Supporting Information for "Decadal variability of the extratropical response to the Madden–Julian Oscillation"

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Text S1. Climate indices

Here, a brief description is given of the indices used to define the AMV, PDO, and ENSO (Figure S1). Publicly available indices are used.

The AMV index (Trenberth & Shea, 2006) is defined by taking the mean of North Atlantic (0–60°N) sea surface temperature (SST) anomalies (taken from the HadISST dataset). This time series is then detrended by subtracting the global mean SST anomaly. A 10-year low-pass filter is applied to isolate the multidecadal variability.

The PDO (Mantua, 1999) is defined as the first EOF of North Pacific (20–70°N) SST anomalies (taken from the HadISST dataset over the reference period 1870—2014). The PDO index is created by projecting SST anomaly data onto this EOF pattern.

The Niño 3.4 index (National Oceanic and Atmospheric Administration Earth System Research Laboratories, 2022) is calculated by taking the mean of equatorial mid-Pacific (5°N–5°S, 170–120°W) SST anomalies (taken from the HadISST dataset). A 5-month running mean is applied to smooth the data. To create Figures S2 and S3, the Niño 3.4 index is averaged over each boreal winter season, to subset our time domain into El Niño, neutral, and La Niña seasons by terciles.

References

Mantua, N. J. (1999). The Pacific Decadal Oscillation: a brief overview for non-specialists. *Encyclopedia of Environmental Change*.

National Oceanic and Atmospheric Administration Earth System Research Laboratories. (2022). *Niño 3.4 SST Index* [Dataset]. Retrieved from `https://psl.noaa.gov/gcos_wgsp/Timeseries/Data/nino34.long.data`

Trenberth, K. E., & Shea, D. J. (2006). Atlantic hurricanes and natural variability in 2005. *Geophysical Research Letters*, *33*(12), L12704. Retrieved from `https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2006GL026894` doi: 10.1029/2006GL026894

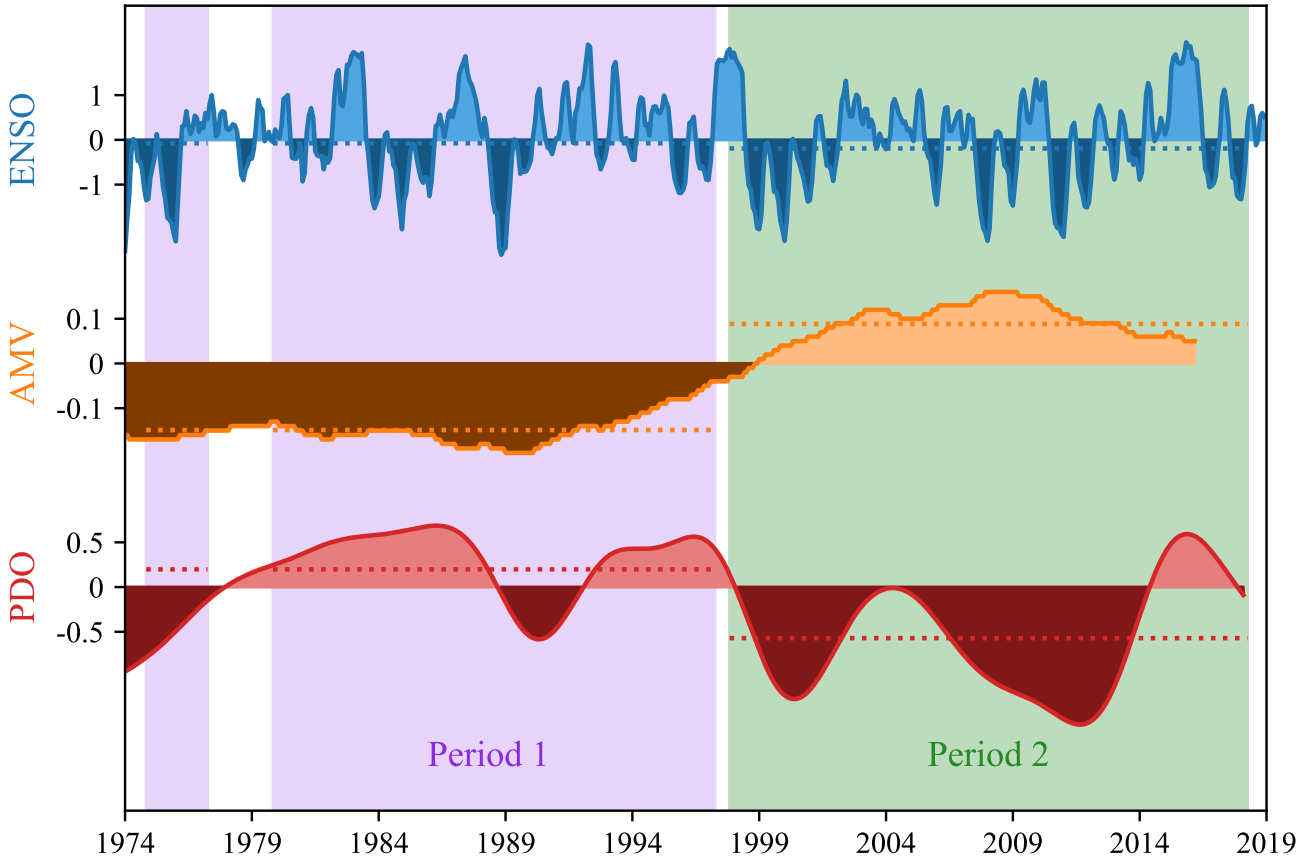

Figure S1. Values of ENSO, PDO and AMV indices (Text S1) over our time domain. Periods 1 and 2 are marked. Dotted lines show the average values of indices for each time period. We use the Niño 3.4 index, PDO index (on which we ran a 5 year low-pass fiter) and AMO index (10 year low-pass filtered) from the NCAR Climate Data Guide.

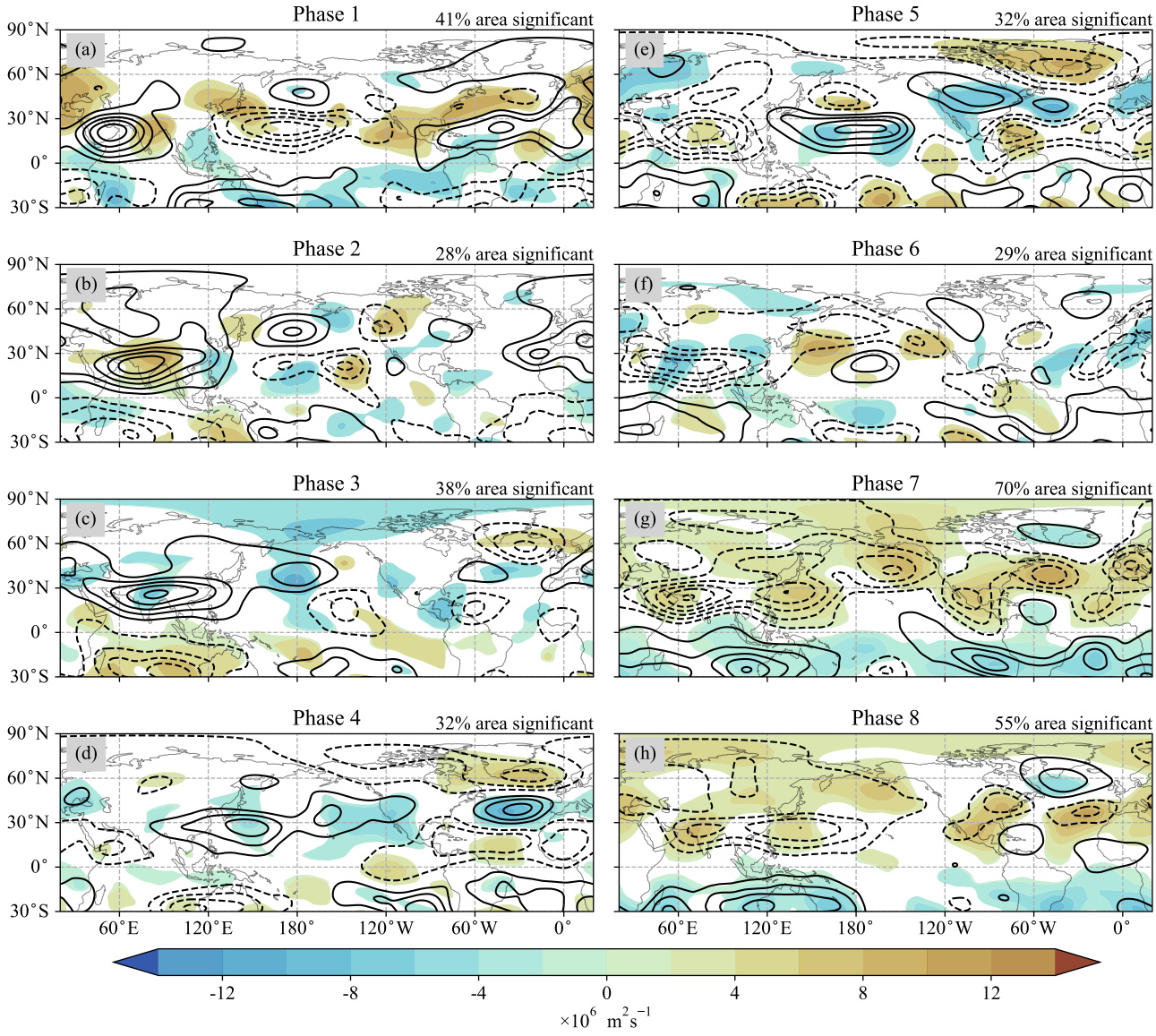

Figure S2. Lag 10-day composites of boreal winter (November–April) 200-hPa streamfunction anomaly for each of the eight MJO phases. Thick black contours represent El Niño years, and shaded contours show the difference between El Niño and La Niña years (La Niña minus El Niño) wherever this difference is significant at the 95% level. The contour interval for both the line and shaded contours is 2×10^6 m^{2}s^{-1}, and dashed contours represent negative values. The zero contour has been omitted. The percentage of the spatial domain in which the difference is significant is stated in the top right of each panel.

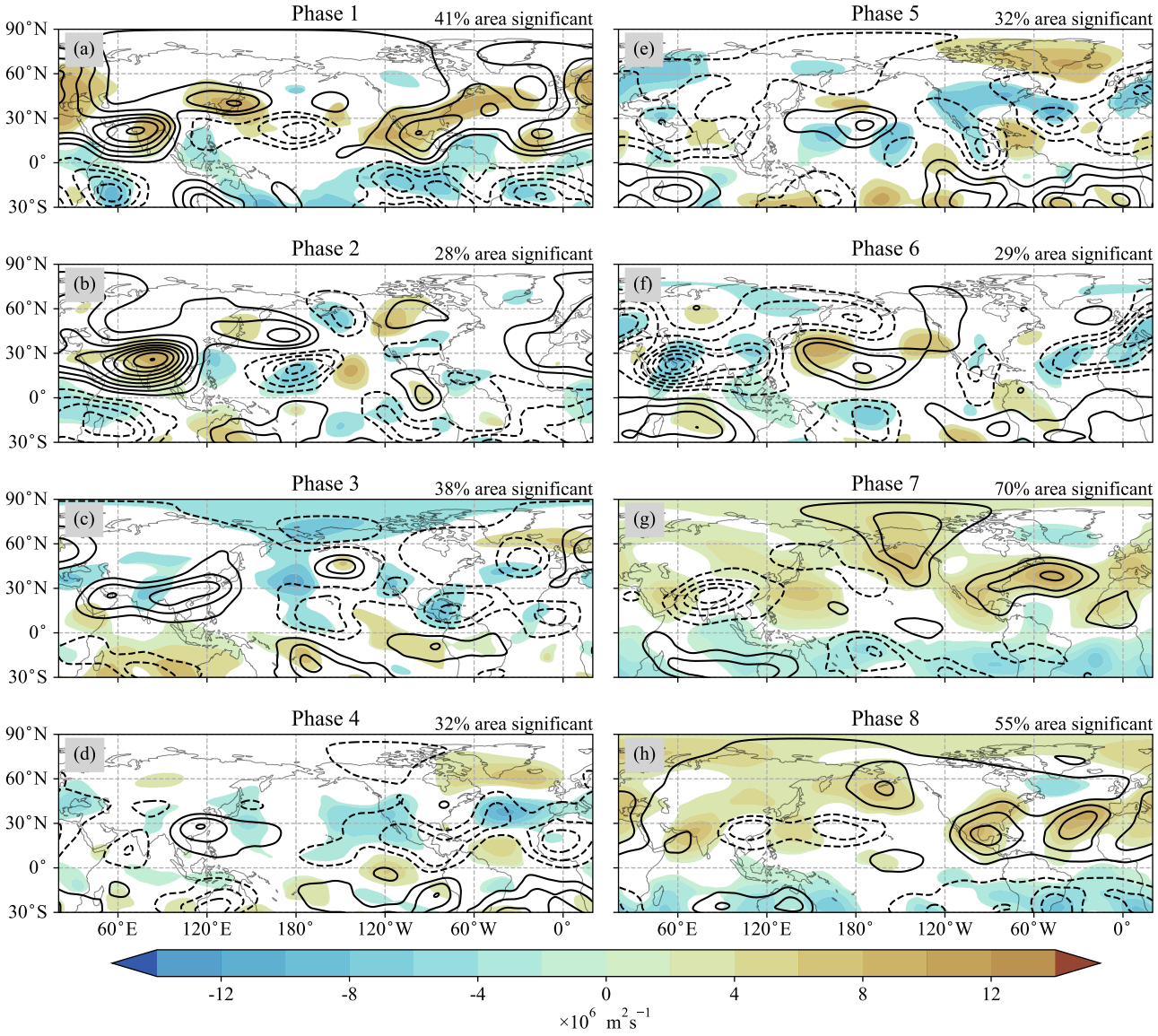

Figure S3. As in Figure S2, but with black contours representing La Niña years.

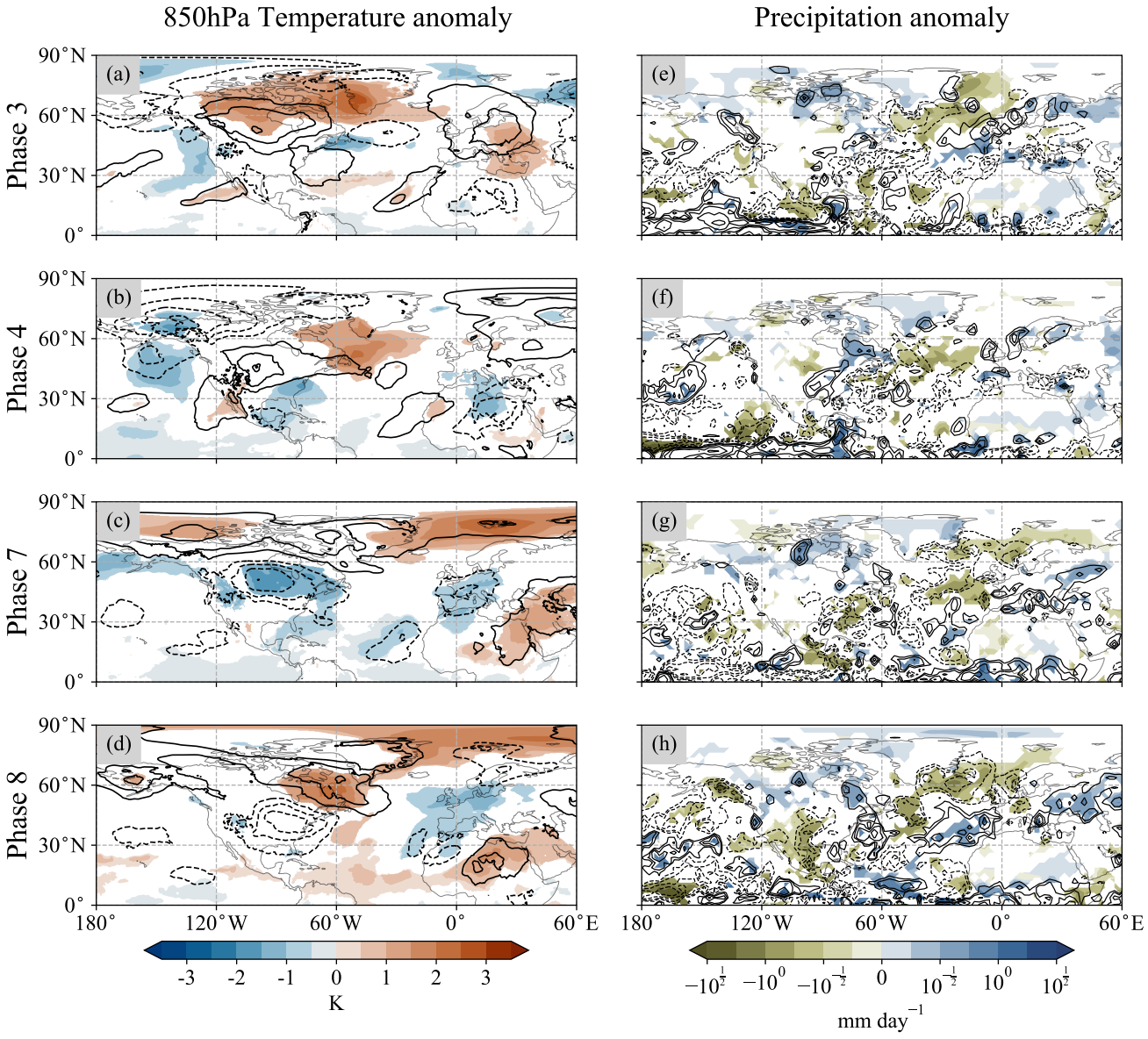

Figure S4. Change in lag 10 day composites of 850-hPa temperature and precipitation anomalies over North America and Europe for MJO phases 3, 4, 7 and 8. Difference between time periods one and two is colour shaded wherever it is significant at the 95% level, with precipitation anomaly plotted on a logarithmic scale. Period two composites are overlaid as green contours for reference. Solid contours represent positive values, dashed contours represent negative values and the zero contour has been omitted. Contour levels are the same for the line contours as they are for the shaded contours.

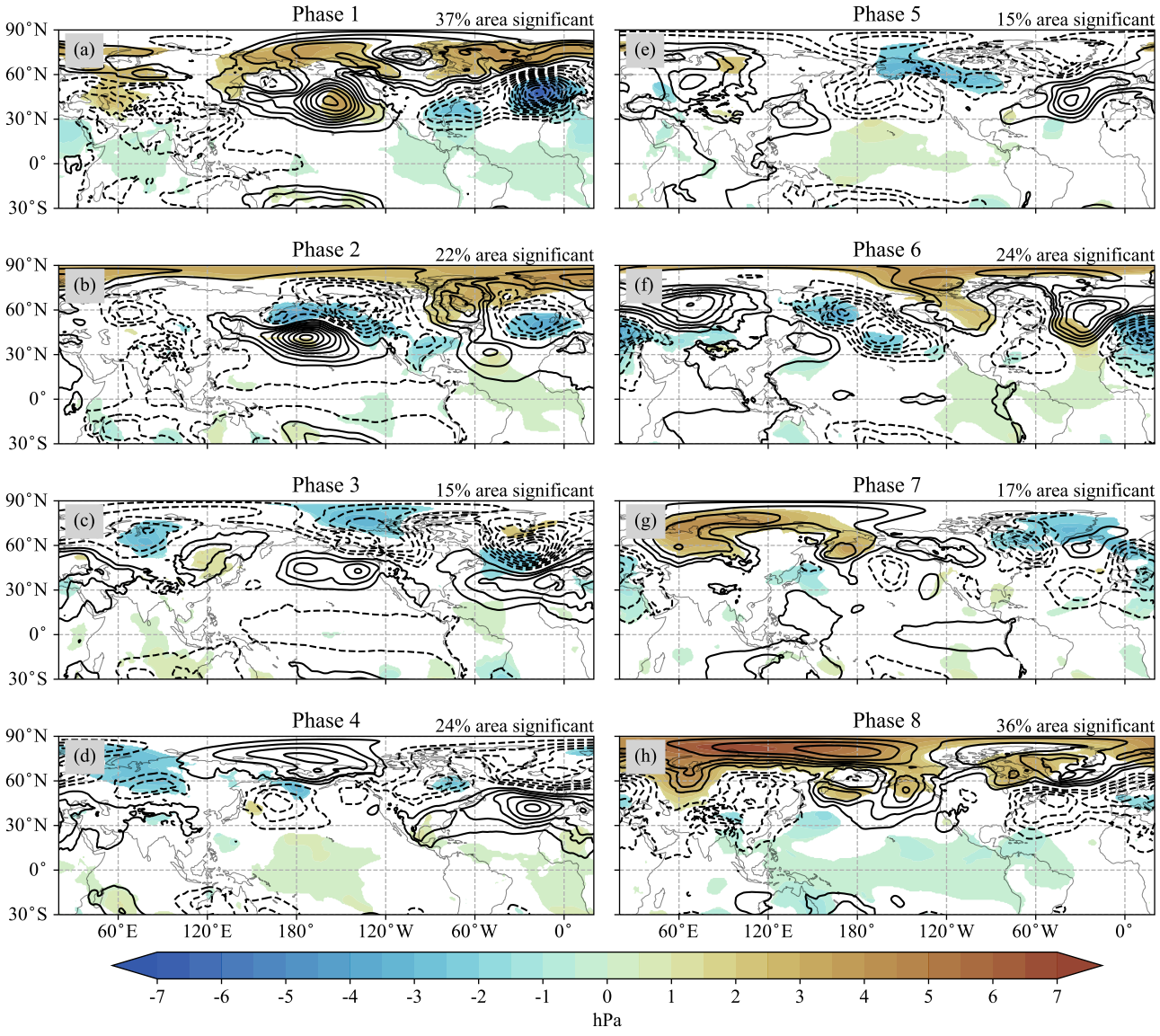

Figure S5. Lag 10-day composites of boreal winter (November–April) mean sea level pressure anomaly for each of the eight MJO phases. Thick black contours represent period two, and shaded contours show the difference between the two time periods(period two minus period one) wherever this difference is significant at the 95% level. The contour interval for both the line and shaded contours is 0.5 hPa, and dashed contours represent negative values. The zero contour has been omitted. The percentage of the spatial domain in which the difference is significant is stated in the top right of each panel.