NWP SAF

RTTOV Version 12.3
Release Note

Version 1.3

5th March 2019

RTTOV Version 12.3 Release Note

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 7 December 2016, 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, DWD and Météo France.

Change record				
Version	**Date**	**Author**	**Approved**	**Remarks**
1.0	13/12/16	JAH		
1.1	31/01/17	JAH		Updates after DRI
1.2	04/04/18	JAH		Updates for RTTOV v12.2
1.3	05/03/19	JAH		Updates for RTTOV v12.3

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1. DOCUMENTATION

The following user documentation is included in the RTTOV package:

- *NWPSAF_ReleaseNote_RTTOV12.3* - this document
- *users_guide_rttov12_v1.3.pdf* - user guide giving full details of how to compile and run RTTOV and how to incorporate it into the user's application
- *rttov-quick-start.pdf* - beginner's guide to getting started with RTTOV
- *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

2. MAIN CHANGES

Detailed lists of the changes between RTTOV v12.3, v12.2, v12.1, and v11.3 are given in section 4 of the user guide. The main changes are given below.

Changes between RTTOV v12.3 and v12.2:

Clear-sky/general simulation updates:

- New CAMEL climatology atlas for IR emissivities: emissivity data based on 2000-2016 climatology, improved treatment of snow, and includes emissivity standard deviations computed from multi-year climatology.
- New option to switch between fixed or parameterised effective angle for downwelling radiance with the Lambertian surface option.
- A new specularity profile skin variable has been added which specifies the weighting for a linear combination of specular and Lambertian downwelling radiances with the Lambertian surface option.
- A new subroutine has been added which makes it easy to use scaled copies of the RTTOV reference profiles for optional trace gases in simulations.

Visible/IR scattering simulations:

- MFASIS has been modified to allow for variable water vapour in affected sensor channels (currently applies to SEVIRI 0.8 micron channel) which greatly improves the fit to the training data.
- An updated parameterisation of the Baran ice cloud property database has been added for visible/IR cloudy simulations which is more spectrally consistent and extends the parameterisation to the far-IR.
- A new option *opts%rt_ir%grid_box_avg_cloud* has been added. If false (the default) then input cloud concentrations for visible/IR cloud simulations should represent the concentration of cloud in the cloudy fraction of the layer (the behaviour of previous versions of RTTOV). If the option is true cloud concentrations for visible/IR cloud simulations should be layer grid-box-average values (consistent with RTTOV-SCATT), which is commonly the quantity output by GCMs. This does not affect simulations with explicit cloud optical properties.
- A new executable has been created which enables the generation of custom aerosol optical property files for use with RTTOV.

HTFRTC:

- All RTTOV trace gases may now optionally vary in the simulation; ozone is now optional.
- Options to calculate overcast radiances and simple cloud (as RTTOV does).
- Option to supply emissivities; IR emissivity atlas interface has been updated to work with HTFRTC.
- Support for all RTTOV gas units options, *do_lambertian* option with new *specularity* profile variable, and the *plane_parallel* option.
- Multi-threaded simulations via parallel interfaces enabled.

Technical updates:

- The wrapper has been updated to support the new options, the specularity profile variable, and to enable simulations with user-generated aerosol optical property files.
- The GUI has been updated to support the new code options, the new specularity profile variable, and to enable choice among the available emissivity atlases.

Changes between RTTOV v12.2 and v12.1:

Clear-sky/general simulation updates:

- New option for solar sea surface BRDF model.
- New options for MW cloud liquid water (CLW) absorption calculations: new permittivity parameterisations and new option to perform calculations on user levels.

RTTOV-SCATT:

- New option to carry out calculations on radiances instead of brightness temperatures.
- New optional output structure containing information required to perform all-sky emissivity retrievals. A new subroutine is included which carries out the retrieval calculation.
- New options for CLW permittivity in "Mietable" generation code (same options as for CLW absorption) and updated Mietable files using new recommended option.
- New options for non-spherical particle optical properties in "Mietable" generation code.
- New Mietable file for MetopSG ICI.
- New OpenMP parallel interface to RTTOV-SCATT.

Visible/IR scattering simulations:

- New option to use MFASIS fast visible cloud scattering parameterisation.
- New CLW optical properties parameterised in terms of particle effective diameter.
- Explicit cloud/aerosol optical properties are optionally active variables in the TL/AD/K models.
- New *scaer* files containing optical properties for 9 CAMS aerosol species.

Principal Components simulations:

- New PC-RTTOV coefficients enabling all variable trace gases (except SO2) and aerosol simulations using OPAC aerosol properties.
- The HTFRTC interface has been rewritten to improve performance.

Technical updates:

- Python wrapper is now compatible with both Python 2 and 3. The wrapper has also been updated to enable MFASIS simulations and to work with the new CAMS aerosol species.
- The RTTOV GUI has been updated to enable MFASIS simulations and to work with the new CAMS aerosol species.
- Build system updated to optionally allow compilation against an external LAPACK library.

Changes between RTTOV v12.1 and v11.3:

Visible/IR scattering updates:

- Discrete Ordinates Method (DOM) multiple-scattering solver for clouds and aerosols: there are independent options available for the treatment of scattering for thermal emission and solar radiation.
- Ice optical properties from the SSEC database replace the old Hexagonal/Aggregate ice shapes.
- Baran2014 ice parameterisation extended to visible/near-IR wavelengths.
- New option to supply cloud and aerosol inputs as mass mixing ratios.

Surface emissivity and BRDF updates:

- New MW sea surface emissivity model, TESSEM2, intended for use with ICI.
- New IR sea surface emissivity model including wind speed and Tskin dependency.
- Updated TELSEM MW land surface and sea-ice emissivity atlas (TELSEM2).
- Updated CNRM MW land surface emissivity atlas.
- New IR land surface emissivity atlas (CAMEL).
- More flexible interface to land surface emissivity and BRDF atlases allowing data from different atlases and for different months and instruments to be loaded concurrently.

Other science updates:

- New coefficients available allowing SO_2 as an optional trace gas.
- Updated NLTE correction.
- Updated PC-RTTOV coefficients including the NLTE correction.
- Capability to call the HT-FRTC PC-based RT model through a PC-RTTOV-like interface.

Technical updates:

- The wrapper now exploits the more flexible interface to the emissivity/BRDF atlases. The wrapper also now supports calls to RTTOV-SCATT and visible/IR scattering simulations where the optical properties are explicitly provided to RTTOV.
- The GUI has been updated to support the new capabilities.
- Improved consistency in subroutine interfaces and derived type naming.
- Optimisation of gas optical depth calculation in particular for v9 predictors with all trace gases.
- Doxygen markup has been added to document user-level subroutines and data types.

3. INSTALLATION

Detailed installation instructions are provided in the user guide. A brief overview is given below.

Extraction

The RTTOV v12.3 package is named *rttov123.tar.gz*. This can be downloaded from the NWP SAF website after registering with the site and agreeing to the terms of the license. To unpack, copy the tarball to a new directory (e.g. *~/rttov123/*) which becomes your RTTOV top-level directory, and do the following:

$ tar xf rttov123.tar.gz

Compilation

It is recommended to compile RTTOV against the HDF5 library (v1.8.8 or later) as this provides the ability to read HDF5 coefficient and land surface BRDF and emissivity atlas files, and to use the GUI. In order to do this you must first edit the file *build/Makefile.local* to point to the location of your HDF5 installation. Usually this involves:

- specifying the path to your HDF5 build in HDF5_PREFIX
- uncommenting the FFLAGS_HDF5 definition appropriate to your compiler
- uncommenting the LDFLAGS_HDF5 definition appropriate to your system

To call HTFRTC through RTTOV requires that you compile against the NetCDF4 library: to do this edit *build/Makefile.local* in a similar fashion as for HDF5 above:

- specify the path to your NetCDF build in NETCDF_PREFIX
- uncomment the FFLAGS_NETCDF definition appropriate to your compiler
- uncomment the LDFLAGS_NETCDF definition appropriate to your system

Then to compile RTTOV you can run the interactive script provided:
$ build/rttov_compile.sh

In order to use the RTTOV GUI and/or the RTTOV Python wrapper you must also have f2py installed on your system. The script detects the presence of f2py and provides the option of compiling the Python-related code.

More details including compatible compilers and information on compiling manually are given in the user guide.

Coefficient files and other ancillary data

The RTTOV package contains all optical depth coefficient files available at the time of release excluding those for hyperspectral sounders. By default coefficient files are found in the *rtcoef_rttov12/* directory. You can download the larger coefficient files from the website:
http://nwpsaf.eu/site/software/rttov/download/coefficients/coefficient-download/

These include the hyperspectral optical depth coefficients, the aerosol/cloud coefficient files for visible/IR scattering simulations, the Mietable files for MW scattering simulations and the PC-RTTOV and HTFRTC coefficient files for PC simulations. The user guide provides more

information about the different types of coefficient files. It is not necessary to download all coefficient files: only those relevant to the simulations you are running are required.

Similarly the land surface BRDF and emissivity atlas files are not included in the package due to their size. These can also be downloaded from the website:
http://nwpsaf.eu/site/software/rttov/download/#Emissivity_BRDF_atlas_data

Verifying the build

RTTOV comes with a comprehensive test suite which is described in the user guide and more fully in the *rttov-test.pdf* document. The RTTOV test scripts and data are contained in the *rttov_test/* directory. You can run a basic test to check your installation as follows.

$ cd rttov_test
$ ./test_rttov12.sh ARCH=myarch BIN=myinstalldir/bin

You must provide the name of the compiler flag file you used when compiling RTTOV (e.g. *gfortran-openmp*). If you specified an installation directory when compiling RTTOV you must provide the location of the *bin/* directory created by the build. If you did not specify an installation directory the *bin/* directory is in your top-level RTTOV folder and you do not need to pass the *BIN=* argument to the test scripts.

This script runs several simulations using coefficient files which are provided in the package and checks the direct, tangent linear, adjoint and Jacobian model output against reference data. If the tests report OK then RTTOV has compiled correctly. (You may see some very small differences to the reference data reported, particularly for the Jacobians: these are due to compiler-dependent differences and are not cause for concern).

Several other test scripts that run different kinds of simulations are included in the package. Some of these require additional files to be downloaded from the website. The user guide provides more details.

4. LICENSE

To use this software, users need to have registered for RTTOV with the NWP SAF (http://nwpsaf.eu/), and to have agreed to the terms of the RTTOV license agreement.

5. PACKAGE CONTENTS

The contents of the package are as follows:

```
ReleaseNote.pdf
docs/
docs/doxygen_config_dev
docs/doxygen_config_user
docs/NWPSAFLogo_gradient_S.png
docs/NWPSAF_ReleaseNote_RTTOV12.3.pdf
docs/readme_rttov_make_scaercoef.txt
docs/rttov12_svr.pdf
docs/rttov_doxygen_readme.dox
docs/rttov_gas_cloud_aerosol_units.pdf
docs/rttov_gui_v12.pdf
docs/rttov-quick-start.pdf
docs/rttov-test.pdf
docs/rttov-wrapper.pdf
docs/users_guide_rttov12_v1.3.pdf
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build/arch/gfortran
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src/main/rttov_fresnel_tl.F90
src/main/rttov_getoptions.F90
src/main/rttov_global.F90
src/main/rttov_htfrtc_interface_mod.F90
src/main/rttov_init_aux_prof.F90
src/main/rttov_init_auxrad_stream.F90
src/main/rttov_init_ircld.F90
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gui/r1Dvar/r1dvarObjects.py	src/main/rttov_integrate_k.F90
gui/r1Dvar/r1dvar.py	src/main/rttov_integrate_tl.F90
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gui/rcontroller/util.py	src/main/rttov_locpat.F90
gui/README	src/main/rttov_locpat_k.F90
gui/rmodel/	src/main/rttov_locpat_tl.F90
gui/rmodel/config.py	src/main/rttov_math_mod.F90
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gui/rttov/data/SO2.txt	src/main/rttov_opdep_9.F90
gui/rttov/default.py	src/main/rttov_opdep_9_k.F90
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gui/rttovgui	src/main/rttov_opdep.F90
gui/rttov_gui.env	src/main/rttov_opdep_k.F90
gui/rttov_gui_f2py.so	src/main/rttov_opdep_tl.F90
gui/rttov/__init__.py	src/main/rttov_opdpscattir_ad.F90
gui/rttov/kmatrix.py	src/main/rttov_opdpscattir.F90
gui/rttov/kpcmatrix.py	src/main/rttov_opdpscattir_k.F90
gui/rttov/list_of_profile_vars.py	src/main/rttov_opdpscattir_tl.F90
gui/rttov/misc.py	src/main/rttov_opts_eq.F90
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gui/rttov/pccomp.py	src/main/rttov_pcscores.F90
gui/rttov/profile.py	src/main/rttov_pcscores_k.F90
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gui/rttov/transmission.py	src/main/rttov_profaux_ad.F90
gui/run	src/main/rttov_profaux.F90
gui/rview/	src/main/rttov_profaux_k.F90
gui/rview/coeff.py	src/main/rttov_profaux_tl.F90
gui/rview/colors.py	src/main/rttov_reconstruct_ad.F90
gui/rview/console.py	src/main/rttov_reconstruct.F90
gui/rview/helpframe.py	src/main/rttov_reconstruct_k.F90
gui/rview/__init__.py	src/main/rttov_reconstruct_tl.F90
gui/rview/kmatrixframe.py	src/main/rttov_refsun_ad.F90

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gui/rview/kpcmatrixframe.py
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gui/rview/kprofileframe.py
gui/rview/layeritem.py
gui/rview/myunits.py
gui/rview/option_help.html
gui/rview/option.py
gui/rview/pcView.py
gui/rview/profileframe.py
gui/rview/profileframeutils.py
gui/rview/r1dvarprofileframe.py
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rttov_test/run_example_cld_mfasis_fwd.sh
rttov_test/run_example_cld_param_fwd.sh
rttov_test/run_example_fwd.sh
rttov_test/run_example_htfrtc_fwd.sh
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rttov_test/test_emis_atlas.2/*
rttov_test/test_example.1/
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rttov_test/test_example.1/prof_mfasis.dat
rttov_test/test_example.1/prof_pc.dat
rttov_test/test_example.1/prof_rttovscatt.dat
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rttov_test/test_rttovscatt.1/profiles2_fmt
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src/test/rttov_make_cld_profile_inc.F90
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src/hdf/rttov_hdf_rttov_coef_pcc1_io.F90
src/hdf/rttov_hdf_rttov_coef_pcc2_io.F90
src/hdf/rttov_hdf_rttov_coef_pcc_io.F90
src/hdf/rttov_hdf_rttov_fast_coef_io.F90
src/hdf/rttov_hdf_rttov_nlte_coef_io.F90
src/hdf/rttov_hdf_s2m_io.F90
src/hdf/rttov_hdf_save.F90
src/hdf/rttov_hdf_skin_io.F90
src/hdf/rttov_hdf_transmission_io.F90
src/main/
src/main/lapack.f
src/main/Makefile
src/main/mod_rttov_baran2014_icldata.F90
src/main/mod_rttov_baran2018_icldata.F90
src/main/mod_rttov_fastem3_coef.F90
src/main/mod_rttov_fastem5_coef.F90
src/main/parkind1.F90
src/main/rttov_add_aux_prof.F90
src/main/rttov_add_opdp_path.F90
src/main/rttov_add_opt_param.F90
src/main/rttov_add_prof.F90
src/main/rttov_add_raytracing.F90
src/main/rttov_ad.F90
src/main/rttov_alloc_ad.F90
src/main/rttov_alloc_aux_prof.F90
src/main/rttov_alloc_auxrad.F90
src/main/rttov_alloc_auxrad_stream.F90
src/main/rttov_alloc_direct.F90
src/main/rttov_alloc_dom_state.F90
src/main/rttov_alloc_ircld.F90
src/main/rttov_alloc_k.F90
src/main/rttov_alloc_mfasis_refl.F90
src/main/rttov_alloc_opdp_path.F90
src/main/rttov_alloc_opt_param.F90
src/main/rttov_alloc_pccomp.F90
src/main/rttov_alloc_pc_dimensions.F90
src/main/rttov_alloc_phfn_int.F90
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src/main/rttov_alloc_profiles_dom.F90
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src/main/rttov_alloc_raytracing.F90
src/main/rttov_alloc_sunglint.F90
src/main/rttov_alloc_tl.F90
src/main/rttov_alloc_traj_dyn.F90
src/main/rttov_alloc_traj.F90
src/main/rttov_alloc_traj_sta.F90
src/main/rttov_alloc_transmission_aux.F90
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src/main/rttov_alloc_trans_scatt_ir.F90
wrapper/ProfileScatt.cpp
wrapper/ProfileScatt.h
wrapper/Profiles.cpp
wrapper/Profiles.h
wrapper/ProfilesScatt.cpp
wrapper/ProfilesScatt.h
wrapper/pyrttov/
wrapper/pyrttov/decorator.py
wrapper/pyrttov/descriptor.py
wrapper/pyrttov_doc/
wrapper/pyrttov_doc/_build/
wrapper/pyrttov_doc/conf.py
wrapper/pyrttov_doc/index.rst
wrapper/pyrttov_doc/library/
wrapper/pyrttov_doc/library/decorator.rst
wrapper/pyrttov_doc/library/descriptor.rst
wrapper/pyrttov_doc/library/index.rst
wrapper/pyrttov_doc/library/option.rst
wrapper/pyrttov_doc/library/profile.rst
wrapper/pyrttov_doc/library/profilescatt.rst
wrapper/pyrttov_doc/library/pyrttov_public.rst
wrapper/pyrttov_doc/library/pyrttov.rst
wrapper/pyrttov_doc/library/rttype.rst
wrapper/pyrttov_doc/Makefile
wrapper/pyrttov_doc/pyrttov
wrapper/pyrttov_doc/_static/
wrapper/pyrttov_doc/_templates/
wrapper/pyrttov_example.py
wrapper/pyrttov/__init__.py
wrapper/pyrttov/option.py
wrapper/pyrttov/profile.py
wrapper/pyrttov/profilescatt.py
wrapper/pyrttov_rttovscatt_example.py
wrapper/pyrttov/rttype.py
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wrapper/rttov_cc_interface.h
wrapper/rttov_c_interface.h
wrapper/Rttov_common.h
wrapper/Rttov.cpp
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wrapper/RttovSafe_example.cpp
wrapper/RttovSafe.h
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wrapper/RttovScatt.h
wrapper/RttovScattSafe.cpp
wrapper/RttovScattSafe_example.cpp
wrapper/RttovScattSafe.h
wrapper/Rttov_visirscatt_example.cpp
wrapper/rttov_wrapper_f2py.so
```