Initial shock, drift and trends in decadal climate predictions in the South Pacific region upon different phases of ENSO

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The South Pacific Ocean (SP) plays a key role on the climate of the Southern Hemisphere. Previous works have shown that sea surface temperature (SST) variability within the basin is highly correlated to temperature and rainfall anomalies over vast regions of Australia, Africa and South America. Furthermore, SST variability exhibits pronounced spectral peaks at around 3 and 11 years, which could be the source of some skill in decadal prediction studies.

In this study we use a set of 5 Global Climate Models (GCMs) and study their skill to predict interannual to decadal SST variability in the SP region: DePreSys, EC-Earth v2, HadCM3, GFDL-CM2.1 and MIROC5. We use both annual values and 4-yr averages, and compute trends, AC and RMSE against observed (ERSSTv3b) SST data.

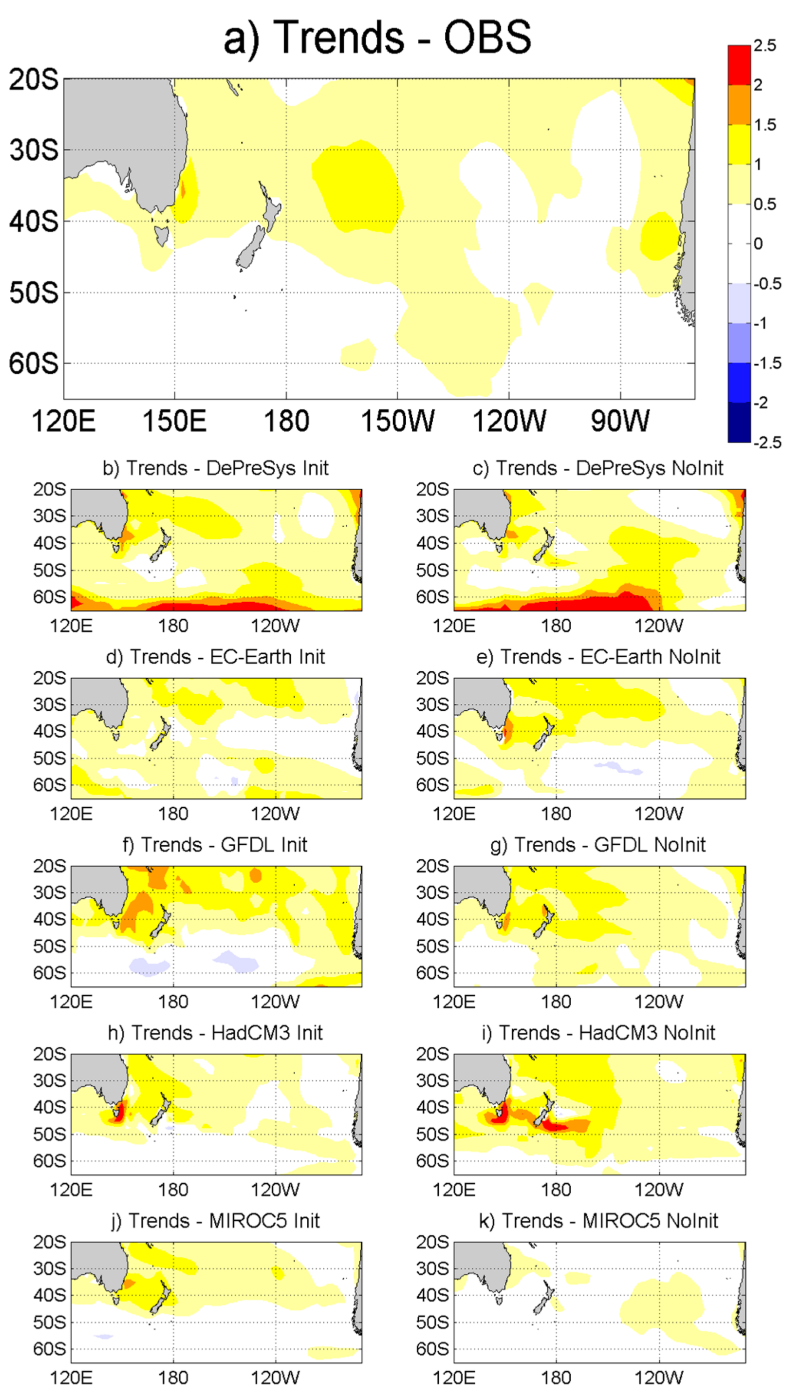

Fig. 1 Trends in SST computed as the slope of the linear regression of SST anomalies onto the global mean temperature in (*a*) the observations-based ERSST dataset and in (*b-k*) the first forecast year of the hindcasts, for Init (left) and NoInit (right) simulations. Units are K K^{-1}.

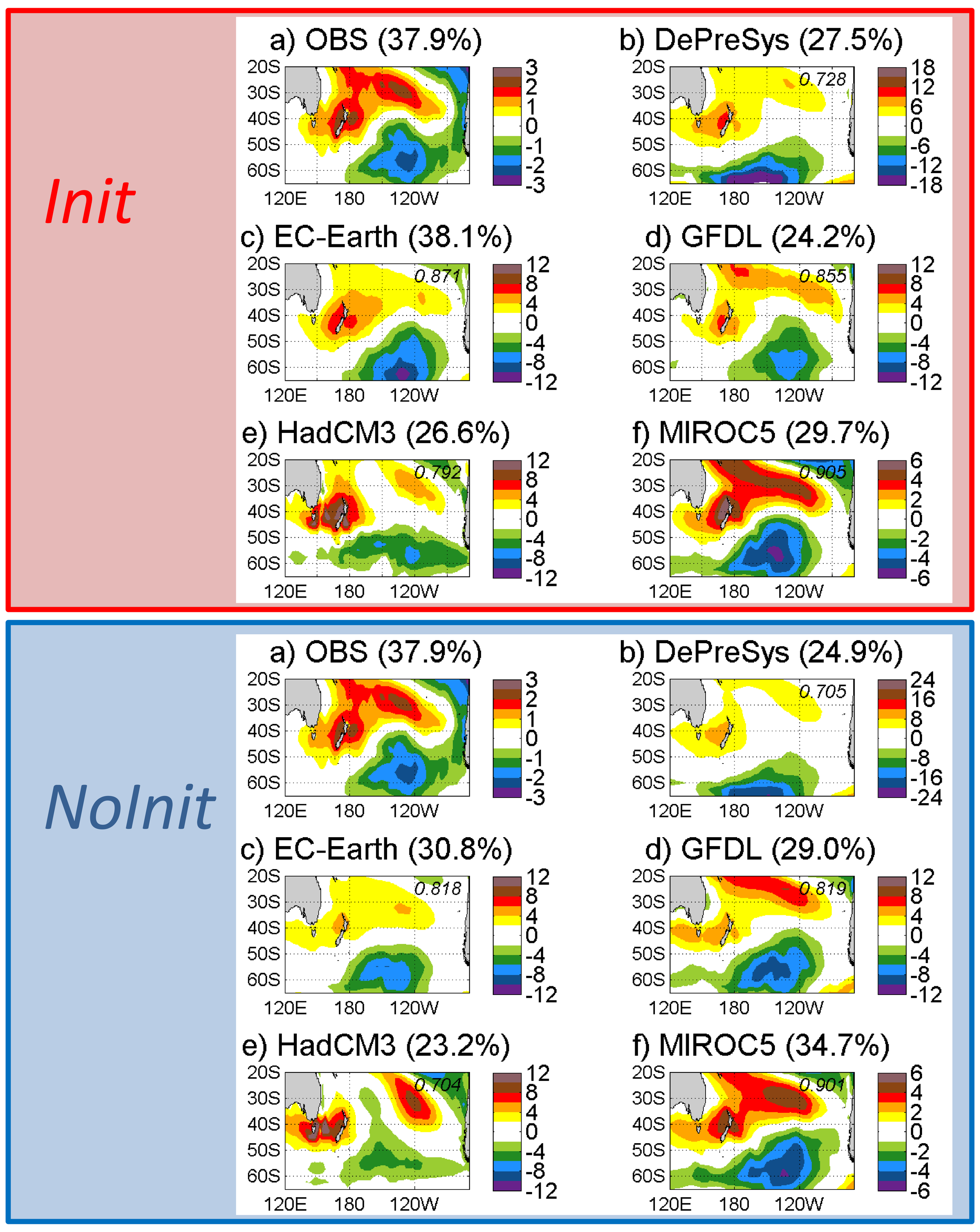

Fig. 2 Spatial patterns of the leading mode of interannual SST variability considering the observations and the first forecast year in the GCMs, for **Init** and **NoInit** experiments. Numbers in the titles indicate the fraction of variance explained by the corresponding field. Numbers within each figure are the spatial correlation coefficients against the observed field.

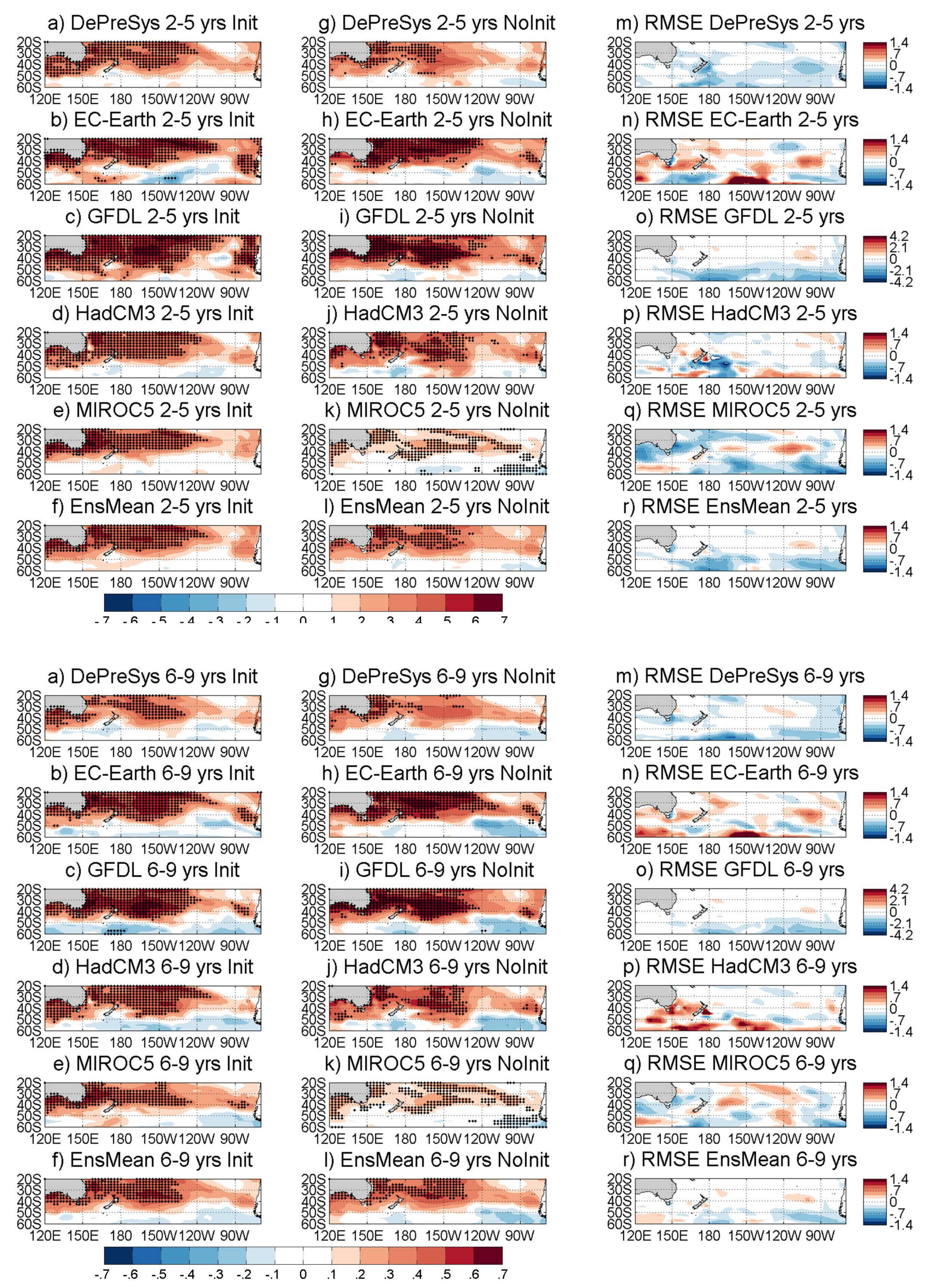

Fig. 3 Skill scores for predictions averaged across forecast times from years 2 to 5 (*top*) and 6 to 9 (*bottom*): (*left and middle columns*) correlation coefficients between the ensemble-mean predicted and observed SST anomalies over the SP region in Init (*left column*) and NoInit (*middle column*) simulations. Black dot stippling denotes significance at the 5% level. (*right column*) RMSE difference of predictions against observed SST anomalies in Init minus NoInit experiments. Note that shading intervals differ between figures. Areas shaded in blue (red) indicate that initialization leads to more (less) accurate predictions. The bottom row shows results for the multi-model ensemble. Units are °C.

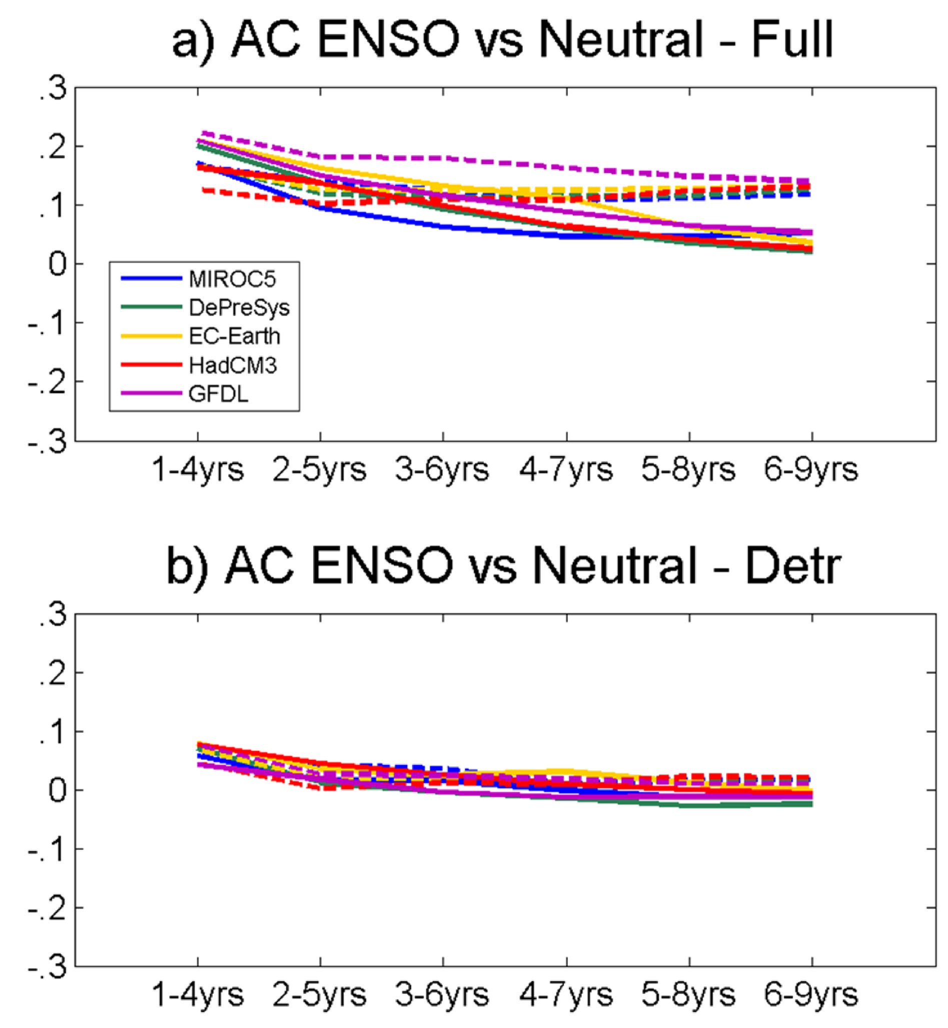

Fig. 4 AC between GCM and observed SST anomalies considering hindcasts initialized in extreme ENSO years (full lines; see text for details) and in neutral ENSO years (dashed lines) for (*a*) full SST values; and (*b*) detrended SST values. The x-axis varies along forecast time averages, from 1-4 yrs to 6-9 yrs.

Most of the GCMs can properly handle the trends in SST (Fig. 1) over subtropical latitudes. With varying skill, they also have the dipolar pattern as their leading mode of variability (Fig. 2), and slightly larger correlation coefficients are attained with the Init runs. AC and RMSE fields (Fig. 3) show a good performance over lower latitudes (large and significant AC values), and initialization appears in most of the cases as a contributor to a better skill, particularly in forecast years 2 to 5 (i.e., closer to the moment of initialization).

When we consider hindcasts initialized under extreme ENSO conditions (i.e, when the Oceanic Niño Index was above +1.5 for El Niño and below -1.5 for La Niña, or between -0.5 and +0.5 for neutral cases), we find a persistent drop in skill throughout the forecast length, and AC becoming lower than those of NoInit runs after forecast year3-4 (Fig. 4a). Interestingly, when SSTs are detrended beforehand, then AC values are mostly identical and non-distinguishable one another (statistically speaking) throughout the forecast period. Here the trend plays thus a major role in shaping the skill of the simulations.

In Fig. 5 we show the evolution of basin-mean SST anomalies under neutral, El Niño or La Niña conditions at initialization. It is interesting to note how initial shock appear clearly when monthly values are taken (right figure) at those GCMs that use full-field initialization (EC-Earth and GFDL). At the annual scale (left and middle figures), the trend in mostly responsible for the observed evolution of the AC values.

Acknowledgments:

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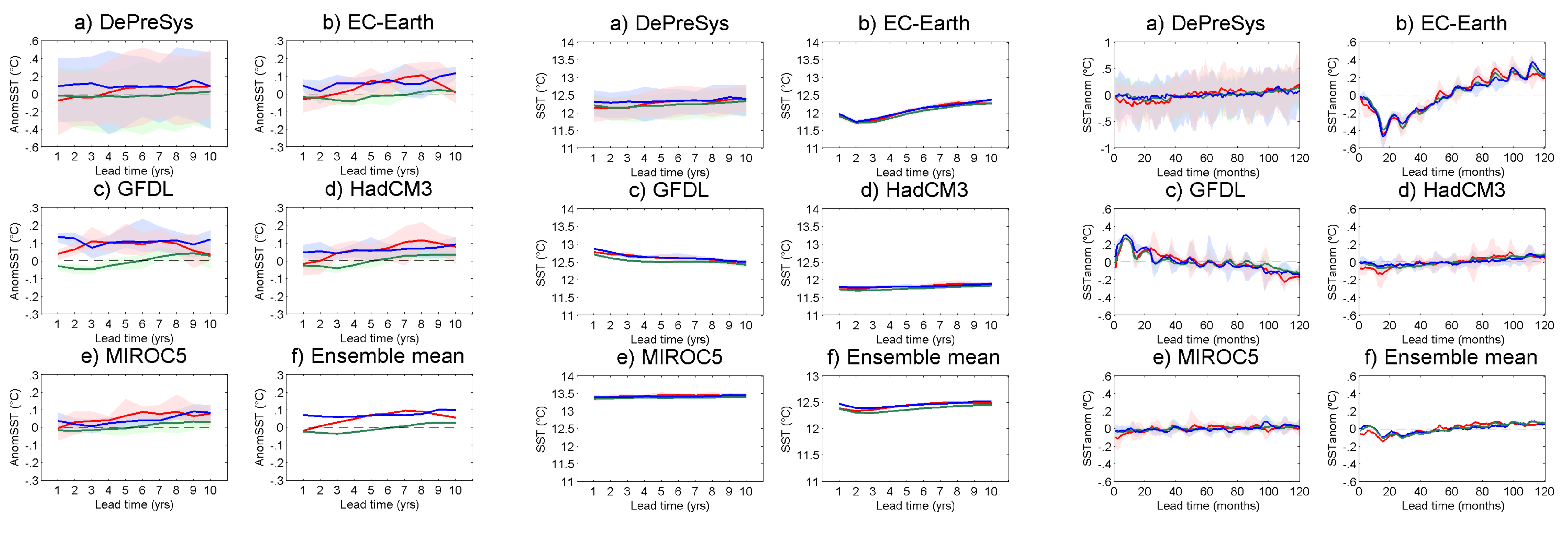

Fig. 5 Mean evolution of basin-mean SST anomalies as a function of lead time in each forecast system, for hindcasts initialized in neutral (green), extreme El Niño (red) and extreme La Niña (blue) years, respectively: annual-mean drift-corrected simulations (*left*), annual-mean raw simulations (*middle*) and monthly-mean raw simulations (*right*). The range between ensemble members in each forecast system is shown in shadings in (*a*)-(*e*). The zero-line is also added for clarity. Note the effect of the initial shock in EC-Earth and GFDL (full field initialization).