2025 Cloud and Environment

Week 4: AEL satellite module – Himawari part – Application

Peng Jen Chen & Shao Yu Tseng

Recap

1. Draw true color image & some RGB composite images
   - True color image depends on personal imagination
   - RGB composite image only constrain the specific band data used for the RGB channel
   - Data source can be alternative (not only AEL satellite module)
2. **hima_plot.rgb_composite(time_list, rgb_product_name, ta_resolution=2, plotting_info=True)**
   - Combine generate_time_list() to rgb_merged()
   - Based on JMA RGB composite formula except true color image
   - Can be further expanded
3. band7Refl(band07_file_name,band07, band13,sun_zth):
   - Band file name for file date to calculate Julian day
   - Output band07 reflectance

AEL satellite module – Himawari part – Application

In this section, you will learn…

- Combine Himawari preprocess & plotting module

Work flow:

1. **Generate data list**
2. **Data pre-process (download & sub-domain extract)**
3. **RGB composite data production**
4. **Plot figure & output .nc file**

AEL satellite module – Himawari part – Application

- **pip install --upgrade ael_satellite_tools (current version 0.0.4)**
- **from ael_satellite_tools.preprocess import Himawari as Himawari**
- **from ael_satellite_tools.plotting import Himawari as Hima_plot**
- **work_path**
  - Associate with saving figure
  - Default setting: current working path
  - Can decide your own work path

Course demo (**week4*.py & week4*.ipynb**)

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

- himawari = Himawari(work_path=[], data_path=data_path, lat_range=lat, lon_range=lon)
- hima_plot = Him_plot(work_path=[], data_path=data_path, plotting_lat_range=lat,plotting_lon_range=lon)

```
print(hima_plot.work_path)
print(himawari.work_path)
```

```
/data/C.jerryjerry9/hima_download
/data/C.jerryjerry9/hima_download
```

0. Get product name

- hima_plot.RGB_composite_name()
  - RGB composite product name

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1. Generate list

- AHI_band, geo = hima_plot.rgb_attribute(rgb_product_name, band_info_only=True)

```
rgb_product_name = ['True color']
AHI_band,geo
```

```
([1, 2, 3, 4], ['sun.azm', 'sun.zth', 'sat.azm', 'sat.zth'])
```

```
rgb_product_name = ['Microphysics 24hr b14']
AHI_band,geo
```

```
([11, 13, 14, 15], [])
```

- himawari.band_name_convert()
- himawari.generate_list()

2. Data pre-process

- himawari.pre_process()

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3. RGB composite data production

- hima_plot.rgb_composite(time_list, rgb_product_name, ta_resolution=2, plotting_info=True)

1. **Read band data in correct ways**
    - Single band; two bands difference; calculate band07refl…
    - Fit resolution
2. **RGB image production**

Optional

- Local adjustment
- Rayleigh correction
- Hybrid band
- RGB enhancement

Necessary

- Rescale value
- RGB merged

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3. RGB composite data production

AHI_band, geo, band_method,

r_functions,g_functions,b_functions,

rs_channel,

min_threshold, max_threshold, reverse_flag,

gamma, self_enh_flag = **hima_plot.rgb_attribute**(rgb_product_name)

- method 0: read one band data
- method 1: band_1 - band_2 (band difference)
- method 2: calculate band07 reflectance
- method 3: band_1 - band_2 but with different resolution

True color

```
print(AHI_band, geo)
print(band_method)
```

```
[1, 2, 3, 4] ['sun.azm', 'sun.zth', 'sat.azm', 'sat.zth']
[[3, 0], [2, 0], [1, 0], [4, 0]]
```

Microphysics 24hr b14

```
print(AHI_band, geo)
print(band_method)
```

```
[11, 13, 14, 15] []
[[13, 15, 1], [14, 11, 1], [13, 0]]
```

AEL satellite module – Himawari part – Application

3. RGB composite data production

AHI_band, geo, band_method,

r_functions,g_functions,b_functions,

rs_channel,

min_threshold, max_threshold, reverse_flag,

gamma, self_enh_flag = **hima_plot.rgb_attribute**(rgb_product_name)

1. local adjustment
2. rayleigh correction
3. hybrid green
4. rescale value
5. rgb enhancement

True color

```
print(r_functions)
print(g_functions)
print(b_functions)
```

```
[True, True, False, True, True]
[True, True, True, True, True]
[True, True, False, True, True]
```

Cloud phase distinction

```
print(r_functions)
print(g_functions)
print(b_functions)
```

```
[False, False, False, True, True]
[True, False, False, True, True]
[True, False, False, True, True]
```

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4. Plot figure & output .nc file

- hima_plot.generate_rgb_nc_file(**rgb_product_name**, **domain_name**)
  - **202312220400_true_color_2km_rgb_east_asia**.nc

    Product **Resol** **Domain name**
  - rgb_array=[], r_band=[], g_band=[], b_band=[]

- hima_plot.generate_rgb_figure(**prefix='rgb_figure'**, **figure_path='himawari_figure'**)
  - **rgb_figure**_true_color_202312220400.png
  - Set hima_plot.work_path or **figure_path** can change the figure folder

- hima_plot.read_rgb_nc_file(full_path_rgb_file_list)
  - Read RGB array

HW4

Plot composite image with satellite module and refine previous HW

- Use RGB composite along with ERA-5 to identify possible stratocumulus
- hima_plot.rgb_composite(time_list, rgb_product_name, ta_resolution=2, plotting_info=True)
- 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

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Online resource

- Near-real time image
  - https://himawari8.nict.go.jp/
- JMA Himawari home page
  - https://www.data.jma.go.jp/mscweb/en/index.html
- JAXA Himawari Monitor
  - https://www.eorc.jaxa.jp/ptree/index.html
- CHIBA Univ. gridded full-disk(FD) data page
  - http://www.cr.chiba-u.jp/databases/GEO/H8_9/FD/index.html
- CWA 衛星產品整合系統
  - https://satimage.cwa.gov.tw/SPD/home
- RGB composite product
  - https://www.jma.go.jp/jma/jma-eng/satellite/RGB_TL.html
- CWA True color description page
  - https://www.cwa.gov.tw/V8/C/W/OBS_Sat_Description.html
- Satellite Measurements of Clouds and Precipitation
  - https://doi.org/10.1007/978-981-19-2243-5

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Appendix

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 = 0.4793907798197780; 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))}