Results from different initialization strategies in the decadal prediction project MiKlip

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1. Introduction

The aim of the MiKlip (Mittelfristige Klimaprognosen) project is to foster basic research on decadal climate prediction and to develop an operational ensemble decadal prediction system with the Earth System Model of the MPI-M (MPI-ESM). Starting from the MPI-M retrospective decadal predictions for the 5th coupled model intercomparison project (CMIP5) the system is successively improved within the MiKlip project. Here, we discuss the impact of oceanic and atmospheric initialization. We analyse also the influence of the ensemble size on the prediction skill. Rather large ensembles are necessary to fulfil the statistical needs of decadal predictions.

2. Impact of oceanic initialization

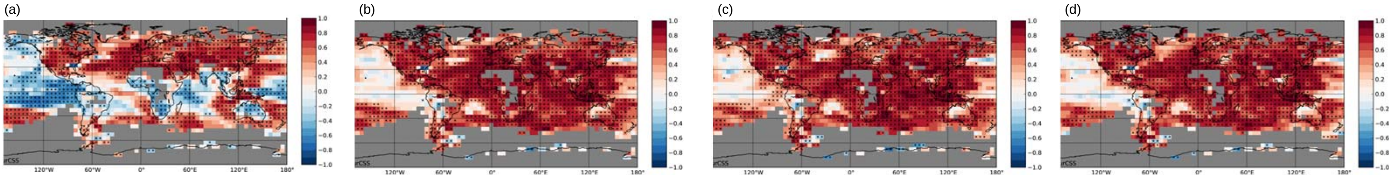
The decadal prediction system is evaluated in terms of its performance over the past 50 years. The retrospective surface air temperature predictions are analysed using the correlation skill for lead times averaged over years 2-5. Large improvements could be achieved in the tropics by changing the initialization method from a stand-alone ocean run to oceanic reanalysis (Fig. 1e). Although changing the initialization technique from anomalies to full-fields changed prediction skill locally (Fig. 1 f,g) the low prediction skill in the eastern Pacific still persists (Fig. 1 c,d).

Baseline 0 (B0) the CMIP5 system:
- Oceanic initial conditions are produced by stand-alone ocean run, forced by fluxes from NCEP/NCAR reanalysis (temperature & salinity – anomalies)
- No atmospheric initialization

Baseline 1 (B1) ORAS4 anomalies:
- Oceanic initial conditions from ORA-S4 reanalysis (temperature & salinity – anomalies)
- Atmospheric initial conditions from ERA40/ERAI (divergence, vorticity, temperature & surface pressure – full-fields)

Prototype (Pr) ORAS4 full-fields:
- Oceanic initial conditions from ORA-S4 reanalysis (temperature & salinity – full fields)
- Atmospheric initial conditions from ERA40/ERAI (divergence, vorticity, temperature & surface pressure – full-fields)

Prototype (Pr) GECCO2 full-fields:
- Oceanic initial conditions from GECCO2 reanalysis (temperature & salinity – full fields)
- Atmospheric initial conditions from ERA40/ERAI (divergence, vorticity, temperature & surface pressure – full-fields)



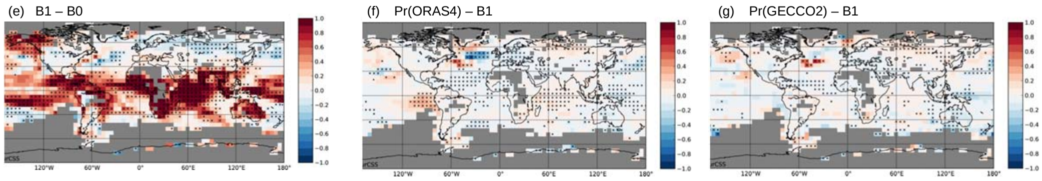


Figure 1: (a-d) Correlation skill of surface air temperature for the successive prediction systems B0, B1 and Pr for prediction leads of 2-5 years initialized yearly between 1960-2003 versus observations from HadCRUT3v. For all systems the LR model resolution is used (for details of resolution see section 4 of this poster) and the ensemble mean of 3 members in case of B0 and 10 members in case of B1 and Pr are analysed. (e-g) Differences in correlation skill between B1 and B0 (e), Pr(ORAS4) and B1 (f), Pr(GECCO2) and B1 (g). Crosses denote skills exceeding the 5-95% confidence test. (Fig. a, b,e from Pohlmann et al. 2013)

3. Impact of atmospheric initialization

The improvements of the decadal prediction system involve in addition to the oceanic also an atmospheric initialization. When a sufficiently high vertical atmospheric resolution is used (MR: 95 levels), the initialization of the atmosphere leads to predictability of the quasi-biennial oscillation (Fig. 2a). The analysis of all systems at different lead times shows that only the B1-MR system has significant prediction skill of up to 4 years (Fig. 2b).

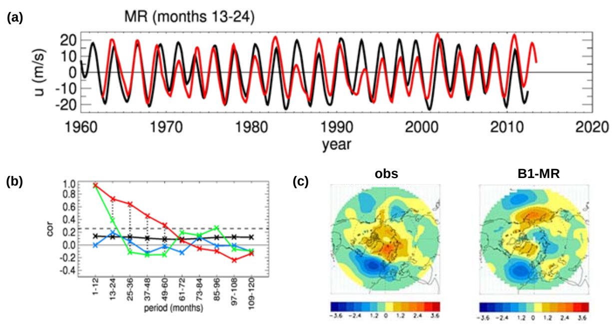


Figure 2: (a) Quasi-biennual oscillation (QBO) time series of monthly and zonal mean zonal wind anomalies at 20 hPa averaged between 10° N and 10° S from observations (black) and the ensemble mean of the hindcasts at lead times 13-24 months for B1-MR (red). (b) Hindcast skill of ensemble mean QBO at 20 hPa as a function of hindcast months for B0-LR (blue), B1-LR (green), B1-MR (red) and uninitialized (black). (c) Composites of sea level pressure (hPa) in winter between easterly minus westerly phases of the QBO from observations and B1-MR (Fig. a,b from Pohlmann et al. 2013, Fig. c from Scaife et al. 2014).

4. Impact of model resolution

The B1 system is investigated in the low resolution version (LR; atm.: T63 L47, oce.: 1.5° L40) and the mixed-resolution (MR; atm.: T63 L95, oce.: 0.4° L40). The higher resolution system shows higher prediction skill especially in the tropical Pacific and Indian Ocean for the average over years 2-5 (Fig. 3).

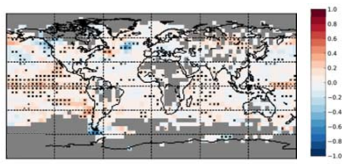
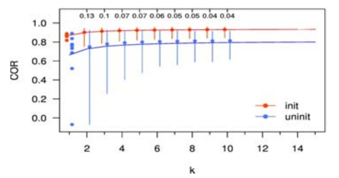


Figure 3: Differences of correlation skills: B1-MR minus B1-LR for prediction leads of 2-5 years Observations are taken from HadCRUT3v. Crosses denote differences exceeding the 5-95% confidence test. (From Pohlmann et al. 2013)

5. Impact of ensemble size

We analyse the influence of the ensemble size on the prediction skill. Dependent on the variables, time scales and regions rather large ensembles are necessary to fulfil the statistical needs for decadal predictions (Fig. 4). The trade-off between hindcast sample and ensemble size is also studied analytically.

Figure 4: Ensemble-mean correlations of North Atlantic sea surface temperatures as function of ensemble size (k) for initialized 2-5 year predictions (red points) and uninitialized runs (light blue points). At k = 1 correlations for the single ensemble members are shown. Vertical lines are the 95% confidence intervals. The numbers at the top give the achieved p-values for the correlation skill score of the initialized runs, taking the uninitialized runs as the reference prediction (null hypothesis: skill score is less than or equal to zero). Solid curves show approximate theoretical ensemble mean correlation improvement with ensemble for initialized predictions (red solid line) and uninitialized runs (blue solid line) (From Sienz et al. 2015).



6. References

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- Scaife, A. A., et al., 2014: Predictability of the quasi-biennial oscillation and its northern winter teleconnection on seasonal to decadal timescales. Geophys. Res. Lett., 41, 1752-1758. doi:10.1002/2013GL059160
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