Using GIIRS for atmospheric composition monitoring A first look taking NH_3 as example

Research and slides by Lieven Clarisse (ULB)

MTG-IRS MAG; June 2020

- 1. GIIRS a few facts
- 2. Cloud detection
- 3. Spectral (post) calibration
- 4. Measurements of Ammonia

FY-4A

- Advanced Geostationary Radiation Imager (AGRI)
- Geostationary Interferometric Infrared Sounder (GIIRS)
- Lightning Mapping Imager (LMI)
- Space Environment Package (SEP)



China area

Full disk

Expected products



http://fy4.nsmc.org.cn/nsmc/en/theme/FY4A.html

16 km resolution at SSP Tab. Parameters of FY-4 GIIRS. FY-4A (R&D) FY-4B (Operational) Range(cm⁻) Resolution Channels Range(cm⁻¹) Resolution Channels LWIR 700~1130 0.8 538 LWIR 700~1130 0.625 688 Spectral Parameters(Normal mode) 1650~2250 S/MIR 1.6 375 S/MIR 1650~2250 1.2 500 VIS 0.55-0.75µm VIS 0.55-0.75µm 1 LWIR/S/MIR 16km SSP LWIR/S/MIR Spatial Resolution 8km SSP VIS 2km SSP 5080 × 5000 km² 5000 × 5000 km² China area China area **Operational Mode** 1000 × 1000 km² 1000 × 1000 km² Mesoscale area Mesoscale area China area China area < 1 hr < 1 hr **Temporal Resolution** $< \frac{1}{2}$ hr Mesoscale area Mesoscale area $< \frac{1}{2}$ hr LWIR $0.5 \sim 1.1$ LWIR 0.3 Sensitivity (mW/m²sr cm⁻¹) S/MIR $0.1 \sim 0.14$ S/MIR 0.06 VIS $S/N > 200(\rho = 100\%)$ VIS $S/N > 200(\rho = 100\%)$ Calibration accuracy (radiation) 1.5k (3σ) 1.0k (3σ) Calibration accuracy (spectrum) 10 ppm (3σ) 5 ppm (3σ) Quantization Bits 13 13

0.8 cm⁻¹ spectral resolution in LWIR band





2016 - 2021

2020?? - 2027

http://www.nsmc.org.cn/NSMC/Channels/FY4A_GIIRS_en.html

http://fy4.nsmc.org.cn/nsmc/en/theme/FY4A.html

Example spectra



2. Cloud detection

based on 4 channels, selected using IASI collocated L2 cloud information ("training database")



2. Cloud detection

based on 4 channels, selected using IASI collocated L2 cloud information ("training database")

Example retrieval, yellow = clouds, blue = clear



2. Cloud detection

based on 4 channels, selected using IASI collocated L2 cloud information ("training database")

Let's zoom in a little! By no means perfect, but pretty good. Note that MODIS background is not perfectly collocated in time.





Example fit over the entire spectral range (CO_2 , H_2O , O_3 mainly). Large shift obvious.

Simple approach of finding radiance shift, by using cross correlation with a library of simulated spectra shifted from -0.5 to 0.5 in steps of 0.001 cm^{-1}

Peak about + 0.26 cm⁻¹

60

55

50

45

40

35

30

25

20 15

10

5

40

Note that this method doesn't work for thick clouds, that are not represented in the forward simulation





Fit without shift



Fit with + 0.26 cm⁻¹ shift

Better fit but not perfect at all



Fit with + 0.26 cm⁻¹ shift

- Best fit obtained using the IASI line shape but with MOPD 0.8 cm HWHM 0.105 cm⁻¹
- Fit is clearly poorer where there is most absorption, likely related to the use of the wrong ILS. S
- Small shift remaining for the wavenumbers around 1100 cm⁻¹

In the next slide we use the hyperspectral range index (HRI). Qualitative estimate of the ammonia column (highly depending on thermal contrast)



Example spectra with lots of NH₃

Hyperspectral index (HRI) ⇒ <u>Qualitative</u> estimate of the ammonia column



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