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# RTTOV for hyperspectral IR sounders: Status and future developments

http://nwpsaf.eu/site/software/rttov


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## Introduction

With the launch of AIRS in 2002, the operational assimilation of hyperspectral IR radiances allowed a considerable advance in Numerical Weather Prediction (NWP) models. For example at Météo-France, the three operational hyperspectral IR sounders (AIRS, IASI and CrIS) provide more than 68% of the total number of observations into the French global NWP ARPEGE model and contribute to more than 25% in modifying the assimilation system. The high spectral resolution of these instruments have greatly contributed to improve temperature and humidity profiles sensitivity. To reach operational requirements, the fast RTTOV model is constantly improved through the NWP SAF project. Furthermore, RTTOV makes an effort for being ahead in research developments to support NWP such as surface, clouds and aerosols IR modeling or coefficients generation for past instruments or for future instruments.

## Status

The current version of RTTOV (11.3) allows the simulation of TOA radiances or Brightness Temperatures for hyperspectral IR sounders listed in Table 1. The fast simulations are based on calculations of atmospheric transmittances using instrument-dependent coefficients. These coefficients are generated from:

- A training dataset of 83 diverse profiles of $H_2O$, $O_3$, $CO_2$, $N_2O$, CO, $CH_4$, $O_2$, NO, $SO_2$, $NO_2$, $HNO_3$, OCS, $N_2$, $CCl_4$, CFC-11, CFC-12 et CFC-14
- LBLRTM version 12.2 (AER 3.2 spectroscopic database and MTCKD 2.5.2 for continuum).

3 versions of coefficients are provided on 54 or 101 layers:

- V7: $H_2O$ and $O_3$ are variable gas, other are fixed gas
- V8: $H_2O$, $O_3$ and $CO_2$ are variable gas, other are fixed gas
- V9: $H_2O$, $O_3$,$CO_2$, $N_2O$, CO, $CH_4$ are variable gas, other are fixed gas

| Instrument status | Name | Platform | Spectral range ($cm^{-1}$) | Spectral resolution ($cm^{-1}$) | Spatial resolution (km) | Period | RTTOV Coefficients | Cloud Aerosol |
|---|---|---|---|---|---|---|---|---|
| Old | IRIS-D | LEO | 400 – 2000 | 1.4 | 94 | 1970-1980 | V8/101L | No |
| Operational | AIRS | LEO | 650 – 2674 | 0.5 - 2 | 13 | > 2002 | V7/54L, V7/101L, V8/101L, V9101L | Yes |
| Operational | IASI | LEO | 645 – 2760 | 0.25 | 12 | > 2006 | V7/54L, V7/101L, V8/101L, V9101L | Yes |
| Operational | CrIS | LEO | 650 – 2550 | 0.625 (FR) – 2.5 (RR) | 14 | > 2012 | V7/54L, V7/101L, V8/101L, V9/101L (for RR and FR) | Yes |
| Future | IASI-NG | LEO | 645 – 2760 | 0.125 | 12 | > 2021 | V7/101L, V8/101L, V9/101L | No |
| Future | MTG-IRS | GEO | 700 – 2175 | 0.625 | 4 | > 2021 | V7/101L, V8/101L (Hamming apodization function) | No |

Table 1. Caracteristics of hyperspectral IR sounders supported by RTTOV and available coefficients

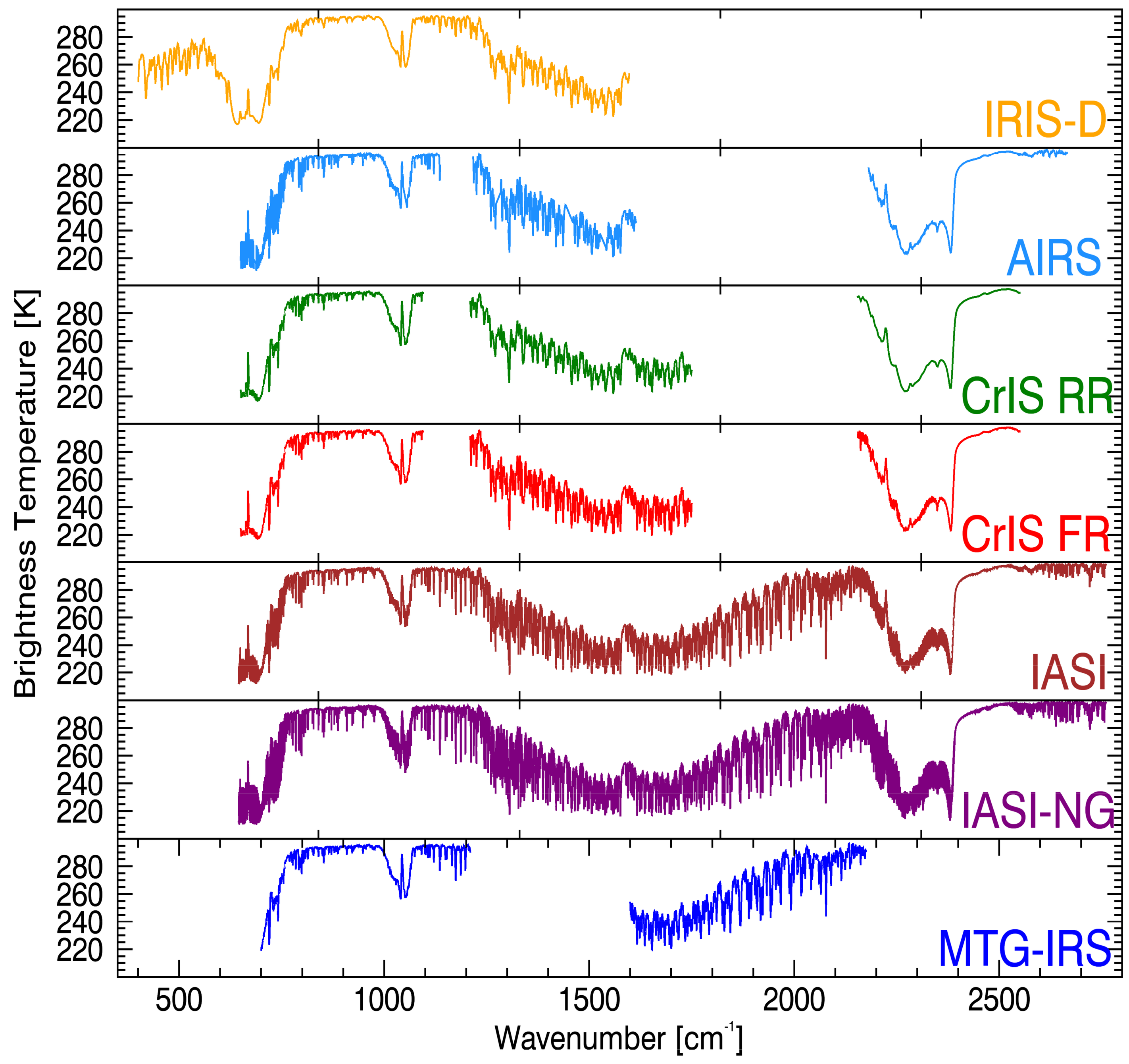


Fig. 1. Typical BT spectra for instruments listed in Table 1 simulated by RTTOV .

## Surface, clouds and aerosols modeling

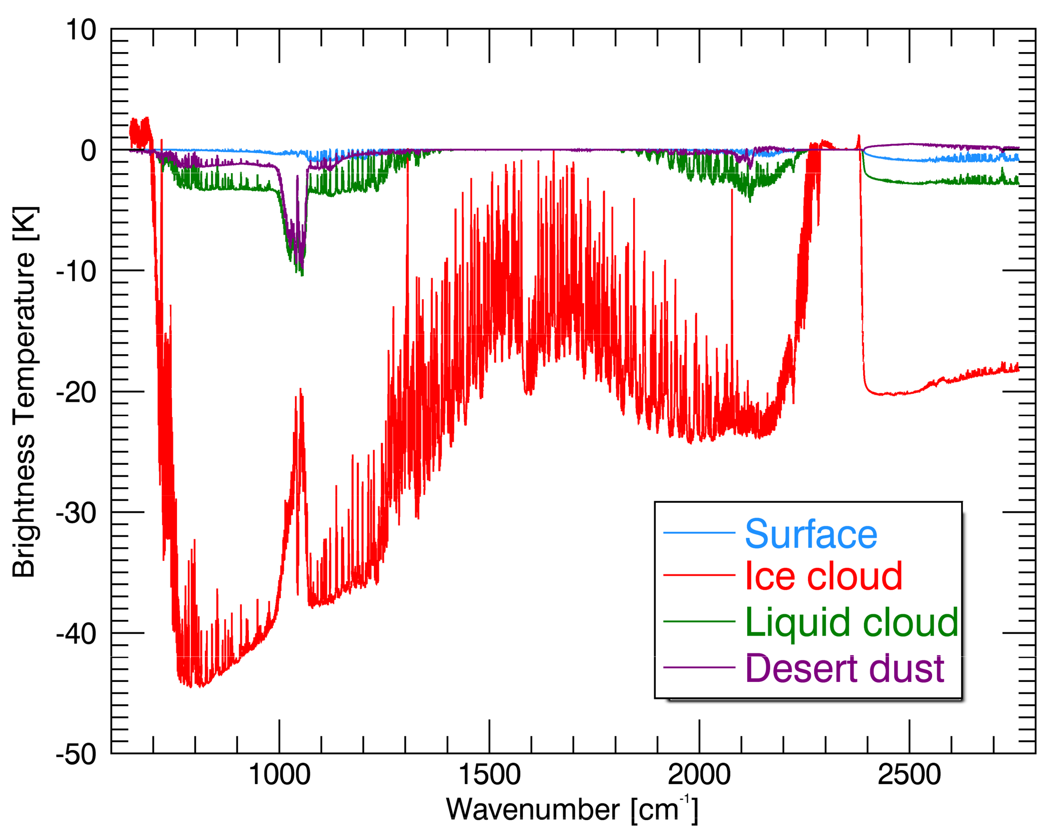


Fig. 2. Typical BT difference spectra for surface, cloud and aerosol effects.

Surface, cloud and aerosol models provided in RTTOV are given in Table 2. Aerosol and cloud scattering are based on the Chou-scaling approximation. The Figure 2 shows IASI-like typical spectra difference between reference spectra (clear-sky and fixed surface emissivity of 0.98) and UWIREMIS atlas (blue), ice cloud (red), liquid cumulus cloud (green) and desert dust (purple).

| Surface | | Cloud | | Aerosol | |
|---|---|---|---|---|---|
| Ocean | Land | Inputs | Models | Inputs | Models |
| ISEM | UWIREMIS | Profile of fractional cover (0-1)<br><br>Profile of liquid Water content (LWC) and ice water content (IWC) in $g.m^{-3}$ | **Liquid phase:**<br>5 models (stratus, cumulus) based on OPAC<br><br>**Ice phase:**<br>11 parameterisations (4 $D_{eff}$ paramétrisations, 2 shapes) and Baran models | Profile of concentration (in $m^{-3}$) | 13 models based on OPAC and in situ measurements: Soot, Sea salt, Mineral, Insoluble, Water soluble, Sulphated droplets, Volcanic ash, Asian dust |

Table 2. RTTOV models for sea and land surface, ice and liquid clouds, and aerosol

## Other capabilities

RTTOV simulations also include the following capabilities:

- Non Local Thermodynamic Equilibrium (NLTE) effect based on CRTM model.

- Solar scattering based on single scattering approximation.

- Principal Component-based simulations (PC-RTTOV).

Examples on IASI-like spectra are shown on Poster S8-88 "Learning from IASI with RTTOV-GUI"

References:


Saunders R, Hocking J, Rundle D., Rayer P, Matricardi M, Geer A, Lupu C, Brunel P, Vidot J. 2013. `RTTOV-11 Science and validation report,` NWPSAF-MO-TV-032, v1.11, 1-31,EUMETSAT NWP-SAF


## Developments for RTTOV 12

The version 12 of RTTOV is planned to be released in December 2016. The new developments for hyperspectral IR sounders will include:

- Adding $SO_2$ as a variable gas: involve predictor definition and create training profiles.
- Adding an option to choose clouds (LWC/IWC or mixing ratio) and aerosols (number density or mixing ratio) units to be in-line with NWP and MACC products.
- Removing old ice cloud parameterisations, only the parameterisation based on the Baran database will remain.
- Updating IR sea surface emissivity model
- Updating IR land surface emissivity atlas (UWIREMIS).
- Interfacing with the radiative transfer model HT-FRTC that includes full scattering model.
- Addressing the variations in $CO_2$, CO, $N_2O$ and $CH_4$ concentration for whole satellite era.
- Adding new PC-RTTOV coefficients (incl. NLTE, all trace gases and aerosols).
- Calculating coefficients for new instruments (i.e., SI-1, CLARREO)