

RTTOV v12.2 Performance Test Log - Appendix to RTTOV v12 Test Plan (NWPSAF-MO-TV-038)

This document describes the tests performed to compare the performance of RTTOV v12.2 with that of RTTOV v12.1. This includes comparisons of execution speed and peak memory usage.

The direct, TL, AD and K models were run separately for the following test cases:

1. MW simulation (ATMS) without interpolation, 54L profile
2. MW simulation (ATMS) with interpolation, 101L profile
3. IR v7 predictor simulation (SEVIRI) with interpolation, 101L profile
4. IR v8 predictor simulation (SEVIRI) with interpolation, 101L profile
5. Visible-only v9 predictor simulation (SEVIRI) with interpolation, 101L profile
6. All trace gas v9 predictor simulation (IASI) without interpolation, 101L profile
7. IR v7 predictor Chou-scaling aerosol simulation (SEVIRI) with interpolation, 50L profile
8. IR v7 predictor Chou-scaling cloud simulation (SEVIRI) with interpolation, 50L profile
9. IR v7 predictor DOM aerosol simulation (SEVIRI) with interpolation, 50L profile
10. IR v7 predictor DOM cloud simulation (SEVIRI) with interpolation, 50L profile
11. Visible-only v9 predictor DOM aerosol simulation (SEVIRI) with interpolation, 50L profile
12. Visible-only v9 predictor DOM cloud simulation (SEVIRI) with interpolation, 50L profile
13. PC-RTTOV simulation (IASI) without interpolation, PCscores only, 101L profile
14. PC-RTTOV simulation (IASI) without interpolation, with reconstructed radiances, 101L profile

The ATMS and SEVIRI coefficients are on 54L and the IASI coefficients are on 101L. In each case the profile surface type was set to sea with *calcemis* and *calcrefl* set to true for all channels. The following options/inputs were used:

- FASTEM6 for MW sea surface emissivity.
- IREMIS for IR sea surface emissivity.
- All trace gas implies the six gases supported by RTTOV v11 (i.e. no SO₂).
- Visible/IR cloud scattering used the OPAC CLW scheme and Baran 2014 ice scheme and used the v12.1 cloud optical property files (the v12.2 files contain additional cloud liquid water optical properties which inevitably increase the memory footprint).
- Visible/IR aerosol scattering used the OPAC optical properties.
- DOM scattering simulations used 8 streams.
- Input units for cloud/aerosol profiles were kg/kg.
- The SEVIRI IR-only and ATMS simulations were run for all channels.
- The SEVIRI visible-only simulations were run for channels 1-3.
- The IASI clear-sky simulations were run for 183 channels.
- PC-RTTOV simulations used the v12.1 NLTE PC coefficient file.
- PC-RTTOV was run with ipcreg 1 (300 predictor channels) and 100 PC scores.
- PC-RTTOV reconstructed radiances were calculated for 300 channels.

All options were selected to make the simulations as similar as possible between v12.1 and v12.2.

1. Speed comparisons

Tests were performed on an Intel desktop (Nehalem) using ifort v17.0.1 and gfortran v4.4.7, a Cray XC-40 (Ivybridge) using the Cray Fortran compiler v8.3.4 and a BULL cluster (Broadwell) using ifort v16.1.150.

The tests were run for a large number of profiles, shown in Table 1.

Test case	Model(s)	Number of profiles
1	direct/TL/AD/K	50000
2	direct/TL/AD/K	50000
3	direct/TL/AD/K	50000
4	direct/TL/AD/K	50000
5	direct/TL/AD/K	50000
6	direct/TL/AD K	5000 1000
7	direct/TL/AD/K	50000
8	direct/TL/AD/K	50000
9	direct/TL AD/K	5000 500
10	direct TL AD/K	5000 1000 50
11	direct/TL AD/K	5000 500
12	direct/TL AD/K	5000 500
13	direct/TL/AD K	1000 100
14	direct/TL/AD K	1000 100

Table 1: Number of profiles used for each timing test.

All tests were run with one profile passed to RTTOV per call and the results are shown in Tables 2 (Intel desktop) and 3 (supercomputer platforms). In addition test case 1 for ATMS was run for 50 profiles per call: the results are shown in Tables 4 and 5. Timings were taken from the test suite and the timing results are shown as *ms per profile*. The colour-coding is as follows:

- green => v12.2 more than 10% faster than v12.1
- yellow => v12.2 5-10% faster than v12.1
- grey => neutral i.e. v12.2 run-time within +/-5% that of v12.1
- orange => v12.2 5-10% slower than v12.1
- red => v12.2 more than 10% slower than v12.1

For v12.2 there has been some optimisation of the v8 optical depth predictor calculations (particularly affecting the K model), the visible/IR cloudy simulations (the impact is only seen for the relatively fast Chou-scaling simulations), and the solar sea surface BRDF calculation for solar-affected channels (particularly affecting the direct model which is run within the TL, AD and K models). The impacts of these updates vary between compilers, but overall v12.2 is generally neutral or faster than v12.1 across all simulation types tested.

PC-RTTOV vs HT-FRTC

Table 6 compares PC-RTTOV and HT-FRTC using ifort v12.0.4 on an Intel desktop. For both models the direct and K runs are simulating 6 profiles in each call and are repeated 5000 and 500 times respectively. The simulations use profiles on 54 levels, request 300 PC scores, and the reconstructed radiance tests request radiances for 300 channels. The PC-RTTOV coefficients used are those from RTTOV v12.1 which allow ozone as the only variable gas, which is the fairest comparison with the current HT-FRTC capability. The HTFRTC implementation in RTTOV v12.1 had significant performance issues: these have been rectified in v12.2 and HTFRTC is now much faster than PC-RTTOV which is expected.

RTTOV interpolator

Tables 7 and 8 show the impact of the RTTOV interpolator on execution time using ifort v12.0.4 on an Intel desktop. The ATMS test with a 54L profile to provide a fair comparison with/without interpolation. Results for each interpolation mode are shown and also results when pressure is an active TL/AD/K variable. (NB Interpolation mode 2 should not be used for TL/AD simulations so these are omitted from the tables - see the user guide). Note that this represents more or less the worst case since for more expensive simulation types the interpolation takes a relatively smaller proportion of the total runtime.

2. Memory comparisons

Peak memory usage was measured using valgrind's massif tool. Tests were performed on an Intel desktop using the gfortran compiler. Table 9 shows the results of the tests. The colour-coding is as follows:

- green => peak memory for v12.2 90% or less than that for v12.1
- yellow => peak memory for v12.2 90-95% than that for v12.1
- grey => neutral i.e. v12.2 peak memory within +/-5% that of v12.1
- orange => peak memory for v12.2 105-110% than that for v12.1
- red => peak memory for v12.2 110% or more than that for v12.1

For the IASI tests the required channels were read in from the full HDF5 coefficient files. The memory usage is dominated by the coefficient reading for these tests as these coefficient files are very large. The IASI tests were repeated after extracting the coefficients for the required channels for each test to separate coefficient files. The results are shown in Table 10.

There is a modest increase in memory requirements (up to 200KB) across all tests reflecting a small amount of additional data being stored in order to implement new capabilities and for purposes of code optimisation.

Test case	Model	Intel gfortran v12.1	Intel gfortran v12.2	Intel gfortran v12.2:v12.1	Intel ifort v12.1	Intel ifort v12.2	Intel ifort v12.2:v12.1
	Direct	0.441	0.436	0.99	0.293	0.283	0.97
1	TL	0.755	0.753	1.00	0.541	0.538	1.00
MW, no interp	AD	0.903	0.913	1.01	0.661	0.657	0.99
	K	1.223	1.22	1.00	0.938	0.925	0.99
	Direct	0.727	0.725	1.00	0.479	0.457	0.95
2	TL	1.217	1.216	1.00	0.84	0.827	0.98
MW, interp	AD	1.493	1.505	1.01	1.007	0.995	0.99
	K	2.063	2.079	1.01	1.389	1.362	0.98
	Direct	0.35	0.351	1.00	0.241	0.241	1.00
3	TL	0.613	0.612	1.00	0.421	0.423	1.00
IR v7 clear	AD	0.738	0.75	1.02	0.503	0.516	1.02
	K	1.008	1.015	1.01	0.707	0.7	0.99
	Direct	0.393	0.368	0.94	0.247	0.259	1.05
4	TL	0.712	0.64	0.90	0.465	0.45	0.97
IR v8 clear	AD	0.899	0.823	0.92	0.558	0.55	0.99
	K	1.557	1.135	0.73	0.864	0.786	0.91
	Direct	0.536	0.537	1.00	0.536	0.38	0.71
5	TL	0.89	0.888	1.00	0.867	0.698	0.81
Visible clear	AD	1.057	1.044	0.99	0.922	0.761	0.83
	K	1.308	1.327	1.01	1.11	0.924	0.83
	Direct	6.884	6.824	0.99	4.328	4.554	1.05
6	TL	11.624	11.506	0.99	7.902	7.726	0.98
All gas clear	AD	13.216	13.31	1.01	9.482	9.348	0.99
	K	40.37	40.47	1.00	30	29.88	1.00
	Direct	0.331	0.331	1.00	0.248	0.244	0.98
7	TL	0.581	0.6	1.03	0.447	0.464	1.04
IR aerosol	AD	0.686	0.712	1.04	0.514	0.531	1.03
Chou-scaling	K	1.041	1.056	1.01	0.8	0.8	1.00
	Direct	0.39	0.386	0.99	0.446	0.41	0.92
8	TL	0.659	0.654	0.99	0.842	0.831	0.99
IR cloud	AD	0.8	0.84	1.05	1.017	0.992	0.98
Chou-scaling	K	1.153	1.141	0.99	1.215	1.081	0.89

Table 2 (continued below): Speed test results, 1 profile per call, Intel desktop. Timings are ms per profile.

	Direct	2.364	2.414	1.02	2.398	2.02	0.84
9	TL	5.79	5.798	1.00	5.892	5.514	0.94
IR aerosol	AD	109.28	110.82	1.01	111.28	111.14	1.00
DOM	K	109.74	112.08	1.02	111.44	110.78	0.99
	Direct	13.806	13.77	1.00	13.528	11.878	0.88
10	TL	33.94	33.61	0.99	34.07	32.23	0.95
IR cloud	AD	861.6	879	1.02	871.4	865.2	0.99
DOM	K	864.6	883.8	1.02	867.2	866.8	1.00
	Direct	4.674	4.754	1.02	4.85	4.008	0.83
11	TL	11.086	11.268	1.02	11.318	10.536	0.93
Visible aerosol	AD	53.18	55.96	1.05	56.82	55.84	0.98
DOM	K	53.44	56.56	1.06	57.24	55.94	0.98
	Direct	6.75	6.77	1.00	6.37	5.708	0.90
12	TL	16.294	16.21	0.99	15.764	14.868	0.94
Visible cloud	AD	51.52	53.36	1.04	55.82	54.84	0.98
DOM	K	51.78	53.48	1.03	56.04	54.84	0.98
	Direct	10.75	10.61	0.99	7.21	7.13	0.99
13	TL	18.57	17.97	0.97	12.8	12.58	0.98
PC	AD	20.36	20.62	1.01	15.27	14.93	0.98
	K	77	76.5	0.99	56.6	56.9	1.01
	Direct	10.84	10.69	0.99	6.75	6.53	0.97
14	TL	18.34	18.06	0.98	12.28	12.05	0.98
PC, rec. rads	AD	20.48	20.63	1.01	14.67	14.51	0.99
	K	120.9	116.1	0.96	81.5	81	0.99

Table 2 (continued from above): Speed test results, 1 profile per call, Intel desktop. Timings are ms per profile.

Test case	Model	Cray v12.1	Cray v12.2	Cray v12.2:v12.1	BULL v12.1	BULL v12.2	BULL v12.2:v12.1
	Direct	0.167	0.169	1.01	0.171	0.168	0.99
1	TL	0.307	0.307	1.00	0.334	0.328	0.98
MW, no interp	AD	0.339	0.338	1.00	0.391	0.381	0.97
	K	0.502	0.494	0.98	0.619	0.612	0.99
	Direct	0.258	0.251	0.97	0.255	0.255	1.00
2	TL	0.47	0.468	1.00	0.498	0.486	0.98
MW, interp	AD	0.526	0.516	0.98	0.576	0.571	0.99
	K	0.738	0.727	0.99	0.895	0.881	0.98
	Direct	0.146	0.141	0.96	0.142	0.145	1.02
3	TL	0.256	0.25	0.98	0.269	0.276	1.03
IR v7 clear	AD	0.281	0.275	0.98	0.312	0.305	0.98
	K	0.376	0.369	0.98	0.47	0.472	1.00
	Direct	0.154	0.144	0.93	0.159	0.158	0.99
4	TL	0.279	0.267	0.96	0.298	0.287	0.96
IR v8 clear	AD	0.314	0.287	0.92	0.34	0.337	0.99
	K	0.517	0.402	0.78	0.566	0.535	0.95
	Direct	0.22	0.166	0.76	0.253	0.197	0.78
5	TL	0.372	0.314	0.84	0.419	0.358	0.85
Visible clear	AD	0.392	0.34	0.87	0.467	0.41	0.88
	K	0.479	0.427	0.89	0.587	0.522	0.89
	Direct	2.32	2.46	1.06	2.006	2.026	1.01
6	TL	4.682	4.766	1.02	3.982	3.866	0.97
All gas clear	AD	5.07	5.228	1.03	5.048	5.01	0.99
	K	20.88	18.64	0.89	15.56	16.01	1.03
	Direct	0.147	0.15	1.02	0.16	0.163	1.02
7	TL	0.276	0.281	1.02	0.315	0.334	1.06
IR aerosol	AD	0.293	0.308	1.05	0.372	0.38	1.02
Chou-scaling	K	0.425	0.427	1.00	0.565	0.572	1.01
	Direct	0.276	0.269	0.98	0.274	0.261	0.95
8	TL	0.502	0.492	0.98	0.563	0.556	0.99
IR cloud	AD	0.557	0.551	0.99	0.655	0.637	0.97
Chou-scaling	K	0.729	0.647	0.89	0.889	0.786	0.88

Table 3 (continued below): Speed test results, 1 profile per call, supercomputer platforms. Timings are ms per profile.

	Direct	1.146	1.172	1.02	1.656	1.68	1.01
9	TL	2.606	2.57	0.99	5.168	5.262	1.02
IR aerosol	AD	61.76	61.48	1.00	94.78	94.48	1.00
DOM	K	61.6	60.4	0.98	94.96	94.86	1.00
	Direct	6.052	5.994	0.99	8.946	9.042	1.01
10	TL	14.85	14.33	0.96	27.94	27.98	1.00
IR cloud	AD	480.4	481.6	1.00	740	739.6	1.00
DOM	K	478.6	481	1.01	735.2	737.2	1.00
	Direct	2.37	2.412	1.02	3.184	3.13	0.98
11	TL	4.862	4.818	0.99	9.326	9.348	1.00
Visible aerosol	AD	28.42	28.38	1.00	46.08	45.9	1.00
DOM	K	29.26	29.44	1.01	46.12	46.04	1.00
	Direct	2.88	2.754	0.96	3.826	3.728	0.97
12	TL	6.762	6.654	0.98	11.366	11.268	0.99
Visible cloud	AD	24.74	23.78	0.96	39.38	38.94	0.99
DOM	K	24.36	24.46	1.00	39.38	39.02	0.99
	Direct	4.23	3.97	0.94	3.52	3.58	1.02
13	TL	8.28	7.96	0.96	6.79	6.67	0.98
PC	AD	9.04	8.9	0.98	8.39	8.29	0.99
	K	31.6	33.7	1.07	39.4	39.2	0.99
	Direct	4.01	4.54	1.13	3.38	3.3	0.98
14	TL	7.89	8.3	1.05	6.65	6.4	0.96
PC, rec. rads	AD	8.84	9.3	1.05	8.16	8.03	0.98
	K	47.1	55.8	1.18	76.2	75.8	0.99

Table 3 (continued from above): Speed test results, 1 profile per call, supercomputer platforms. Timings are ms per profile.

Test case	Model	Intel gfortran v12.1	Intel gfortran v12.2	Intel gfortran v12.2:v12.1	Intel ifort v12.1	Intel ifort v12.2	Intel ifort v12.2:v12.1
	Direct	0.39	0.386	0.99	0.236	0.231	0.98
1	TL	0.659	0.654	0.99	0.433	0.425	0.98
MW, no interp	AD	0.8	0.84	1.05	0.547	0.541	0.99
	K	1.153	1.141	0.99	0.851	0.832	0.98

Table 4: Speed test results, 50 profiles per call, Intel desktop. Timings are ms per profile.

Test case	Model	Cray v12.1	Cray v12.2	Cray v12.2:v12.1	BULL v12.1	BULL v12.2	BULL v12.2:v12.1
	Direct	0.143	0.142	1.00	0.12	0.12	1.01
1	TL	0.262	0.267	1.02	0.233	0.228	0.98
MW, no interp	AD	0.302	0.298	0.98	0.285	0.283	0.99
	K	0.541	0.538	0.99	0.506	0.509	1.01

Table 5: Speed test results, 50 profiles per call, supercomputer platforms. Timings are ms per profile.

Model	Simulated output	PC-RTTOV	HT-FRTC	HT-FRTC:PC-RTTOV
Direct	PC scores	5.64	2.10	0.37
	Rec. rads	5.74	2.24	0.39
K	PC scores	69.88	27.09	0.39
	Rec. rads	115.07	60.46	0.53

Table 6: Speed test results comparing PC-RTTOV and HT-FRTC. Timings are ms per profile.

Interp mode	Model	No interp	Interp	Interp:No interp
1	Direct	0.292	0.336	1.15
	TL	0.539	0.638	1.18
	AD	0.682	0.777	1.14
	K	0.977	1.137	1.16
2	Direct	0.292	0.322	1.10
	TL	N/A		
	AD			
	K			
3	Direct	0.292	0.329	1.13
	TL	0.539	0.616	1.14
	AD	0.682	0.753	1.10
	K	0.977	1.121	1.15
4	Direct	0.292	0.345	1.18
	TL	0.539	0.671	1.25
	AD	0.682	0.816	1.20
	K	0.977	1.182	1.21
5	Direct	0.292	0.350	1.20
	TL	0.539	0.651	1.21
	AD	0.682	0.807	1.18
	K	0.977	1.165	1.19

Table 7: Speed test results directly comparing each interpolation mode with no interpolation. Test carried out for 54L ATMS coefficients with a 54L profile. Timings are ms per profile.

Interp mode	Model	No interp	Interp	Interp:No interp
1	TL	0.538	0.668	1.24
	AD	0.678	0.861	1.27
	K	0.984	2.083	2.12
3	TL	0.538	0.650	1.21
	AD	0.678	0.824	1.22
	K	0.984	1.689	1.72
4	TL	0.538	0.723	1.34
	AD	0.678	0.913	1.35
	K	0.984	2.170	2.21
5	TL	0.538	0.712	1.32
	AD	0.678	0.878	1.30
	K	0.984	1.781	1.81

Table 8: As for Table 7, but with pressure as an active variable in the TL/AD/K (i.e. lgradp=true).

Test case	Model	v12.1 peak memory (MB)	v12.2 peak memory (MB)	v12.2:v12.1
	Direct	1.745	1.934	1.11
1	TL	1.745	1.934	1.11
MW, no interp	AD	1.745	1.934	1.11
	K	2.437	2.568	1.05
	Direct	1.745	1.934	1.11
2	TL	1.984	2.121	1.07
MW, interp	AD	2.002	2.139	1.07
	K	2.95	3.107	1.05
	Direct	1.168	1.358	1.16
3	TL	1.461	1.599	1.09
IR v7 clear	AD	1.468	1.605	1.09
	K	1.832	1.973	1.08
	Direct	1.224	1.396	1.14
4	TL	1.518	1.66	1.09
IR v8 clear	AD	1.524	1.667	1.09
	K	1.934	2.097	1.08
	Direct	1.322	1.521	1.15
5	TL	1.61	1.792	1.11
Visible clear	AD	1.613	1.795	1.11
	K	1.893	2.076	1.10
	Direct	707.6	707.8	1.00
6	TL	707.6	707.8	1.00
All gas clear	AD	707.6	707.8	1.00
	K	707.6	707.8	1.00
	Direct	1.505	1.64	1.09
7	TL	1.727	1.858	1.08
IR aerosol	AD	1.731	1.862	1.08
Chou-scaling	K	2.143	2.257	1.05
	Direct	1.935	2.045	1.06
8	TL	2.459	2.582	1.05
IR cloud	AD	2.458	2.581	1.05
Chou-scaling	K	4.018	4.147	1.03

Table 9 (continued below): Memory test results.

	Direct	1.685	1.823	1.08
9	TL	2.454	2.591	1.06
IR aerosol	AD	2.464	2.601	1.06
DOM	K	2.877	2.997	1.04
	Direct	2.045	2.178	1.07
10	TL	4.135	4.263	1.03
IR cloud	AD	4.145	4.273	1.03
DOM	K	5.705	5.834	1.02
	Direct	2.012	2.211	1.10
11	TL	2.11	2.211	1.05
Visible aerosol	AD	2.111	2.211	1.05
DOM	K	2.252	2.35	1.04
	Direct	2.474	2.68	1.08
12	TL	2.666	2.679	1.00
Visible cloud	AD	2.663	2.679	1.01
DOM	K	3.12	3.145	1.01
	Direct	708.4	708.6	1.00
13	TL	708.4	708.6	1.00
PC	AD	708.4	708.6	1.00
	K	708.4	708.6	1.00
	Direct	708.4	708.6	1.00
14	TL	708.4	708.6	1.00
PC, rec. rads	AD	708.4	708.6	1.00
	K	708.4	708.6	1.00

Table 9 (continued from above): Memory test results.

Test case	Model	v12.1 peak memory (MB)	v12.2 peak memory (MB)	v12.2:v12.1
	Direct	21.23	21.3	1.00
6	TL	21.23	21.3	1.00
All gas clear	AD	21.23	21.3	1.00
	K	48.76	49.06	1.01
	Direct	105.1	105.3	1.00
13	TL	105.1	105.3	1.00
PC	AD	105.1	105.3	1.00
	K	137.4	137.8	1.00
	Direct	68.85	69.05	1.00
14	TL	68.85	69.05	1.00
PC, rec. rads	AD	68.85	69.05	1.00
	K	88.03	88.46	1.00

Table 10: IASI memory test results with coefficient extraction.