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A simple coupled assimilation approach for improved initialization of decadal climate predictions

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We introduce a simple data assimilation approach applied to the coupled global climate model *EC-Earth3.3.1*, aiming at producing initial conditions for decadal climate hindcasts and forecasts. We rely on a small selection of assimilated variables, which are available in a consistent manner for a long period, providing good spatial coverage for large parts of the globe, that is sea-surface temperatures (SST) and near-surface winds.

Given that these variables play a role directly at or very close to the ocean-atmosphere interface, we assume a comparably strong cross-component impact of the data assimilation. Starting from five different free-running *CMIP6-historical* simulations in 1900, we first apply surface restoring in the model's ocean component towards monthly means of *HadISST1*. After integrating this five-member ensemble with only assimilating SST for the period 1900-1949, we start additionally assimilating (nudging) 6-hourly near-surface winds (vorticity and divergence) taken from the ERA5 reanalysis from 1950 onwards. To mitigate the risk of model drifts after initializing the decadal predictions and to account for known instationary biases of the model, we assimilate anomalies of all variables that are calculated based on a 30-year running mean.

By assimilating near-surface data over several decades before entering the actual period targeted by the decadal hindcasts/forecasts for CMIP6-DCPP, we expect the coupled model to be able to ingest a significant share of observed climate evolution also in deeper ocean layers. This would then potentially serve as a source of predictive skill on interannual-to-decadal timescales.

We show that the presented assimilation approach is able to force the coupled model's evolution well in phase with observed climate variability, positively affecting not only near-surface levels of the atmosphere and ocean but also deeper layers of the ocean and higher levels of the atmosphere as well as Arctic sea-ice variability. However, we also present certain problematic features of our approach. Two examples are significantly strengthened low-frequency variability of the AMOC and a wind bias resulting into generally reduced evaporation over ocean areas.