Radiance Simulator v3.2 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 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 / changed by	Remarks
0.1	15/01/2021	J. Hocking	First draft
0.2	09/02/2021	J. Hocking	Updates during beta phase
0.3	10/03/2021	J. Hocking	Updates after beta phase
0.4	30/03/2021	J. Hocking	Updates after internal review
1.0	18/01/2022	J. Hocking	Updates for v3.1
1.1	26/07/2023	J. Hocking	Updates for v3.2
1.2	26/07/2023	J. Hocking	Updates after internal review

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-041-RadSim_ProductSpec.pdf
NWPSAF-MO-DS-042-RadSim_TopLevelDesign.pdf
NWPSAF-MO-UD-051-RadSim_UserGuide.pdf
NWPSAF-MO-TV-047-RadSim_TestPlan.pdf
NWPSAF-MO-UD-052-RadSim_ReleaseNote.pdf
```

2. CHANGES FOR THIS RELEASE

The following list contains details of the changes made between versions 3.1 and 3.2.

RadSim capabilities

- The *radsim_geo_obs.py* script now optionally outputs scan line and scan position columns in the output obs data file to aid matchups of simulations to observations.

NWP model-specific ingest/interpolation capabilities

- Unified Model: enable 1.5m specific humidity (stash 3237) as an optional alternative input to existing 1.5m relative humidity (stash 3245) for the RTTOV 2m q input.

RTTOV interface

- RadSim v3.2 is compatible with RTTOV v13.2 and cannot be used with earlier versions.
- New SURFEM-Ocean emissivity model is selected via *fastem_version*=7. This is now the default microwave sea surface emissivity model.
- New *rayleigh_depol* config namelist option (true by default).
- New *opdep13_gas_clip* config namelist option (true by default).
- New *pol_mode* config namelist option (“empirical”/1 by default) and new *rttov_pol_coeff_file* option to optionally specify full path to the pol coef file required for *pol_mode=2* (if unspecified, code assumes this file is in the *rttov_hydrotable_dir* directory and has its unmodified default file name).
- MFASIS-NN model is available via *vis_scatt_model*=4. The directory or full file path to the NN coef file are specified in *rttov_mfasis_nn_dir* and *rttov_mfasis_nn_file* respectively. NB the *run_mfasis* option is now a short-cut to enable MFASIS-NN rather than the look-up-table (LUT) version. MFASIS-LUT may be run by setting *vis_scatt_model=3.*

All bug fixes and updates for RadSim v3.1 listed here have been applied in v3.2: https://nwp-saf.eumetsat.int/site/software/radiance-simulator/radsim-code-updates-and-known-issues/

The following list contains details of the changes made between versions 3.0 and 3.1.

RadSim capabilities

- RadSim v3.1 is compatible with RTTOV v13.0 and v13.1. The latest version of RTTOV is always recommended.
- RadSim can optionally compute satellite zenith and azimuth angles for geostationary sensors. This is activated by the new configuration namelist option *calc_geo_sat_angles*, and calculated angles are for a geostationary sensor above location *geo_sat_lat, geo_sat_lon,* and at altitude *geo_sat_height.*
- Footprint simulations: two new options have been added, *write_footprint_file* and *read_footprint_file,* that each specify a separate netCDF file that can be used to create and subsequently read footprint data for footprint simulations in cases where the observation locations and footprints, and the model grid remain the same between runs such as for GEO sensors. This can speed up subsequent runs.

NWP model-specific ingest/interpolation capabilities

- Enable ingest of ECMWF CAMS GRIB fields including CAMS aerosol species for aerosol-affected simulations.
- ICON: allow optional ingest and use of liquid and ice cloud particle size fields for VIS/IR cloud simulations.
- ICON: add alternative GRIB paramIds for cell latitude/longitude datasets for compatibility with newer versions of ecCodes.
- All GRIB fields except ICON: previously GRIB files had to contain a multi-level field *after* the surface pressure field in order to correctly compute pressure levels from the coefficients stored in the GRIB file. This restriction no longer applies.
- Unified Model: Enable use of bulk cloud fraction (stash 266) if area cloud fraction (stash 265) is unavailable (but area cloud fraction should be used if possible).

Other updates

- The code had the definitions of “validity” and “data” times the wrong way round. This has been addressed in the code, and the contents of the “validity_time” and “data_time” attributes in the output netCDF files are now swapped compared to previous releases. Where they differ, “data time” refers to the analysis time and “validity time” to the forecast time of specific fields.

All bug fixes and updates for RadSim v3.0 listed here have been applied in v3.1: https://nwp-saf.eumetsat.int/site/software/radiance-simulator/radsim-code-updates-and-known-issues/

The following list contains details of the changes made between versions 2.2 and 3.0.

RadSim capabilities

- Enable simulation of satellite footprints: this is done by taking the mean radiance over all grid points that fall within an ellipse of user-specified dimensions around each observation.
- New Python script *radsim_geo_obs.py* to generate obs data files for geostationary sensors.
- New options *write_tskinjac, write_wind10mjac, write_emissjac* to output additional Jacobians for Tskin, 10m wind u/v components, and surface emissivity.
- Option to output channel height assignments consistent with the NWP SAF CADS (Cloud/Aerosol Detection Software) package. Activated by setting the new config namelist variable *cads_height_assign_threshold* to a positive value (usually 0.01) representing the threshold.
- New option *write_geom_height* to output geometric heights of pressure levels calculated by RTTOV.

NWP model-specific capabilities

- Support for ingest of HARMONIE GRIB fields.
- Support for ingest of JMA GRIB files (clear-sky simulations only).
- A new option *use_all_atlas_months* has been added for use with the NWP SAF profile datasets. If enabled, all 12 months of emissivity and/or BRDF atlas data are loaded so that the correct monthly emissivities/BRDFs can be used with each profile. Note that this may require a lot of memory.

RTTOV interface

- The radiative transfer model used for simulations has been updated to RTTOV v13.0 and new features of this model have been exploited (see below). RadSim v3.0 cannot be used with RTTOV v12.
- New configuration namelist variable *rttov_coeffs_options* which can be used to specify additional text in the optical depth coefficient filenames (e.g. “_o3co2” or “_ironly”).
- New configuration namelist variable *ssu_co2_cell_pressure* which can be used to specify the cell pressures when using the SSU PMC shift coefficient files.
- Updated universal gas constant to latest value from NIST consistent with RTTOV v13.
- Remove deprecated RTTOV options *fix_hgpl* and *reg_limit_extrap* and use RTTOV v13 default option values.
- New RTTOV options available: *rayleigh_single_scatt, rayleigh_max_wavelength, rayleigh_min_pressure, dom_rayleigh* (the last only available with cloud scattering, not clear-sky). Also *ice_polarisation* for RTTOV-SCATT.
- Change default VIS/IR cloud ice parameterisation (*ircloud_ice_scheme*) to the Baran 2018 scheme.
- Extend support for RTTOV VIS/IR CLW Deff scheme to all input models by using the RTTOV v13 internal parameterisation of effective diameter (Deff).

- Update the RadSim CLW Deff parameterisation for ICON (using the density field) to be consistent with the RTTOV v13 CLW Deff parameterisation.
- RTTOV-SCATT updates to use the new default NWP SAF hydrotable files. For UM fields, the frozen cloud concentration is assigned to cloud ice since the old “totalice” hydrometeor type no longer exists.
- Implement flux conversion to kg/kg in RadSim for rain/snow (the RTTOV-SCATT flux conversion feature is deprecated). Output rain/snow fields are in kg/kg regardless of input data units (affects NWP SAF profile datasets and UM fields).
- New config variables *default_brdf_land* and *default_brdf_seaice* which can be used to override the RTTOV default land/seaice BRDFs either where the BRDF atlas is not used or where the atlas has no data.

Technical updates

- New configuration namelist variable *output_file* allows optional specification of output file name.
- If *output_file* is unspecified, the default output file name is now based on the data validity time (e.g. the forecast time) of the first set of fields in the NWP model file rather than the nominal validity time (e.g. analysis time).
- The GRIB API library is no longer supported as it is deprecated. RadSim must be compiled against the ecCodes library.
- Updated *radsim_plot_example.py* script to enable plotting diffs of datasets.

Internal/other changes

- The RTTOV option to supply cloud concentrations to RTTOV as layer averages is now used: internal change, this has no impact on outputs.
- Disable ingest and use of individual liquid/ice cloud fractions for VIS/IR cloud simulations as this is not currently a recommended way of running cloudy RTTOV simulations.
- Relative humidities calculated by RadSim are clipped to a minimum value of 0.1% in order to avoid negative values that sometimes occurred in the high atmosphere.

All bug fixes and updates for RadSim v2 listed here have been applied in v3.0:
https://nwp-saf.eumetsat.int/site/software/radiance-simulator/radsim-code-updates-and-known-issues/

3. LIMITATIONS AND KNOWN ISSUES

3.1 Limitations

There are some limitations that users should be aware of.

3.1.1 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 DWD ICON model, from the HARMONIE 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 model uses an irregular grid: currently nearest-neighbour spatial interpolation is used for this, but a more sophisticated interpolation scheme may be implemented in a future release.
  - 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.

3.1.2 Processing options

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

- Use of variable trace gas (CO_2, N_2O, CO, CH_4, SO_2) profiles - but note that the background CO_2 profile used in the simulations can be modified.
- Aerosol simulations are supported using CAMS fields for the nine CAMS species for which optical properties are supplied in RTTOV aerosol optical property files.

3.1.3 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.

3.2 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 (FASTEM, TESSEM2, 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 from a limited area model with rotated pole and those using IR/MW sea surface emissivity models (FASTEM, TESSEM2, IREMIS) and the solar sea BRDF model.

4. PACKAGE CONTENTS

The Radiance Simulator code is distributed in the gzipped tar file

`radsim-3.2.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/
filelist
radsim_check_install
radsim_install
readme.txt
src/
user.cfg

./build/cfg:
common.cfg
cray-ifort.cfg
gfortran.cfg
```

```
./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_calc_geo_sat_angles.f90
radsim_calc_meto_plevels.f90
radsim_calc_plevels.f90
```

```
ifort.cfg
nagfor.cfg
pgfortran.cfg
xlf.cfg

./build/include:
radsim_calc_geo_sat_angles.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_cfg.interface
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_model.interface
radsim_read_netcdf.interface
radsim_read_obsdata.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-041-RadSim_ProductSpec.pdf
NWPSAF-MO-DS-042-RadSim_TopLevelDesign.pdf
NWPSAF-MO-TV-047-RadSim_TestPlan.pdf
NWPSAF-MO-UD-051-RadSim_UserGuide.pdf
NWPSAF-MO-UD-052-RadSim_ReleaseNote.pdf
Test_Log_RadSim3.0.pdf
Test_Log_RadSim3.1.pdf
Test_Log_RadSim3.2.pdf
```

```
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_cfg.f90
radsim_read_ecprof137.f90
radsim_read_ecprof60.f90
radsim_read_ecprof91.f90
radsim_read_ff_headers.f90
radsim_read_fieldsfile.f90
radsim_read_grib.f90
radsim_read_model.f90
radsim_read_netcdf.f90
radsim_read_obsdata.f90
radsim_read_pp.f90
radsim_readwrite_nf90.f90
radsim_run_batch.f90
radsim_set_fields.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
```