NWP SAF

RTTOV version 12
Product Specification

Version 1.2

25th January 2017

RTTOV Version 12 Product Specification

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 29 June 2011, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, KNMI and Météo France.

Change record				
Version	**Date**	**Author**	**Approved**	**Remarks**
1.0	11/11/2016	JAH		Initial version
1.1	19/12/2016	JAH		Updated after comments by S. Keogh
1.2	25/01/2017	JAH		Updated after DRI

Table of Contents

1. INTRODUCTION 4

1.1 Reference documents 4

2. PURPOSE 4

3. FUNCTIONALITY 4

4. SOFTWARE ORGANISATION 6

5. INPUTS / OUTPUTS 6

6. SYSTEM REQUIREMENTS 7

6.1 Language 7
6.2 Supported platforms 7
6.3 Performance 7
6.4 Interface requirements 7
6.5 Operational and resource requirements 8

7. DOCUMENTATION 8

8. LIST OF REQUIREMENTS 8

1. INTRODUCTION

This document defines the specification for Version 12 of RTTOV, in accordance with the requirements of the NWP SAF. The Product Specification describes the deliverable from the point of view of the user.

1.1 Reference documents

[RD-1] NWPSAF-MO-UD-037 RTTOV v12 user guide
[RD-2] NWPSAF-MO-TV-038 RTTOV v12 Test Plan
[RD-3] NWPSAF-MO-TV-041 RTTOV v12 Science and Validation Report

2. PURPOSE

RTTOV is a fast radiative transfer model for simulating top-of-atmosphere visible, infrared (IR) and microwave (MW) clear-sky and cloudy radiances for downward-viewing space-borne sensors. It is intended for use in NWP data assimilation systems, retrieval applications (for example 1DVAR), generating simulated imagery, reanalysis projects and instrument cal/val activities, among others. It consists of a forward model and associated tangent linear (TL), adjoint (AD) and Jacobian (K) models.

3. FUNCTIONALITY

RTTOV v12 will perform the following functions

Simulations types:
RTTOV v12 will carry out the following kinds of simulations

- RQ-3.1 Visible, IR and MW clear-sky simulations
- RQ-3.2 MW clear-sky simulations treating cloud liquid water as an absorber only
- RQ-3.3 IR simulations with a simple black cloud top at given pressure and with given cloud fraction
- RQ-3.4 Visible simulations with a simple Lambertian cloud top at given pressure and with given cloud fraction
- RQ-3.5 Visible/IR scattering simulations in the presence of aerosols and/or clouds with pre-defined particle optical properties
- RQ-3.6 Visible/IR scattering simulations in the presence of aerosols and/or clouds with user-provided particle optical properties
- RQ-3.7 MW scattering simulations in the presence of cloud and/or hydrometeors (via the RTTOV-SCATT interface)
- RQ-3.8 Principle Component (PC) simulations for hyperspectral IR sounders
- RQ-3.9 Tangent linear (TL), adjoint (AD) and Jacobian (K) calculations will be implemented for all simulation types.

RTTOV v12 will support the following additional features

- RQ-3.10 Simulation of Zeeman effect in high-peaking SSMI/S and AMSU-A channels
- RQ-3.11 Simulation of SSU radiances with correction for varying CO_2 cell pressure in the instrument
- RQ-3.12 Optional inclusion of bias correction for non-local thermodynamic equilibrium effects
- RQ-3.13 Option to treat the surface as a Lambertian reflector
- RQ-3.14 Capability to run simulations with multiple threads using OpenMP

Coefficient input/output:
RQ-3.15 RTTOV v12 will provide subroutines to read RTTOV coefficient files in ASCII, Fortran unformatted ("binary") and HDF5 formats. These will allow a subset of channels to be read from the coefficient files.

RQ-3.16 RTTOV v12 will provide an executable to convert coefficient files between ASCII, binary and HDF5 formats and to optionally extract a subset of channels to a new coefficient file.

RQ-3.17 RTTOV v12 will provide executables to convert RTTOV v10/v11 format optical depth (*rtcoef*) files to and from RTTOV v12 format. These will work with ASCII and HDF5 format files.

Surface emissivity and BRDF:
RQ-3.18 RTTOV v12 will provide internal models for sea surface reflectance and emissivity.

RQ-3.19 RTTOV v12 will provide atlases for land surface BRDF and emissivity which can be used to provide BRDF and/or emissivity values for input to RTTOV.

RTTOV GUI:
RQ-3.20 RTTOV v12 will provide a graphical user interface (GUI) which enables direct and Jacobian (K) model simulations to be performed and the results visualised. The RTTOV GUI will support clear-sky, visible/IR scattering and PC-RTTOV simulations including use of the land surface emissivity and BRDF atlases and will provide a 1DVAR capability.

RTTOV wrapper:
RQ-3.21 RTTOV v12 will provide interfaces so that it may be called from C++ and Python. The RTTOV wrapper will support clear-sky and visible, IR and MW scattering direct and K model simulations, including use of the land surface emissivity and BRDF atlases.

4. SOFTWARE ORGANISATION

The Fortran source code is stored in a number of directories under the *src/* directory. The directories group source files broadly according to function. The following directories are included in the package provided to users:

brdf_atlas	subroutines for accessing the land surface BRDF atlas
coef_io	subroutines for reading/writing coefficient files
coef_io_11	subroutines for converting v12 coefficient files to/from v10/v11 format
emis_atlas	subroutines for accessing the land surface emissivity atlases
gui	subroutines for the Fortran side of the RTTOV GUI
hdf	subroutines for input/output of RTTOV structures and data in HDF5 format
main	core subroutines and modules for RTTOV
mw_scatt	subroutines for the RTTOV-SCATT MW scattering model
mw_scatt_coef	subroutines for generating Mietable files for RTTOV-SCATT
other	ancillary subroutines which may be helpful for users
parallel	subroutines defining the parallel (OpenMP) interface to RTTOV
test	subroutines for testing RTTOV and example code for users
wrapper	subroutines for the Fortran side of the C++/Python wrapper

The compilation process creates a library for each subdirectory in *src/*. Users only need to link against those libraries which are used in their application.

In addition to the Fortran source code the package also contains the Python source files for the RTTOV GUI in the top-level *gui/* directory and the C++ and Python source files and example code for the C++/Python wrapper in the top-level *wrapper/* directory.

5. INPUTS / OUTPUTS

The primary inputs to RTTOV are the atmospheric and surface variables describing the profile to be simulated. These are grouped into the *rttov_profile* structure which is described fully in the User Guide [RD-1].

The *rttov_direct* (direct model) subroutine accepts as input:

- a structure of type *rttov_options* containing options which configure various aspects of the simulation
- an array of type *rttov_profile* containing the input atmospheric and surface data pertinent to the simulation being performed, size [*nprofiles*]
- a coefficient structure pre-populated by calling the *rttov_read_coefs* subroutine
- an array of type *rttov_chanprof* and of containing lists of channels and profiles for every radiance to be simulated, size [*nchanprof*]
- an array of surface emissivities [*nchanprof*]
- a logical array for selecting RTTOV's internal emissivity calculation if true [*nchanprof*]
- an array of surface BRDFs [*nchanprof*]
- a logical array for selecting RTTOV's internal BRDF calculation if true [*nchanprof*]
- optional structures containing optical parameters for visible/IR aerosol and cloud scattering simulations [*nlevels*, *nchanprof*]

The outputs are arrays of:

- surface to space transmittances [*nchanprof*]
- level to space transmittances [*nlevels*, *nchanprof*]
- overcast radiances at each input level [*nlayers*, *nchanprof*]
- overcast radiance from user-specified cloud top [*nchanprof*]
- radiances [*nchanprof*]
- brightness temperatures [*nchanprof*] (not for channels below 3 microns)
- bi-directional reflectance factors (BRFs) [*nchanprof*] (solar-affected channels only)
- PC scores [*npcscores*, *nprofiles*]
- Surface emissivities used by RTTOV [*nchanprof*]
- Surface BRDFs used by RTTOV [*nchanprof*]

6. SYSTEM REQUIREMENTS

6.1 Language

RQ-6.1 RTTOV is written in Fortran 90 and makes use of a few common Fortran 95 features. It is compliant with the Fortran 2003 standard (there are a small number of exceptions to this). The test suite additionally makes use of Perl (v5.6 or later) and Python (v2.7 or later). The RTTOV GUI is written in Python which uses f2py to interface to the Fortran GUI subroutines. The wrapper supports calls to RTTOV from C++ and Python, the latter also using f2py.

6.2 Supported platforms

RQ-6.2 Unix/Linux platform including AIX and Cray. RTTOV is tested with a number of compilers as listed in the User Guide [RD-1]. RTTOV supports parallel processing using OpenMP via RTTOV's parallel interface and is also tested in an operational MPI environment. The full list of platforms/compilers with which RTTOV v12 has been successfully tested is given in the Test Log accompanying the Test Plan [RD-2].

6.3 Performance

RQ-6.3 RTTOV v12 shall be comparable to (or more efficient than) RTTOV v11.3 in speed and memory requirements for equivalent simulations. Comparisons of RTTOV v11.3 and v12 in terms of speed and peak memory usage for a variety of simulation types will be documented in the Test Log accompanying the Test Plan [RD-2].

6.4 Interface requirements

RQ-6.4 The interface to RTTOV v12 will be very similar to that for RTTOV v11. The differences will result from the requirements of new functionality and improvements to the consistency of the interface.

6.5 Operational and resource requirements

RQ-6.5 The core RTTOV v12 calculation routines (*rttov_direct/tl/ad/k.F90* and *rttovscatt/_tl/_ad.F90*) shall be "thread safe" to be able to run on MPP machines.

7. DOCUMENTATION

The following user documentation is included in the RTTOV package:

- *NWPSAF_ReleaseNote_RTTOV12.1.pdf* - summary of the package contents and compilation instructions
- *users_guide_rttov12_v1.0.pdf* - user guide giving full details of how to compile and run RTTOV and how to incorporate it into the user's application
- *rttov_gui _v12.pdf* - user guide for RTTOV GUI
- *rttov-wrapper.pdf* - user guide for the C++/Python interface to RTTOV
- *rttov-test.pdf* - detailed description of the RTTOV test suite
- *rttov-htfrtc_interface.pdf* - user guide for the RTTOV/HT-FRTC interface

8. LIST OF REQUIREMENTS

This section details specific requirements to be addressed in the RTTOV v12 Test Plan [RD-2].

RQ-8.1 RTTOV v12 shall perform all the functions listed in Section 3 of this document (requirements RQ-3.1 - RQ-3.21).

RQ-8.2 The software should be successfully built, following the instructions in the User Guide [RD-1].

RQ-8.3 The software should meet the system requirements listed in Section 6 of this document (requirements RQ-6.1 - RQ-6.5).

RQ-8.4 The various test suite scripts shall run to completion and shall have no unexpected differences relative to the reference results provided.

RQ-8.5 RTTOV v12 will reproduce RTTOV v11 radiances to within expected margins for identically configured simulations. Generally the differences in radiances between v11 and v12 are of the order of hundredths of a Kelvin for identically configured simulations, but in some cases at the very highest zenith angles (e.g. above 75 degrees) one can observe differences of the order of a tenth of a Kelvin. These differences will be documented in the Science and Validation Report [RD-3].