

Radiance Simulator v1.0 Test Plan

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0.1	20/08/2014	A. Smith	Final draft			
0.2	23/09/2014	A. Smith	Updated after beta-testing			
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1 INTRODUCTION

This document defines the Test Plan for the NWP SAF Radiance Simulator in accordance with the guidelines set out in [RD-1]. The aim of the Test Plan is to verify that the requirements of the product specification in [RD-2] are met.

1.1 Reference documents

[RD-1]NWPSAF-MO-SW-002: Development Procedures for Software Deliverables[RD-2]NWPSAF-MO-DS-027: Radiance Simulator Product Specification[RD-3]NWPSAF-MO-DS-033: Radiance Simulator User Guide

2 TESTED ITEMS

The following items are covered as defined in [RD-1]:

- 1. Coding
- 2. Module and Integration tests
- 3. Validation tests
- 4. Portability tests
- 5. Beta testing
- 6. User documentation

2.1 Coding

Code is checked for conformance with appropriate coding standards by a reviewer who is independent of the development process. The majority of the code is written in Fortran-90 with the addition of some features from Fortran-2003. These additional features are supported by most modern compilers and have been approved for use in Met Office operational systems.

2.2 Module and Integration tests

The Radiance Simulator consists of a set of Fortran subroutines and modules which are compiled and linked to a single program unit. Independent module testing is not applicable in this case; all testing is performed as an integrated package.

The standard test procedure is to compile and run the code for a single instrument in a standard (largely default) configuration. The purpose of this is to ensure that the code compiles successfully without warning messages and runs to completion under test conditions. The procedure is repeated using a variety of compilers/platforms (see section on Portability below). Further tests are performed as part of the validation process.

An admin script, not included with the distribution, is used to run the test. It does the following:

1. Run the make_release.pl script to produce the distribution file

make_release.pl is another admin script. It performs two functions - first it generates the compilation instruction set for the installation and then second it packages this up with all the required source code in a distribution file.

2. Transfer the distribution file to the test folder, unpack and install the code

This is to check that the distribution file produced by *make_release.pl*, and which will eventually form the official release, compiles successfully. The default compiler used for this purpose is *ifort*.

3. Run the code with a standard configuration

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The standard configuration is the following

- Input model data: Met Office 32-bit PP file containing analysis fields for 00 UTC on 01/06/2014. The PP file is obtained by converting an operational suite fieldsfile. The Radiance Simulator can read fieldsfiles but the PP file has been chosen as the reference dataset due to its smaller size.
- Satellite instrument: Metop-1(B), AMSU-A, all channels.
- Input observation data: File generated from operational output consistent with the above satellite instrument and model data.
- All other options with default values (see the User Guide [RD-3]) with the exception of clw_data which is switched on (=T in the namelist file) to match the processing applied in the operational system more closely.

Timing tests are also included.

2.3 Validation tests

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The purpose of the validation tests is to check that the main functions of the Radiance Simulator are performing correctly. As described in the Product Specification [RD-2], these are

- Ingest of NWP model fields (several formats)
- Ingest of observation data files
- Interpolation of model fields to observation positions
- Setup and running of the radiative transfer model (RTTOV)
- Writing of results and associated data to an output file

The list of tests to be performed is as follows

1. General validation test

This uses output from the standard configuration integration test (see item 3 in section 2.2 above) and an additional test run substituting MHS for AMSU-A (but in all other



ways identical). Output results from the Radiance Simulator are compared with those obtained independently from the Met Office operational system. If results agree to within an acceptable tolerance where similar processing has been applied then all processing steps are effectively validated.

2. 64-bit PP file test

Configuration identical to the AMSU-A component of test 1 but using the 64-bit equivalent PP file. Results are compared with those from test 1. Note that this test is included for completeness but from version 9.0 of the UM, 64-bit files should no longer be used.

3. Fieldsfile test

Configuration identical to the AMSU-A component of test 1 but using the equivalent Fieldsfile. Results are compared with those from test 1.

4. GRIB file test

Technical test for simulation from a GRIB file. The test file is one from ECMWF containing 80400 data points. Other configuration options:

- Satellite instrument: Metop-1(B), AMSU-A, all channels.
- No input obs data (not available)
- 5. NWP SAF 60L profiles + IR scattering code

Technical test for simulation from the NWP-SAF 60L profile set (13495 profiles). Also tested is the use of the IR scattering code with the HIRS instrument.

6. NWP SAF 91L profiles + MW scattering code

Technical test for simulation from the NWP-SAF 60L profile set (5000 profiles). Also tested is the use of the MW scattering code with the AMSU-A instrument.

7. Miscellaneous options test

The AMSU-A component of test 1 is rerun with all output control options switched on with the exception of ozone Jacobian production which is not available as there are no ozone profiles in the test file. Output brightness temperatures are checked against the control. This verifies that the use of RTTOV-K code to perform the same simulation is setup correctly and confirms whether the additional requested variables are written out successfully.

8. Heavy load test

This is similar to the general validation test but using IASI. Different output options are tried to test the limits.



2.4 Portability tests

This is a run of the standard configuration (integration) test for each of the supported compilers and platforms. These are

- *ifort* on Dell i686 (Linux)
- pgfortran on Dell i686 (Linux)
- gfortran on Dell i686 (Linux)
- *xlf* on IBM Power7 (AIX)

The compiler used for validation testing (ifort) is defined as the control. Results from the other tests are cross-checked against the control run. Specifically, the output brightness temperatures from each of the test runs should be near-identical to those of the control (making allowances for rounding error).

Beta testers using different systems will be invited to submit reports on compilation and performance.

2.5 Beta testing

Beta testers are instructed to test the compilation and execution of the package on their own platform and operating system. The specific test to be performed is that of the general validation test (Test 1 in section 2.3). This will help assess ease of use of use of the code and will verify that all main components of the code have run successfully. The same test datasets used in the general validation test will be made available. In addition, testers are asked to critically review the User Guide and other supporting documentation. Where significant bugs are identified, the tester will be asked to re-test the code after changes have been made to confirm satisfactory operation.

Answers to the following questions will be collected and recorded in the Software Development Record

- 1. Is the software installation straightforward?
- 2. What hardware platform, operating system and compiler did you use to build the executable? Did you use a 32-bit or 64-bit system? What versions of external libraries were used?
- 3. Did you encounter any problems building the package on your system?
- 4. How easy was it to set up and run the code? Did you encounter any problems?
- 5. Do you think the results are acceptable?
- 6. Is the User Guide [RD-3] clear and comprehensive?
- 7. Assess whether the overall package meets the requirements of the Product Specification [RD-2].
- 8. Do you have any suggestions for improvements?

2.6 User Documentation



The Radiance Simulator documentation will be reviewed in-house by one or more people not on the development team and externally by beta-testers.

3 REQUIREMENTS TRACEABILITY MATRIX

This section demonstrates how the requirements listed in the Product Specification relate to the test plan.

Table 1: Requirements traceability

Requirement	Testing method	Test plan reference	Comment
8.1 Functionality	Test run	2.3	
8.2 Release Note	Inspection	2.2	
8.3 Compile test / User instructions	Beta-test	2.5	
8.4 Portability	Test run	2.4	
8.5 Accuracy	Test run	2.3	

4 TEST RESULTS

The following checklist summarises the tests performed and outlined in the document. Timing results are indicative only.

INTEGRATION/PORTABILITY TESTING					
Compiler Platform	Date tested	Outcome			
Complier, Platform		Compile	Run		
ifort, Linux	20/08/2014	OK. No warnings	Control. Time taken = 21s		
pgfortran, Linux	20/08/2014	OK. No warnings	Results identical. Time taken= 61s		
gfortran, Linux	20/08/2014	OK. No warnings	Results identical. Time taken=48s		
xlf, AIX	20/08/2014	OK. No warnings	Results equivalent (see note 1). Time		
			taken=69s		

VALIDATION TESTING						
Test number	Description	Date tested	Outcome			
1	General	20/08/2014	See section 4.1 below			
2	PP file, 64-bit	20/08/2014	Results identical to control			
3	Fieldsfile, 64-bit	20/08/2014	Results similar to control (see note 2)			
4	GRIB file	20/08/2014	Test successful			
5	NWP SAF 60L profiles +	20/08/2014	Test successful			
	IR scattering					
6	NWP SAF 91L profiles +	20/08/2014	Test successful			
	MW scattering					
7	Miscellaneous options	20/08/2014	Results identical to control. Time taken=57s			
8	Heavy load	16/09/2014	See section 4.2 below. Time taken=4585s			

Notes:

- 1. Maximum brightness temperature difference of approx. 0.3×10^{-5} K.
- 2. Maximum brightness temperature difference of approx. 0.11K.



4.1 General validation testing

The general validation test uses Met Office operational NWP system output as the control dataset, but the operational system includes additional processing that is not replicated in the Radiance Simulator. A true like-for-like comparison is not possible but to help get as close as we can, only points that have the same RTTOV surface type identifier are compared (this may differ in a few cases because the operational system uses observation data to help classify surface type). Other points to note about why values may differ are:

- RTTOV-9 is used operationally and with different coefficients
- Fastem-2 is used operationally for microwave surface emissivity
- Interpolated surface fields may differ significantly near coastlines and the sea-ice edge
- Operational processing is done on fixed levels (the 43 RTTOV coefficient levels). The Radiance Simulator runs on model levels which are interpolated to the new 54 RTTOV levels inside RTTOV.

Three microwave channels are displayed in the following histogram plots – a tropospheric temperature sounding channel (AMSU channel-6 from Metop-B), a humidity channel (MHS-3 from Metop-B) and a window channel (AMSU channel-1 from Metop-B).

AMSU-6 results are all within 0.2K and the majority within 0.1K of the operational system. For MHS-3 the vast majority are within 1K and most within 0.4K. The results for AMSU-1 show more variation and in a few cases some large differences, most likely due to a combination of the above factors.



amsua channel 6 brightness temp diff (K): control-test



amsua channel 1 brightness temp diff (K): control-test



mhs channel 3 brightness temp diff (K): control-test

4.2 Heavy load test

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Successful runs have been performed with IASI (all channels) in the otherwise standard configuration but switching on Jacobian or transmittance output and occasionally emissivity output resulted in failure due to lack of virtual memory. This is a system dependent failure – on some systems it may be possible to use these options but it is not envisaged that users will require these when running with a full set of channels for a whole simulated orbit. It also failed when simulating on the global model grid instead of the smaller set of observation positions. This does not mean however that simulations cannot be done for IASI in a non-standard configuration. If a simulation in any configuration fails, users may always try running the code with subsets of channels and merging the results later.



4.3 Beta testing

Below is the post-testing summary from Reima Eresmaa (sent by email). Only minor changes were considered necessary to documentation and code. These have all been addressed. A problem was found with the initial installation but this was resolved following an email exchange and then sending a replacement distribution file to test the prescribed fixes.

I have looked at your simulator in more detail now and I think it runs as expected on my system. I was able to run the general validation test as outlined in the test plan and got reasonablelooking histograms out from the python script (see the attached output files). I am not sure what is an acceptable tolerance here. To me the departures look quite small, with a possible exception of AMSU-A channel 14. It might be that I am using a different set of rttov coefficients that explains most of the differences.

I noticed that the simulator requires specific liquid water content to be included in the input GRIB file even if clw_data, run_scatt and ir_addclouds are all set to false. Is this intentional? I understood from the user guide that this should not be the case.

Another minor issue that I found is that satid=0 is currently not allowed. I think it should be, as one might want to simulate ATMS and/or CRIS radiances from the Suomi NPP satellite.

I also have a couple of suggestions and typo-type corrections to the user guide:

-Please note that the 91L profile dataset contains vertical profiles not from analyses but short-range forecasts (I am not sure if this is the case in the 60L dataset as well).

-In Section 4.3, it is not fully obvious which ones of the required fields are surface fields and which are to be provided on model levels.

-In Section 2.3, the name of wrapper routine appears bin/run_radsim in one place but it should be bin/radsim_run consistently.

-Table of contents contains extra text that I guess is not meant to be there (between entries 3 and 4).

-In the description of input data variables in Section 4.1, a reference is made to section 3.3 while it should be to 4.3 (model datafile).



Finally, my answers to the list of questions to beta testers are as follows.

1. The software installation is straightforward.

2. I used a 64-bit system and pgfortran compiler on a SUSE Linux (Intel) computing platform. Versions of the external libraries are GRIB API 1.13.0, NETCDF 4.2, RTTOV 11.1, HDF5 1.8.9

3. At first attempt there were issues in the installation step, but these were successfully solved and the updated version of the package installed smoothly.

4. Running the code is easy.

- 5. Yes, I think the results are acceptable.
- 6. The user guide is clear and comprehensive.

7. The overall package meets the requirements outlined in the product specification.

8. See above for some minor suggestions and corrections. Also, depending on the planned time frame of the initial and subsequent releases, one might at some point want to consider preparing for the availability of another ECMWF profile dataset (on 137 levels): this is going to come out within a couple of months from now.