

NWP SAF

NWPSAF 1D-Var Test Plan

Version 1.1.1

22nd June 2018

NWP SAF 1D-Var Test Plan

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.

Copyright 2014, EUMETSAT, All Rights Reserved.

Change record			
Version	Date	Author/changed by	Remarks
0.1	17/02/14	P. Weston	First version, based on Met Office 1D-Var test plan
0.2	21/05/14	P. Weston	Updated after testing of NWPSAF 1D-Var v1.0 beta
0.3	29/05/14	P. Weston	Updated with new header, new document ID, new copyright statement and changed font following comments from B. Conway
0.4	13/06/14	P. Weston	Updated after comments from D. Faucher
1.0	22/08/14	P. Weston	Version valid for NWPSAF 1D-Var v1.0
1.1	21/02/17	F. Smith	Version valid for NWPSAF 1D-Var v1.1
1.1.1.	22/06/18	S. Havemann	Version valid for NWPSAF 1D-Var v1.1.1. Updated following a bug fix in the liquid water path calculation. Further updated following comments from S. Keogh

Table Of Contents

Table of Contents

1	INTRODUCTION	4
2	TESTED ITEMS	4
2.1	Module testing	4
2.2	Integration and validation tests	4
2.3	Portability testing.....	5
2.4	Backwards Compatibility	5
2.5	Comparison with NWPSAF Radiance Simulator	6
2.6	Beta testing.....	6
3	REQUIREMENTS TRACEABILITY MATRIX	7
	APPENDIX A - NWP SAF 1DVAR V1.1 BETA TESTING.....	8

		<h1>NWPSAF 1D-Var Test Plan</h1>	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
---	---	--------------------------------------	---

1 Introduction

Version 1.1 of the NWPSAF 1D-Var is very similar in scope to Version 1.0. The main features added at this release are

- Support for RTTOV-12 (see Product Specification Section 7)
- Support for the use of PC-RTTOV (see Product Specification Section 7), and the use of PC Score observations
- Support for the use of Radiance observations
- Extra diagnostic output files, including Averaging Kernels (addressing a request via the NWPSAF Helpdesk, ticket PWjhKnDq7).

Additionally, the code has been partially restructured to aid maintenance, and the interface routines to old, unsupported RT models have been removed. The restructuring does not affect the output of the 1D-Var.

All unsupported RT models have been removed from the code. The supported RT models are now RTTOV 11.3 and RTTOV 12.

The GUI provided at the last release has been retired, after consultation with users and as agreed by the steering group, because the functionality has been replaced by the RTTOV GUI.

A bug in the liquid water path calculation was found in Version 1.1 which has been now fixed. The fixed version is released as Version 1.1.1 together with new test data which have been generated for the affected tests. The specifics relating to the release of Version 1.1.1 are described in the last two paragraphs of section 2.2.

2 Tested Items

2.1 Module testing

Modules are tested through visual line-by-line inspection of code and, where there is doubt, through the temporary output of variable values.

2.2 Integration and validation tests

The code is compiled and must do so without warning messages other than those that are explained in the readme.txt file and the User Guide that accompanies the code. Consistency between programming units is ensured at compile time through the explicit use of interface blocks.

Sets of test retrievals are run using example simulated observations from ATOVS, ATMS, AIRS, IASI, CrIS and SSMIS. These observation files are distributed with the deliverable. Test scripts are included with the software package (as described in the User's Guide). Reference output from test runs is stored in the Sample_Output_RTTOVxx Subdirectories. The tests may be easily run through executing the supplied shell scripts (WorkDir/Run_1DVar_test.ksh and similar).

		<h2>NWPSAF 1D-Var Test Plan</h2>	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
---	---	--------------------------------------	---

Note that a bug was found in the version 1.1., which has been fixed in this release (version 1.1.1). It affected microwave retrievals that included the liquid water path.

In the 1DVar source code file NWPSAFMod_LiquidWater.f90 the order of the arguments to the function Layers_to_LWP was incorrect (i.e. different to that of the calls to this routine from NWPSAF_SetupBackground.f90 and from the routine NWPSAF_Minimize.f90).

All the sample test data distributed with the code for SSMIS_43L (for RTTOV11 / RTTOV12 and ifort / gfortran) were affected by the bug and new sample test data have been generated.

2.3 Portability testing

Test for compilation without errors or warnings and for successful runs (using the above tests) on a variety of different platforms. The package will be tested by the developer on the following platforms:

- NAGWare Fortran 95 compiler Release 5.2(721) on Dell Precision T3500 (Linux)
- Portland Group Compiler Technology Fortran 90 compiler version 11.7 on Dell Precision T3500 (Linux)
- Portland Group Compiler Technology Fortran 90 compiler version 14.6 on Dell Precision T3500 (Linux)
- Portland Group Compiler Technology Fortran 90 compiler version 15.1 on Dell Precision T3500 (Linux)
- Intel Fortran Compiler version 12.0.4 on Dell Precision T3500 (Linux)
- GNU Fortran 90 compiler version 4.4.7 on Dell Precision T3500 (Linux)
- GNU Fortran 90 compiler version 6.2.0 on Dell Precision T3500 (Linux)

N.B. There are warnings internal to RTTOV when compiling on many compilers. A further warning of an unused variable occurs if the user opts to compile with the pre-processing directive EmissAtlas=0 in the makefile.

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

Results of portability testing are summarised in the document nwpsaf-mo-tv-009_portability.pdf

2.4 Backwards Compatibility

Release 1.1 of the 1D-Var is not backwards compatible with 1.0 without modification to the code. This is because

- RTTOV v11.3 has changes in default behaviour with respect to RTTOV v11.1
- Default behaviour of the 1D-Var has been updated to match the better science of RTTOV 11.3 and RTTOV 12 (e.g. better interpolation inside RTTOV; newer emissivity modelling).
- RTTOV v11.1 can no longer be used in the 1D-Var because there are differences in the interface that would create a maintenance overhead.

		<h2>NWPSAF 1D-Var Test Plan</h2>	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
---	---	--------------------------------------	---

The code can be forced to produce results consistent with the previous release by changing various settings throughout the code. During development, the traceability back to the previous version was tested, to confirm that the restructuring of the code has had no effect on the output of the 1D-Var.

With default settings, for ATOVS on 54 vertical levels, the differences between versions 1.0 and 1.1 of the NWPSAF-1DVar are as follows:

- The Background forward-modelled brightness temperatures differ by a maximum of 0.16 K (0.1%) in AMSU-A Channel 1. For channels without sensitivity to surface water vapour, the agreement is exact.
- The Retrieved forward-modelled brightness temperatures differ by a maximum of 0.336 K (0.22%) in HIRS Channel 20 and AMSU-A Channel 1. For channels not affected by the surface humidity (note, through background error correlation, this means all humidity sensitive channels are affected by the surface), the agreement is exact.
- The Retrieved temperature profile differs by a maximum of 0.007 K (0.0025%) in the lower troposphere.
- The Retrieved humidity profile differs by a maximum of 206 ppmv (4.2%) at 786 hPa.

2.5 Comparison with NWPSAF Radiance Simulator

For this release, the forward calculation for a selected background profile was compared with output from the NWPSAF Radiance Simulator for AMSU-A. Differences in behaviour of the two codes can be traced through to different settings in the RTTOV options, and as a result of differences in QC checks on the humidity variables. There was agreement in most channels for default RTTOV12 calculations to within 0.01K.

2.6 Beta testing

Beta testers are instructed to test the compilation and execution of the package on their own platform and operating system. Testers were asked to check the new installation procedure and to review the new functionality (notably the use of PC-RTTOV). In addition, they are asked to critically review the User's 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.

Beta testers also contribute to the Integration & Validation testing by locally running the test scripts provided with the 1D-Var, and thus contributing to the Portability Tests and User Document Tests.

3 REQUIREMENTS TRACEABILITY MATRIX

This section demonstrates how the requirements listed in the Product Specification document NWPSAF-MO-DS-025 relate to the test plan.

Table 2: Requirements traceability

Requirement	Testing method	Test plan reference	Comment
7.1 Release Note completeness	Inspection	N/A	
7.2 Building and linking	Test	2.2	Integration and validation testing
7.3 Compile and run on specified platforms	Test	2.3	Portability testing
7.4 Generic test runs	Test	2.2	
7.5 Use of RTTOV-12	Test	2.2	
7.6 Use of PC-RTTOV	Test	2.2	

		NWPSAF 1D-Var Test Plan	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
---	---	------------------------------------	---

APPENDIX A - NWP SAF 1DVar v1.1 beta testing

In this section, the comments from beta-testers are in *Courier* font.
Responses of the developer to the comments are in *Arial Italics*.

Comments from Peter Weston, ECMWF

Platform: Linux

Compiler: gfortran

Problems identified:

1)

Compilation fails on line 253 of NWPSAF_RTTOV_Initialise.f90:

```
IF (RT_opts(1) % rt_ir % pc % addradrec = .false.) THEN
```

This is acceptable to ifort, but not to gfortran. Line changed to

```
IF ( .NOT. RT_opts(1) % rt_ir % pc % addradrec ) THEN
```

2)

Compiling the code with EmissAtlas set to 0 gives the following error:

```
Warning: rttov_dealloc_coefs.interface:3: Illegal preprocessor directive
```

```
../src/main/NWPSAF_RTTOV11_Interface.f90:411.15:
```

```
path=Atlas_Dir,          & ! in
1
```

```
Error: Keyword argument requires explicit interface for procedure 'rttov_setup_emis_atlas' at (1)
```

```
../src/main/NWPSAF_RTTOV11_Interface.f90:419.15:
```

```
path=Atlas_Dir          ) ! in
1
```

```
Error: Keyword argument requires explicit interface for procedure 'rttov_setup_emis_atlas' at (1)
```

```
../src/main/NWPSAF_RTTOV11_Interface.f90:442.21:
```

```
Emissivity = Surf_Emiss%emis_in ) ! out
1
```

Again, this is compiler-specific, but is solved by adding a pre-processor directive in NWPSAF_RTTOVxx_Interface.f90 to ensure that this block of code is ignored unless compiling with EmissAtlas=1

The first warning message is internal to RTTOV and occurs with most compilers.

3)

Once the code was compiled I tried running the IASI and ATOVS tests but got hit by the same failure each time, the relevant part is copied below:

		NWPSAF 1D-Var Test Plan	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
--	--	------------------------------------	---

```

*** Error in `./NWPSAF_1DVar': free(): invalid pointer:
0x00002b50ce78e120 *** ===== Backtrace: =====
/lib64/libc.so.6(+0x7364f) [0x2b50cf27264f]
/lib64/libc.so.6(+0x78eae) [0x2b50cf277eae]
/lib64/libc.so.6(+0x79b87) [0x2b50cf278b87]
./NWPSAF_1DVar[0x4308ee]
./NWPSAF_1DVar[0x4052cd]
./NWPSAF_1DVar[0x405a94]
./NWPSAF_1DVar[0x405aea]
/lib64/libc.so.6(__libc_start_main+0xf5) [0x2b50cf220be5]
./NWPSAF_1DVar[0x404745]

```

Program received signal SIGABRT: Process abort signal.

Backtrace for this error:

```

#0  0x2B50CE7AAB57
#1  0x2B50CE7AB15E
#2  0x2B50CF23454F
#3  0x2B50CF2344C9
#4  0x2B50CF235957
#5  0x2B50CF272653
#6  0x2B50CF277EAD
#7  0x2B50CF278B86
#8  0x4308ED in nwpsaf_processdata_ at NWPSAF_ProcessData.f90:773
(discriminator 3)
#9  0x4052CC in nwpsaf_1dvar_ at NWPSAF_1DVar.f90:142
#10 0x405A93 in nwpsaf_1dvar_driver at
NWPSAF_1DVar_Driver.f90:187

```

Line 773 of NWPSAF_ProcessData is:

```

IF (ASSOCIATED(RT_Params % TotalRadiances) ) DEALLOCATE(RT_Params
% TotalRadiances)

```

Again, this error is compiler-dependent and can be traced back to a missing NULLIFY statement – the association status cannot be checked with some compilers because the array was not initially nullified. The relevant lines were added to NWPSAF_Read_Observations

4)

The results are not exactly the same as the sample output but are in the same ballpark (maximum differences in the retrieved BTs were 0.5K (~0.2%) for IASI and 0.1K (~0.04%) for ATOVS, however there were similar magnitude differences in the background BTs too!).

		NWPSAF 1D-Var Test Plan	Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018
---	---	------------------------------------	---

The lack of agreement can be traced back to different settings being used for sample data. This has been rectified.

Comments from Tim Hultberg, EUMETSAT

Platform: Linux (64-bit)

Compiler: gfortran v4.8.3

1)

Initial problems were similar to issues 1-3 reported by Pete Weston.

2)

Now I am trying to run the `Run_1DVar_test.ksh` but there seems to be some hardcoded paths

Error: required file

`/data/local/frfh/NWPSAF_1DVar/r1508_HTFRTC_LHR/1DVar/AIRS_COEFFS_D
IR//Bmatrix` does not exist

though I have removed any such dirs from the `Run_1DVar_test` script.

I searched for `r1508_HTFRTC_LHR` in the directory tree and found it in several places both in code and in NL files. I guess I will be able to dig out (though I don't see anything in the documentation) where to change this and move forward. But in any case I think there is something here which does not work optimally.

At this point the coefficients directory required setting in the `ControlData.NL` file, but in order to place the correct contents in the directory prior to running the code, it was also required in the calling script. The requirement to set it in two places was clearly irritating, and was solved by removing it from the namelist. The value is now set in the code by using the fortran command `Get_Environment_Variable`. The same process is used for the output directory name.

3)

Just to let you know that your updated package compiled without any problems on my linux box. Your `run_test` script also worked fine and I got results for all cases except when the coefficient files are in H5 format - in these cases an error of reading the coefs was reported.

These comments referred to the output of `Run_1DVar_test.ksh`

The H5 format problem is due to problems with the local installation of the HDF5 library not working for the reviewer, and nothing to do with the 1D-Var

The remaining comments were received regarding testing with PC-RTTOV:

4)

A request for the User Manual to be in PDF format

<p>The EUMETSAT Network of Satellite Application Facilities</p>	 <p>NWP SAF Numerical Weather Prediction</p>	<p style="text-align: center;">NWPSAF 1D-Var Test Plan</p>	<p>Doc ID : NWPSAF-MO-TV-033 Version : 1.1.1 Date : 22/06/2018</p>
---	--	---	--

The manual has been printed to pdf and this will be included with this release as well as the html file.

Confusion over the naming of the input files when using PC-RTTOV and RTTOV-12.

This confused an internal reviewer also. Coefficient files can be named with more information than `rtcoef_Series_Platform_Instrument.H5` – the `readme.txt` file and `User Manual` have been updated to explain to the user that any extra characters in the file name need to be removed when linking it in to the working directory.

5)

Missing `Run_1DVar_test_PC.ksh`

The file was added to the repository and sent out to beta-testers

6)

Ok, after some renaming [of the coefficient files] it kind of runs, but says that that `ldvar` was not performed because O-B was too high. [Probably this is not what was expected] If I had had some more time I would have tried to find out how to relax the check of initial O-B...

This is a problem with the settings used to generate the PC observation file relative to the settings used in the 1D-Var itself. The observation file has been updated so that it should match with the settings used in the 1D-Var.

Comments from Javier Andrey-Andres, Meteo-France

Platform: Linux, debian stable

Compiler: gfortran 4.9.2

1)

Again, problems 1),2) and 3) reported by Pete Weston, and problems 5) and 6) of Tim Hultberg were also reported by Javier.

2)

I was looking at your `70LBmatrix`. The pressure levels is in Pa instead of hPa. Is the Software able to deal with this change of units?

The Met Office 1D-Var had units of Pa, and the 70L profile files were created for use with the last release of that code. The V1.0 of the NWPSAF 1D-Var used Pa. V1.1 has been updated to accept profiles on either Pa or hPa levels.

Yesterday I got some error from `rttov_checkinput` saying surface pressure not valid.

The code to switch between units had not been correctly applied to the surface pressure field. This was corrected.

3)

Your scripts work perfectly, even using the input files from `rttov 12`. I have not plotted the results to compare them, but the minimization goes ok without problems.