Supplementary Materials

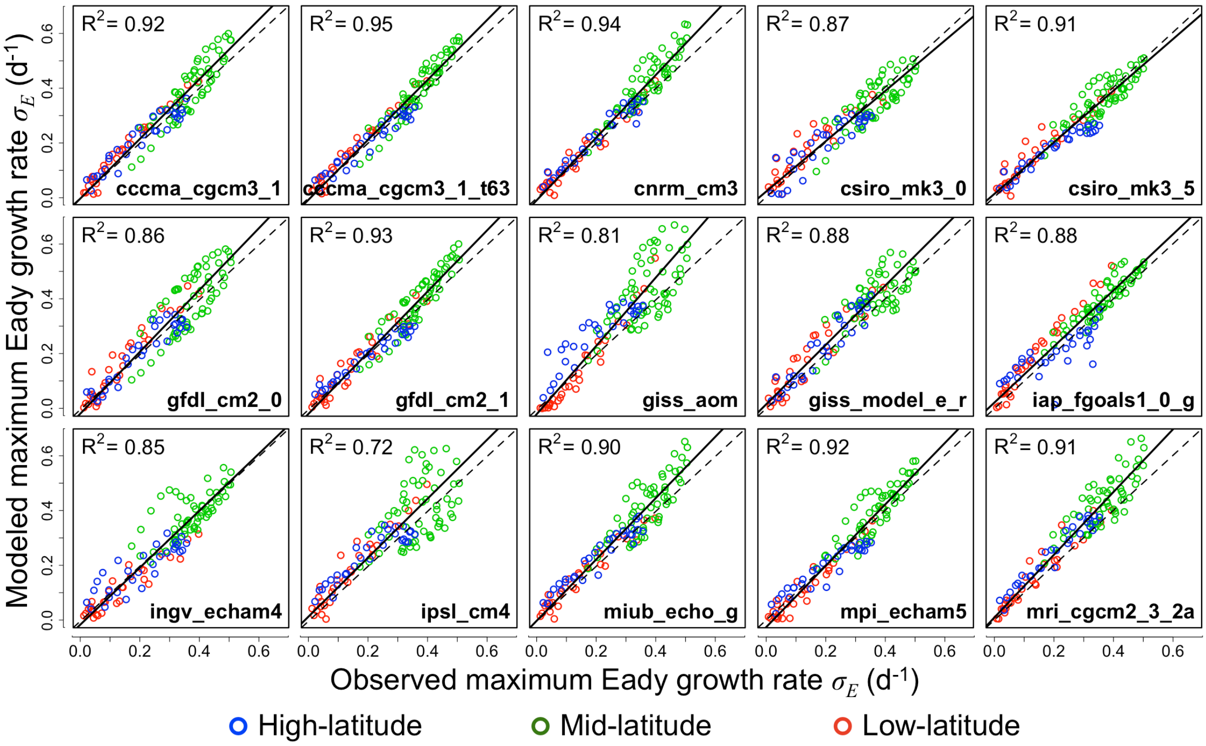

Figure 1. Scatterplots of modeled vs. observed Western Hemisphere baroclinicity in terms of maximum Eady growth rates for 1981-2000. Observed values are from NCEP/NCAR Reanalysis 1, and modeled values from 15 IPCC AR4 GCMs. GCM names are given in each panel. Each data point represents the growth rate for one 4° latitude by one pressure level (from 850, 700, 600, 500, 400, 300 hPa) bin, and the ensemble of points represents the Northern Hemisphere separated as low-latitude (south of 24°N), mid-latitude (24°-64°N), and high-latitude (north of 64°N). The solid black line is the reduced major-axis regression slope, with coefficient of variation (R^2) also given. The 1:1 line is shown as dashed.

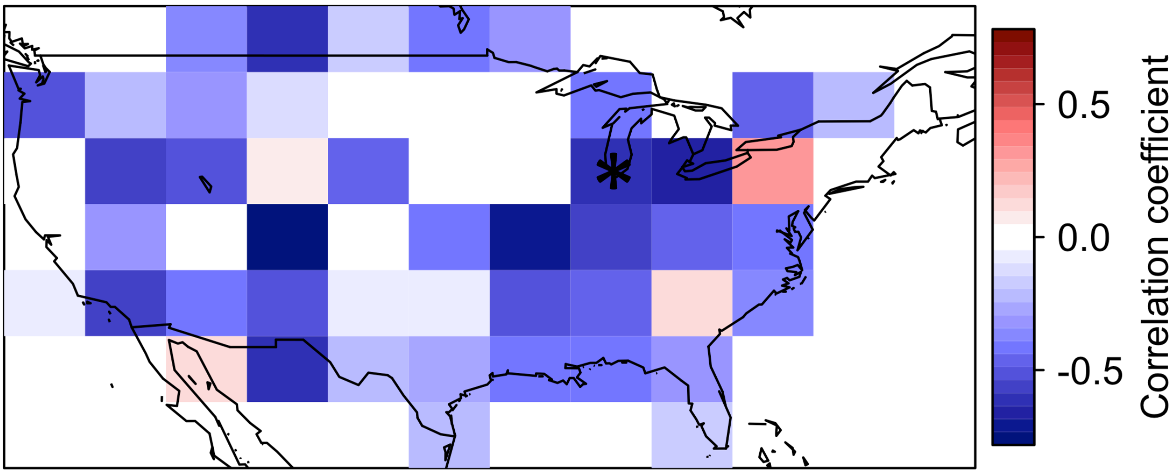

Figure 2. Inter-model correlations of 1981-2000 mean periods of dominant meteorological modes with the modeled baroclinicity measured as the maximum Eady growth rates for 44°-48°N and 850-500 hPa across the 15 IPCC AR4 GCMs. The asterisk marks the Chicago grid cell for which the correlation scatterplot is shown in Fig. 5 of the main text.

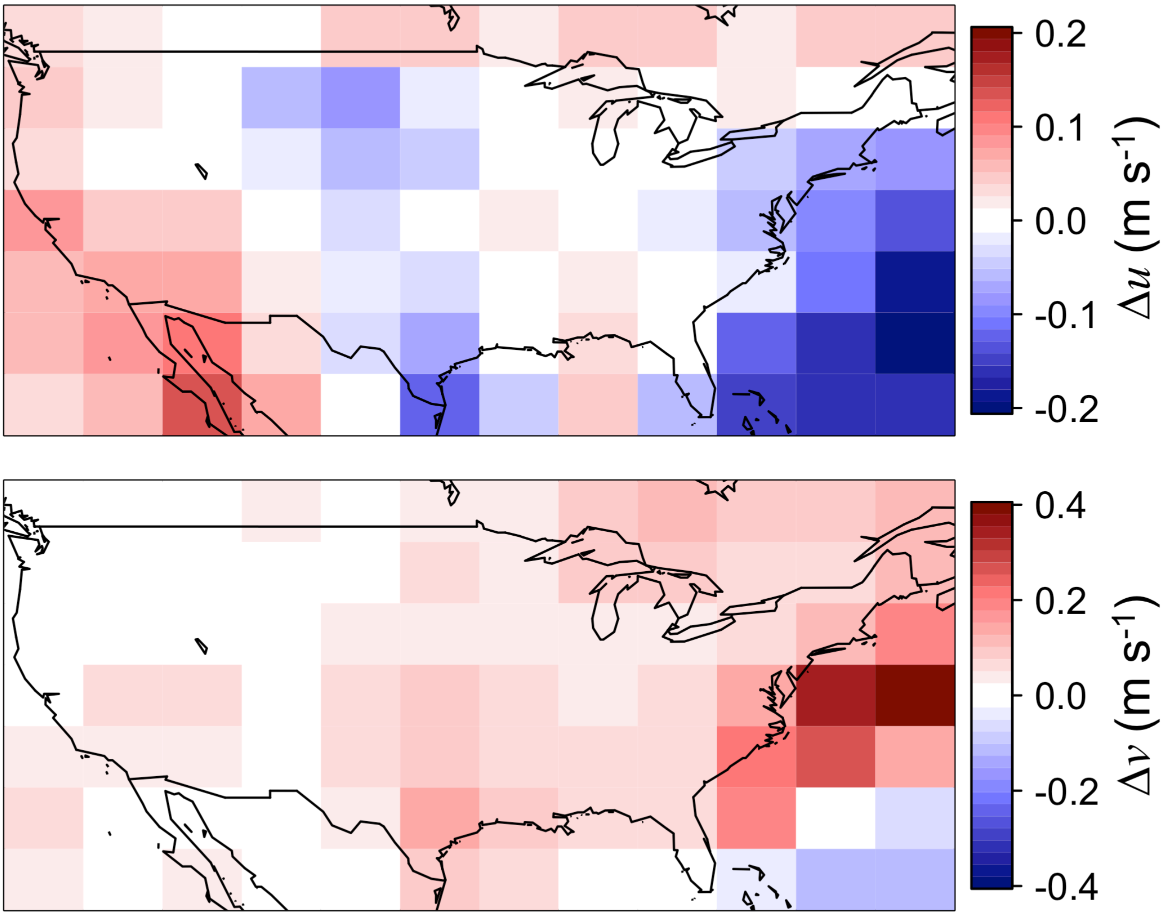

Figure 3. Weighted-average 2000-2050 changes in surface *u*-wind (top) and *v*-wind (bottom) in the 15 IPCC AR4 GCMs. Values shown are calculated using the Bayesian-REA approach by Tebaldi et al. (2004, 2005).

Sensitivity of $PM_{2.5}$ to meteorological modes: a theoretical framework

Here we present a theoretical framework for understanding the $PM_{2.5}$-to-period relationship ($dPM_{2.5}/dT$) as discussed in *Sect. 2* of the main text. The period of meteorological modes is an appropriate predictor for $PM_{2.5}$ because it marks the onset and termination of a synoptic-scale event relevant for $PM_{2.5}$ air quality. We first illustrate using a box model for a given region and consider two idealized extreme cases. The evolution of pollutant concentration *C* follows

$$\frac{dC}{dt} = S - FC \tag{1}$$

where *S* represents source and *F* is the removal (e.g., by ventilation and wet deposition) rate.

The first extreme case is when *S* is constant and *F* is periodic (here modeled as a periodic Kronecker delta function with period T). This can describe a region where local sources are important regular contributors to ambient $PM_{2.5}$ concentrations, and synoptic transport (e.g., by cold fronts or synoptic-scale inflows) removes $PM_{2.5}$ periodically. Case 1 in Fig. 4 illustrates the idealized $PM_{2.5}$ time series following Eq. (1) before and after a 50% increase in T. Longer periods between two removal events (marked by the abrupt $PM_{2.5}$ decrease) allow more pollutant accumulation, thus $dPM_{2.5}/dT > 0$. This interpretation is valid even when *F* takes another form as long as it is periodic.

The second extreme case, as shown by Case 2 in Fig. 4, is when *F* is constant and *S* is modeled as a periodic Kronecker delta function. This can represent a region where synoptic transport periodically brings in pollutant from other source regions (e.g., by warm fronts) or induces intermittent local sources (e.g., wind-blown particles from the surface). Longer periods between two source events (marked by the abrupt $PM_{2.5}$ increase) allow more time for dilution and ventilation, thus $dPM_{2.5}/dT < 0$. However, this interpretation is appropriate only when a source event induces the same time-integrated concentration when T increases (e.g., when pollutant comes in a puff as in Case 2 or when the duration of source inflow remains constant even though the overall T increases).

The reality should lie between these two extreme cases depending on the exact form and periodicity of sources and ventilation.

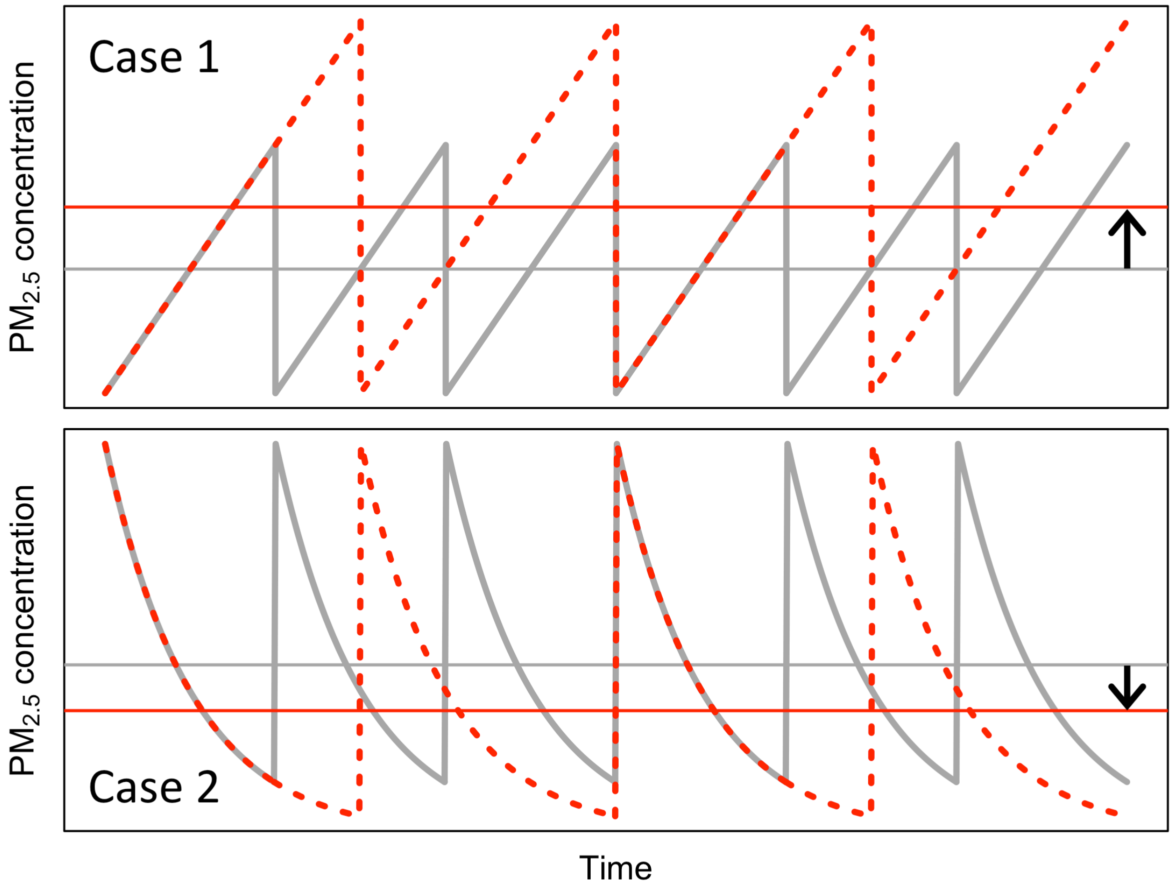

Figure 4. Idealized time series of $PM_{2.5}$ concentrations before (thick gray solid line) and after (thick red dash line) a 50% increase in the periods of synoptic transport for two extreme cases as described in text. The gray and red thin horizontal lines represent the temporal mean $PM_{2.5}$ concentrations before and after the period increase, respectively.