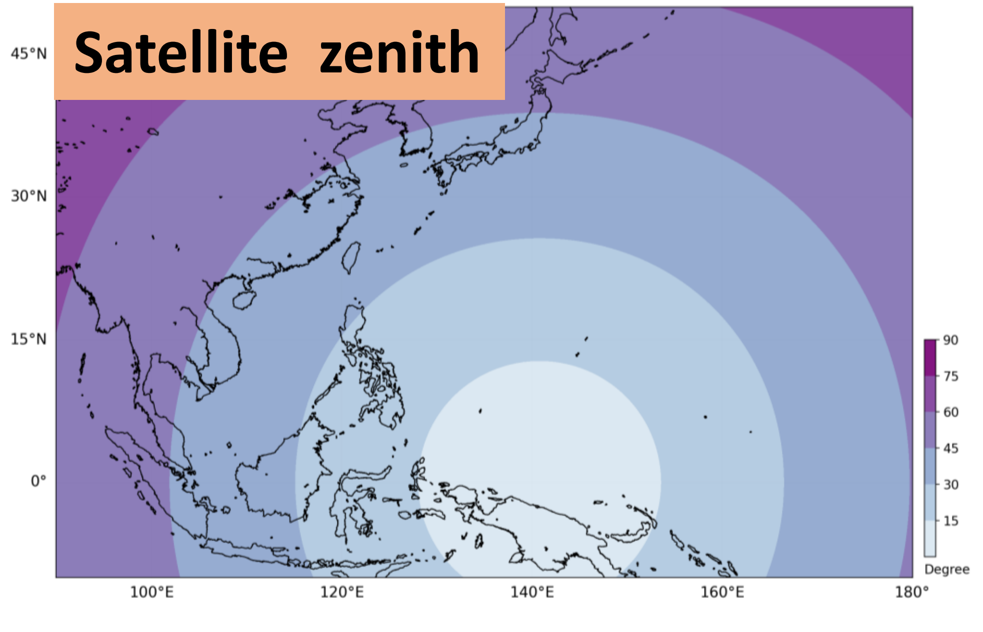
Himawari geometries data









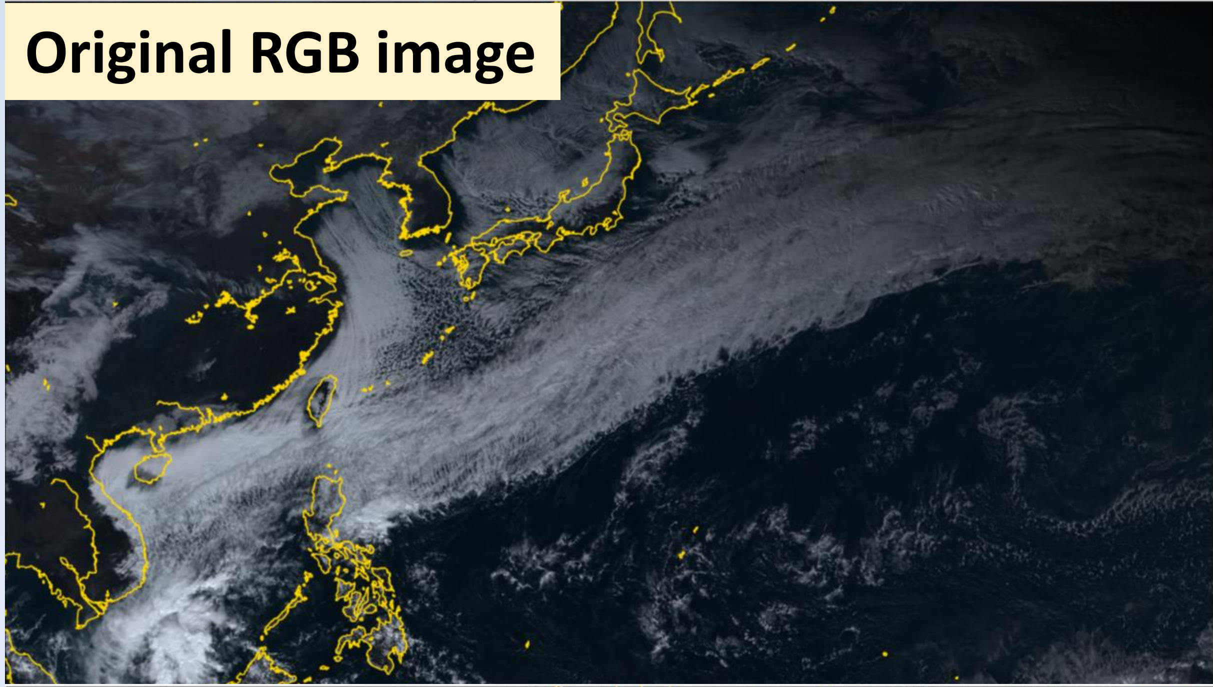


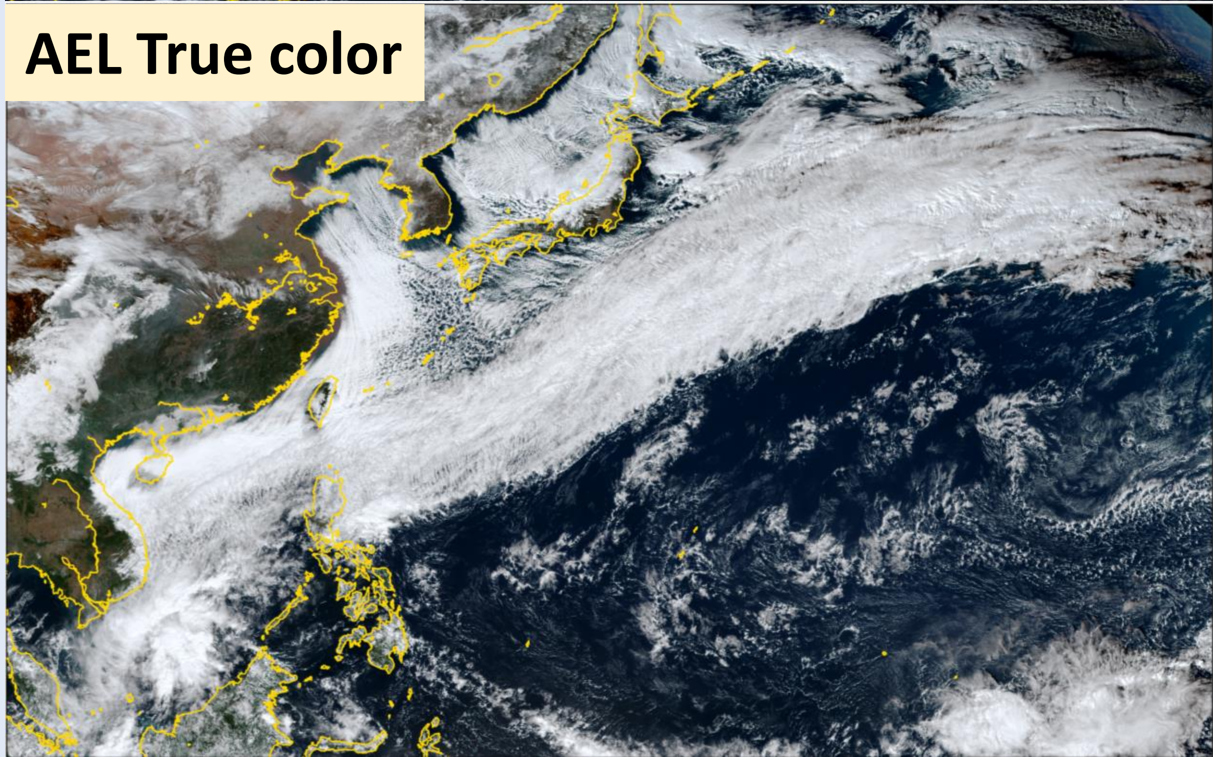
True color (reproduction) image

- Color shading similar to the visual perception of the naked eye
- Sensitive for aerosols: smoke, dust, and volcanic ash
- Daytime only
- Lower suitability for detailed cloud analysis

Image production process:

1. **Fit resolution** ~~(resolution sharpening)~~
2. **Local adjustment:** balance brightness differences due to sun zenith angles
3. **Rayleigh scatter correction:** remove the bluish haze ~~(Pathlength correction)~~
4. **Hybrid green:** combine band02 and band04 as hybrid green
5. **Image enhancement:** brightening the dark area of the image





AEL satellite module – Himawari plotting part – True color

In this section, you will learn…

- How to process original data for **true color image** production
- Plotting true color image & output data as easy-accessing format

Work flow:

1. **Read essential data files & fit resolution**
2. **Local adjustment**
3. **Rayleigh scatter correction**
4. **Hybrid green**
5. **Image enhancement**
6. **Plot figure & output .nc file**

- Data for **true color image** production:
  - **AHI_band = [1,2,3,4] (CEReS band name: EXT01, VIS01~03)**
  - **geo = ['sun.azm', 'sun.zth','sat.azm', 'sat.zth']**

AEL satellite module – Himawari plotting part – True color

- **pip install --upgrade ael_satellite_tools**
- from ael_satellite_tools.plotting import Himawari
- data_path = '/data/cloud2025/[Your_path]/[himawari_data_folder]'
- **lat = [12, 32]**
- **lon = [110, 130]**
- hima_plot = Himawari(data_path=data_path, **plotting_lat_range=lat,plotting_lon_range=lon**)
- True color data example: /data/C.jerryjerry9/hima_download/himawari_data
  - 2023/12/22 04:00UTC; 2025/02/08 03:00UTC; 2025/02/26 04:00UTC
- **0. Generate data list**
- hima_plot.generate_time_list()
- hima_plot.generate_data_list()
  - According to selected time period and data generate file list for reading data

Course demo (**week3*.py & week3*.ipynb**)

- /data/cloud2025/homework_data/
- https://github.com/jerryjerry9/cldenv_2025

AEL satellite module – Himawari plotting part – True color

1. Read essential data files & fit resolution

- hima_plot.read_nc_file()
  - Input file name list
  - missing2nan: missing value convert to nan
- hima_plot.fit_resolution()
  - Set target resolution from 0.5km to 4km
  - Can provide lon-lat information of target resolution

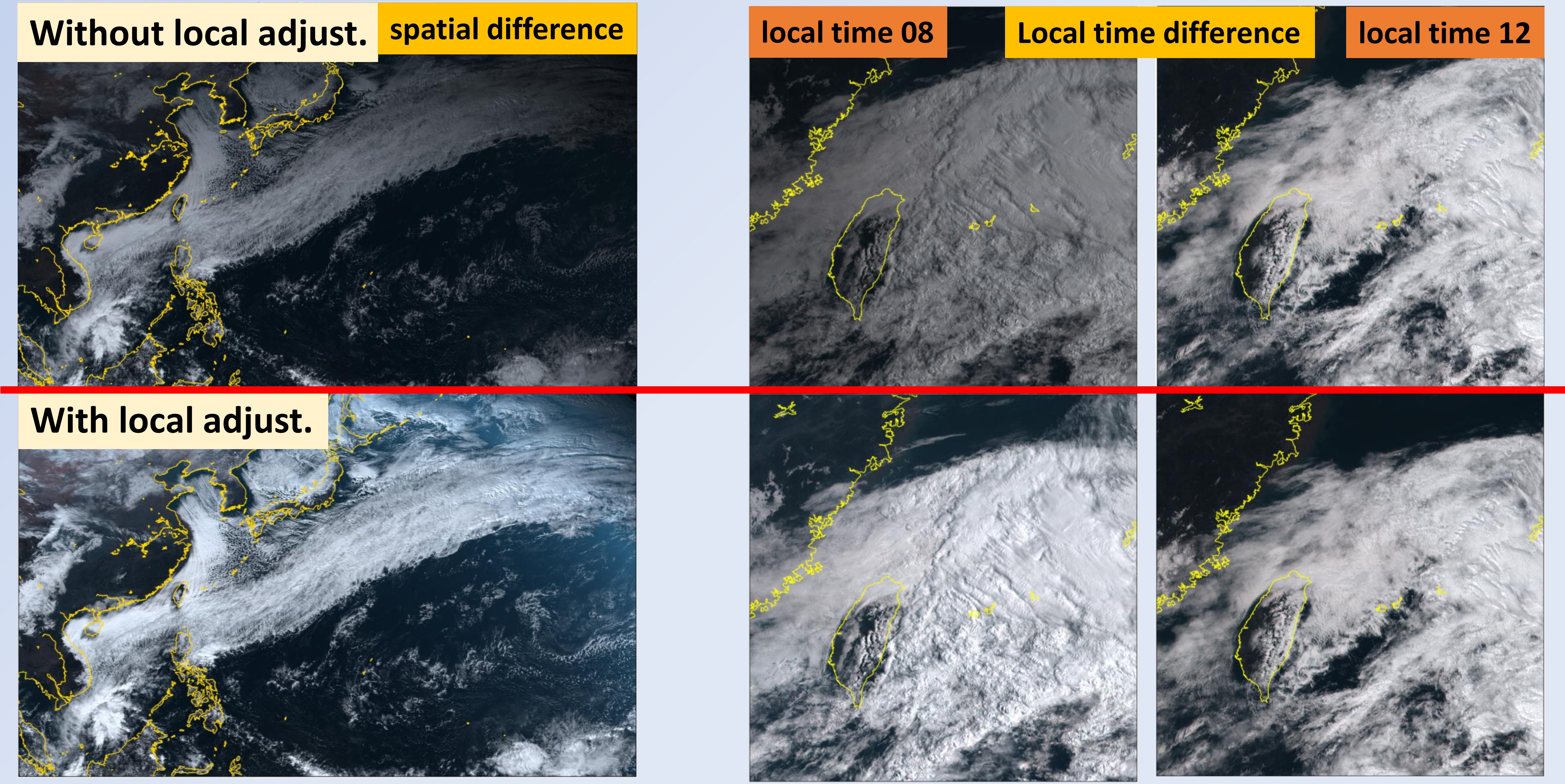
```
202312220400_band_01.nc
202312220400_band_02.nc
202312220400_band_03.nc
202312220400_band_04.nc
202312220400_4km_sun_azm.nc
202312220400_4km_sun_zth.nc
202312220400_4km_sat_azm.nc
202312220400_4km_sat_zth.nc
```

```python
ta_resolution = 2
output_data_list = []
output_file_list = []
for file_name in full_path_file_list:
    nc_data_list,file_lon_list,file_lat_list,read_file_list = \
        hima_plot.read_nc_file(file_name,missing2nan=True)

    fit_data_array_list, plotting_lon, plotting_lat = \
        hima_plot.fit_resolution(nc_data_list,read_file_list,
                                 ta_resolution,fit_lonlat_output=True)
    output_data_list.append(fit_data_array_list[0])
    output_file_list.append(read_file_list[0])
```

```python
band_r = output_data_list[2]
band_g = output_data_list[1]
band_b = output_data_list[0]
band_04 = output_data_list[3]
sun_azm = output_data_list[4]
sun_zth = output_data_list[5]
sat_azm = output_data_list[6]
sat_zth = output_data_list[7]
```

Local adjustment: balance brightness differences due to sun zenith angles



Local adjustment: code & function

2. Local adjustment

- hima_plot.local_adjustment()
  - Input: band data & sun zenith angle
  - Can reduce the adjustment at the high sun zenith angle area (blending)

Calculation example code

```
local_rad = np.radians(sun_zh)
local_adjust = np.cos(local_rad)
band_rr = band_r/local_adjust
```

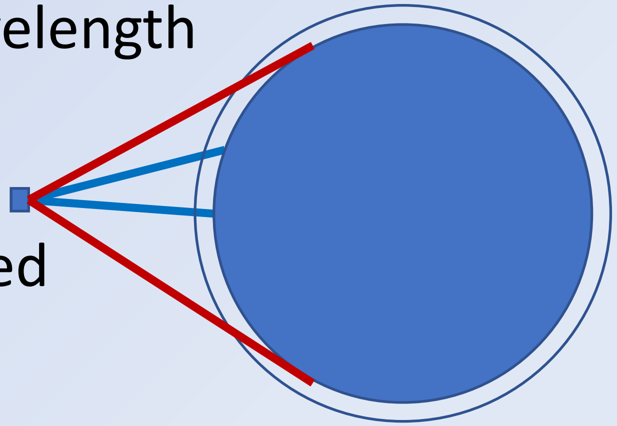
Zenith angle ↑ local adjust. ↑

Function example

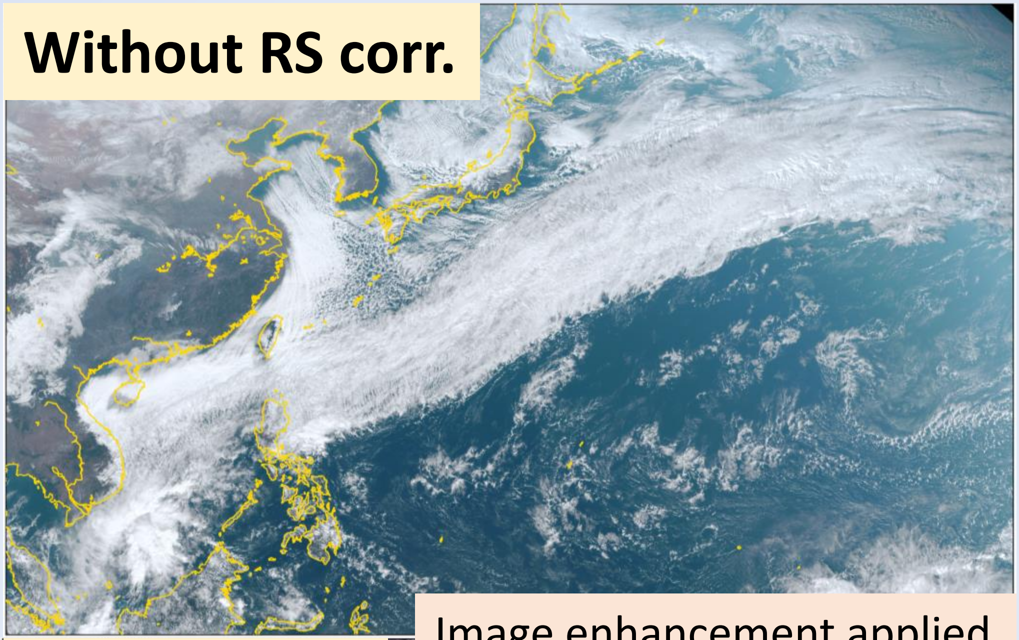
```
angle=78
reduce_adjust = True
band_rr = hima_plot.local_adjustment(band_r,sun_zth,reduce_adjust_angle=angle,
                                     reduce_high_zenith_adjust=reduce_adjust)
```

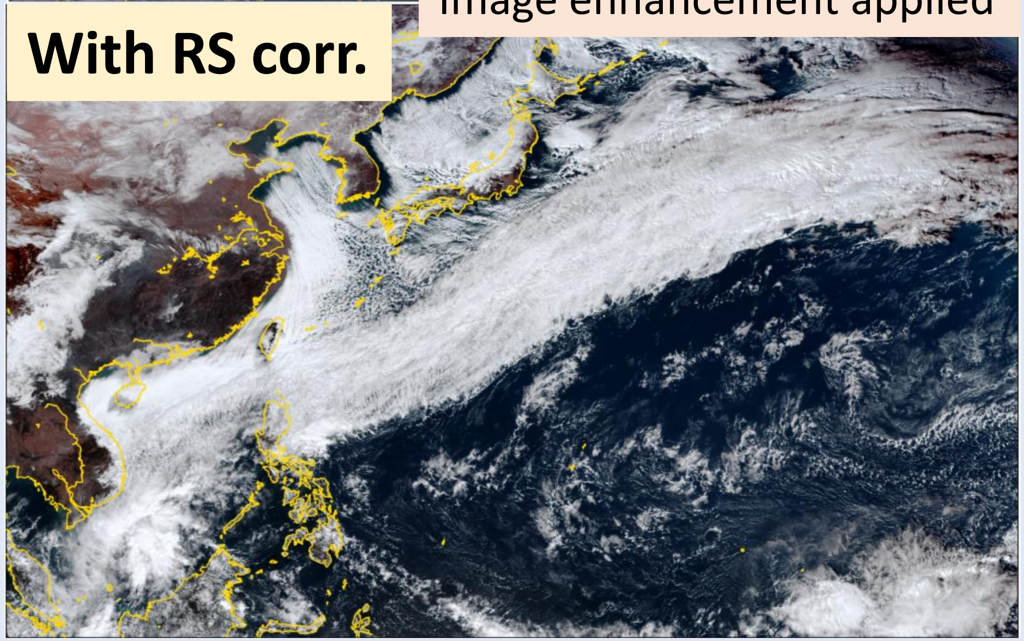
Rayleigh scattering correction: Remove the bluish haze

- Sun zenith angle & Satellite zenith angle
- Relative azimuth angle between sun & satellite
- More sensitive to shorter wavelength



Pathlength correction (not applied in the current module):
reddening at high zenith angles





Rayleigh scattering correction: code & function

3. Rayleigh scatter correction

- hima_plot.rayleigh_correction()
  - Can reduce the correction at the high sun zenith angle area

Calculation example code

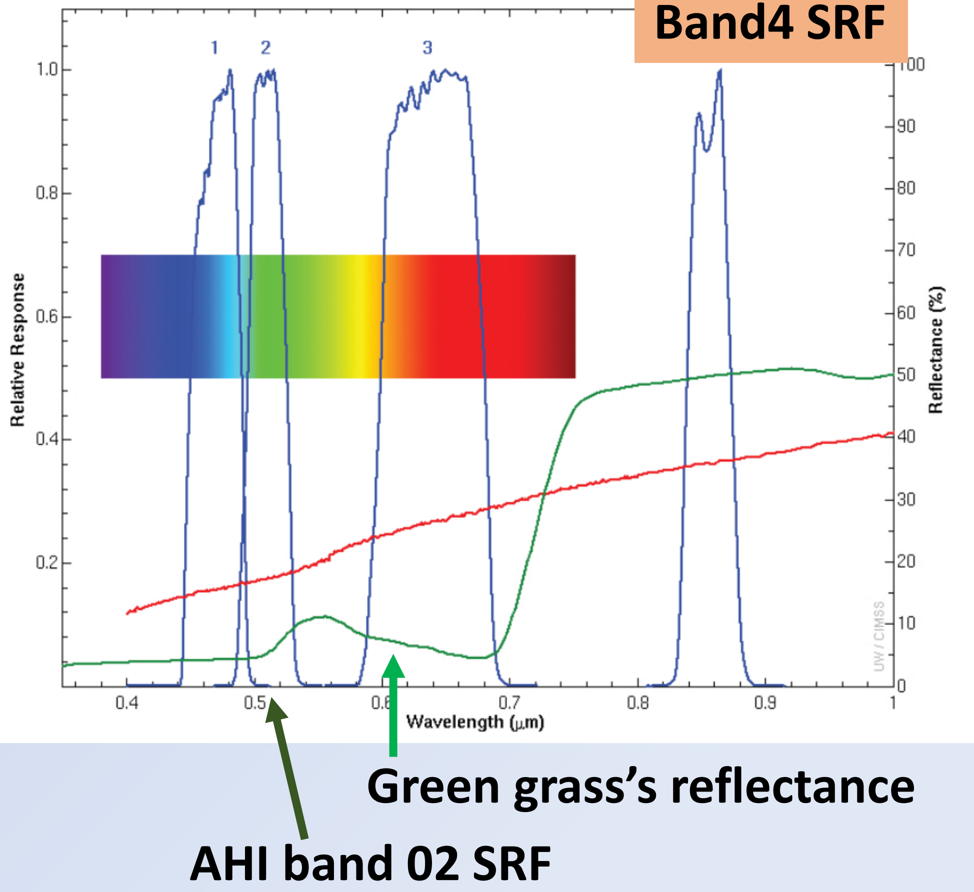
```
from pyspectral.rayleigh import Rayleigh
rs_corr = Rayleigh('Himawari-9', 'ahi')
refl_corr_band_b = hima.get_reflectance(sun_zth, sat_zth, sun_azm-sat_azm, 'ch1', band_rr)
refl_corr_band_b_reduce = hima.reduce_rayleigh_highzenith(sun_zth, refl_corr_band_b,
                                                          reduce_corr_angle,
                                                          max_zenith, strength)
cor_band_b = band_bb - refl_corr_band_b_reduce
```

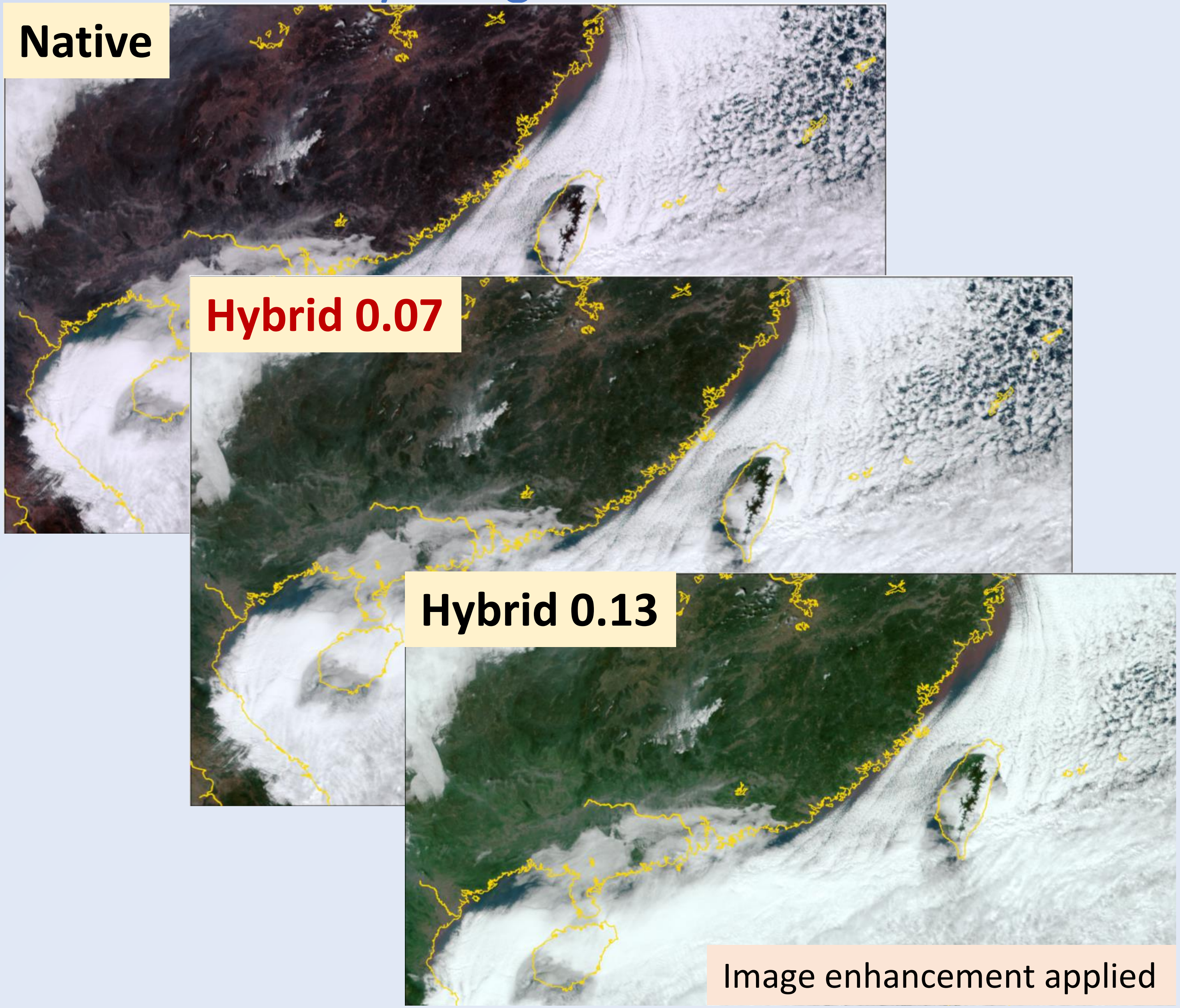
Function example

```
rs_channel = ['ch1']
reduce_corr_angle = 78
strength = 1
reduce_corr = True
corr_band_b = hima_plot.rayleigh_correction(time_list, sun_azm, sun_zth, sat_azm, sat_zth, band_bb,
                                            rs_channel[0], red_band=band_rr,
                                            reduce_corr_angle=reduce_corr_angle, strength=strength,
                                            reduce_rayleigh_corr = reduce_corr)
```

Hybrid green: combine band02 & band04 as hybrid green

FIG. 1. Response functions for the first four AHI bands, shown along with the visible rainbow for reference and green grass vegetation and red-brown sandy loam surface reflectance from the ASTER spectral database.





Hybrid green: code & function

4. Hybrid green

- hima_plot.hybrid_band()
  - Input: band data 1, band data 2, and data 2 ratio
  - Can define your own hybrid ratio

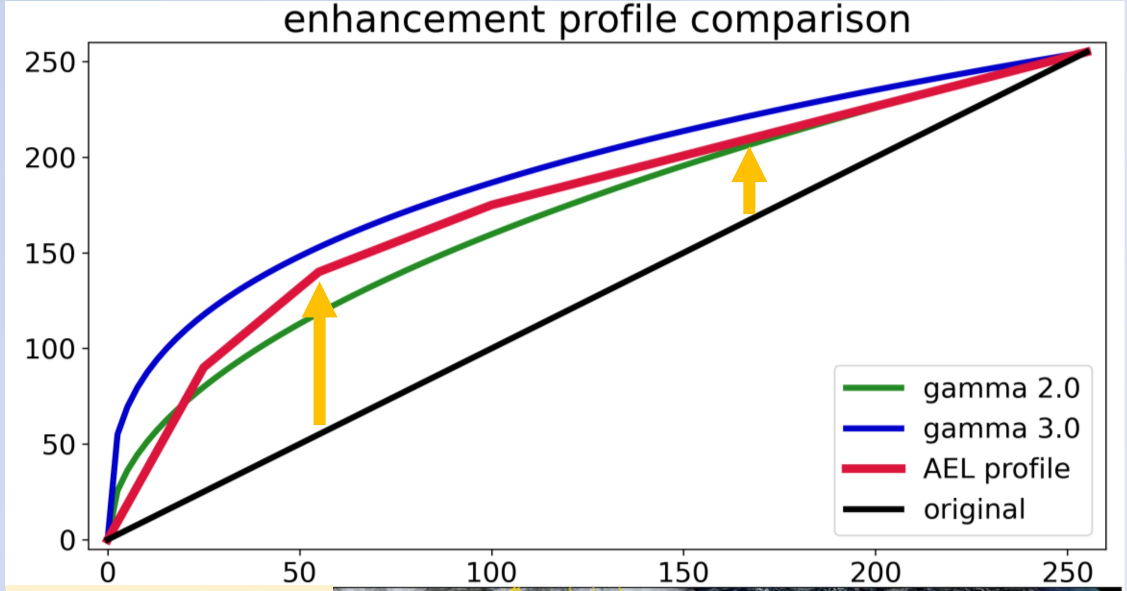
Calculation example code

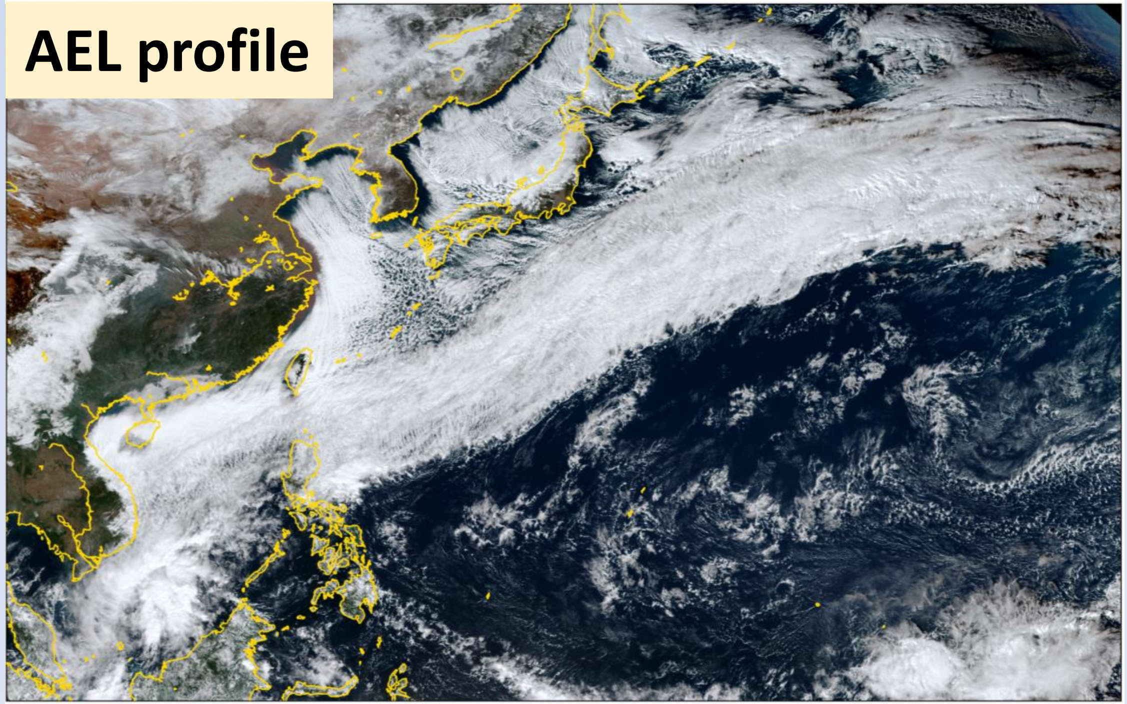
```
hybrid_green = 0.93*(corr_band_g) + 0.07*(band_04)
```

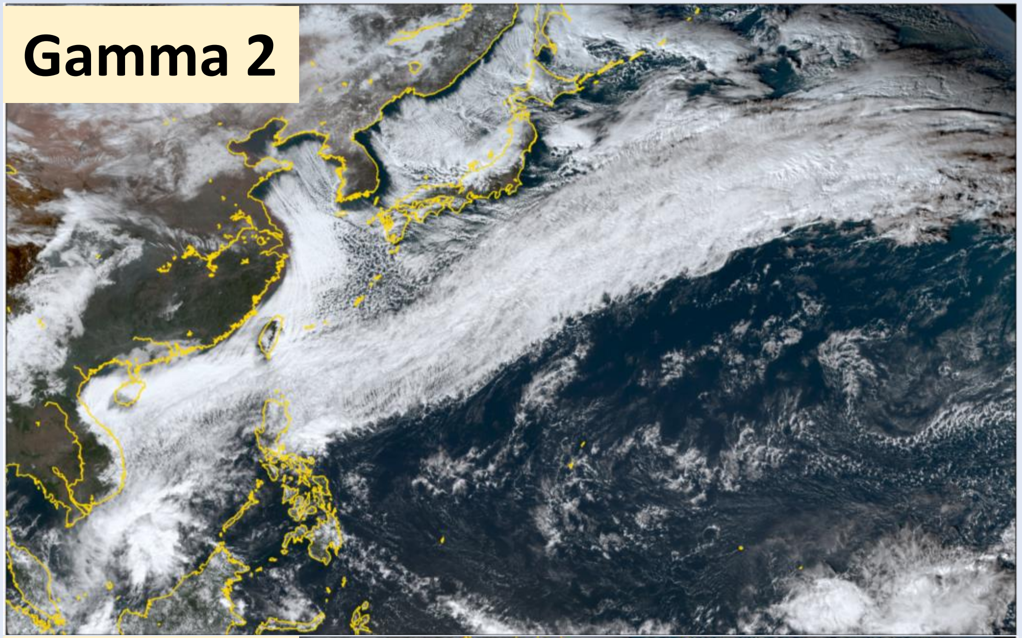
Function example

```
hybrid_green = hima_plot.hybrid_band(corr_band_g, band_04, data_2_ratio=0.07)
```

Image enhancement: Brightening the dark area of the image







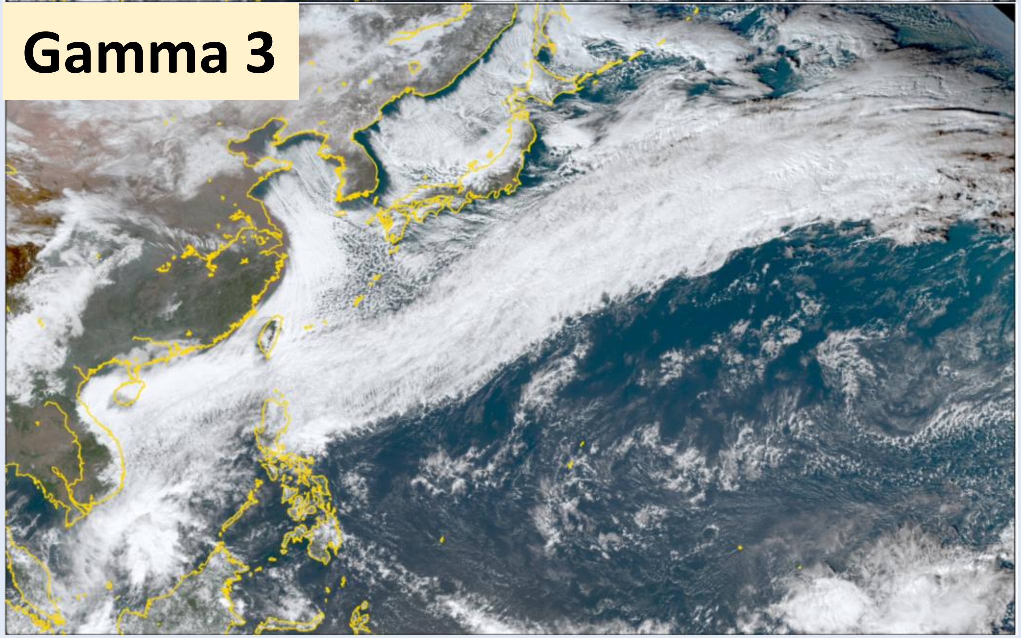


Image enhancement: Code & function

5. Image enhancement

- hima_plot.rescale_value()
  - Rescale the data value to the range of 0 ~ 1 depending on scale range

Calculation example code

```
corr_band_r[corr_band_r < 0] = 0
corr_band_r[corr_band_r > 100] = 100
rescaled_band_r = corr_band_r/100
```

Function example

```
min_threshold = [0]
max_threshold = [100]
rescaled_band_r = hima_plot.rescale_value(corr_band_r,
                                          min_threshold[0], max_threshold[0], reverse = False)
```

Image enhancement: Code & function

5. Image enhancement

- hima_plot.rgb_enhancement()
  - Either gamma enhancement or self-defined profile can be applied
  - Can design your own enhancement profile

Calculation example code

gamma

```
enh_r = (rescaled_band_r)**(1/gamma)
```

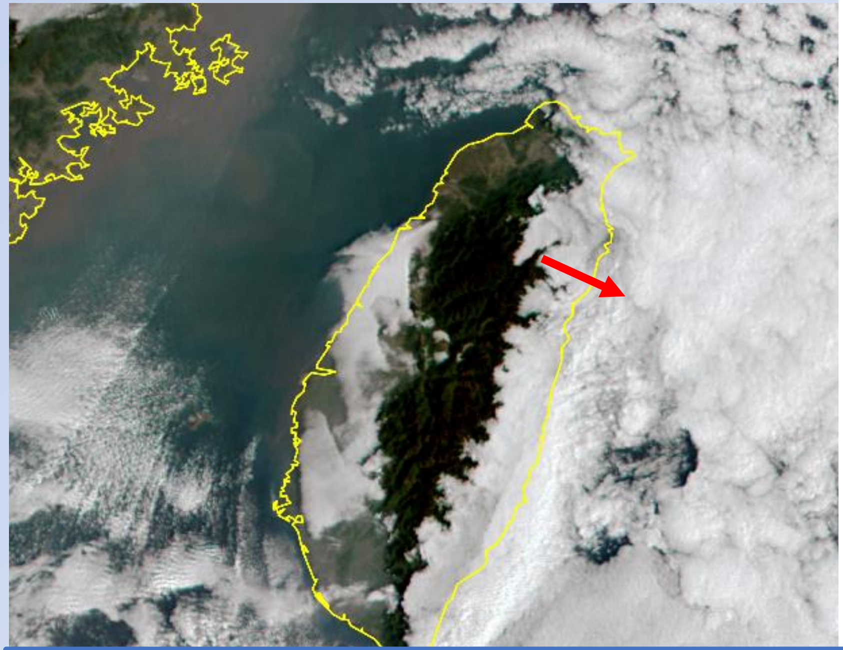
Self-defined profile

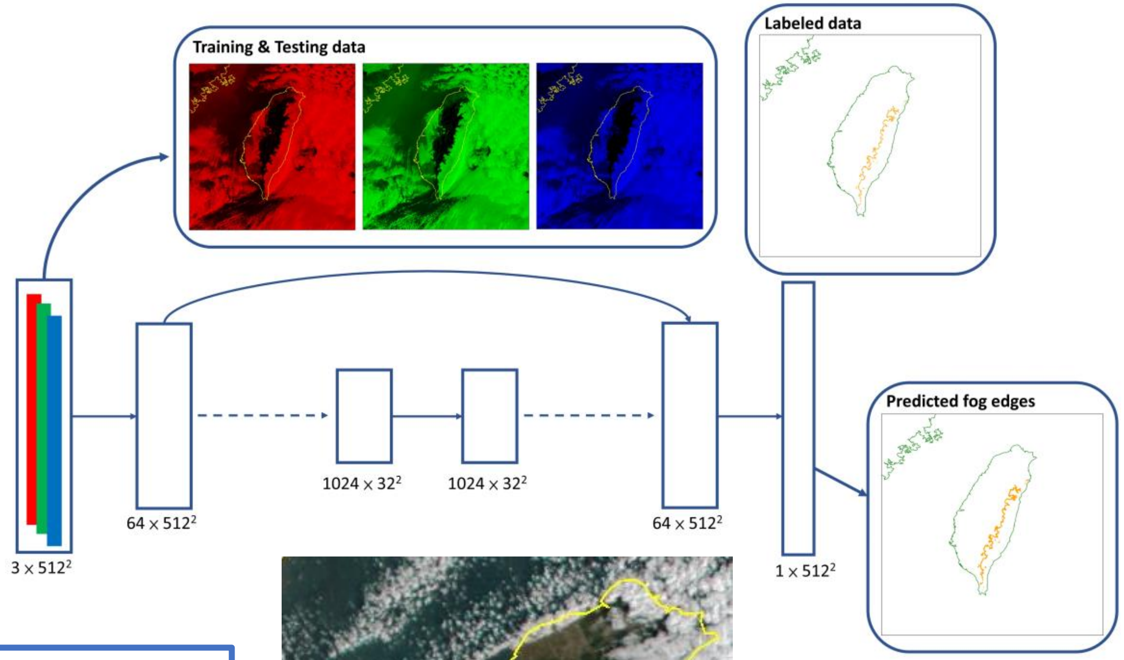
```
rescaled_band_r = rescaled_band_r*255
ori_value = [0, 25,  55, 100, 255]
enh_value = [0, 90, 140, 175, 255]
enh_r = rescaled_band_r/255
```

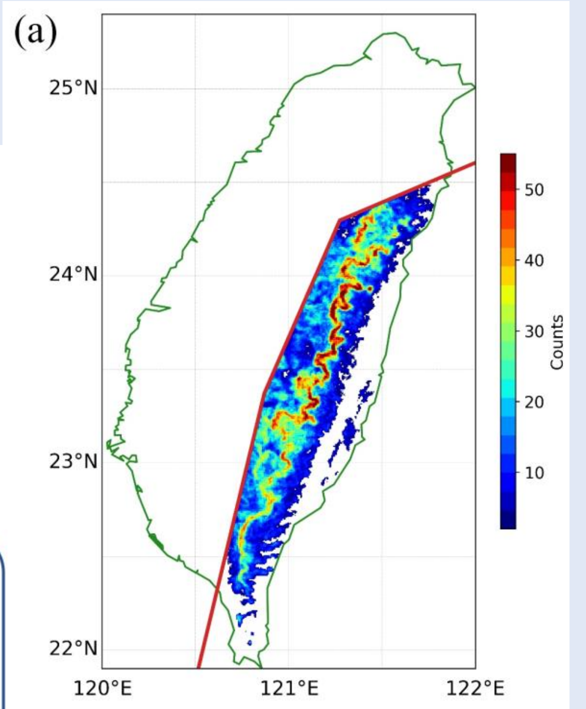
Function example

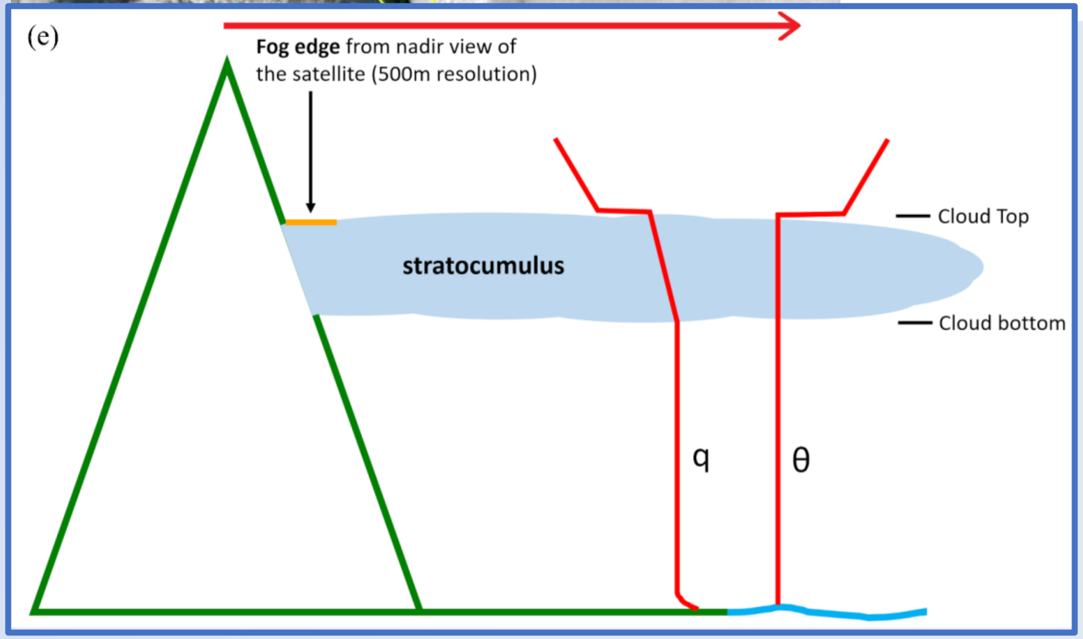
```
gamma = [2]
profile_ID = 0 # 0: AEL profile
self_defined_profile = None
self_prof= [True]
enh_r = hima_plot.rgb_enhancement(rescaled_band_r,gamma=gamma[0],profile_ID=profile_ID,
                                  self_defined_profile=self_defined_profile, self_defined_enhance=self_prof[0])
```

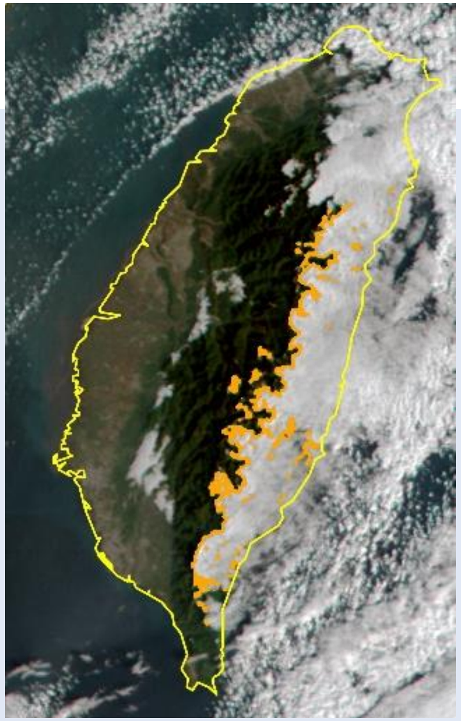
True color image application – Fog detection

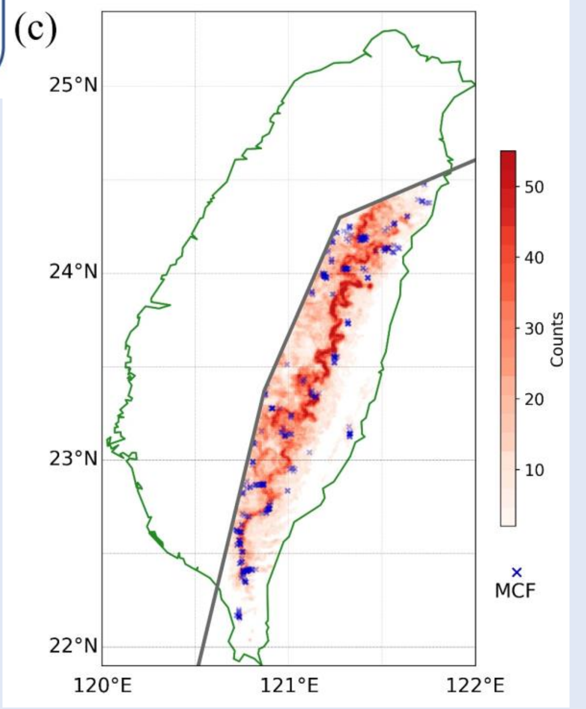








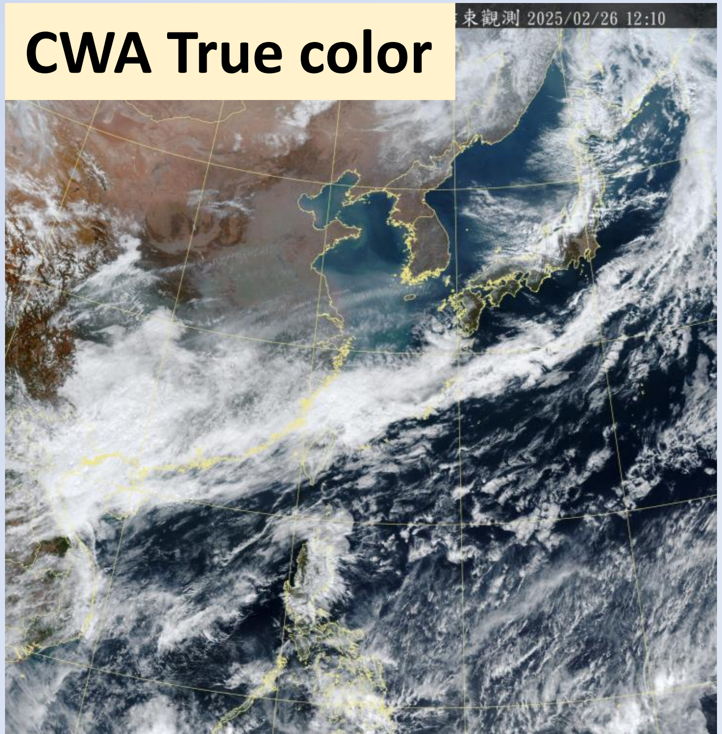


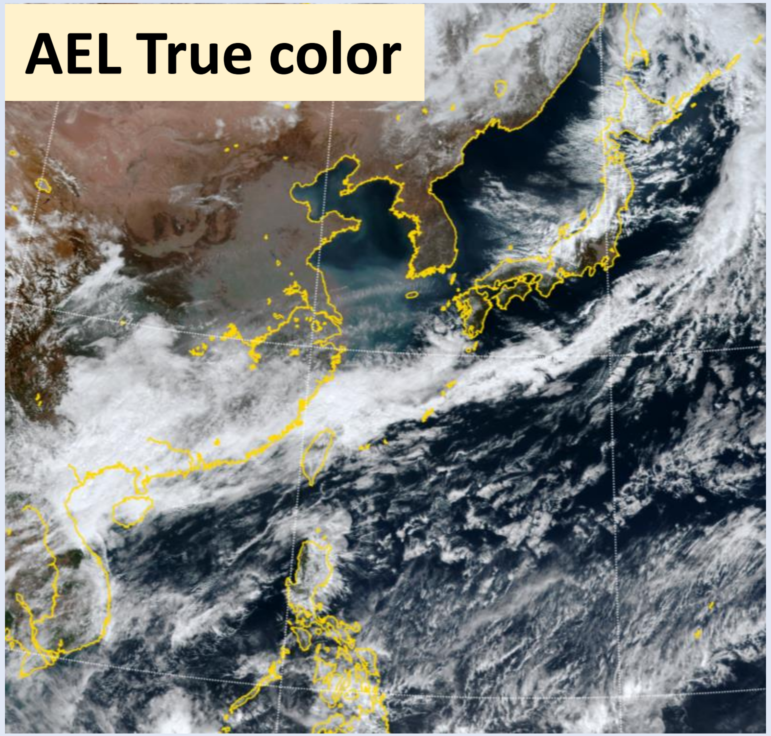


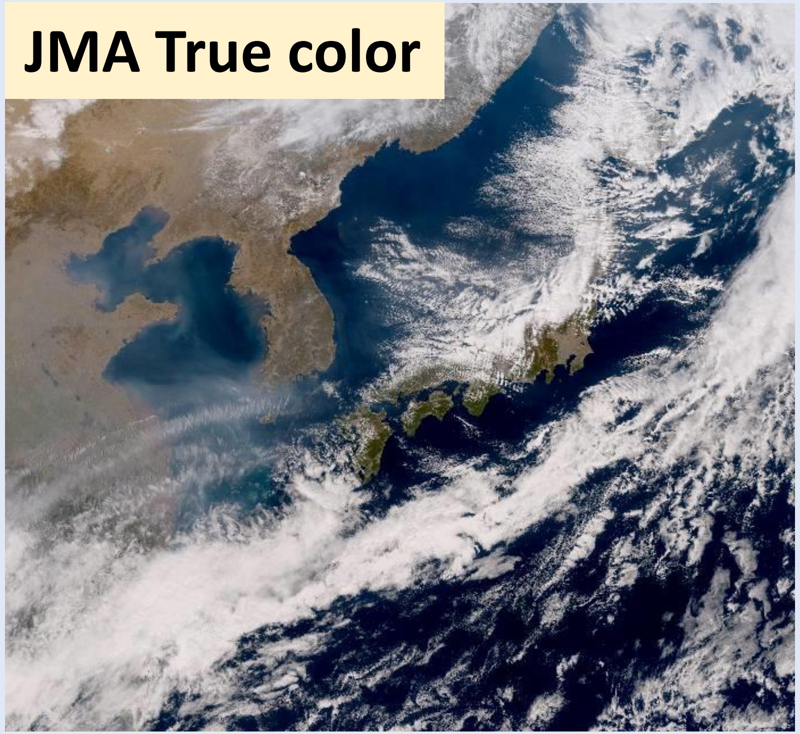
(Chen et. al. 2024)

Discussion:

1. Local adjustment have over correction on the edge of sunset and sunrise
2. Rayleigh correction: only on band01, band02, and band03 in our module
   - Without pathlength correction cause the reddening at high zenith angles, the conditions of high cloud, and high aerosol concentration atmosphere
3. Resolution sharpening
4. The formula of true color highly depend on the personal judgement







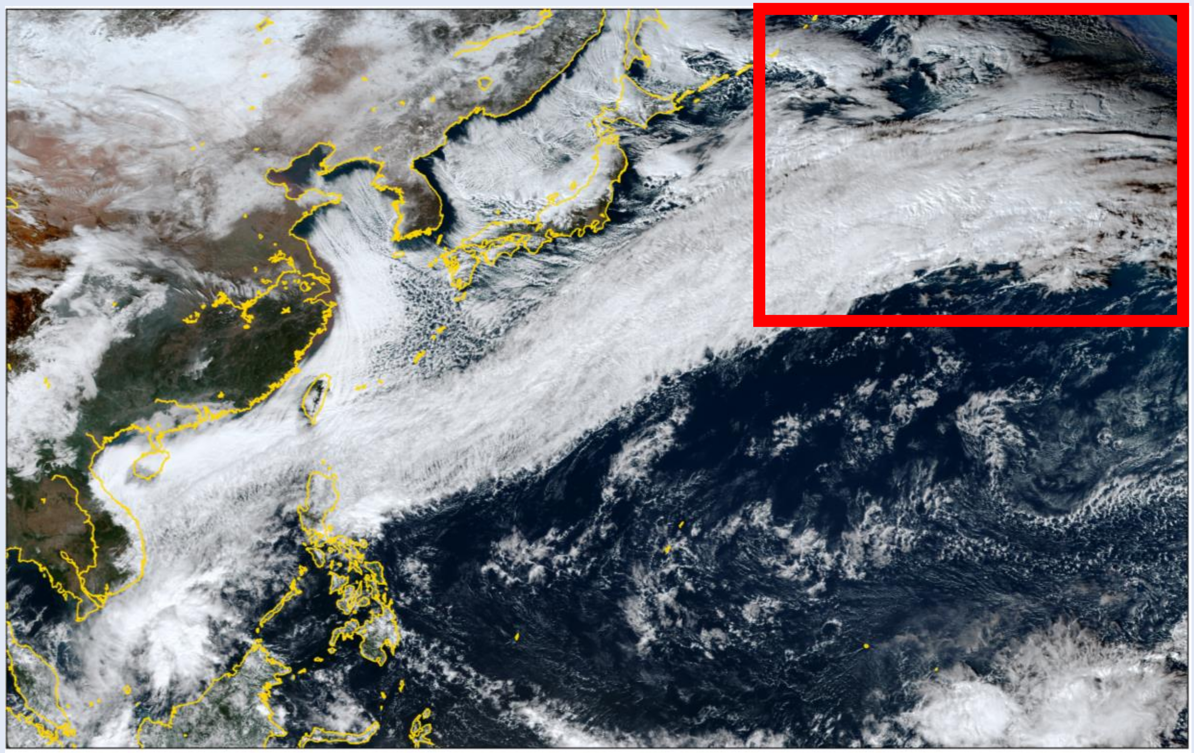
AEL satellite module – Himawari plotting part – True color

6. Plotting figure & Output .nc file

- hima_plot.rgb_merged()
  - Merge red, green, blue band data into 3D RGB array (array shapr: (lat, lon,**3**))

Under developing

- hima_plot.generate_rgb_figure()
  - Default: save fig in the working folder
- hima_plot.generate_rgb_nc_file()
  - Save .nc file in data_path/composite_data



Application

1. AHI band to CEReS band

- himawari.band_name_convert(AHI_band)

2. Reduce local adjust. (blending)

3. Reduce RS correction

4. Self-defined profile

- Self_defined_profile = [[0, …, 255], [0, …, 255]]

AEL satellite module – Himawari plotting part – RGB composite

In this section, you will learn…

- How to process original data for **RGB composite** product

Work flow:

1. **Read essential data files & fit resolution**
2. **Local adjustment (optional, depending on data characteristic)**
3. ~~**Rayleigh scatter correction**~~
4. ~~**Hybrid green**~~
5. **Image enhancement**
6. **Plot figure & output .nc file**

- Data for **RGB composite** image production:
  - **AHI_band = depending on product demand**
  - **geo = usually only need 'sun.zth'**

RGB composite image – cloud phase distinction

RGB composition with recommended thresholds and related specifications for Cloud Phase Distinction RGB

Color	AHI bands	Central wave length [μm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13	10.4	219.6K	280.7K	1.0	Cloud top temperature	Warm clouds	Cold clouds
Green	B03	0.64	0%	85%	1.0	Cloud optical thickness	Thin clouds	Thick clouds Snow-covered land Sea ice
Blue	B05	1.6	1%	50%	1.0	Cloud phase Snow and ice	Ice clouds	Water clouds

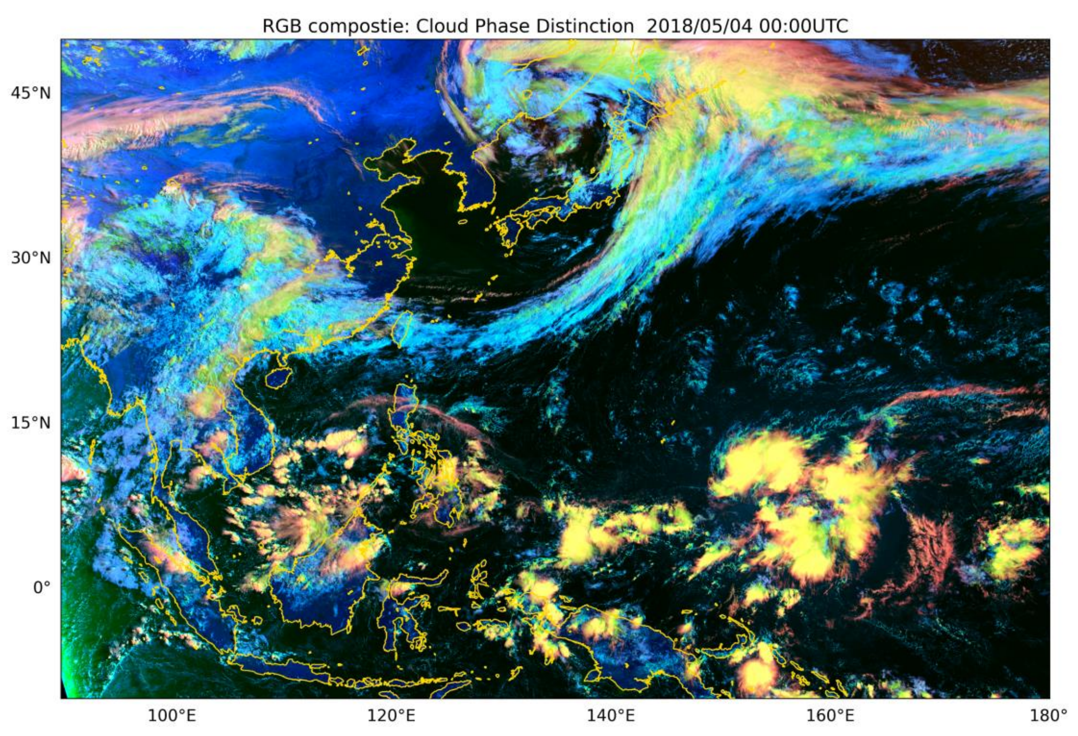
Image enhancement

- Usually **lower Tbb** represent cloud

May need to **Reverse** the rescale_value function

Unit: albedo

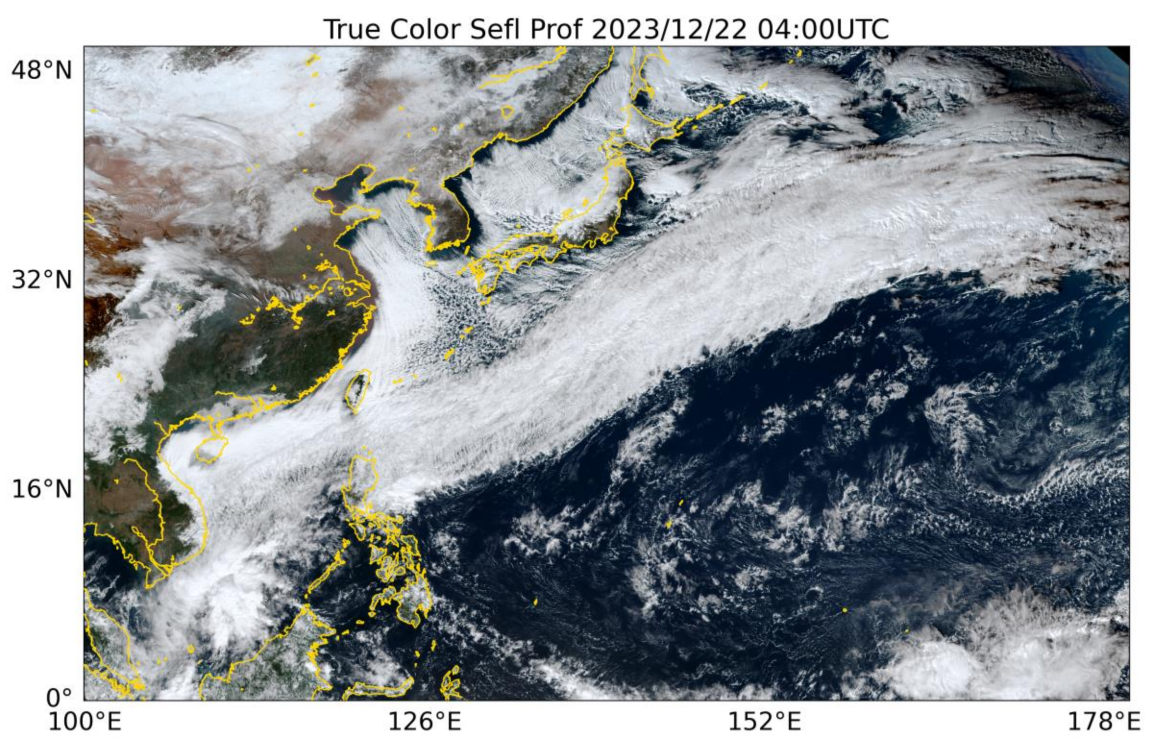
May apply **Local adjustment**

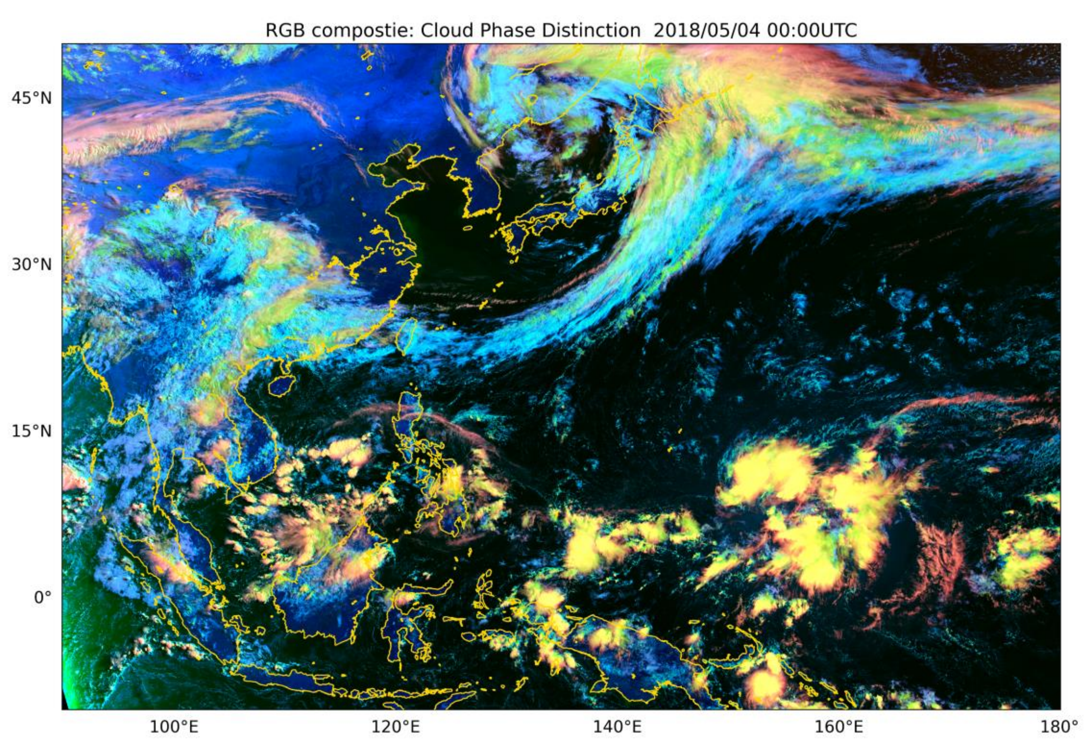


HW3

Practice one himawri-8/9 true color image and composite

- RGB composite information
  - RGB_QG_List_en.pdf
  - https://www.dropbox.com/scl/fo/gtal89soh9sebdvja8cii/ABt3NzShv5Nil4wSYV6CHAU?rlkey=r4ot3myowabzvu8lsnbz8ka90&st=lqc9vj3r&dl=0





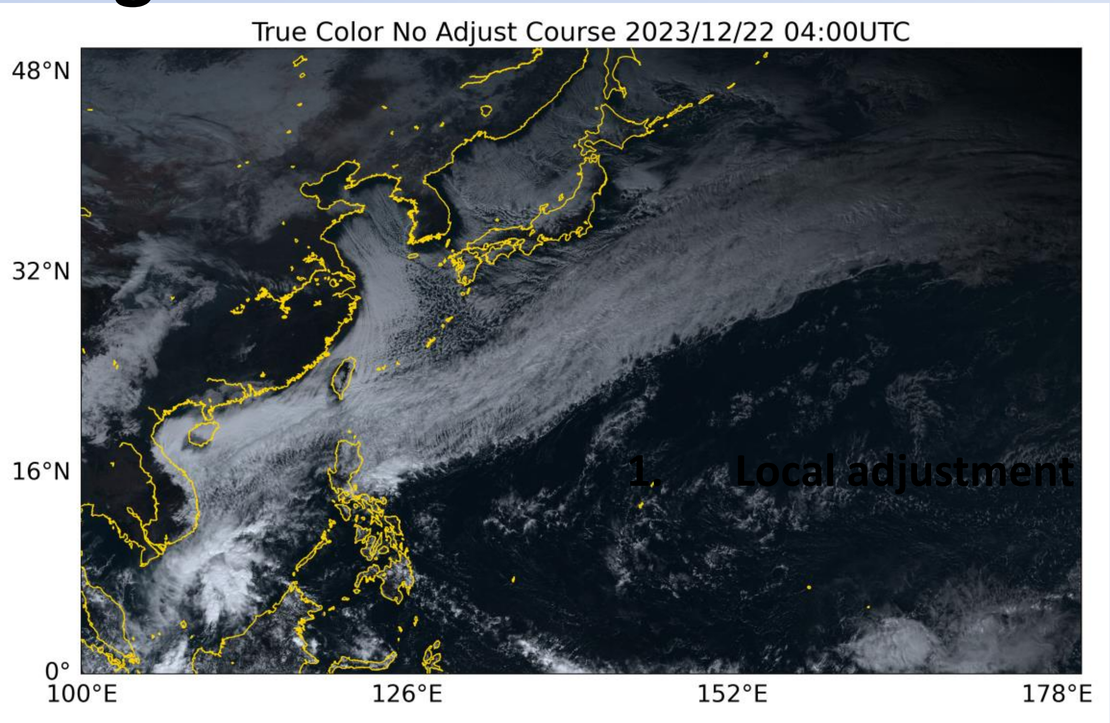
Reference

- Broomhall, M. A., Majewski, L. J., Villani, V. O., Grant, I. F., & Miller, S. D. (2019). Correcting Himawari-8 Advanced Himawari Imager Data for the Production of Vivid True-Color Imagery, *Journal of Atmospheric and Oceanic Technology*, *36*(3), 427-442. Retrieved Sep 29, 2022, from https://journals.ametsoc.org/view/journals/atot/36/3/jtech-d-18-0060.1.xml
- Miller, S. D., Schmit, T. L., Seaman, C. J., Lindsey, D. T., Gunshor, M. M., Kohrs, R. A., Sumida, Y., & Hillger, D. (2016). A Sight for Sore Eyes: The Return of True Color to Geostationary Satellites, *Bulletin of the American Meteorological Society*, *97*(10), 1803-1816. Retrieved Sep 29, 2022, from https://journals.ametsoc.org/view/journals/bams/97/10/bams-d-15-00154.1.xml
- Peng-Jen Chen, Wei-Ting Chen, Chien-Ming Wu, Shih-Wen Tsou, Min-Hui Lo, Machine learning detection of fog top over eastern Taiwan mountains from Himawari-8 satellite true-color images, Remote Sensing Applications: Society and Environment, Volume 34, 2024, 101203, ISSN 2352-9385, https://doi.org/10.1016/j.rsase.2024.101203.
- SHIMIZU Akihiro, Introduction to Himawari-8 RGB composite imagery
  - https://www.data.jma.go.jp/mscweb/technotes/msctechrep65-1.pdf
- RGB composite quick guide
  - https://www.jma.go.jp/jma/jma-eng/satellite/RGB_TL.html

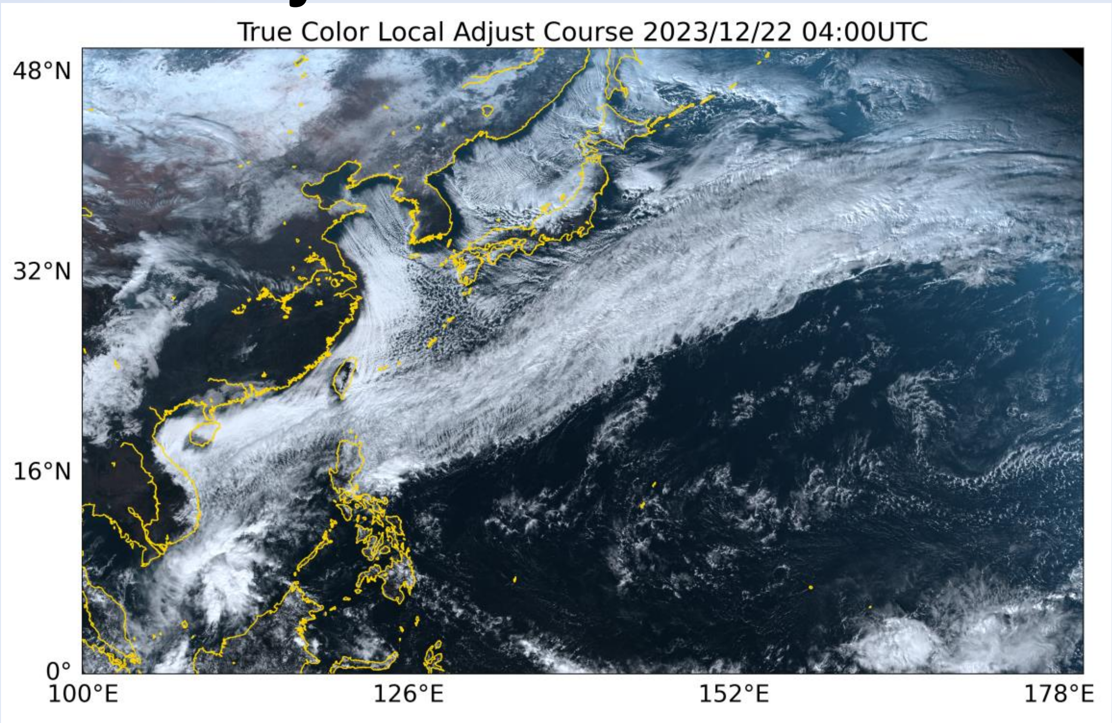
END

Appendix

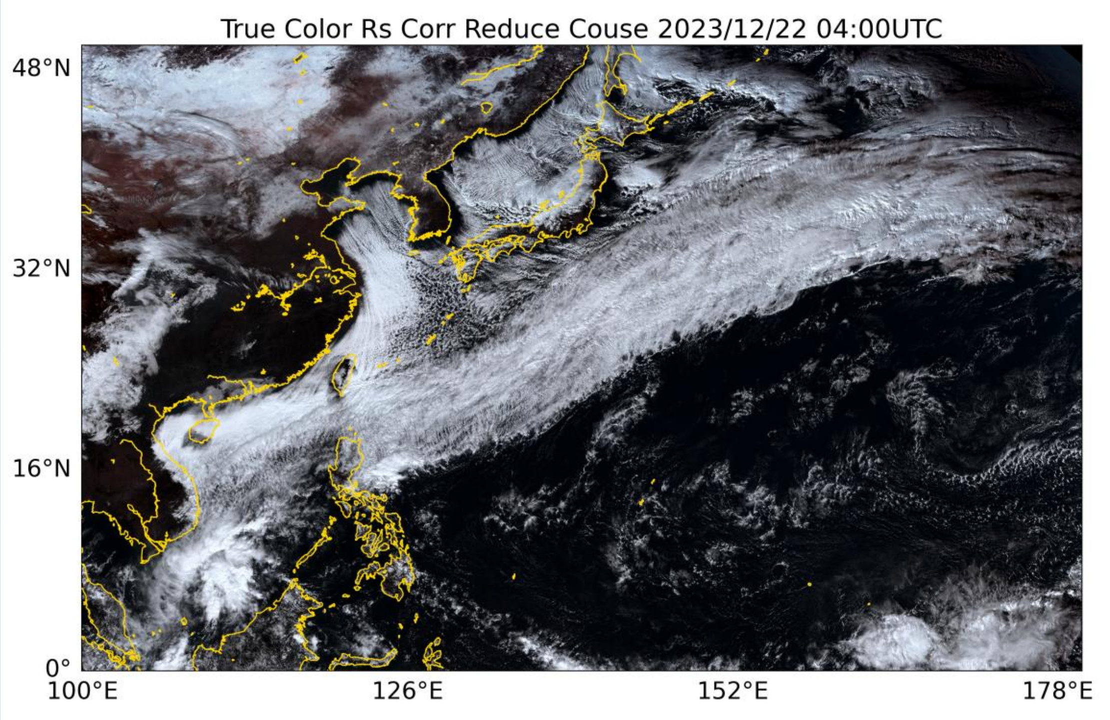
Original RGB



Local adjustment



Rayleigh scatter correction



Hybrid green

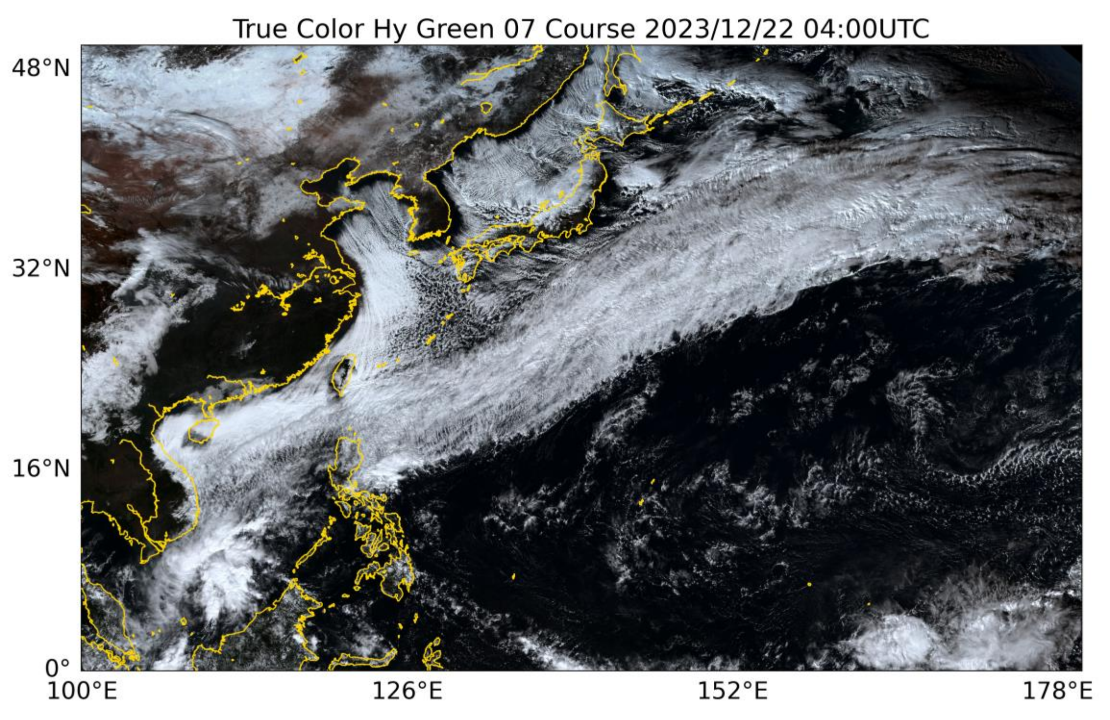
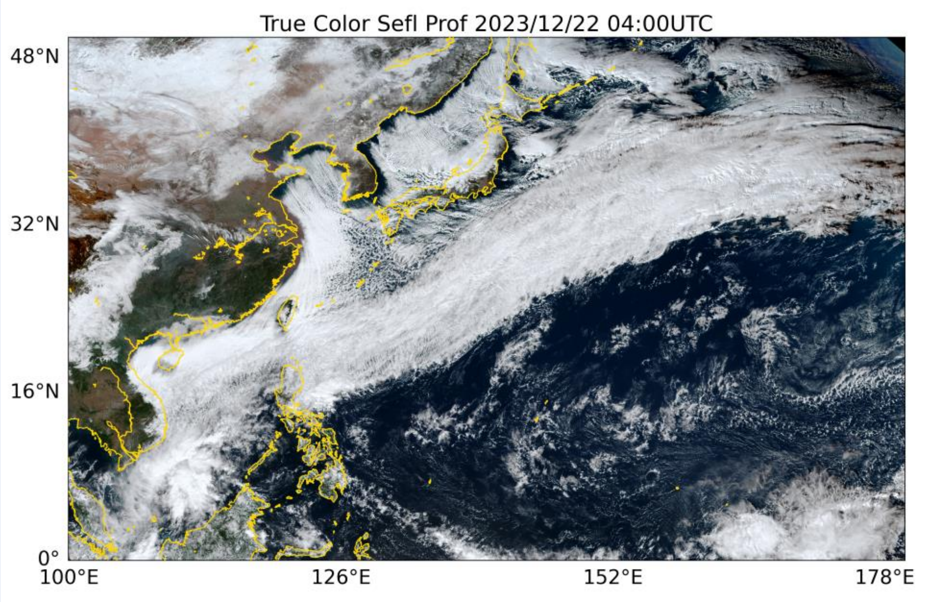


Image enhancement



Band 07 solar reflectance

- Band 07 (3.9 µm) is the IR band. To get band 07 solar reflectance (**R07refl**) , some calculating approaches must be applied with the band 13 (10.4 µm) Tbb data.
- **R07refl = 100*(Rtot - Rtherm) / (TOARAD - Rtherm)**
  - Rtot: the measured total radiance
  - Rtherm: the thermal component of radiance
  - TOARAD: the solar constant at the top of the atmosphere for 3.9 µm
- **Rtot = (c1*(ν^3))/{exp[(c2*ν) / (a + b*(Tb3.9) + c*(Tb3.9^2))] - 1}**
- **Rtherm = (c1*(ν^3)*R3.9corr) / {exp[(c2*ν) / (a + b*(Tb10.4) + c*(Tb10.4^2))] - 1}**
  - R3.9corr is set to 1 (R3.9corr is a correction term for absorption by CO2 which can be ignored for Band 07)
  - c1 = 1.19104*10^(-5); c2 = 1.43878; ν = 2575.767
  - a = 0.479390779819778O; b = 0.999234381214647; c = 1.85684785537253*10^(-7)
- **TOARAD = (C3.9 / ESD^2)*cos(θ)**
  - C3.9 = 4.0877 ;ESD = 1.0 - 0.0167*cos(2π*(JulianDay - 3) / 365)
  - JulianDAY: the number of days since the beginning of January 1st 4713 B.C. (e.g., January 1st 2019 is 2,458,485)
  - ESD: earth-sun distance (in Astronomical Units); θ: the solar zenith angle; θsat: satellite zenith angle
  - TOARAD has been simplified, ori-eq: TOARAD = (c3.9 / ESD^2)*cos(θ)*exp{-(1 - R3.9corr)*(cos(θ) / cos(θsat))}

Day snow fog

RGB composition with recommended thresholds and related specifications for
Day Snow-Fog RGB

Color	AHI bands	Central wave length [µm]	Min [%]	Max [%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B04	0.86	0%	102%	1.6	Cloud optical thickness Snow and ice	Thin clouds	Water clouds Snow-covered land/sea ice
Green	B05	1.6	0%	68%	1.7	Cloud phase (and size) Snow and ice	Ice clouds with large crystals Snow-covered land/sea ice	Thick water clouds with small droplets
Blue	B07refl	3.9	2%	45%	1.95	Cloud phase and size Snow and ice	Ice clouds with large crystals Snow-covered land/sea ice	Thick water clouds with small droplets

Natural color

RGB composition with recommended thresholds and related specifications for Natural Color RGB

Color	AHI bands	Central wave length [µm]	Min [%]	Max [%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B05	1.6	0%	99%	1.0	Cloud phase Snow and ice	Ice clouds Snow-covered land/sea ice	Water clouds
Green	B04	0.86	0%	102%	0.95	Cloud optical thickness Green vegetation	Thin clouds	Thick clouds Snow-covered land Vegetation
Blue	B03	0.64	0%	100%	1.0	Cloud optical thickness	Thin clouds	Thick clouds Snow-covered land Sea ice

Day cloud phase

RGB composition with recommended thresholds and related specifications for
Day Cloud Phase RGB

Color	AHI bands	Central wave length [μm]	Min [%]	Max [%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B05	1.6	0%	50%	1.0	Cloud phase	Ice clouds	Water clouds
Green	B06	2.3	0%	50%	1.0	Cloud size (and phase)	Thick clouds with large particles	Thick clouds with small particles
Blue	B01	0.47	0%	100%	1.0	Cloud optical thickness	Thin clouds	Thick clouds Snow-covered land Sea ice

Cloud phase distinction

RGB composition with recommended thresholds and related specifications for
Cloud Phase Distinction RGB

Color	AHI bands	Central wave length [μm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13	10.4	219.6K	280.7K	1.0	Cloud top temperature	Warm clouds	Cold clouds
Green	B03	0.64	0%	85%	1.0	Cloud optical thickness	Thin clouds	Thick clouds Snow-covered land Sea ice
Blue	B05	1.6	1%	50%	1.0	Cloud phase Snow and ice	Ice clouds	Water clouds

Night microphysics

RGB composition with recommended thresholds and related specifications for
Night Microphysics RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13-B15	10.4-12.4	-3.0K	7.5K	1.0	Cloud optical thickness	Thin clouds	Thick clouds
Green	B07-B13	3.9-10.4	-7.0K	2.9K	1.0	Cloud phase	Thin ice clouds	Thick fog/ water clouds
Blue	B13 (inverse)	10.4	243.7K	293.2K	1.0	Cloud top temperature Surface temperature	Cold clouds Cold surface	Warm clouds Warm surface

24-hr microphysics

RGB composition with recommended thresholds and related specifications for
24-hour Microphysics RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13-B15	10.4-12.4	-3.0K	7.5K	1.0	Cloud optical thickness	Thin ice clouds	Thick clouds
Green	**B13 – B11** **B14 – B11**	8.6-10.4 /8.6-11.2	0.8K -0.4K	5.8K 6.1K	1.3 1.1	Cloud phase	Ice clouds	Water clouds
Blue	B13 (inverse)	10.4	248.6K	303.2K	1.0	Cloud top temperature Surface temperature	Cold clouds Cold surface	Warm clouds Warm surface

Day microphysics

RGB composition with recommended thresholds and related specifications for Day Microphysics RGB

Color	AHI bands	Central wave length [µm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B04	0.86	0%	102%	0.95	Cloud optical thickness	Thin clouds	Thick clouds
Green	B07refl	3.9	2%	82%/38% (warm/cold season)	2.6/1.8 (warm/cold season)	Cloud phase and size Snow and ice	Ice clouds with large ice crystals	Water clouds with small droplets
Blue	B13 (inverse)	10.4	203.5K	303.2K	1.0	Temperature	Cold thick clouds	Warm clouds Warm surface

Day convective storms

RGB composition with recommended thresholds and related specifications for
Day Convective Storms RGB

Color	AHI bands	Central wave length [µm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B10-B08	7.3-6.2	-5.0K	36.0K	1.0	Cloud top height	Low-level clouds	High-level clouds
Green	**B07-B13**	10.4-3.9	-1.0K	61.0K	0.5	Cloud top particle size and temperature	Large ice particles with weak updrafts	Small ice particles with strong updrafts
Blue	**B05-B03**	0.64-1.6	-80%	26%	0.95	Cloud top phase	Ice clouds	Water clouds

Day deep clouds

RGB composition with recommended thresholds and related specifications Day Deep Clouds RGB

Color	AHI bands	Central wave length [µm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13-B08	10.4-6.2	-5.0K	35.0K	1.0	Cloud top temperature	Thin clouds	Thick clouds (with overshooting tops)
Green	B03	0.64	70%	100%	1.0	Cloud optical thickness Rough texture of cloud tops	Thin clouds	Thick clouds
Blue	B13 (inverse)	10.4	243.6K	292.6K	1.0	Cloud top temperature Surface temperature	Cold clouds	Warm surface

Air mass

RGB composition with recommended thresholds and related specifications for Airmass RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B10-B08	7.3-6.2	0.0K	25.8K	1.0	Vertical water vapor distribution Mid-high level clouds	Mid-level humidity Mid-level clouds	Dry upper levels High-level clouds
Green	B13-B12	10.4-9.6	-4.3K	41.5K	1.0	Tropopause height based on ozone Clouds at all levels	Low tropopause (polar air mass) with ozone-rich content	High tropopause (tropical air mass) with low ozone content
Blue	B08	6.2	208.0K	242.6K	1.0	Water vapor distribution in upper-level High clouds	Dry upper-levels warm brightness temperature	Moist upper-level cold brightness temperature

Simple water vapor

RGB composition with recommended thresholds and related specifications for Simple Water Vapor RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13	10.4	202.3K	279.0K	10.0	Cloud top temperature	Warm clouds	Cold clouds
Green	B08	6.2	214.7K	242.7K	5.5	Water vapor distribution at upper level High clouds	Dry upper levels Warm brightness temperatures	Moist upper levels Cold brightness temperatures
Blue	B10	7.3	245.1K	261.0K	5.5	Water vapor distribution at mid-level Mid-level clouds	Dry mid-levels Warm brightness temperatures	Moist Mid-levels Cold brightness temperatures

Differential Water Vapor

RGB composition with recommended thresholds and related specifications for Differential Water Vapor RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B10-B08	7.3-6.2	-3.0K	30.0K	3.5	Vertical water vapor distribution Mid-/high-level clouds	Mid-level humidity Mid-level clouds	Dry upper levels High-level clouds
Green	B10	7.3	213.2K	278.2K	2.5	Water vapor distribution at mid-level	Dry mid-levels Warm brightness temperatures	Moist mid-levels Cold brightness temperatures
Blue	B08	6.2	208.5K	243.9K	2.5	Water vapor distribution in upper level High clouds	Dry upper levels Warm brightness temperatures	Moist upper levels Cold brightness temperatures

Ash

RGB composition with recommended thresholds and related specifications for Ash RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13-B15	10.4-12.4	-3.0K	7.5K	1.0	Cloud optical thickness Volcanic ash	Thin ice clouds	Thick clouds Volcanic ash
Green	**B13 – B11** **B14 – B11**	8.6-10.4 /8.6-11.2	-1.6K -5.9K	4.9K 5.1K	1.2 0.85	Cloud phase	Thin ice clouds Volcanic ash	Water clouds SO_2 gas plume
Blue	B13 (inverse)	10.4	243.6K	303.2K	1.0	Cloud top temperature Surface temperature	Cold clouds Cold surface	Warm clouds Warm surface

Dust

RGB composition with recommended thresholds and related specifications for Dust RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B13-B15	10.4-12.4	-3.0K	7.5K	1.0	Cloud optical thickness Dust	Thin ice clouds	Thick clouds Dust
Green	**B13 – B11** **B14 – B11**	8.6-10.4 /8.6-11.2	0.9K -0.5K	12.5K 15.0K	2.5 2.2	Cloud phase	Thin ice clouds Dust	Water clouds Deserts
Blue	B13 (inverse)	10.4	261.5K	289.2K	1.0	Cloud top temperature Surface temperature	Cold clouds Cold surface	Warm clouds Warm surface

Fire temperature

RGB composition with recommended thresholds and related specifications for Fire Temperature RGB

Color	AHI bands	Central wave length [µm]	Min [K/%]	Max [K/%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B07	3.9	273.0K	350.0K	1.0	Temperature Cloud phase	Thick water clouds	Fire hotspots (with lower temperature)
Green	B06	2.3	0%	50%	1.0	Temperature Cloud phase and size	Thin ice clouds with large ice particles	Fire hotspots (with mid temperature) Thick water clouds with small droplets
Blue	B05	1.6	0%	50%	1.0	Temperature Cloud phase	Thin ice clouds	Fire hotspots (with higher temperature) Thick water clouds

Natural fire color

RGB composition with recommended thresholds and related specifications for Natural Fire Color RGB

Color	AHI bands	Central wave length [µm]	Min [%]	Max [%]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	B06	2.3	0%	100%	1.0	Temperature Clouds	Thin clouds	Fire hotspots Thick clouds
Green	B04	0.86	0%	100%	1.0	Cloud optical thickness Green vegetation	Thin clouds Burn scars	Thick clouds Vegetation Snow-covered land Sea ice
Blue	B03	0.64	0%	100%	1.0	Cloud optical thickness	Thin clouds Burn scars	Thick clouds Snow-covered land Sea ice Smoke

SO2

RGB composition with recommended thresholds and related specifications for SO2 RGB

Color	AHI bands	Central wave length [µm]	Min [K]	Max [K]	Gamma	Physical relation to	Smaller contribution to signal of	Larger contribution to signal of
Red	**B09– B10**	7.3-6.9	-6.0K	5.0K	1.0	SO_2 Thick clouds Vertical water vapor distribution	Thin ice clouds Dry mid-upper levels	Mid-/high-level SO_2 Thick high level clouds
Green	**B13 – B11** **B14 – B11**	8.6-10.4 /8.6-11.2	-1.6K -5.9K	4.9K 5.1K	1.2 0.85	SO_2 Cloud phase	Thin ice clouds	SO_2 Water clouds
Blue	B13 (inverse)	10.4	243.6K	303.2K	1.0	Cloud top temperature Surface temperature	Cold clouds Cold surface	Warm clouds Warm surface