Evaluation of the radiative transfer model
RTTOV-13.0 at ECMWF

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1. Introduction

The use of satellite radiance observations in NWP depends directly on the accuracy of the radiative transfer model, RTTOV (Saunders et al., 2020), developed within the context of EUMETSAT NWP-SAF activity. This study summarises the evaluation in the IFS of the very latest release of the radiative transfer model, RTTOV-13.0 with updated microwave scattering model RTTOV-SCATT and coefficient databases. An overview of the performance of RTTOV-13.0 in the IFS will be presented along with a look at recent harmonization and upgrades of infrared radiative transfer, spectroscopy and trace gas assumptions via the replacement of all RTTOV coefficients for hyperpectral sounders. The evaluation is performed through comparison of radiative transfer simulations with RTTOV-12.2 and through an analysis of departure characteristics against observations. The impact on forecasts is also investigated through a series of assimilation experiments.

Scientific changes from RTTOV-12.2 to RTTOV-13.0 relevant to the IFS include:

• Updates to RTTOV-SCATT (Geer, 2021; Geer et al., 2021), including:
  - New default microphysical configuration;
  - New active sensor capability;
  - Approximate treatment of polarised scattering from oriented ice particles;
  - Reduced minimum cloud fraction threshold;
  - RTTOV-13+ v13 MW Changes to treatment of cosmic MW background radiation in MW simulations;
  - New optical depth coefficient files are available based on an updated optical depth parameterization;
  - New interface allows for an arbitrary number of hydrometeors determined by the “hydrotable” optical property files;
  - IR scattering

2. RTTOV-13.0 assessment in the ECMWF’s IFS

Assimilation experiments were run in the CY47R1 version of the ECMWF system at T6399 resolution (~29 km) over 7 months (20th June to 30th September 2019 and 1st December 2019 to 31st March 2020):

• Control: ECMWF data assimilation and forecasting model with all operational observations and using RTTOV-12.2 and the IFS operational IR and MW coefficient files.

• RTTOV-13.0: Same system configuration as Control, except that RTTOV-13.0 replaced RTTOV-12.2

• RTTOV-13.0 + v13 MW: Same system configuration as RTTOV-13.0, except using the new v13 optical depth parametrisations for all MW sensors.

Results vs Control

• RTTOV-13 + v13 MW and RTTOV-13+ v13 MW have similar impacts to fits in to situ accuracy and humidity from radiosondes and in situ wind observations from radiosondes, profiler, pilot, and aircraft (e.g., Fig. 1-4).

• v13 MW improves fits to temperature and humidity sensitive observations from ATMS and CrIS more than RTTOV-15 (Fig. 1-4).

• Features in the background fits for the all sky sensors: some channels have reduced std. dev. and others increased std. dev. at high frequencies (e.g., 183 GHz) the std. dev. is better; at mid frequencies (e.g., 89 - 157 GHz), increased scattering improved biases as an average but also increased std. dev. (Fig. 1-g).

• Results of the RTTOV-13.0 with updated 13 microwave coefficient files provide generally neutral to positive forecast impact.

3. Infrared Radiative Transfer improvements in the IFS

A third experiment has been carried out, RTTOV-13 + v13 MW + IR: same configuration as RTTOV-13 + v13 MW, but using harmonized infrared coefficients trained with the state-of-the-art line-by-line calculations (LBLRTM-2.0), a new fast transmittance scheme for variable trace gases and more vertical layers.

3.1. RTTOV-13 + v13 MW + IR

- A new fast transmittance model for variable trace gases has been developed.
- Improved first-guess fits to background observations and significant positive forecast impact.
- The new v13 coefficient databases for the infrared sensors trained with LBLRTM 12.8, also available with RTTOV-13.0, have been evaluated in passive monitoring runs. Results from these initial experiments are encouraging and are documented in Hocking et al. (2021).

3.2. RTTOV-13 + v13 MW + IR and Control

- RTTOV-13.0 with updated 13 MW coefficient files are considered for submission in CY48R1 of the IFS configuration for operational implementation in 2022. Results from experiments in the ECMWF operational NWP system are positive, showing similar or reduced background standard deviations with the RTTOV-13 and the new v13 MW predictors coefficient files for a variety of microwave and infrared sensors; positive impact on forecast scores;
- The new v13 coefficient databases for the infrared sensors trained with LBLRTM 12.8, also available with RTTOV-13.0, have been evaluated in passive monitoring runs. Results from these initial experiments are encouraging and are documented in Hocking et al. (2021). Further examinations are needed to assess the impact of using the IR coefficients based on the new v13 predictors and evaluate their benefit in an assimilation context.

4. Summary

- Upgrade and harmonization of infrared radiative transfer, spectroscopy and trace gas assumptions in the IFS via replacement of all RTTOV coefficients for hyperspectral sounders. This has resulted in a better fit to background observations and significant positive forecast impact.
- Changes were submitted to IFS CY47R1 - planned to become operational in October 2021
- RTTOV-13.0 with updated 13 MW coefficient files are considered for submission in CY48R1 of the IFS configuration for operational implementation in 2022. Results from experiments in the ECMWF operational NWP system are positive, showing similar or reduced background standard deviations with the RTTOV-13 and the new v13 MW predictors coefficient files for a variety of microwave and infrared sensors; positive impact on forecast scores;
- The new v13 coefficient databases for the infrared sensors trained with LBLRTM 12.8, also available with RTTOV-13.0, have been evaluated in passive monitoring runs. Results from these initial experiments are encouraging and are documented in Hocking et al. (2021). Further examinations are needed to assess the impact of using the IR coefficients based on the new v13 predictors and evaluate their benefit in an assimilation context.

References

Geer et al., 2021, Hydrometeor optical properties for microwave and sub-mm radiative transfer in RTTOV v13.0, submitted to GMD.

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