



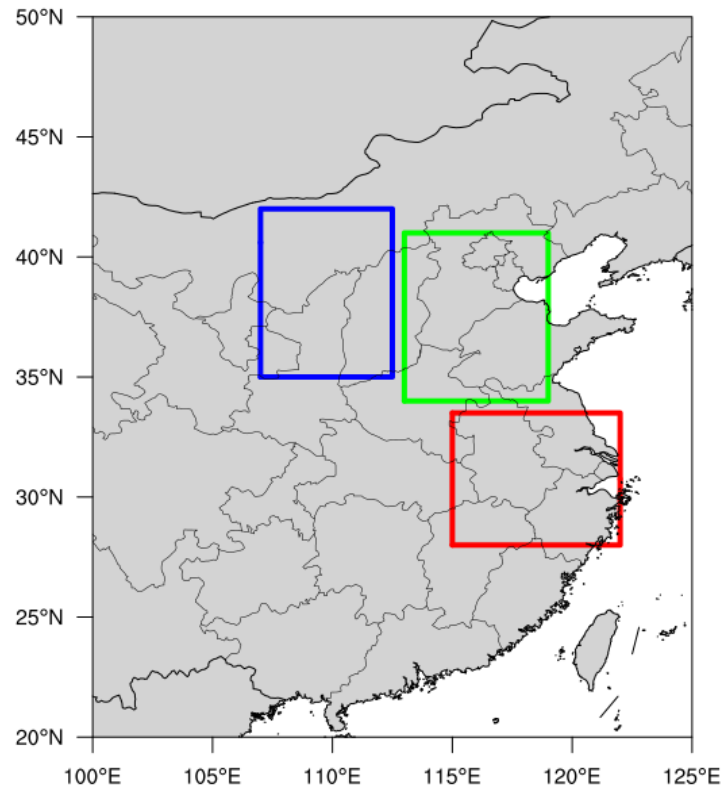
Supplement of

An underappreciated cyclonic-like circulation affects high summer ozone in North China Plain

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2 **Figure S1.** Geographic domains of the NCP, NW, and SE regions. Green, blue, and red rectangles
3 denote the NCP (34°–41°N, 113°–119°E), NW (34°–42°N, 107°–112.5°E), and SE (28°–33.5°N,
4 113°–122°E) regions, respectively.

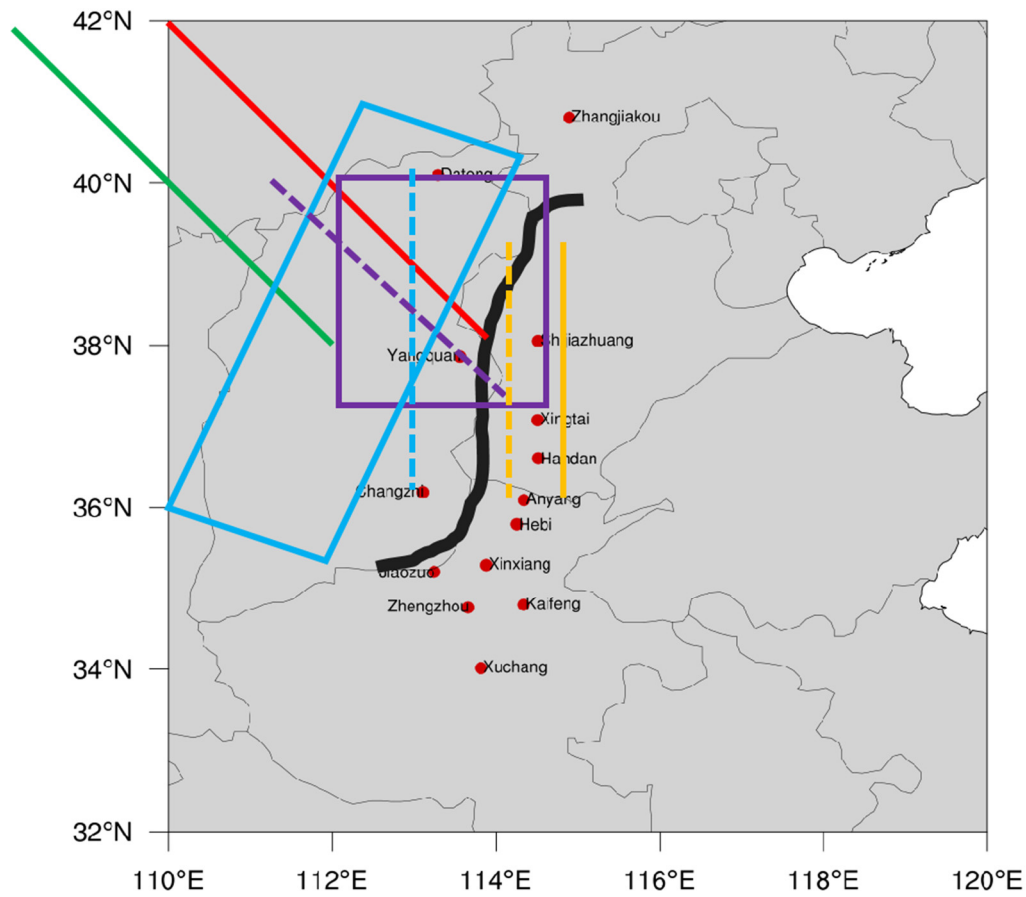
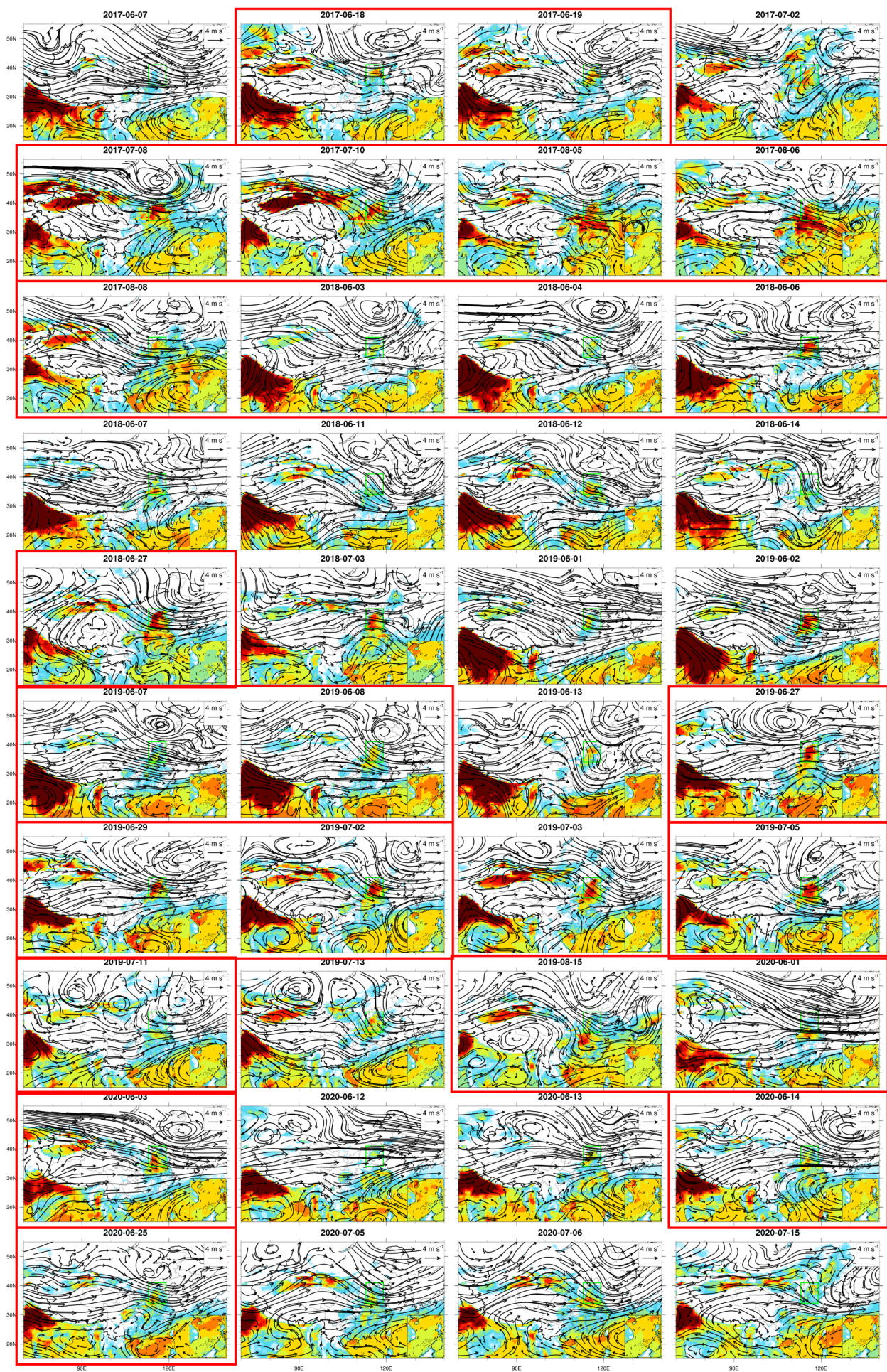


Figure S2. Locations of transects used to identify northwesterly flow associated with cyclonic-like circulation. The green solid line represents the transect adopted by Chen and Lu (2016). The red solid line, purple boxed line, purple dashed line, blue boxed line, blue dashed line, yellow solid line, and yellow dashed line denote transect_1 through transect_7, respectively. Transect 3 achieves the highest accuracy in detecting cyclonic-like circulation and is therefore used in this study to identify northwesterly flow associated with cyclonic-like circulation.



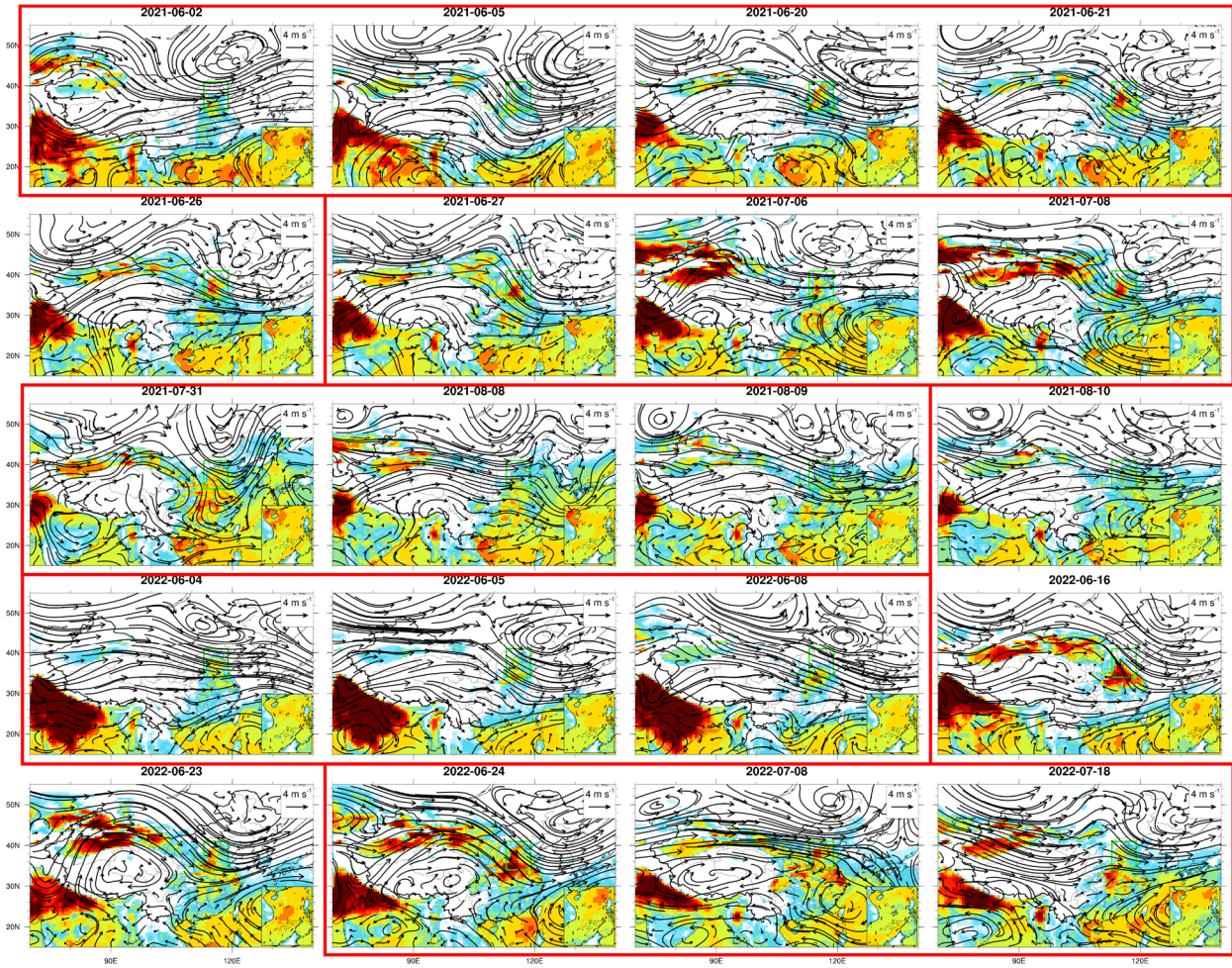


Figure S3. Absolute wind fields for all individual days identified by the cyclonic-like circulation index. Arrows denote absolute wind vectors, and shading represents 2-m air temperature. Red boxes indicate days that coincide with those identified as cyclonic-like circulation days through manual inspection.

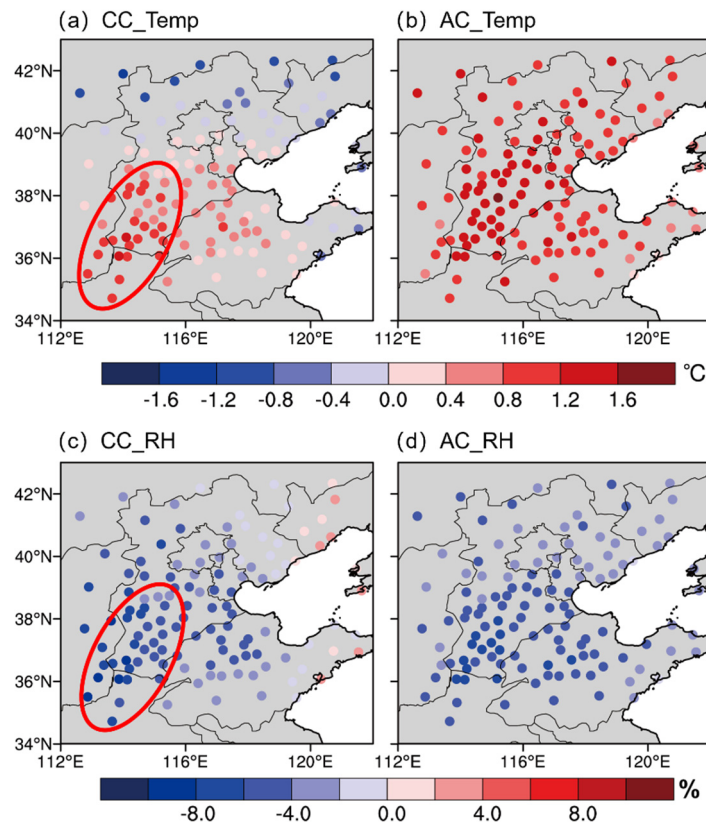


Figure S4. Anomalies in observed (a, b) 2-m temperature and (c, d) relative humidity under cyclonic-like circulation (left) and anticyclonic circulation (right). The red circles highlight the pronounced warming and drying over the adjacent plains of the Taihang Mountains under cyclonic-like circulation.

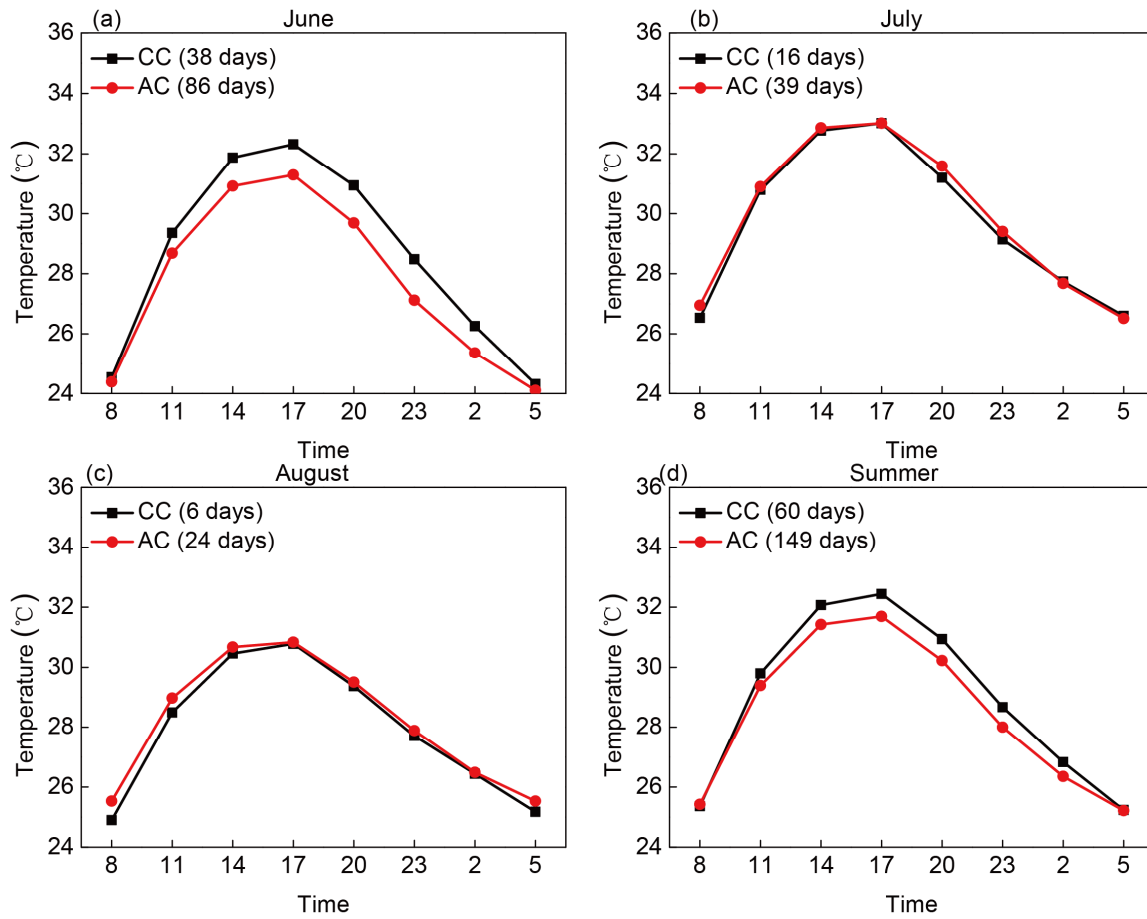


Figure S5. Diurnal temperature variations at stations (37°N, 115°E) in the western NCP under cyclonic-like circulation (black line) and anticyclonic circulation (red line) in (a) June, (b) July, (c) August, and the (d) summer mean during 2017-2022.

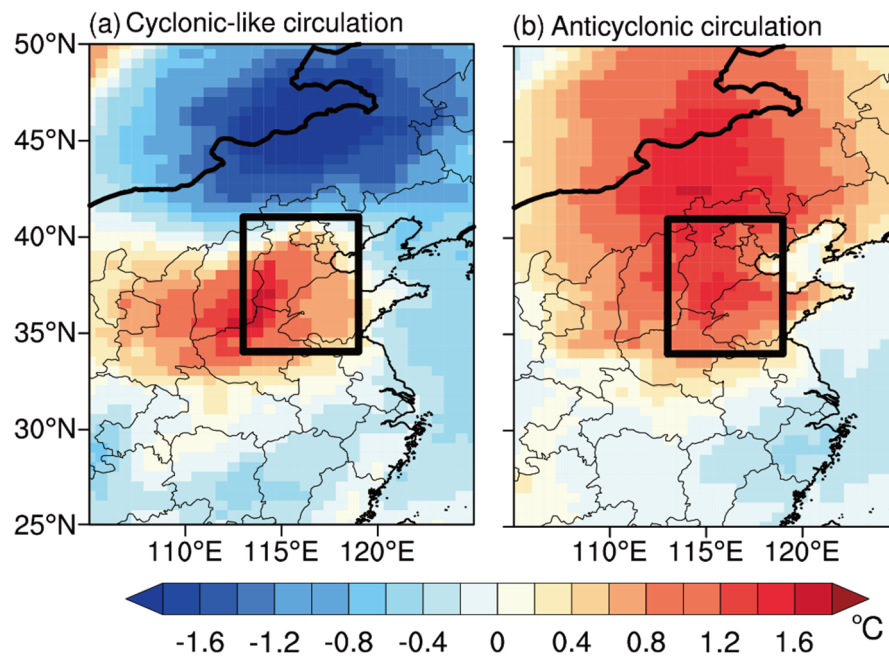
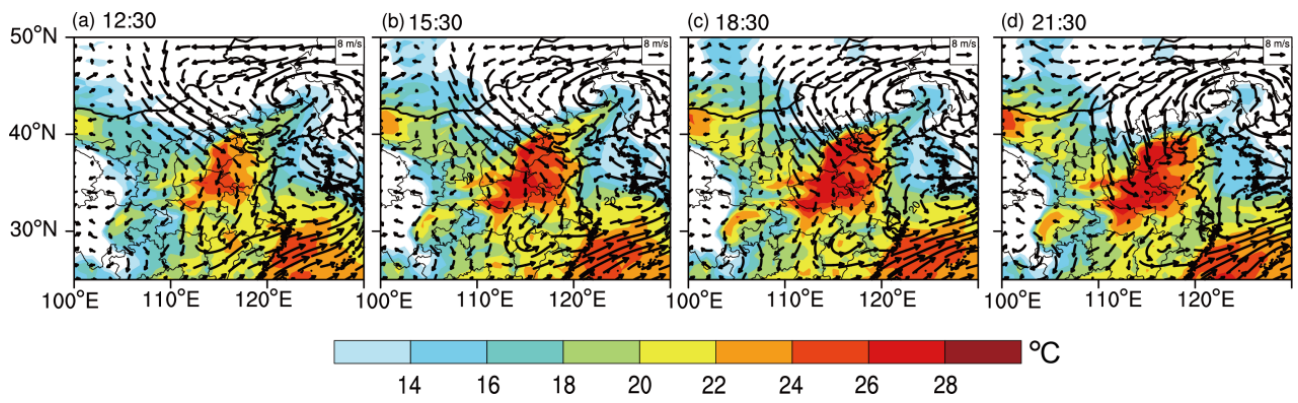


Figure S6. Temperature anomalies under (a) cyclonic-like circulation and (b) anticyclone circulation. The black rectangles denote the NCP. Anomalies are calculated by subtracting the corresponding multi-year mean for June, July, and August, respectively.



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30 **Figure S7.** Spatial pattern of the 850 hPa wind field (vectors) and surface temperature (filled colors)

31 on 5 June 2022.

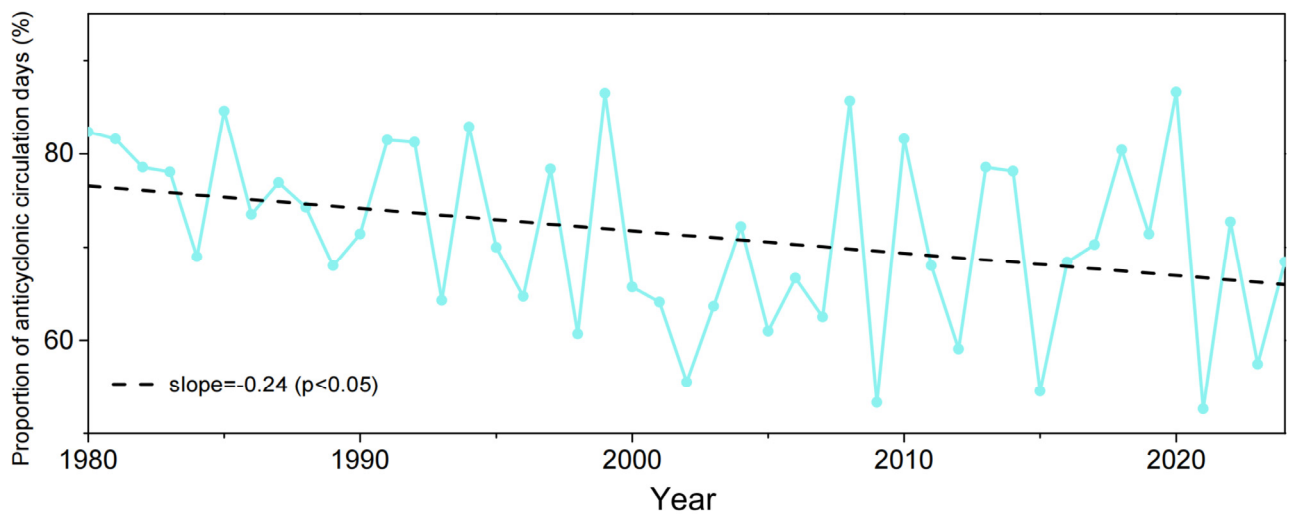
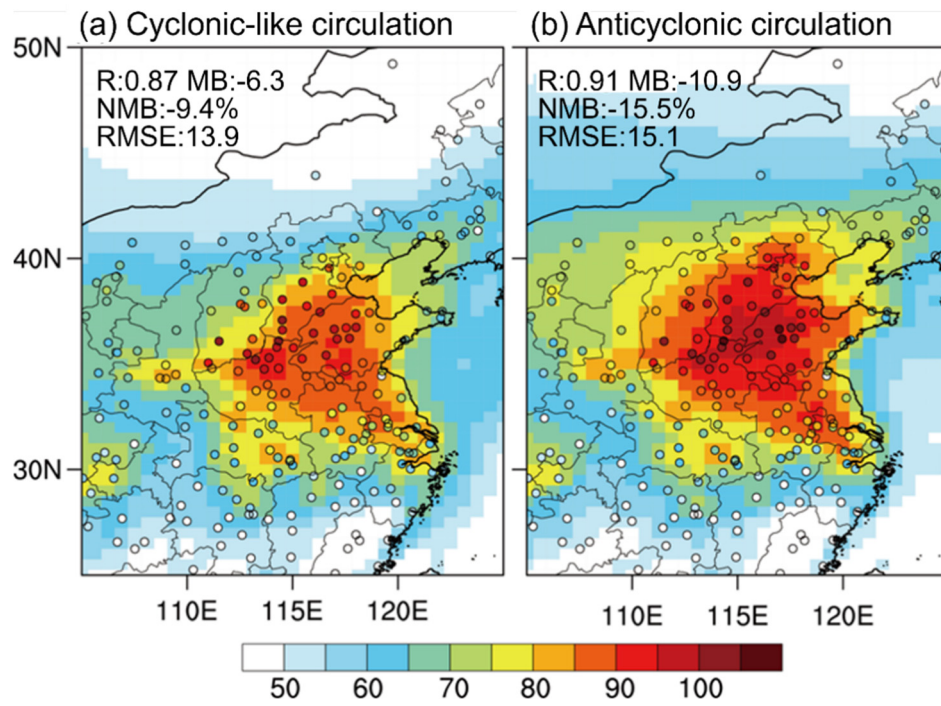
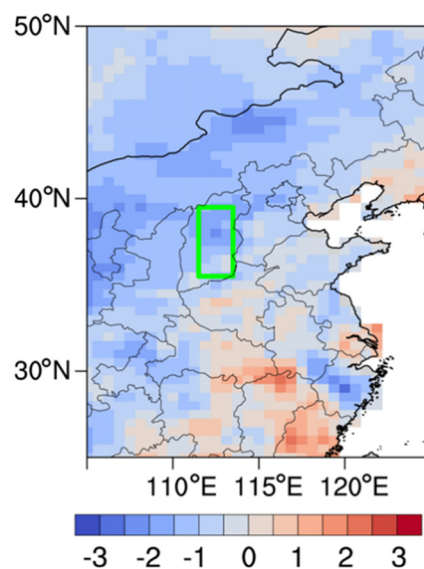


Figure S8. Long-term trends of the proportion of anticyclonic circulation on days with temperatures exceeding 32 °C in the NCP in summer from 1980 to 2024. Long-term trends of the proportion of anticyclonic circulation on days with temperatures exceeding 32 °C in the NCP in summer from 1980 to 2024. The dash line indicates the linear fitting trend.



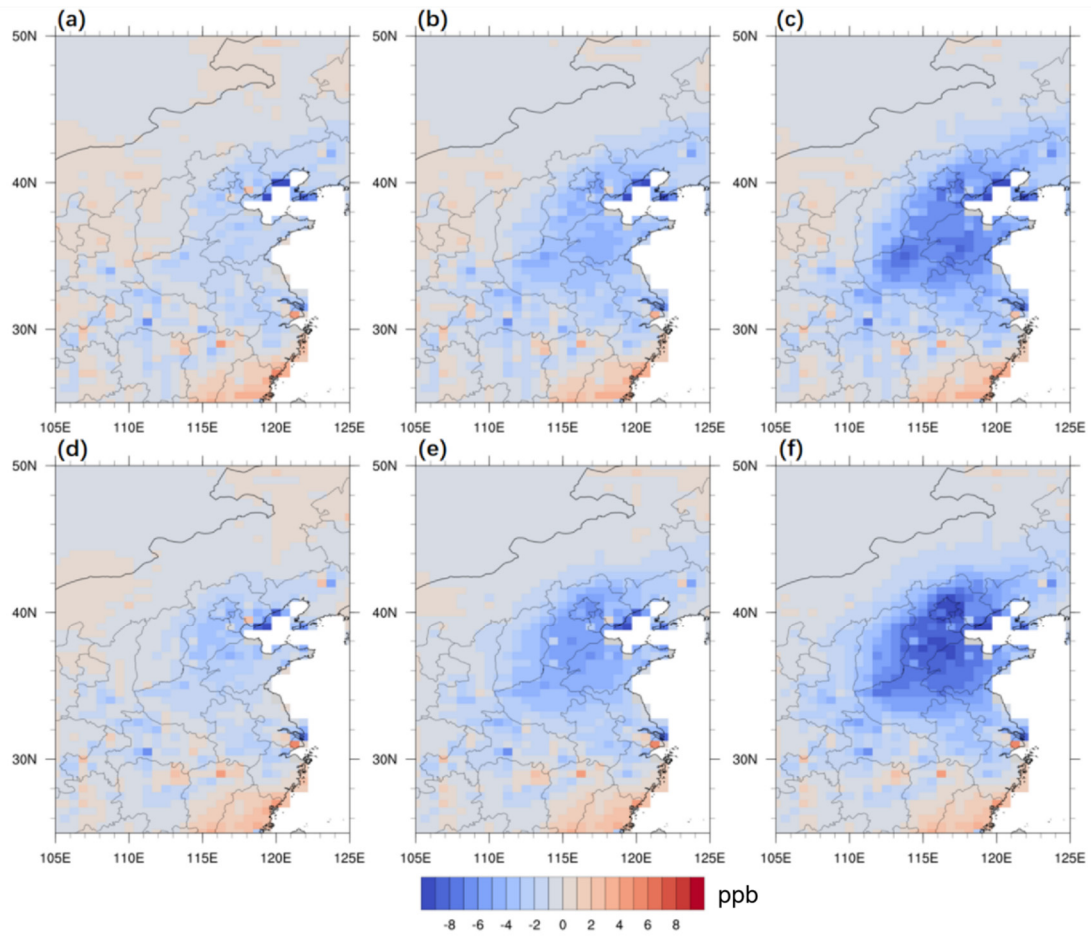
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38 **Figure S9.** Validation of the simulated MDA8 ozone concentrations against the observed data under
 39 (a) cyclonic-like circulation and (b) anticyclonic circulation. Filled colors represent the simulation
 40 results and dots denote the observations. Values in the upper left are mean bias (MB), normalized mean
 41 bias (NMB), and root-mean-square error (RMSE).



42

43 **Figure S10.** Changes in ozone concentrations resulting from setting BVOC emissions over the
 44 mountainous region to zero. The green rectangle indicates the region where MEGAN-derived BVOC
 45 emissions were turned off, while all other model settings remained unchanged from the control
 46 simulation.



47

48 **Figure S11.** Response of MDA8 ozone concentration to (a, d) 10%, (b, e) 30%, and (c, f) 50%
 49 reductions in both NO_x and VOCs emissions over the NCP region under cyclonic-like circulation
 50 (upper panel) and anticyclonic circulation (lower panel).

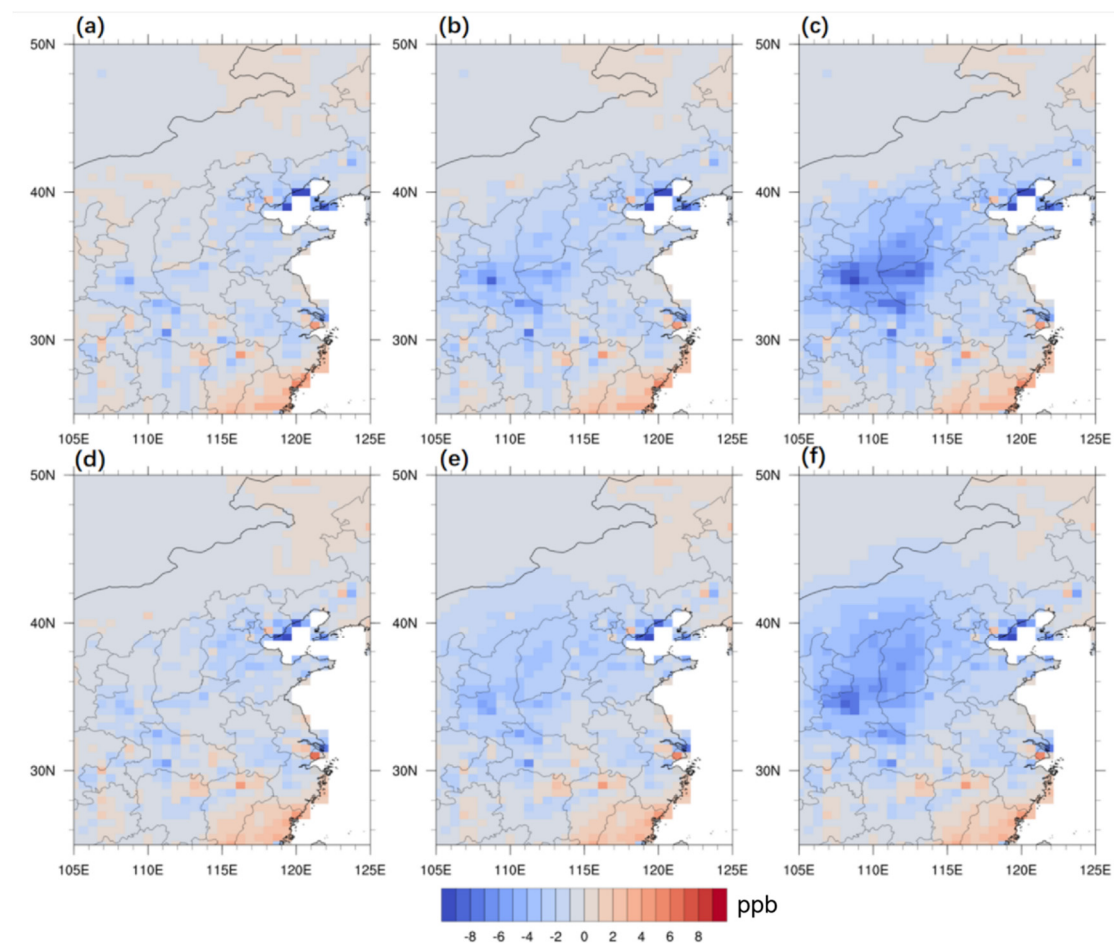
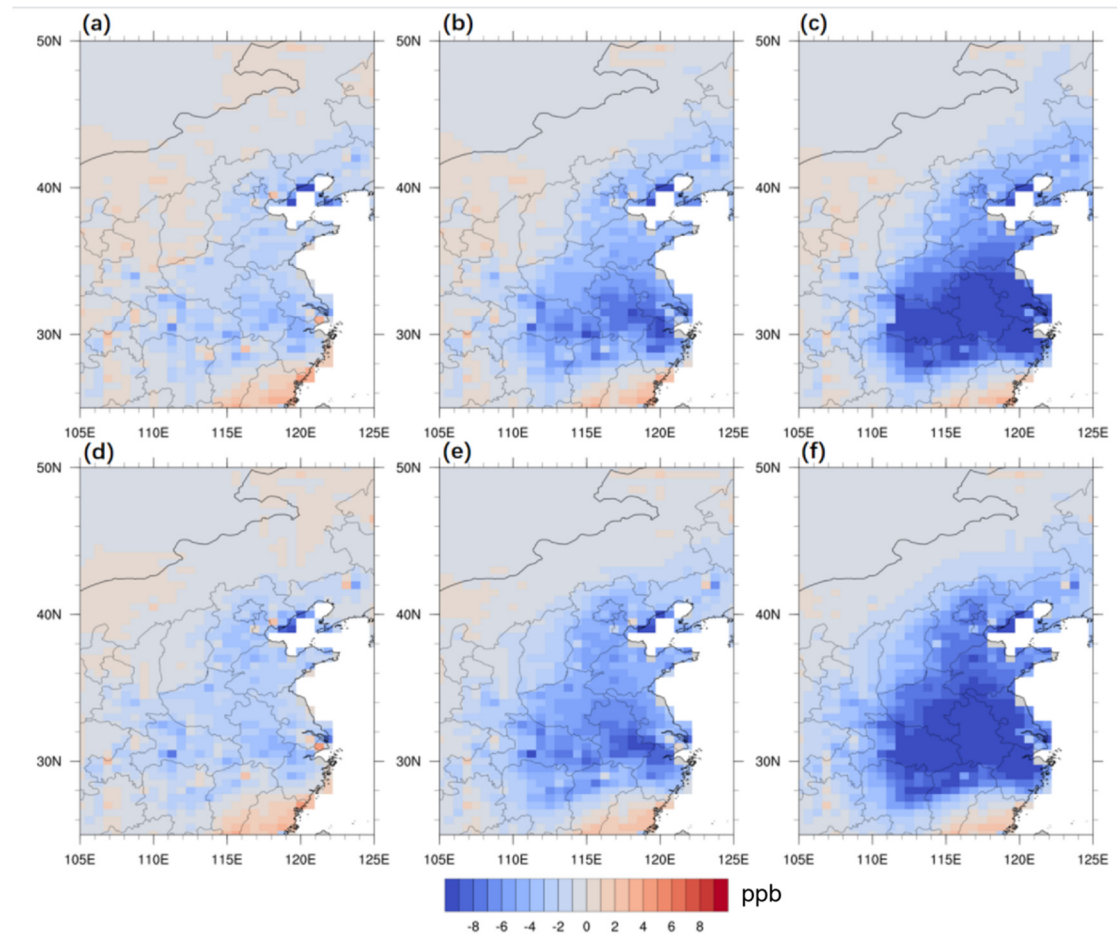


Figure S12. Response of MDA8 ozone concentration to (a, d) 10%, (b, e) 30%, and (c, f) 50% reductions in both NO_x and VOCs emissions over the NW region under cyclonic-like circulation (upper panel) and anticyclonic circulation (lower panel).



56

57 **Figure S13.** Response of MDA8 ozone concentration to (a, d) 10%, (b, e) 30%, and (c, f) 50%
 58 reductions in both NO_x and VOCs emissions over the SE region under cyclonic-like circulation (upper
 59 panel) and anticyclonic circulation (lower panel).