# Detection of clouds and aerosols over land and sea by day and night from hyperspectral observations in the thermal infrared


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## Introduction

The determination of clear/cloud flag is a prerequisite for many applications related to the interpretation of radiances measured by infrared sounders in terms of geophysical variables through inverse radiative transfer models. Here, we present a detection scheme specifically dedicated to high-spectral-resolution infrared sounders such as the IASI instrument that aims at detecting both cloud and aerosol contamination in radiances.

## Methodology

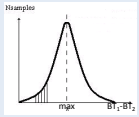
The detection scheme discriminates between 5 situations: high clouds (cirrus), middle clouds, low clouds, aerosols and clear-sky.

It is based on nine tests for which histograms of BT differences of selected channels having different response to clouds and aerosols are first derived from the observations; then threshold tests values are applied.

Computation of histograms:

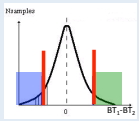
$$\Delta BT^{test\ i} = BT^{i}_{channel\ 1} - BT^{i}_{channel\ 2}$$

- for each test (2 channels).
- over 3 months, centered on the month.
- for each angle of view (15 angles).
- for various configurations: land (northern and southern hemispheres), sea, day, night.
- over land: for several emissivity clusters (Capelle et al. 2012)).




Computation of monthly histogram peaks

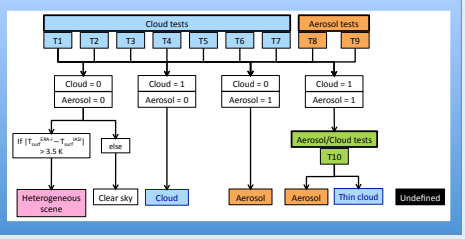
Determination of constant thresholds for the centered histograms over sea/land/desert



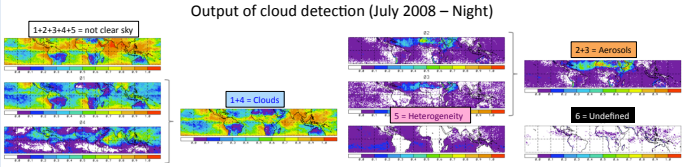

**Detection of CLOUDS or AEROSOLS**

**10 tests (couples of IR/IR or IR/MW channels) :**

- **7 tests** to detect clouds (high, middle and low) .
- **2 tests** to detect aerosols.
- **1 test** to discriminate clouds from aerosols when both are detected.




Output of cloud detection (July 2008 – Night)

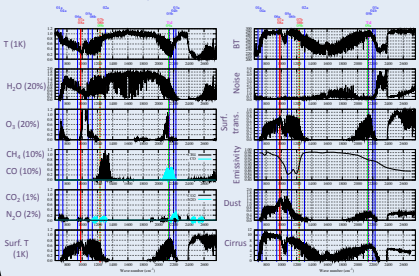



## Channel selection

Channels are selected based on their sensitivities to atmospheric and surface variables. For **high and middle clouds**, use is made of differences between infrared and microwave channels (IASI-AMSU), the latter being ~not sensitive to clouds. For **low clouds** and **aerosols**, use is made of difference between IASI channels located at 10, 8 and 4 µm

| Tests | Channels 1-2 Index | Channels 1-2 ω ($cm^{-1}$) | Channels 1-2 λ (µm) | Pmax (hPa) ≈ | Hmax (km) ≈ | Detection Kind | |
|---|---|---|---|---|---|---|---|
| 1 | 0193 - AMSUA8 | 693,00 - AMSUA8 | 14,4 - A8 | 150 | 13,7 | H-Clouds | |
| 2 | 2634 - AMSUA6 | 1303,25 - AMSUA6 | 7,7 - A6 | 450 | 6,4 | H-Clouds | |
| 3 | 6343 - AMSUA5 | 2230,50 - AMSUA5 | 4,5 - A5 | 700 | 3,0 | H/M-Clouds | |
| 4 | 0404 - 0222 | 745,75 - 2209,25 | 13,4 - 4,5 | 850 | 1,5 | H-Clouds | H-Clouds |
| 5 | 1738 - 5995 | 1079,25 - 2143,50 | 9,3 - 4,7 | 950 | 0,5 | H-Clouds | L-Clouds |
| 6 | 1177 - 1953 | 939,00 - 1133,00 | 10,6 - 8,8 | 950 | 0,5 | H-Clouds | L-Clouds |
| 7 | 1341 - 2349 | 980,00 - 1232,00 | 10,2 - 8,1 | 950 | 0,5 | Aerosols/H-Clouds | |
| 8 | 1335 - 2362 | 978,50 - 1235,25 | 10,2 - 8,1 | 950 | 0,5 | Aerosols/H-Clouds | |
| 9 | 5957 - 2357 | 2134,00 - 1234,00 | 4,7 - 8,1 | | | Aerosols | Clouds |

**•Sensitivities of IASI channels to various atmospheric and surface components (averaged over the whole TIGR tropical situations) and channel locations**




For each channel and each TIGR situation, we compute the variation of BT (in K) obtained for a given variation of one atmospheric variable using the Jacobians computed by 4A/OP-2012 (*Scott and Chédin*, 1981) and the last version of GEISA (*Jacquinet-Husson* et al., 2011).

$$\Delta T_B(T) = \sum_{nl=1}^{nl+42} \frac{\partial T_B}{\partial T}(nl) * \Delta T(nl) \quad \text{for T}$$

$$\Delta T_B(q_{gas}) = \sum_{nl=1}^{nl+42} \frac{\partial T_B}{\partial q_{gas}}(nl) * \Delta q_{gas}(nl) \quad \text{for a gas}$$

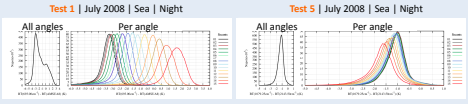
For dust (AOD=0.2 and alt.=2.4km) and cirrus (De=60µm, IWP=0.1 and alt.=7.5km), use is made of 4A coupled to DISORT.

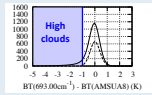
Spectral emissivity is a IASI climatology from Capelle et al. (2012).

Noise is computed at the BT of the scene.

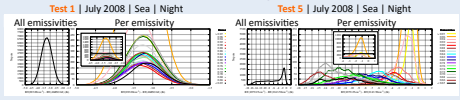
## Histograms and thresholds

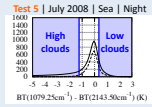
**• Over sea: influence of the scan angle**




**• Over land: influence of the emissivity**

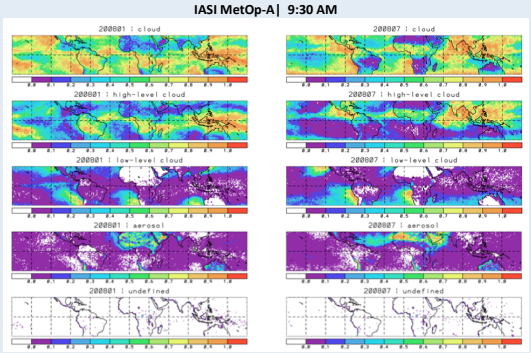


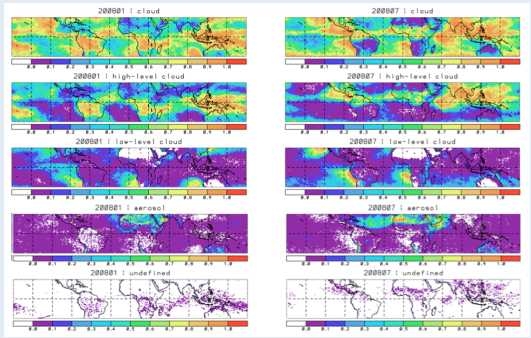

For low clouds and aerosols, use is made of difference between IASI channels located at 10, 8 and 4 µm, which implies taking into account the surface characteristics over land. This is achieved by using the surface emissivity derived from IASI observations (Capelle et al., 2012) and by computing histograms according to the emissivity.

## Results and validation

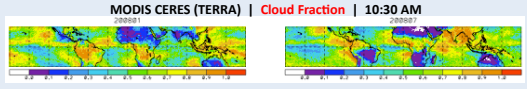
IASI MetOp-A | 9:30 AM



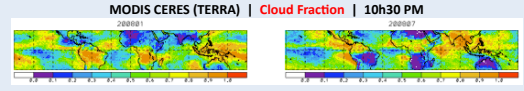

IASI MetOp-A | 9:30 PM



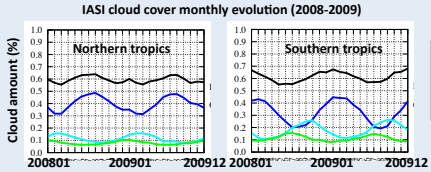

MODIS CERES (TERRA) | Cloud Fraction | 10:30 AM




MODIS CERES (TERRA) | Cloud Fraction | 10h30 PM

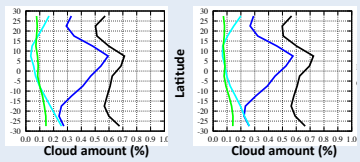



IASI cloud cover monthly evolution (2008-2009)



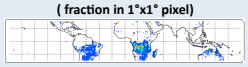

Total Cloud Amount
High Cloud Amount
Mid Cloud Amount
Low Cloud Amount

IASI cloud cover annual latitudinal evolution (2008)

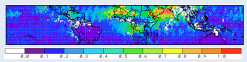



**Detection of dust aerosols (July 2008)**

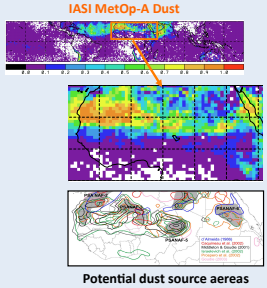
MODIS | Biomass burning ( fraction in 1°x1° pixel)



MISR | Aerosol Optical Depth at 555nm (Green Band)



IASI MetOp-A Dust



Potential dust source aereas (Formenti et al., 2011)