Report on stay at ZAMG

16/10~10/11, 2017, Vienna, Austria

New ALADIN-LAEF phase I

::Supervised by
Yong Wang (ZAMG)
yong.wang@zamg.ac.at

::Author
Martin Belluš (SHMU)
martin.bellus@shmu.sk

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::Acknowledgement

Many thanks to Ulf Andrae for providing the important fix for GL tool issue. I very much appreciate his prompt and accurate email communication. I would like to thank Florian Weidle for his precious time and for sharing his knowledge about ECMWF's Supervisor Monitoring Scheduler (SMS) with me. I am also grateful to the whole ZAMG team for the hospitality and friendly atmosphere.

::Foreword

During this 4-weeks stay we had one simple but technically quite demanding task. The main goal was to put together all the pieces defineding new ALADIN-LAEF suite (so called phase I). The system was run for the first time in such complete configuration, consisting of several upgrades (see chapter II). The new system was qualitatively verified against the first 16 members of global ECMWF ensemble for the two weeks period (see chapter III). Resources needed for the operations of ALADIN-LAEF phase I were estimated as well. Furthermore, some crucial questions regarding the future of LACE's ensemble system are discussed in chapter IV and Conclusions.

::I Boundary conditions issue (fixed bug)

It was discovered during my previous stay at ZAMG (May/2017), that the conversion/interpolation tool (GL) used to create boundary conditions for ALADIN-LAEF wrongly extracts the sea surface temperature and land surface temperature from the input global GRIB files. Skin (skt) and sea-surface (stt) temperature fields were ignored and monthly constants from the climatology were used instead. Due to this error the interpolated surface temperature in the initial conditions of ALADIN-LAEF was not following reality and was not modified between the consecutive model runs. This was indeed a big issue when such boundary conditions were used in the dynamical adaptation experiments. Even in the experiments with the regular surface assimilation cycle (which is our case) the SST could have been wrong (since SST is not assimilated within CANARI but rather copied from the analysis of driving model).

In the following lines the FA file statistics (coupling files created by GL tool) for the surface temperature are shown. One can see that the values are identical for both March days while differ for February. For the sake of control, soil temperature fields (PROFTEMPERATURE) are checked as well and they are obviously OK.

```
#   LBC_201702110001+000   #    min        max        mean       std
PROFTEMPERATURE            2.585E+02   2.970E+02   2.798E+02   6.889E+00
#   LBC_201703140001+000   #    min        max        mean       std
PROFTEMPERATURE            2.622E+02   3.005E+02   2.823E+02   6.828E+00
#   LBC_201703180001+000   #    min        max        mean       std
PROFTEMPERATURE            2.624E+02   2.984E+02   2.822E+02   6.440E+00

#   LBC_201702110001+000   #    min        max        mean       std
SURFTEMPERATURE            2.522E+02   2.970E+02   2.789E+02   7.596E+00
#   LBC_201703140001+000   #    min        max        mean       std
SURFTEMPERATURE            2.551E+02   2.971E+02   2.812E+02   7.260E+00
#   LBC_201703180001+000   #    min        max        mean       std
SURFTEMPERATURE            2.551E+02   2.971E+02   2.812E+02   7.260E+00
```

We have technically isolated the very problem, prepared some test cases and contacted the GL experts from HIRLAM community. The bug was quickly localized by Ulf Andrae. He provided the fix for the code, which was then implemented and tested (see the compilation hints in the Appendix). Actually, there were two fixes applied to the GL tool. The first one to treat the proper surface fields interpolation (*ala/intp_ecmwf_surface.f90*) and the second one to correct the data extrapolation to e.g. deep fjords not visible in the ECMWF files (*grb/fill_missing.f90*). The first one was rather crucial (see Fig.1), while the second has only a small and geographically very localized impact (not shown).

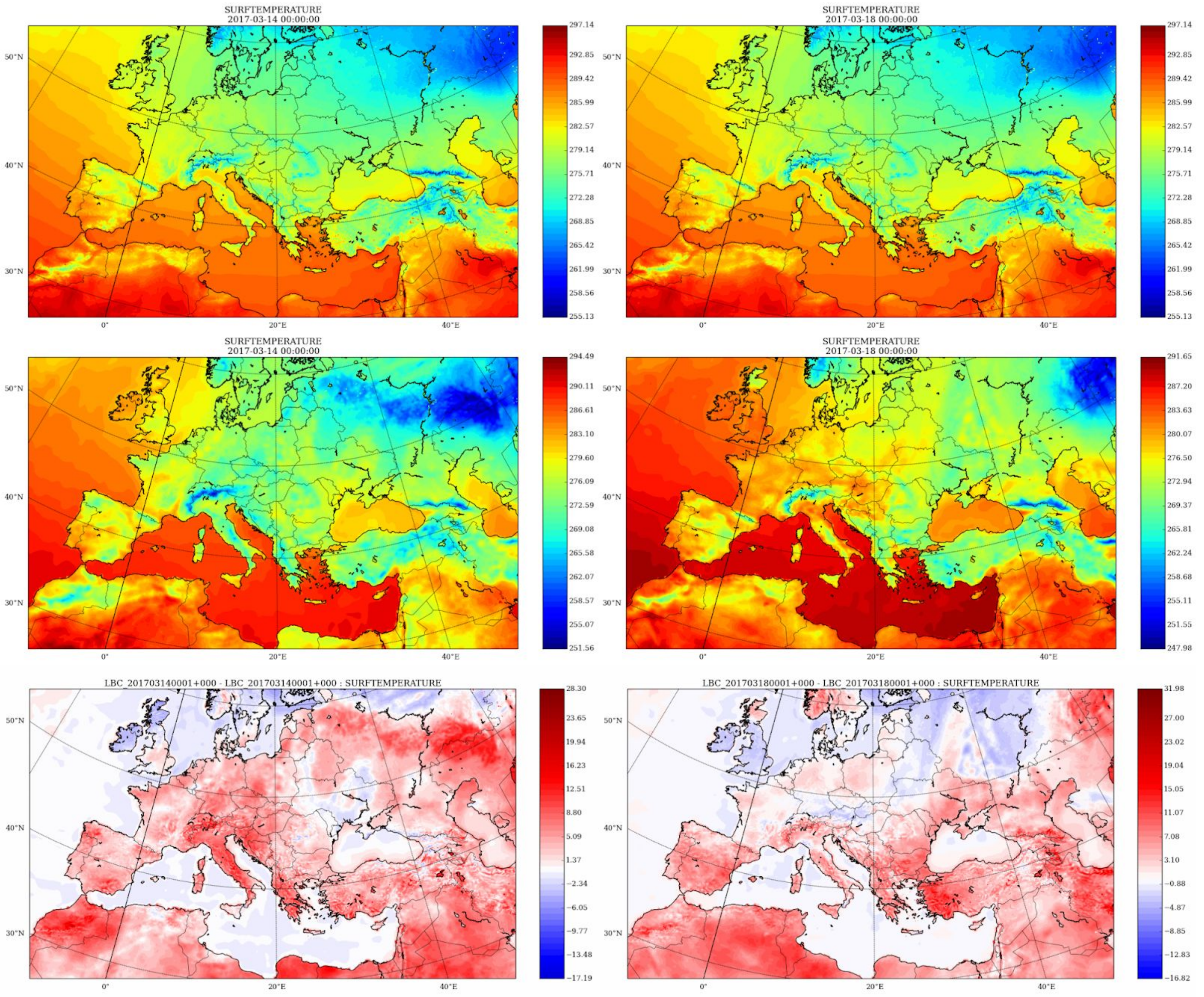

Fig.1: *SST/LST initial conditions for 2 different days of March 2017 (left and right) with bugged version of interpolation tool in the first row and fixed one in the second row. The impact on SST/LST field is rather huge (shown in the third row as a difference between the first two).*

All boundary conditions used in the following experiments were recreated by corrected GL tool.

::II ALADIN-LAEF phase I configuration

Quite a lot of changes were made recently to the ALADIN-LAEF system with respect to its current operational configuration (domain size and resolution, model version, new perturbations, etc.). Therefore, it was decided to proceed with its operational implementation in two phases. Within the first phase the ESDA with internally perturbed observations, stochastic perturbation of physics tendencies for the surface prognostic fields and new ALARO-1 multiphysics have been included. This went together with the model upgrade from cy36 to cy40, increased horizontal resolution from 11 to 5 km and thickening of vertical levels from 45 to 60. Due to technical reasons the domain size has been altered as well.

ALADIN-LAEF phase I configuration and its data flow is being described in the following scheme (Fig.2) and all the applied perturbations are listed in the Table 1.

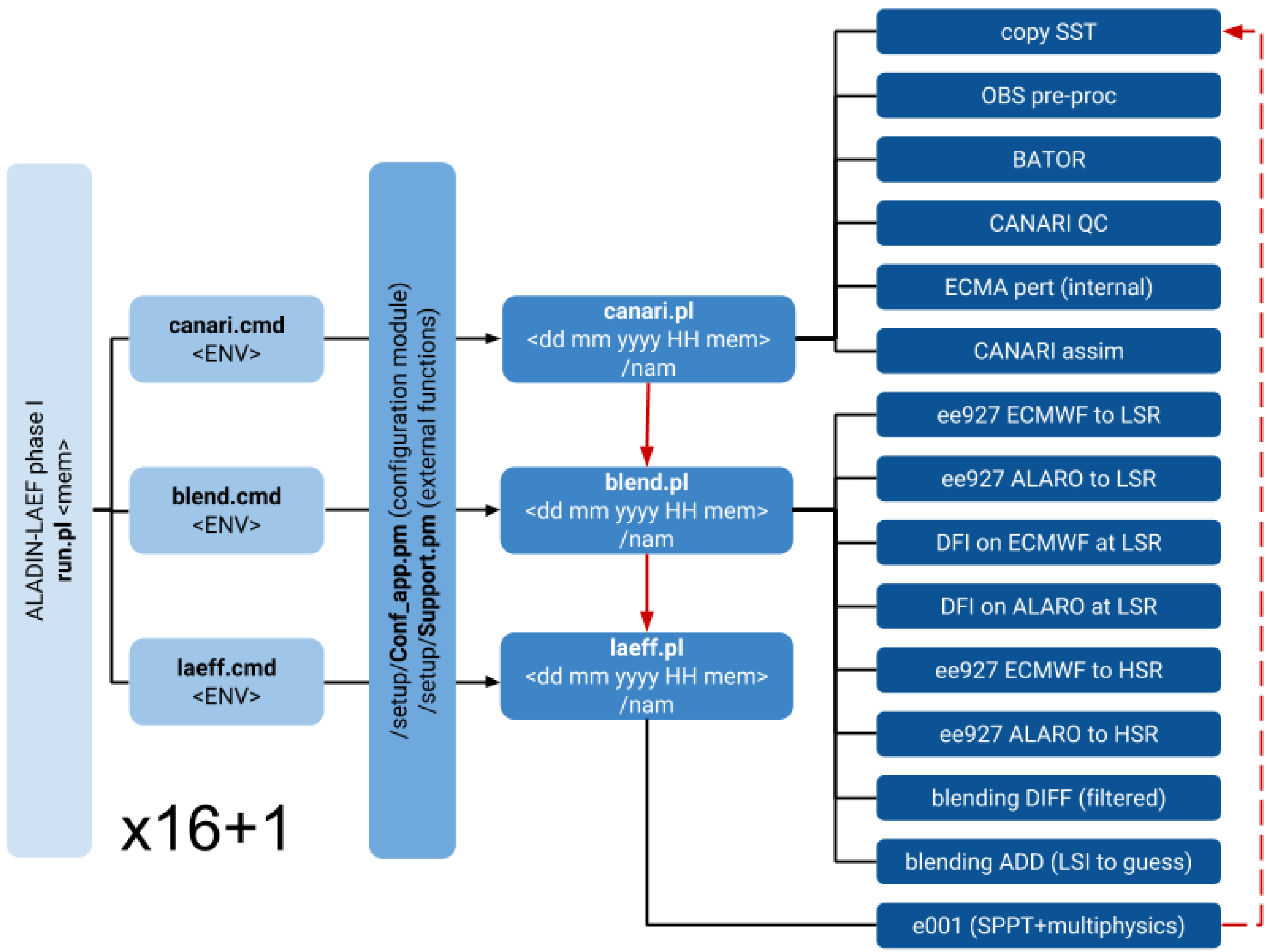

Fig.2: *ALADIN-LAEF phase I configuration scheme.*

Tab.1: *Uncertainty simulation in ALADIN-LAEF phase I configuration.*

	IC	LBC	model
surface	ESDA (OBS pert by screening)	SFC fields are not coupled	SPPT for ISBA fields
upper-air	ECMWF-EPS and 1st guess spectral blending by digital filter	downscaled ECMWF-EPS	ALARO-1 multiphysics

::III Verification against ECMWF-EPS

There is no doubt that the main motivation for running an operational version of a regional EPS being its added value over the global ensemble. Therefore, we have verified new ALADIN-LAEF phase I against the downscaling of corresponding 16 ECMWF-EPS members for surface as well as for the upper-air parameters. It must be stressed, that while for the surface verification the SYNOP observations from 1355 sites were used, the ECMWF analyses were applied in the upper-air. Verification period contains 17 days from May 15 till May 31, 2016. We have performed also the significance test by bootstrapping method with 5000 samples and block length of 3. This is shown by thin lines in the plots, where they denote 10% and 90% confidence intervals for given experiment.

The statistical scores for the surface parameters are shown in Figure 3. The ensemble spread and RMSE of ensemble mean are closer to each other for screen-level temperature and relative humidity, while the spread is increased and RMSE is slightly decreased. Diurnal cycle of errors is clearly smoothed and the percentage of outliers is significantly reduced. Those are very positive results. The smaller ensemble spread in case of precipitation is apparently caused by reduced bias.

The impact on upper-air fields, especially at 500 hPa level is rather neutral, as it is shown in Figure 5. However, at the top of boundary layer for 850 hPa the temperature scores are somehow deteriorated after 24 hours of integration (see Fig.4). It is not yet clear what could be the source of such behaviour. Same issue can be observed for relative humidity. Perhaps it could be caused by the drying effect due to the execution of surface SPPT scheme, since such an issue is well known (however it was believed that this is related mostly to the upper-air SPPT). To the contrary, the scores for wind speed at 850 hPa level are slightly improved over the ECMWF-EPS downscaling.

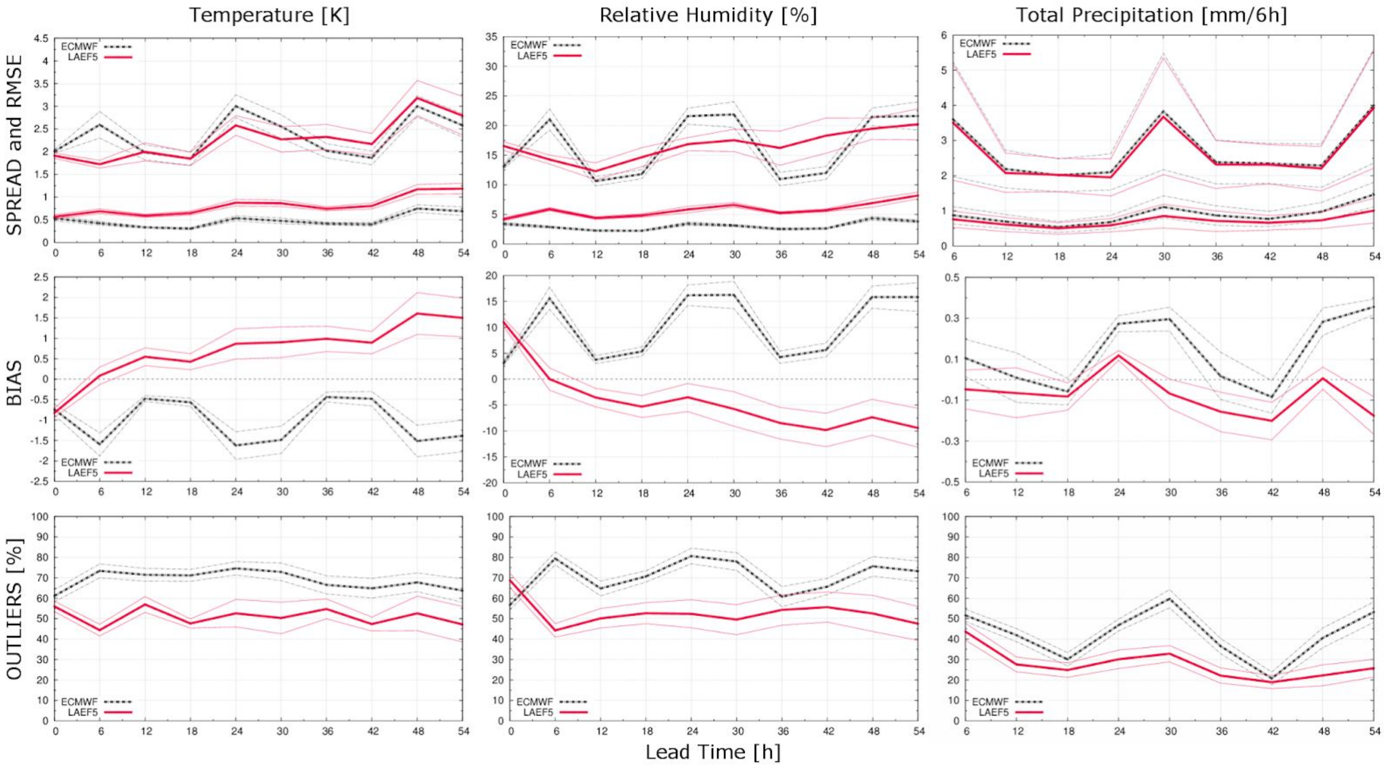

Fig.3: *ALADIN-LAEF phase I (red lines) and ECMWF-EPS downscaling (gray dashed lines) for surface parameters.*

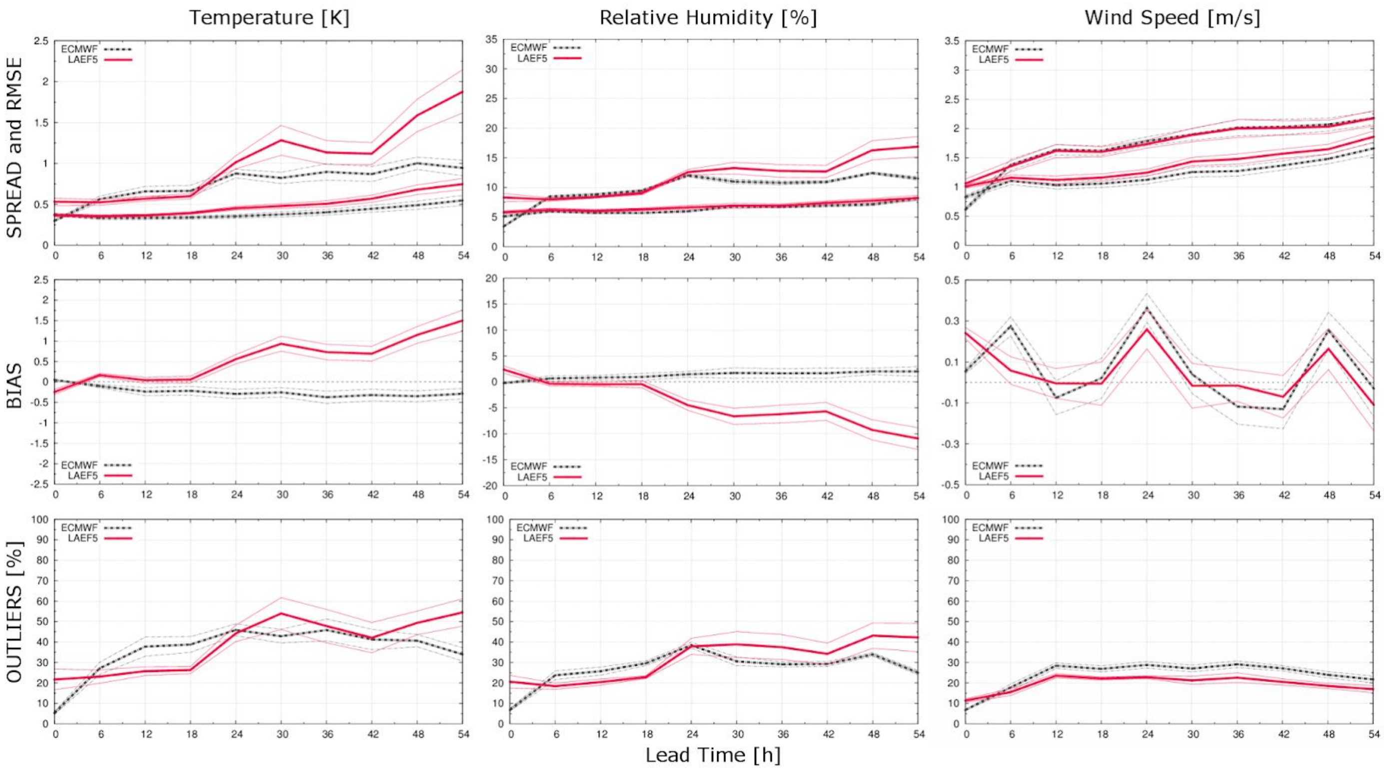

Fig.4: *ALADIN-LAEF phase I (red lines) and ECMWF-EPS downscaling (gray dashed lines) for parameters at 850 hPa.*

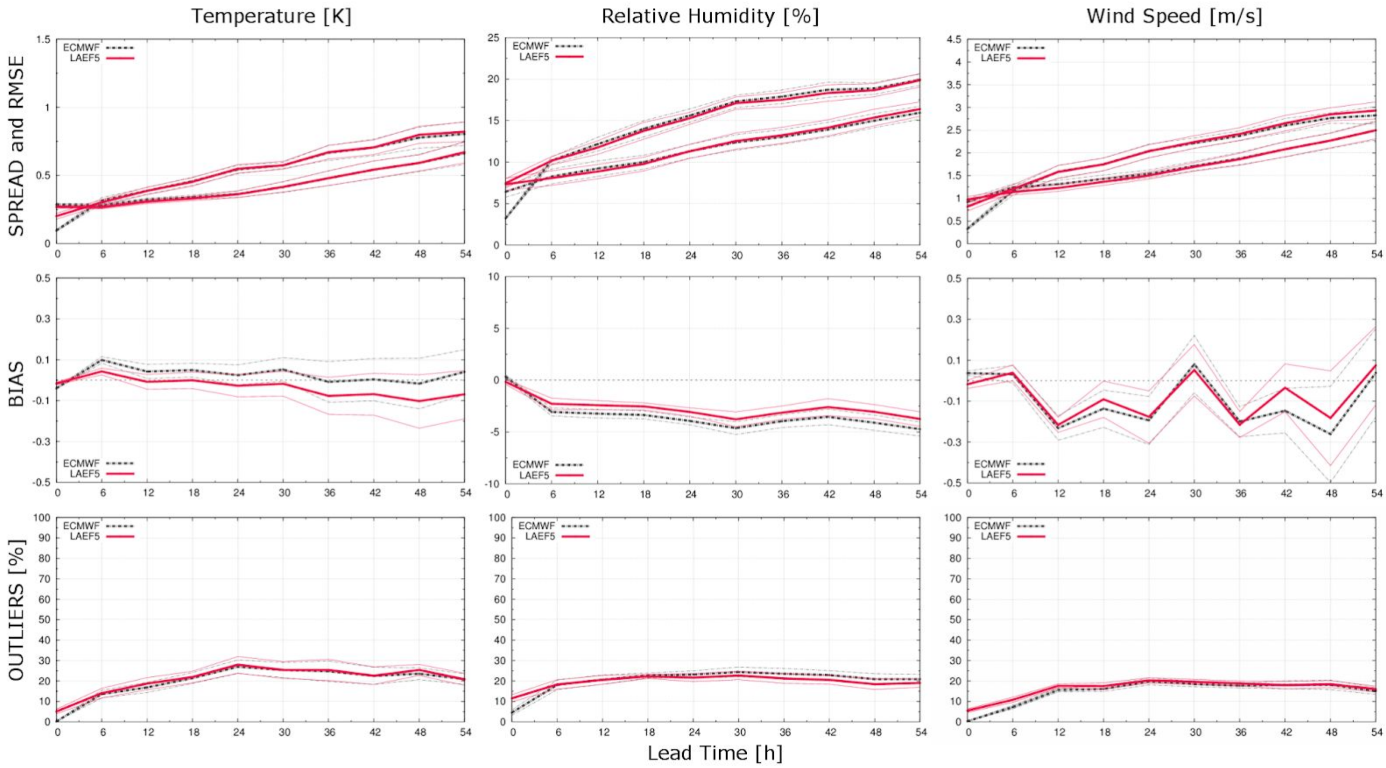

Fig.5: *ALADIN-LAEF phase I (red lines) and ECMWF-EPS downscaling (gray dashed lines) for parameters at 500 hPa.*

::IV Operational implementation

There are several aspects which need to be considered carefully and it is really a pity that they were not taken into account much earlier in the process.

The first aspect is technical. The current LAEF operational suite runs under Supervisor Monitor Scheduler (SMS) utilizing rather old and unmaintained scripts. Honestly, it is very difficult to get familiar with the current status of the operational scripts and make any dramatic changes in there (new ALADIN-LAEF phase I would have required many of them). We also know, that SMS have been already superseded by object oriented ecFlow (client/server workflow package), which helps improve maintainability and allows easier modifications. Furthermore, the proprietary scripting language used by SMS (CDP), have been replaced by Python. Since the support for SMS is already limited and will definitely end within ~2 years, it might be wise to rewrite the operational LAEF suite from the scratch using ecFlow. This would require of course the additional manpower.

Second aspect is the cost (which is partly also a political issue). Yearly consumption of the ALADIN-LAEF phase I operations would easily reach 130 Mio SBUs (approximated according the recent experiment), which is roughly 13-times more in comparison with the current version. This can be only afforded if other LACE countries and Turkey will provide additional SBUs.

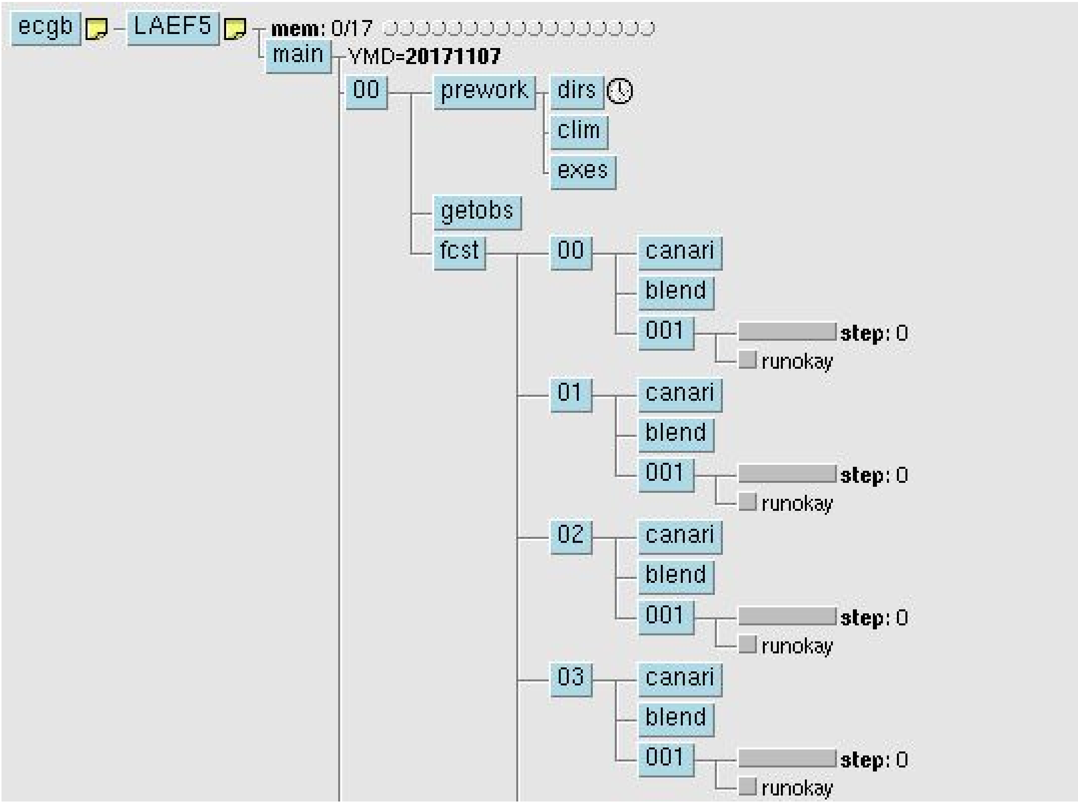

Fig.6: *An example of ALADIN-LAEF suite defined in SMS, displayed by graphical user interface XCDP.*

::Conclusions

The problem of land-surface and sea-surface temperature fields in the initial conditions was successfully solved. The boundary conditions for 2-weeks period were recreated and downscaling of ECMWF-EPS was rerun. This was necessary for a proper reference to our LAEF experiments. Furthermore, new ALADIN-LAEF phase I configuration was finally put together, tested and verified against the mentioned reference. It contains ensemble of surface data assimilation (ESDA) with internally perturbed screen-level observations, upper-air spectral blending, stochastic perturbation of physics tendencies (SPPT) for ISBA prognostic fields and new ALARO-1 multiphysics (additionally to the model upgrade from cy36 to cy40, increased horizontal and vertical resolution and redefined domain). The added value of new ALADIN-LAEF over the downscaled ECMWF-EPS is obvious for the surface parameters, while it is rather neutral for the upper-air. However, due to the aspects mentioned in the previous section we have to admit, that our plan to get it into the operations by the end of the year (2017) was too ambitious. This is going to be postponed to the next year (2018) when it is clear how many resources we have been allocated and how many of them could be given by LACE partners. Also the decision whether to use SMS or ecFlow have to be taken and technical difficulties related to the operational implementation must be resolved.

::Appendix

Full EXP on 16 members:

```
PERIOD: 20160515 ~ 20160531 (=> 17 days verification for 12 UTC run)
START:  Cold start from DW analyses LAEF5 2016051512.
OBS:    OPLACE only (obs_long_yyyymmddHH - vguest:/home/guest/bellus/obs/get_obsoul.pl)

1) LAEF5                  - started Thu Oct 19 08:15:01 GMT 2017  1.46 mil BU
-----------------------------------------------------------------------------
   Clean downscaling of ECMWF EPS - first 16 members - at 5km@cy40. LBCs were
   created by gl_grib_api (fixed) from ECMWF global grib files, so the surface
   temperature (SST/LST) is now correct. This is meant to be compared to new
   LAEF5 phase I.

   data (ECFS)
   ===========
   GRIBS: ec:/kmxy/GRIBS/LAEF5.gribs.20160515-20160531.tar.gz
   ICMSH: ec:/kmxy/LAEF5/TCC/lae
   LBC:   ec:/kmxy/LAEF5/TCC/lbc

2) LAEF5F                 - started Tue Oct 24 07:28:01 GMT 2017  2.69 mil BU
-----------------------------------------------------------------------------
   New LAEF5 phase I (canari:ESDA_sc, blend, e001:sfc_SPPT + ALARO-1_MP).
   Cold start from DW analyses LAEF5 2016051512.
   IMPORTANT:  a) CNF_FILE=CC, CNF_INIT=CC
               b) in BLEND keep SFC from LAEF member in step [8]
                  and no time shift in step [2] since ald_org comes from
                  CANARI assimilation and not from previous run
                  (like in pure blending cycle)
               c) in CANARI exclude surface exchange at the end - step [7]
                  because now the upper-air from LAEF should enter blending

   data (ECFS)
   ===========
   GRIBS: ec:/kmxy/GRIBS/LAEF5F.gribs.20160515-20160531.tar.gz
   ICMSH: ec:/kmxy/LAEF5F/TCC/lae
```

GL tool compilation at ECMWF's computer:

SRC: /perm/ms/at/kmxy/gl_grib_api

The compilation is not that straightforward, one has to unload and load different modules in given order prior to the compilation (by gmake), otherwise some errors may appear.

```
module swap PrgEnv-cray PrgEnv-intel
module unload intel
module load intel/14.0.3.174
module unload grib_api eccodes/2.1.0
module load grib_api/1.14.5
module load intel
```