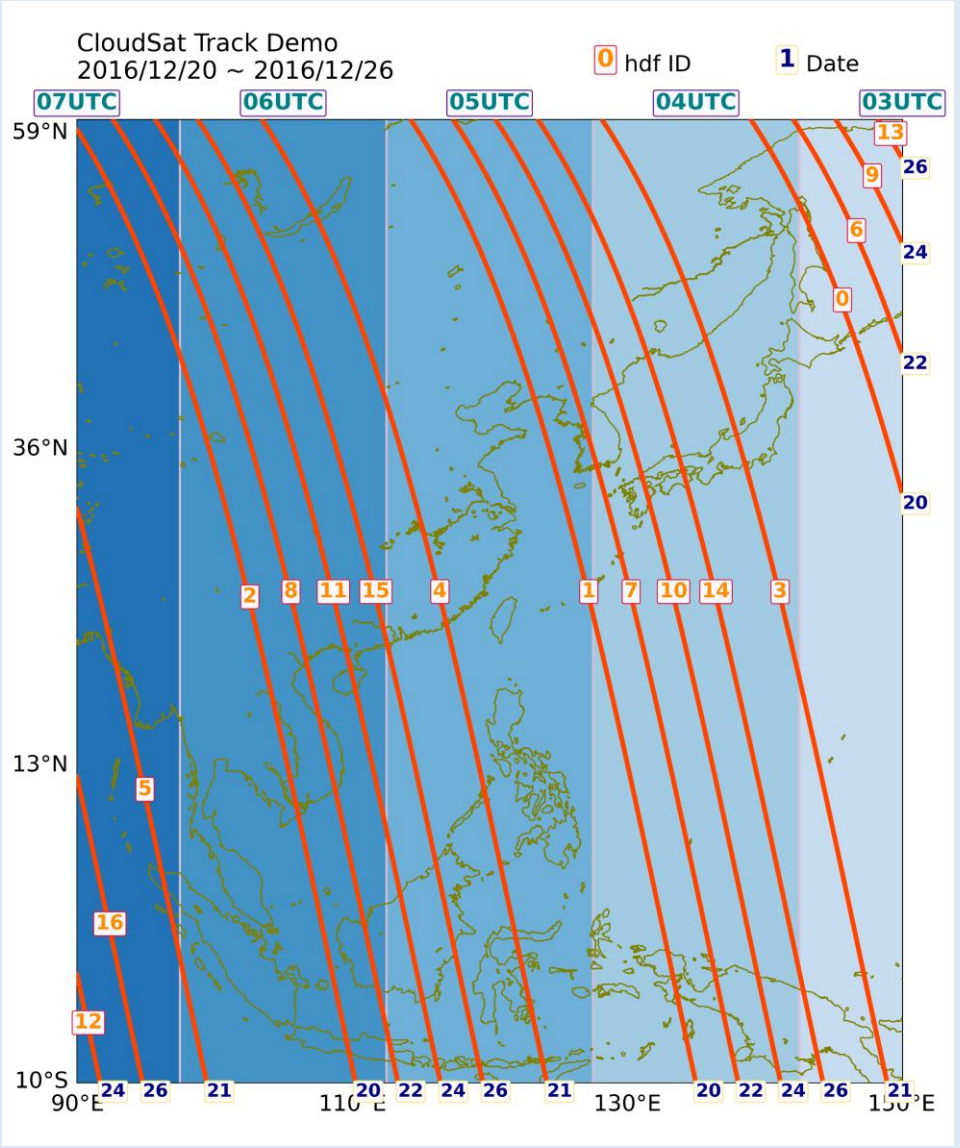
2025 Cloud and Environment

Week 6: AEL satellite module – FS3 & FS7 RO part

Peng Jen Chen

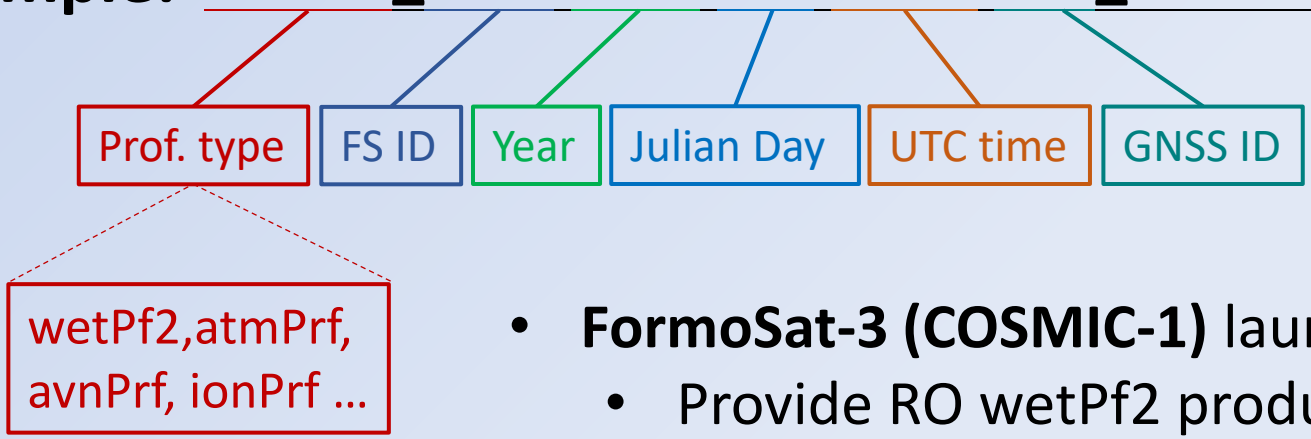
Recap - CloudSat

1. cloudsat.plot_track(file_list)
   - CloudSat **tracks**
   - Hdf ID: sub_domain_file_list[**0**]
   - Examine period: 2016/12/**20** ~ 2016/12/**26**
   - Approximate **UTC time** when tracks pass through
2. Plot profile setting
   - Y axis ratio (size)
   - Default = 5; higher: extend y axis; lower: flatten y axis



FS3 & FS7 RO – Introduction

File name example: **wetPf2_C2E3.2024.110.19.16.R04_0001.0001_nc**



- **FormoSat-3 (COSMIC-1)** launch at 2006/4/14 :
  - Provide RO wetPf2 product: **2006/4/30 ~ 2019/12/10**
- **FormoSat-7 (COSMIC-2)** launch at 2019/6/25 :
  - Provide RO wetPf2 product: **2019/10/1 ~ current**

- **wetPf2:** Atmospheric occultation profile with moisture information included and **interpolated to 100 meter height levels**
- **atmPrf:** Atmospheric profile without moisture information
- **bfrPrf:** Lower resolution profile under WMO format for modelers
- **avnPrf:** Profile generated from the NCEP AVN 12 hour forecast files
- **echPrf:** Profile generated from the ECMWF high resolution gridded analysis

AEL satellite module – RO

In this section, you will learn…

- **Read FS3 & FS7 RO profile data**
  0. Read RO.nc file by netCDF4 module
  1. Read FS3 & FS7 RO.nc file by **AEL satellite module**
- **Filter target file(s) over your study domain during specific time period**
  1. Generate file list in the specific time period
  2. Filtering files over your study domain
- **Visualize the RO data**
  1. Plot RO profiles distribution with Himawari or CloudSat data
  2. Plot vertical profile of atmosphere
- **Compare with ERA5 or sounding data**
  1. Extracte ERA5 daily data base on profile lat-lon information
  2. Compare sounding data around Taiwan or east Asia

AEL satellite module – RO

- **pip install --upgrade ael_satellite_tools (current version 0.0.8)**
- **from ael_satellite_tools.preprocess import RO**
- **data_path = '/data/dadm1/obs/RO_profile' (default setting)**
  - No need to download data
  - data_path/**[satellite name]/[YYYY]/[julian day]**
- lat = [-10, 60]
- lon = [90, 150]
- ro = RO(work_path=[],lat_range=lat,lon_range=lon)
- ro.ro_information()
  - Information from FS3 & FS7 RO.nc file
  - Use ncdump for detail information

Course demo (**week9*.py & week9*.ipynb**)

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

AEL satellite module – RO

Read FS3 & FS7 RO profile data

0. Read RO.nc file by netCDF4 module

- Global attributes: bad = **“0”** profile generated; bad = **“1”** **no** profile generated

1. Read FS3 & FS7 RO.nc file by AEL satellite module

- ro. read_profile(file_list, ‘Var’)
  - Return var_profile_list

```
netcdf wetPf2_C006.2017.153.22.50.G09_2021 {

// global attributes:
                :errstr = "No wetPf2 netCDF file created" ;
                bad = "1" ;
}
```

```
// global attributes:
                :inverter = "OASIS ION-free 1DVAR" ;
                :source_code_version = "2.2" ;
                bad = "0" ;
                :errstr = "" ;
                :atmPrf = "atmPrf_C006.2017.153.09.44.G20_2021.0390_nc" ;
                :fgsPrf = "ef5Prf_C006.2017.153.09.44.G20_2021.0390_nc" ;
                :lat = "-56.551, Nominal latitude (degrees North)" ;
                :lon = "169.018, Nominal longitude (degrees East)" ;
```

```
dimensions:
        MSL_alt = 799 ;
variables:
        float MSL_alt(MSL_alt) ;
                MSL_alt:standard_name = "MSL_alt" ;
                MSL_alt:long_name = "Geometric height above MSL" ;
                MSL_alt:units = "km" ;
                MSL_alt:missing_value = -999.f ;
                MSL_alt:valid_range = 0.f, 60.f ;
        float sph(MSL_alt) ;
                sph:standard_name = "sph" ;
                sph:long_name = "Specific humidity" ;
                sph:units = "g/kg" ;
                sph:missing_value = -999.f ;
                sph:valid_range = 0.f, 80.f ;
        float rh(MSL_alt) ;
                rh:standard_name = "rh" ;
                rh:long_name = "Relative humidity" ;
                rh:units = "%" ;
                rh:missing_value = -999.f ;
                rh:valid_range = 0.f, 100.f ;
```

AEL satellite module – RO

Filter target file(s) over your study domain during specific time period

1. **Generate file list in the specific time period**

- ro.generate_list(time_period, satellite_overlap = **'both'**)
  - Generate the **global** FS3 & FS7 RO file list based on the specified **time period**
  - During overlapping periods(2019/10/01 ~ 2019/12/10), specific RO observations can be filtered
  - satellite_overlap = **'both', 'fs3',or 'fs7'**

```
full_path_file_list = ro.generate_list(time_period,
                                       satellite_overlap='fs3')
```

```
2019110420 2019110516
```

```
full_path_file_list[0]
```

```
'/data/dadm1/obs/RO_profile/fs3/2019/309/wetPf2_C006.2019.309.08.40.G11_2021.0390_nc'
```

```
full_path_file_list = ro.generate_list(time_period,
                                       satellite_overlap='fs7')
```

```
2019110420 2019110516
```

```
full_path_file_list[0]
```

```
'/data/dadm1/obs/RO_profile/fs7/2019/308/wetPf2_C2E1.2019.308.20.00.G28_0001.0001_nc'
```

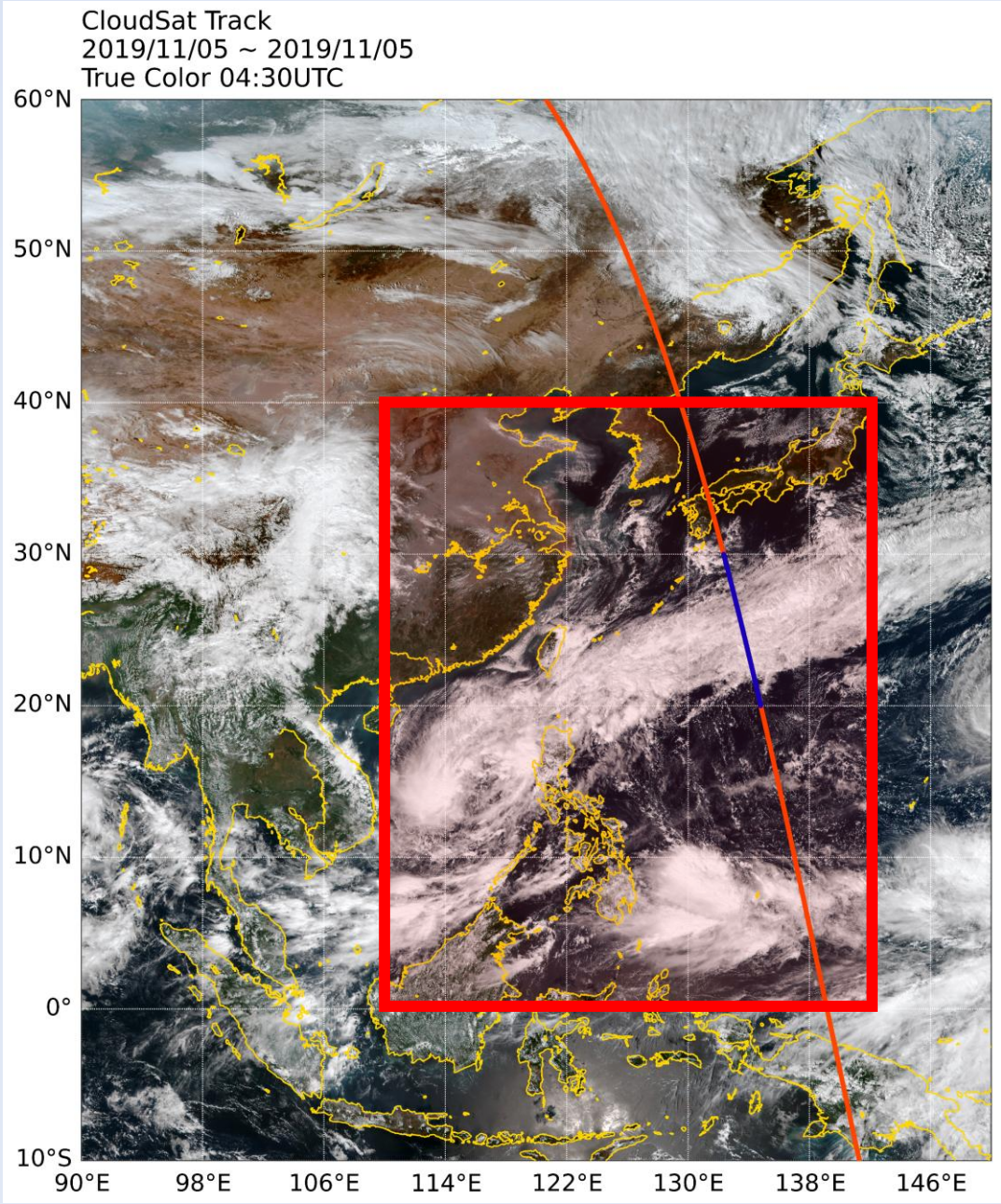
AEL satellite module – RO

Filter target file(s) over your study domain during specific time period

2. Filtering files over your study domain

- ro.sub_domain_check()
  - Read lon-lat info at the lowest point of each RO profile as profile's location
  - Filter the **effective sub-domain** RO file list
  - bad = 0; default lon-lat setting

  Optional:
  - extracted_lon_range = [110, 142]
  - extracted_lat_range = [10, 40]
  - lonlat_list = True (provide the lon-lat info. of profile's location)

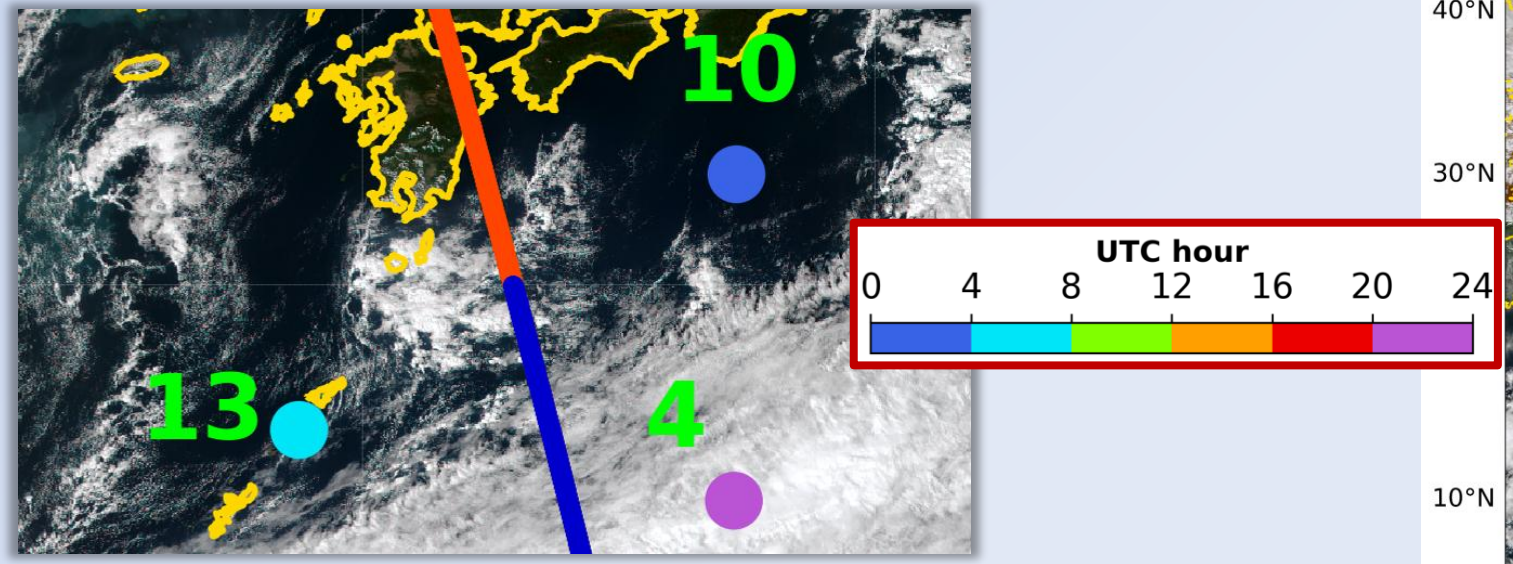


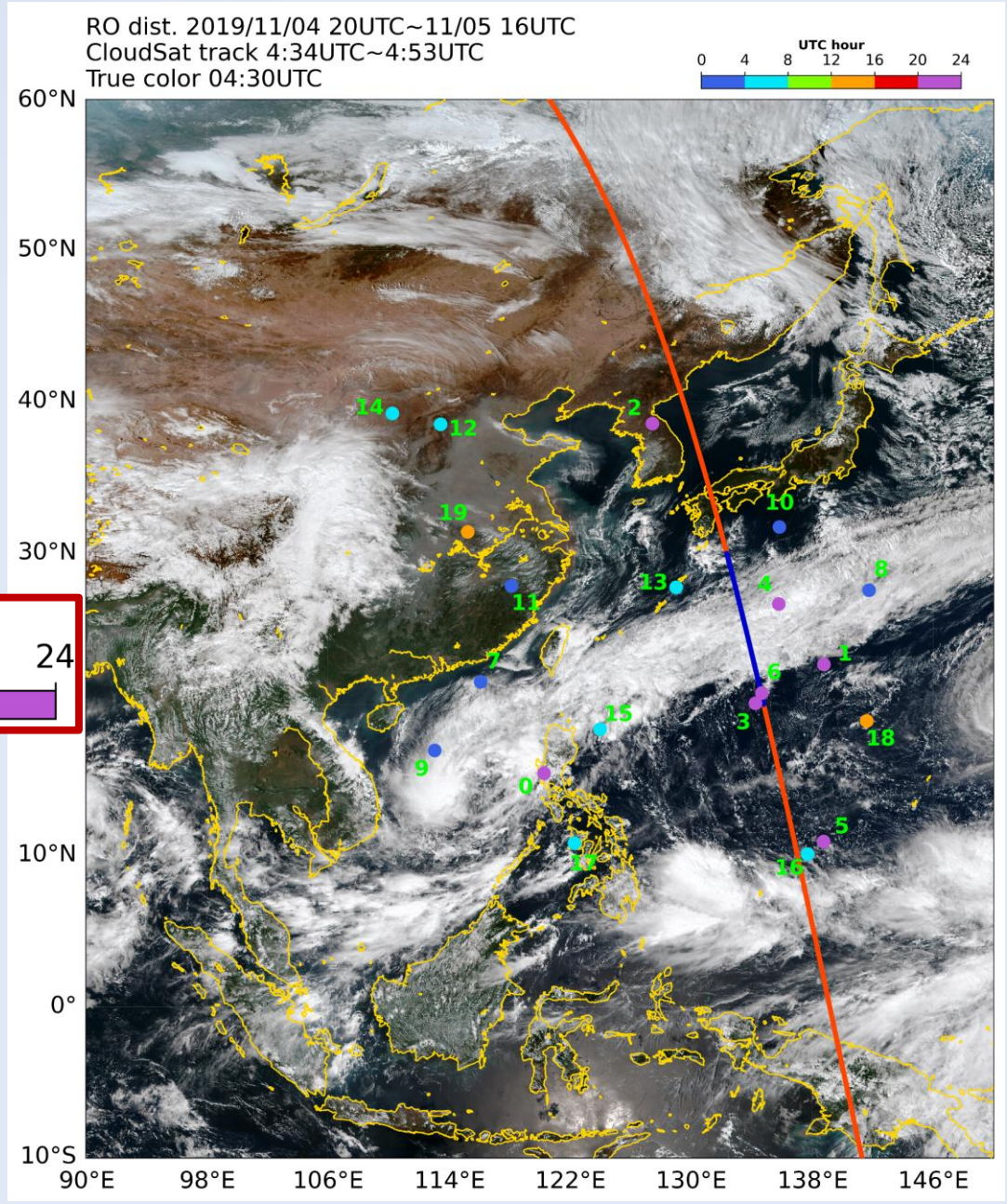
AEL satellite module – RO

Visualize the RO data

1. **Plot RO profiles distribution with Himawari or CloudSat data**

- ro.plot_ro_distribution()





- **Color** of the circle: **UTC time** of the RO profile
- **Number** of the circle: the **RO file's index** in the input file list

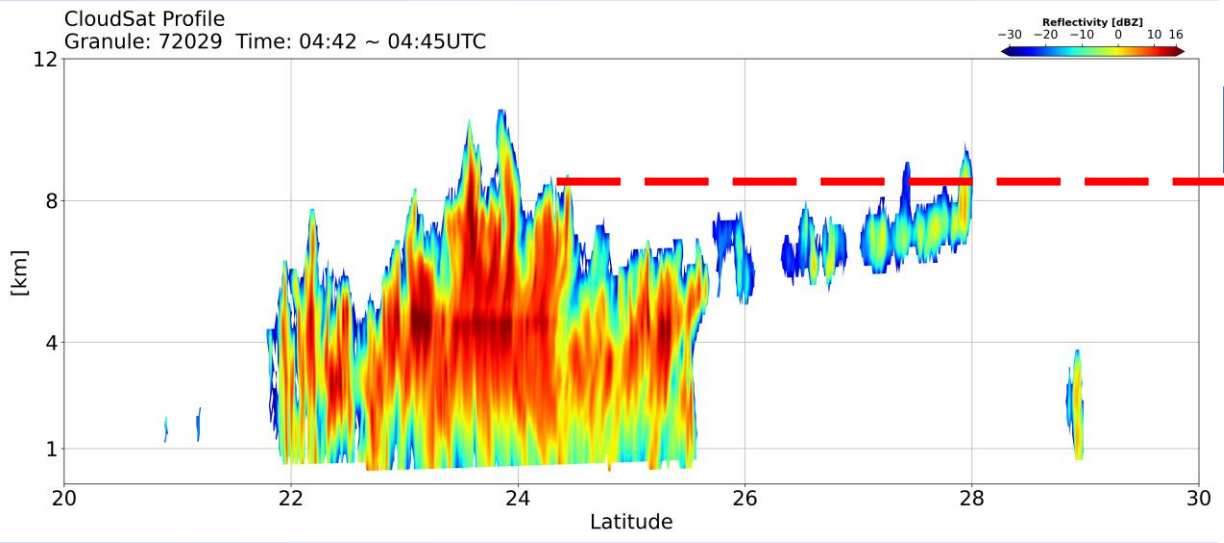
AEL satellite module – RO

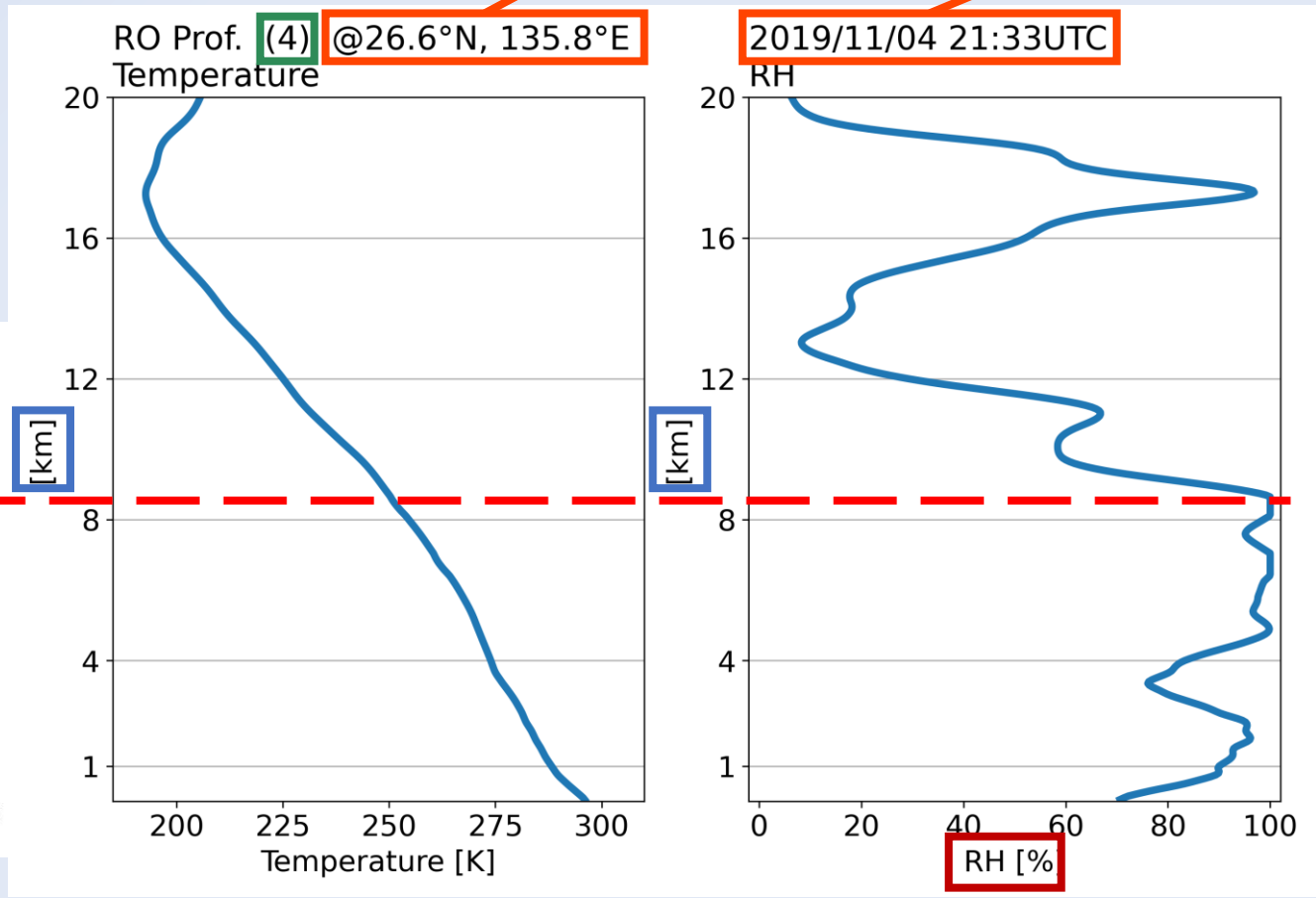
Visualize the RO data

2. Plot vertical profile of atmosphere

- ro.plot_ro_profile()
  - Left fig: temperature prof.
  - Right fig: moisture prof.
  - moist_type= ‘rh’ or ‘sph’ or ’Vp’
  - height_type= ‘MSL_alt’ or ‘Pres’

- By default, plot profiles sequentially based on the input file list
- Plot specific profile by specifying prof_num (RO file’s index)





AEL satellite module – CloudSat

- **Compare with ERA5 or sounding data**
  1. **Extracte ERA5 daily data base on profile lat-lon information**
- Each profile data point has its own lon-lat value
  2. **Compare sounding data around Taiwan or east Asia**

```
print('Height:',vertical_prof[0][0])
print('Lat:',prof_lat[0])
print('Lon:',prof_lon[0])
```

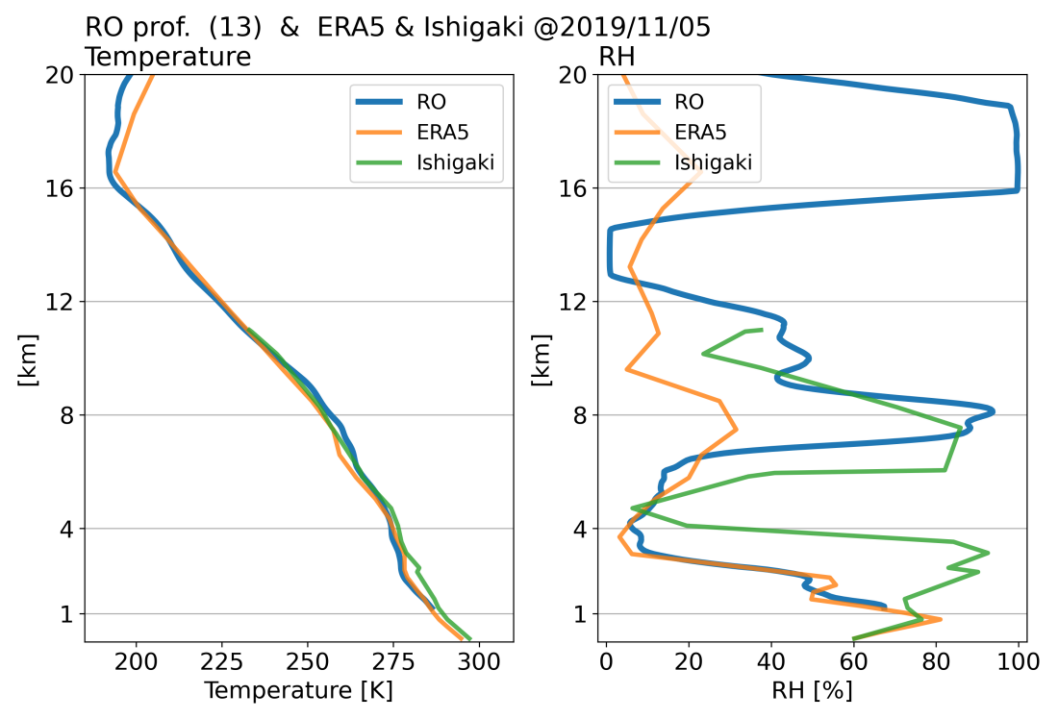
```
Height: 0.05
Lat: 26.630709
Lon: 135.80121
```

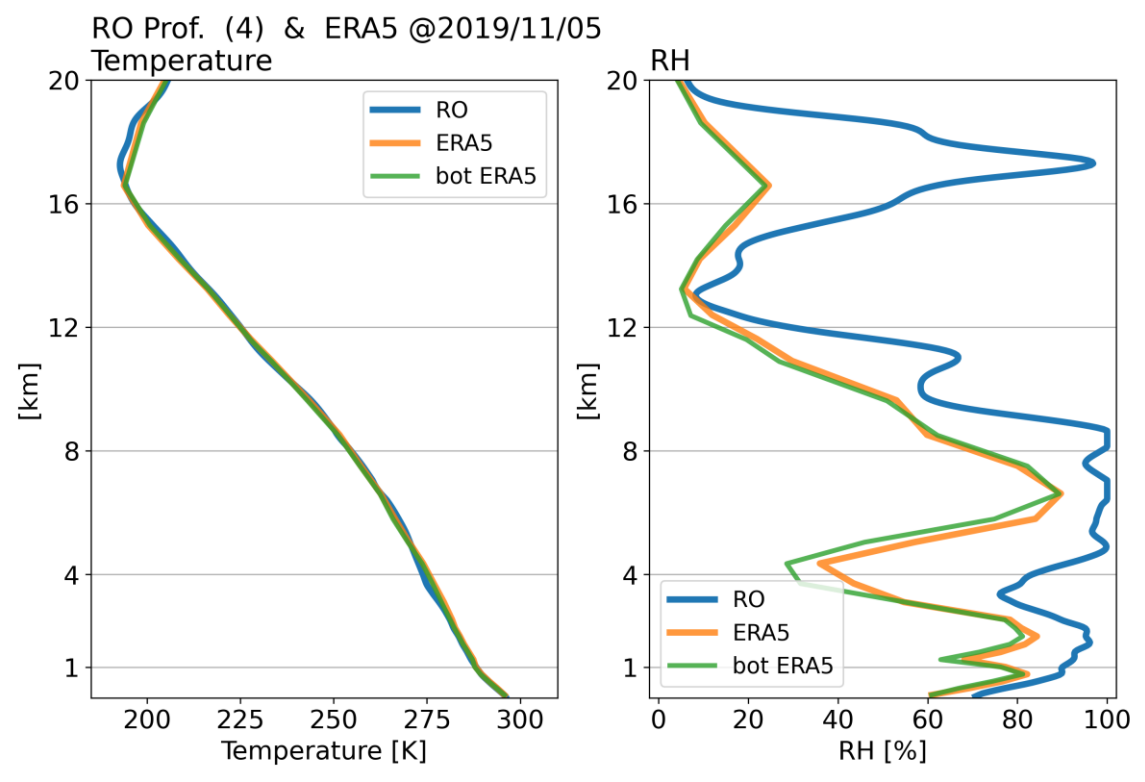
```
print('Height:',vertical_prof[0][400])
print('Lat:',prof_lat[400])
print('Lon:',prof_lon[400])
```

```
Height: 20.1
Lat: 25.910137
Lon: 134.63628
```

```
print('Lat range:',sorted(era5_lat))
print('Lon range:',sorted(era5_lon))
```

```
Lat range: [25.5, 25.75, 26.0, 26.25, 26.5, 26.75]
Lon range: [134.5, 134.75, 135.0, 135.25, 135.5, 135.75]
```

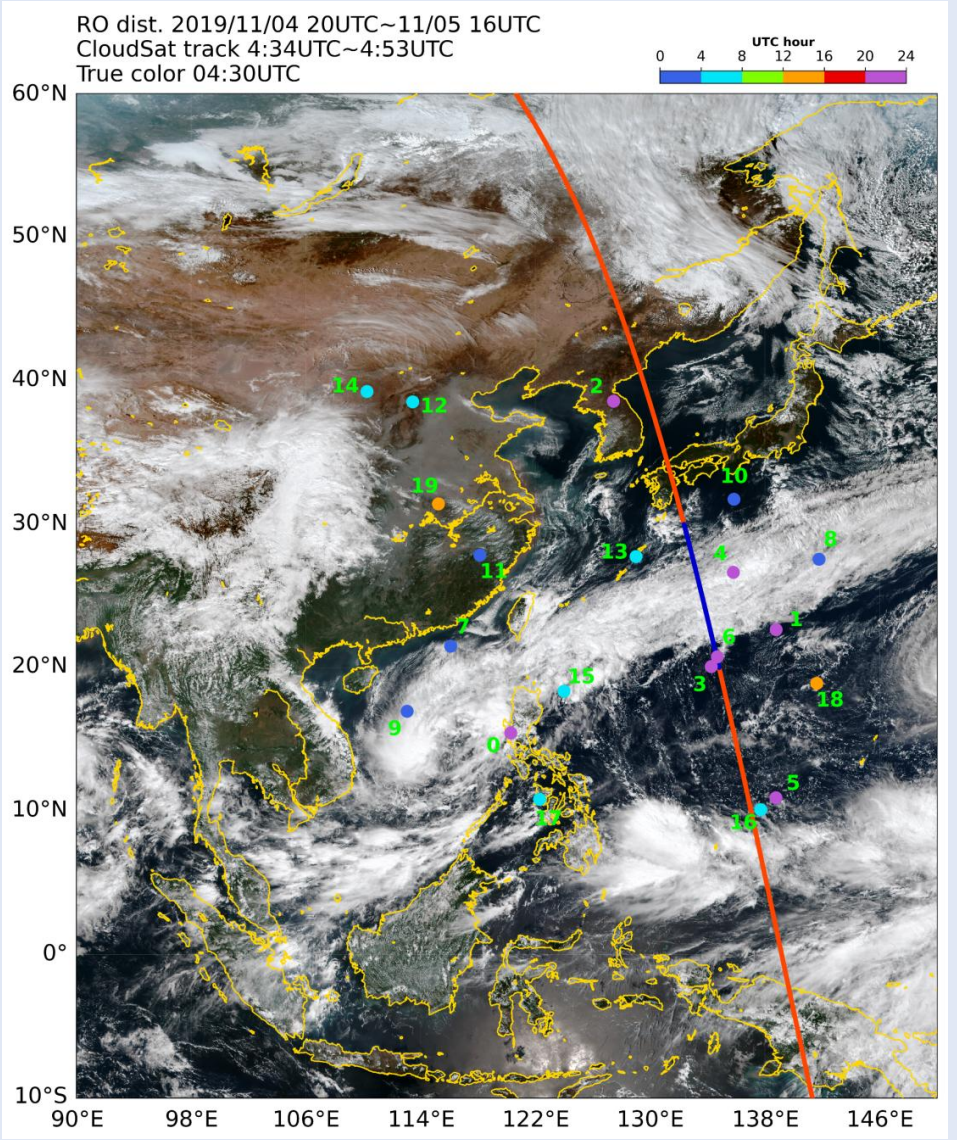




HW9: examine the RO profile in a cold surge case & compare with ERA5 and the sounding data

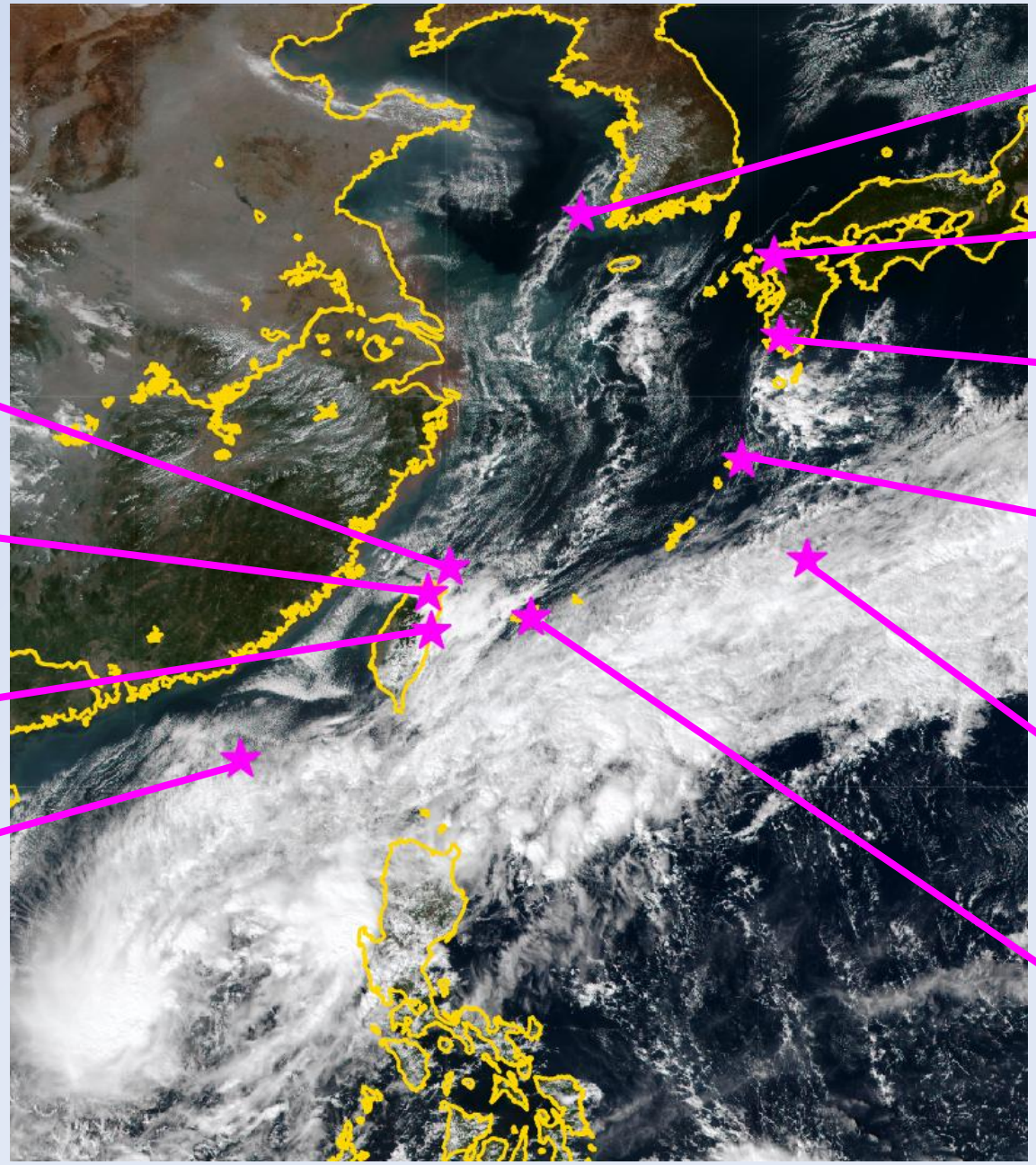
- Ro profile distribution
- Vertical profile (Temp., RH, q, Vp, skew-T, ...)
- Sounding data: /data/dadm1/obs/Radiosonde
  - **/CWA_Radiosonde/** (starting date is various)
    - 466920(Taipei), 466950(Pengchiayu), 466990(Hualien)
  - **/PCCU_Radiosonde/**
    - TW: 46692; 46695; 46699; 46810; JP: 47918; 47945;47909; 47827; 47807; KR: 47169

  University of Wyoming Radiosonde (alternative sounding source)
  - **/Radiosonde/UWyoming_Radiosonde_Ishigaki/** (.txt)
  - /data/dadm1/obs/sounding_uwyo (.csv)
    - .csv file download script: sndUtils.py



PCCU Radiosonde

- Sounding Stations



46695
彭佳嶼
(Pengchiayu)

46692
台北(Taipei)

46699
花蓮(Hualien)

46810
東沙(Dongsha)

47169
黑山島(Heuksando)

47807
福岡(Fukuoka)

47827
鹿兒島(Kagoshima)

47909
奄美大島/名瀬/本茶峠(?)
(AmamiOshima/Naze/Funchatoge Honchatoge)

47945
南大東島
(MinamidaitoJima)

47918
石垣島
(IshigakiJima)

AEL satellite module – RO – function list

RO function

- ro.generate_list()
  - Generate global file list
- ro.sub_domain_check()
  - Fliter effective & sub-domain file list
- ro.read_profile()
  - Read data
- ro.plot_ro_distribution()
  - Plot RO data distribution with Himawari or CloudSat data
- ro.plot_ro_profile()
  - Plot vertical RO profile of atmosphere
  - ro.plot_profile_unit()

```
### plot figure
sub_plot_num = 2
fig, ax1 = plt.subplots(1, sub_plot_num, figsize=(10, 6.8), tight_layout=True)
ro.plot_profile_unit(ax1,temp_prof[0],vertical_prof[0],'Temp','RO',
                     [0,20],6,
                     sub_plot_num=sub_plot_num,plot_num=1,
                     linewidth=4,alpha=1)
ro.plot_profile_unit(ax1,era5_t,era5_z,'Temp','ERA5',
                     sub_plot_num=sub_plot_num,plot_num=1,
                     linewidth=4,alpha=0.8,profile_label=True,axis_setting=False)
```

Online resource

- COSMIC Data Analysis and Archive Center (CDAAC)
  - https://cdaac-www.cosmic.ucar.edu/cdaac/
- Taiwan Analysis Center for COSMIC (TACC)
  - https://tacc.cwa.gov.tw/v2/index.html
- Taiwan Space Agency (TASA)
  - https://tacc.cwa.gov.tw/v2/index.html
- Data access
  - https://data.cosmic.ucar.edu/gnss-ro/
- UCAR COSMIC-2 Data page
  - https://doi.org/10.5065/t353-c093

END

Appendix

Satellite observation cover period