Project 374 – Evaluation of the new version of the RCM COSMO-CLM

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Introduction

CLM 3.2 was the last official standard version of the regional climate model CLM which had been used by the members of the CLM Community for a variety of regional climate investigations. This version had been substantially evaluated and showed an excellent performance. It had been used to regionalize several global climate change scenarios of the global climate model ECHAM5-MPIOM (Max-Planck Institute for Meteorology MPI-M) for the Fourth Assessment Report (AR4) of the IPCC. These simulations are known as the so called "consortium runs" (Hollweg et al. 2008) and have been widely used for numerous climate impact studies and further climate research programs like "Klima2" or "Klimzug". This model version had also been used for simulations included in the ENSEMBLES project (van der Linden and Mitchell, 2009).
In the further course, the members of the CLM Community introduced several extensions into the model. These were joined with the new operational weather forecast version of the model. The reunification of the two model branches resulted in a new model version, which offers a number of principal improvements and extensions. The version COSMO-CLM 4.8_clm17 was determined as the current standard version of the CLM Community after an extensive evaluation of the quality of long term simulation results. This model version is used by a couple of CLM Community members, for example to contribute RCM simulations to the ongoing CORDEX project in the framework of the IPCC AR5. Some parts of the evaluation results and a comparison to the quality of the former standard version are presented here.

Evaluation Simulations

- old standard version: **EVAL-3**
- new standard version, setup 1 (by CLM Community): **EVAL-4-PCB**
- new standard version, setup 2 (according COSMO-EU setup of the DWD): **EVAL-4-DWD**

Standard Evaluation Concept

- use of the same model grid (0.165°) and domain (Europe, figure 1)
- forcing: ERA-40; period: (1979) 1981-2000
- comparison with at least two observation data sets to show the quality of the model result and the uncertainty thereof
- area means for sub-regions (figure 1) of monthly and annual means or sums
- other special scores

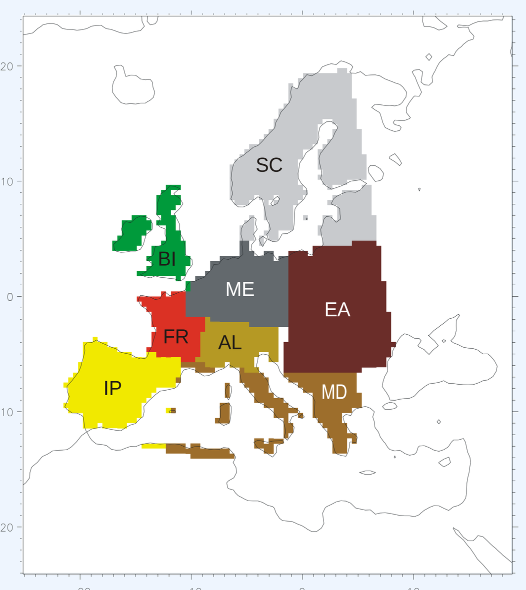

Figure 1: Model domain for standard evaluation simulations including the eight considered sub-regions (according to PRUDENCE and ENSEMBELS projects) .

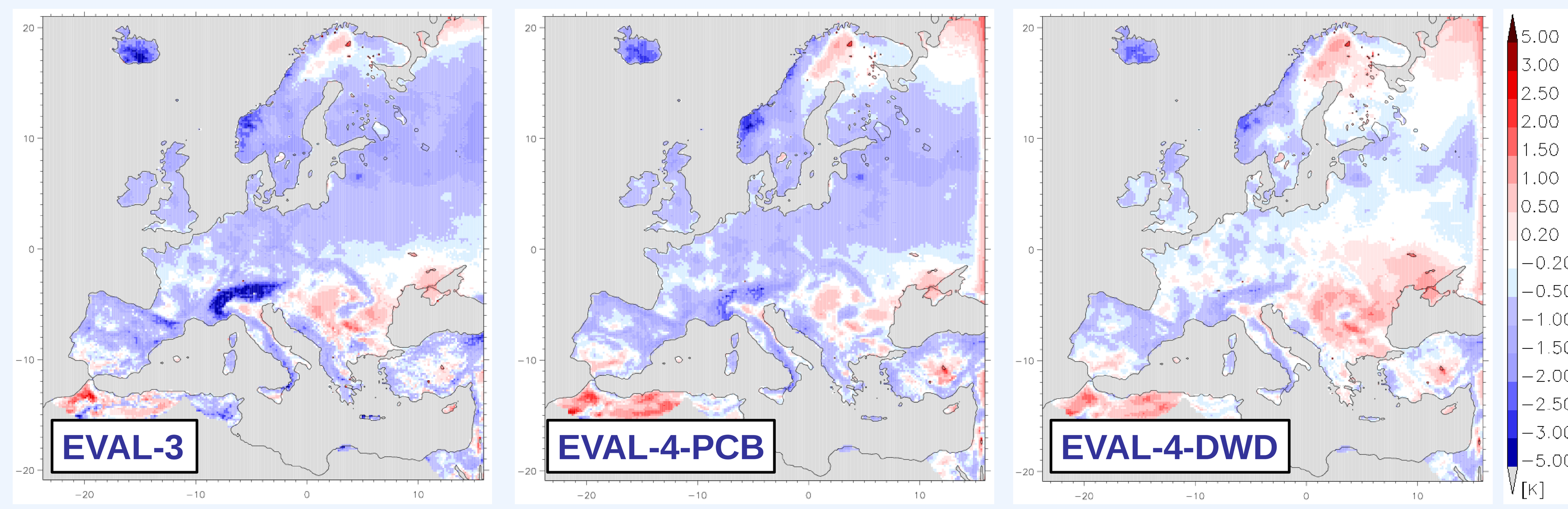

Figure 2: Difference of annual mean 2m-temperature between the evaluation runs and the E-OBS reference data set.
• EVAL-4-PCB produce comparable temperatures as the old evaluation, but the cold bias is reduced in some regions (e.g. Alps)
• EVAL-4-DWD shows no more Europe-wide cold bias and so a substantial improvement

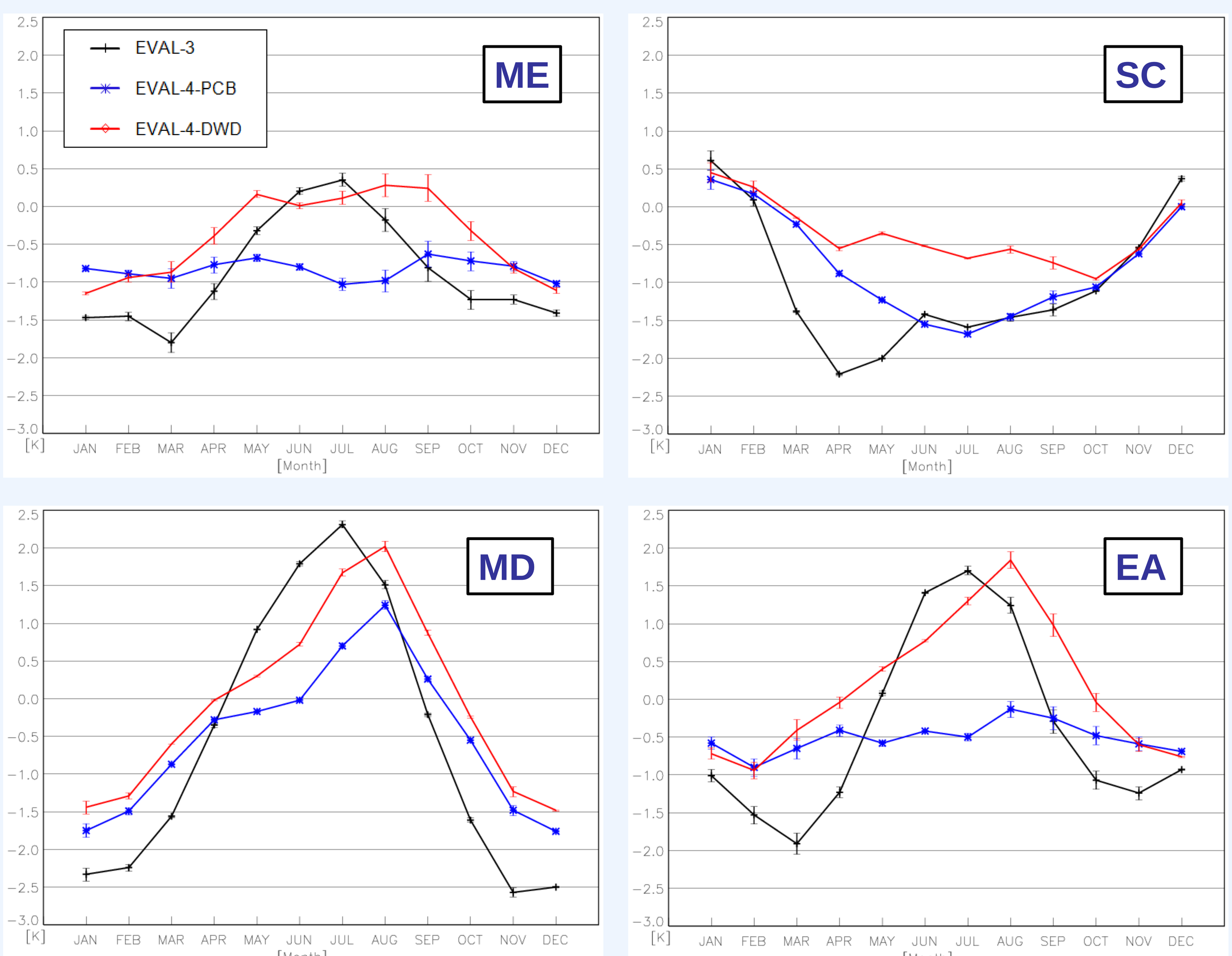

Figure 3: Difference of monthly mean 2m-temperature between the evaluation runs and the reference data sets E-OBS and CRU for some selected sub-regions.The full lines and bars represent mean value and range of the deviations from both reference data.
• In most cases the simulated summer temperatures are slightly warmer (up to 0.5 K) and winter temperatures generally colder (-1 to -1.5 K) than the reference data. Only Scandinavia (SC) has an opposite seasonal trend.
• The strongest deviations occur in the Mediterranean (MD) sub-region with a seasonal bias between ± 2 K.
• The new simulations have a smoother seasonal variation of the temperature bias throughout the year. This is a clear improvement of the new version.
• EVAL-4-DWD produces lower summer temperatures in each sub-region
• The difference between the two reference data sets (E-OBS and CRU) is quite small in most regions, so the uncertainty is only small compared to the bias of the model.

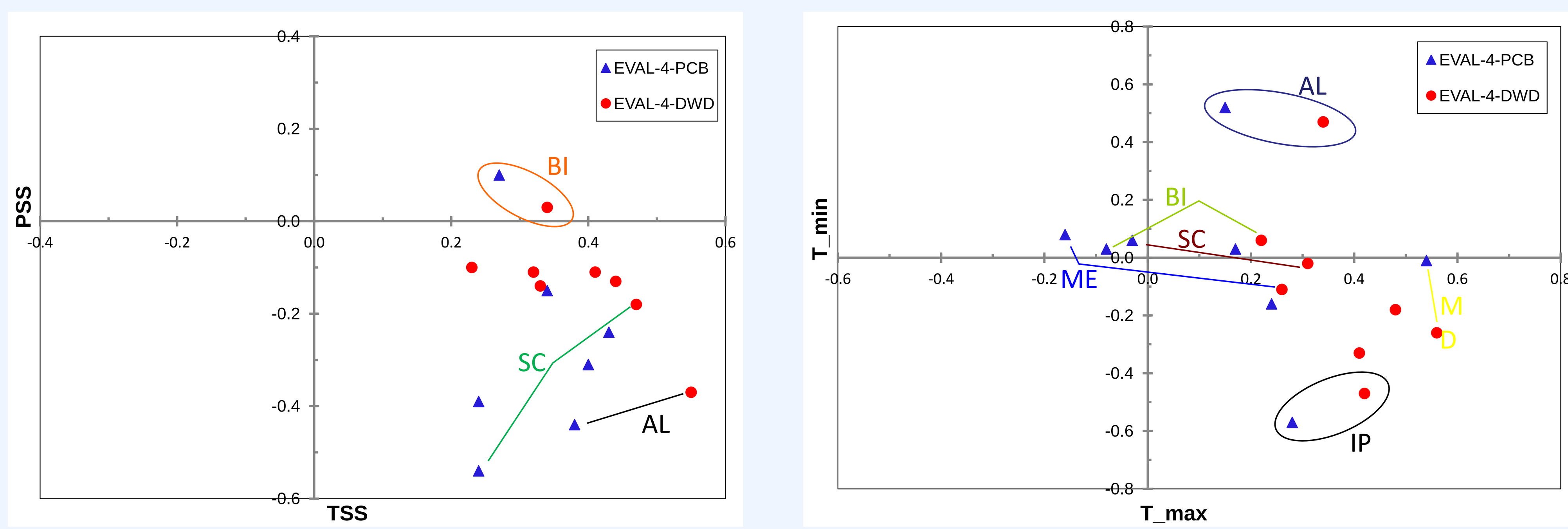

Figure 4: Relative Skill Score diagrams for daily mean temperature (TSS) and total precipitation (PSS) on the left side and for daily maximum temperature (T_max) and minimum temperature (T_min) on the right panel for all eight sub-regions. The scores are calculated in relation to the deviation of EVAL-3 from the E-OBS reference data:

temporal root mean square difference:
simulation – observation
divided by:
temporal root mean square difference:
reference simulation - observation

$$BSS^k = 1 - \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(S_i^k - O_i^k)^2}}{\sqrt{\frac{1}{N}\sum_{i=1}^{N}(R_i^k - O_i^k)^2}}$$

• The mean temperature is improved in all cases compared to the old model version EVAL-3.
• The skill of precipitation is less than in EVAL-3 in nearly all sub-region, AL shows the smallest score. Only BI show a better result in the new evaluation simulations.
• The maximum temperature is improved in nearly all cases, greatest in sub-region MD. Only EVAL-4-PCB shows some sub-region with worse results than EVAL-3.
• The minimum temperature gives a wide spread of quality development, with a tendency to degradation. AL shows a large improvement, IP the worst development.

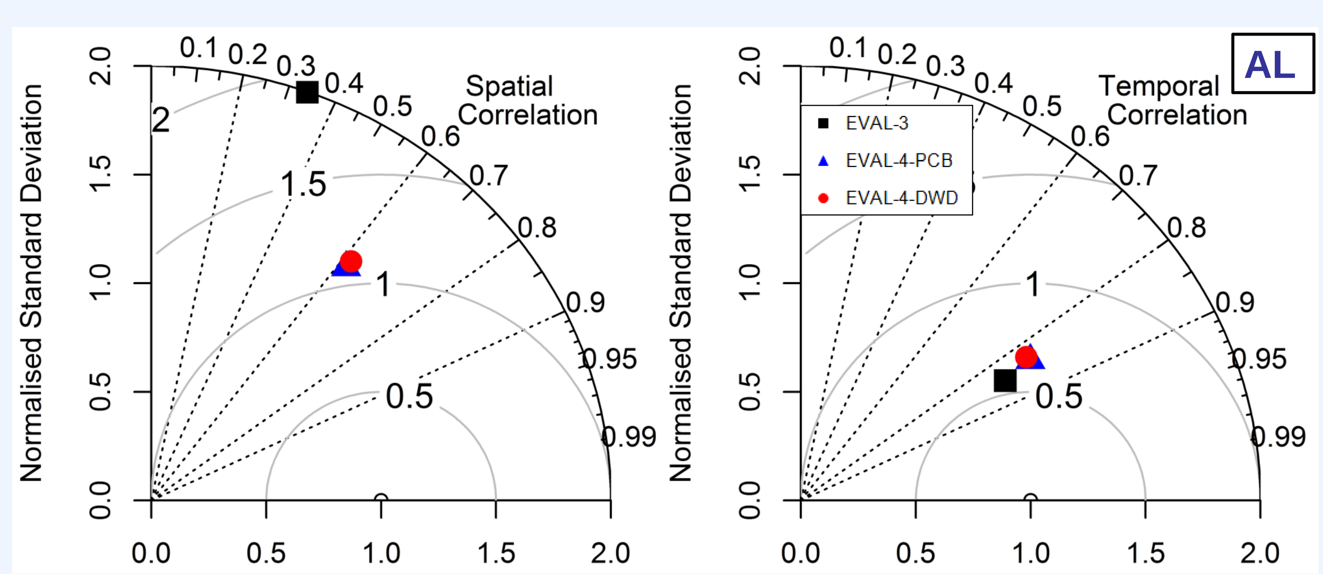

Figure 5: Taylor Diagrams combine the spatial or temporal standard deviation of a climatological field and the correlation of the simulated field with the reference data E-OBS. The figure shows them for precipitation in the sub-region AL, the simulations show difficulties in simulating adequate precipitation pattern especially in mountainous areas like the Alps.
• The spatial structure (left) of the simulation is less smooth than that of the reference data, both new simulations reduce this overestimated standard deviation.
• The temporal correlation (right) is between 0.8 and 0.9. The simulation fits better in most of the other sub-regions.
• The corresponding values of the temperature (no figure) show a better accordance between simulations and reference.

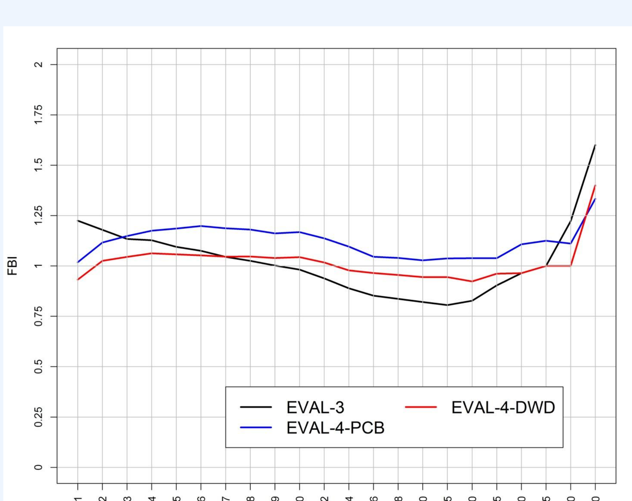

Figure 6: Frequency bias (FBI) of daily precipitation intensities (mm/d) for Germany calculated as the ratio of the simulated frequencies to the frequencies of the REGNIE reference data of DWD .
• All simulations fit well to the reference data set. But, the number of days in the upper classes are overestimated.
• EVAL-4-DWD shows a substantial improvement compared to the old simulation EVAL-3.

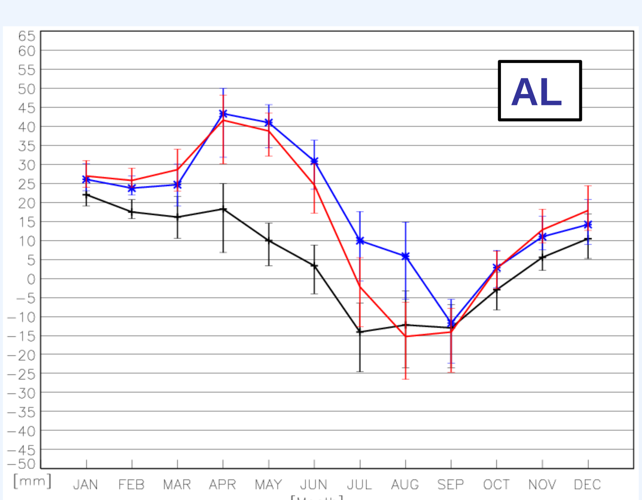

Figure 7: Difference of monthly precipitation sum from the reference data sets E-OBS, CRU and GPC in the Alps. The full lines and bars represent mean value and range of the deviations from reference data.
• The new version produces larger precipitation sums than the old evaluation run, and so in most sub-regions (no figure) even a larger overestimation. Only EVAL-4-DWD shows in some regions a comparable result. The strongest overestimation occurs in the Alps.
• But, the variability of the reference data differs from region to region. In ME it is small, in AL it is largest and nearly in the order of magnitude of the BIAS.

Conclusions

- mean temperature: cold bias in winter was reduced by new model version
- overestimation of temperature in Southern Europe reduced
- daily maximum temperature improved
- spatial distribution of precipitation improved, god frequency distribution

But:
- still existing deficits with daily temperature range, minimum, maximum temperature
- no improvement of the overestimated precipitation sum

References

van der Linden P., and J.F.B. Mitchell (eds.), 2009: ENSEMBLES: Climate Change and its Impacts: Summary of research and results from the ENSEMBLES project. Met Office Hadley Centre, FitzRoy Road, Exeter EX1 3PB, UK. 160pp
Hollweg H.-D., U. Böhm, I. Fast, B. Hennemuth, K. Keuler, E. Keup-Thiel, M. Lautenschlager, S. Legutke, K. Radtke, B. Rockel, M. Schubert, A. Will, M. Woldt, C. Wunram, 2008: Ensemble simulations over Europe with the regional climate model CLM forced with IPCC AR4 global scenarios. Gruppe Modelle & Daten, Hamburg, Technical Report, No. 3, pp 146, ISSN 1619-2257