Different types of drift in two seasonal forecast systems and their dependence on ENSO

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Summary

Seasonal forecasts are increasingly employed to provide regional climate predictions. For the quality of these to improve, regional biases caused by local processes must be reduced. This study uses two seasonal forecast systems to examine drifts in temperature and precipitation and compares them to the bias in the free-running version of each model. Drifts are considered from daily to multi-annual time scales. We find that initialization error and small amounts of initial precipitation mean that the bias found over the first few days can be different from that in the free-running model (not shown on this poster). Some drifts are simply too slow to have a big impact on seasonal forecasts, even though they are important for climate projections. We define three types of drift: asymptoting, overshooting and inverse drift (away from the long-term bias). Precipitation almost always has an asymptoting drift. Temperatures on the other hand, vary between the two forecasting systems, where one tends to overshoot and the other to have an inverse drift. Finally, we ask whether there are state-dependent drifts between forecasts initialized with different ENSO phases. The magnitude of equatorial sea surface temperature drifts, both in the Pacific and other ocean basins, vary depending on the initial conditions. This is also seen for precipitation, where averaging over all hindcast years when calculating biases can hide details of the response to different ENSO phases.

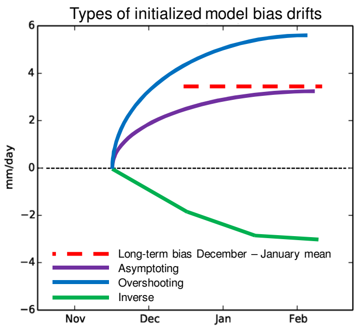

Figure 1 Schematic of the types of drifts encountered in the two seasonal forecast systems. The red dashed line represents the bias in a spun-up control integration using the same model. The hindcasts are initialized 1 November (and 1 May) for at least 15 hindcast years with at least 8 ensemble members. The drifts represent the average development of the bias over all hindcasts and ensemble members. The type of drift is diagnosed from the December – February mean bias. Asymptoting drift is of the same sign and smaller than the long-term bias. Overshooting drift is the same sign and larger than the long-term bias. Inverse drift is of the opposite sign to the long-term bias. Figure 2 shows the drifts we found.

Models and methods

This study uses the hindcasts from two operational seasonal forecast systems to study the evolution of biases as a function of forecast lead time. The Beijing Climate Center - Climate Prediction System (BCC-CPS) is the seasonal prediction system of the Beijing Climate Center (BCC) at the China Meteorological Administration (CMA). BCC-CPS is based on the BCC Climate System Model version 1.1m (BCC CSM1.1m). Its atmospheric component has a T106 horizontal resolution and the ocean horizontal resolution is 1°×1° refined to 1/3° in the tropics. The Met Office Unified Model (UM) Global Coupled configuration 2 (GC2) version of HadGEM3 is used in the Global Seasonal forecast system version 5 (GloSea5) at the Met Office. The horizontal resolution in the atmosphere is N216 and in the ocean is 1/4°. We have used spun-up, free-running model versions of the BCC and HadGEM3-GC2 models as controls to determine the long-term biases. To assess model biases and drifts we use 30 years (1981-2010) of Reynolds NOAA OI V2 high resolution SST. We used this product as it is on a 1/4° grid that can resolve sharp SST gradients. We also did not want to favour any forecast system by using the SST data set it is initialized with. To evaluate precipitation we use the same 30 years of GPCP V2.2 Combined Precipitation data set. Further details on the method can be found in the caption for Figure 1.

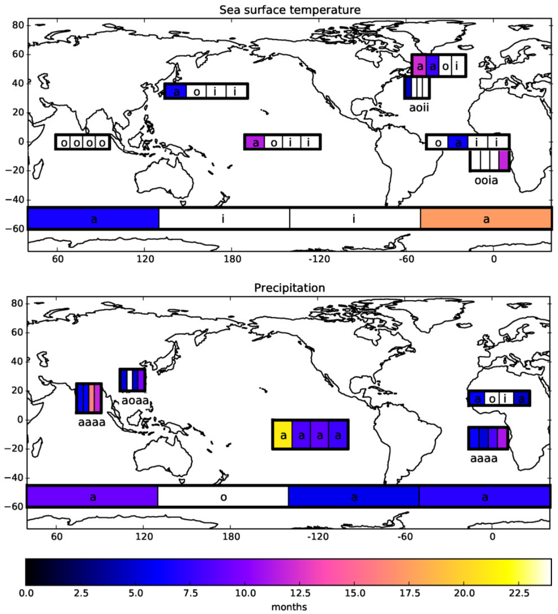

Figure 2 Types of drift encountered in the two forecast systems (letters) and the time scale of the asymptoting drifts in months (colours) for SST (top) and precipitation (bottom). From the left, the first two boxes within each region refer to BCC-CPS for May and November start dates, respectively. The last two boxes are for GloSea5 for the same months. The types of drift (Figure 1) are (a)symptoting, (o)vershooting and (i)nverse drift.

Drifts in SST and precipitation

Overall the long-term biases are similar between the models, but how those biases are reached is different. Figure 2 shows that asymptoting drift is most common for precipitation, but not for SST, where BCC-CPS tends to overshoot and GloSea5 tends to inverse drift. This is true for both the tropics and the extra-tropics. We have not been able to determine why precipitation and SST tend to have different drifts. It is especially strange in the tropics where these two variables are often coupled. The difference between models in the SST drift can probably be explained by how they most efficiently gain/loose heat to reach their long-term bias. However, GloSea5 warms in the northern hemisphere and cools in the tropics even though the long-term biases are the opposite. There is only one region where both initial months and both forecast systems have the same drift, that is an overshoot in the Indian Ocean SST. Most asymptotic drifts reach the long-term mean in 8 months or less (especially precipitation), but there are exceptions such as the Southern Ocean SST in November for GloSea5 and precipitation in the Pacific ITCZ in May for BCC-CMS, which take much longer. In addition, the other drift types obviously take longer than the length of a seasonal forecast to reach the long-term bias. This implies that some of the climate model biases are less important for the seasonal forecasts.

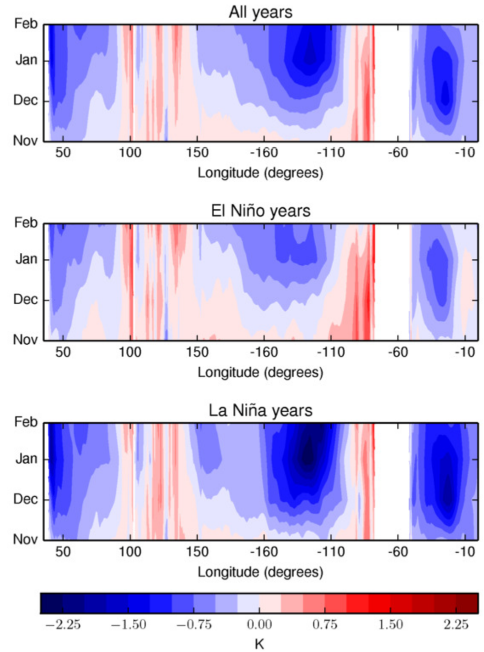

Figure 3 Hovmuller plot of GloSea5 SST bias drift averaged over 5°S – 5°N for the Indo-Pacific and Atlantic Oceans. This is the average drift over all hindcasts and ensemble members (see the caption of Figure 1). The top panel shows the average drift for all hindcast years (1996 – 2010). The middle panel shows the drifts for only the years with an El Niño in the initial conditions and the bottom panel is for only La Niña years. There are five El Niño years and six La Niña years in the hindcast set and the difference between the two ENSO states is significant for the NINO3.4 region (not checked elsewhere).

ENSO dependence

Both forecast systems have a different bias evolution, in terms of the magnitude of the drift, for NINO3.4 SST for different ENSO initial conditions. The BCC model has a mean state that is biased cold and BCC-CMS drifts the most when initialized with an El Niño state. In contrast, HadGEM3-GC2 has a mean state that is biased warm and drifts the most when initialized with a La Niña state. Figure 3 shows the average drift in Gloseа5 for each ENSO state. The drift is strongest in the western Indian Ocean, East Pacific and the central Atlantic for La Niña years. There also appears to be some propagation towards the maritime continent. The eastward propagation that starts from about 50°E in November has a speed of roughly 1 m/s, consistent with an equatorial Kelvin wave, which could have been caused by a change in the wind forcing from initialization to the free-running forecast. The westward propagation starting at about 160°W is faster, so is not a Rossby wave and could be mediated by the atmosphere. Another explanation for these drifts is a re-adjustment of the thermocline in the ocean.

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