Report on stay at ZAMG

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Adaptation of Stochastic Pattern Generator (SPG) for Austrian AROME domain

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Introduction

The ensemble prediction is an important tool of probabilistic numerical weather prediction. Ensemble forecasts can represent the initial condition uncertainty and model errors. The latter one can be achieved by three main approaches: the multimodel/multiensemble method, which mixes different models; the multiphysics method, which changes physical parametrizations (or some of their parameters) in a single prediction model; and stochastic physics methods, like SPPT. The last method is based on introducing perturbations into the equations of a single numerical model (Bouttier et al. 2012). The first representation of model uncertainty was introduced in the EPS by Buizza et al. (1999.), in 1998. This original version of SPPT will be referred as the BMP scheme, it uses uniformly sampled random patterns that are piecewise constant in space and time. The perturbations are multivariate (see in Buizza et al. 1999), thus to impose spatial correlations, the same random numbers are used in the whole column over boxes 10° by 10° in latitude and longitude as well. The temporal correlation is achieved by using the same numbers over six consecutive model time steps. In case of supersaturation (critical humidity), the perturbations of temperature and humidity are not applied. After the BMP there was a revised SPPT scheme, which better represents the model uncertainty and it is not prone to create non-physical horizontal gradients in perturbed atmospheric fields (Belluš, 2014). The random number in revised SPPT is defined by Gaussian distribution (Palmer et al. 2009), which has 0 mean (to keep the model energy budget unchanged) and small standard deviation (Szűcs, 2015). However the r values are not constant horizontally and in time, but they are not independent either. In ALADIN model family the spectral pattern generator is responsible for these values (Szűcs, 2015). More details can be found in Palmer et al. 2009.

Instead of the current pattern generator, the SPPT can employ a stochastic pattern generator (SPG), which has many attractive properties. Its basic solver is also spectral-space based and it was developed for limited area models; the acceptable range of correlation values is wider than in a current pattern generator, and it has 2D and 3D space versions as well, while the generated noise is theoretically Gaussian (Tsyrulnikov et al. 2016) (Szűcs, 2017).

After the development of the AROME, SPPT with SPG has been a long-term plan for RC LACE countries for many years. Following the proposal for further work by Mihály Szűcs, a 4-week stay was dedicated to continue his work. This report summarizes the results so far and findings of the stay.

Adaptation of the SPPT with SPG code

During my first ALADIN LACE stay in ZAMG, Vienna, I worked with a test version of AROME ensemble system (C-LAEF). My goal was to adapt the SPPT SPG (Stochastic Pattern Generator, 3D) binary with cycle 40 (which was the result of the work of Mihály Szűcs) and run it for the Austrian AROME domain and make a verification with the LAEF package.

The main script which name is masterscript_cy40_laef_qsub.sh can be found on CCA (ECMWF computer) in the /home/ms/at/kmek/reka folder. The user can find the main settings in the first lines which are flexible.

I used the following setting: time interval from 2016.07.05. to 2016.07.07., 00 and 12 UTC runs. The forecast range was 30 hours, with 3 hour coupling frequency with ECMWF. There was no data assimilation. The COUPLING files are read from the /scratch/ms/at/kmek/reka/COUPL folder, but the scratch is cleaned after the 30 days, so the user has to copy the files there, when starting an experiment. The scripts, namelists and binaries can be found under /home/ms/at/kmek/reka/SCR, /NAMEL and /BIN folders.

For the new SPG experiment a new binary was created by Clemens Wastl, which name is MASTERODB_spg. It was used for the reference experiment as well. For the SPPT experiment without SPG the MASTERODB_sppt binary was created. These files can be found in the BIN directory.

After generating the new binary I adapted this masterscript_cy40_laef_qsub.sh script from Clemens Wastl under my account, and prepared it to run for a test time interval. For the selected time period I had to copy the right COUPLING and CLIM files and define three different experiments in the masterscript: a reference experiment, without SPPT and SPG (named: aref), one with SPPT, with default pattern generator (name: asppt) and the last experiment, SPPT with SPG (name: aspg). For generating the SPG field we had to create the following new namelist block in the namel_001_CY40T1_spg namelist:

```
&NAMSPSDT
LSPSDT={lspsdt}, !.TRUE. to activate SPPT
LSPG_SDT={lspg}, !TRUE to activate SPG
SDEV_SDT(1)={std}, !Standard deviation (suggested value 0.5)
SPGLAMBDA_SDT={lambda}, !resolution dependent SPG setting, you can define it with the external program
SPGMU_SDT={mu}, !resolution dependent SPG setting, you can define it with the external program
SPGSIGMA_SDT={sigma}, !resolution dependent SPG setting, you can define it with the external program
SPGQ_SDT={spgq}, !The order of SPG scheme (0.5 is the conventional value)
SPGADTMAX_SDT={a_dt_max}, !SPG setting, suggested value is 3.0
SPGADTMIN_SDT={a_dt_min}, !SPG setting, suggested value is 0.1
XCLIP_RATIO_SDT={xclip_ratio_sdt}, !Clipping ratio (suggested value 2.0, which is the default)
NQSAT_SDT={nqsat_sdt}, !Supersaturation check option (suggested value 3)
NSEED_SDT={mb} !Seed
/
```

There are three domain dependent variables (SPGLAMBDA_SDT, SPGMU_SDT, SPGSIGMA_SDT) which need to be determined by an external program. The program can be found under this link: https://github.com/cyrulnic/SPG

After the external program installation, (which can be found under /home/ms/at/kmek/reka) within its structure the user can find a config file which is the key to define these variables. Be careful with the domain size, because in the output file we want to obtain the correct parameters.

The exact values which were used in the namelist block are the followings:

```
&NAMSPSDT
  TAU_SDT(1)=7200.,
  XLCOR_SDT(1)=60000.,
  LTAPER_BL0=.TRUE.,
  LTAPER_ST0=.TRUE.,
  LSPSDT=.FALSE.,
  LSPG_SDT=.TRUE.,
  SDEV_SDT(1)=0.5,
  SPGLAMBDA_SDT=0.24955,
  SPGMU_SDT=0.0004662,
  SPGSIGMA_SDT=0.00000008981,
  SPGQ_SDT=0.5,
  SPGADTMAX_SDT=3.0,
  SPGADTMIN_SDT=0.1,
  XCLIP_RATIO_SDT=2.0,
  NQSAT_SDT=3.0,
  NSEED_SDT=1.
```

But it has to be said, that these values were not optimized.

When everything was right with the namelist settings we started to run the experiments for 20160707 00 UTC, in the beginning with 3 members and 6 forecast hours. When we were convinced that the program works well, we started to run 3 experiments from 20160705 12 UTC to 20160707 12 UTC with 16 eps members.

After the forecast has been run, I adapted the LAEF verification package and created some comparative figures under my account.

In Fig. 1. we can see the ROC score of the 3 different experiments during this time interval. The red line is the reference experiment without SPPT, the green line is the SPPT experiment with current pattern generator and the blue line is the SPPT experiment with SPG. As you can see, there is not much difference between these experiments, which might be caused by the lack of settings' optimization of the SPG experiment, and/or the very short verification period.

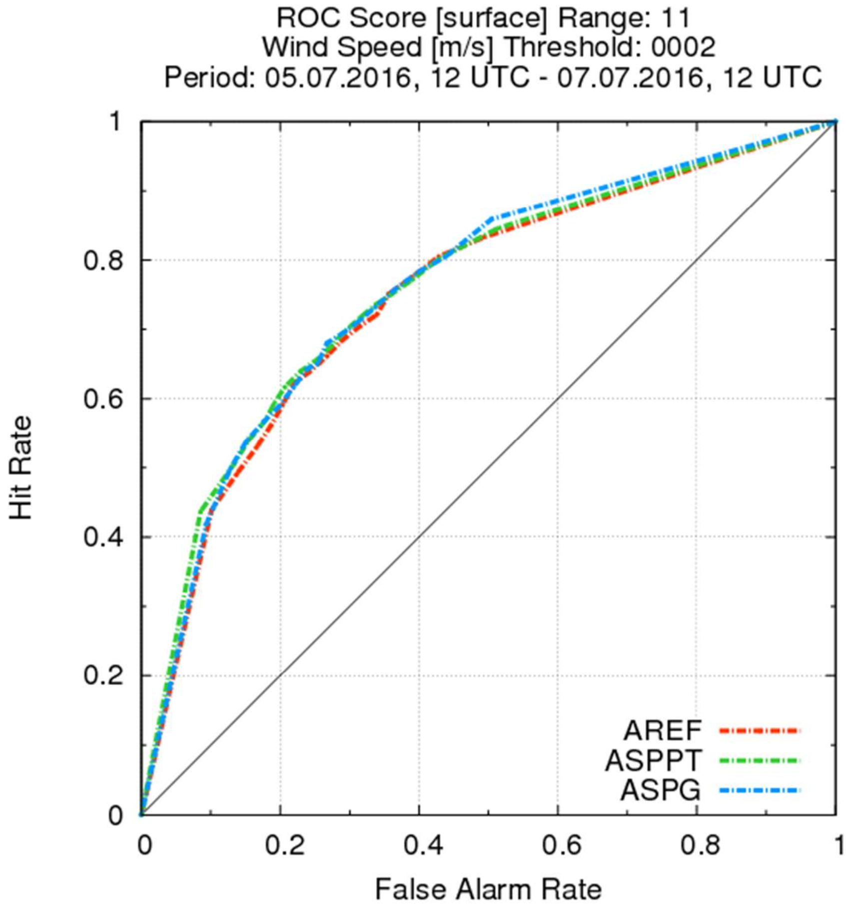

Fig.1. ROC score of the 3 experiments in the examined time interval, in case of wind speed forecast

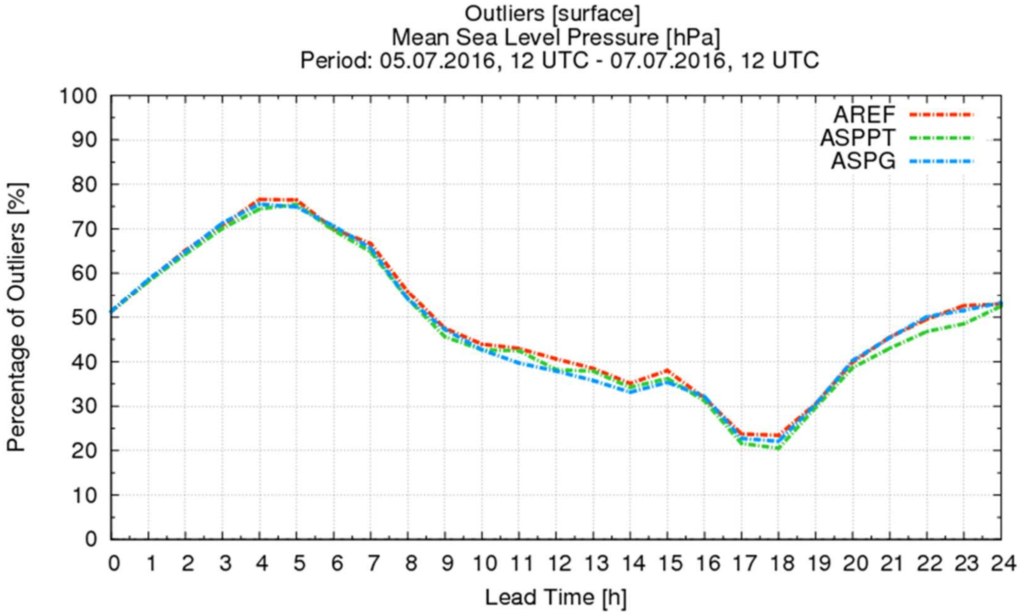

Fig.2. Outliers of the 3 experiments in the examined time interval, in case of mean see level pressure forecast

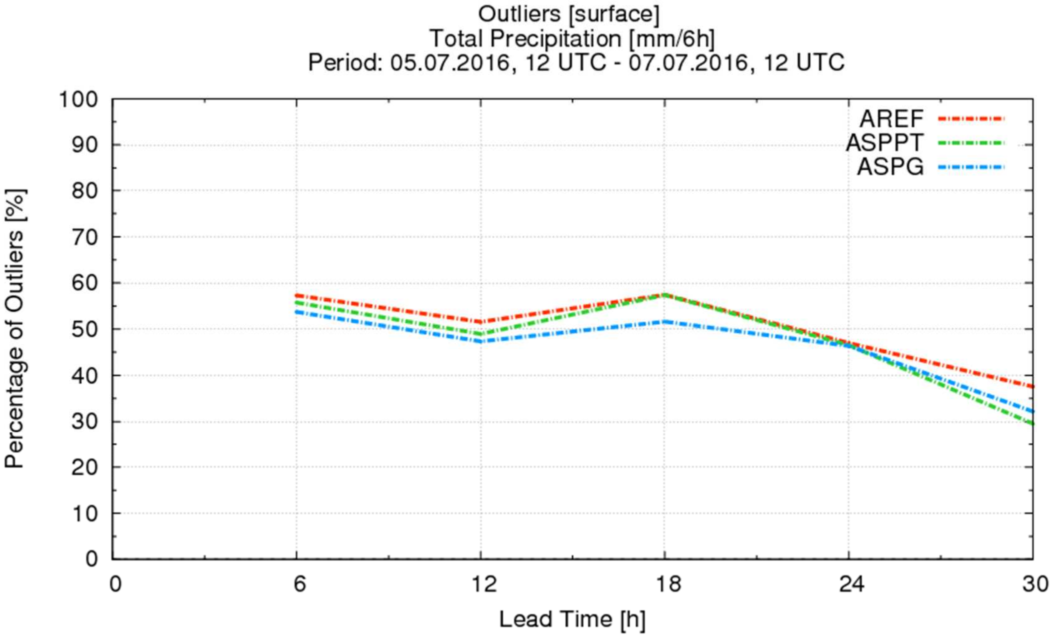

Fig.3. Outliers of the 3 experiments in the examined time interval, in case of total precipitation forecast

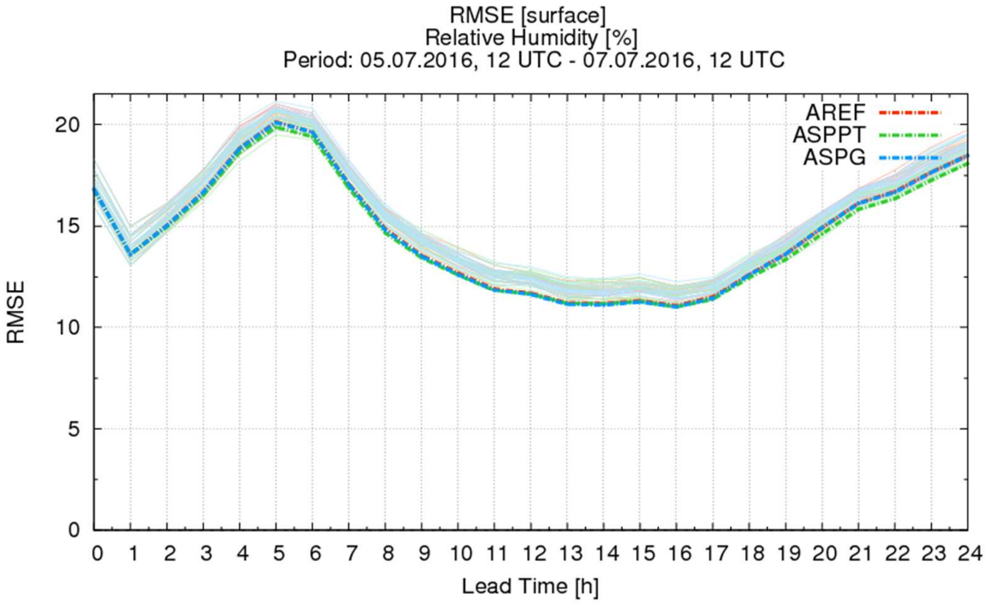

Fig.4.

RMSE scores of the 3 experiments in the examined time interval, in case of relative humidity forecast

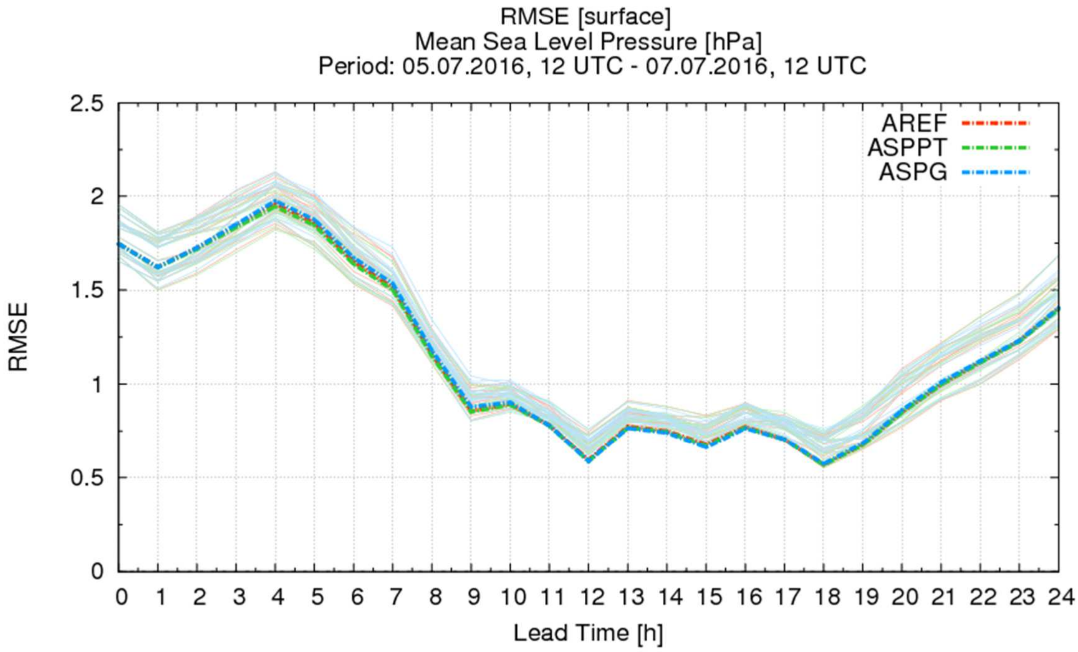

Fig.5. RMSE scores of the 3 experiments in the examined time interval, in case of mean sea level pressure forecast

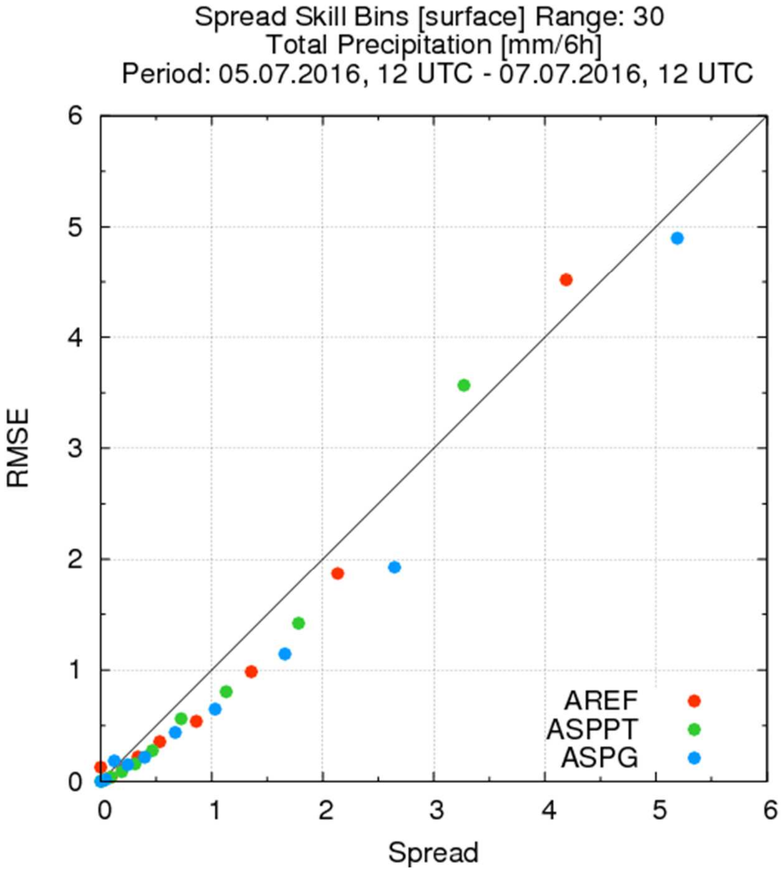

Fig.6. Spread Skill Bins of the 3 experiments in the examined time interval, in case of total precipitation forecast

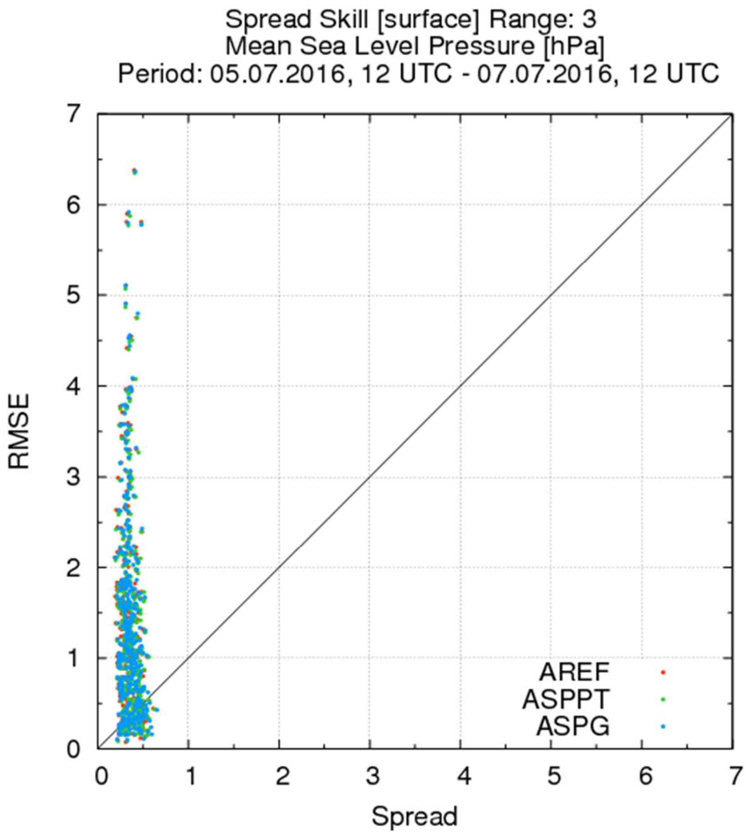

Fig.7. Spread Skill diagram of the 3 experiments in the examined time interval, in case of mean sea level pressure forecast

In Fig. 2. - 7. the reader can see the same nature of the 3 different experiments.

To reach the optimized setting, the user can start to change the config file setting in the external program, or the namelist variables. It should be run more than three days and maybe other time period.

Conclusion

According to the diagrams, there seems to be not much additional benefits of the SPG generator, compared to the SPPT standard pattern generator. But the results are not statistically relevant because of the short time period and the SPG pattern generator wasn't optimized, so it makes sense to create more case studies for longer time periods with this method and test more setting to reach the optimized settings, what can be the topic of the next stay.

Acknowledgement

Finally, I would like to say thank you for Mihály Szűcs for his supportive attitude, and I kindly appreciate the help of Clemens Wastl, who supervised me during my stay, he was very helpful and cooperative during out mailing.

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