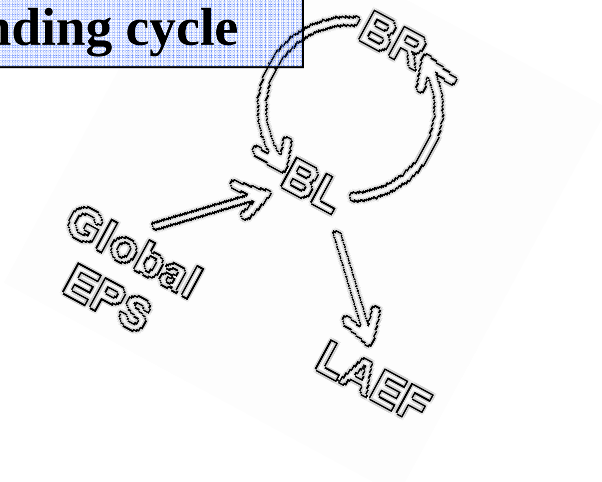
Report on stay at ZAMG

09/02 – 03/04/2009, Vienna, Austria

Initial conditions for LAM EPS by breeding-blending cycle



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:: Content

:: Acknowledgement

I don’t want to be repetitive, but have to state as usually that I am very grateful to the whole local NWP team (including new staff members) for their hospitality and friendly atmosphere. I have found here again really peaceful and productive place to work. Thanks!

:: Foreword

The general and well known idea of blending in NWP is the combination of large scale features resolved by global model analysis with the small scale features provided by limited area model (usually by short-range forecast – the guess). This procedure is commonly known and largely used in deterministic NWP systems as the pseudo-assimilation method. However, we try to use the similar technique in completely new application and thus this work is direct continuation of our previous research in the field of LAM generated initial perturbations for running LAM EPS.

Since the global model perturbations (ECMWF EPS) are based on singular vector technique, while LAM (ALADIN) generated perturbations by breeding are physically very different, there is inconsistency between such LAM initial conditions and driving global EPS boundary conditions. We suppose that with spectral blending technique applied within breeding cycle, we can produce physically consistent (with global EPS LBCs) initial conditions ready for consecutive LAM EPS integration. Such LAM EPS initial states can profit from containing large scale uncertainties originated by singular vector technique, while still keeping the small scale perturbations resolved by LAM (which are actually replacing just some unrealistic numerical noise in downscaled global model files resulting from their interpolations into the finer grid).

Further we would like to demonstrate that the implementation of spectral blending within breeding cycle has also positive impact on the LAM EPS verification scores. Our experiments with differently prepared initial conditions (for two months period driven by ECMWF EPS consisting of 16 members) show the advantages of breeding-blending method over the pure breeding approach. Significantly better results can be achieved if additional surface perturbation (none-cycled one) is used together with breeding and upper air spectral blending cycle. Such strategy for obtaining perturbed initial conditions for LAM EPS gives already better results than simple downscaling of global EPS.

:: I LAM generated perturbations

Initial LAM perturbations used in our experiments are based on breeding technique. The difference between two parallel integrations (one labelled as *positive* and the other as *negative*) for 12 hours coupled with ECMWF EPS is rescaled and centred around the analysis of ECMWF control run. The differences are actually computed only for some meteorological variables like 3D fields of Temperature, Specific Humidity, Wind components and also for surface Pressure. By this means, two new initial states (perturbed) for the subsequent limited area ensemble forecasting are created. These LAM generated perturbed initial conditions are further blended with the corresponding ECMWF EPS initial states in order to ensure said compatibility between INIT and LBC files. (For detailed information about the blending procedure please see the RC LACE report from last year - M. Belluš, 2008: Combination of large scale initial conditions uncertainty with small scale initial perturbations obtained by breeding cycling using blending technique in LAEF experiments.)

However, as it was observed in our former experiments and verifications – the perturbations created by breeding method are sufficient in the upper atmosphere but too weak near the surface. Hence we have introduced a vertically dependent scaling factor. A quadratic function of actual model level was used to keep the original magnitude of scaling factor untouched approximately down to the 850 hPa level (about 1.5 km altitude) and then slowly growing it towards the surface with strong increase near the ground (for the last model levels).

Our introduced function for vertically variable scaling factor [1] reads:

$$scalef\,(jlev) = \frac{1}{(jlev-\alpha)^2} + \beta \qquad [1]$$

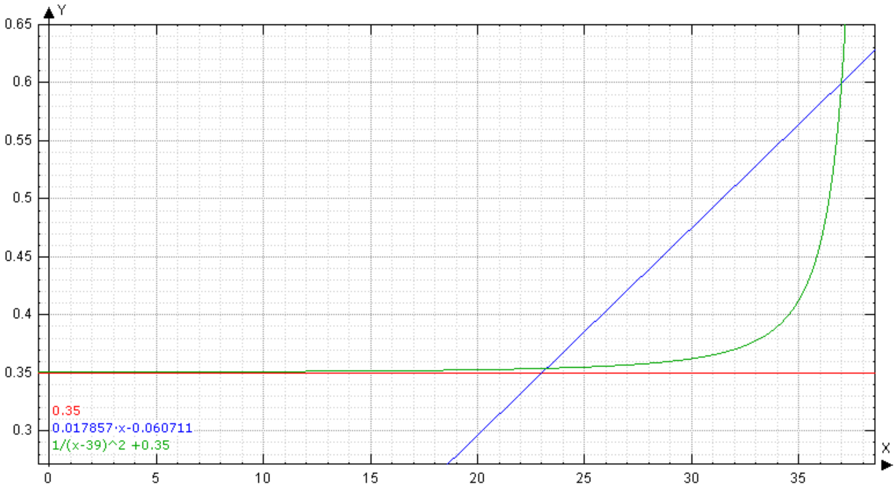
Where β is minimum scaling factor (0.35) and α is 39 (which means, that having the maximum number of model levels equal to 37 – the maximum possible scaling factor will be 0.60 at the lowest 37th level).

This scaling factor is finally "rescaled" or normalized by average magnitude of temperature difference between so called *positive* and *negative* ensemble members (which are 12 hour forecasts from previous breeding cycle) at approximately 850 hPa level [2].

$$scale(jlev) = \frac{scalef\,(jlev)}{\sqrt{\frac{1}{n}\sum \Delta p_n{}^2}} \qquad [2]$$

At the end, new perturbed initial conditions (a_p, a_n) are computed by adding and subtracting one half of $\Delta p(field, jlev)$ scaled by our new $scale(jlev)$ to the actual unperturbed analysis A [3]. Mind, that scaling strength (i.e. perturbation magnitude) can be now different for each model level.

$$a_{p1}(field, jlev) = A(field, jlev) + scale(jlev) * \frac{1}{2}\Delta p(field, jlev)$$
$$a_{n1}(field, jlev) = A(field, jlev) - scale(jlev) * \frac{1}{2}\Delta p(field, jlev) \qquad [3]$$



::Fig.1 Vertical dependency of scaling factor (x-model level, y-scaling factor)

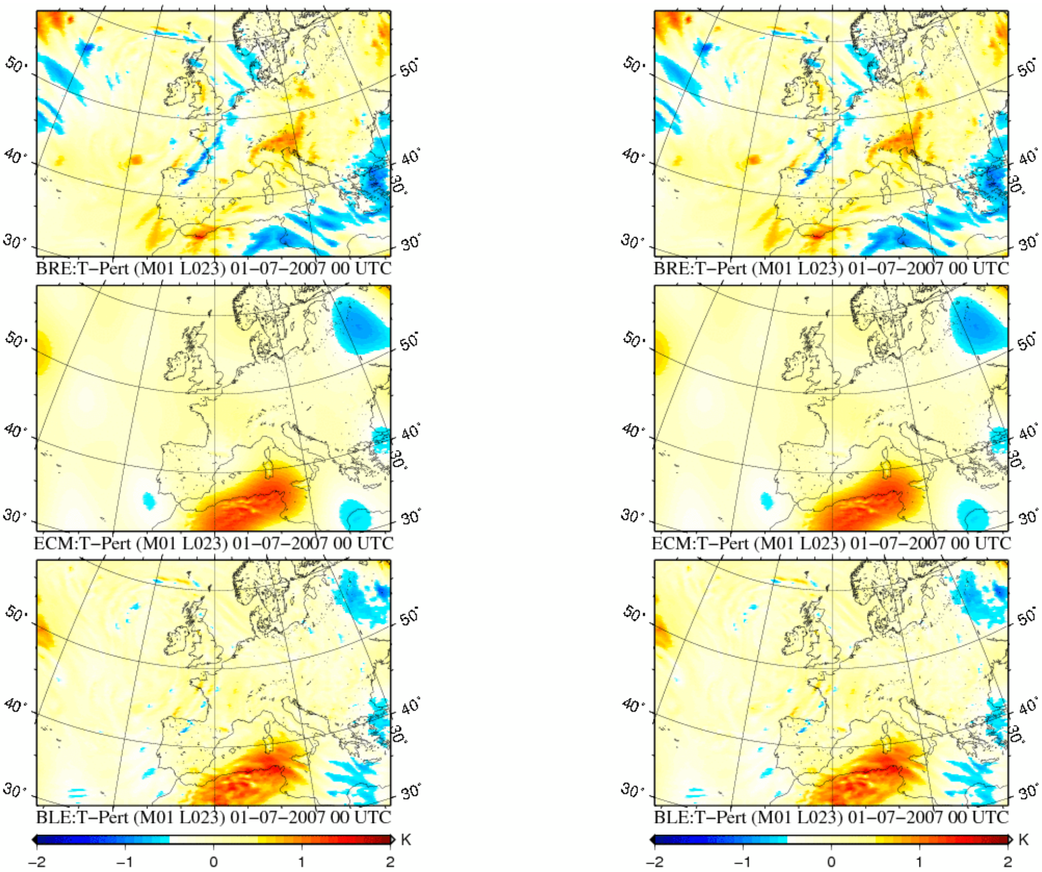
LEVEL: 1	SCALEF:	0.350692520776	SCALE:	0.475285654205
LEVEL: 2	SCALEF:	0.350730460190	SCALE:	0.475337072636
LEVEL: 3	SCALEF:	0.350771604938	SCALE:	0.475392835185
LEVEL: 4	SCALEF:	0.350816326531	SCALE:	0.475453445349
LEVEL: 5	SCALEF:	0.350865051903	SCALE:	0.475519481746

LEVEL: 6	SCALEF: 0.350918273646	SCALE: 0.475591611971
LEVEL: 7	SCALEF: 0.350976562500	SCALE: 0.475670609540
LEVEL: 8	SCALEF: 0.351040582726	SCALE: 0.475757374707
LEVEL: 9	SCALEF: 0.351111111111	SCALE: 0.475852960234
LEVEL: 10	SCALEF: 0.351189060642	SCALE: 0.475958603473
LEVEL: 11	SCALEF: 0.351275510204	SCALE: 0.476075766612
LEVEL: 12	SCALEF: 0.351371742112	SCALE: 0.476206187545
LEVEL: 13	SCALEF: 0.351479289941	SCALE: 0.476351944688
LEVEL: 14	SCALEF: 0.351600000000	SCALE: 0.476515540305
LEVEL: 15	SCALEF: 0.351736111111	SCALE: 0.476700008620
LEVEL: 16	SCALEF: 0.351890359168	SCALE: 0.476909057529
LEVEL: 17	SCALEF: 0.352066115702	SCALE: 0.477147256391
LEVEL: 18	SCALEF: 0.352267573696	SCALE: 0.477420287861
LEVEL: 19	SCALEF: 0.352500000000	SCALE: 0.477735289982
LEVEL: 20	SCALEF: 0.352770083102	SCALE: 0.478101327512
LEVEL: 21	SCALEF: 0.353086419753	SCALE: 0.478530051431
LEVEL: 22	SCALEF: 0.353460207612	SCALE: 0.479036637676
LEVEL: 23	SCALEF: 0.353906250000	SCALE: 0.479641148851
LEVEL: 24	SCALEF: 0.354444444444	SCALE: 0.480370551629
LEVEL: 25	SCALEF: 0.355102040816	SCALE: 0.481261777142
LEVEL: 26	SCALEF: 0.355917159763	SCALE: 0.482366489444
LEVEL: 27	SCALEF: 0.356944444444	SCALE: 0.483758745175
LEVEL: 28	SCALEF: 0.358264462810	SCALE: 0.485547736257
LEVEL: 29	SCALEF: 0.360000000000	SCALE: 0.487899870620
LEVEL: 30	SCALEF: 0.362345679012	SCALE: 0.491078916416
LEVEL: 31	SCALEF: 0.365625000000	SCALE: 0.495523306098
LEVEL: 32	SCALEF: 0.370408163265	SCALE: 0.502005819260
LEVEL: 33	SCALEF: 0.377777777778	SCALE: 0.511993691391
LEVEL: 34	SCALEF: 0.390000000000	SCALE: 0.528558193171
LEVEL: 35	SCALEF: 0.412500000000	SCALE: 0.559051935085
LEVEL: 36	SCALEF: 0.461111111111	SCALE: 0.624933476257
LEVEL: 37	SCALEF: 0.600000000000	SCALE: 0.813166451033

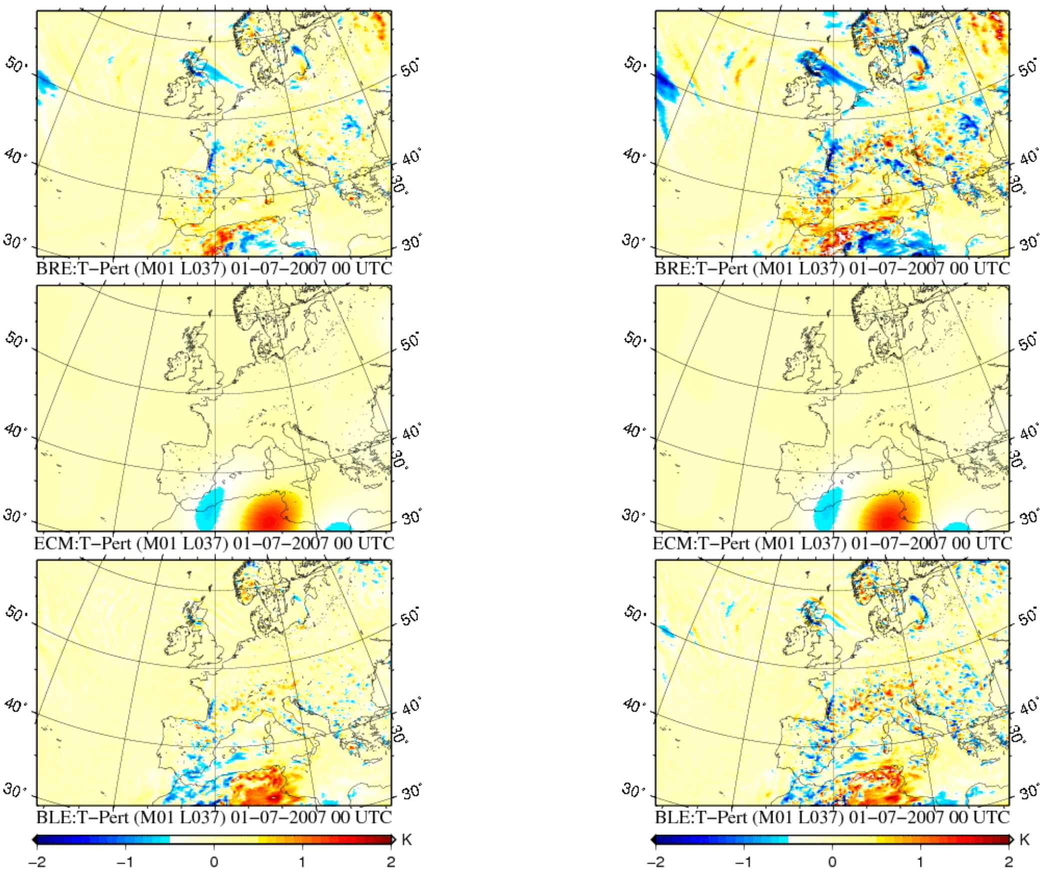
::Tab 1 New scaling factor and its rescaled value for each level (depending on actual conditions)

The following experiment shows the LAEF initial perturbations generated by breeding-blending cycle (after 20 days of cycling for ensemble member 01) at 23rd and 37th model levels. The first one is approximately at 850 hPa level and the second one is the lowest model level near the ground. Perturbed fields using constant scaling (0.35) and the new implemented vertically variable scaling (0.35-0.60) are shown. For each field, there is the perturbation produced by LAM breeding method (top), corresponding ECMWF global model perturbation (middle) and finally new initial perturbation after blending procedure, which can be used for LAEF integration (bottom). Temperature field is on **Fig.2** and **3**, zonal Wind component on **Fig.4**, **5** and meridional Wind component on **Fig.6**, **7**.

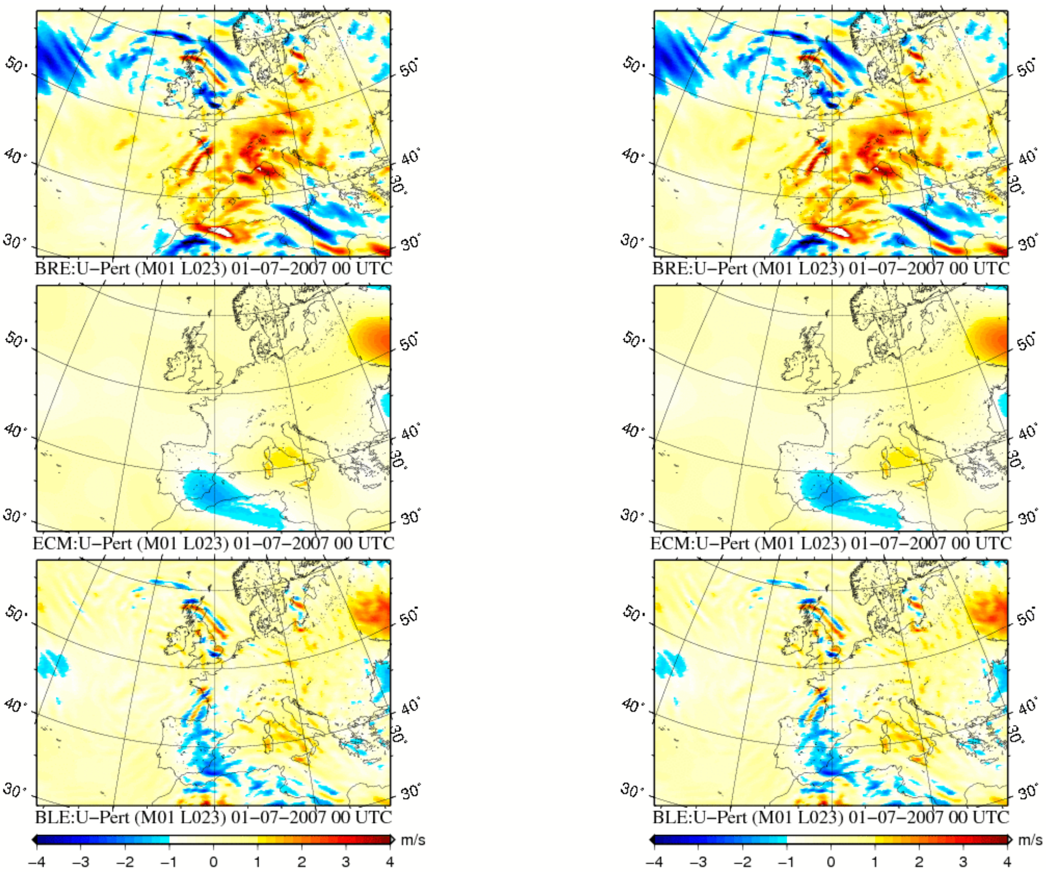
It is evident, that while the perturbations at about 850 hPa level are identical for both types of scaling, the perturbations near surface are significantly increased in the result when vertically variable scaling factor was applied. Moreover, the combination of small scale perturbations with the global model uncertainty can be also observed very clearly in the new initial conditions after blending procedure. Thanks to blending, new initial states inherited both the low frequency signal from ECMWF SV and high frequency signal resolved by ALADIN breeding (in some well-balanced way due to digital filter).



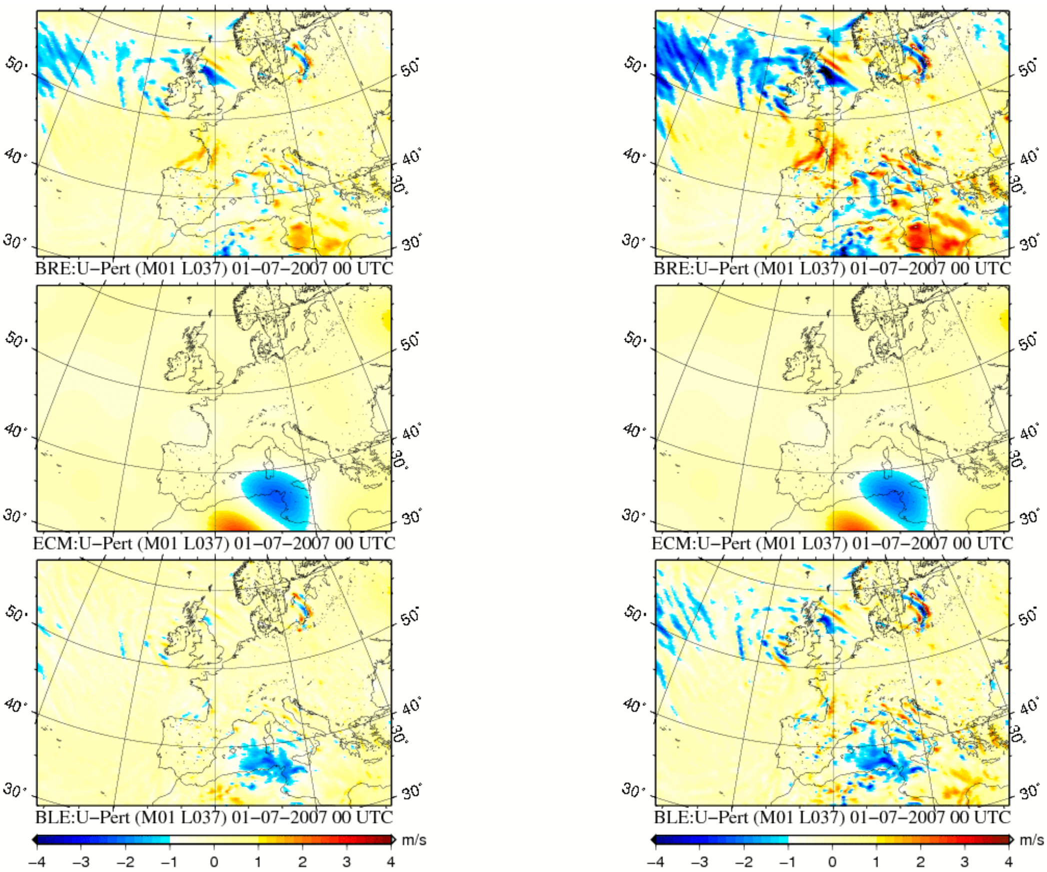
::Fig.2 T-perturbation at 850 hPa: constant scaling (left) and vertically variable scaling (right)



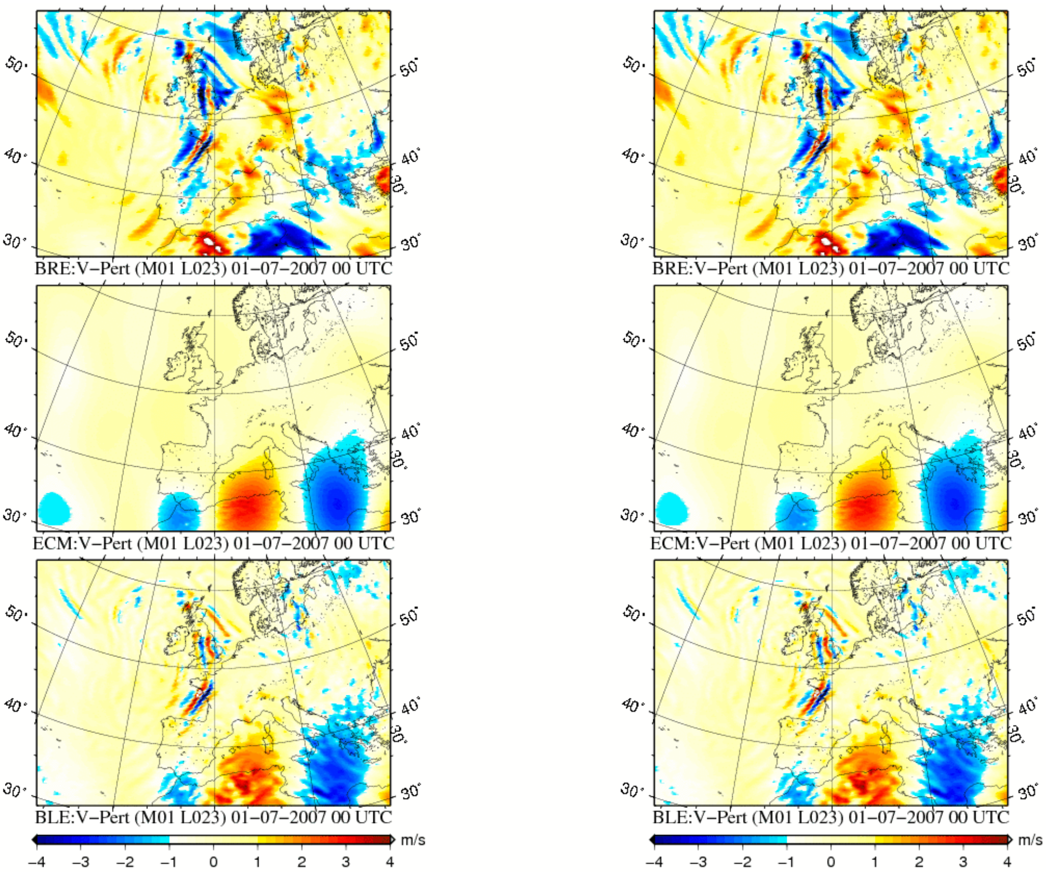
::Fig.3 T-perturbation near surface: constant scaling (left) and vertically variable scaling (right)



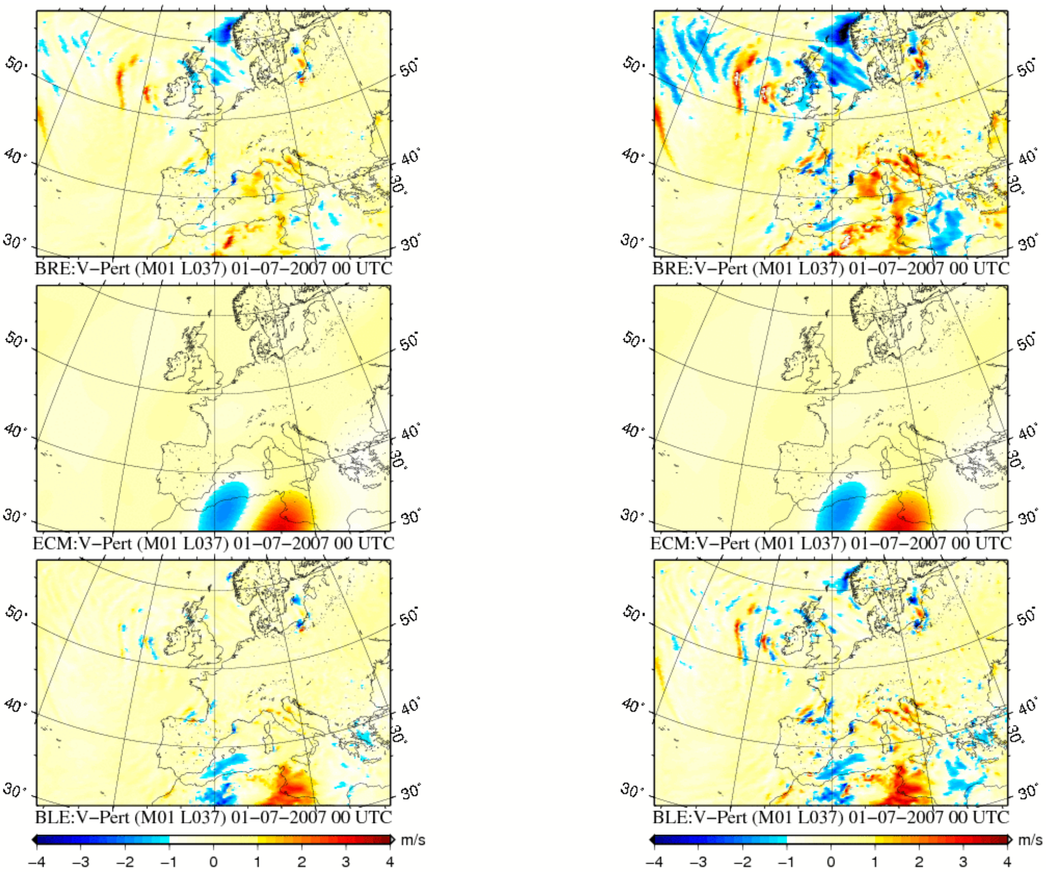
::Fig.4 U-perturbation at 850 hPa: constant scaling (left) and vertically variable scaling (right)



::Fig.5 U-perturbation near surface: constant scaling (left) and vertically variable scaling (right)



::Fig.6 V-perturbation at 850 hPa: constant scaling (left) and vertically variable scaling (right)



::Fig.7 V-perturbation near surface: constant scaling (left) and vertically variable scaling (right)

:: II Different LAEF configurations

All the experiments mentioned here were carried out on operational LAEF domain with 18 km horizontal resolution (225x324 grid points) and 37 vertical levels. For breeding and blending procedures (ee927, e001, DFI, blend) recent ALADIN cycle cy32t1 was used, while for LAEF integration with in-line fullpos an older but well-tried version cy25t1 was applied. Integration was done for 16 members (8 pairs from breeding) up to 54 hours and only for 00 UTC network time (while breeding-blending cycle was certainly performed every 12 hours).

For more details about the technical settings of the experiments and information about the basic application bricks which were used to build the individual LAEF configurations - please see the last chapter in this report.

To test the effect of different approaches in preparation of initial conditions for LAM EPS, we have ran the following set of experiments for selected period of 2 months (20-06-2007 ~ 20-08-2007) coupled by ECMWF global ensemble prediction system. (Cold start of breeding cycle with an initial "warming up" was done for the previous 10 days, i.e. from 10-06-2007 till 20-06-2007.)

Different LAEF configurations:

BRCC – breeding cycle with constant scaling factor (0.35)
BRCV – breeding cycle with vertically variable scaling factor (0.35-0.60)
BBCC – breeding-blending cycle with constant scaling factor (0.35)
BBCV – breeding-blending cycle with vertically variable scaling factor (0.35-0.60)
BBCS – breeding-blending cycle with constant scaling factor and additional surface perturbation
BRCL – breeding cycle with large initial spread (0.90) [tested only for 20 days]
BBCL – breeding-blending cycle with large initial spread (0.90) [tested only for 20 days]

and

DOWN – pure downscaling of global ECMWF EPS (used as our reference)

Verification results from the above mentioned experiments will be reported in the next chapters.

:: III Verification methods

The main goal of EPS is to approximate the expected probability density function of the predicted variable by a finite set of deterministic forecast realizations. Hence, it is far from trivial to verify such complex information against the single observed values. Several approaches exist to compare real-valued observations to the ensemble forecast, taking into account its full information content, but there is no general agreement on which one is the best.

Moreover, the forecast can be verified not only to the exact reality, but sometimes (or more often) we have to use just the best possible estimate of the true instead (for instance model analysis). Verification is the process, which has to evaluate the quality of the forecast.

However for us, the most important point is to compare the quality of different forecasting systems to each other and show to what extent one system gives better results than the other.

There are many types of existing forecasts and each of which needs to be verified with slightly different methods. For our purpose of probabilistic forecast verification, we have used the verification package prepared within RC LACE cooperation (E. Hagel, A. Kann, R. Mladek, 2006-2007) and to confront our experiments with the reference (pure downscaling of global ECMWF EPS) we have chosen the following appropriate verification scores.

Reliability diagram: *It answers the question, how well the predicted probabilities of an event correspond to their observed frequencies.*

The diagram plots the observed frequency against the forecast probability, where the range of forecast probabilities is divided into several bins. The sample size in each bin is shown as a histogram on the right side of our plots, which is the measure of forecast sharpness. By sharpness it is meant the tendency of the forecast to predict the extreme values (probabilities near 0 and 1, as opposed to values clustered around the mean). Sharpness is a property of forecast only (climatology has no sharpness), and forecast can have this attribute even if it is wrong. But in such case it would have poor reliability.

Reliability is indicated by the distance of the plotted curve from the diagonal. The deviation from the diagonal gives the conditional bias. If the curve lies below the line, this indicates overforecasting, i.e. probabilities too high. Points above the line indicate underforecasting, i.e. probabilities too low. The flatter the curve in the reliability diagram, the less resolution it has. By resolution it is meant the forecast ability to resolve the set of events into subsets with different frequency distributions. Even if the forecast is wrong, the forecast system may have resolution if successfully separates one type of outcome from another. So called “climatology forecast” does not discriminate at all between events and non-events, and thus has no resolution.

Relative Operating Characteristics - ROC: *It answers the question, what is the ability of the forecast to discriminate between events and non-events.*

The diagram plots hit rate versus false alarm rate, using a set of increasing probability thresholds (for example, 0.05, 0.10, 0.15, 0.20 etc.) to make the yes/no decision. The area under the ROC curve is frequently used as a score. Perfect score is 1.0, while 0.5 indicates forecast with no skill (diagonal line in the diagram). By no skill it is meant here, that the probability of detection of an event is the same as its false alarm rate. Such forecast is of course useless.

ROC measures the ability of the forecast to discriminate between two alternative outcomes, thus measuring the forecast resolution. It is not sensitive to bias in forecast, hence saying nothing about reliability. Therefore, it is good to combine ROC with reliability diagram and vice versa. A biased forecast may still have good resolution and produce a good ROC curve, which means that it may be possible to improve the forecast through calibration. The ROC can thus be considered as a measure of potential usefulness.

Ranked Probability Score: *It answers the question, how well did the probability forecast predict the category that the observation fell into.*

It can be expressed by the following formula:

$$RPS = \frac{1}{M-1}\sum_{m=1}^{M}\left[\left(\sum_{k=1}^{m} p_k\right)-\left(\sum_{k=1}^{m} o_k\right)\right]^2 \qquad [4]$$

Where M is the number of categories, p_k is the predicted probability in forecast category k, and o_k is a 0/1 (yes/no) indicator for the observation in category k.

It measures the sum of squared differences in cumulative probability space for a multi-category probabilistic forecast and hence penalizes forecasts more strictly when their probabilities are further from the actual observation. The range of possible values for RPS is from 0 to 1, while the perfect score is zero.

Continuous version of this score can be considered as a RPS with the infinite number of classes each of zero width. It is focused on the entire range of possible values for a given weather parameter. Continuous ranked probability score (CRPS) is defined by formula:

$$CRPS = \int_{-\infty}^{\infty}\left(P_f(x) - P_o(x)\right)^2 dx \qquad [5]$$

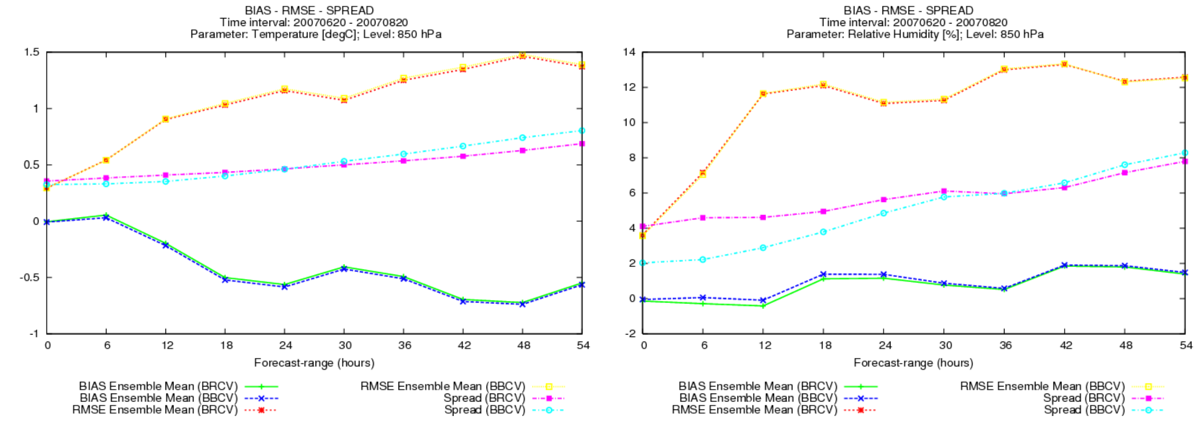
For a deterministic forecast system CRPS reduces to the mean absolute error. Therefore, this score can be easily interpreted as an error measure and moreover, it is in the same units as the verified variable.

Further, we will use also standard verification scores like BIAS, RMSE and SPREAD, which don’t need to be explained here. We can just remark, that in our experiments, BIAS and RMSE are computed for the ensemble mean rather than for one deterministic forecast. It has to be taken into account as well, that the rare the event is, the larger number of samples is necessary for the meaningful verification. (Most of our experiments were verified for 2 months period.)

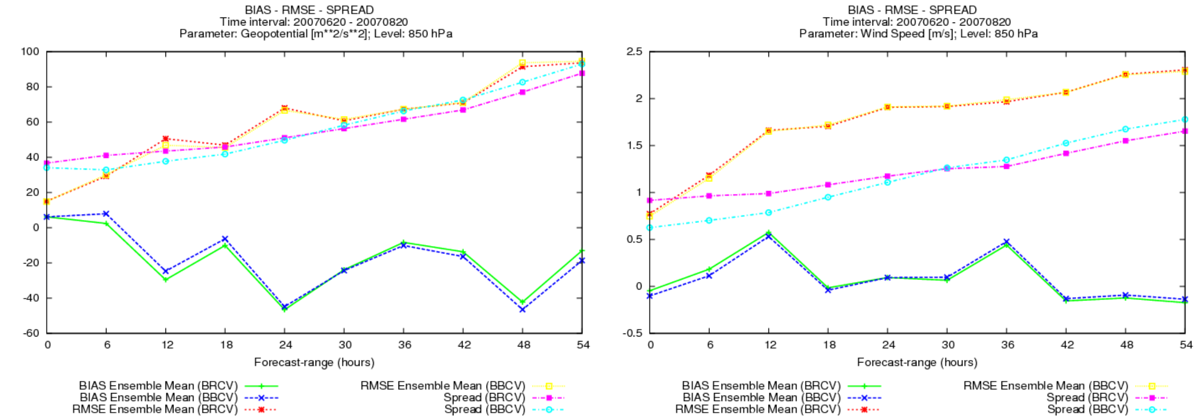
:: IV Breeding vs. breeding-blending cycle

Now we would like to demonstrate the profit of the upper air spectral blending implementation within the breeding cycle on the ensemble spread. For such purpose we have verified BRCV versus BBCV experiments (i.e. breeding cycle versus breeding-blending cycle, both with vertically variable scaling factor - which is not so important here since the scores at 850 hPa level are considered).

The following charts for Temperature, Relative Humidity, Geopotential and Wind speed at 850 hPa level display smaller BBCV spread (than BRCV one) at the beginning of the forecasting period. Approximately after the first 24 hours of integration it starts to grow faster. Then, till the end of the forecast BBCV spread is already larger than BRCV one, while BIAS and RMSE are rather identical for both experiments for all lead times. Ensemble spread is improved in BBCV experiment, but it is still not growing fast enough to be corresponding to RMSE (both should be almost equal in well performing system). Here the ensemble spread is much smaller than RMSE of ensemble mean all the time (except Geopotential), which is called underdispersive system.



::Fig.8 BIAS, RMSE and SPREAD for Temperature (left) and Relative Humidity (right) at 850 hPa level



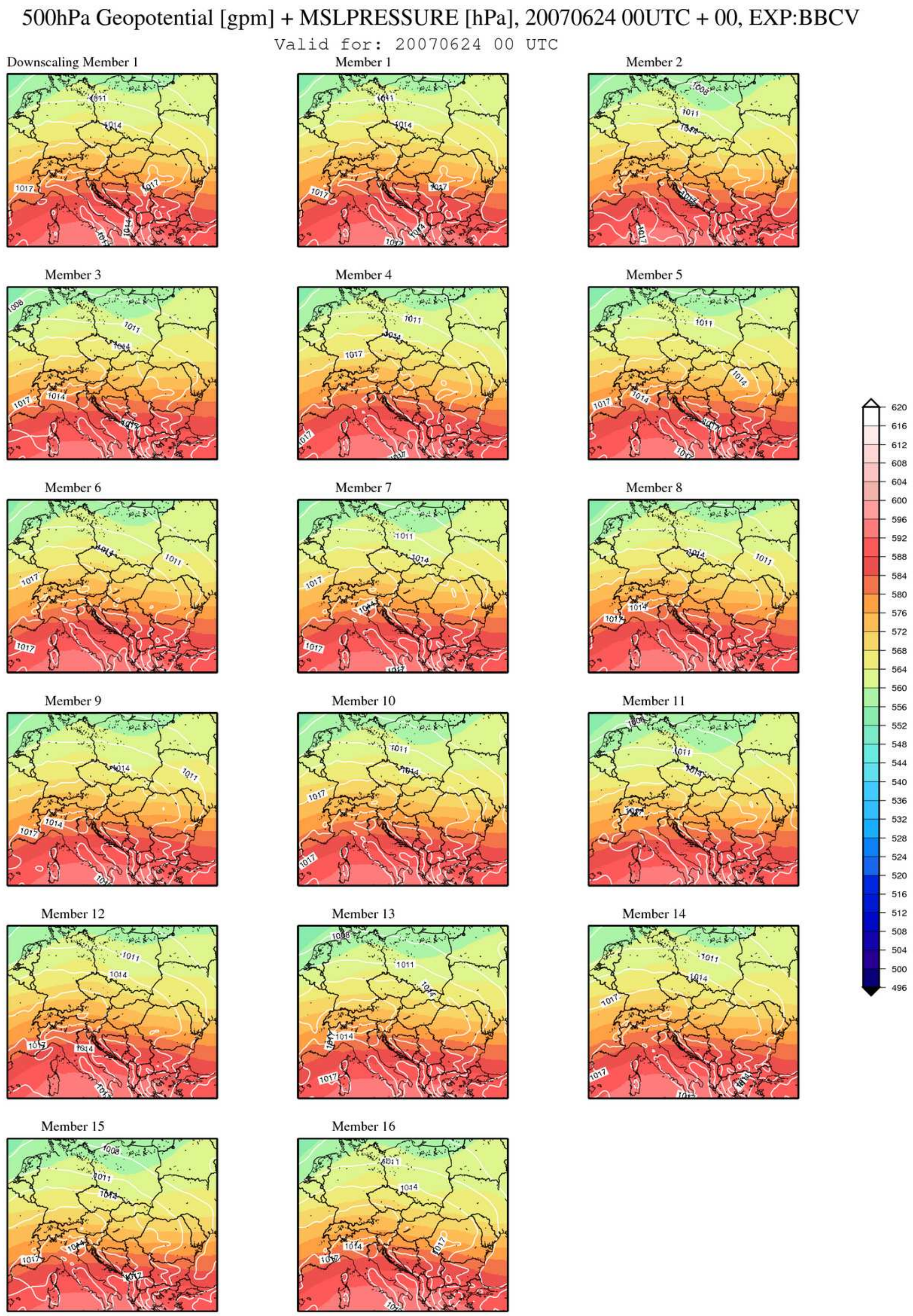
::Fig.9 BIAS, RMSE and SPREAD for Geopotential (left) and Wind speed (right) at 850 hPa level

To investigate even further the influence of blending on the ensemble spread, we decided to run and verify short (20 days) experiments with quite large initial scaling factor in breeding (BRCL, BBCL). Such scaling values (0.90) are indeed not suitable for serious LAEF application, but can be used conveniently for demonstration, since the effect is well magnified.

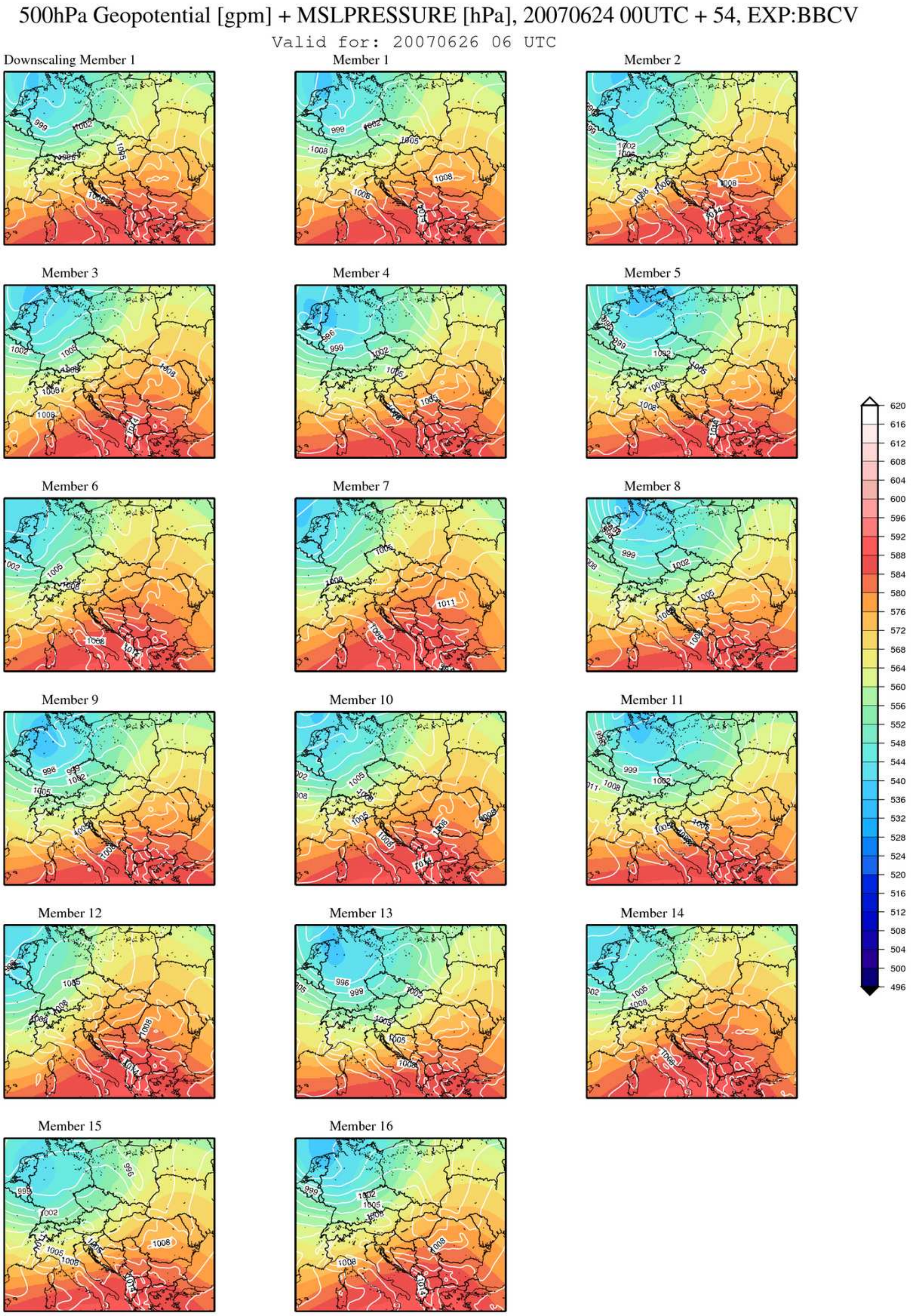
From the verification results we have learned, that even very big initial spread generated by breeding cycle is after blending procedure strongly corrected towards the initial spread of downscaled system. The ensemble spread was only marginally increased for early lead times. For longer lead times both downscaling and breeding-blending experiments had better growing spread, while the one of pure breeding cycle had tendency to stagnate.

Since all our systems are indeed underdispersive (including downscaled global ECMWF EPS), for further ensemble spread improvement we have to propose either the ensemble calibration method or application of multiphysics (different physical parameterizations) in breeding procedure (which was already implemented in our application, but not yet fully tested).

Finally, just for the illustration of how similar on first sight might be the atmospheric fields for different ensemble members but definitely not the same in details, the Geopotential at 500 hPa together with MSL-Pressure for BBCV configuration is shown on the following post-stamp maps.



::Fig.10 Geopotential at 500 hPa and MSL-Pressure valid at 24-06-2007 00UTC +00h for all 16 members + 1st downscaling member for control (beginning of integration)

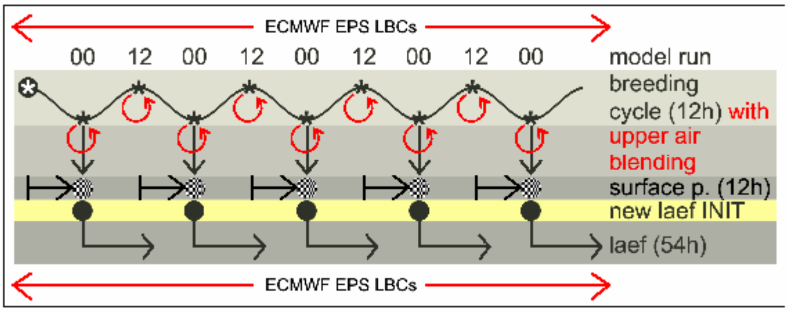


::Fig.11 Geopotential at 500 hPa and MSL-Pressure valid at 24-06-2007 00UTC +54h for all 16 members + 1st downscaling member for control (end of integration)

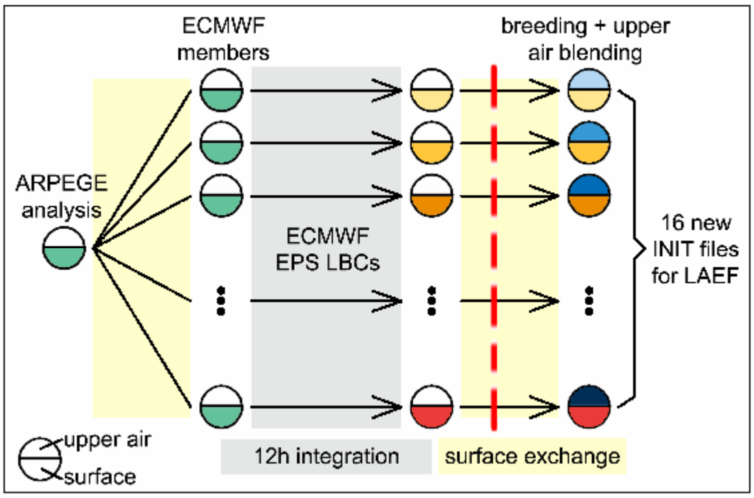
:: V Downscaling of global EPS vs. LAM EPS

In this chapter the advantage of LAM generated perturbations over the simple downscaling of global EPS is demonstrated on ensemble verification results. The verification is done for full 2 months period and both experiments are verified against the ECMWF analysis. BBCS configuration (breeding-blending cycle with surface perturbation) is confronted with pure ECMWF EPS downscaling.

The scheme of BBCS configuration of LAM EPS is shown on **Fig.12** and the procedure of creating the surface perturbation is explained on **Fig.13**.



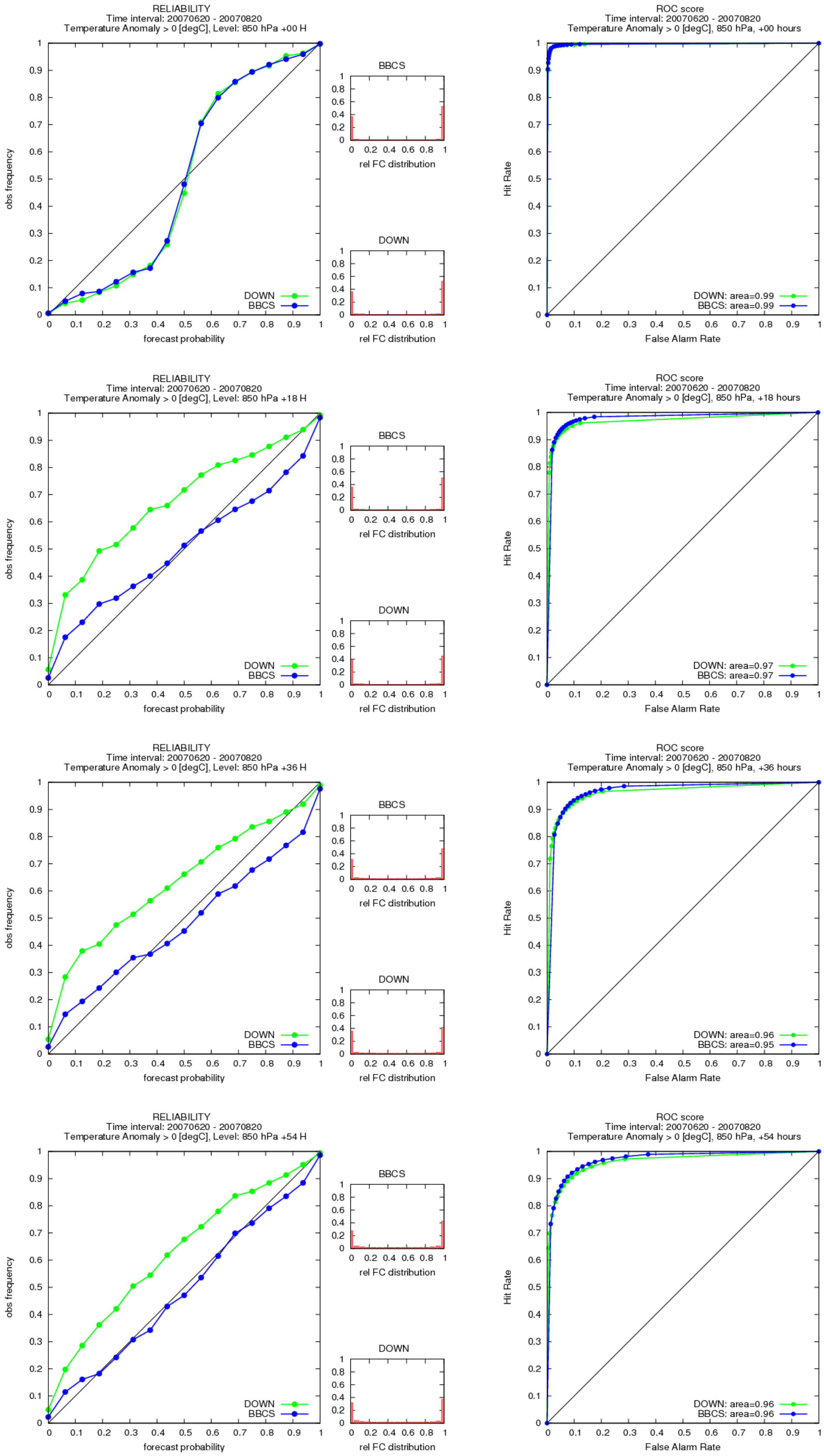
::Fig.12 BBCS configuration



::Fig.13 Surface perturbation procedure

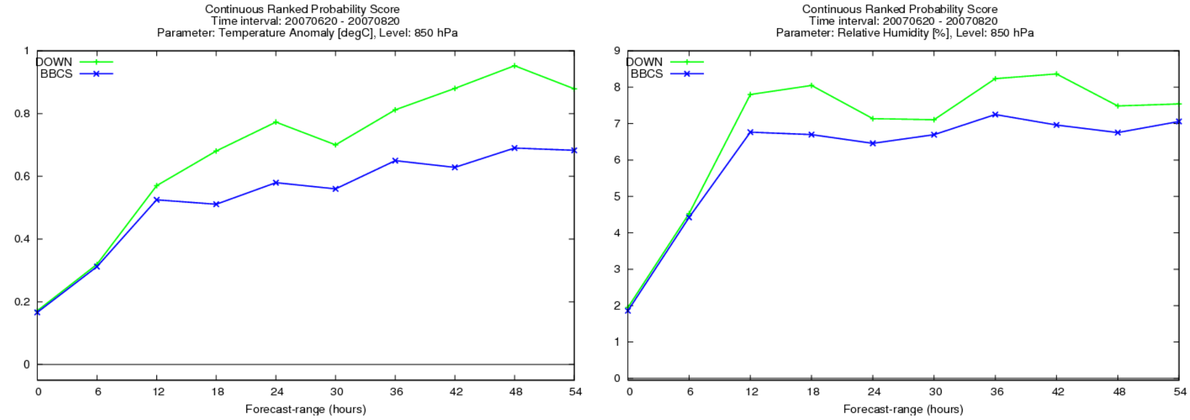
In other words, we have replaced the surface fields in each ECMWF EPS member by the surface taken from the corresponding ARPEGE analysis. Thus, we had 16 perturbed ECMWF members with one uniform set of surface fields. After 12h integration coupled with the particular ECMWF EPS LBCs, we have obtained already 16 perturbed sets of surface fields (based on ARPEGE analysis and now even somehow compatible with ECMWF couplings). Different colours in the picture (**Fig.13**) mean different perturbations, while the uncoloured file parts are not necessarily the same (but are thrown away afterwards and are not really used). It is also possible to use various physical parameterizations for that 12h integration in order to make the spread for surface fields even larger (but this was not tested yet in our experiments).

The following verification results show significant improvement in almost every score for our BBCS LAM EPS configuration over the pure global EPS downscaling approach.

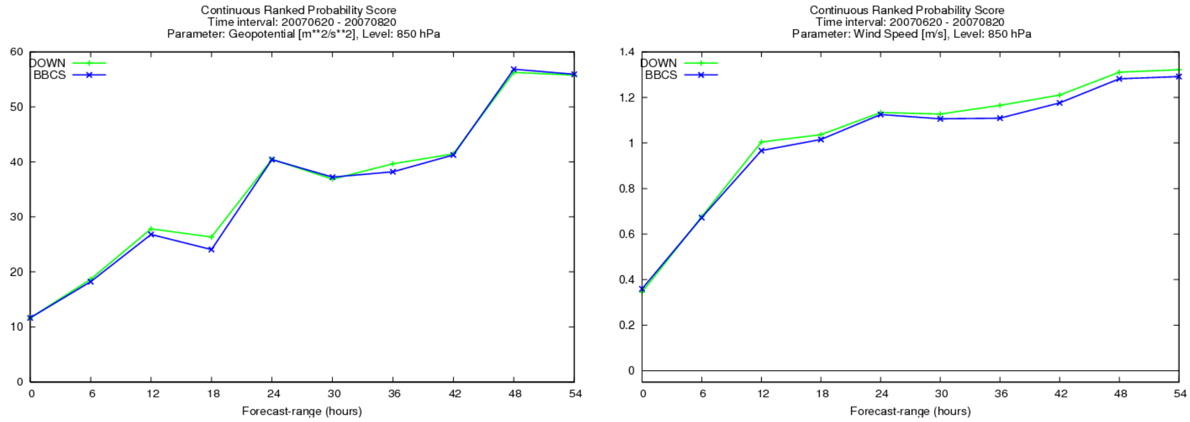


::Fig.14 Reliability diagrams (left) and ROC curves (right) for ΔT > 0 at 850 hPa level for forecast ranges +00, +18, +36 and +54 (from top to bottom)

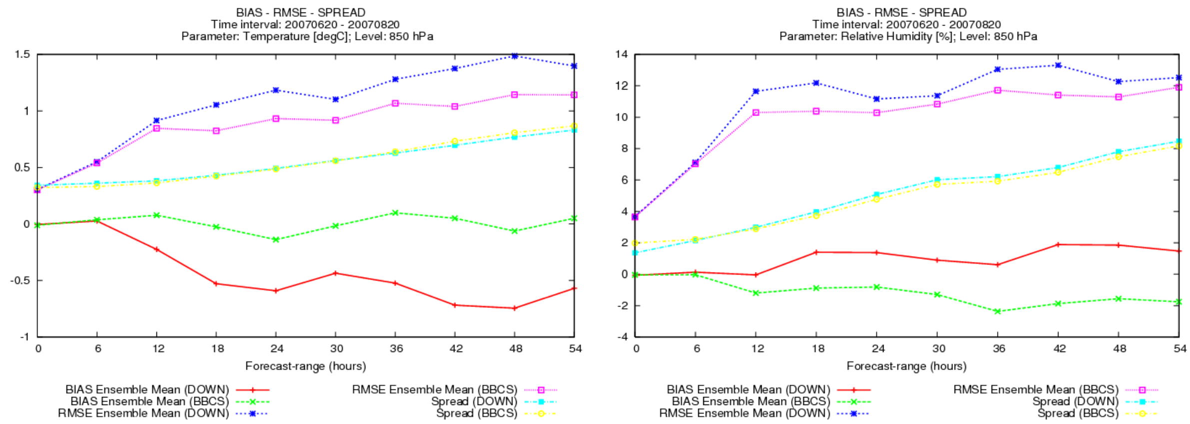
While according ROC score both systems perform for temperature at 850 hPa level very well, the reliability diagrams display how much the bias of simply downscaled global ensemble system was reduced in our BBCS experiment. (ROC score is not sensitive to bias, as it was said in former chapter.) However, it must be also mentioned, that this bias reduction in LAM EPS was mainly caused by perturbed surface exchange in initial files (even if these are the verification results at 850 hPa pressure level and for the whole integration length). Both systems have good sharpness as well.



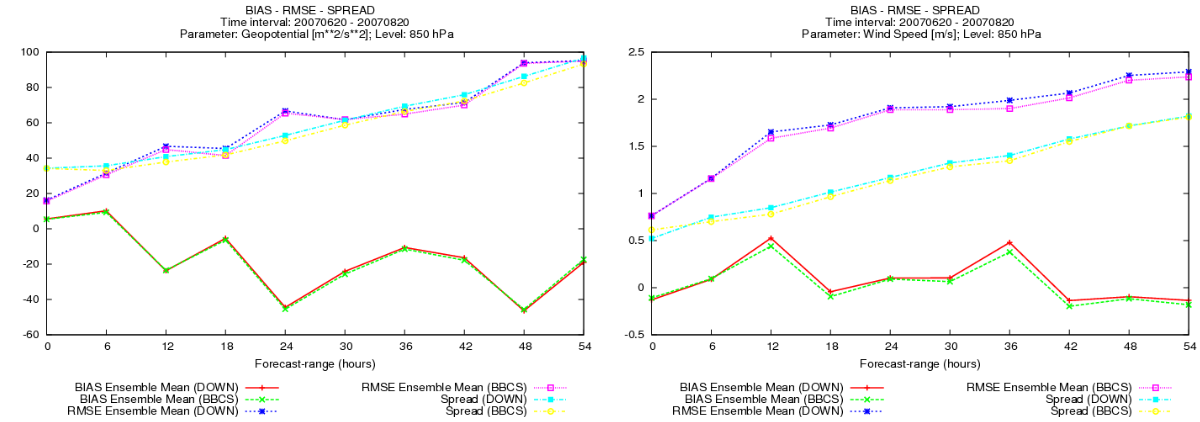
::Fig.15 CRPS for Temperature anomaly (left) and Relative Humidity (right) at 850 hPa level



::Fig.16 CRPS for Geopotential (left) and Wind speed (right) at 850 hPa level



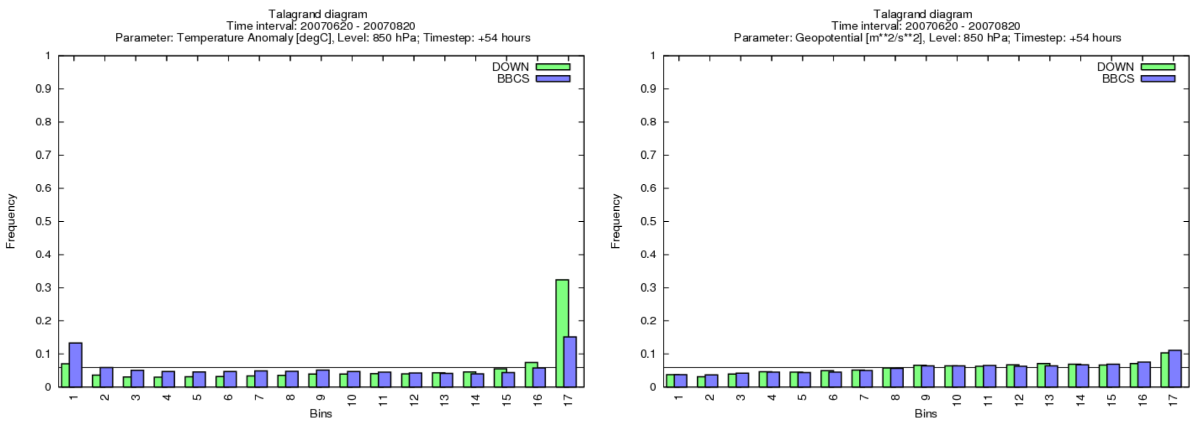
::Fig.17 BIAS, RMSE and SPREAD for Temperature (left) and Relative Humidity (right) at 850 hPa level



::Fig.18 BIAS, RMSE and SPREAD for Geopotential (left) and Wind speed (right) at 850 hPa level

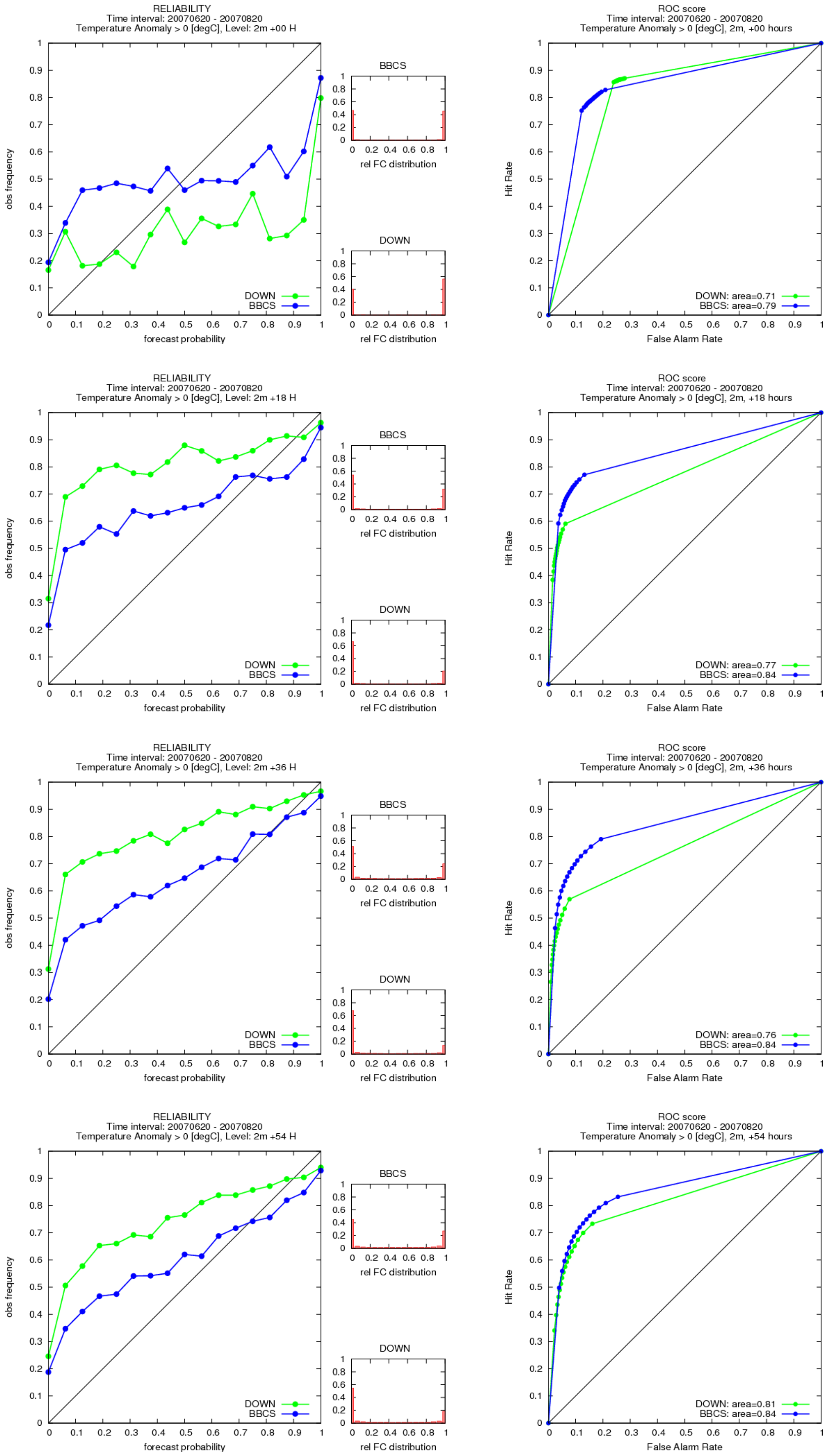
Continuous ranked probability scores are better for all verified parameters at 850 hPa level for our BBCS experiment, while the relatively biggest improvement over the purely downscaled global EPS can be seen in temperature field.

It can be also concluded, that both BIAS and RMSE of the ensemble mean are in BBCS experiment reduced for all parameters in comparison with simple downscaling, while this improvement is again most visible in temperature field. Regarding the ensemble spread the results are rather neutral.

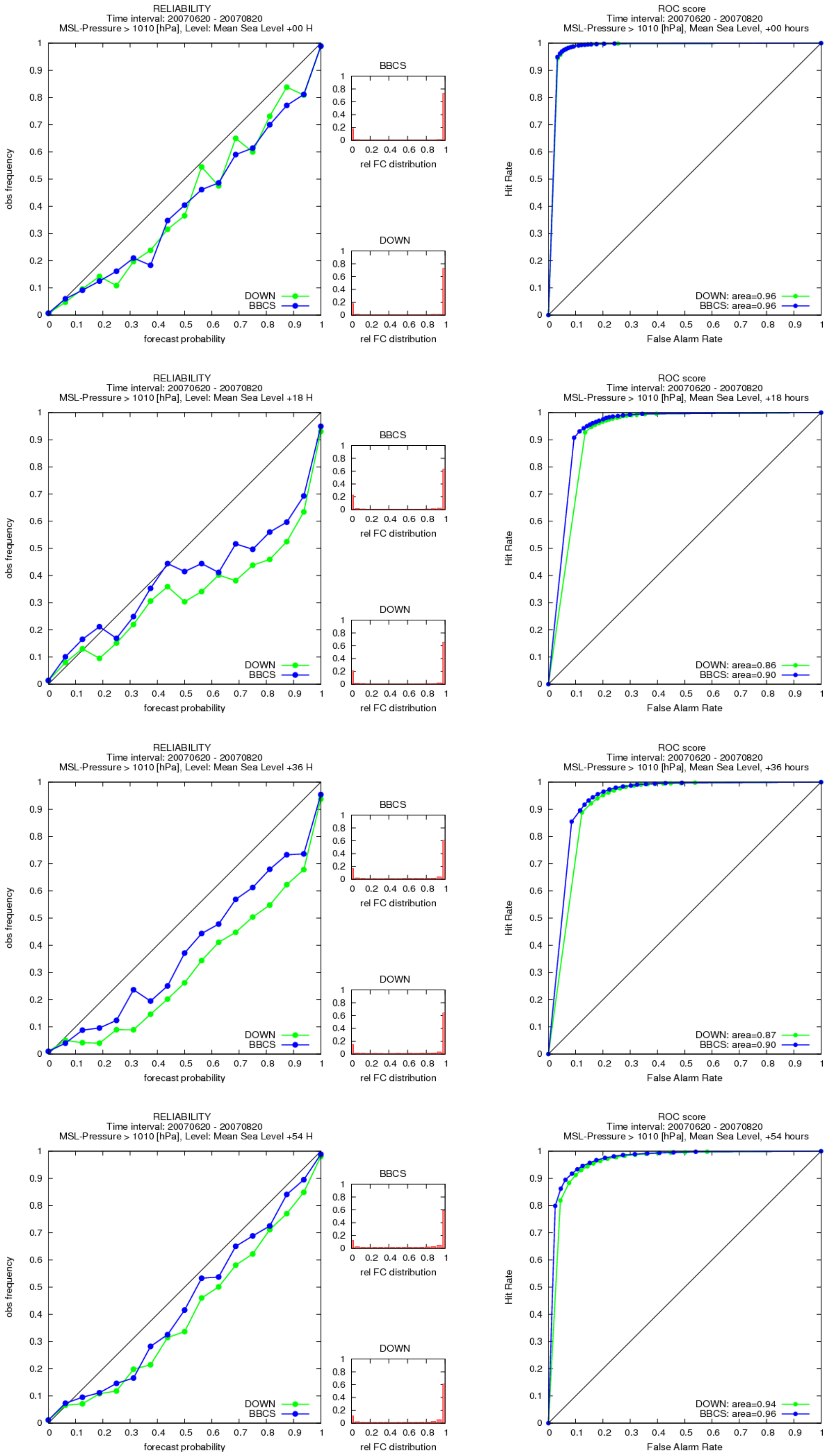


::Fig.19 Talagrand diagram for Temperature anomaly (left) and Geopotential (right) at 850 hPa level, both for +54h forecast range

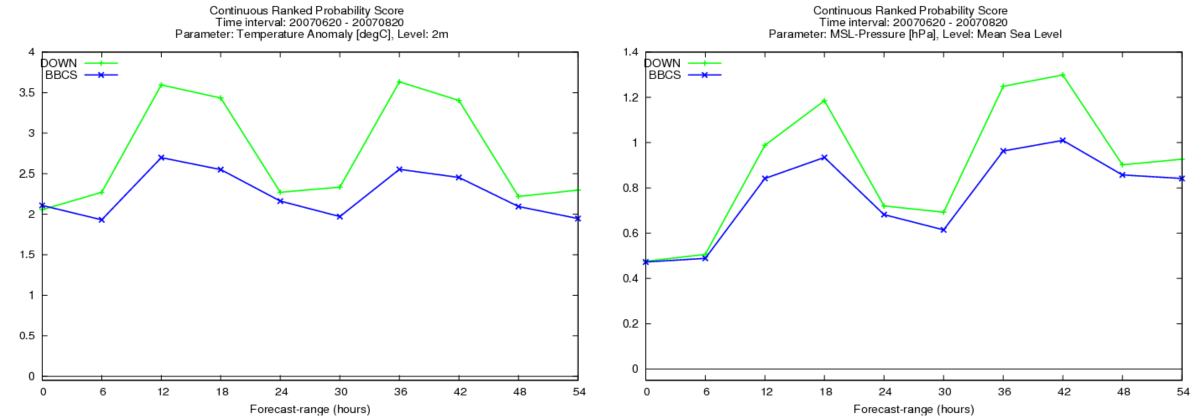
Talagrand diagrams indicate underdispersion (not enough spread) and bias for both systems, while at least bias was quite reduced for temperature field in our BBCS experiment. This is in agreement with the rest of the verification scores. Improving the spread is necessary (but not sufficient condition) to have better ensemble system. Randomly sampled weather parameters from the same season for the long enough period, would provide a flat distribution in the Talagrand diagram, but of course with no predictive skill.



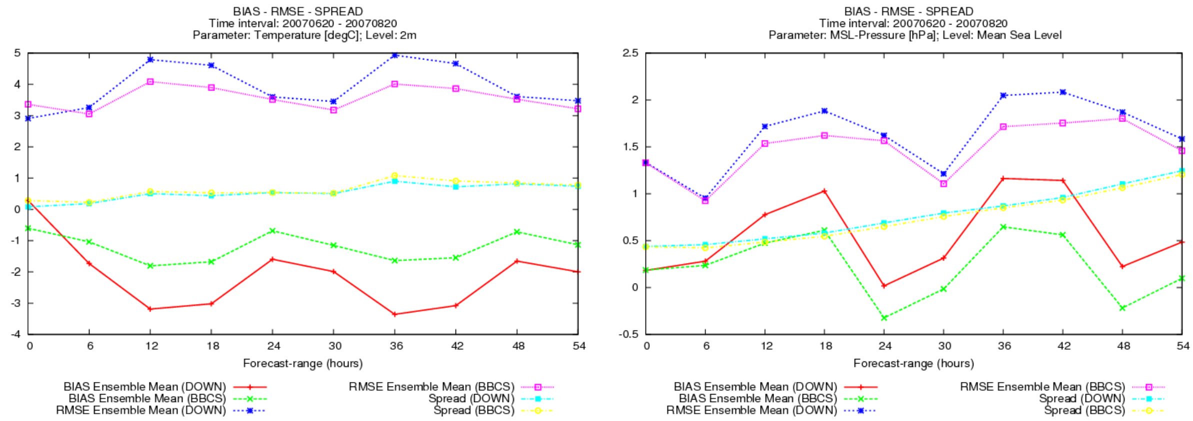
::Fig.20 Reliability diagrams (left) and ROC curves (right) for ΔT > 0 at 2m level for forecast ranges +00, +18, +36 and +54 (from top to bottom)



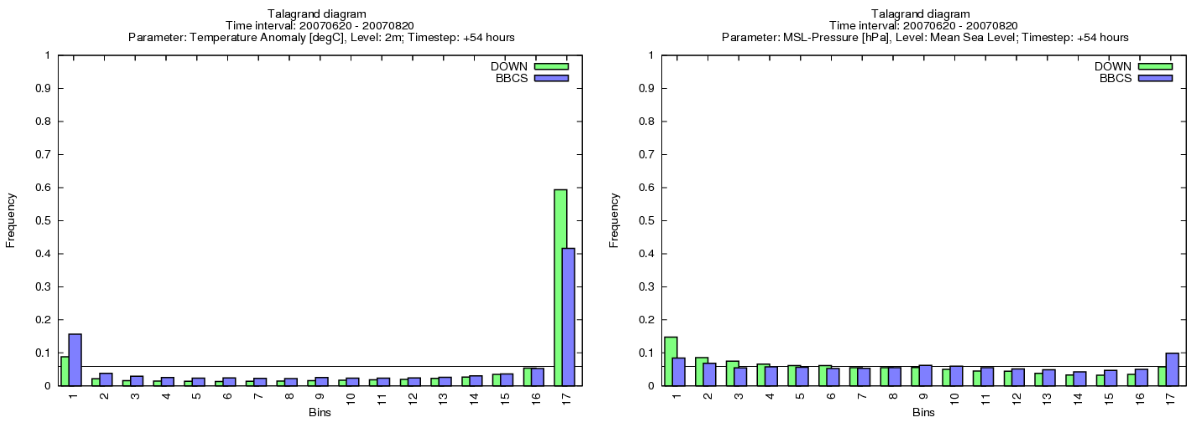
::Fig.21 Reliability diagrams (left) and ROC curves (right) for MSLP > 1010 hPa at sea level for forecast ranges +00, +18, +36 and +54 (from top to bottom)



::Fig.22 CRPS for Temperature anomaly at 2m (left) and MSL-Pressure at sea level (right)



::Fig.23 BIAS, RMSE and SPREAD for Temperature at 2m (left) and MSL-Pressure at sea level (right)



::Fig.24 Talagrand diagram for Temperature anomaly at 2m (left) and MSL-Pressure at sea level (right), both for +54h forecast range

Regarding the verification scores for surface parameters it can be summarized, that BBCS (system with LAM generated perturbed initial conditions) performs again better than downscaled global EPS. Further (in CRP scores of surface fields) the effect of diurnal cycle can be seen (which is of course not present in the upper air). This surface effect is obviously minimized in our BBCS experiment. The same can be mostly observed in BIAS and RMSE scores too.

:: VI Some useful information

For possibility to construct whatever LAEF configuration, the basic bricks (applications) were written in Perl during the previous stay. Now they were even improved with some new functionality. The scripts were modified in order to allow running experiments with different scaling factor within breeding cycle. Hence, new ENV variable CNF_SCALE was introduced. In combination with CNF_FILE and CNF_INIT, different possibilities to construct LAEF experiments exist. Fortran source codes for breeding of 3D upper air fields and surface pressure were also modified. The computation of scaling factor as a function of current model level was introduced and implemented in the code.

The basic applications (bricks for constructing LAEF experiments) can be found on *zaanfe1.zamg.ac.at* in */home/laef/bellus/app* (containing the subdirectories for the sources */bin*, for the namelists */nam* and for debug data processing if it is switched on – subdirectory */wrk* as well). Here are their short descriptions:

breed :
SCRIPT TO PERFORM BREEDING IN ORDER TO GENERATE
PERTURBED INITIAL CONDITIONS CENTERED AROUND THE
GLOBAL CONTROL ANALYSIS (POSITIVE AND NEGATIVE)
WHICH IS CAPABLE TO RUN BOTH THE COLD START AND
BREEDING CYCLE PROCEDURES

blend :
SCRIPT TO PERFORM SPECTRAL BLENDING IN ORDER TO OBTAIN
NEW INTIAL STATE FOR LAEF AS A COMBINATION OF ECMWF EPS
SINGULAR VECTOR MEMBER AND ALADIN BREEDING MEMBER WHICH
SUPPOSE TO BE MORE CONSISTENT WITH THE EPS COUPLINGS

surfp :
THIS SCRIPT PREPARES PERTURBED SURFACE FIELDS BASED ON
12H OLD ARPEGE SURFACE ANALYSIS BY DOING THE 12H FORECAST
COUPLED WITH ECMWF EPS SV MEMBERS WHICH IS AT THE END
ADDED TO THE UPPER AIR BLENDING INIT FILE READY FOR LAEF

laeff :
FINAL LAEF INTEGRATION: IT DEPENDS ON CNF_INIT (DEFINED
VIA ENV), WHICH INITIAL CONDITIONS WILL BE USED, BE IT:
BLENDING FILE WITH EXCHANGED SURFACE FIELDS (APP SURFP)
OR BLENDING FILE (APP BLEND) OR JUST BREEDING FILE
(APP BREED) OR FILE FROM BREEDING-BLENDING CYCLE WITH
EXCHANGED SURFACE (BX)

The Perl scripts for submitting the individual experiment's jobs automatically to HPC queuing system are located on *zaanfe1.zamg.ac.at* in */home/laef/bellus/exp* (BBCC, BBCV, BBCL, BRCV, BRCL, etc.). These are in fact the small batch scripts where all available bricks (the above mentioned applications) are easily combined into the appropriate LAEF configuration. In the scripts, job ID is used to wait via qwait for the finish of previous application (return code is controlled). Subsequent job is submitted only if the former process finished successfully. The batch scripts should be launched from frontend (*zaanfe1.zamg.ac.at*) via nohup, because they are usually running for several days to weeks. (Eventually the output can be redirected to some log file, e.g. nohup ./run.pl > bbcv.log.)

All applications and scripts are deeply self-documented, so the basic orientation even for not fully involved person should be possible (hopefully).

Fortran source codes for creating the breeding perturbations of 3D atmospheric fields and surface pressure can be found on *zaanfe1.zamg.ac.at* in */home/bellus/src_breeding*.

System settings for the individual applications (basic bricks) are summarized in the next table. They can be used for estimating the given LAEF configuration requirements.

APP	NPROC	MEM	USER time	REAL time	SIZE/run
breed	8 CPUs	16 GB	13.5 x 8 => 2h	20m	373 MB
blend	4 CPUs	8 GB	5 x 16 => 1h30m	25m	280 MB
Laeff	8 CPUs	25 GB	23.5 x 16 => 6h30m	1h10m	184 MB
surfp	1 CPU	10 GB	3.15 x 16 => 1h	55m	476 MB

::Tab.2 Individual application settings (on NEC SX-8R HPC)

INPUTS:
ECMWF EPS members used as the boundary conditions and ECMWF unperturbed control analysis for breeding:

/data/laef/EXPER_mbell/<yyyy><mm><dd><HH>/EPSLAEF<mb>.tar.gz

For extracting the particular files from the archive, our handy scripts can be used:

(version for NEC) */home/laef/bellus/bin_NEC/get_lbc_nec.pl*
(version for frontend) */home/bellus/bin/get_lbc.pl*

OUTPUTS:
Intermediate results from individual processes such as breeding, blending, etc. (historical files) are saved automatically in:

/data/laef/RESULT/mbell/<bre|bbc>/<scale>/<yyyy><mm><dd><HH>/

Final outputs from LAEF integration (already fullpos files) are stored in:

/data/laef/RESULT/mbell/lae/<scale>/<yyyy><mm><dd><HH>/

Grib files for the verification can be prepared from fullpos files using the scripts at *zasmlpc1.zamg.ac.at* (*/daten2/mgruppe/bellus/fa2grb/*). All created gribs are automatically moved to mounted storage:

/laefinca/laef/laef_exp/<yyyy><mm><dd><HH>/ PFLA<EEEE><mb>+00<RR>.grb

RESULTS:
Verification results (final scores in ascii tables, images in PS and GIF format) can be found for different experiments on *zasmlpc3.zamg.ac.at* in */home/bellus/verif/DATA_OUT*.

:: Conclusion

We have shown in our experiments that LAEF with breeding-blending cycle gives better results than the LAM ensemble system initialized just by breeding cycle alone. Initial perturbations generated by breeding method can be successfully merged with the original global uncertainty produced by singular vector technique via upper air spectral blending procedure. This procedure on one side ensures the physical compatibility between LAM EPS initial states and global EPS lateral boundary conditions, and on the other side it even slightly improves the ensemble spread. However, small spread for longer lead times (which is still present in our experiments and also in downscaled global EPS) can be hopefully solved rather by additional ensemble calibration and/or by using different physical parameterizations in breeding and surface perturbation procedures (which was already implemented but not fully tested). Furthermore, breeding-blending cycle with additional surface perturbation (none cycled one) performs already significantly better than the simple global EPS downscaling approach. As the last but not least blending benefit can be mentioned its "pseudoassimilation" effect, where unrealistic small scale features produced in downscaled global files by spatial interpolations are replaced by physically meaningful high frequencies resolved by limited area model.

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