MAIA Cloud Detection, IASI/AVHRR Cloud Clearing & Their Impact on Sounding Retrieval

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AVHRR Characteristics



Six-channel imaging radiometer Spectral range : 0.6 to 12.8 μm IFOV size at nadir: 1.1 km Swath : ±55.4 deg / 1464 km

	Central wavelength (µm)
1	0.630
2	0.862
3a	1.161
3b	3.740
4	10.8
5	12.8



IASI IR Imager

The IIS (integrated imager system) which consists of a broad band radiometer measuring between 833 cm⁻¹ and 1000 cm⁻¹ (12 μ m and 10 μ m)





AVHRR SRF overlay on IASI Spectrum

Radiance Analysis related IASI Level 1C MDR (Measurement Data Record)

Name	Description	Units	Dimension / scan line
GS1cSpect	Level 1C spectra	W/m ² /sr/m ⁻¹	8461 x 4 x30
IDefCcsChannelId	Identification of AVHRR channel or pseudo-channels used in Radiance Analysis		6 x 1
GCcsRadAnalNbClass	Number of identified classes in the sounder FOV		4 x 30
GCcsRadAnalWgt	Sounder FOV radiance analysis (% covered by each class)		7 x 4 x 30
GCcsRadAnalY	Y angular position of the center of gravity	degrees	7 x 4 x 30
GCcsRadAnalZ	Z angular position of the center of gravity	degrees	7 x 4 x 30
GCcsRadAnalMean	Mean AVHRR radiances (all channels) of the Sounder FOV classes	W/m ² /sr/m ⁻¹	6 x 7 x 4 x 30
GCcsRadAnalStd	Standard Deviation AVHRR radiances (all channels) of the Sounder FOV classes	W/m ² /sr/m ⁻¹	6 x 7 x 4 x 30

IASI L1C Data and Information

Descending Granule 257, 22 scan lines, starting at 00:02:57 UTC , ending on 00:05:53 UTC on May 21, 2007



GCcsRadAnalMean - Channel 3

GCcsRadAnalStd - Channel 3



IASI START: 20070521000257Z GCcsRadAnalStd [W/m²/sr/m⁻¹] Class 5, Channel 3



IASI START: 20070521000257Z GCcsRadAnalMean [W/m²/sr/m⁻¹] Class 5, Channel 3



GCcsRadAnalMean - Channel 6

GCcsRadAnalStd - Channel 6





This is the study case: IASI 00:02:57UTC on May 21, 2007

Mask AVHRR for Inversion ATOVS (MAIA) AVHRR Cloud Mask and Classification Lydie Lavanant

The MAIA cloud detection algorithm is a succession of thresholds tests applied to every AVHRR situation to various combinations of the AVHRR channels. A Pixel is declare to be cloudy if one test is not satisfied (so a pixel is said to be 'clear' if all tests are satisfied).

The series of tests applied depend on:

- the surface type (land, sea or coast)
- the solar zenith angle which determines the period of the day (day, twilight or night)

and if there is or not specular reflection during the daytime (sunglint). The tests are done on single channels (11 μ m brightness temperature, visible reflectance), on combination of channels, in BT, for 11-12 μ m (T4-T5), 11-3.7 μ m (T4-T3), 3.7-12 μ m (T3-T5), on spatial local variances of channels 1,2,4,3-4 computed on a 3×3 box centered on each AVHRR pixel.





AVHRR Clear BT of averaged clear clusters within IASI FOVs



AVHRR Clear BT of weighted clear clusters within IASI FOVs



AVHRR Clear BT Difference of weighted and averaged clusters within IASI FOVs

IASI Vs. AVHRR (MAIA IASI Clear Pixels only)



AVHRR observed clear BT Vs. IASI clear convolved to AVHRR

Cloud-cleared IASI data is consistent with the independent AVHRR Measurement Analysis



500

1000

1500

IASI FOVs

2000

2500

3000

data convolved to AVHRR band 5 (12 um)



IASI/AVHRR Cloud Cleared BT at 926 cm⁻¹



IASI/AVHRR Clear and Cloud Cleared BT at 926 cm⁻¹

IASI/AVHRR Synergistic Single-Channel N* Cloud-Clearing General Principal

After Smith



IASI spectrum of cloud cleared FOV and nearby clear FOV

Estimation of cloudcleared error



IASI spectrum difference of cloud cleared FOV and nearby clear FOV cloud fraction = 41%



IASI spectrum difference of cloud cleared FOV and nearby clear FOV cloud fraction = 41% 22

L1C Radiance at 902.5 cm⁻¹

Descending Granule 257, 22 scan lines, starting at 00:02:57 UTC , ending on 00:05:53 UTC on May-21, 2007



MAIA FOV Cloud Free Percentage (top) and Cloud Fraction (bottom)



MAIA Cloud Mask versus simple Cloud Mask

"Cldmask1f" Cloud Mask (05-21-2007)





cldv

-clear

Cloud Mask from simple 10.5,11.5,12.5 µm tri-spectral and on/off technique (cloudmask1f.m)

MAIA Cloudmask with clear if CldFrac < 0.01



IASI 05-21-2007 granules (descending) selected

for Noise-filtering





23:38:58 till 23:41:41 23:41:54 till 23:44:57 23:44:58 till 23:47:53

00:02:57 till 00:05:53 00:05:53 till 00:08:57

In total 13440 profiles, minus 839 bad (acc. GQisFlagQual) \rightarrow 12601 profiles

IASI Radiometric Noise



PC Noise-Filtering, Cloud Clearing & Retrieval

- 1. Calculate Eigenvectors from a dataset (5 granules on 05-21-2007, in total 12601profiles) of normalized (scaled by NEdT) IASI radiances separately for the 3 bands.
- Perform Reconstruction using number of eigenvectors determined by Factor Indicator Function (D. Turner et al, 2006). Additional few more eigenvectors are added to ensure little measurement information is lost in the processing.
- **3.** Compute estimated noise (= 'Observed minus Reconstructed')
- 4. Apply eigenvectors on the selected single granule and perform Cloud Clearing
- 5. Perform retrieval on partially cloudy pixels using 1) clear-sky,2) all-sky, and 3) cloud-cleared regression coefficients

PC Estimated Noise (Observed minus Reconstructed) Vs. Spec. Noise NeN (black)



PC Estimated Noise (Observed minus Reconstructed) Vs. Spec. Noise NeN (black)



PC Noise Filtered Effect on Cloud-Clearing



RMS of CCed minus NFed CCed

Granule 20070521000257Z

IASI Cloudy Channel Detection Using Cloud-Cleared Radiance



From noise-filtered cloud-cleared radiances

Channel is considered cloudy if:

Res1 < abs(Res2)*-3

Where Res1 = Obs minus CCed (or NFed Obs minus NFed CCed)

And Res2 = Obs minus NFed Obs

IASI Granule 20070521000257Z

IASI Cloudy Channel Detection Using Cloud-Cleared Radiance

Selected Examples



Cloudy Channel Detection from CCed (left) and NFed CCed (right) Spectrum



Cloudy Channel Detection from CCed (left) and NFed CCed (right) Spectrum



Cloudy Channel Detection from CCed (left) and NFed CCed (right) Spectrum



Retrieval on original, cloud-cleared and noise filtered cloud-cleared radiances Humidity at 500 hPa

RTV A

IASI Retrieval: 20070521000257Z Humidity [g/kg] at 496.63 mbar



RTV B IASI Retrieval: 20070521000257Z



1.5 **ECMWF** ECMWF Analysis: 20070521000257Z Humidity [g/kg] at 496.63 mbar 0.5

AllSky RTV on original Rad Simple CMask

AllSky RTV on original Ra MAIA CMask

RTV C IASI Retrieval: 20070521000257Z Humidity [g/kg] at 496.63 mbar



Clear RTV on CC Rad Clear RTV on original Rad

IASI CC Retrieval: 20070521000257Z Humidity [g/kg] at 496.63 mbar

RTV D





Retrieval on original, cloud-cleared and noise filtered cloud-cleared radiances Humidity at 700 hPa

RTV A

IASI Retrieval: 20070521000257Z Humidity [g/kg] at 706.565 mbar



RTV B





AllSky RTV on original Rad Simple CMask

AllSky RTV on original Rad MAIA CMask

RTV C IASI Retrieval: 20070521000257Z Humidity [g/kg] at 706.565 mbar



Clear RTV on original Rad

IASI CC Retrieval: 20070521000257Z Humidity [g/kg] at 706.565 mbar

RTV D

Clear RTV on CC Rad



Retrieval on original, cloud-cleared and noise filtered cloud-cleared radiances Temperature at 500 hPa

RTV A

IASI Retrieval: 20070521000257Z Temperature [K] at 496.63 mbar



IASI Retrieval: 20070521000257Z Temperature [K] at 496.63 mbar

RTV B



240

AllSky RTV on original Rad Simple CMask

AllSky RTV on original Rad MAIA CMask

RTV C IASI Retrieval: 20070521000257Z Temperature [K] at 496.63 mbar



Clear RTV on original Rad

IASI CC Retrieval: 20070521000257Z Temperature [K] at 496.63 mbar

RTV D



Clear RTV on CC Rad



Retrieval on original, cloud-cleared and noise filtered cloud-cleared radiances Temperature at 700 hPa

RTV A

IASI Retrieval: 20070521000257Z Temperature [K] at 706.565 mbar



AllSky RTV on original Rad Simple CMask

> **RTV C** IASI Retrieval: 20070521000257Z Temperature [K] at 706.565 mbar



Clear RTV on original Rad

RTV B



AllSky RTV on original Rad MAIA CMask

> **RTV D** IASI CC Retrieval: 20070521000257Z



Clear RTV on CC Rad



ECMWF

ECMWF Analysis: 20070521000257Z

Temperature [K] at 706.565 mbar

Clear RTV on CC NF Rad

250

260

255

280

275

270

265

260

Impact of the Cloud mask on the Retrieval RMS and Mean of differences

'AllSky RTV_cldmask1f minus RTV_maiaCM'

RTV A minus B 10 100 0.1 -- Bias RMS 0.5 200 50 Pressure [mbar] Pressure [mbar] Pressure [mbar] 5 300 100 10 400 50 500 100 600 500 700 800 500 900 1000 🖵 -0.5 1000 1000 E -0.1 2 Π 0.5 Ο 0.1 0.2 Temperature Error [K] Ozone RMS Error [ppmv] Humidity Error [g/kg]

RMS (solid) and Mean (dashed) of RTV differences



RMS (solid) and Mean (dashed) of **RTV** differences

RMS and Mean of RTV differences



RTV_CC_NF... clear RTV on noise-filtered CC radiances

MAIA Cloud Detection, IASI/AVHRR Cloud Clearing & Their Impact on Sounding Retrieval Summary

➢MAIA is used to assist the clear/cloud mask of IASI IFOV using IASI level 1C Cluster information of AVHRR (Mean & STD).

DECMWF/Met France NWP model inputs is modified to accept NCEP model analysis.

> Preliminary result demonstrates the utility of the cloud-clearing for

Cloudy channel determination

□Initial cloud-cleared radiance retrieval

≻Clouds mask and cloud-cleared radiances are to be used in the study of cloudy sounding and cloud property retrieval performance.