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Comparison of surface freshwater fluxes from different climate forecasts produced through different ensemble generation schemes.

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The decadal variability and its predictability of the surface net freshwater fluxes is compared in a set of retrospective predictions, all using the same model setup, and only differing in the implemented ocean initialisation method and ensemble generation method. The basic aim is to deduce the differences between the initialization/ensemble generation methods in view of the uncertainty of the verifying observational data sets. The analysis will give an approximation of the uncertainties of the net freshwater fluxes, which up to now appear to be one of the most uncertain products in observational data and model outputs. All ensemble generation methods are implemented into the MPI-ESM earth system model in the framework of the ongoing MiKlip project (www.fona-miklip.de). Hindcast experiments are initialised annually between 2000-2004, and from each start year 10 ensemble members are initialized for 5 years each. Four different ensemble generation methods are compared: (i) a method based on the Anomaly Transform method (Romanova and Hense, 2015) in which the initial oceanic perturbations represent orthogonal and balanced anomaly structures in space and time and between the variables taken from a control run, (ii) one-day-lagged ocean states from the MPI-ESM-LR baseline system (iii) one-day-lagged of ocean and atmospheric states with preceding full-field nudging to re-analysis in both the atmospheric and the oceanic component of the system - the baseline one MPI-ESM-LR system, (iv) an Ensemble Kalman Filter (EnKF) implemented into oceanic part of MPI-ESM (Brune et al. 2015), assimilating monthly subsurface oceanic temperature and salinity (EN3) using the Parallel Data Assimilation Framework (PDAF). The hindcasts are evaluated probabilistically using fresh water flux data sets from four different reanalysis data sets: MERRA, NCEP-R1, GFDL ocean reanalysis and GECCO$_2$. The assessments show no clear differences in the evaluations scores on regional scales. However, on the global scale the physically motivated methods (i) and (iv) provide probabilistic hindcasts with a consistently higher reliability than the lagged initialization methods (ii)/(iii) despite the large uncertainties in the verifying observations and in the simulations.