Toward Seamless Prediction: Calibration of Climate Change Projections Using Seasonal Forecasts

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In their recent article on seamless prediction, Palmer et al. (2008, hereafter P08) suggested that the same chain of physical processes is responsible for both seasonal variations and long-term climate change. This led them to recalibrate climate change projections for the end of the century using seasonal hindcast scores. They concluded that "the analysis of multimodel seasonal forecast reliability diagrams provides a means to quantitatively discount the climate change probabilities in the light of diagnosed model unreliability."

Where reliability of seasonal predictions is low, this process inevitably results in a strong discounting of climate change signals back toward current climatological conditions. However, what if processes are at work in future climate projections that did not strongly influence past seasonal variability? If these processes are reliably modelled, recalibrating climate projections using seasonal hindcast reliability may then discount useful climate projections. While seasonal time-scale processes are no doubt important, we suggest that this gives good reason to question the hypothesis set out in P08.

There is growing evidence that seasonal and centennial climate changes can indeed operate by different mechanisms. This is perhaps not surprising, given that unprecedented changes in the Earth's climate are expected in the twenty-first century compared to the past period for which we have seasonal hindcasts. One marked example is climate change in circulation over the extratropical Northern Hemisphere. Most climate change projections show a reduction in sea level pressure over the Arctic and a corresponding increase in sea level pressure at midlatitudes. These pressure changes correspond to more westerly conditions across northern Europe and associated changes in the Atlantic–European storm track and rainfall (Solomon et al. 2007). However, it is important to note that this climate change signal has a very different structure to the natural year-to-year variability and does not project onto seasonal modes of variability (Keeley et al. 2008). In the case of natural year-to-year variability, low Arctic pressure is associated with cooling of the overlying troposphere. In contrast, the climate change signal shows a warming of the overlying troposphere. This suggests that the surface signal of climate change has a very different structure and a very different forcing mechanism to past seasonal variability (Woollings 2008). A likely candidate for this anomalous behaviour in climate change projections relative to past variations is the extensive melting of sea ice in the future climate. This melting is of course not represented in sets of past seasonal hindcasts. Indeed, many seasonal hindcasts used in P08 do not even initialize year-to-year sea ice changes at all in their forecasts.

P08 argued that climate projections of atmospheric circulation and rainfall for northern Europe could be discounted based on poor seasonal reliability. However, in our example above, where the projected climate signal does not operate through the same modes of variability, P08's assumption of the same chain of physical processes operating across seasonal to climate time scales is clearly broken, and the P08 method likely discounts useful climate projection information.

We also note other fundamental reasons why seasonal forecast reliability may not be a good guide to the reliability of climate projections. Both initial condition errors and omission of greenhouse gas increases lead to errors in the seasonal hindcasts

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used by P08 (e.g., Liniger et al. 2007). These errors inevitably reduce the reliability of seasonal hindcasts, but they do not affect centennial climate projections where greenhouse gases are specified to increase and initial condition information is long forgotten. Again, this suggests that seasonal forecast estimates of reliability do not apply to climate projections, and the P08 method likely discounts useful climate projection information.

Given that we have illustrated clear counterexamples where the processes controlling seasonal forecasts are independent of those controlling centennial predictions, then to argue that a single chain of processes is responsible for seasonal and centennial variability is no longer valid. However, even in the extreme hypothetical case where seasonal and centennial variability are decoupled, it is not immediately obvious that twenty-first-century climate projections will turn out to be reliable. If seasonal variability is large enough and seasonal processes are unreliable in models, then they could still swamp any climate change signals and lead to poor reliability of climate projections. It is therefore important to check whether seasonal variability is large enough to invalidate climate projections in this case. We do this using the third climate configuration of the Met Office Unified Model (HadCM3; Gordon et al. 2000) and a moderate (A1B) emissions scenario. This model projects a trend of 5.6 K century^{-1} for northern European winter surface temperature, and 43 mm century^{-1} for northern European winter mean rainfall results over the coming century. By comparing this with observed standard deviations from Hadley Centre and Climatic Research Unit (CRU) observational data (Brohan et al. 2006; Hulme et al. 1998) for temperature and rainfall of 2.2 K and 23 mm, respectively, it is easily verified that climate change in the frequency of upper tercile rainfall or temperature events are highly reliable over a century-long hindcast set.[1]

Similar arguments can be made for the example in P08 in which poor predictability of teleconnections and atmospheric blocking could be enough to render the regional signal resulting from climate change unreliable. We identified extremely blocked seasons in observational data (Brohan et al. 2006; Hulme et al. 1998) from anomalies relative to a 20-yr running mean to allow for climate change and low-frequency variability. The winter of 1962/63 is one of the coldest on record and the winter 1963/64 is the driest. Again, assuming the alternative extreme hypothesis to that in P08—that seasonal and centennial changes are decoupled for northern Europe—we compared these coldest and driest winters with HadCM3 winter climate projections for northern Europe. Under these conditions the projected climate change signal for the end of the twenty-first century is still too large to be discounted by any moderate increase in blocking. In addition, we are not aware of any observed trend toward increased winter blocking in the coming century. We also enhanced our simple linear comparison by including nonlinearity to allow the climate change signal itself to be proportional to the fraction of time that is unblocked. Even in this case, an increase in blocking that is equivalent to the driest winter in the twentieth century occurring every 5 yr would be needed by 2100 to counter the projected climate change in northern European winter rainfall.

CONCLUDING REMARKS. There are potentially many mechanistic chains that connect climate forcings to regional climate impacts in addition to the single chain of processes presented by P08. We have given examples of processes that affect climate projections but are not well represented in seasonal forecasts, and, similarly, errors in seasonal forecasts that do not affect climate projections. The strength of the relationship between climate forcing and climate impacts is therefore not equal in strength to the weakest link in the chain of processes suggested in P08.

We agree with P08 that some processes on seasonal time scales are poorly represented in climate models, and that these processes influence near-term climate. However, to assume that seasonal reliability applies on centennial time scales is not always valid, as illustrated by our examples. Once this assumption is relaxed, poor reliability of seasonal forecasts is not sufficient to make end-of-century climate change signals unreliable, and very large systematic changes in processes highlighted by P08, such as blocking, would be needed to discount end-of-century climate change signals for the highly variable northern European region.

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[1] Data are area means for the northern European region defined in P08 as 40°–70°N, 20°W–40°E, and we repeated the calculation for a grid point over the United Kingdom, with the same conclusion.

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