A Flexible Forecast System for Decadal Climate Predictions (FLEXFORDEC)

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1. Aims

FLEXFORDEC stands out as a key project within MiKlip: it is the centre project for the MiKlip Module D “Synthesis”; it comprises the development of the central prediction system for decadal climate forecast; and it includes the overall coordination of MIKlip (project office).

The central system being established in FLEXFORDEC comprises an ensemble prediction system (EPS) including a complex data assimilation architecture (comparable to NWP), inclusion of new relevant climate system components (e.g., land surface and sea-ice), and the generation of a sufficiently large ensemble. The EPS is embedded in a well-designed prediction system and model environment infrastructure for pre-operational test case.

2. Hindcast and Forecast Simulations

For each of the three project development stages (DS) a set of hindcasts and forecasts are performed.

For DS1, following the CMIP5 hindcasts (baseline version 0) a new stream of hindcasts/forecasts is run (baseline version 1). The system is based on the MPI Earth System Model in medium resolution (MPI-ESM-MR) including:

- atmospheric (ERA40/interim) and ocean (ORA-S4) assimilation via nudging; instead of ocean only (NCEP forced MPIOM) as in version 0
- yearly initialisation for the period 1961-2012
- 10 members (lagged initialisation)

FOR DS2/3, we will integrate the recommendation from the other Modules. We envisage an increase of ensemble size (with ensemble perturbations relying on e.g. atm./ocean 3DVAR/EnKF[1]) and model resolution.

Example of baseline version 1 (test example with low resolution):

(a) baseline version 0 **(b) baseline version 1**

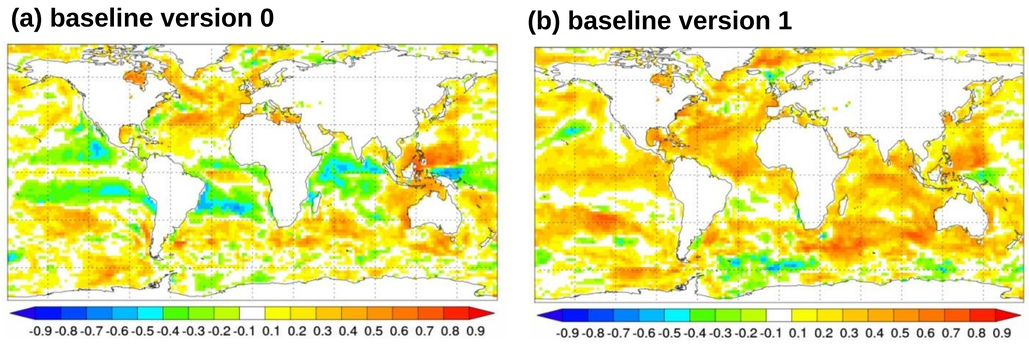


Figure 1: Correlation of sea surface temperature between observations and the ensemble mean year 2 hindcast for (a) baseline version 0 (CMIP5) and (b) baseline version 1 (MPI-ESM-LR). Here, the period 1961-2001 is considered. In baseline version 1 the strong bias in the tropical region is reduced.

[1]Ensemble Kalman Filter

3. Ensemble prediction system infrastructure

The synthesis of the research across all of MiKlip takes the form of incorporating suggestions for improvements to the prediction system, e.g. data assimilation and initialisation (Module A), representation of processes (Modules B and C), mechanisms and understanding of ensemble spread (Module E).

This requires code implementation into the software environment and respective testing and evaluation, optimisation for the HPC environment and re-running of the model spin-up in the case of modifications in process representation.

For the EPS, a technical infrastructure is implemented accounting for the ensemble generation and data assimilation. In a first step, 3DVar from DWD is transformed to MPI-ESM. In parallel, ocean data EnKF and ensemble strategies are developed (see AODA-PENG). In a second step, the different components are merged.

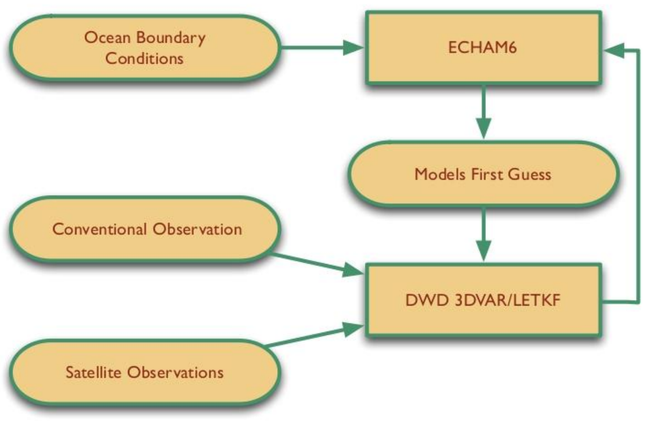


Figure 2: Basic workflow for using standard weather prediction assimilation cycle from DWD in MPI-ESM.

4. Model environment infrastructure

Facing a large ensemble size and a complex assimilation architecture, we need a model environment infrastructure especially tailored to this requirements. It has to be as user-friendly as possible, offer a maximum of utility, in particular easy failure recovery, and a high degree of parallelization. We decided on an object-oriented approach to make the infrastructure as modular and reusable as possible.

As a skeleton we chose Cylc, a meta-scheduler developed at NIWA. It is a tool for efficient control of complex distributed suites of interdependent cycling tasks. These tasks have their private cycle time and are self-spawning. Suites can be stopped and restarted in any state of operation and dynamically adapt to insertion and removal of tasks, their delays or failures. Cylc can run suites distributed across heterogenous networks.

Example of Cylc for a 2-member forecast initialised 2012:

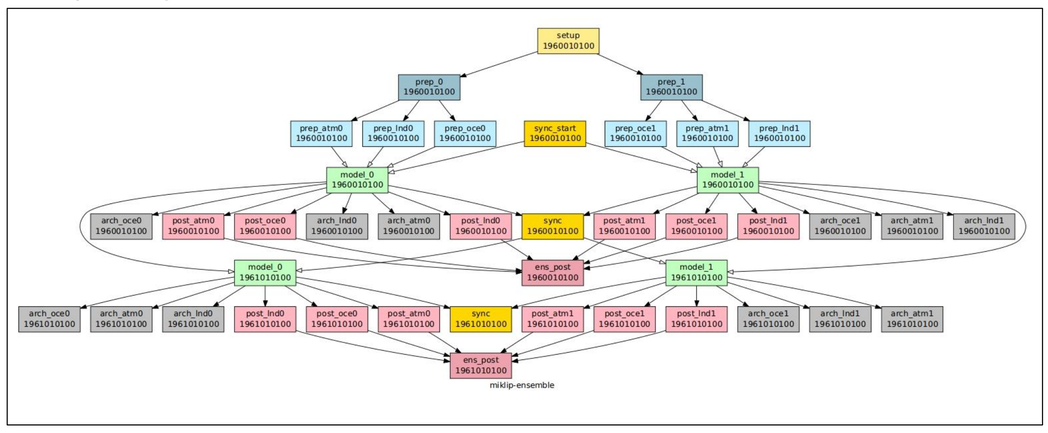
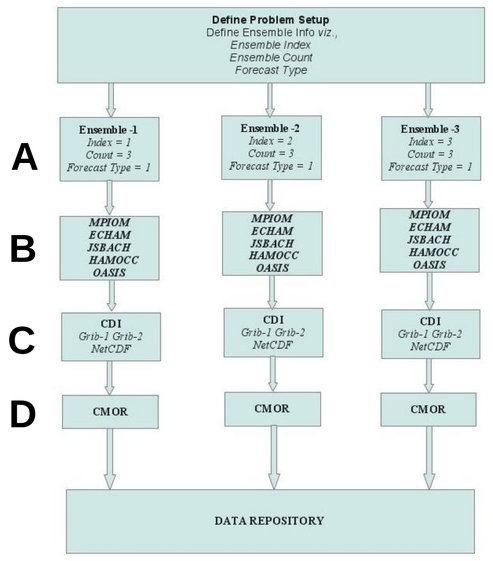


Figure 3: A 2-member forecast indicated as model 1 and 2 (green), their post-processing (red) and archiving scripts (grey) controlled by the synchronizer (dark yellow). The synchronizer also controls the ensemble post-processing (dark red) and visualisation (not shown). At the beginning, a setup script (light yellow) initiates a preparation script for each climate component (blue).

5. Post-processing and communication

The results of the decadal hindcasts and forecasts will be made available to our partners in MiKlip; to the partners in charge of end-user support such as the Climate Service Centre (CSC) and the Deutscher Wetterdienst (DWD); as well as by publicising of the results on a web page. This requires a systematic implementation of post-processing routines and easy-to-use visualisation of raw data.

Further, a central aim is a standardised evaluation/validation of the global and regional prediction systems (see INTEGRATION). During DS1/2 we implement all necessary meta-data description into MPI-ESM and provide standard data formats, such as CMOR, GRIB and ncdf.



Example of workflow meta-data implementation and data formats

Figure 4: A suite of meta-data is defined (A) and model code (B) and Climate Data Interface (C) adapted. Finally, post-processing is applied for standarised CMOR NetCDF format (D).

6. MiKlip Office

MiKlip encompasses 35 sub-projects distributed among the five modules. The management and coordination of this large project is performed in the MiKlip Office, whose tasks include:

- **MiKlip organisation**: e.g. synchronisation of information and software flow, general assemblies, organisation of report writing, liaison with external advisory board (EAB), etc.
- **MiKlip outreach activities**, web page www.fona-miklip.de, electronic newsletters, web-based discussion groups for information transfer (redmine), etc.

Together with the DKRZ, the MiKlip Office further maintains the MiKlip Data Server, which is a platform to distribute data from the central regional and global prediction systems and their respective evaluations to the project partners.

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