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# Using HadGEM3-AO initialised case studies to assess medium-range hindcast skill and investigate modelled El Nino biases

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Currently the UK Met Office (UKMO) uses atmosphere-only models for operational short-range (1-5 day) and medium-range (1-15 day) forecasts. This study examines the extra predictability and other research benefits to be gained by coupling the latest version of the UKMO atmospheric model (HadGEM3-A) to fully interactive ocean (NEMO) and sea ice (CICE) models, initialised using archived UKMO operational atmospheric analyses along with ocean and sea ice analyses generated using the latest UKMO ocean and sea ice data assimilation system (FOAM-NEMOVAR). A set of 15-day hindcast case studies have been completed using this coupled HadGEM3-AO configuration at ∼60km horizontal resolution with 85 atmospheric levels (model top around 85km) and 75 depth levels in the ocean. Large scale dynamical fields such as geopotential height are the most improved with interactive air-sea coupling as compared to atmosphere-only control runs with persisted SST anomalies. Coupled feedback processes via SST also improve precipitation and relative humidity biases over the Maritime Continent. Comparisons with longer (10-100 year) coupled climate simulations using the same model configuration indicate that these 15 day simulations exhibit similar biases to the longer climate simulations. For example both systems exhibit a warm surface temperature bias in the central USA in northern hemisphere summer, a cold SST bias in the northern Atlantic Ocean in northern hemisphere summer and a warm SST bias in the southern ocean in southern hemisphere summer. Analysis of the growth of these errors in computationally cheap and directly verifiable 15-day hindcasts provides a potentially powerful tool to investigate and potentially fix persistent climate model biases. For example, extending the 15-day coupled hindcast to 2 months allows us to assess the ability of the model to correctly forecast El Nino events. We illustrate this approach with a case study of the 2009 El Nino. Currently HadGEM3-AO does not predict the full amplitude of the 2009 El Nino when it is initialised 2 months before the event peaked. The model fails to generate a strong enough westerly wind burst event that in reality occurred within a few days of the start date. Sensitivity tests that improve the strength of westerly wind bursts, and hence the El Nino forecast itself are discussed, which suggest the need for further improvements in the model's simulation of atmospheric convection.