Evaluation of the recent reference beta releases (5.0.x)

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Abstract

Several HIRLAM beta releases have been made so far this year following the official release of HIRLAM reference 5.0.0. Among the released 6 beta versions (from 5.0.1 to 5.0.6), some of them are expected to have significant meteorological impacts, and the rest are more in technical natures. This notes provides, in various details, preliminary evaluations of those beta versions with meteorological significances. The main focuses are in the beta release 5.0.4 (STRACO shallow convection update) and the latest 5.0.6 (CBR turbulence scheme update).

Observation verification and statistical diagnoses of forecasted cloud and precipitation fields confirm that the STRACO update generally reduce low cloud covers and precipitation, but overall it has little impact on traditional verification scores. On the other hand, verification study reveal strikingly negative impacts of the CBR update.

1 Brief review of the recent HIRLAM beta releases

Following the official introduction of HIRLAM reference version 5.0.0 on Feb 29, 2001, six beta releases have been made available (see the release notes on HexNet for details). Among those beta versions (5.0.x):

Beta release 5.0.1, available on April 9, 2001, is mainly of technical nature. It consists of minor bug fixes and code revisions, with little meteorological impact expected.

Beta release 5.0.2, available on May 28, 2001, introduces the new script system mini-SMS and additional corrections on coding errors. Although the version is expected to have little meteorological impact when running at standard option, the release incorporated, for the first time, the HIRLAM variational data assimilation system, HIRVDA, into the reference system. HIRVDA is introduced as an independent package, and linked to the rest of the HIRLAM components through mini-SMS scripts. Technically, the 3DVAR analysis can be launched by specifying the analysis option in the mini-SMS script, with the output used by the HIRLAM grid point model in the forecast. The integration of HIRVDA with HIRLAM under mini-SMS has been grossly checked by this author in late March through a pre-implementation parallel runs, in which a 10-day summer/autumn period was run with 3DVAR/OI options and results compared through observation verification against EWGLAM data. The verification confirmed similar findings from earlier studies using HIRVDA system, with 3DVAR achieving generally more favorable scores for important weather parameters than OI, and in addition, 3DVAR results in a general reduction in forecasted precipitation amounts, as well as a lower system noise than the OI ones.

Beta release 5.0.3, available on June 25, 2001, features mainly the recoded initialization interface. At standard option, the initialization scheme (digital filtering initialization, DFI) is nearly identical to the previous reference version. Prior to the implementation, the revised code was validated by several parallel data assimilation runs with the observation verification scores shown to be nearly identical to the original version (Huang and Yang, HIRLAM NL 38, p167-173). The new initialization interface also made available the option of incremental DFI (IDFI). Recently, numerical studies have been made by Yang and Huang using various initialization options in 5.0.3 to investigate the HIRLAM spin-up problem of moisture fields (mainly precipitation and cloud water). The study confirmed some suspected deficiencies in the current DFI scheme, such as the tendency of excessive control (harmful for potentially useful meso-scale features), and the deep reduction in precipitation rate and cloud water following the initialization. As a remedy, IDFI is found to be able to improve on these area to a satisfactory degree, with little impacts on other forecast quantities. These results will be reported in separate write-up.

Beta release 5.0.4, available on July 2, 2001, contains the modifications to STRACO condensation scheme. The update is proposed by Bent Hansen Sass at DMI to address the shortcomings in the original scheme (see Sass's upcoming HIRLAM technical report). The lack of description of shallow convection processes in the turbulence and condensation schemes is believed to be responsible for the often excessive low cloud cover in the HIRLAM forecasts, which in turn has been assumed as a major cause of significant bias in near-surface and lower boundary layer forecast quantities. The evaluation of the implemented update in 5.0.4, in terms of verification results with 3D data assimilation/forecast runs, is the main subject of this notes, detailed in Section 2.

Beta release 5.0.5, available on July 9, 2001, contains the technical update which corrects a bug introduced at the beta version 5.0.2 in OI analysis. The bug causes no update of analysis error coefficients following each assimilation cycle. The impact of the bug is not systematic but generally perceived to have minor importance.

Beta release 5.0.6, available on September 24, 2001, contains the update to the CBR turbulence scheme according to Lenderink, KNMI. Note that prior to this update, it was found that there exists conflict between this update and the shallow convection update to STRACO scheme (5.0.4), see De Rooy's notes in this issue of NL. The direct cause of such conflict is thought to be due to the changed leveling of TKE (from full level to half level) and the assumption of the former in the STRACO update (in which TKE is used explicitly for the first time in STRACO). It was thus deemed necessary to re-tune STRACO shallow convection update to accommodate the change of TKE profile in the CBR update. As a consequence, the STRACO update (v5.0.4) was not included in v5.0.6. The Section 3 reports some preliminary validation results using this latest update (5.06).

2 Recent STRACO update, beta release 5.0.4

All experiments referred to in this notes have been performed at ECMWF computer facility using various versions of reference HIRLAM system. The computational model domain is the default one in the reference model, with 114*110*31 grid points and at 0.5 degree resolution, on rotated grid. 36 hours forecasts are conducted 4 times a day, following OI analysis. Parallel runs for 5 periods and a total of about 2 months are available for comparisons:

A: 2000050600-2000052100, the standard HIRLAM 5 test period for spring/summer season; HIRLAM versions 5.0.0 and 5.05 are compared;

B: 2000081818-2000082900, a relatively dry summer/autumn period characterized by occasional small precipitation events; HIRLAM reference version 5.03 and 5.04 are compared. Note that in this pair of experiments, the newly implemented incremental DFI were used in both runs.

C: 1995082418-1995090400, a summer/autumn period featured by many heavy precipitation episodes. HIRLAM versions 5.03 and 5.05 are compared.

D: 2001020100-2001021100, a 10-day winter period. HIRLAM versions 5.02 and 5.04 are compared.

E: 1999120100-1999121100, the period covering the 1999 Danish storm, with HIRLAM versions 5.03 and 5.05.

As are indicated above, not all experiments had been designed to test the net impact of STRACO update. But the comparisons made with these runs are believed to represent the impact of such update anyway, because, as reviewed in Section 1, the only changes from 5.00 to 5.05 that has meteorological impact is the STRACO update introduced in version 5.04

2.1 Observation Validation

Observation verification of the above forecasts has been conducted against EWGLAM synoptic and sounding data.

Surface and upper air quantities. We choose to present here verifications plots of three episodes out of the 5 cases mentioned above, because parallel forecasts using v5.0.6 (CBR updates) are also available for these periods. In the verification plots, results for the three HIRLAM versions

Table 1: Contingency table for precipitation, 20000506-0521 (12-24 hour forecasts)

V5.0.0						V5.0.5					
obs→ ↓for	O1	O2	O3	O4	O5	obs→ ↓for	O1	O2	O3	O4	O5
F1	4277	118	106	52	34	F1	4333	134	121	66	36
F2	980	182	77	37	18	F2	959	197	74	35	17
F3	443	225	318	87	33	F3	407	196	308	76	31
F4	35	26	49	45	11	F4	37	20	49	46	11
F5	14	5	21	17	12	F5	13	9	19	15	13

(control, STRACO update and CBR update) are plotted together. The results from v5.0.6 will be discussed in next section.

Figure 1 show the observation verification for the 10-day summer/autumn period (1995082418-090400). The period featured several consecutive cyclones passing through northern Europe with many heavy rain episodes. As are shown in the figure, the curves representing RMS and bias scores of runs using 5.0.3 (stars) and 5.0.5 (circles) are rather close to each other for most of displayed parameters. The STRACO update is seen to result in marginal improvement in surface and 850 mb quantities, but overall the differences are too small to be conclusive.

Figure 2 are verification for the first 10-day winter period (19991201-121100). The initial stage of that period includes the major storm event which affected Danish area severely. Again, the STRACO update seemed to have left little imprints on the verification score, except a slightly worse bias in relative humidity.

The verification for the second 10-day winter period (2001020100-021100) (Figure 3) again show overall small differences, but for this period, the STRACO update seemed to have marginally negative impact on height fields. Also, the relative humidity fields at upper level become significantly worse.

Verification scores for the other two periods, one for spring/summer case (A), another for a dry summer/autumn case (B), have also been examined and overall there are no significant trends caused due to STRACO update. It is thus concluded that all in all the observation verification scores suggest generally small impact in association with the introduction of shallow convection scheme.

Accumulated Precipitation The verification of 12 hr accumulated precipitation is done with 5 class of precipitation: (0-0.2, 0.2-1,1-5,5-10 and above 10 mm). Since the results from different periods are rather consistent on this aspect, we present here only the contingency table for the first validation period.

The table indicates that for the two-week period, the version 5.05 with STRACO update has resulted in an overall improvement in the match of precipitation, most notably in the class 1 (no or low precipitation events), see column O1. Generally, there is also reduced cases with over-prediction in the low classes (most clearly in the blocks of F2/O1,F3/O1). Similar features are also seen in verification of the other examined periods. Overall, the changes in precipitation verifications due to STRACO update can be summarized as being slightly positive: consistently better in low precipitation events, and neutral in higher precipitation classes.

2.2 Examination of domain averaged cloud cover and precipitation rate

The impact of shallow convection update on cloud and precipitation prediction can also be evaluated by checking statistic time series averaged over model domain. In Figure 4, time series of low cloud cover (below 2km) and precipitation rate averaged from forecasts for 4 episodes are plotted, separately. For the period 20000506-0521 (Figure 4a), STRACO update seems to change little the predicted low clouds, but for the other three cases in summer/autumn and winter periods, the update has obviously caused reduction of predicted low cloud cover by various degree. Moreover, the STRACO update is also shown to cause overall reduction in predicted total precipitation amount, which can be seen clearly in the plots for all cases examined. Both of these changes are within expectation and believed to be desirable.

It is probably also relevant to add here that, since Sept. 1, 2001, the STRACO update has also been implemented into DMI's pre-operational forecast system, and preliminary verification confirmed improvement in precipitation forecasts. In addition, the update is believed to have improved prediction of diurnal cycle of 2 meter temperature and relative humidity.

As a side note, the averaged precipitation rate time series from Figure 4 a,c and d can be seen as a clear proof that there exits rather severe precipitation spin-up following the DFI (the default initialization procedure in HIRLAM reference model). The spin-up process seem to take as long as around 6 hour. Accordingly, the accumulated precipitation in the initial stage of forecast is significantly lower than those accumulated in later forecast period. As a contrast, in case B (Figure 4b), (2000081818-082900), where the incremental DFI has been applied in both runs, the spin-up feature in precipitation is significantly reduced. This confirms rather convincingly the potential of IDFI in control of moisture spin-up.

To summarise, the validation results above indicate that the shallow convection updates for STRACO scheme results in generally reduced low cloud cover, reduced total precipitation amount, and consistently, although marginally, improved precipitation forecast in no/low precipitation classes. The modification has, on the other hand, shown very small impacts on the observation verification of other traditional parameters, such as MSLP, T2m, V10m etc. This also suggests that there remain important challenges in improving further physically parameterization, not only the condensation scheme itself, but also other related areas such as surface and turbulence parameterization schemes.

3 Recent CBR update, beta release 5.0.6

Validation of 5.0.6 here was done in the last minute and only observation verification scores have been examined. As mentioned in Section 2, forecasts for three 10-day episodes are compared using HIRLAM beta version 5.0.6 and earlier version (5.0.3). Other aspects of the experiment configurations are similar to the ones reported in Section 2.

In Figure 1, 2 and 3, the verification results with CBR update 5.0.6 are represented by solid squares. The features displayed in the three plots are strikingly consistent and surprising. On one hand, the CBR updates significantly improve scores for V10m, and higher up, there is also some tendency of improved bias in wind fields (but not in RMS). In addition, there are some improvement in the RH at 2m for the two winter cases. On the other hand, the MSLP and geopotential heights at upper air levels for all three periods have become significantly worse in bias, and, in association with that change, RMS scores have also become significantly worse. The modification also causes some degree of worsening in T2m bias, and deterioration in temperature at 850 and 700 mb. Overall, the benefit in the improved wind forecasts seem to have been strongly overshadowed by significant degradation of other parameter fields. Obviously, the performance of the CBR update, as implemented in 5.0.6, is not what has been expected and it certainly calls for swift action.

4 Concluding remarks

Results of several parallel runs using various versions of HIRLAM 5.0.x have been discussed here, with focus on evaluations of the two recent important code modifications in condensation (STRACO) and turbulence parameterization scheme (CBR). It is important to stress here that most of the reported parallel runs here have not been designed principally for validation purpose. The limited size of computation domain and coarse resolution used in this study was chosen due to practical consideration of computation efficiency at the ECMWF computer facilities. This, however, may greatly compromise the validity of the conclusions derived here. Needless to say, more reliable and solid validation results should be achieved by use of a more proper model domain at adequate resolution.

Acknowledgment The investigations reported here have benefited from discussions with members of the HIRLAM management group and colleagues at DMI, especially Bent Hansen Sass.

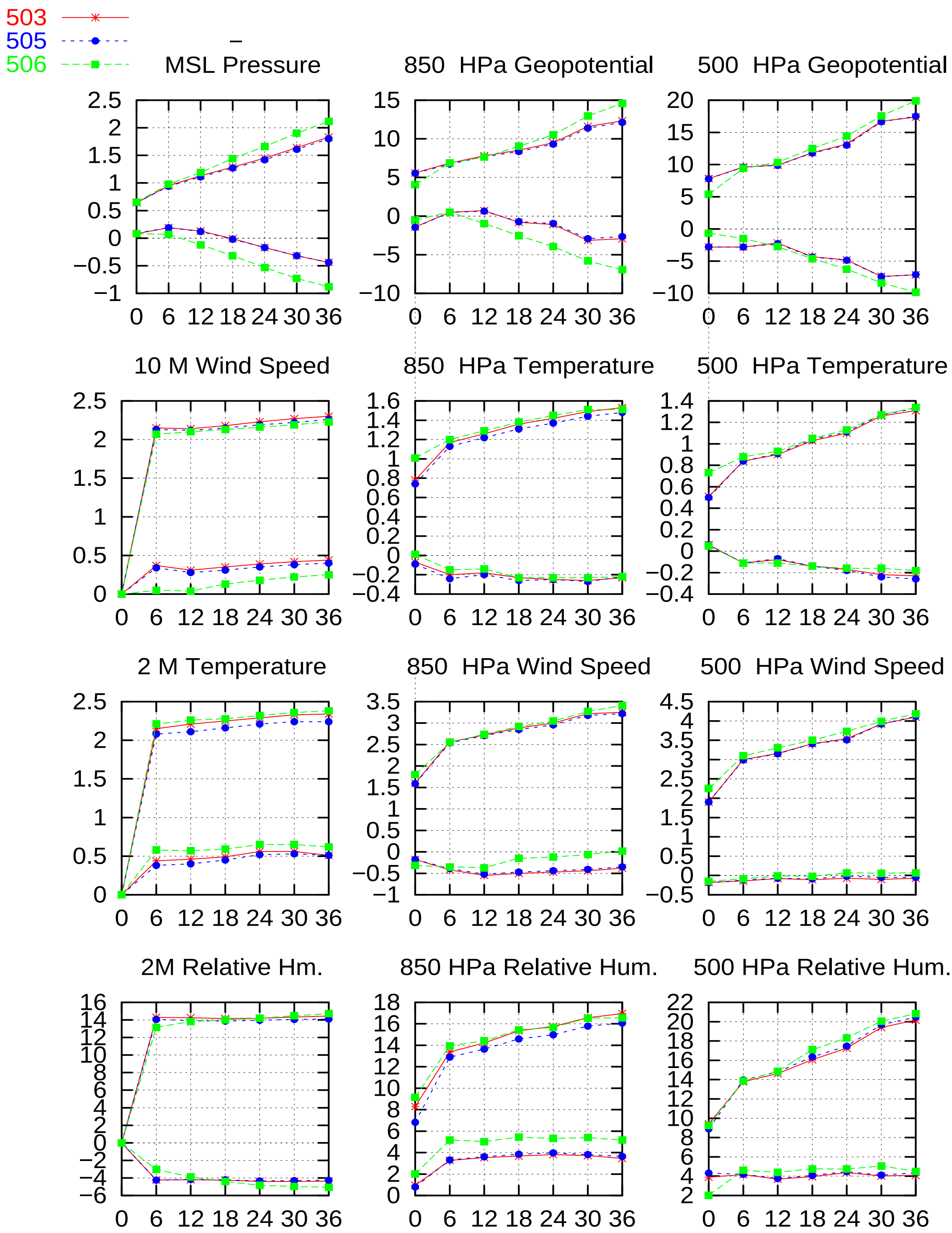

Figure 1: Observation verification against EWGLAM stations for surface (first column),, 850mb (second column) and 500mb (third column) variables. 503 stands for control run without STRACO or CBR updates, 504 for run using 5.0.4 with STRACO update, and 506 using 5.0.6 with CBR update.

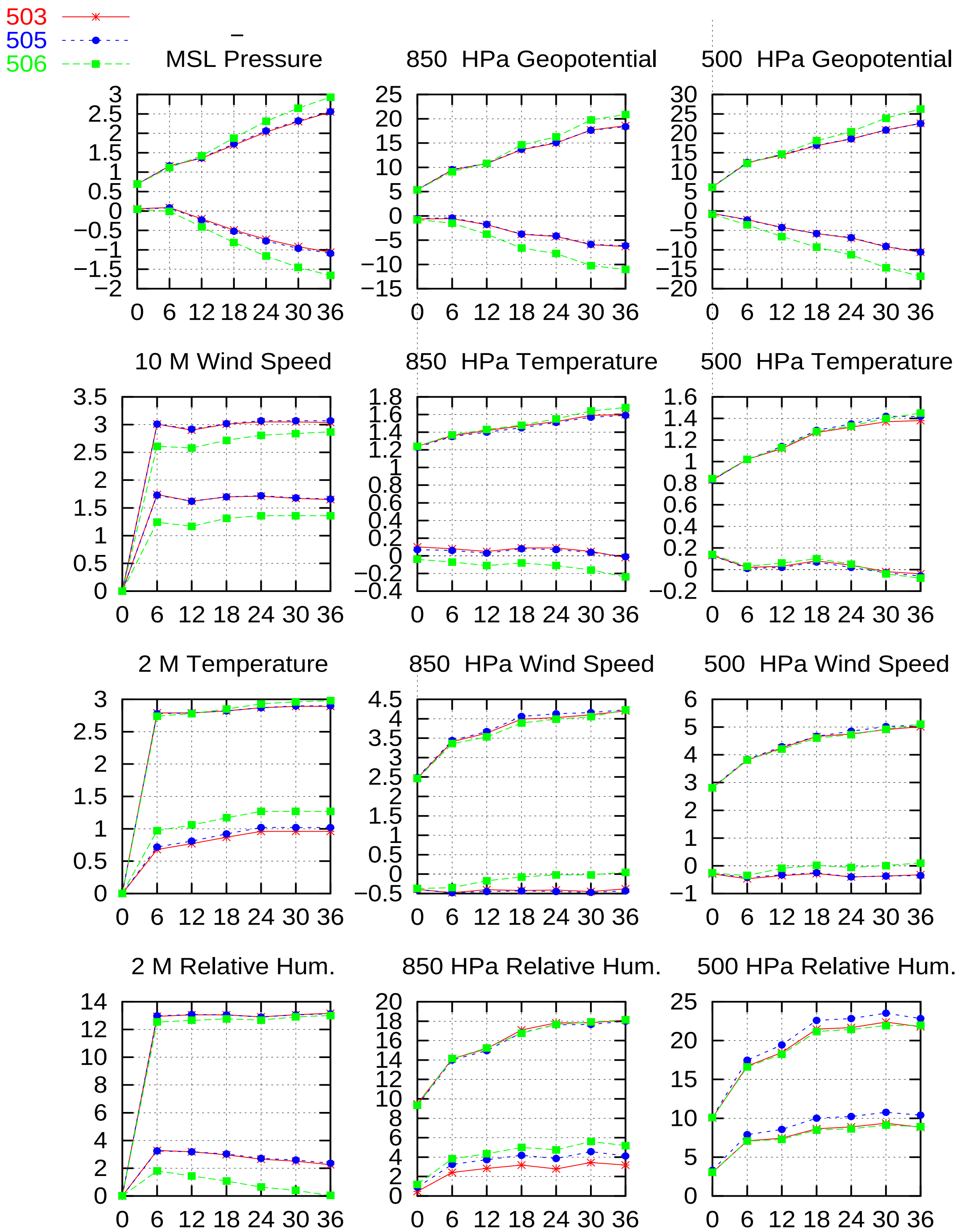

Figure 2: same as Figure 1 but for the period of 1999120100 and 121100.

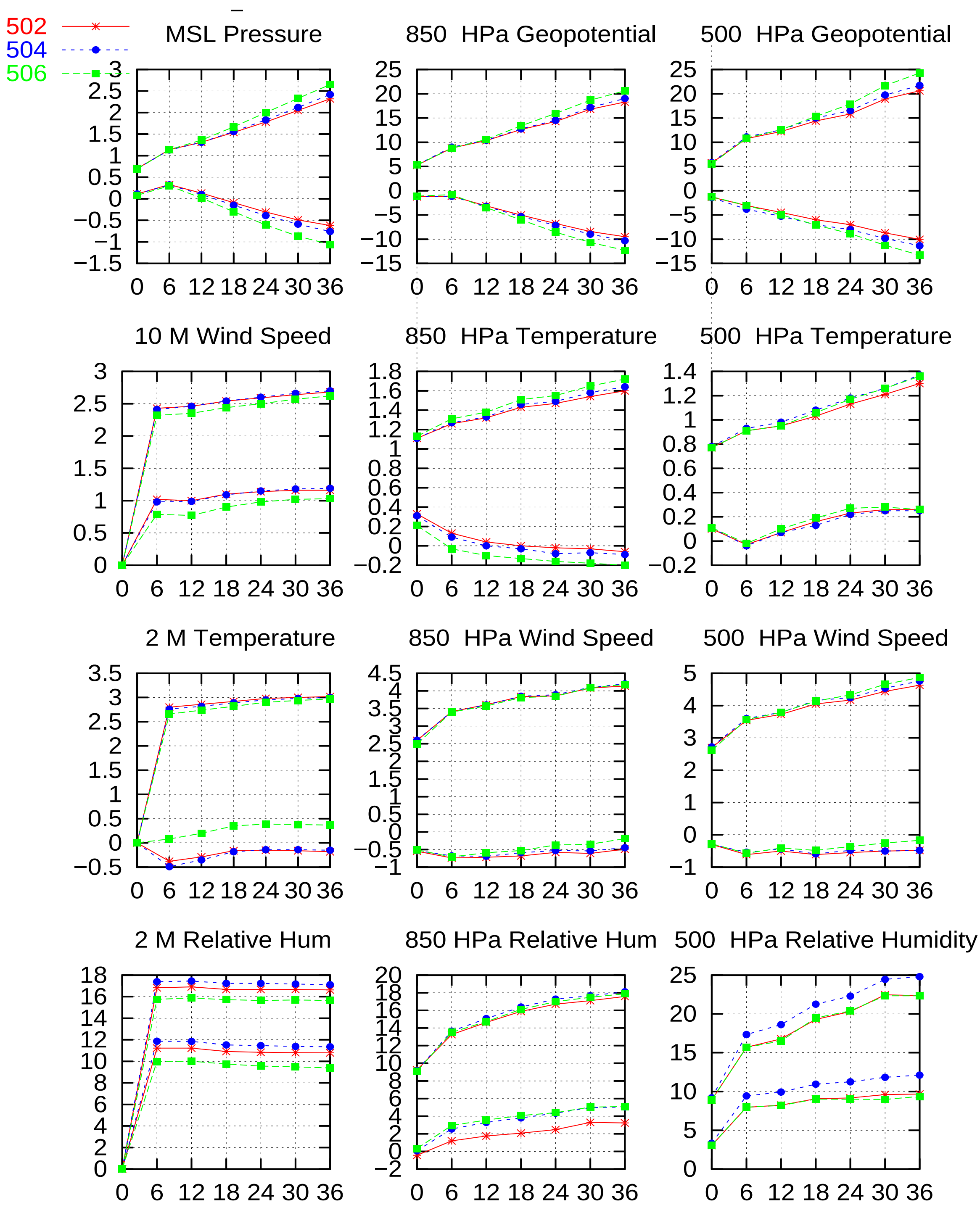

Figure 3: same as Figure 1 but for the period of 2001020100 and 021100.

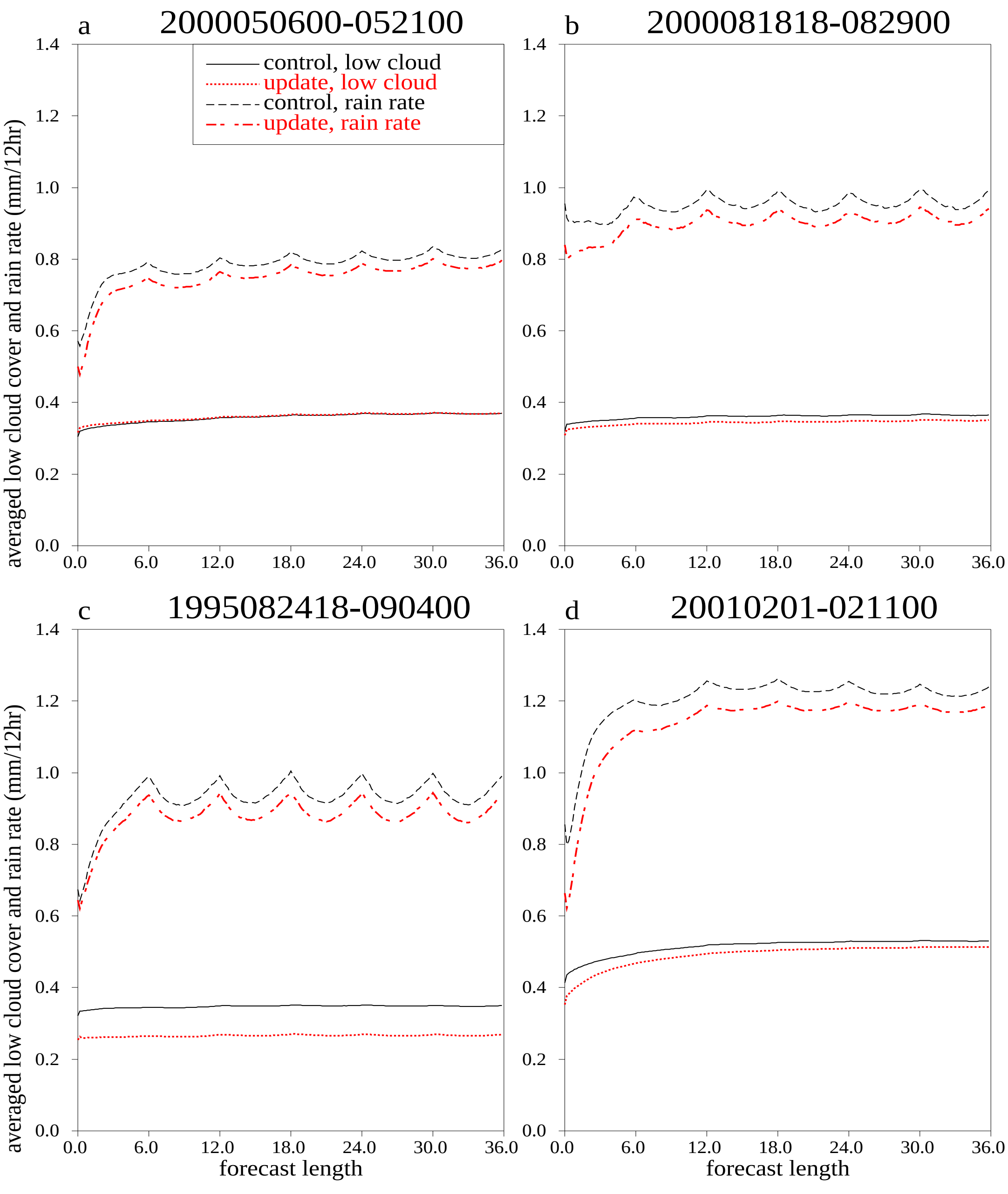

Figure 4: Comparison of domain averaged statistic time series for the predicted low cloud cover and rain rate using HIRLAM versions prior- and post- STRACO shallow convection update. The plotted averages are valid for four experiment periods, as indicated in the figures.