

Supplementary Information

Arctic Cyclones Have Become More Intense and Longer-lived Over the Past Seven Decades

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Introduction

The supplementary information includes seven figures showing an EnCAI and AO comparison, the EnCAIs in September and march, strong cyclone tracks during winter and summer in the three reanalysis datasets, multi-decadal climatology of the maximum Eady Growth Rate (EGR) at 900 hPa and Geopotential Height (GHT) at 500 hPa and 50 hPa (winter)/300 hPa (summer), and Potential Vorticity (PV) at 300 hPa for the winters (October-March) from 1985/86-2020/21 and 1950/51-1984/85 and for the summers (April-September) from 1986-2021 and 1950-1985.

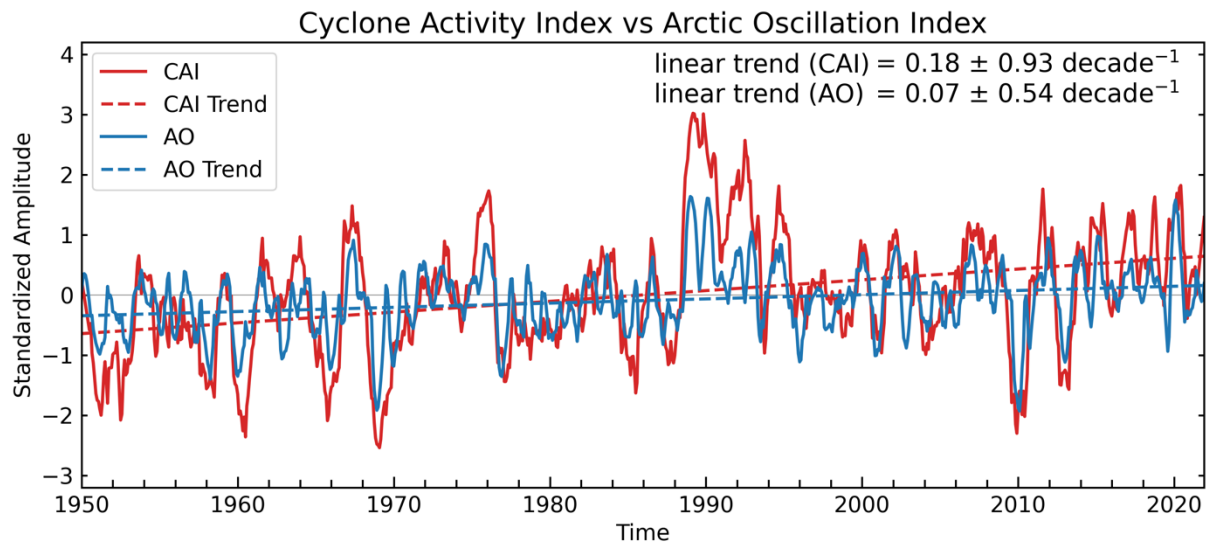
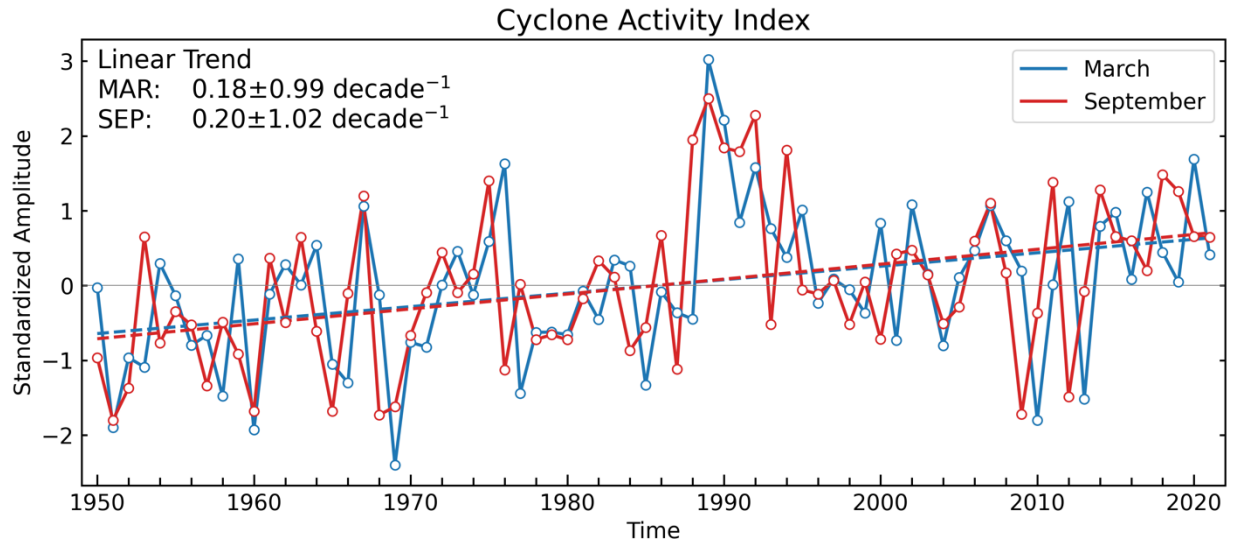


Fig. S1: EnCAI and AO indices. The monthly EnCAI (in red) averaged from those in the three reanalysis datasets and the monthly AO index (in blue) from the NOAA Climate Prediction Center (https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml). The dashed lines represent their corresponding linear trends.



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32 **Fig. S2: EnCAIs in March and September.** The standardized EnCAIs for March (blue) and
 33 September (red) when the Arctic sea ice extent reaches its maximum and minimum values in the
 34 climatological annual cycle.

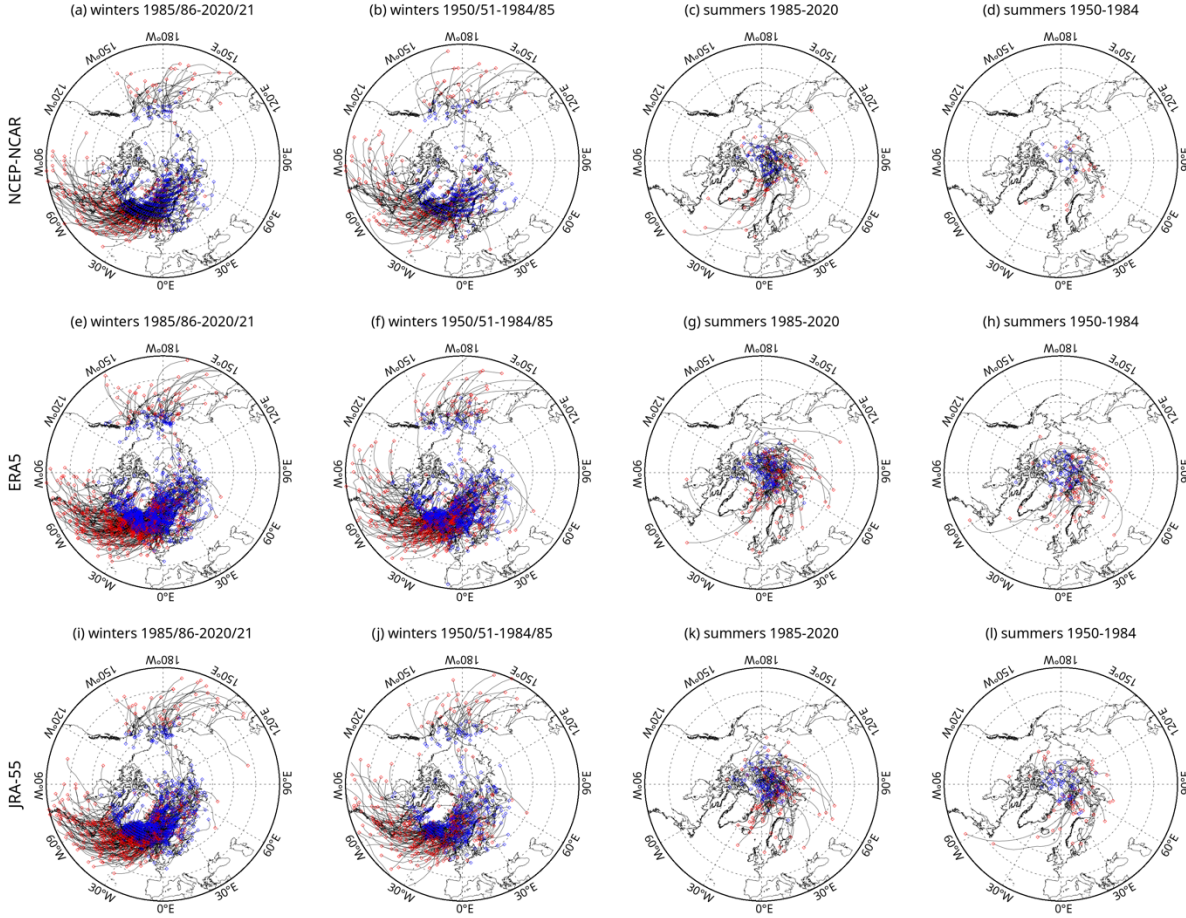
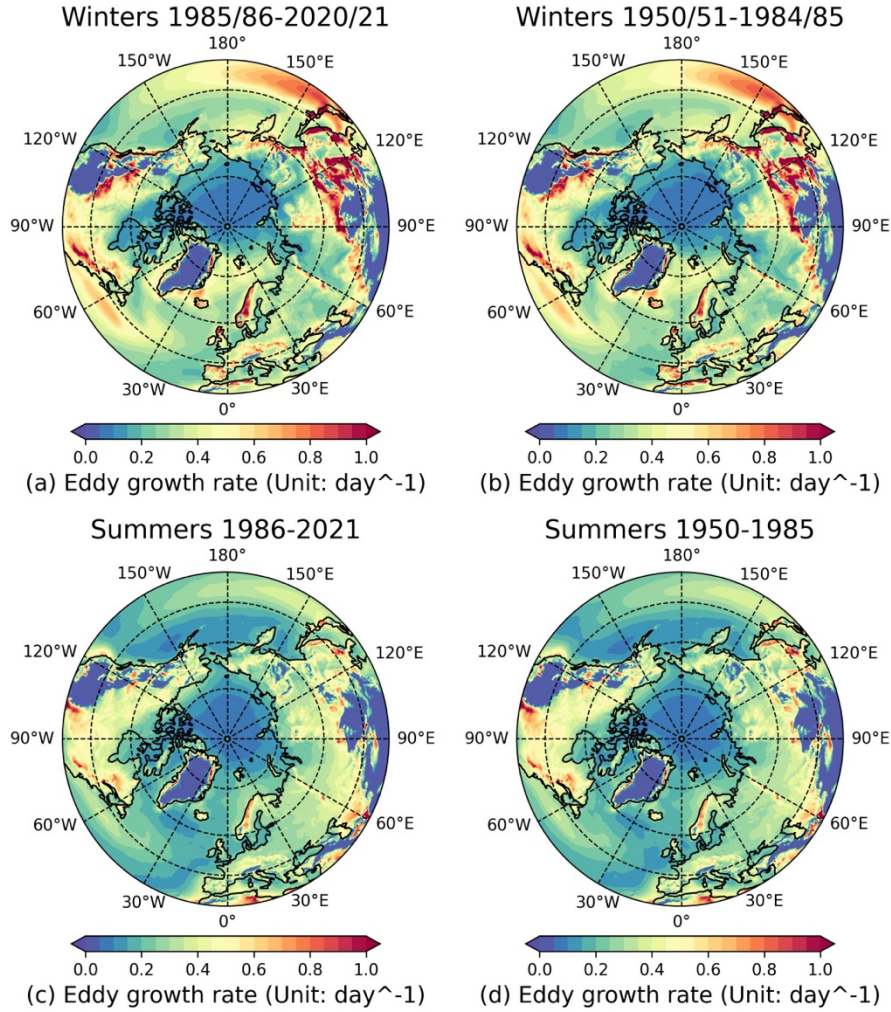


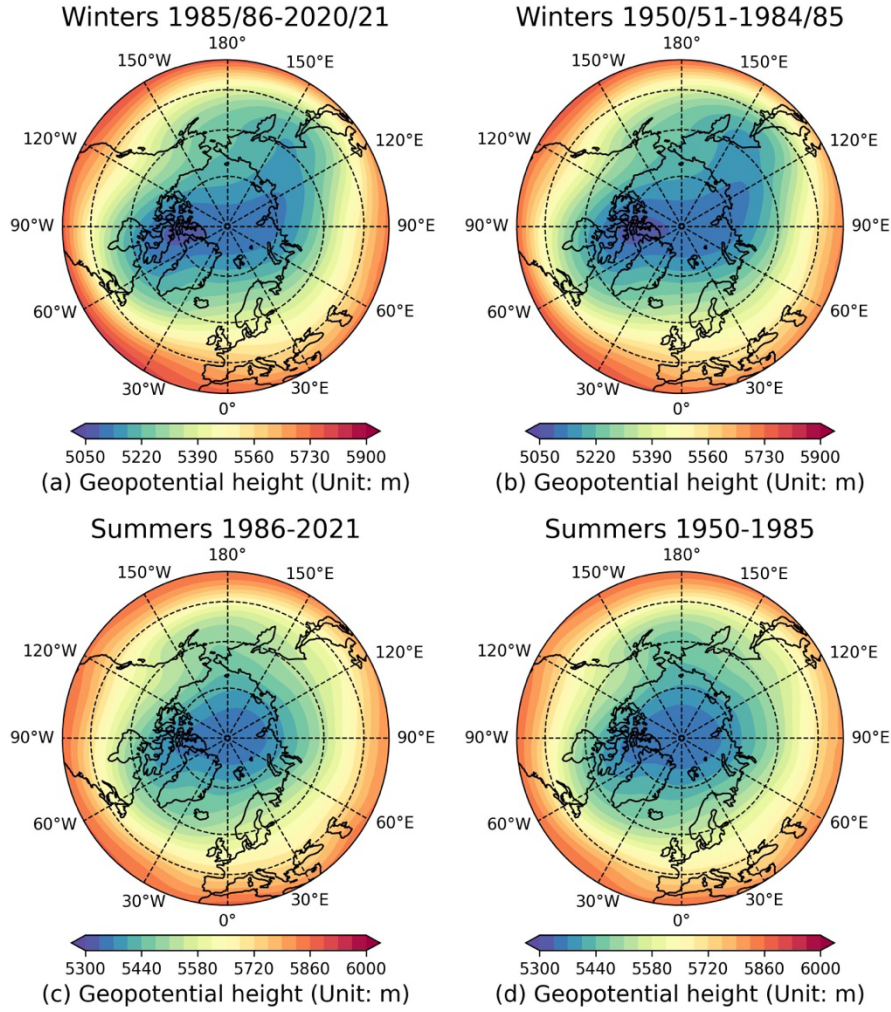
Fig. S3: Cyclone tracks during winter and summer: The tracks of the cyclones whose averaged central SLP deeper than 970 hPa after entering the Arctic (north of 60°N) during the winters of (a) 1985/86 - 2020/21 and (b) 1950/51 - 1984/85 in the NCEP/NCAR reanalysis dataset. (e)-(f) and (i)-(j) are the same as (a)-(b) but for the ERA5 and JRA-55. (c)-(d), (g)-(h), and (k)-(l) are the same as (a)-(b), (e)-(f), and (i)-(j) but for the summers of 1986 - 2021 and 1950 - 1985. The selected summer cyclones have averaged central SLP deeper than 985 hPa after entering the Arctic (north of 60°N) and reach the central Arctic (north of 80°N). The red and blue circles indicate the locations of cyclogenesis and cyclolysis. Comparison of the tracks indicates that higher resolution dataset captures more cyclones, which is more obvious for the summer season. Strong summer cyclones

45 are mainly generated withing the Arctic, while a large portion of strong Arctic winter cyclones
 46 originate from the midlatitudes and the subarctic.



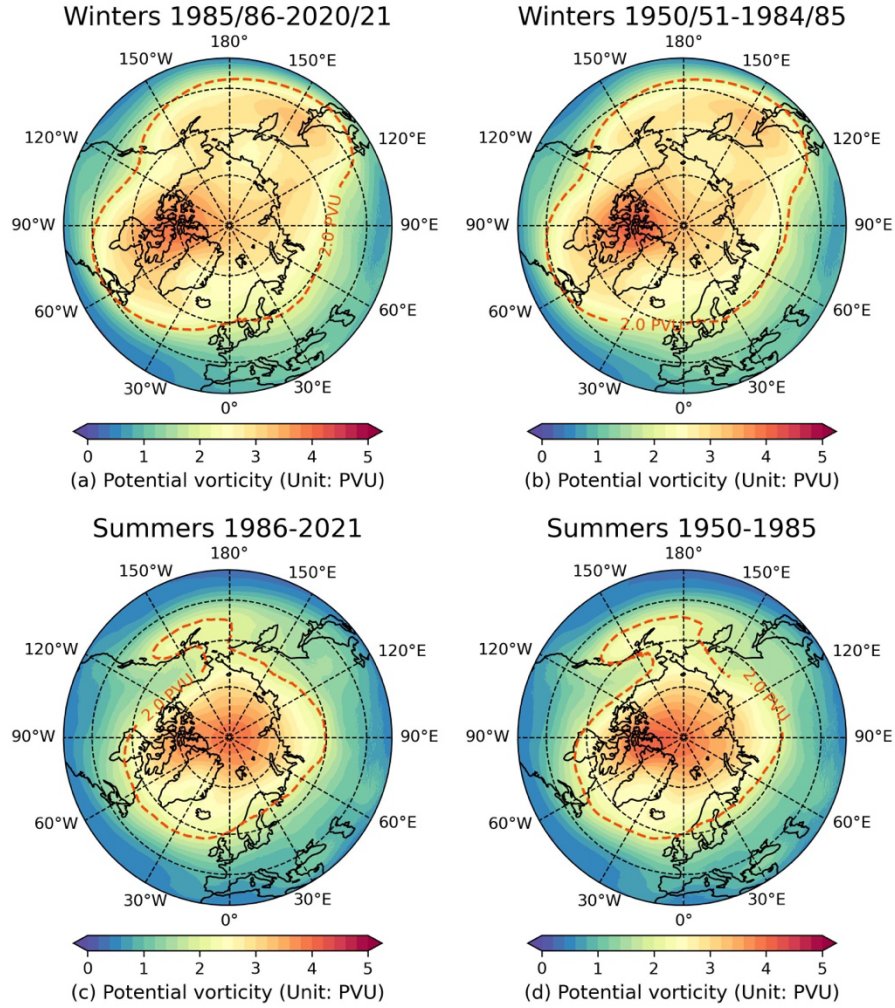
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48 **Fig. S4: Climatological mean states of baroclinic instability.** The multi-decadal climatological
 49 mean maximum Eady Growth Rate (EGR) for the winters from (a) 1985/86-2020/21 and (b)
 50 1950/51-1984/85. (c) and (d) are the same as (a) and (b) but for the summers from 1986-2021 and
 51 1950-1985, respectively. The unit is day⁻¹.



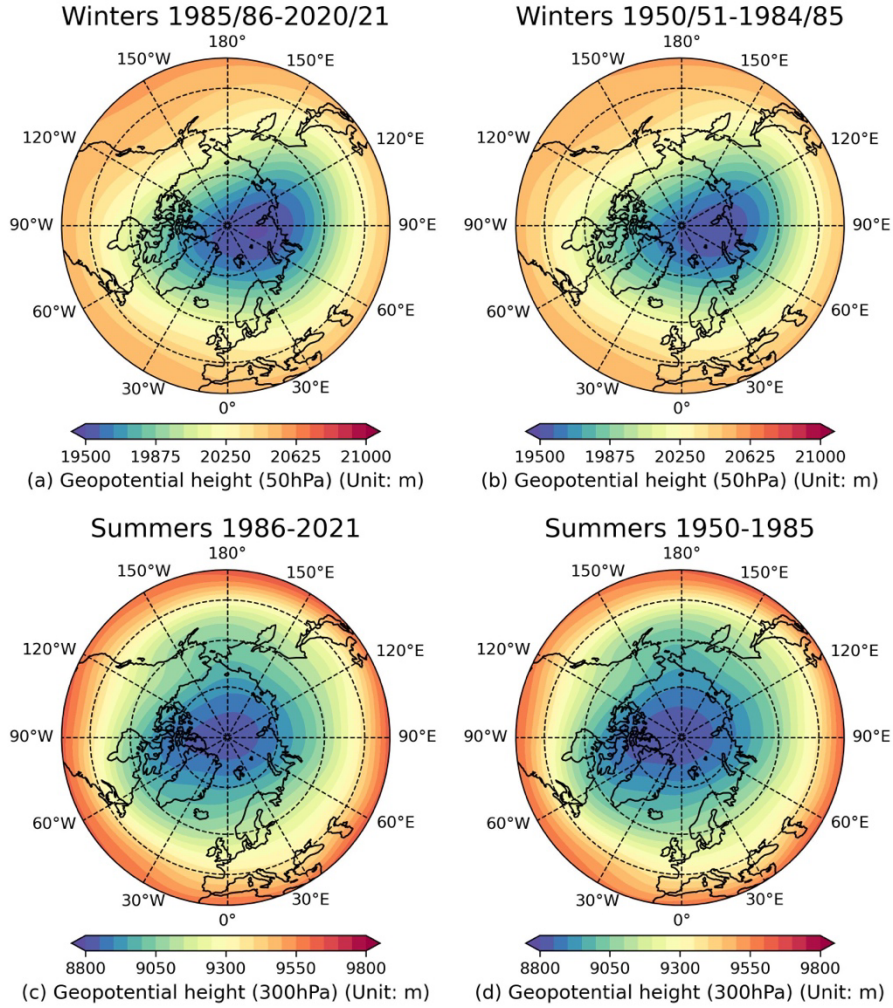
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53 **Fig. S5: Climatological mean states of the tropospheric circulation.** The multi-decadal
 54 climatological mean 500 hPa geopotential height (GHT) for the winters from (a) 1985/86-2020/21
 55 and (b) 1950/51-1984/85. (c) and (d) are the same as (a) and (b) but for the summers from 1986-
 56 2021 and 1950-1985, respectively. The unit is meter.



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58 **Fig. S6: Climatological mean states of 300 hPa PV.** The multi-decadal climatological mean 300
 59 hPa potential vorticity (PV) for the winters from (a) 1985/86-2020/21 and (b) 1950/51-1984/85.
 60 (c) and (d) are the same as (a) and (b) but for the summers from 1986-2021 and 1950-1985,
 61 respectively. The unit is PVU ($10^{-6} \text{ m}^2 \text{ s}^{-1} \text{ K kg}^{-1}$). The red dashed contour line represents 2.0 PVU,
 62 which indicates the intersection of the dynamic tropopause and 300 hPa surface.



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64 **Fig. S7: Climatological mean states of the stratospheric circulation.** The multi-decadal
 65 climatological mean 50 hPa geopotential height (GHT) for the winters from (a) 1985/86-2020/21
 66 and (b) 1950/51-1984/85. (c) and (d) are the same as (a) and (b) but at 300 hPa for the summers
 67 from 1986-2021 and 1950-1985, respectively. The unit is meter.