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Supplementary Information for

Climate network percolation reveals the expansion and weakening of the tropical component under global warming

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This PDF file includes:

Other supplementary materials for this manuscript include the following:

Table S1. CMIP5 climate simulation models used in this study. Resolutions are given as the number of latitude×longitude grid points.

Source	RCP8.5	RCP4.5	Historical	Resolution	Label number
ACCESS1-0	YES	NO	YES	145×192	1
ACCESS1-3	YES	YES	YES	145×192	2
CCSM4	YES	YES	YES	192×288	3
CMCC-CESM	YES	NO	YES	48×96	4
CMCC-CM	YES	YES	YES	240×480	5
CMCC-CMS	YES	YES	YES	96×192	6
CNRM-CM5	YES	NO	YES	128×256	7
CSIRO-Mk3-6-0	YES	YES	YES	145×192	8
CanESM2	YES	YES	YES	96×192	9
GFDL-CM3	YES	YES	YES	64×128	10
GFDL-ESM2G	YES	NO	YES	90×144	11
GFDL-ESM2M	YES	YES	YES	90×144	12
GISS-E2-H	YES	YES	YES	90×144	13
GISS-E2-H-CC	YES	YES	YES	90×144	14
GISS-E2-R	YES	YES	YES	90×144	15
GISS-E2-R-CC	YES	YES	YES	90×144	16
HadGEM2-AO	YES	YES	YES	145×192	17
HadGEM2-CC	YES	NO	YES	145×192	18
HadGEM2-ES	YES	YES	YES	145×192	19
inmcm4	YES	YES	YES	120×180	20
IPSL-CM5A-LR	YES	NO	YES	96×96	21
IPSL-CM5A-MR	YES	NO	YES	143×144	22
IPSL-CM5B-LR	YES	NO	YES	96×96	23
MIROC-ESM	YES	NO	YES	64×128	24
MIROC-ESM-CHEM	YES	NO	YES	64×128	25
MPI-ESM-LR	YES	YES	YES	96×192	26
MPI-ESM-MR	YES	YES	YES	96×192	27
MRI-CGCM3	YES	YES	YES	160×320	28
MRI-ESM1	YES	NO	YES	160×320	29
NorESM1-M	YES	YES	YES	96×144	30
NorESM1-ME	YES	YES	YES	96×144	31

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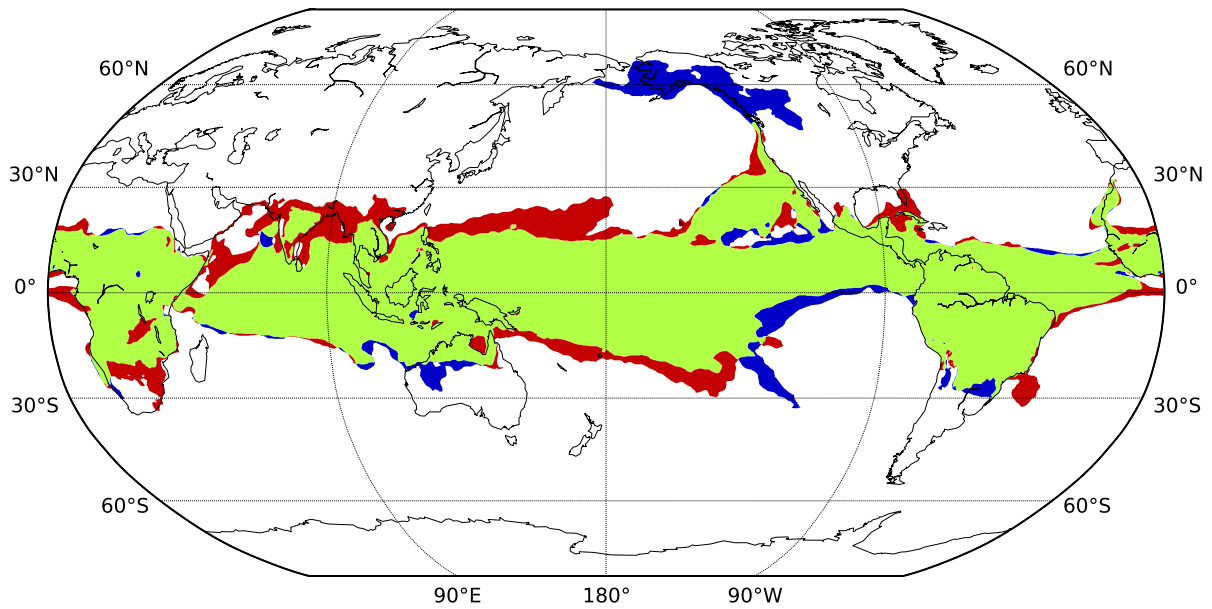
Fig. S1. The difference in the tropical percolation component between the first and the last five years of the ERA–Interim data. In the map, the green, blue and red colors represent the stable, removing and adding nodes, respectively.
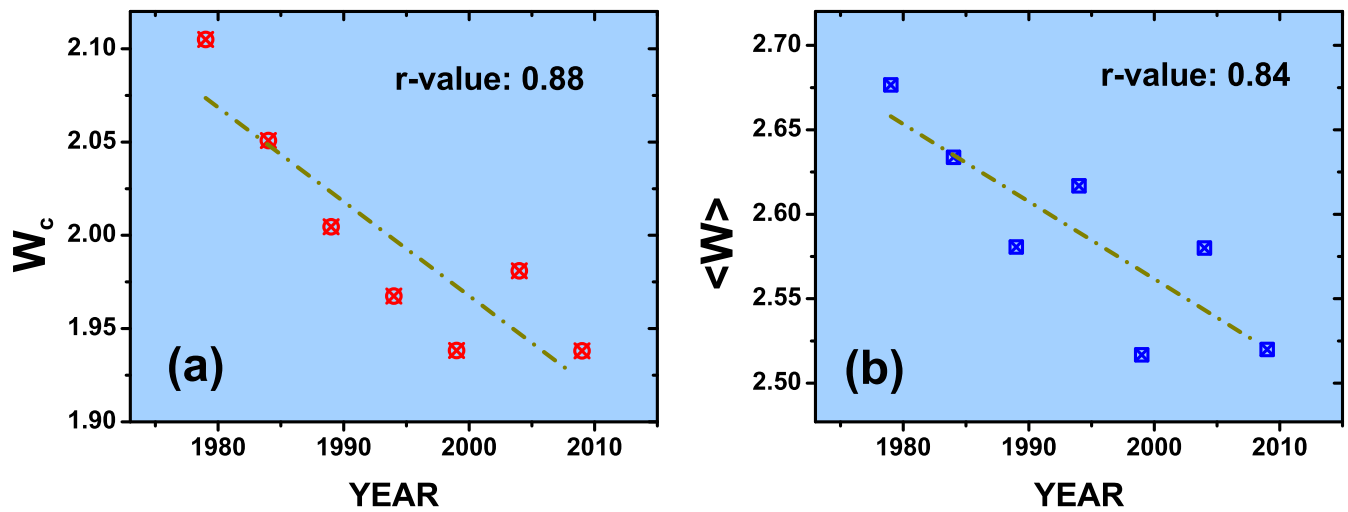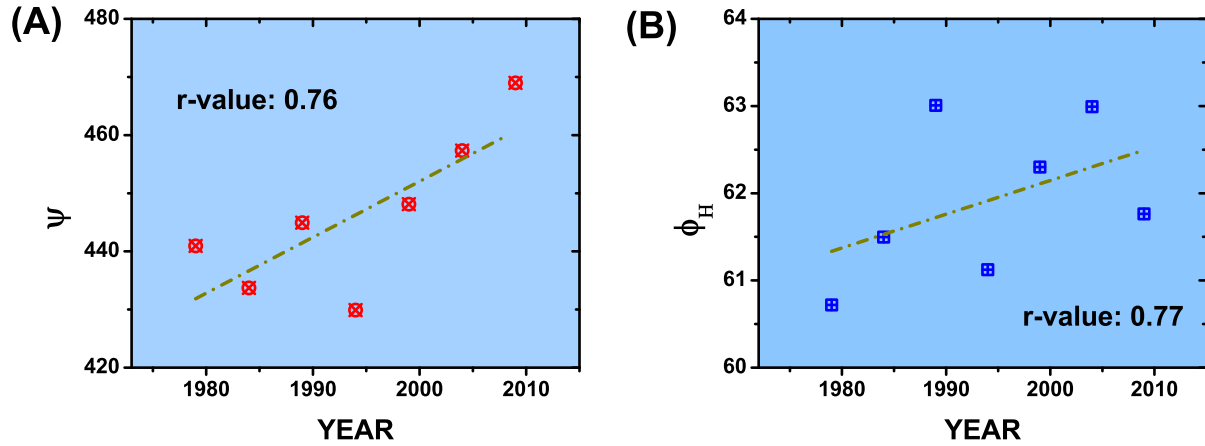
ERA Interim

Fig. S2. The decrease in the intensity of the tropical component for the ERA-Interim reanalysis data with time. (a) For the weight of the critical bond or link; (b) the average of the weights of all added links before the percolation threshold.

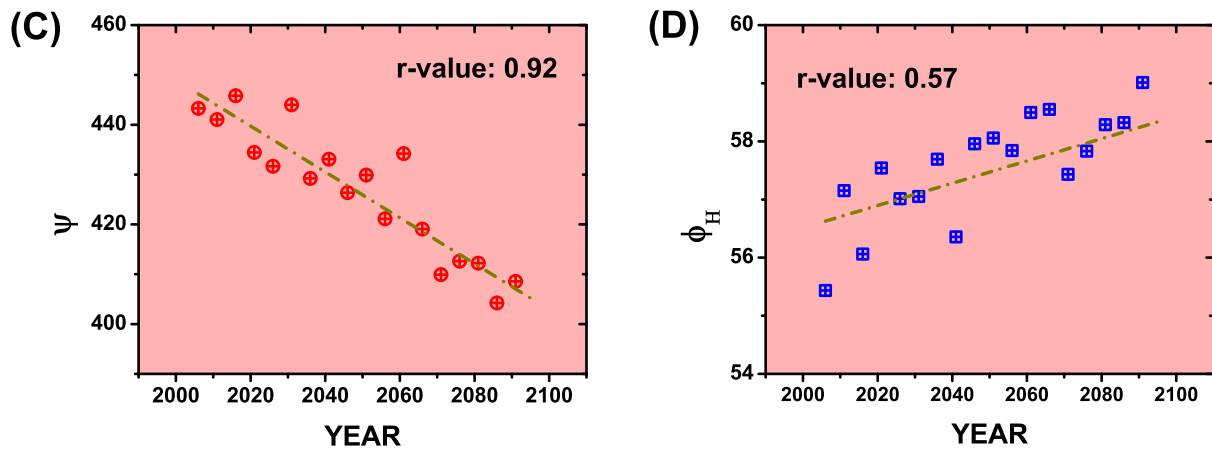Jingfang Fan, Jun Meng, Yosef Ashkenazy, Shlomo Havlin and Hans Joachim Schellnhuber

Fig. S3. Changes in the intensity, Ψ, and width, ϕ_H, of the HC against time for (A-B) the ERA-Interim reanalysis data and (C-D) for a model under the RCP8.5 scenario. Linear correlation coefficients (r-values) are given in the plots.
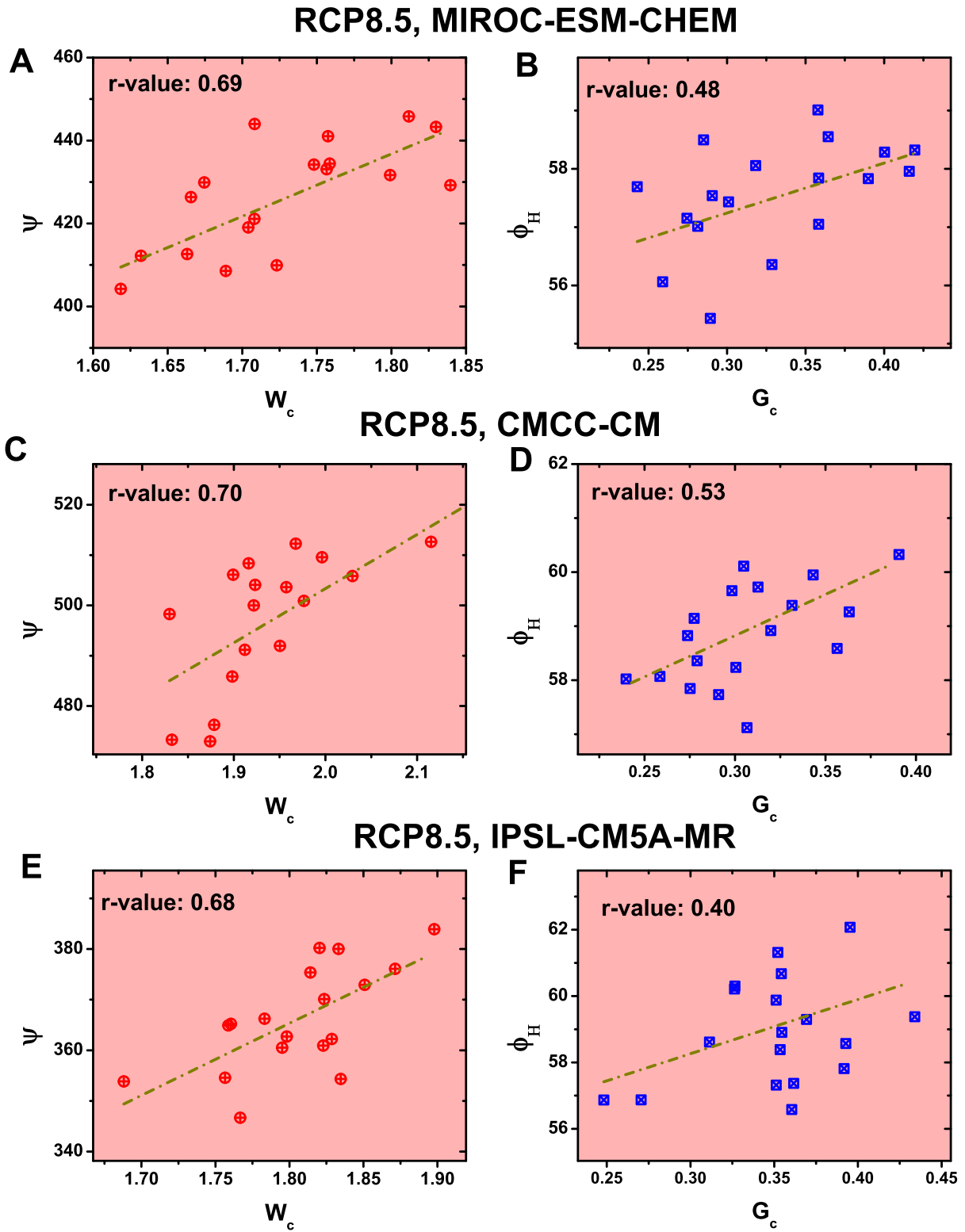
Fig. S4. Strong linear relationship between network variables (W_c, G_c) and Hadley cell indices (Ψ, ϕ_H). (A-B) For model MIROC-ESM-CHEM; (C-D) for CMCC-CM; (E-F) for IPSL-CM5A-MR. The r-values are given in the plots.

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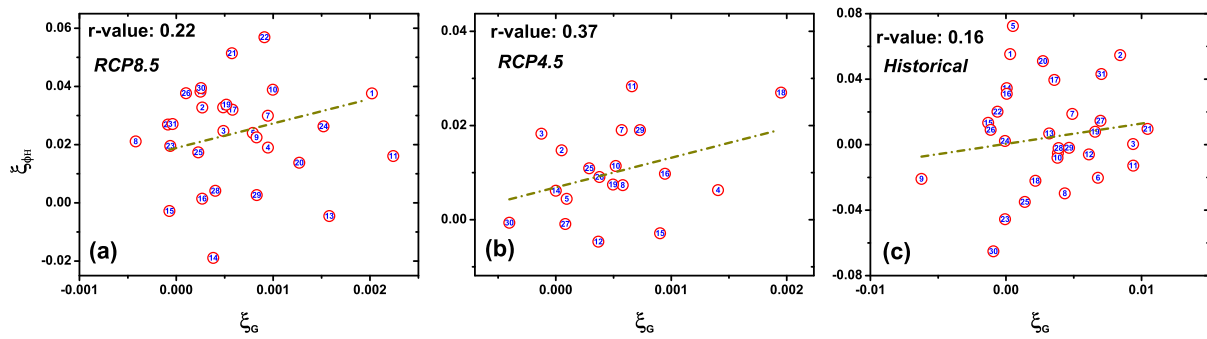
Fig. S5. Changes in the width of the HC, ξ_{ϕ_H}, against the width of the network tropical component, ξ_G, for (a) RCP8.5, (b) RCP4.5 and (c) Historical data. Linear correlation coefficients (r-values) are given in the panels.
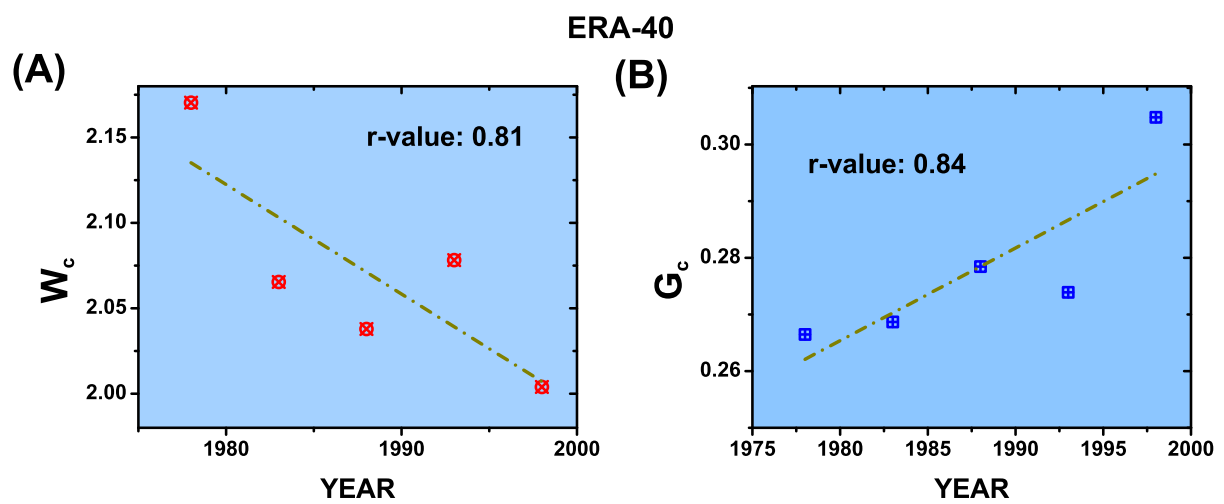
Fig. S6. Expansion and weakening of the tropical component for the ERA–40 reanalysis data. W_c is the weight of the critical link; G_c is the normalized size of the tropical component just below the r_c.

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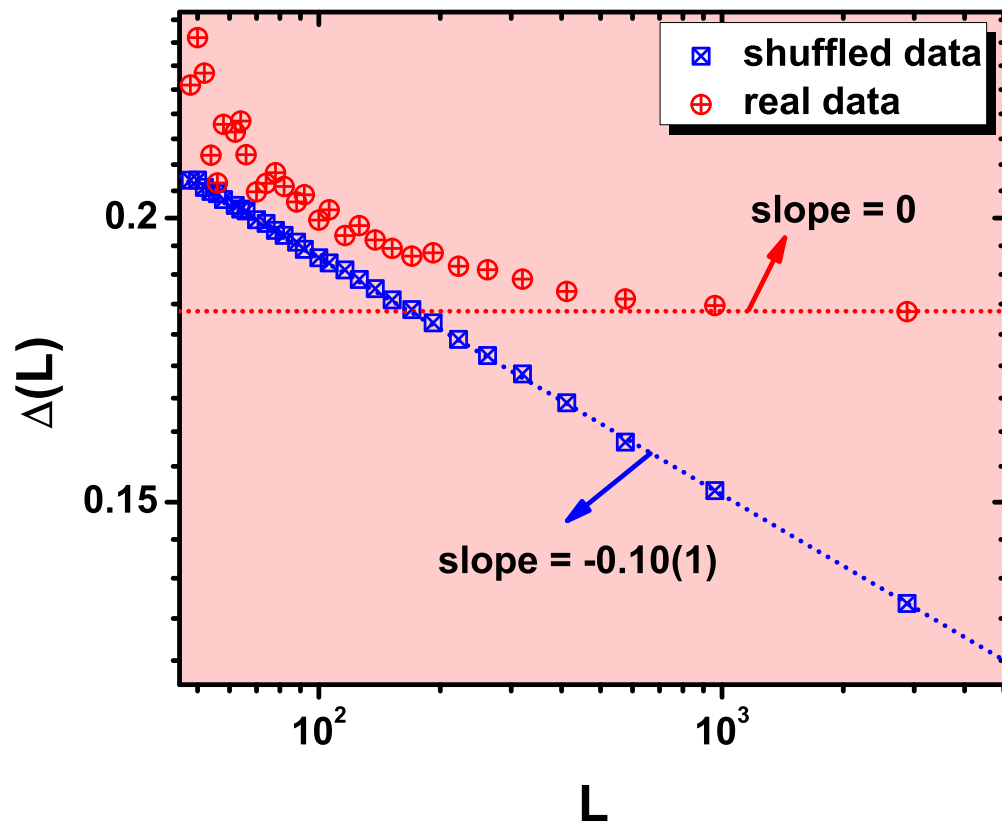
Fig. S7. Log-log plot of the largest gap $\Delta(L)$ versus the network system size L for original data (red) and shuffled data (blue). For the real data, the slope seems to approach zero for large L, suggesting a discontinuous phase transition. For the real data, L is increased simply by increasing the resolution. For the shuffled data, the slope approaches 0.10, which suggests a continuous phase transition with a known critical exponent $\beta/\nu = 5/48$. L is defined as the number of nodes in the zonal direction.
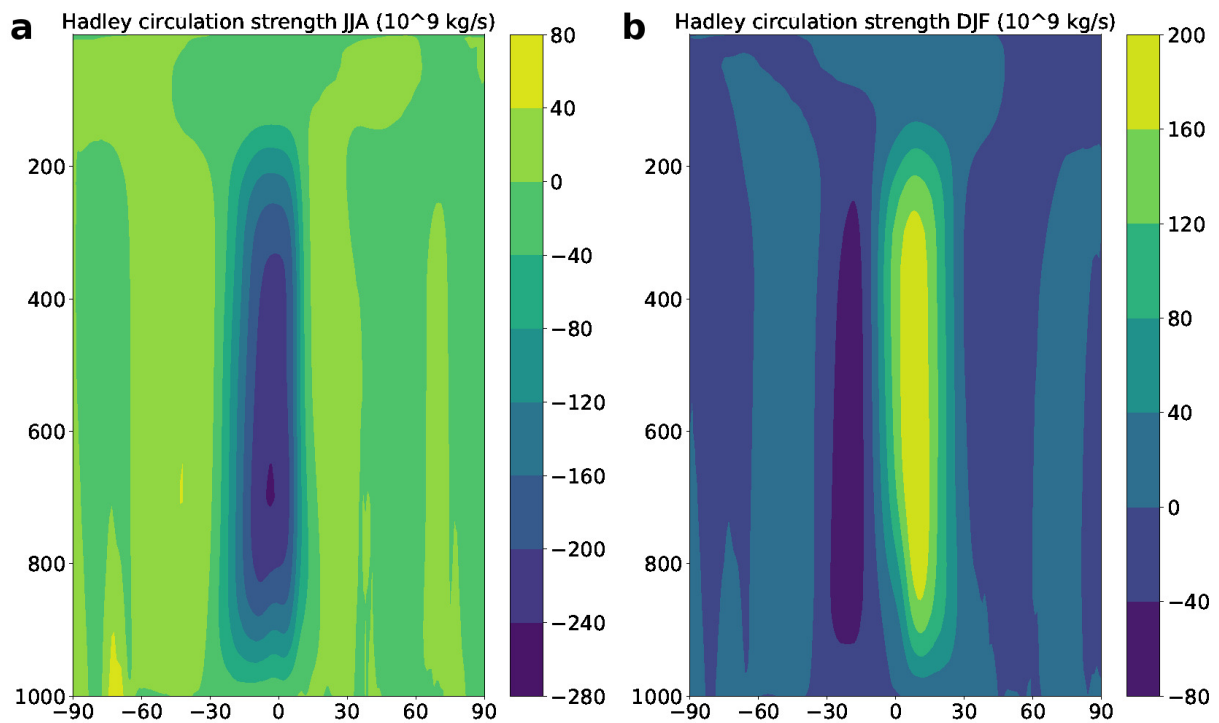
Fig. S8. Cross-section of zonal-mean mass stremfunction Ψ for annual-mean conditions in units of $10^9\ kgs^{-1}$ based on 1979-2016 ERA-Interim reanalysis data. (a) For the boreal summer in June-July-August and (b) for the boreal winter in December-January-February.

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Movie S1. The dynamical evolution of the climate networks. The links are sorted in decreasing order of strength and then added one by one according to decreasing strength W, r is the fraction number of links, G is the relative size of the largest cluster (indicated by red color). See main text for more details.