First experiences with RTTOV8 for assimilating AMSU-A data in the DMI 3D-Var data assimilation system

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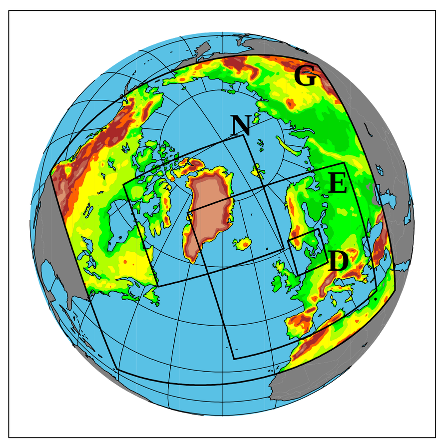
Introduction

AMSU-A data has been used operationally at DMI since 2002. Impact studies (e.g. Amstrup (2003, 2004)) have demonstrated a clear positive impact in winter months. The radiative transfer model used in the analysis is RTTOV7, available from the NWP SAF (Numerical Weather Prediction Satellite Application Facility). A newer version, RTTOV8 (subrelease 5), was made available in November 2004 and has been implemented in the HIRLAM variational data assimilation system (HIRVDA), including the updates since the original release. See Schyberg et al. (2003) for further details concerning the implementation in HIRVDA.
The main difference between the RTTOV7 and RTTOV8 packages used in this study is the use of FASTEM-3 instead of FASTEM-2 (see `http://www.metoffice.com/research/interproj/nwpsaf/rtm/rttov8_svr.pdf`). The RTTOV7 optical depth predictors have been used to make the coef£cient £les that are available from the NWP SAF home page.
The current status is that we have made an impact study using the old operational DMI-HIRLAM set-up (see below). Results from this study are presented on this poster. It is likely that tests will be made with the current operational set-up in preparation for an operational implementation in the fall of 2005 and also for making a test including data from NOAA-N.

Set-up of the experiments

In the "Observing System Experiment" made here we used January 2005 with 3 hour data assimilation cycles (using the HIRLAM 3D-VAR system) and a 48 hour gridpoint forecast with the DMI-HIRLAM-G and DMI-HIRLAM-E models (Sass et al. (2002)). In the HIRLAM 3D-VAR system the following observation types (and observation quantities) were used: SYNOP, DRIBU, SHIP (pressure), TEMP (temperature, wind and speci£c humidity), PILOT (wind), AIREP (temperature and wind), QuikScat (near surface wind) and Atmospheric Motion Vectors (AMV) from Meteosat-8. The data were screened using the following checks: 1) Bad reporting practices, 2) Black list check, 3) First guess check, 4) Multi-level check, 5) RDB check, and 6) Redundancy check. The £nal thinning for AMSU-A data in DMI-HIRLAM was 0.9°.



Model Identi£cation	G	N	E	D
grid points (mlon)	202	194	272	182
grid points (mlat)	190	210	282	170
No. of vertical levels	31	31	31	31
horizontal resolution	0.45°	0.15°	0.15°	0.05°
time step (dynamics)	240 s	100 s	100 s	36 s
time step (physics)	720 s	300 s	300 s	108 s

Figure 1: Operational DMI-HIRLAM domains

Table 1: The values in the diagonal of the observation error covariance matric. All off-diagonal elements are 0.

channel	1	2	3	4	5	6	7	8	9	10
error (K^2)	900	900	900	90	0.35	0.35	0.35	0.35	0.70	1.40

Statistics of observations against model £rst guess

The necessary statistics for bias correction (Harris-Kelly scheme used here) is derived using the available observations from locally received data and from EARS (EUMETSAT ATOVS Retransmission Service) for a 5.5 month period starting from June 1st 2003. The model derived data are made using archived £rst guess £elds (3 hour forecasts) from the operational DMI-HIRLAM-G runs. The data used in the statistics are checked in the same way as in the model runs except with less thinning. The bias and rms statistics for NOAA16 AMSU-A channels 1-10 of observed brightness temperatures against model £rst guess derived brightness temperatures in 3 latitude bands are given in Figure 2. There are small differences of the statistics in the 3 bands, as was also seen in the original studies. This is the reason for having different bias-correction for data south of 45°N, for data north of 65°N, and for data in between. It is also seen that the statistics for channels 1-3 ("surface channels") are quite different when using RTTOV7 than when using RTTOV8. This must be due to the differences between FASTEM-3 and FASTEM-2. For the other channels the statistics are much more similar. Note that the number of data used in the statistics are not the same. That is due to different cloud mask based exclusions when using RTTOV7 and RTTOV8. The cloud mask (see Schyberg et al. (2003)) is based on a NOAA/NESDIS developed algorithm that uses observed and model derived AMSU-A channel 1 and 2 brightness temperatures.

Figure 3 shows the effect of bias correction on the statistics for RTTOV8 derived NOAA16 AMSU-A channels 4-10 data. The raw data have biases and the distributions are to some extend asymmetric. The distributions of the bias corrected data show very nice Gaussian behavior.

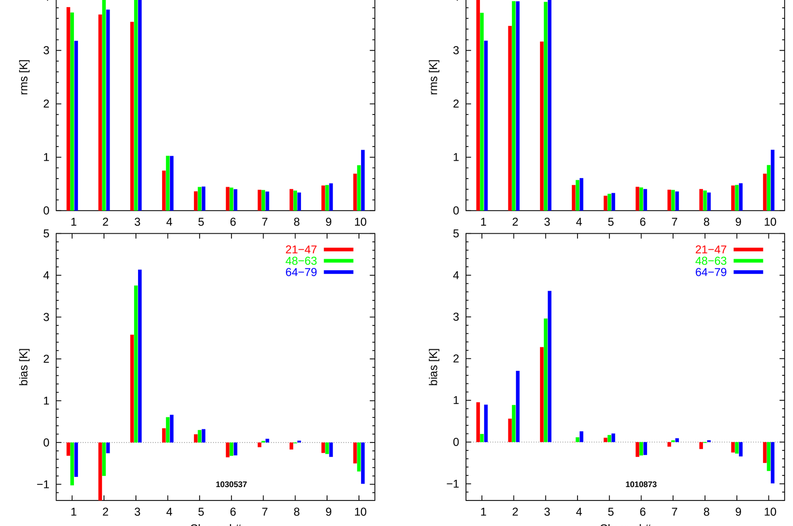


Figure 2: Statistics of NOAA16 AMSU-A data as function of latitude using RTTOV7 (left) and RTTOV8 (right). Raw data from a 5.5 month period from June 1st 2003 to November 19th 2003.

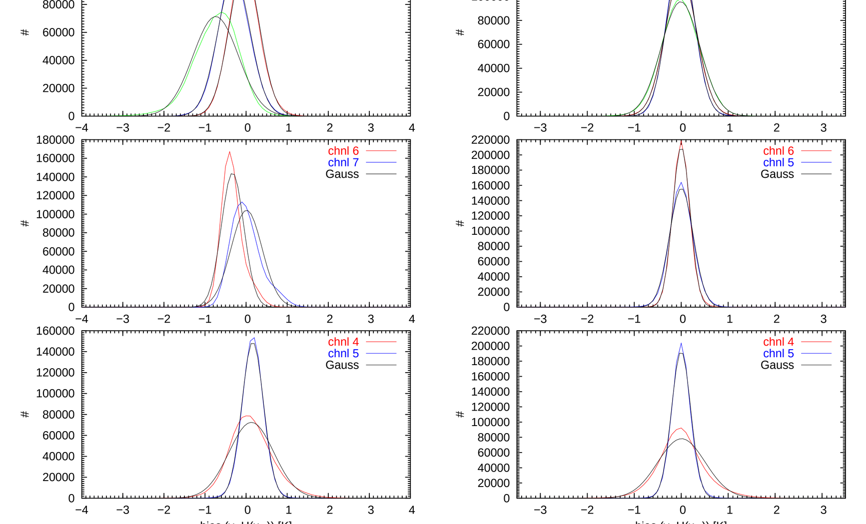


Figure 3: Statistics of NOAA16 AMSU-A data using RTTOV8. Raw data left hand side and bias-corrected data right hand side.

Results from model runs

The results from the two model runs are compared in different ways. A standard observation veri£cation, where forecast results are compared to standard SYNOP and radiosonde observations using an EWGLAM (European Working Group on Limited Area Model) station list, is done (see Figure 4). The impact is basically neutral. Results of forecasted 12 h precipitation against observations from SYNOP stations at 06 UTC and 18 UTC are given in terms of standard contingency tables (see Tables 2-4). The £ve precipitation classes are (precipitation amounts in mm): $P1 < 0.2$, $0.2 \leq P2 < 1.0$, $1.0 \leq P3 < 5$, $5 \leq P4 < 10$ and $P5 \geq 10$. P is either F (forecast) or O (observation) in the tables. Only results for the DMI-HIRLAM-E (D1E with RTTOV7 and D1D with RTTOV8) models is given in the tables. The differences are fairly small except for D1D consistently having the better number in the O1/F1 (no or small amounts of precipitation) entries.

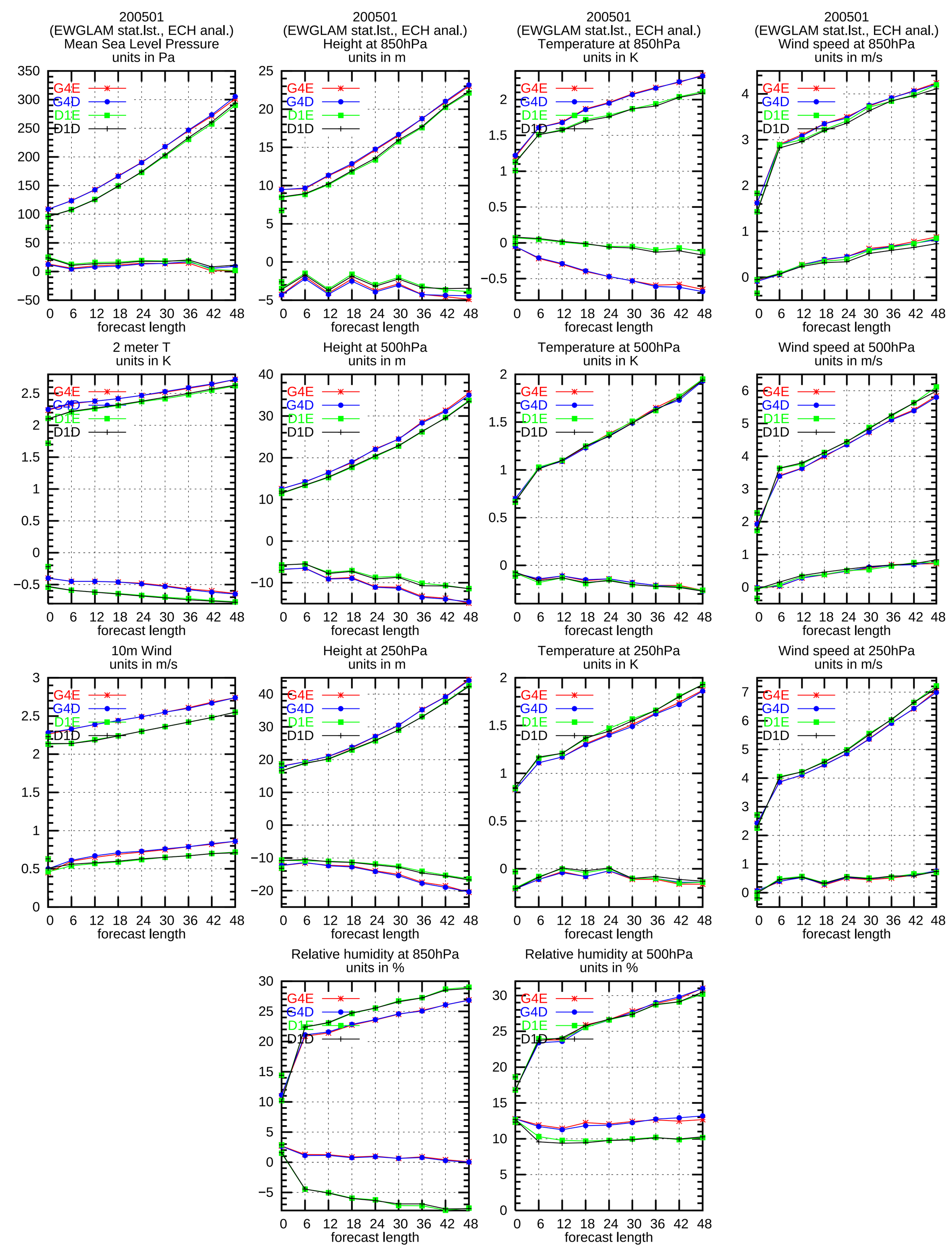


Figure 4: Observation veri£cation against EWGLAM stations for parameters speci£ed in the plot. G4E/G4D is DMI-HIRLAM-G area models and D1E/D1D is DMI-HIRLAM-E area models. The G4E/D1E run has used RTTOV7 and the G4D/D1D run has used RTTOV8.

Table 2: Contingency table for 200501 (6–18 h forecasts). EWGLAM station list.

D1E (DMI-HIRLAM-E, RTTOV7) 200501							D1D (DMI-HIRLAM-E, RTTOV8) 200501						
obs→ ↓for	O1	O2	O3	O4	O5	sum	obs→ ↓for	O1	O2	O3	O4	O5	sum
F1	**6787**	334	82	22	**26**	7251	F1	**6799**	315	75	23	**26**	7238
F2	3442	**1078**	429	32	11	4992	F2	3462	**1088**	443	23	13	5029
F3	1218	1158	**1681**	319	66	4442	F3	1194	1160	**1692**	339	64	4449
F4	70	79	310	**254**	107	820	F4	63	88	287	**247**	108	793
F5	**10**	16	62	74	**114**	276	F5	**9**	14	67	69	**113**	272
sum	11527	2665	2564	701	324	17781	sum	11527	2665	2564	701	324	17781
%FO	59	40	66	36	35	56	%FO	59	41	66	35	35	56

Table 3: Contingency table for 200501 (18–30 h forecasts). EWGLAM station list.

D1E (DMI-HIRLAM-E, RTTOV7) 200501							D1D (DMI-HIRLAM-E, RTTOV8) 200501						
obs→ ↓for	O1	O2	O3	O4	O5	sum	obs→ ↓for	O1	O2	O3	O4	O5	sum
F1	**6708**	367	114	27	**29**	7245	F1	**6737**	369	109	29	**26**	7270
F2	3419	**1091**	519	40	16	5085	F2	3402	**1057**	488	44	17	5008
F3	1298	1103	**1577**	334	70	4382	F3	1294	1128	**1613**	341	65	4441
F4	82	80	294	**234**	97	787	F4	72	94	298	**216**	107	787
F5	**20**	24	60	66	**112**	282	F5	**22**	17	56	71	**109**	275
sum	11527	2665	2564	701	324	17781	sum	11527	2665	2564	701	324	17781
%FO	58	41	62	33	35	55	%FO	58	40	63	31	34	55

Table 4: Contingency table for 200501 (30–42 h forecasts). EWGLAM station list.

D1E (DMI-HIRLAM-E, RTTOV7) 200501							D1D (DMI-HIRLAM-E, RTTOV8) 200501						
obs→ ↓for	O1	O2	O3	O4	O5	sum	obs→ ↓for	O1	O2	O3	O4	O5	sum
F1	**6463**	433	157	40	**30**	7123	F1	**6516**	413	161	46	**32**	7168
F2	3390	**938**	499	56	18	4901	F2	3351	**961**	508	55	16	4891
F3	1386	1119	**1475**	325	70	4375	F3	1378	1115	**1503**	321	78	4395
F4	110	93	323	**206**	102	834	F4	100	93	284	**201**	87	765
F5	**23**	24	57	69	**99**	272	F5	**27**	25	55	73	**106**	286
sum	11372	2607	2511	696	319	17505	sum	11372	2607	2511	696	319	17505
%FO	57	36	59	30	31	52	%FO	57	37	60	29	33	53

Conclusion

As expected the impact is fairly small by using RTTOV8 instead of RTTOV7 since the main change is the use of FASTEM-3 instead of FASTEM-2 and the "surface channels" are given very small weight in the data assimilation.
The memory consumption is somewhat smaller using RTTOV8 compared to using RTTOV7 in our implementation (including some cleanup of the code when using RTTOV8). This is important when considering the future instrument types such as IASI. However, the CPU time spend in the RTTOV part of the code is much larger when using RTTOV8 on the DMI SX-6 vector machine.
Future tests including data over sea ice and land, as well as tests with AMSU-B, HIRS and MHS (from NOAA-N when available), is under consideration.

References

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