Using T799 IFS initial and boundary conditions in the ALADIN/HU model

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1. Preface

The work presented in this document was carried out in the framework of the ECMWF Special Project "Investigation of coupling the ALADIN and AROME models to boundary conditions from ECMWF and ERA model data". In this study the use of the T799 IFS forecasts as initial and boundary conditions to the ALADIN/HU model was investigated. This work was the direct continuation of the study performed by Gergely Bölöni using T511 IFS forecasts to drive ALADIN/HU with dynamical adaptation [1]. In this study not only higher model resolutions (both in IFS and ALADIN) were tested but in addition to dynamical adaptation the 3D-VAR data assimilation technique was also applied.

2. Description of the experiments

The experiments were carried out for the period of 8-21 August, 2006 with the ALADIN CY28T3 model version using 8 km horizontal resolution with 49 levels (up to 5 hPa). The integration domain is shown in Figure 1. In each experiment two 48 hour model integrations were performed at 00 and 12 UTC. The 3D-VAR experiments started 4 days earlier (on 4 August) but the first 4 days were regarded as a warm-up period and no forecasts were performed for them. In 3D-VAR a 6 hour assimilation cycle was used with SYNOP (only Z), AIREP, AMV, TEMP and Wind profiler observations and satellite radiances (NOAA AMSU-A and AMSU-B sensors). All the IFS initial and boundary conditions were prepared on the HPCE system of ECMWF using the scripts developed for the Special Project [2].

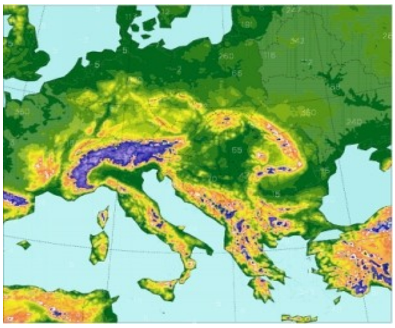

Figure 1: The integration domain and orography of the ALADIN/HU model

3. Handling of the surface fields

One of the problems of the BC generation process stems from the fact that IFS and ARPEGE/ALADIN use different surface schemes. It means that not all the required surface fields for ARPEGE/ALADIN are directly available in the IFS analyses/forecasts. Although this problem is handled by configuration 901 (it converts IFS GRIBs into ARPEGE FA files) by deriving all the required fields, it is well known that the present solution in 901 is not satisfactory. Instead it was suggested that for the IFS-driven ALADIN runs all the surface fields in the initial condition file should be replaced with the surface fields of the corresponding ARPEGE analysis. This replacement has to be done only for the initial conditions since surface fields are not coupled from the boundary conditions files during the ALADIN integration. The effect of this change can be clearly seen in Figure 2 showing that the surface field replacement provides better results for surface parameters. As a consequence this solution was applied in all the experiments presented in this paper.

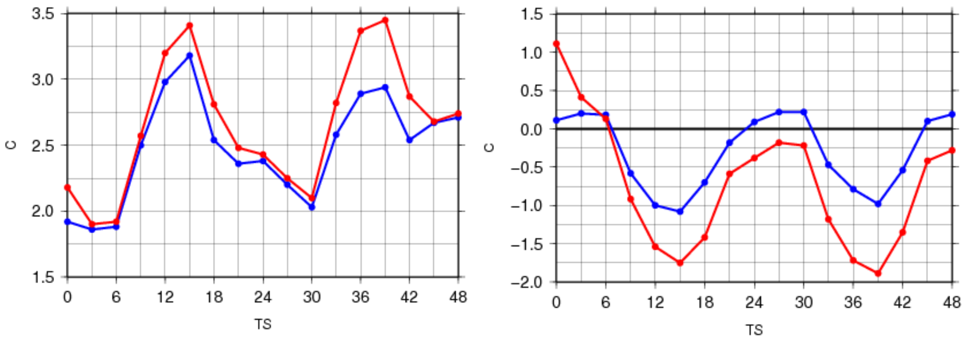

Figure 2: RMSE (on the left) and bias (on the right) scores for T2m for one 48 h ALADIN/HU integration using T799 IFS BCs. The red curve represents the default surface handing solution while the blue curve the modified one. The verification was performed against SYNOP observations.

4. Using the 00 and 12 UTC IFS runs as BC

In the first set of experiments dynamical adaptation driven by ARPEGE and IFS was tested. Two experiments were carried out:

- **ARPE_dyna**: initial and boundary conditions provided by ARPEGE
- **ECMF_dyna**: initial and boundary conditions provided by IFS T799 (stream oper)

Regarding the surface fields the two experiments gave similar results for both the 00 and 12 UTC runs (Figure 3). It is not surprising at all because all the surface fields in the initial condition files were are taken from ARPEGE.

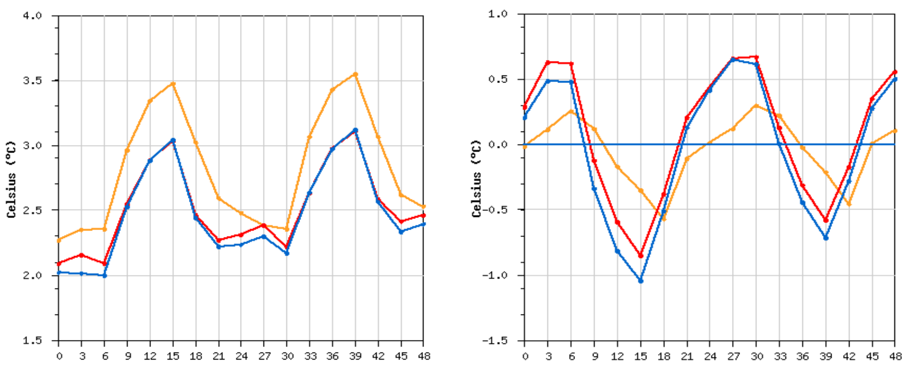

Figure 3: RMSE (on the left) and bias (on the right) scores for T2m for the 00 UTC runs. The red curve denotes ARPE_dyna, the blue curve denotes ECMF_dyna and the orange one represents the operational IFS forecast available at HMS. The verification was performed against SYNOP observations.

The verification of the upper air fields exhibited large differences between the experiments: ECMF_dyna proved to be significantly better both in terms of RMSE (Figure 4) and bias scores. The difference is larger at 00 UTC and smaller at the 12 UTC where it occurs only in the upper troposphere. ARPE_dyna is proved to be better than ECMF_dyna only for relative humidity in the upper troposphere. However, it is well known that relative humidity measurements from the European TEMP soundings at this height are not fully reliable so this feature should be neglected.

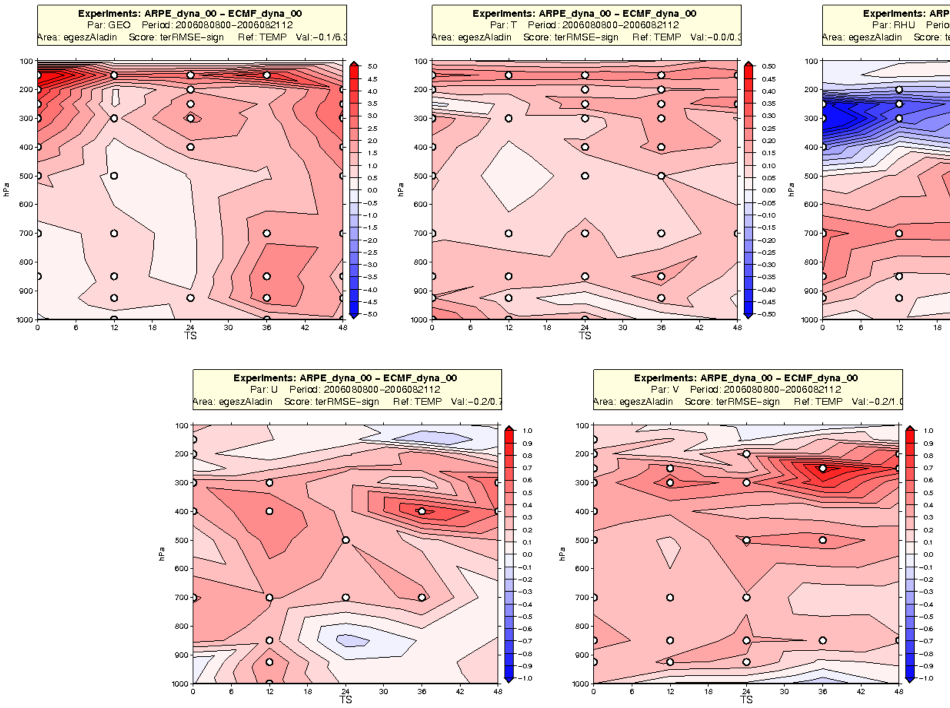

Figure 4: Difference of RMSE scores of the 00 UTC forecasts of ARPE_dyna and ECMF_dyna. Red shades indicate that ECMF_dyna is better, while blue shades indicate the opposite. White circles show that the difference is significant on a 90% confidence level. The verification was performed against TEMP observations. The figure order is the following (from left to right): Z, T, RHU, U and V.

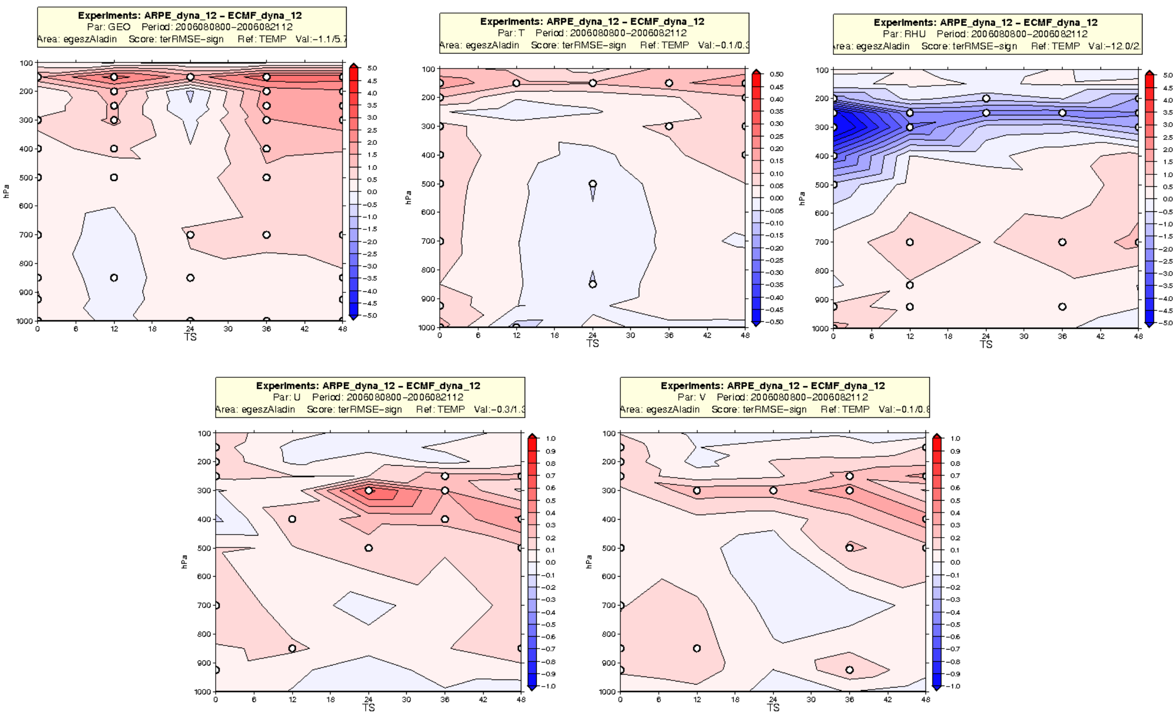

Figure 5: The same plots as in Figure 4 but this time for the 12 UTC runs.

5. Using the 06 and 18 UTC runs as BC

Unlike ARPEGE, the operational IFS runs are not available at the desired time for the operational ALADIN applications. For instance, the 00 UTC ALADIN/HU run ends at 3:30 UTC but the 00 UTC IFS integration starts only after 5:00 UTC. Thus for operational purposes only the previous IFS runs could be used as initial and boundary conditions to ALADIN. These runs are as follows:

- the 18 UTC IFS run (stream SCDA) providing BCs for the 00 UTC ALADIN run
- the 06 UTC IFS run (stream SCDA) providing BCs for the 12 UTC ALADIN run

This 6h-shifted BC usage was tested both with dynamical adaptation and 3D-VAR data assimilation. The following experiments were carried out:

- **ARPE_dyna**: dynamical adaptation using ARPEGE as initial and boundary conditions (in fact it is the same experiment as in the previous chapter)
- **ARPE_3d**: 3D-VAR with ARPEGE (both in the analysis cycling and in the forecast production ARPEGE was used as BC)
- **ECM6_dyn**: dynamical adaptation using IFS SCDA runs as initial and boundary conditions
- **ECM6_3d**: 3D-VAR with IFS SCDA runs (both in the analysis cycling and in the forecast production IFS SCDA was used as BC)

In the 3D-VAR experiments the same method as in the dynamical adaptation was applied to the surface: the surface fields in the first guess were replaced with the surface fields of the corresponding ARPEGE analysis.

5.1 Surface verification

Regarding the surface parameters the largest difference between the experiments was found for T 2m (Figure 6). It can be seen that the two 3D-VAR runs performed similarly for both RMSE and BIAS.

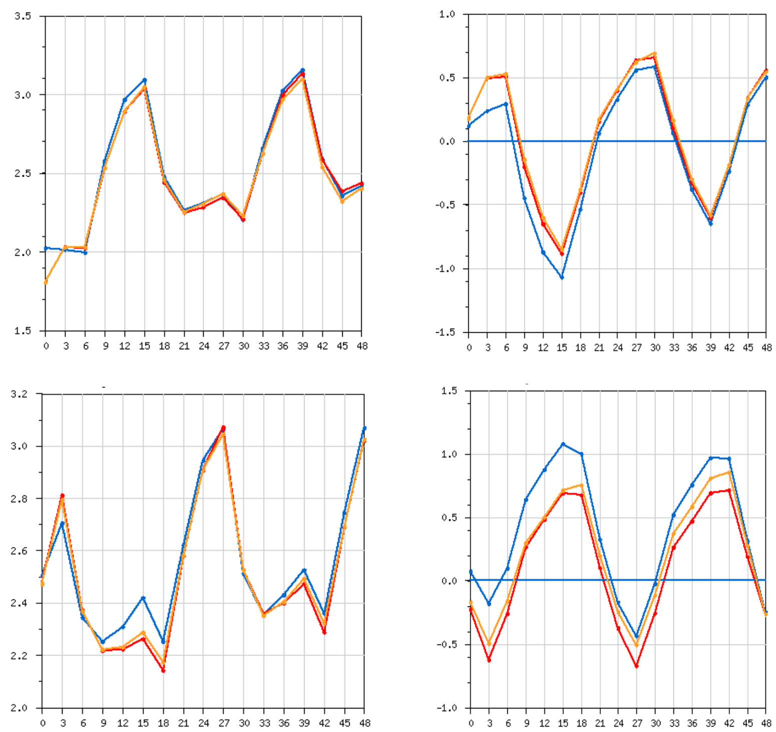

Figure 6: RMSE (on the left) and BIAS (on the right) scores for T2m for the 00 (top row) and 12 (bottom row) UTC runs. The red curve denotes ARPE_3d, the orange curve denotes ECM6_3d and the blue one denotes ECM6_dyna. The verification was performed against SYNOP observations.

Concerning the ECM6 experiments the use of 3D-VAR could slightly improved the RMSE scores but the bias scores indicate a systematic difference between dynamical adaptation and 3D-VAR. For RHU 2m and wind 10 m the differences were even smaller.

The verification of the precipitation forecast was also performed against SYNOP observations. ARPE_3d and ECM6_3d were compared using contingency tables for 12 and 24 h precipitation sums. The main conclusion is that for precipitation existence and for smaller precipitation rates (< 2 mm) ECM6_3d performed slightly better, but for large values (> 10mm) ARPE_3d is slightly better. Nevertheless, the differences are rather small. The results for the 24h precipitation for the 00 UTC runs are summarized in Figure 7 and 8.

előrejelzés	=0	<=2	<=10	>10	Osszesen
=0	918	213	170	79	1380
<=2	1908	1262	421	99	3690
<=10	500	1089	907	339	2835
>10	68	199	396	401	1064
Osszesen	3394	2763	1894	918	8969

megfigyelés

	=0	<=2	<=10	>10
B=	0.407	1.336	1.497	1.159
PC=	0.672	0.562	0.675	0.868
POD=	0.270	0.457	0.479	0.437
FAR=	0.335	0.658	0.680	0.623
F=	0.083	0.391	0.309	0.082
KSS=	0.188	0.066	0.170	0.354
TSS=	0.238	0.243	0.237	0.254
ETS=	0.119	0.031	0.096	0.198
HSS=	0.212	0.060	0.145	0.331
OR=	6.090	1.308	2.052	8.643
ORSS=	0.718	0.134	0.345	0.793

Figure 7: Contingency tables and the corresponding parameters for the 24h precipitation forecasts (from 3 to 30h) of the 00 UTC ARPE_3d runs.

előrejelzés	=0	<=2	<=10	>10	Osszesen
=0	945	226	148	87	1406
<=2	1888	1270	451	104	3713
<=10	483	1078	911	347	2819
>10	78	189	384	380	1031
Osszesen	3394	2763	1894	918	8969

megfigyelés

	=0	<=2	<=10	>10
B=	0.414	1.344	1.488	1.123
PC=	0.676	0.561	0.678	0.867
POD=	0.278	0.460	0.481	0.414
FAR=	0.328	0.658	0.677	0.631
F=	0.083	0.394	0.305	0.081
KSS=	0.196	0.066	0.176	0.333
TSS=	0.245	0.244	0.240	0.242
ETS=	0.124	0.031	0.098	0.188
HSS=	0.221	0.060	0.150	0.316
OR=	6.330	1.310	2.112	8.029
ORSS=	0.727	0.134	0.357	0.778

Figure 8: Contingency tables and the corresponding parameters for the 24h precipitation forecasts (from 3 to 30h) of the 00 UTC ECM6_3d runs.

5. 2 Upper air verification

For the upper air parameters (Figure 6) ECM6_dyna obviously turned to be worse than ECMF_dyna but it is still nearly of the same quality as ARPE_dyna (see the first column in Figure 9-12). The introduction of 3D-VAR improved the forecast quality in the first 12 hours for both ECM6 (see the middle column in Figure 6) and ARPE (not shown). Thus both for ECM6 and ARPE 3D-VAR turned to be better than dynamical adaptation. Comparing the 3D-VAR configurations we can conclude that the effect of 3D-VAR is more significant for ECM6 and ECM6_3d is even slightly better in the first 12 hours then ARPE_3d. Similar results were found for the other parameters.

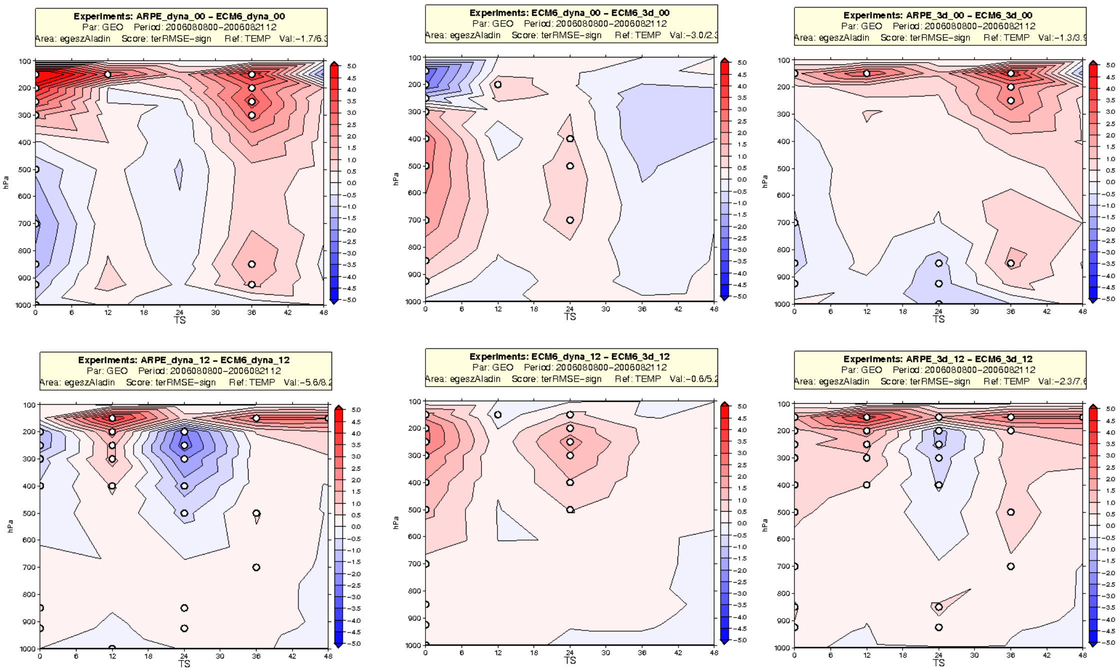

Figure 9: Difference of RMSE scores of the 00 (top row) and 12 UTC forecasts for Z. Left column: ARPE_dyna minus ECM6_dyna. Middle column: ECM6_dyna minus ECM6_3d. Right column: ARPE_3d minus ECM6_3d. Red shades indicate that the model to be subtracted is better (e.g. ECM6_dyna in the left column), while blue shades indicate the opposite. White circles show that the difference is significant on a 90% confidence level. The verification was performed against TEMP observations in every 12 hours.

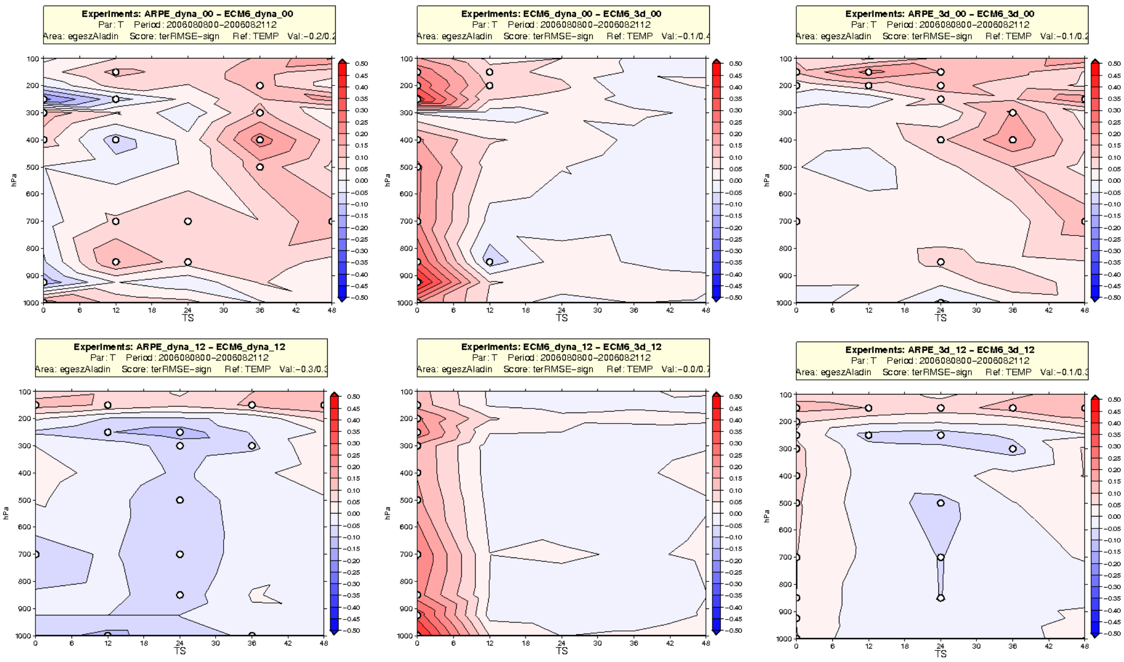

Figure 10: The same plots as in Figure 9 but this time for the temperature.

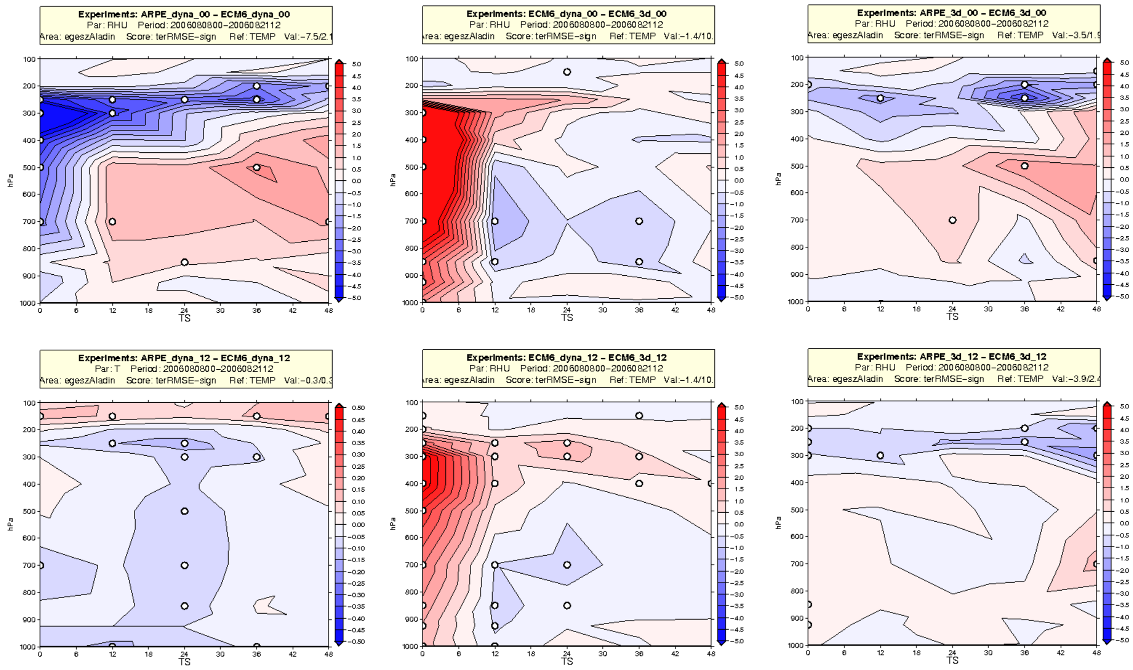

Figure 11: The same plots as in Figure 9 but this time for the relative humidity.

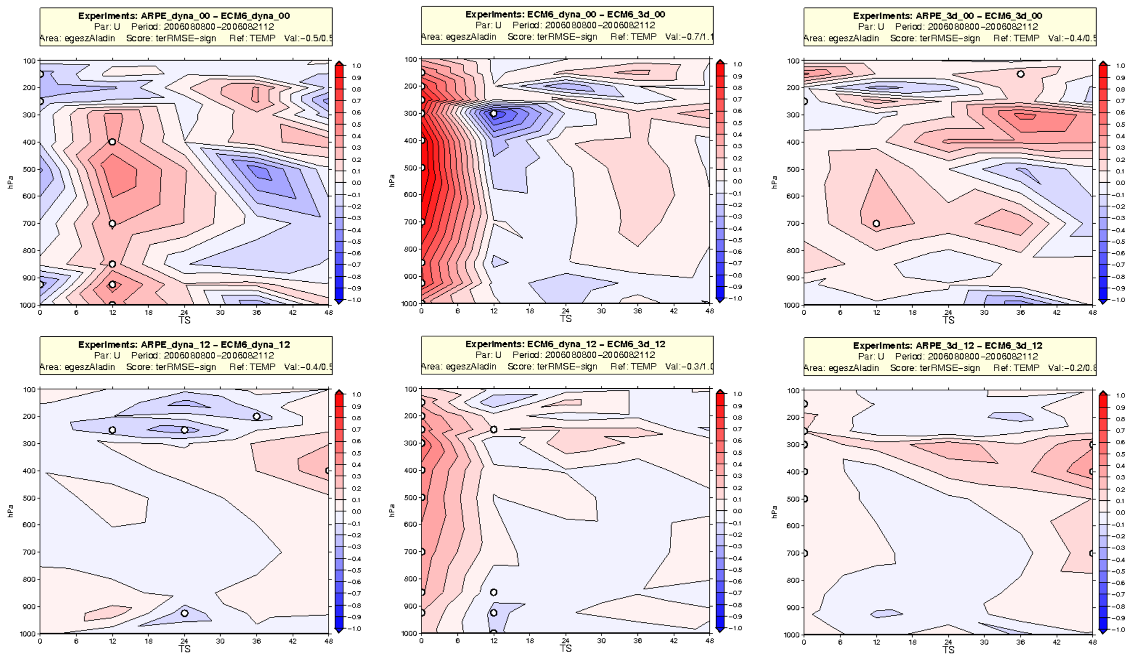

Figure 12: The same plots as in Figure 9 but this time for the U wind component.

6. Conclusions

It was shown that ALADIN based on dynamical adaptation performs better for the upper air parameters with IFS BCs than with ARPEGE ones. However, unlike ARPEGE, in a real-time environment only the 6h earlier IFS run is available as BC to ALADIN. The usage of the 6h earlier IFS run was tested both with dynamical adaptation and 3D-VAR data assimilation. It turned out that this kind of IFS BC usage is optimal when 3D-VAR is used in ALADIN. In this case the upper air scores are even slightly better than in 3D-VAR with ARPEGE. The detailed evaluation of the results (weather events, case studies) is still to be done.

Another important issue is the question of the optimal use of IFS surface fields. The recent solution should be further developed and a more advanced method should be applied.

References

[1] Bölöni G.: ALADIN coupled with ECMWF/IFS, Presented at the 16th ALADIN workshop, May 16-19, 2006, Sofia. Available online at:
http://www.cnrm.meteo.fr/aladin/meetings/Wk2006/presentations/tuesday/G_boloni_ECM_LBC.pdf

[2] Kertész S.: Preparing ALADIN BCs on ECMWF HPCF. Available online at:
http://www.rclace.eu in the Documents -> Local Documents menu