Project: **807**

Project title: **Module D**

Old title during MiKlip first phase: **A flexible forecast system for decadal climate predictions - FLEXFORDEC**

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Report period: **1.1.2014 - 31.12.2015**

Principal aim

A key deliverable of FLEXFORDEC to MiKlip and its project partners is the provision of a full suite of model experiments and hindcast with the central prediction system. During the initial period of MiKlip, FLEXFORDEC has provided decadal hindcasts based on MPI-ESM in a low resolution (LR, baseline version 0) and yearly initialization for CMIP5. During the course of the development stage one (DS1, 09.11-03.13) of MiKlip an improved initialization was developed in low resolution (LR, baseline version 1), and also updated to a higher resolution (MR, baseline version 1). During DS2 (4.13-8.14) of MiKlip, the prototype decadal prediction system was developed, again using MPI-ESM-LR.

Benchmarks achieved during the first phase of MiKlip

During DS1, a key problem has emerged, that is the large negative bias which occurs within the tropical Pacific directly after initialization and last ~4-5yrs (Müller et al. 2012). The first aim was to reduce this bias in the hindcasts. A few initial tests gave best results with ocean initialization from ORAS4 or GECCO2 and with additional initialization of the atmosphere from ERA-40/ERA-Interim. The better availability of ORAS4, which is regularly updated, let us initially prefer data from the oceanic reanalysis ORAS4. With this initialization a new set of hindcasts (baseline version 1) of yearly initialized 10 ensemble members in LR and 5 ensemble members in MR was completed during DS1.

The performance of the hindcasts from baseline version 0 and 1 has been compared (Pohlmann et al. 2013, Kadow et al. 2015, Müller et al. 2015). The new oceanic initialization improves the performance considerably in terms of surface air temperature over the tropical oceans on the 2-5 years time-scale, which also helps to improve the prediction skill of global mean surface air temperature on this time scale. The higher model resolution improves the prediction skill of surface air temperature over the tropical Pacific even further. Through the newly introduced atmospheric initialization, the quasi-biennial oscillation exhibits prediction skill of up to 4 years when a sufficiently high vertical atmospheric resolution is used (Pohlmann et al. 2013, Scaife et al. 2014). Additionally, the impact of stratospheric volcanic aerosol on decadal scale predictability was analyzed (Timmreck et al. 2015). The results show that volcanic aerosol significantly affects decadal predictability of global mean surface air temperature in the first years after strong volcanic eruptions. Additionally, winter storms are skillfully predicted over large parts of the Northern Hemisphere, however, most of the skill is associated with external forcing from transient greenhouse gas and aerosol concentrations, already included in the uninitialized simulations (Kruschke et al. 2015).

During DS2, the prototype decadal prediction system was developed. As an alternative to the initialization method used for baseline version 1 (anomalies from the observations are added to the model climatology to avoid drift in the hindcasts) the full-field method was applied (in this case the drift is to be removed a posteriori). A rather large ensemble of 15 members initialized from ORA-S4 and 15 members initialized from GECCO2 oceanic reanalysis was produced. A comparison of the baseline-1 and prototype systems and the initialization with ORA-S4 versus GECCO2 is underway (Kröger et al. 2015). The advantages from a large ensemble size are described in a joint study with MiKlip module-E (Sienz et al. 2015). It is shown that small ensembles, as well as hindcast sample sizes lead to biased test performances in a way that the detection of a present prediction skill is hampered.

Over continental regions, however, the forecast skill still is strongly reduced, such as for the North Atlantic/European region, where skill is limited by SST bias and unresolved atmospheric processes (e.g., Müller et al. 2012). Increase of model resolution and the reduction of the North Atlantic SST bias, however, have been shown to resolve key atmospheric parameters such as blocking frequency and NAO (Scaife et al. 2011, Scaife et al. 2014, Butler et al. 2015). Recently, Ghosh et al (2015) could demonstrate the relevance of blocking for the impact of North Atlantic decadal variability on European summer climate. Furthermore, it has been shown that the blocking frequency increases with model resolution (e.g. Berckmans et al. 2012). To prepare a higher resolution version of MPI-ESM for decadal climate predictions, MPI-ESM-HR (T127L95/TP04L40) was tuned at CSCS and DKRZ during the report period. A control run is underway during the remainder of 2015. MPI-ESM-HR will be the underlying system for the next set of decadal climate predictions.

The hindcast, together with further simulations and observational datasets for the evaluation of the hindcasts, are all hosted on a dedicated server – the MiKlip server, accessible for all project members. To facilitate the use of the data, the hindcasts were standardised according to the CMOR-standard, as it was used for CMIP5. Upon request of the project partners the CMIP5 variable list was extended with some MiKlip-specific variables. The server now has around 140 registered users, of which some 50 are actively using it. The MiKlip server is also home to the central evaluation system (CES), allowing the CES and its users easy access to all hindcasts and observational data. Both Miklip Server and CES have been applied in various publications throughout the modules. An example is a special issue in Meteorologische Zeitschriften organized by module E.

FLEXFORDEC has additionally produced decadal forecasts for the decadal prediction exchange project led by the MetOffice (Smith et al. 2013,http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel). This prediction accrues from an international activity to exchange decadal predictions in near real-time, in order to assess differences and similarities, provide a consensus view to prevent over-confidence in forecasts from any single model, and establish current collective capability. The data of the baseline1 simulations were provided to the EU-FP7-Projekt SPECS project for comprehensive multi-model evaluations.

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