CORRESPONDENCE

Comments on "Multiyear Predictions of North Atlantic Hurricane Frequency: Promise and Limitations"

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Vecchi et al. (2013, hereafter V13) show that retrospective decadal predictions (reforecasts) of multiyear North Atlantic hurricane frequency have high correlations with observations, in agreement with an earlier study (Smith et al. 2010, hereafter S10). However, V13 state that "the skill in the initialized forecasts comes in large part from the persistence of a mid-1990s shift by the initialized forecasts, rather than from predicting its evolution." Here, we provide a different interpretation of the Met Office Decadal Prediction System (DePreSys) reforecasts, showing that these would have provided clear evidence for an impending reversal to a period of above average hurricane frequency had they been available in 1994, before the observed increase occurred. This is illustrated in Fig. 1a, which shows the information that would have been available in 1994. DePreSys reforecasts starting from 1991 onward clearly predict an increase in hurricane numbers, in fact to levels higher than ever simulated before by this modeling system, while observed counts remained low (including each individual year from 1991 to 1994; not shown).

The conclusion in V13 that DePreSys did not predict the 1995 shift is partly based on their analysis of the difference in storm counts averaged over years 2–6 minus the first year of each forecast (Fig. 7 in V13; cf. Fig. 1c). V13 argue that observations straddling the 1995 shift (green triangles in Fig. 1c) are unusually large in this statistic, whereas the DePreSys forecasts are not (blue histogram in Fig. 1c). However, in DePreSys, this statistic is particularly sensitive to the forecast initialized in 1990, which erroneously predicted a very active hurricane season for 1991. Furthermore, this forecast was unaware of the eruption of Mount Pinatubo in June 1991, which likely suppressed hurricane numbers in that year (Evan 2012) and of course was unpredictable. If we exclude 1990 and consider the forecasts starting after Pinatubo, between 1991 and 1993, then DePreSys (red histogram in Fig. 1c) hindcasts predicted an increase similar to that observed.

How much confidence could we have had in the DePreSys forecasts of a shift in hurricane frequency? Assessment of previous reforecasts is inconclusive: the decline from the mid-1960s was successfully captured, but the maximum in the late 1970s was not predicted (Fig. 1a) and forecasts beginning in the late 1970s incorrectly predicted an increase (although these were unaware of the impending eruption of El Chichón, which likely decreased hurricane numbers; Evan 2012). We therefore examine the physical mechanisms driving the increased hurricane numbers predicted during

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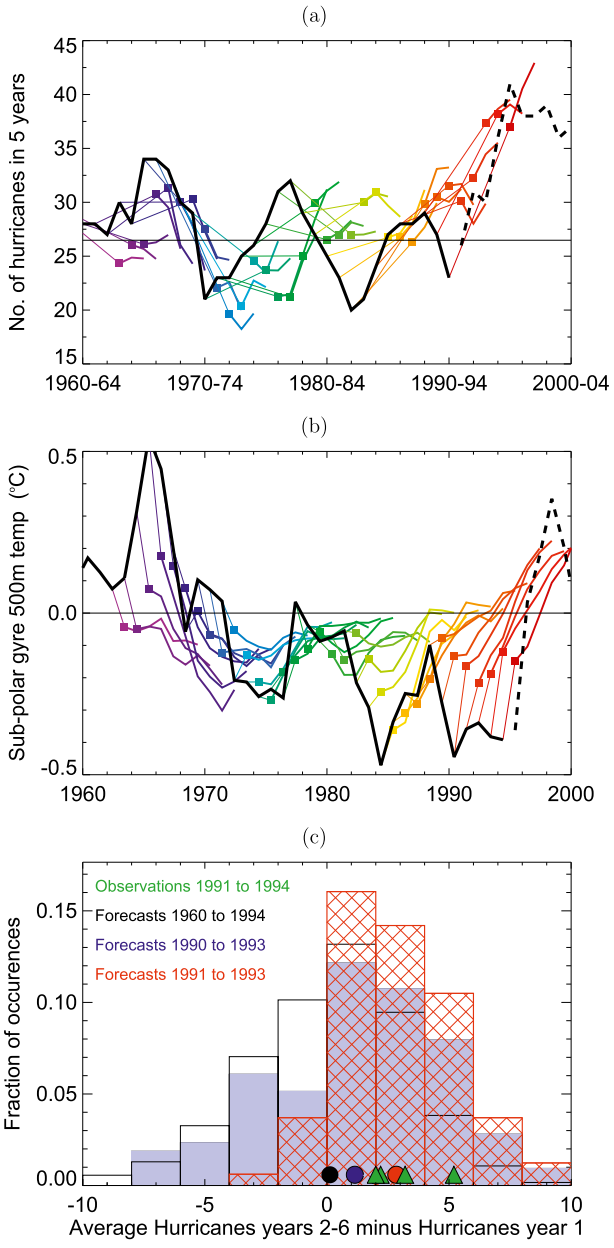

FIG. 1. Retrospective predictions of a shift in hurricane numbers, information that would have been available in 1994, showing observations (solid black) and DePreSys reforecasts (colored) of (a) the number of Atlantic hurricanes in rolling 5-yr periods and (b) annual temperatures averaged over the upper 500 m of the North Atlantic subpolar gyre (relative to the mean over 1951–2006). Dashed black curves show the observations after 1994 that would not have been available at the start of the forecast. Reforecasts (thick colored lines with squares showing the first forecast period) are connected with thin lines to the latest observations that would have been available at the start of the forecast. Observed hurricane counts are taken from the Atlantic basin hurricane database (HURDAT; Landsea 2007), with the long-term average of 26.5 $(5\,\mathrm{yr})^{-1}$ hurricanes shown by the horizontal line in (a). Observations of the subpolar gyre are taken from the Met Office ocean analysis (Smith and Murphy 2007). Reforecasts start on 1 Nov in each year, up to 1994, and were initialized before the observed transition to increased hurricane activity. (c) Histograms showing forecast differences in storm counts averaged over years 2–6 minus year 1 (as in V13, Fig. 7), for all reforecasts starting between 1960 and 1994 (black), between 1990 and 1993 (blue), and between 1991 and 1993 (red). Solid circles show the means of the respective histograms, and the green triangles show the observed values. As in S10, noise is reduced by combining three consecutive start dates to provide 27 ensemble members. DePreSys storms in (a),(c) are tracked from daily sea level pressure data (as in S10), although an index based on hurricane main development region minus tropical sea surface temperature shows similar results.

the early 1990s. Atlantic tropical storm numbers in DePreSys are strongly influenced by ocean temperatures in the North Atlantic subpolar gyre (SPG; S10; Dunstone et al. 2011), which control the latitude of the Atlantic intertropical convergence zone (Kang et al. 2008). DePreSys forecasts of the SPG temperature also predicted a clear increase during the 1990s (Fig. 1b), consistent with the predictions of increased hurricane numbers. The reasons for the predicted warming of the SPG, which eventually occurred very rapidly in 1995, are well understood (Robson et al. 2012a,b; Yeager et al. 2012): the ocean was preconditioned by the prolonged positive North Atlantic Oscillation (NAO) in the late 1980s and early 1990s, which increased the strength of the Atlantic meridional overturning circulation (AMOC) and associated northward transport of heat by the ocean, thereby warming the North Atlantic. The precise timing and rapidity of the SPG warming depended on the precise timing of a shift in the NAO that could not be predicted far in advance (Robson et al. 2012a), so that DePreSys reforecasts warm too early. Nevertheless, initialized predictions with DePreSys (Robson et al. 2012b) and an independent modeling system (Yeager et al. 2012) clearly captured the increased AMOC and northward heat transport, providing clear evidence of an impending shift in SPG temperatures, and hence hurricane frequency in DePreSys.

Decadal predictions that merely persist a shift in climate after it has happened, as suggested by V13, would be of limited utility. It is therefore encouraging that DePreSys could have provided guidance on the evolution of hurricane numbers before the 1995 shift and predicted not just a relaxation back to neutral levels but a clear shift to elevated activity before this began (Fig. 1a).

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