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Supplement of

Reconciling conflicting evidence for the cause of the observed early 21st century Eurasian cooling

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Description of the autoregressive model used in Section 5

Our AR1 model is defined by the following equation:

$$T_{i+1} = \rho_{-1} T_i + \sigma \sqrt{1 - \rho_{-1}^2} N(0,1), \tag{1}$$

where σ is the standard deviation of Eurasian DJF temperature, ρ_{-1} is the partial lag-1 autocorrelation, and N(0,1) is Gaussian noise. The model represents temperature at one timestep (T_{i+1}) is dependent on the previous value (T_i) plus noise. While the lag autocorrelations over the full period are small and not statistically significant, we use a nominal value here of ρ_{-1} = 0.2 in order to maintain the form of the above equation. The parameter space for a range of ρ_{-1} and σ values was examined and it was found that the impact on the generated trends in the choice of ρ_{-1} is small compared to the impact of the value of σ, which ranges from $<$1 K to nearly 2 K for decadal time scales (Supplemental Figure S4), and represents a factor of two difference in the expected spread from internal variability. With the AR1 model, we create 20,000 time series, each 15 years long and starting from the initial temperature of T_0 = 0 K. For each of these time series, we determine the temperature trend over the 15-year period, so that together they provide us with a PDF of Eurasian DJF temperature trends consistent with the observed 15-year trends over the period covered by the reanalysis (Figure 5b). We believe this model is adequate for the purpose of illustrating our explanations, but more complex and accurate model can possibly be devised after examining the statistical properties of the observed time series more deeply.

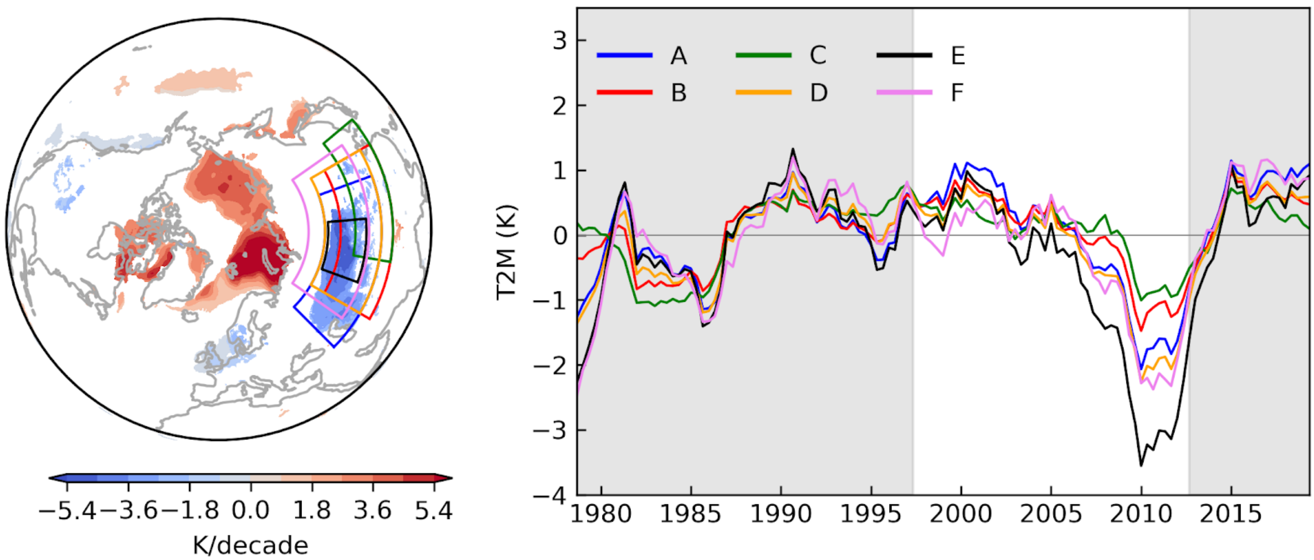

Figure S1. Left: Trends in 2 metre air temperature as in Figure 1. Boxes with various colors show the selected regions for calculating the Eurasian cooling. Regions include 40-60°N, 45-110°E (blue), 35-55°N, 60-120°E (yellow; He et al. 2020), 35-50°N, 80-130°E (green; Kug et al. 2015), 40-60°N, 60-120°E (orange; Mori et al. 2014), 46-59°N, 70-95°E (black; Outten and Esau 2012 Figure 1) and 45-65°N, 55E-125°E (violet; Ogawa et al. 2018). Right: Anomaly of 2 metre air temperature averaged over the various boxes for the period of 1998 to 2012.

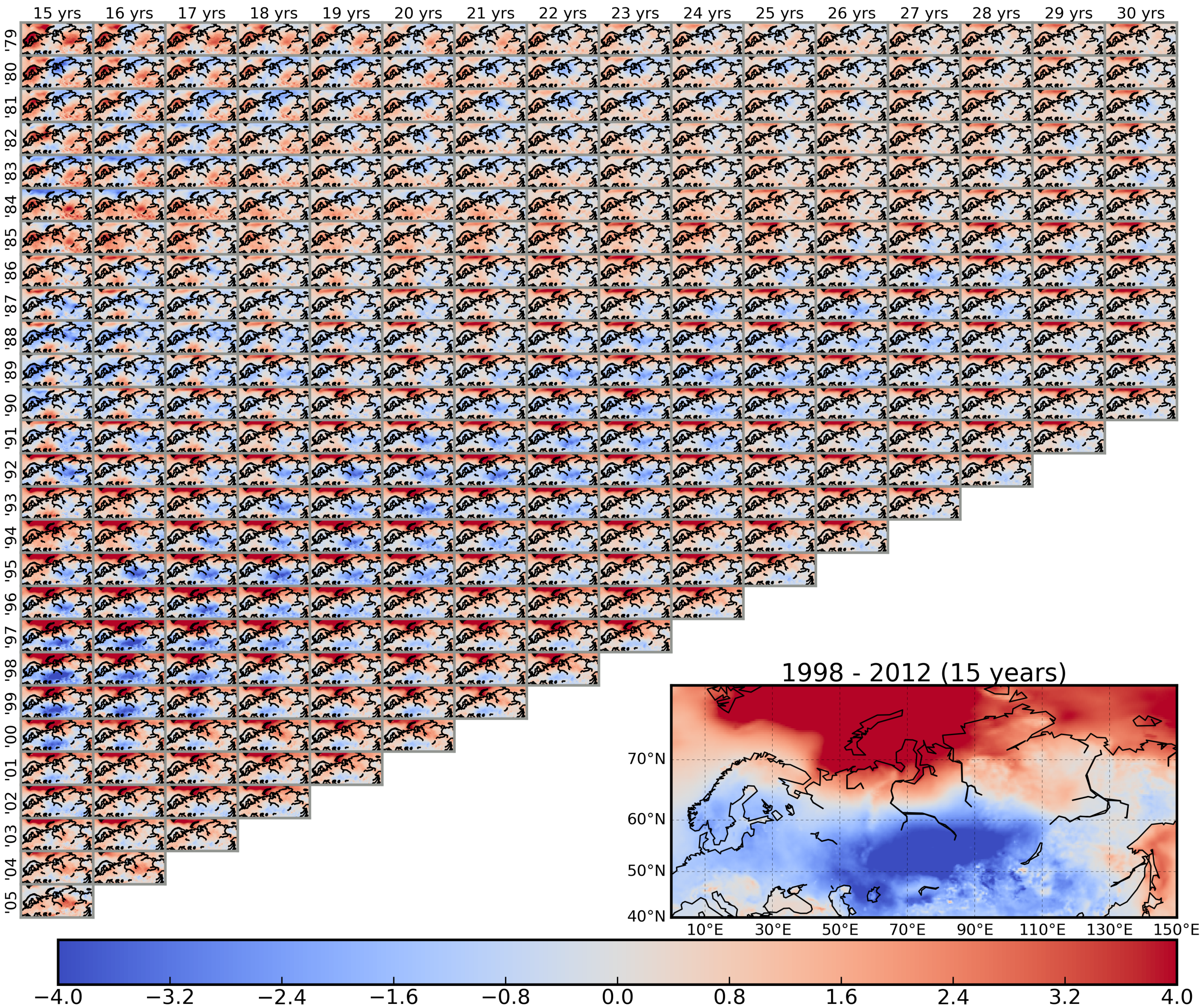

Figure S2. Trends in DJF-mean 2-metre air temperature in ERA5 reanalysis for periods ranging from 15 to 30 years in length (columns) and for starting years ranging from 1979 to 2005 (rows), as in Figure 2 but showing all trends without removal for non-significance. The domain shown is 0-150°E and 40-80°N. The inset (bottom right) shows an expanded view of the panel corresponding to the 15-year period highlighted in Figure **??**a, from DJF 1998 to DJF 2012.

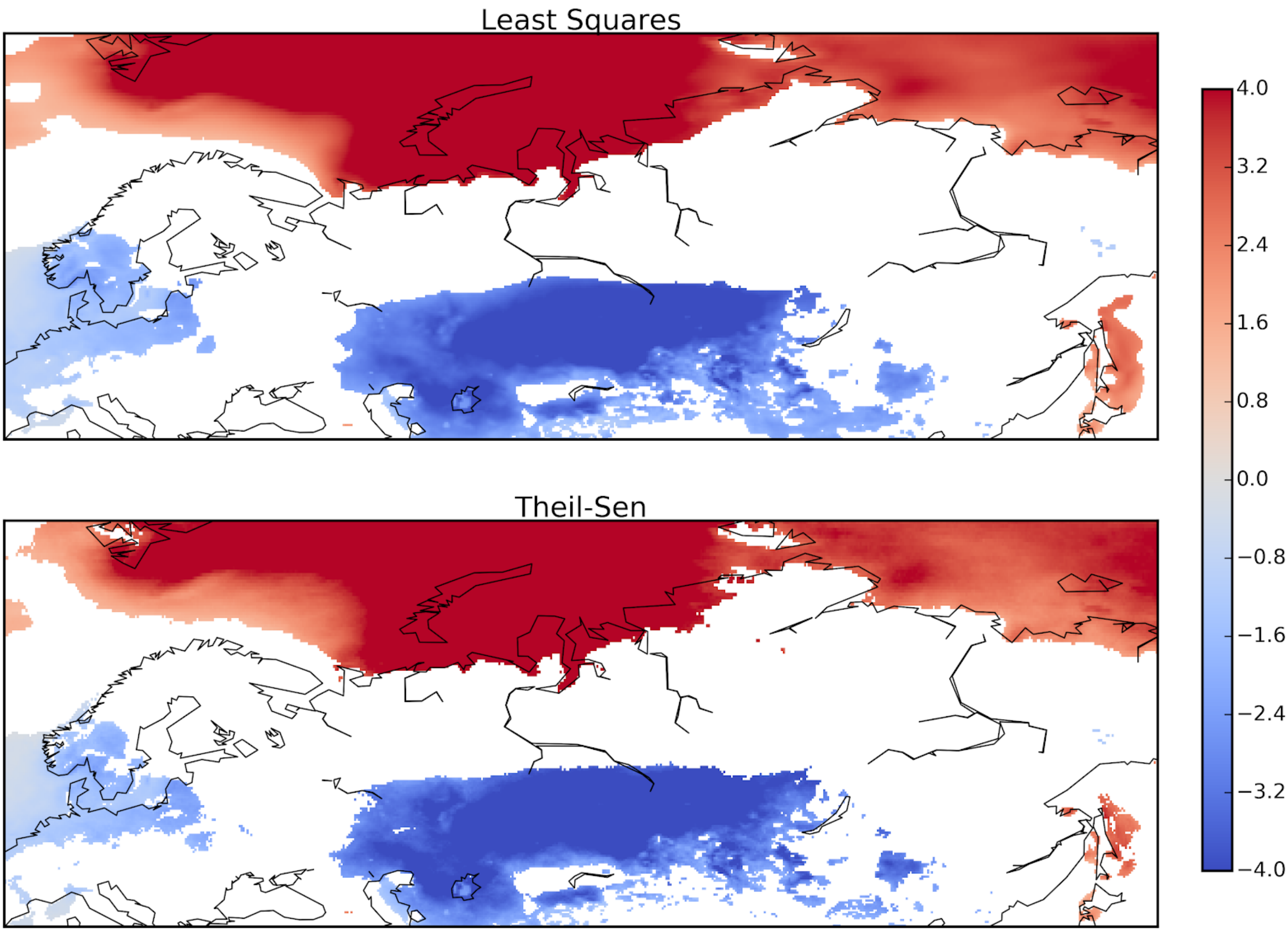

Figure S3. Trends in DJF mean 2-metre air temperature in ERA5 reanalysis for 1998 to 2012, calculated using the least squares (top) and Theil-Sen (bottom) methods.These are shown over the domain of 0-150°E and 40-80°N. Trends are only shown for locations that are significantly different at the 95% level from the mean Northern Hemisphere trend for the given period.

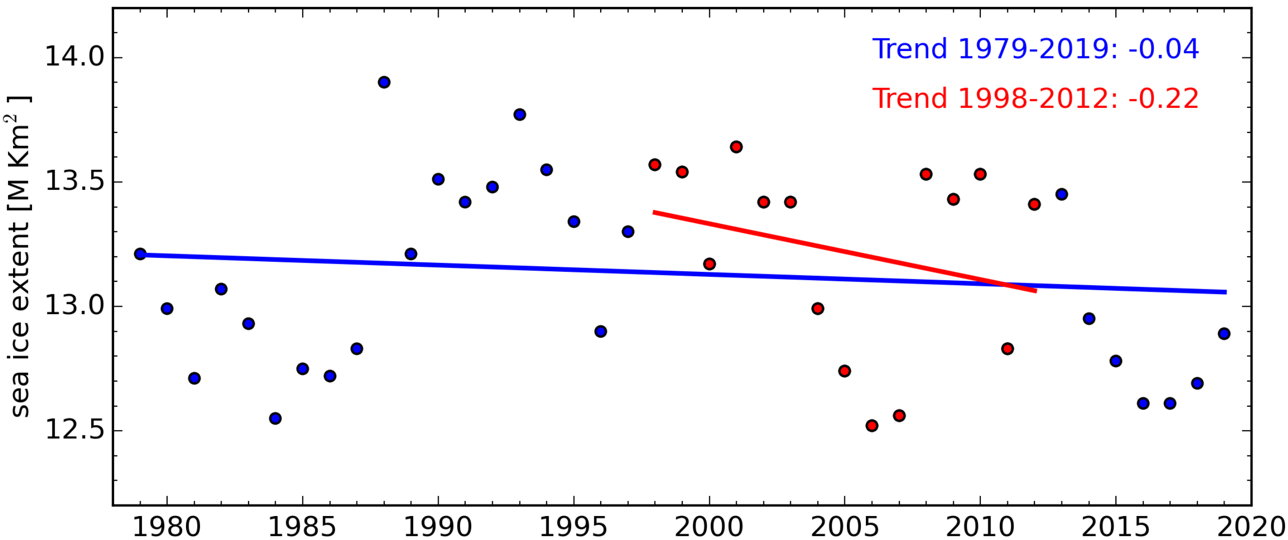

Figure S4. The March Arctic sea ice extent (dots) and its linear trend (solid lines) in National Snow Ice Data Centre (NSIDC) dataset in million sq. km. Trends are calculated over two periods, 1979-2019 (blue) and 1998-2012 (red).

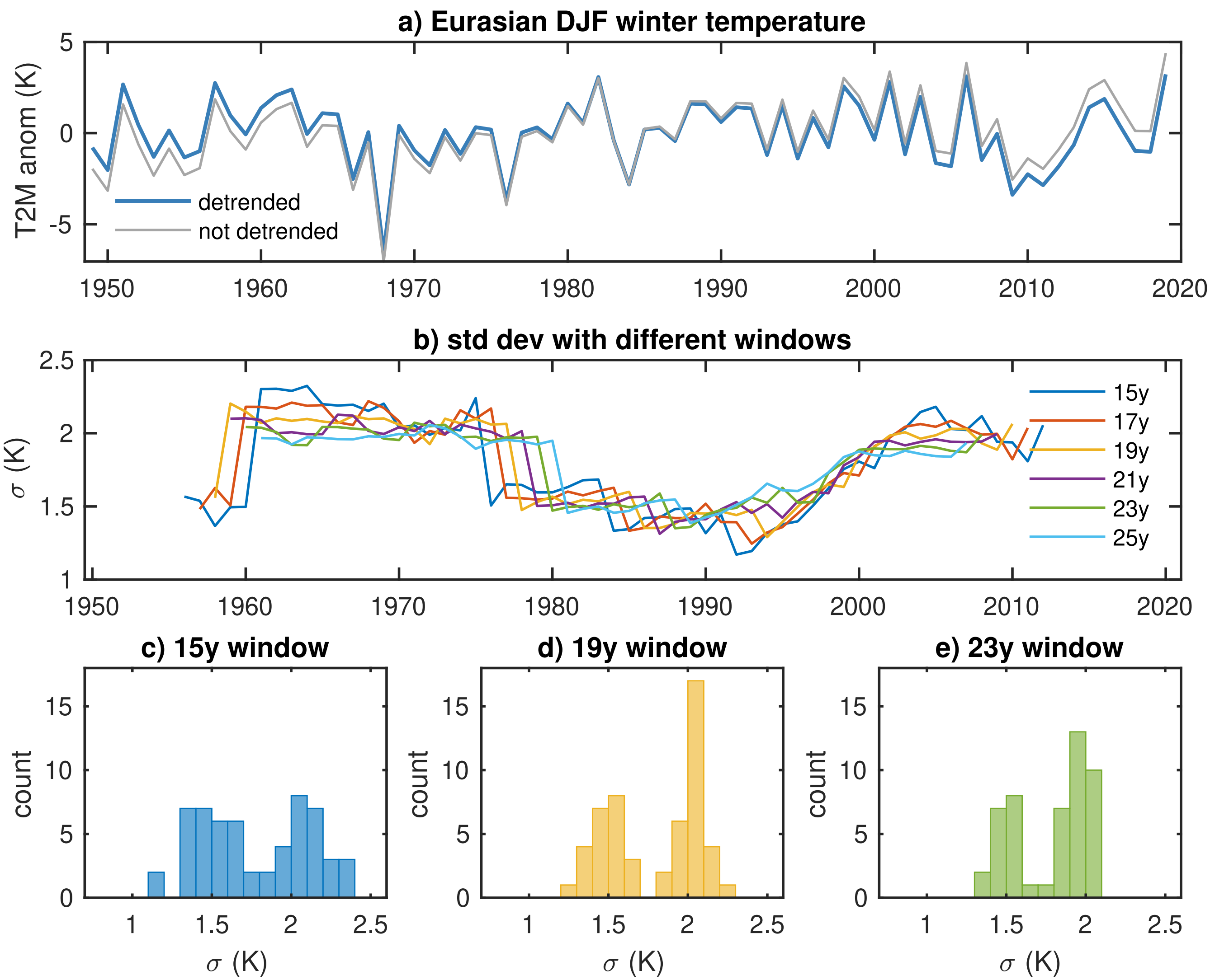

Figure S5. Eurasian winter temperature variability. a) Time series of 2-metre winter temperature anomalies from the ERA5 reanalysis area-averaged over 40-60°N and 60-120°E. The year corresponds to the December of each DJF season. b) Centered running standard deviation σ of the temperature time series for different windows (in years). (c-e) Histograms of standard deviations for three of the window lengths in (b).