Supplemental Material

Supplemental Material for "Skillful climate forecasts of the tropical Indo-Pacific Ocean using model-analogs"

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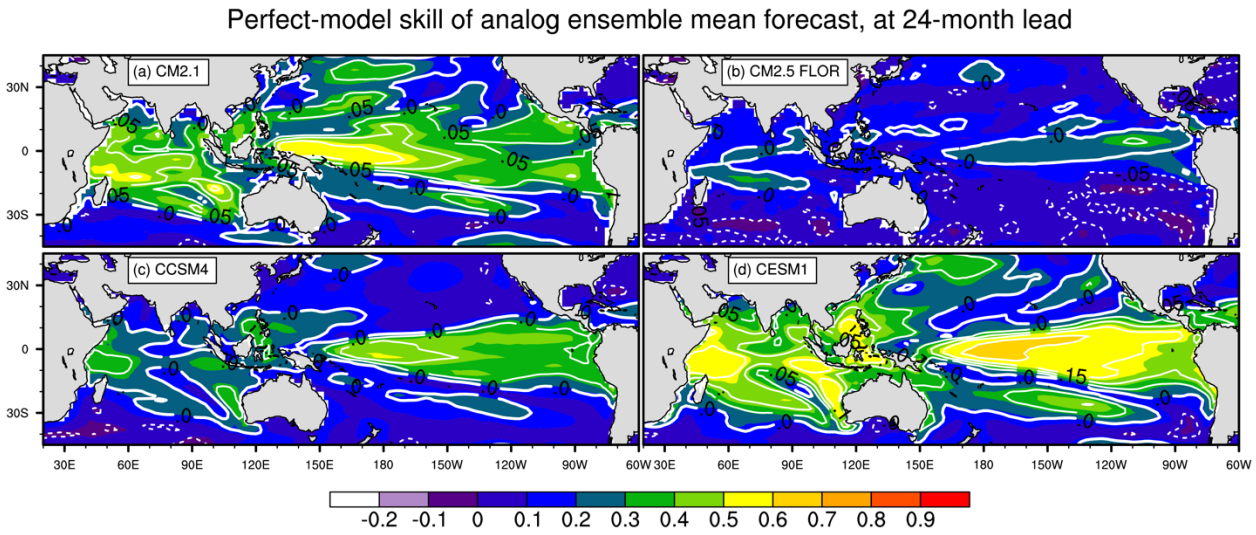

Figure S1 Perfect-model skill of ensemble-mean model-analog forecast of SSTA at 24-month lead for the verification period in (a) CM2.1 (b) CM2.5 FLOR (c) CCSM4 and (d) CESM1. Shading denotes local anomaly correlation and contours RMS skill score. For each model, the first two hundred years of its control run was used as the verification period, with the remaining data used for the data library. Contour/shading interval is 0.05/0.1.

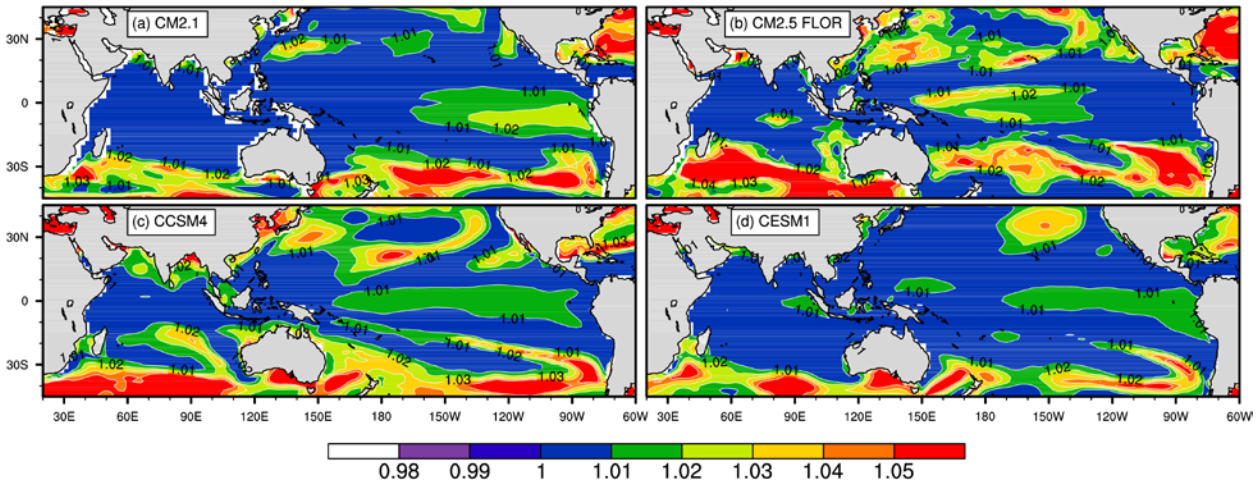

Figure S2 Perfect-model skill of ensemble-mean model-analog forecast of SSTA at 6-month lead for the verification period in (a) CM2.1 (b) CM2.5 FLOR (c) CCSM4 and (d) CESM1. Shown is $\rho^2 + \epsilon^2$, where ρ and ϵ denote local correlation and standardized RMS error. For each model, the first two hundred years of its control run was used as the verification period, with the remaining data used for the data library.

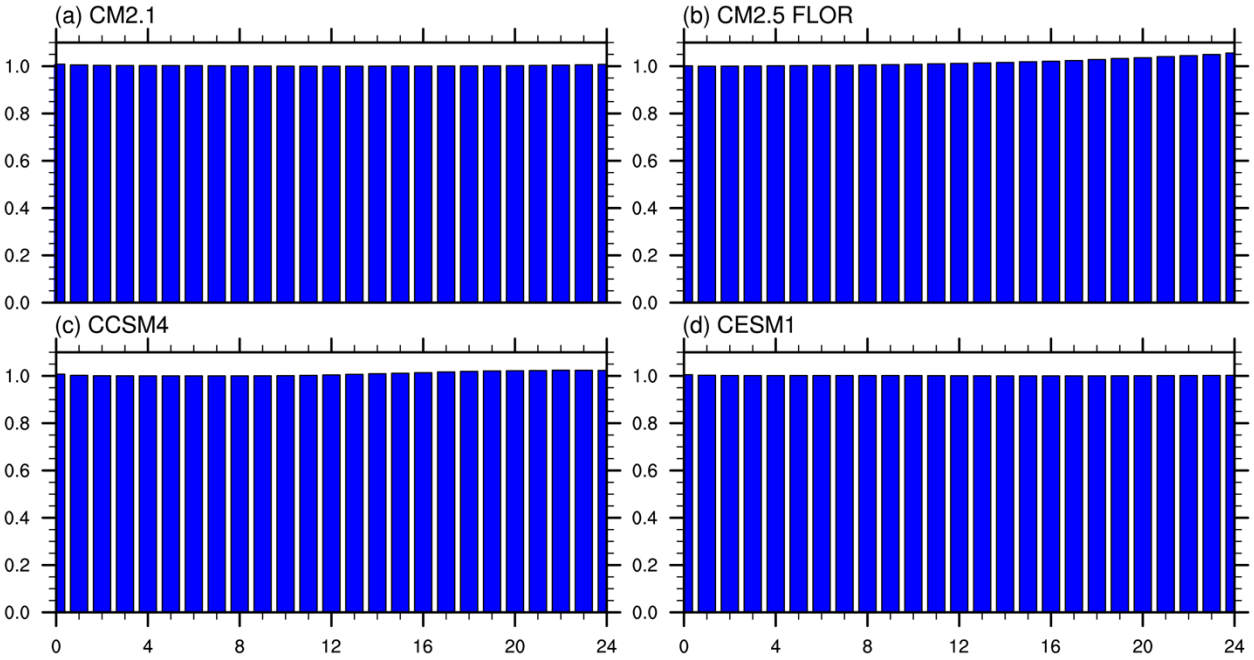

Figure S3. Measure of Evolution of SST forecast skill in the training region from initial condition to 24-month lead. Shown is $\rho^2 + \epsilon^2$, where ρ and ϵ denote correlation and standardized RMS error, taking into account all grid points in the training region and all forecasts with identical lead time.

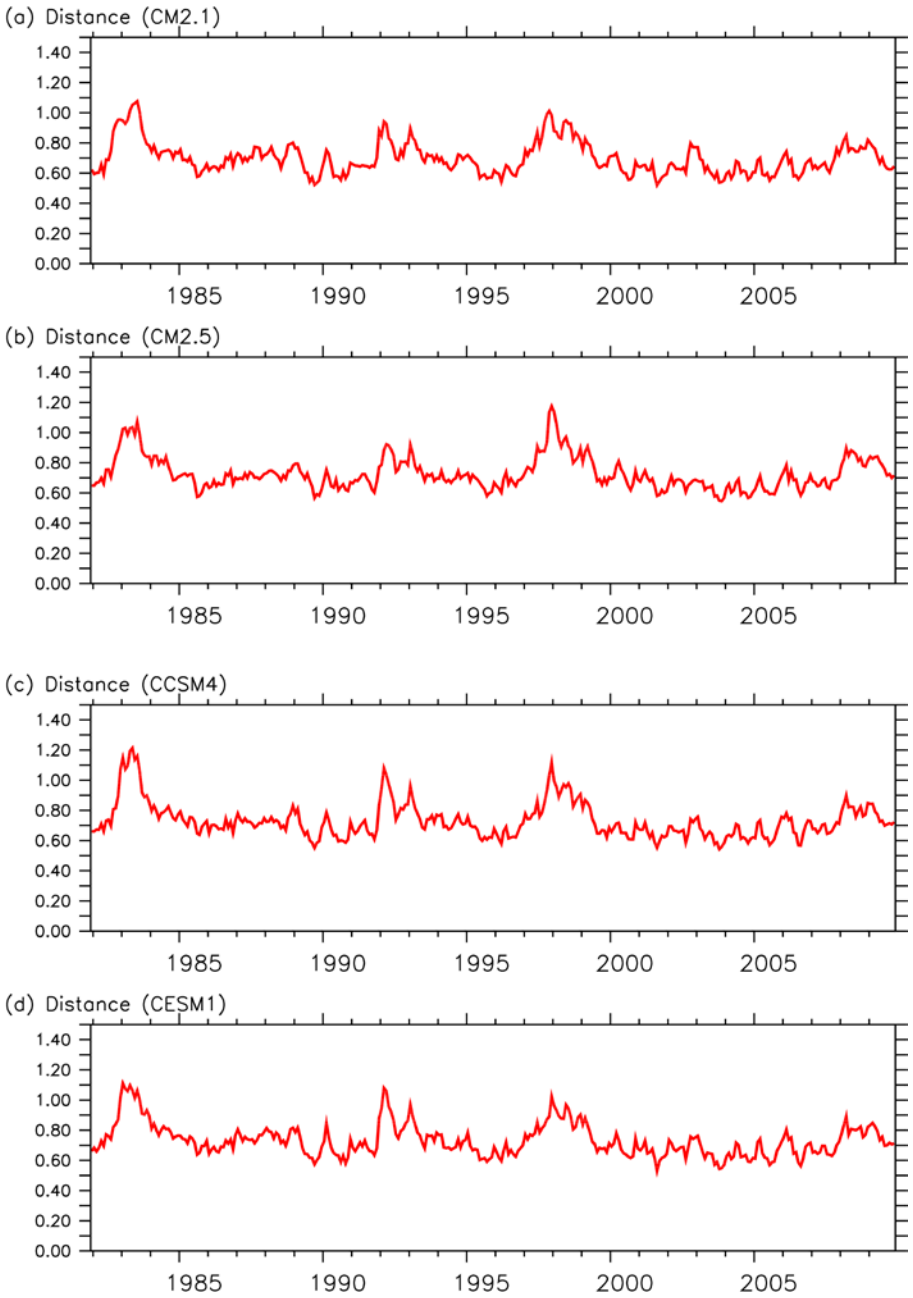

Figure S4 Distance (d_K) calculated using the ensemble mean of fifteen analogs calculated from (a) CM2.1 (b) CM2.5 FLOR (c) CCSM4 and (d) CESM1. Analogs are searched for observed states from December 1981 to November 2009 based on each model.

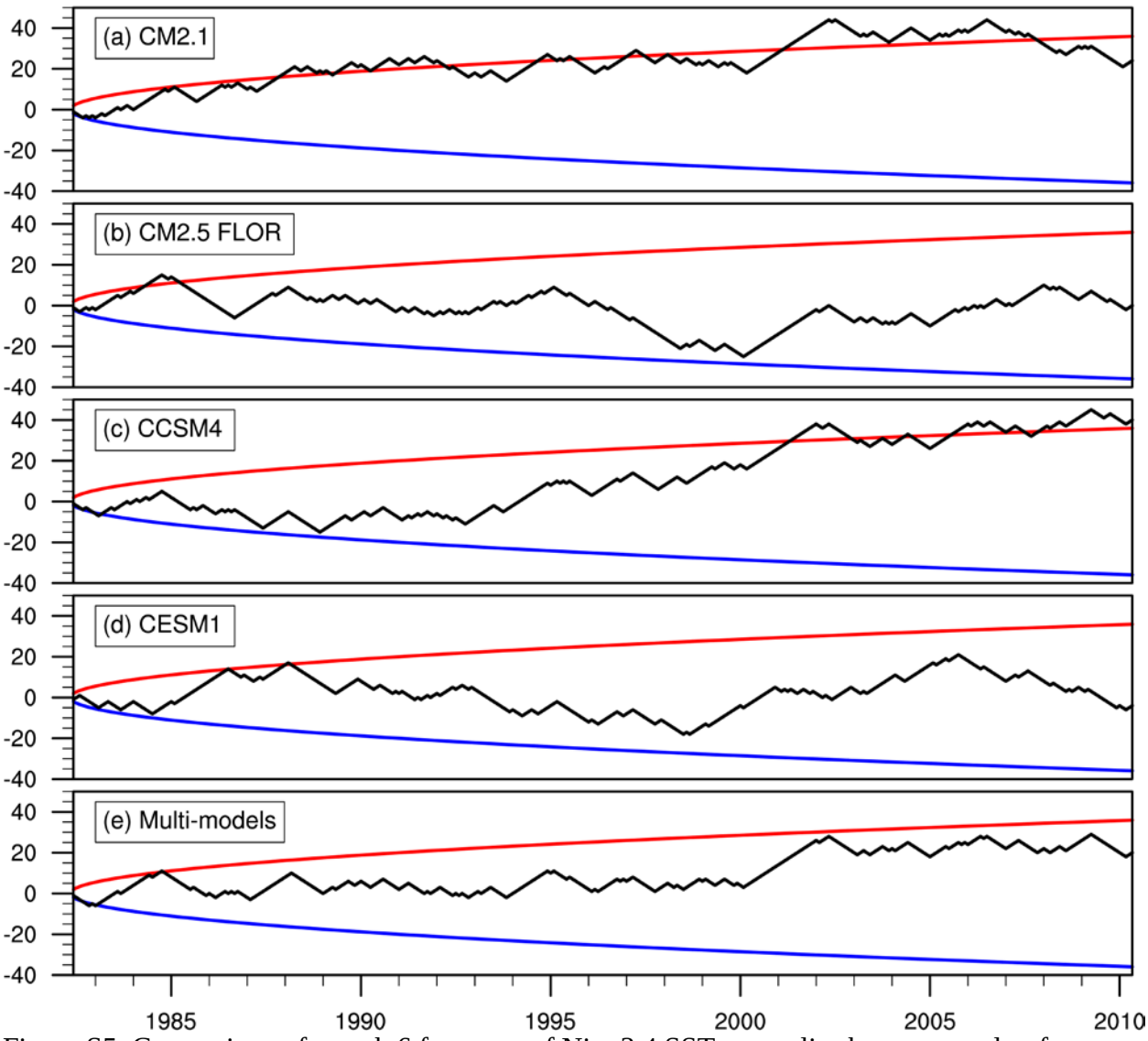

Figure S5. Comparison of month 6 forecasts of Nino3.4 SST anomalies between analog forecasts and corresponding NMME forecasts in (a) CM2.1 (b) CM2.5 FLOR (c) CCSM4 (d) CESM1 and (e) four-model grand mean. In the comparison, only ensemble means are employed. The count increases by 1 when RMS skill score of analog forecasts is more than that of corresponding NMME forecasts, and decreases by 1 otherwise. The count is accumulated forward in time for each model separately, over all initial months and years, thereby tracing out a random walk. The red and blue lines indicate the range of counts that would be obtained 95% of the time under independent Bernoulli trials for $p = 1/2$. A random walk extending above the red lines indicates that analog forecasts display higher RMS skill score significantly more often than expected for independent Bernoulli trials (i.e., analog forecasts are more skillful than the corresponding NMME forecasts). On the other hand, a random walk extending below the blue line indicates that analog forecasts display higher skills significantly less often than expected for independent Bernoulli trials (i.e., analog forecasts are less skillful than the corresponding NMME forecasts). Readers are referred to Delsole and Tippett (2016) for more details on comparing forecast skills based on random walks.

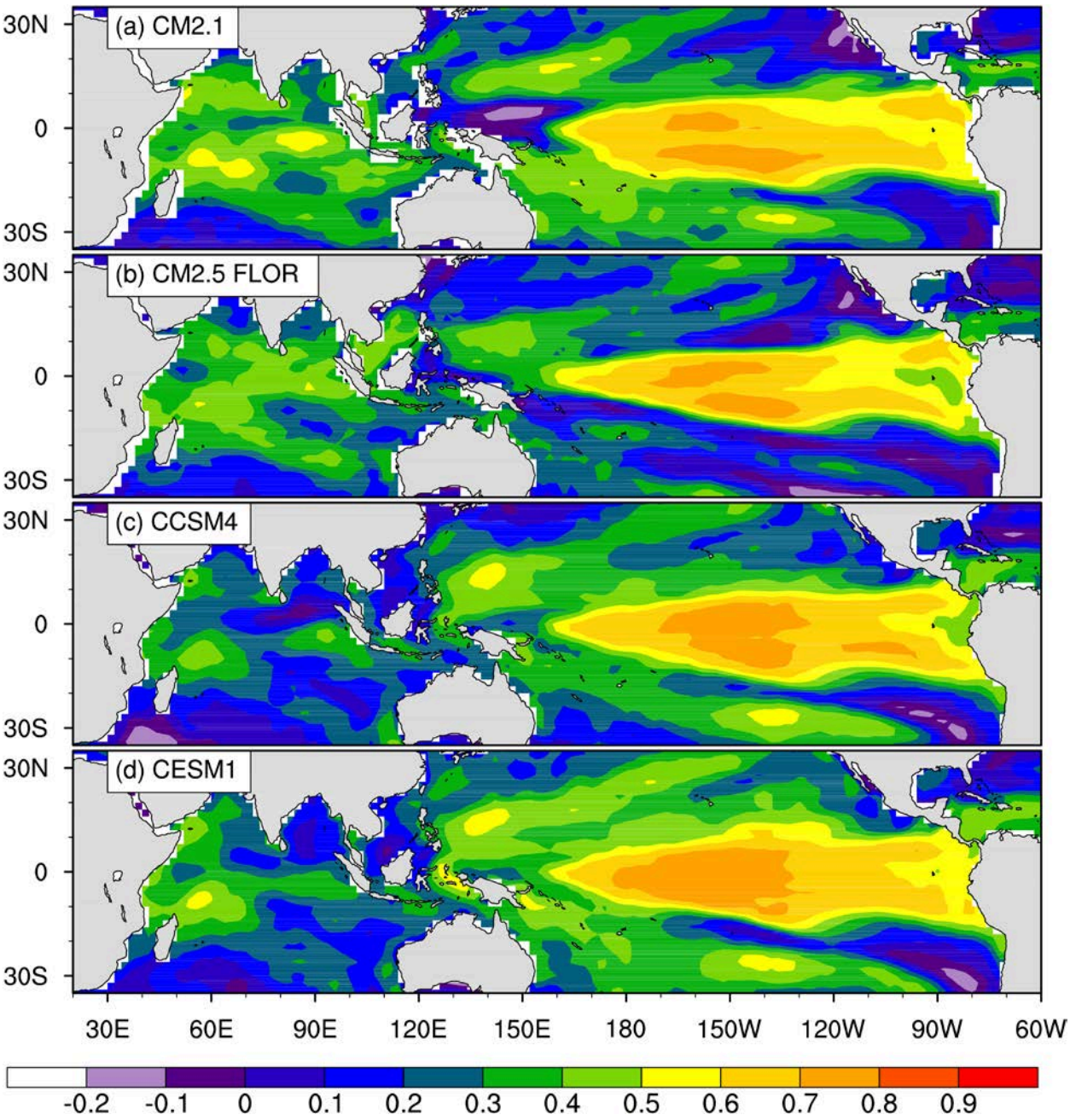

Figure S6. Analog hindcast skill of observed SST variations at six-month lead based on (a) CM2.1 (b) CM2.5 FLOR (c) CCSM4 and (d) CESM1. Shadings denote correlation. Here, analogs are based on a distance taking into account velocity in trajectory: $d^2(t,t') = \sum_{i=1}^{2}\sum_{j=1}^{J}\left(\left(\frac{x_j^i(t)}{\sigma_X^i} - \frac{y_j^i(t')}{\sigma_Y^i}\right)^2 + \left(\frac{dx_j^i(t)}{\sigma_X^i} - \frac{dy_j^i(t')}{\sigma_Y^i}\right)^2\right)$, where $dx_j^i(t) = x_j^i(t) - x_j^i(t-1)$ and $dy_j^i(t') = y_j^i(t') - y_j^i(t'-1)$. Compare with the upper four panels of the left hand side of Fig. 10.