Project: bb0931

Project title: ReKliEs-De

Project lead: Heike Hübener

Report period: 01.01.2016 - 31.12.2016

Node hours at the 12th of October 2016

Granted: 188582 Node hours
Accounted: 150338 Node hours
Remaining: 38244 Node hours

The WLA approved 10 REMO simulations for the project partner HZG/GERICS. The REMO simulations are on the EURO-CORDEX grid for two different horizontal resolutions: five simulations with a horizontal resolution of 0.44 ° with a grid size of 129x121x27 and five with a horizontal resolution of 0.11° with a grid size of 433x433x27.
Five different GCMs (HadGEM2-ES, EC-Earth run 12, CNRM-CM5 run 1, CanESM2, MIROC5 run 1) for the historical and the scenario RCP8.5 time period from 1950 till 2100 have be used as forcing for the REMO simulations on 0.44 ° horizontal resolution. Within the RekliEs-De Project we use a double nesting procedure. We use the results of each REMO simulation with 0.44 ° horizontal resolution as boundary forcing for the high resolution simulations on 0.11 ° (table 1).

All simulations with 0.44 ° horizontal resolution are finished, one simulation on the high 0.11 ° horizontal resolution is finished and 4 high resolution simulations are still running (about 35 years each are left to be calculated).

GCM	**REMO 0.44**	**REMO 0.11**
HadGEM2-ES (RCP8.5)	1949-2099 (finished)	1949-2067 (running)
EC-Earth run 12 (rcp8.5)	1948-2100 (finished)	1948-2100 (finished)
CNRM-CM5 run1 (RCP8.5)	1950-2100 (finished)	1950-2059 (running)
CanESM2 (RCP8.5)	1950-2100 (finished)	1950-2066 (running)
MIROC5 run1 (RCP8.5)	1948-2100 (finished)	1948-2057 (running)

Table1: Status of the REMO-Simulation at the 12.10.2016

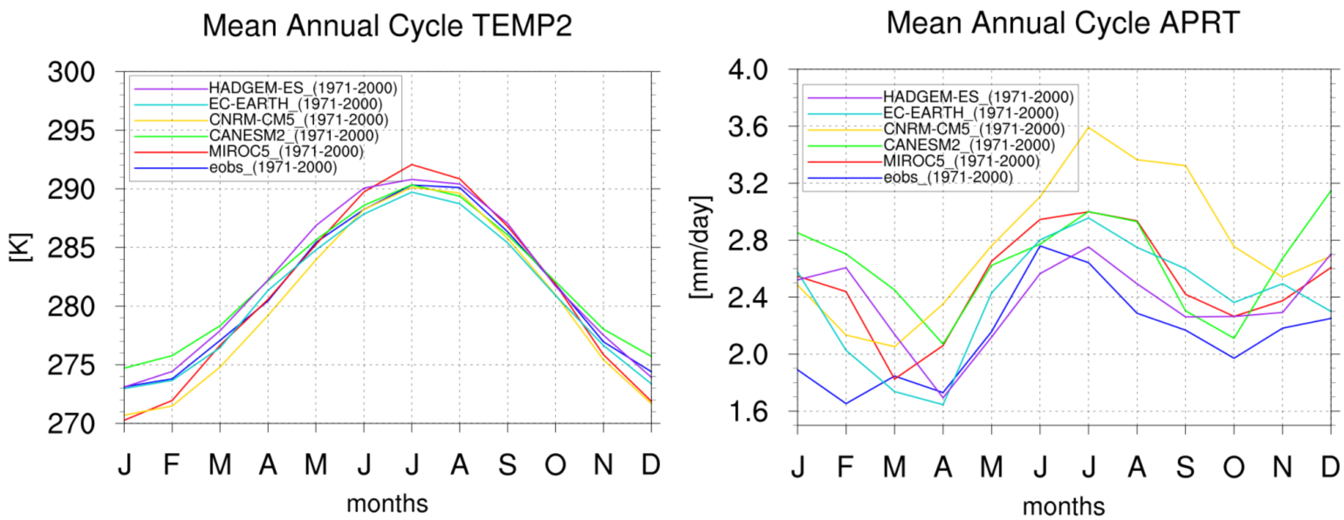


Figure 1 shows the mean annual cycle 1971-2000 of the results from the REMO simulations (0.11 °) averaged over the years 1971-2000 forced with HadGEM2-ES (purple), forced with EC-Earth (light blue), forced with CNRM-CM5 (yellow), forced with CanESM2 (green), forced with MIROC5 (red) and the reference data set E-OBS* (blue). The results are averaged over Germany. The results for temperature [K] are shown on the left and for precipitation on the right [mm/day].

The temperature and precipitation E-OBS* observations and the results of all simulations are averaged over the time period 1971-2000 and over the ReKliEs domain. The comparison of the thirty year mean annual cycle (1971-2000) of temperature and precipitation shows reasonable results. The deviations between observations and the REMO results vary depending on the forcing GCM. The mean winter temperature deviates between +/- 2 K from the observations. The mean summer temperature deviates between -1 and +1.5 K from the observations (figure 1). All simulations overestimate the winter precipitation by 0.5 – 0.8 mm/day compared to the observations. In summer the different simulations show a wider bandwidth and the deviation from the observation is between 0 to 0.8 mm/day (figure 1).

REMO was calculated on a horizontal resolution of 0.11 °. These results were interpolated to the 0.22 ° E-OBS* grid to be able to compare both (figure 2). The preliminary comparison between REMO results and E-OBS* data shows reliable results. The deviation between each REMO-GCM combination and the reference data show different horizontal patterns.

*Haylock, M.R., N. Hofstra, A.M.G. Klein Tank, E.J. Klok, P.D. Jones, M. New. 2008: A European daily high-resolution gridded dataset of surface temperature and precipitation. J. Geophys. Res (Atmospheres), 113, D20119, doi:10.1029/2008JD10201

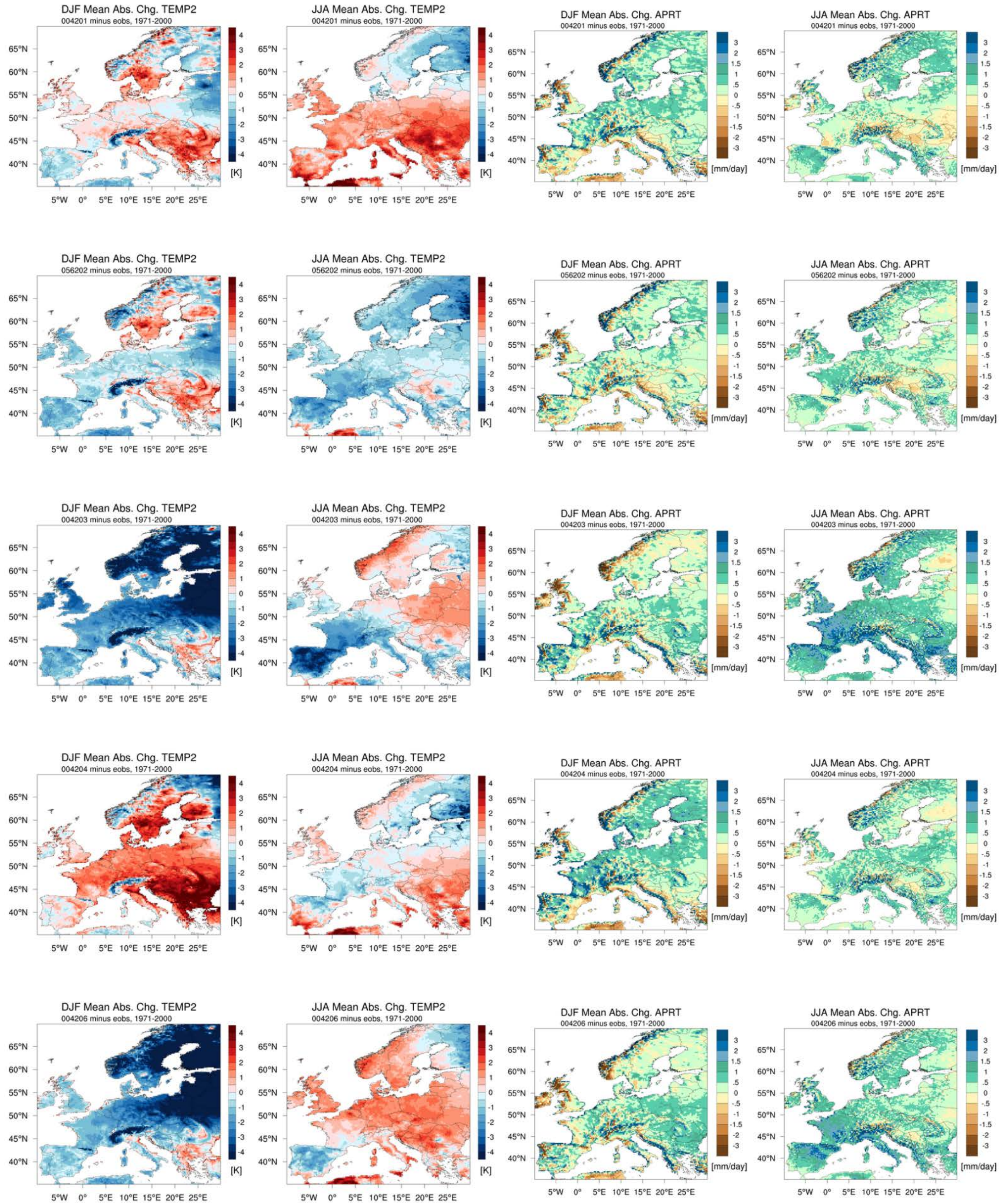


Figure 2 shows from left to right the winter (djf) and summer (jja) mean 1971-2000 difference of temperature and precipitation between REMO (from top to bottom: forced HadGEM2-ES, forced with EC-Earth, forced with CNRM-CM5, forced with CanESM2, forced with MIROC5) and the E-OBS* data. The REMO results are interpolated to the E-OBS grid.

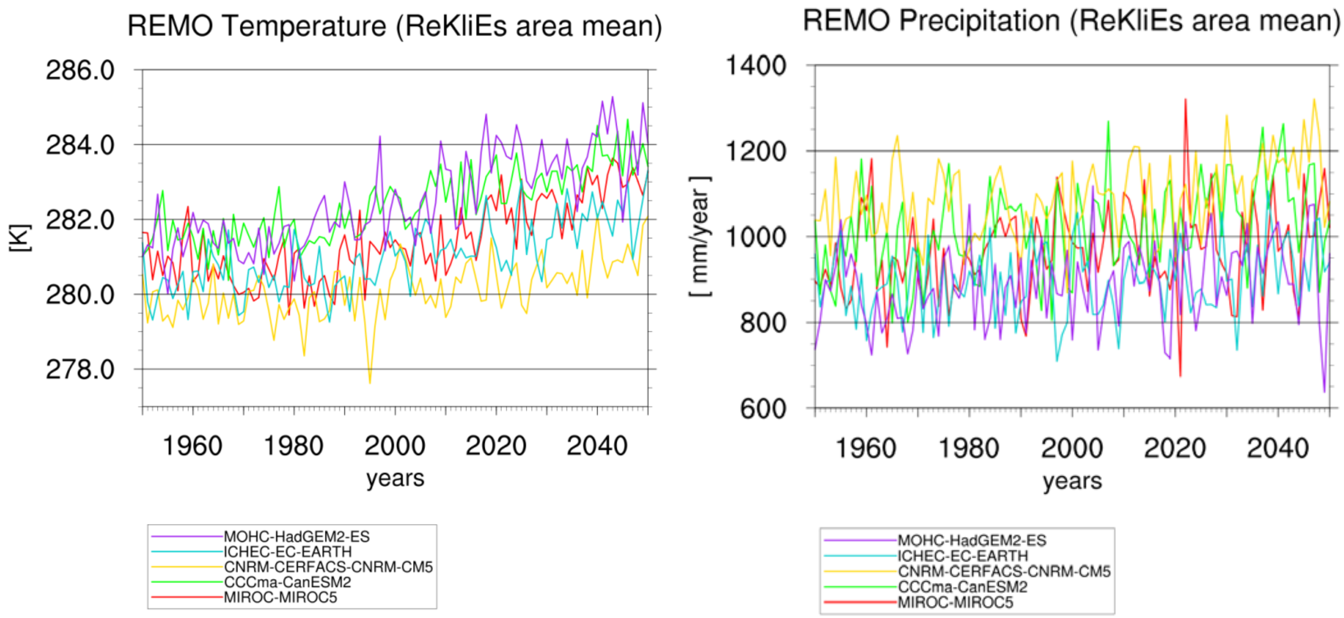


Figure 3 shows the annual mean of the results from the REMO simulations (0.11 °) averaged over the ReKliEs domain for the time period 1950 -2050 forced with HadGEM2-ES (purple), forced with EC-Earth (light blue), forced with CNRM-CM5 (yellow), forced with CanESM2 (green) and forced with MIROC5 (red).The results for temperature [K] are shown on the left and for precipitation on the right [mm/year].

The annual mean temperature and precipitation results of the different REMO simulations are averaged over the ReKliEs domain. During the time period 1950 till 2050 the bandwidth of the yearly mean temperature results is about 2 K and increases with time beginning in 1990. The REMO results from the simulation forced with CNRM-CM5 are the coldest and forced with HadGEM2-Es are the warmest. The annual mean precipitation results show an annual bandwidth of 400 mm/year. The REMO results from the simulation forced with CNRM-CM5 are the wettest over the whole time period (figure3).

The mean seasonal temperature and precipitation changes between 2021-2050 minus 1971-2000 of each of the 5 simulations show large differences in the horizontal distribution (figure 4). The first rough estimate shows a bandwidth in temperature change for the ReKliEs domain from 1.5 till 2.5 K in winter (DJF) and 0.5 till 2 K in summer (JJA). In the ReKliEs domain the precipitation change of all simulations shows an increase about 10 % in winter, except for the REMO simulation forced with MIROC5, which shows no clear precipitation change in winter +/- 10 %. In summer only the REMO simulation forced with CanESM2 shows an increase about 10% over the ReKliEs domain, the other 4 simulations vary between +/- 10%.

These preliminary results show big differences between the REMO simulations depending on the forcing GCM for the historical time period and for the future temperature and precipitation change. This shows the big effort to run REMO with 5 different GCM forcings is reasonable to investigate the bandwidth and uncertainty of possible future climate change.

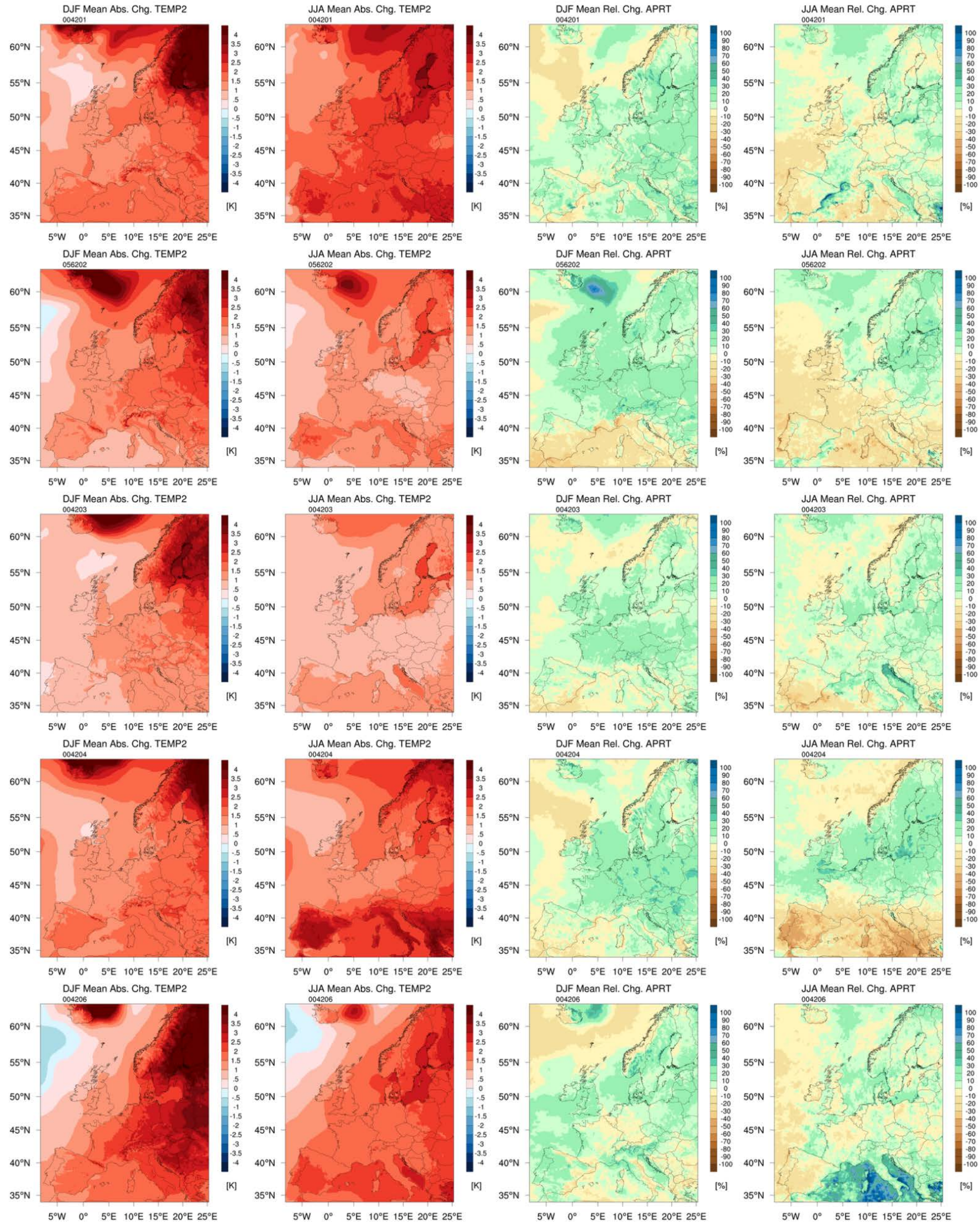


Figure 4 shows from left to right the winter (djf) and summer (jja) mean temperature and precipitation difference between 2021-2050 and 1971-2000 of the REMO simulations (from top to bottom: forced HadGEM2-ES, forced with EC-Earth, forced with CNRM-CM5, forced with CanESM2, forced with MIROC5).

Answers to the comments of the Reviewer

Project: bb0931
Project title ReKliEs-De
Project lead: Heike Hübener
Allocation period: 01.01.2016 - 31.12.2016
Project title: Regionale Klimaprojektionen Ensemble für Deutschland (ReKliEs-De)

These are the remarks by the reviewers on your allocation request:

Third-party project, reasonably argued proposal. I do have two issues with the project, however:

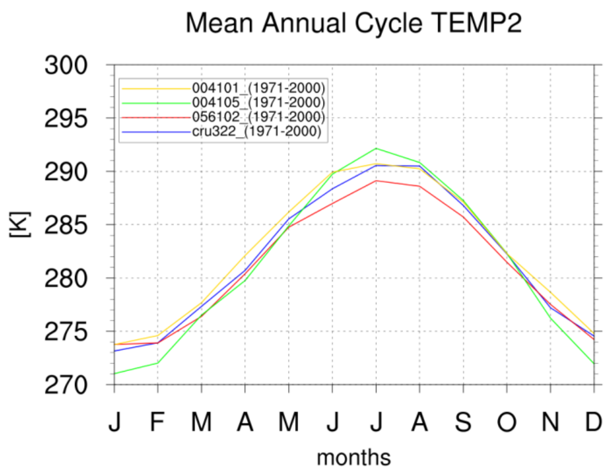
1) **They seem to not have been able to make the model run under the set-up needed for the project by the time of proposal submission. Is there any hope it will run next year? What is the state of the project at the time of the WLA-session?**

Answer: The EURO-CORDEX setup is used for REMO in the ReKliEs-De Project. REMO performs very well on the EURO-CORDEX domain. This has already been published for example in Jacob (2012, 2014), Kotlarski (2014), Teichmann (2013), Prein (2014) and Vautard (2013). Within the RekliEs-De Project we use a double nesting procedure. We use the results of 5 different global models each as forcing for Remo2009 on 0.44° horizontal resolution and later on the results from REMO with 0.44 ° horizontal resolution are each used as boundary forcing for the high resolution simulations on 0.11 ° (table 1).

GCM	REMO 0.44	REMO 0.11
EC-Earth run 12 (rcp8.5)	1948-2074 (running)	1948-1998 (running)
HADGEM2-ES (RCP8.5)	1949-2099 (finished)	1949-1969 (running)
MIROC5 run1 (RCP8.5)	1948-2089 (finished)	
CNRM-CM5 run1 (RCP8.5)		
CANESM2 (RCP8.5)		

Table1: Status of the REMO-Simulation at the 14.01.2015

First results of the REMO Simulation with 0.44°horizontal resolution (Figure 1):



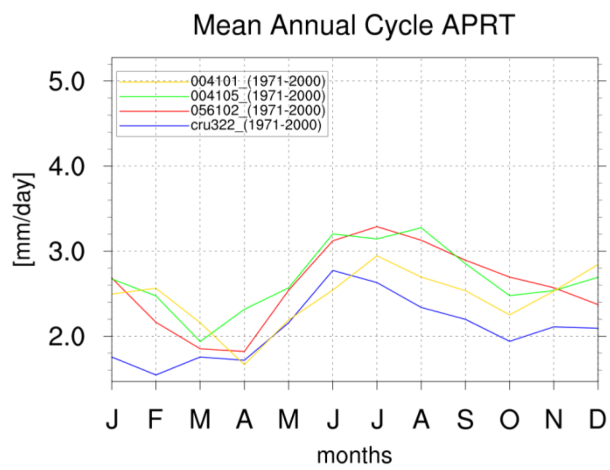


Figure 1 shows the annual cycle of the results from the REMO simulations (0.44 °) forced with HADGEM2-ES (yellow), forced with EC-Earth (red), forced with MIROC5 (green) and the reference data set CRU (blue). The results are averaged over Germany. The results for temperature [K] are shown on the left and for precipitation on the right [mm/day].

First results of the REMO Simulation with 0.11°horizontal resolution (figure 2-4):

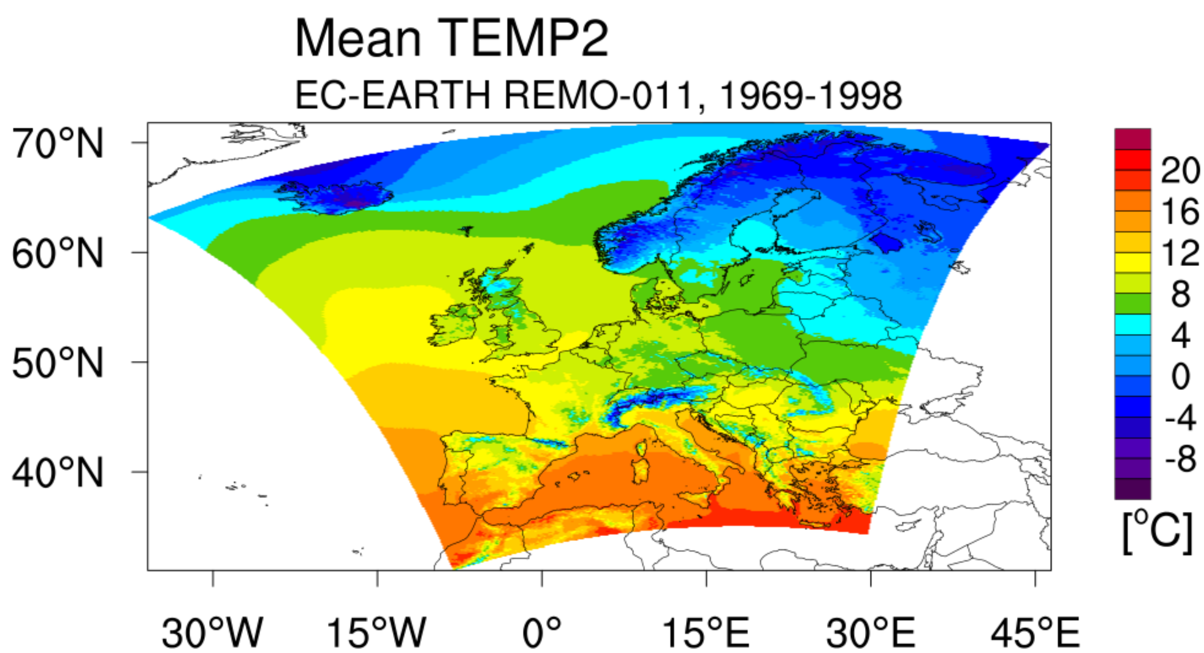


Figure 2 shows the mean temperature [°C] 1969-1998 calculated by REMO on 0.11° horizontal resolution over Europe.

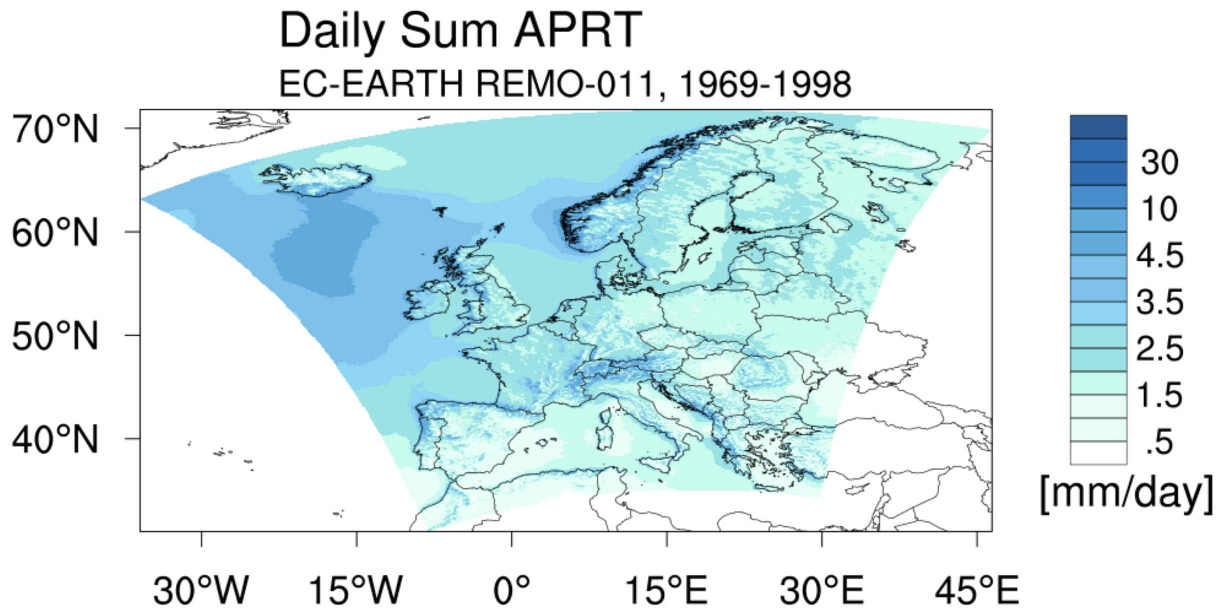


Figure 3 shows the mean precipitation sum [mm/day] 1969-1998 calculated by REMO on 0.11° horizontal resolution over Europe.

REMO was calculated on a horizontal resolution of 0.11°. These results were interpolated to the CRU grid, to be able to compare both (figure 4). The preliminary comparison between REMO results and CRU data shows reliable results. The deviation of temperature is between +/- 1 K. Only at the coasts and in orographic structured regions the deviation is higher. The quality of CRU data in the coastal regions and the applied height correction needs to be revised. The deviation for precipitation is in the size of +/- 0.5 mm/day and higher in orographic structured regions.

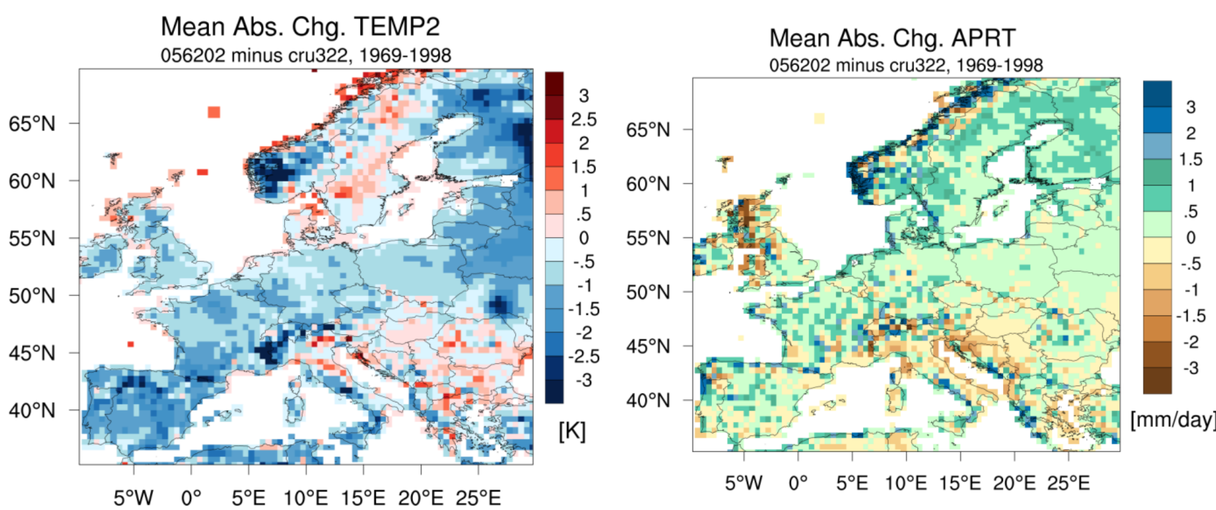


Figure 4 shows the mean differences for the time period 1969-1998 between the REMO results forced with EC-EARTH and CRU data for temperature [K] (left) and precipitation [mm/day] (right).

2) **It is appreciated that the proposers provided the scaling diagram in Fig. 2, yet I do not agree with their conclusion. If they use 144 instead of 288 CPUs, they have to wait 1.22 times as long to get the results for a given run, while they would use by a factor of 1/1.61 less CPU-hours of the machine, corresponding to a 40% cut. I think that the scarcity of CPU hours has priority, hence my suggestion below.**

Answer: The reviewer's remark concerning the scaling factor of the model is appreciated. However, the scaling data was actually retrieved from test runs on the HLRE-3 Pitbull system. Since the production phase of the Mistral system has started, we could improve the performance by using the bullxmpi compiler instead of the intelmpi implementation. This results in a better scaling performance than on the pitbull test system. By using 288 processors instead of 144, we can actually improve the wallclock runtime by about 30%, which results in a scaling factor of 1.42 (about 70 min./per month wallclock time instead of 100 min.). Since we have to compute 150 years per model run, this saves about a month of wallclock time which is crucial for the ReKliEs-De project in order to finish all runs as soon as possible. However, since the model's performance in general has improved on the Mistral production system, the granted computing time is still sufficient and very much appreciated.

We appreciate your advice and will apply for HPSS doku next time.

Literature:

Jacob, D., A. Elizalde, A. Haensler, S. Hagemann, P. Kumar, R. Podzun, D. Rechid, A.R. Remedio, F. Saeed, K. Sieck, C. Teichmann, and C. Wilhelm (2012): Assessing the Transferability of the Regional Climate Model REMO to Different Coordinated Regional Climate Downscaling Experiment (CORDEX) Regions. Atmosphere, Vol. 3, No.1, pp. 181-199. DOI:10.3390/atmos3010181.

Jacob, D. et al. (2014): EURO-CORDEX: New high-resolution climate change projections for European impact research. Regional Environmental Change Vol. 14, Issue 2, pp. 563-578.DOI:10.1007/s10113-013-0499-2.

Kotlarski, S., K. Keuler, O. B. Christensen, A. Colette, M. Deque, A. Gobiet, K. Goergen, D. Jacob, D. Luethi, E. van Meijgaard, G. Nikulin, C. Schaer, C. Teichmann, R. Vautard, K. Warrach-Sagi and V. Wulfmeyer (2014): Regional climate modeling on European scales: a joint standard evaluation of the EURO-CORDEX RCM ensemble. Geoscienticfic Model Development, Vol. 7, Issue 4, pp. 1297-1333. DOI: 10.5194/gmd-7-1297-2014.

Teichmann, C., B. Eggert, A. Elizalde, A. Haensler, D. Jacob, P. Kumar, C. Moseley, S. Pfeifer, D. Rechid, A.R. Remedio, H. Ries, J. Petersen, S. Preuschmann, T. Raub, F. Saeed, K. Sieck and T. Weber (2013): How does a regional climate model modify the projected climate change signal of the driving GCM: A study over different CORDEX regions using REMO. Atmosphere. Vol. 4, pp. 214-236. DOI: 10.3390/atmos4020214.

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