Radiance Simulator v4.0 Release Note

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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 September 2021, 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 / changed by	Remarks
0.1	06/01/2025	J. Hocking	First draft
1.0	07/04/2025	J. Hocking	Updates after beta test
1.0.1	11/06/2025	J. Hocking	Updates after DRR

1. DOCUMENTATION

The following documents are relevant to this release. Full instructions on how to install the package are included in the User Guide and also in the `readme.txt` file which can be found in the top level of the package distribution file.

```
NWPSAF-MO-DS-053-RadSim_ProductSpec.pdf
NWPSAF-MO-DS-054-RadSim_TopLevelDesign.pdf
NWPSAF-MO-TV-052-RadSim_TestPlan.pdf
NWPSAF-MO-UD-061-RadSim_UserGuide.pdf
NWPSAF-MO-UD-062-RadSim_ReleaseNote.pdf
```

2. REFERENCING RADSIM

RadSim v4.0 has the following DOI: https://doi.org/10.15770/EUM_SEC_CLM_1008

When citing RadSim it may be described as:

The Radiance Simulator is an operational product developed and distributed by the EUMETSAT Satellite Application Facility for Numerical Weather Prediction (NWP SAF) and can be downloaded from https://nwp-saf.eumetsat.int/.

3. CHANGES FOR THIS RELEASE

The following list contains details of the changes made between versions 3.2 and 4.0.

RadSim capabilities

- New options *interp_nn_spatial* and *interp_nn_temporal* to select nearest-neighbour instead of (bi)linear for spatial and temporal interpolation to avoid physically inconsistent interpolated profiles and/or cases where interpolation is not so desirable (e.g. cloud fields).

Outputs

- Add a namelist option *write_clearsky* to output clear radiances/BTs/reflectances in addition to the total radiances for hydrometeor scattering simulations.
- When *write_geom_height* is true write out heights of both full- and half-levels.
- The output values for *lsm* and *zsurf* are taken from the obs data file when present as these are the values used in the simulations by preference. Previously these were being overwritten by values from the model data (if present) when the *write_profiles* option is true.

NWP model-specific ingest/interpolation capabilities

- Pressure on half-levels is now a mandatory input to RTTOV v14.0. For UM model data, it is strongly recommended that pressure half-levels (rho levels) are present in the input file, but if not then pressure on full-levels (theta levels) must be present and an approximation for the rho-level pressures is made. For ICON model data, either pressure full- or half-levels must be present in the input file. For other model sources, pressure half-levels or full-levels may be present, or otherwise the relevant coefficients are used to compute them from the surface pressure.

- The 2m temperature and water vapour fields are now both optional (controlled by *use_t2m* and *use_q2m* namelist variables).
- For UM fieldsfiles only, enable reading of data for a sub-set of (or specific) forecast time(s) to reduce memory footprint (previously data for all forecast times present in the model data file were always read in).
- For UM model data, enable ingest of RAL3 cloud fields which separate frozen hydrometeors and cloud ice into separate stash codes. These are read into the cloud ice field for input to RTTOV and are summed if both are present in the input model file.
- Enable ingest of aerosol fields from ICON-ART model data files for the aerosol species supported by RTTOV ICON optical property files.
- Enable ingest of the NWP SAF 60L MACC profile dataset (allows variable CO_2 and CH_4, and aerosols using CAMS properties), 60L CAMS profile dataset (allows variable CO and SO_2), and 137L CAMS profile dataset (allows variable CO_2, N_2O, CO, CH_4, SO_2, and aerosols using CAMS properties). In all cases, ingest of fields for hydrometeor scattering simulations is also supported.

RTTOV interface

- RadSim v4.0 is compatible with RTTOV v14.0 and cannot be used with earlier versions.
- Exploit features of RTTOV v14.0:
  - Expose all RTTOV options relevant to RadSim via namelist configuration variables.
  - All namelist variables corresponding to RTTOV options have the same name as the RTTOV options (the new *rttov_verbose* option is the only exception).
  - Scattering simulations for MW sensors are now configured and run in a very similar way to those for IR sensors.
  - Remove features no longer supported (e.g. MFASIS-LUT, HTFRTC).
  - New *multi_surface* config namelist option to enable heterogeneous surfaces. This uses land fraction and sea-ice fraction (where present in the model data file) to account for land, sea, and sea-ice fractions for each simulated profile.
- Add support for Zeeman effect by allowing the magnetic field variables to be specified in the obs data file (an obs data file must be provided when using Zeeman-enabled coefficients).
- RTTOV quality flags are now output in *qcrttov* (previously *qcrttov* contained the RTTOV error status, but this is either 0 (success) or 1 (failure) and is already indicated in *qcflags*). The separate MFASIS *qcflag* bit is no longer set as this is included in the RTTOV quality flags.
- Add a new *rttov_verbose* option to give explicit control over the RTTOV verbosity. Previously the RTTOV verbose option was automatically set to true when *output_mode* was set to 2 or 3.

Technical updates

- Rename some configuration namelist variables to be consistent with the RTTOV naming convention (in particular “emiss” -> “emis” and “coeff” -> “coef”).
- Add option for obs data files in netCDF including optional netCDF file output from *radsim_geo_obs.py* script.

- Make ecCodes an optional dependency: it is now only required when ingesting model data files in GRIB format.
- Enable linking RadSim against an external LAPACK library when RTTOV was compiled against an external LAPACK library.

All bug fixes and updates for RadSim v3.2 listed here have been applied in v4.0: https://nwp-saf.eumetsat.int/site/software/radiance-simulator/radsim-code-updates-and-known-issues/

4. LIMITATIONS AND KNOWN ISSUES

4.1 Limitations

There are some limitations that users should be aware of.

4.1.1 Input files

- Met Office UM data files:
  - The use of packed files is not supported and will not be supported in any future release. The UM *convieee* routine should be used to unpack the data in advance of running the Radiance Simulator. Temporal interpolation is not supported for UM PP files.
- GRIB files:
  - Currently, those originating from ECMWF (including CAMS aerosol fields), from the ICON and ICON-ART models, from the HARMONIE-AROME model, and from JMA are supported. Variations in the way pressure level fields can be stored and in the parameter IDs used for each field, mean that each data source must be supported individually. Support for other sources may be added in future releases based on user requests and the availability of test datasets.
  - The ICON and ICON-ART models use an irregular grid: currently only nearest-neighbour spatial interpolation is supported for these models.
  - Support for JMA datasets is currently limited to clear-sky simulations only. This is due to the test datasets not containing cloud fields. Given suitable test data cloud simulations could be enabled in a future RadSim release.
- NetCDF files:
  - Currently, netCDF files must conform to the standards and format of those generated by the *grib_to_netcdf* tool from the ecCodes library. RadSim therefore supports ECMWF data in netCDF format. Support for other sources may be added in future releases based on user requests and the availability of test datasets.

4.1.2 Processing options

The following processing options are not supported or are otherwise limited. They may be implemented or further developed in a future release:

- Aerosol simulations are supported using CAMS fields only for the nine CAMS species for which optical properties are currently supplied in RTTOV aerosol optical property files.

- Similarly, aerosol simulations are supported using ICON-ART fields only for the seven ICON-ART species for which optical properties are currently supplied in RTTOV aerosol optical property files.

4.1.3 Other capabilities

The following capabilities have certain limitations:

- The footprint simulation capability models footprints as ellipses. This may not be the optimal choice for all types of sensor, for example visible/IR radiometers where pixel footprints are more rectangular.
- The orbit simulation capability is restricted to geostationary satellites.

4.2 Known Issues

The following is a list of known problems that may be addressed in a future release. Please report any additional problems via the NWP SAF helpdesk at https://nwp-saf.eumetsat.int/site/help-desk/

The following are not handled correctly:

- Interpolation of staggered grids. This applies only to the components of the surface wind field which are currently assumed to be coincident with the regular grid. Surface wind is only used for IR/MW sea surface emissivity models (SURFEM-Ocean, FASTEM, IREMIS) and the solar sea BRDF model. This usually has only a minor effect on results and is not an important factor in general for radiance simulation.
- Rotation of vector fields. This applies only to the surface wind field. Affected simulations are those using data from a limited area model with rotated pole and using IR/MW sea surface emissivity models (SURFEM-Ocean, FASTEM, IREMIS) and/or the solar sea BRDF model.

5. PACKAGE CONTENTS

The Radiance Simulator code is distributed in the gzipped tar file

`radsim-4.0.tar.gz`

Contents of the unpacked distribution file are listed below (listing is the direct output from the ls –R command). Instructions on building the code can be found in the `readme.txt` file and in the User Guide.

```
.:
build/
doc/
etc/
radsim_check_install
radsim_install
readme.txt
src/
user.cfg

./build/cfg:
common.cfg
cray-ifort.cfg
gfortran.cfg
ifort.cfg
nagfor.cfg
pgfortran.cfg
xlf.cfg

./build/include:
radsim_alloc_obs.interface
radsim_calc_geo_sat_angles.interface
radsim_calc_icon_plevels.interface
radsim_calc_meto_plevels.interface
radsim_calc_plevels.interface
radsim_calc_solar_angles.interface
radsim_check_ff_packing.interface
radsim_check_fields.interface
radsim_convert_fields.interface
radsim_dealloc_ff_hd.interface
radsim_dealloc_model.interface
radsim_dealloc_obs.interface
radsim_error_report.interface
radsim_esat.interface
radsim_grib_paramid_name.interface
radsim_grid_calc.interface
radsim_grid_init.interface
radsim_grid_rotate.interface
radsim_init_obs_out.interface
radsim_init_rttov_data.interface
radsim_interp_horiz.interface
radsim_interp_index.interface
radsim_interp.interface
radsim_interp_unstructured.interface
radsim_model_to_obs.interface
radsim_model_to_rttov.interface
radsim_print_cfg.interface
radsim_print_grid.interface
radsim_print_ob.interface
radsim_qsat.interface
radsim_read_camsprof137.interface
radsim_read_camsprof60.interface
radsim_read_cfg.interface
```

```
./etc:
nwp_saf_t_test.atm
nwp_saf_t_test.sfc
obsdata_example.txt
obsdata_example_v1.txt
radsim_cfg_basic.nl
radsim_cfg_example.nl
radsim_check_install.nl
radsim-metop_2_amsua-check_install.nc
rtcoef_metop_2_amsua.dat

./src/code/main:
radsim_alloc_obs.f90
radsim_calc_geo_sat_angles.f90
radsim_calc_icon_plevels.f90
radsim_calc_meto_plevels.f90
radsim_calc_plevels.f90
radsim_calc_solar_angles.f90
radsim_check_ff_packing.f90
radsim_check_fields.f90
radsim_convert_fields.f90
radsim_dealloc_ff_hd.f90
radsim_dealloc_model.f90
radsim_dealloc_obs.f90
radsim_error_report.f90
radsim_esat.f90
radsim.f90
radsim_grib_paramid_name.f90
radsim_grid_calc.f90
radsim_grid_init.f90
radsim_grid_rotate.f90
radsim_init_obs_out.f90
radsim_init_rttov_data.f90
radsim_interp.f90
radsim_interp_horiz.f90
radsim_interp_index.f90
radsim_interp_unstructured.f90
radsim_mod_cfg.f90
radsim_mod_constants.f90
radsim_model_to_obs.f90
radsim_model_to_rttov.f90
radsim_mod_functions.f90
radsim_mod_io.f90
radsim_mod_process.f90
radsim_mod_types.f90
radsim_print_cfg.f90
radsim_print_grid.f90
radsim_print_ob.f90
radsim_qsat.f90
radsim_read_camsprof137.f90
radsim_read_camsprof60.f90
radsim_read_cfg.f90
radsim_read_ecprof137.f90
```

```
radsim_read_ecprof137.interface
radsim_read_ecprof60.interface
radsim_read_ecprof91.interface
radsim_read_ff_headers.interface
radsim_read_fieldsfile.interface
radsim_read_grib.interface
radsim_read_maccprof60.interface
radsim_read_model.interface
radsim_read_netcdf.interface
radsim_read_obsdata_check.interface
radsim_read_obsdata.interface
radsim_read_obsdata_nc.interface
radsim_read_obsdata_text.interface
radsim_read_pp.interface
radsim_run_batch.interface
radsim_set_stash.interface
radsim_setup_rttov.interface
radsim_store_stash.interface
radsim_write_netcdf_init.interface
radsim_write_netcdf_model.interface
radsim_write_netcdf_obs_1d.interface
radsim_write_netcdf_obs_nd.interface

./doc:
NWPSAF-MO-DS-053-RadSim_ProductSpec.pdf
NWPSAF-MO-DS-054-RadSim_TopLevelDesign.pdf
NWPSAF-MO-TV-052-RadSim_TestPlan.pdf
NWPSAF-MO-UD-061-RadSim_UserGuide.pdf
NWPSAF-MO-UD-062-RadSim_ReleaseNote.pdf
Test_Log_RadSim4.0.pdf
```

```
radsim_read_ecprof60.f90
radsim_read_ecprof91.f90
radsim_read_ff_headers.f90
radsim_read_fieldsfile.f90
radsim_read_grib.F90
radsim_read_maccprof60.f90
radsim_read_model.f90
radsim_read_netcdf.f90
radsim_read_obsdata_check.f90
radsim_read_obsdata.f90
radsim_read_obsdata_nc.f90
radsim_read_obsdata_text.f90
radsim_read_pp.f90
radsim_readwrite_nf90.f90
radsim_run_batch.f90
radsim_set_stash.f90
radsim_setup_rttov.f90
radsim_store_stash.f90
radsim_write_field_nc.f90
radsim_write_netcdf_init.f90
radsim_write_netcdf_model.f90
radsim_write_netcdf_obs_1d.f90
radsim_write_netcdf_obs_nd.f90

./src/code/utils:
radsim_calc_pz.f90
radsim_calc_wp.f90
radsim_mod_utils.f90

./src/scripts:
radsim_geo_obs.py
radsim_plot_example.py
radsim_run.py
```