Supplementary information to Identifying global patterns of stochasticity and nonlinearity in the Earth System

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We present a detailed analysis of the measure proposed in the main text to assess atmospheric response to solar forcing: we analyse the role of the interval in which we search for the minimum distance between time series, and we compare with an alternative measure. We also present a comparison of the results obtained from the two databases (NCEP CDAS1 and ERA Interim).

In the main text we search for the minimum of the difference between two time-series, $x_i(t)$ and $y_i(t)$, Eq. (1) (reproduced here for convenience),

$$d_i = \sum_{t=1}^{L} |y_i(t) - x_i(t+\tau_i)|, \tag{1}$$

with τ_i in the interval $[0,4]$. In Fig. 1 we discuss the influence of searching the minimum in the intervals $[0,2]$, $[0,3]$ and $[0,5]$. We observe that similar spatial patterns are obtained, confirming the robustness of the methodology.

As discussed in the main text, if instead of using $|y_i(t) - x_i(t+\tau_i)|$ to define the difference, we use $(y_i(t) - x_i(t+\tau_i))^2$, then d_i is equal to $2(1-\rho_i)$ where ρ_i is the cross-correlation coefficient between $y_i(t)$ and $x_i(t+\tau_i)$. In Fig. 2 we compare the two approaches, and again we obtain very similar spatial patterns.

Figures 3 and 4 display the comparison of the results obtained from the two databases (NCEP CDAS1 and ERA Interim) and we observe a good qualitative agreement, except for well-localized regions, where extreme values occur as discussed in the main text.

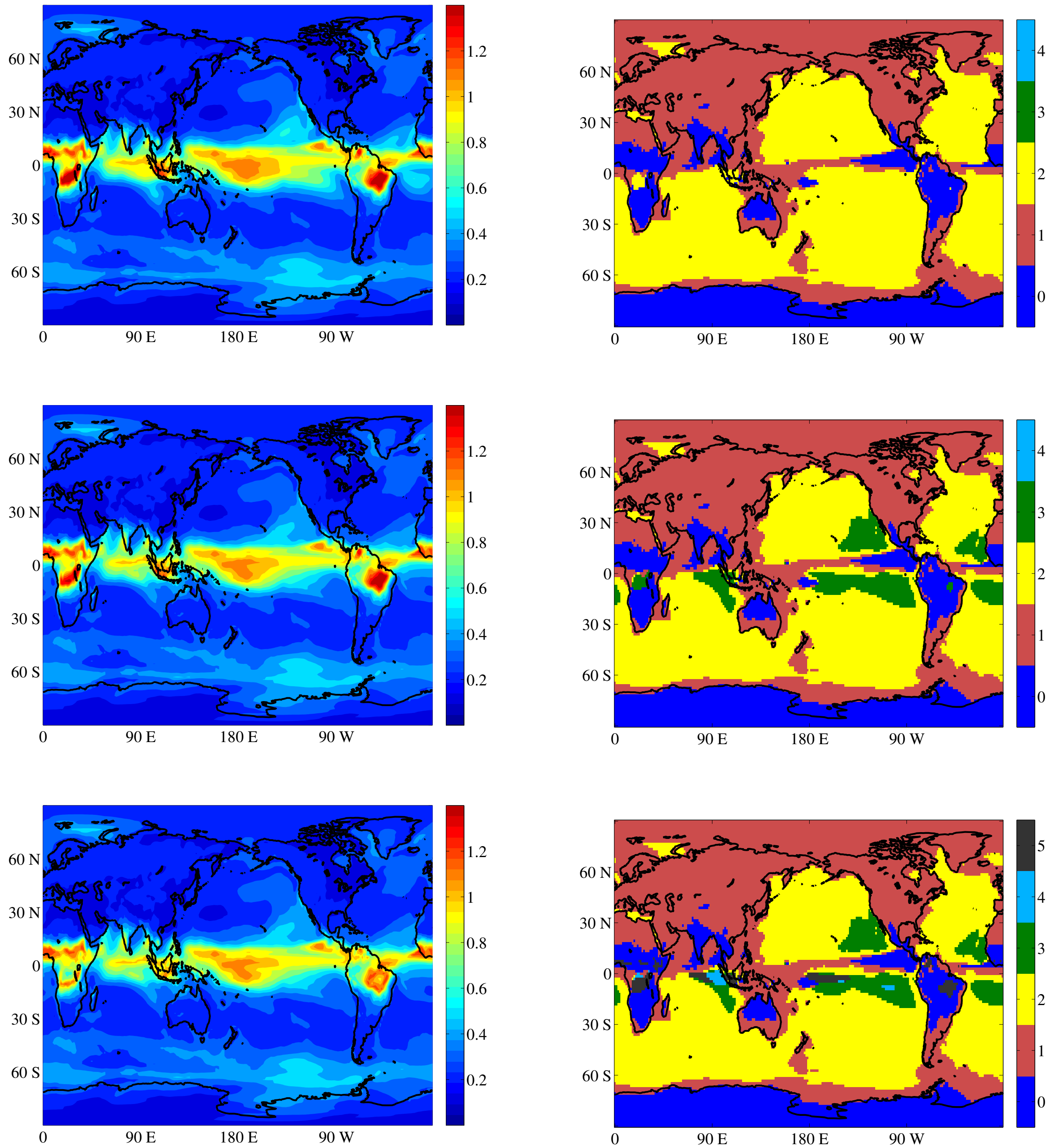

FIG. 1. Maps of distances d_i (left) calculated from Eq. (1) when the forcing and the response are shifted $\tau_i \in [0, 2]$ (a), $\tau_i \in [0, 3]$ (b) and $\tau_i \in [0, 5]$ (c). Maps of respective lags τ_i (left).

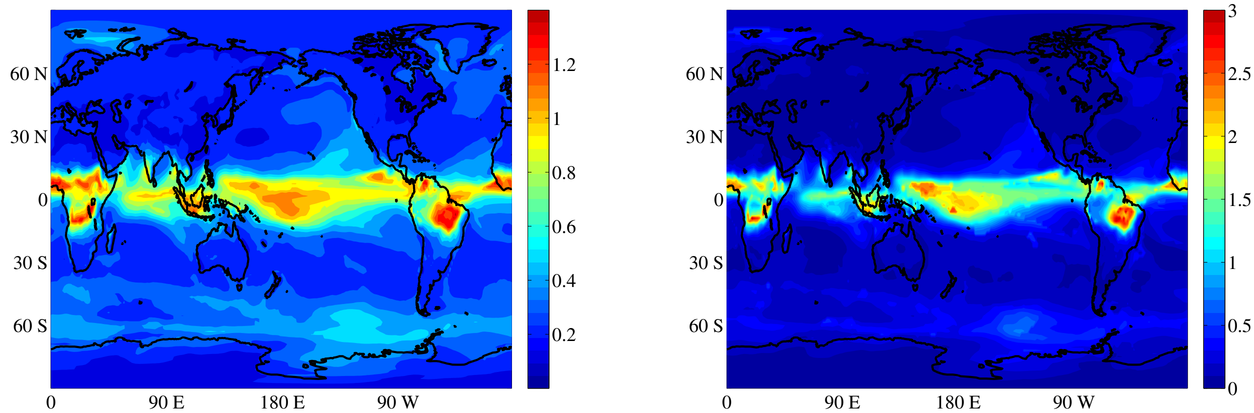

FIG. 2. Map of distances d_i calculated from Eq. (1) (a), and when is calculated from Eq.(1), but replacing $|y_i(t) - x_i(t + \tau_i)|$ by $(y_i(t) - x_i(t + \tau_i))^2$. In both cases, the forcing and the response are shifted τ_i, with $\tau_i \in [0, 4]$.

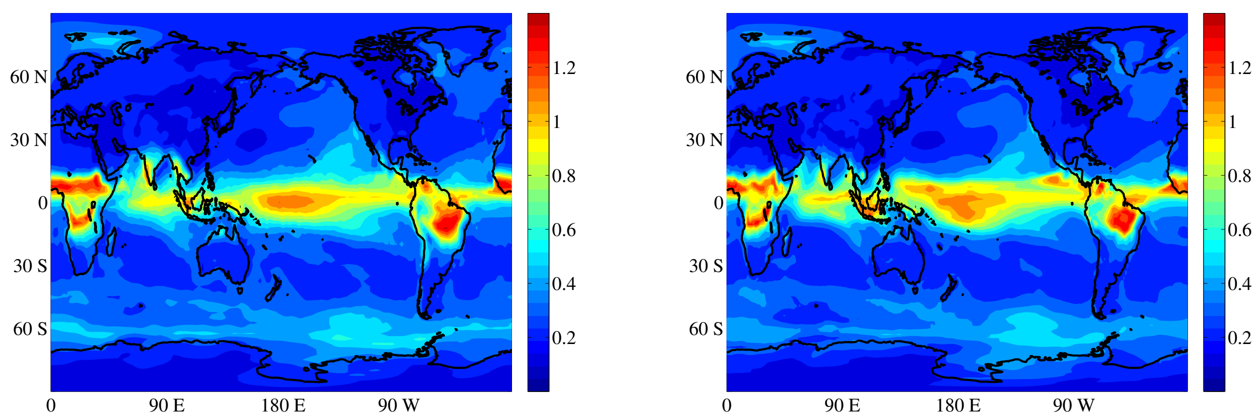

FIG. 3. Map of distances d_i calculated from Eq. (1) with $\tau_i \in [0, 4]$ obtained from NCEP CDAS1 (left) and ERA Interim (right).

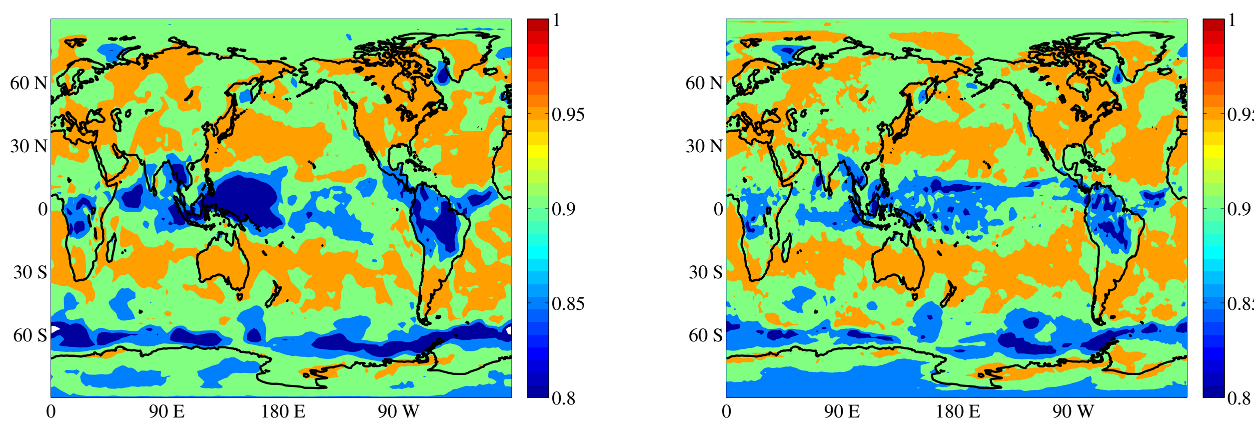

FIG. 4. Entropy maps obtained from NCEP CDAS1 (left) and ERA Interim (right), computed from SAT time-series.