Supplement Material

for

A significant mechanism of stratospheric O_3 intrusion to atmospheric environment: a case study of North China Plain

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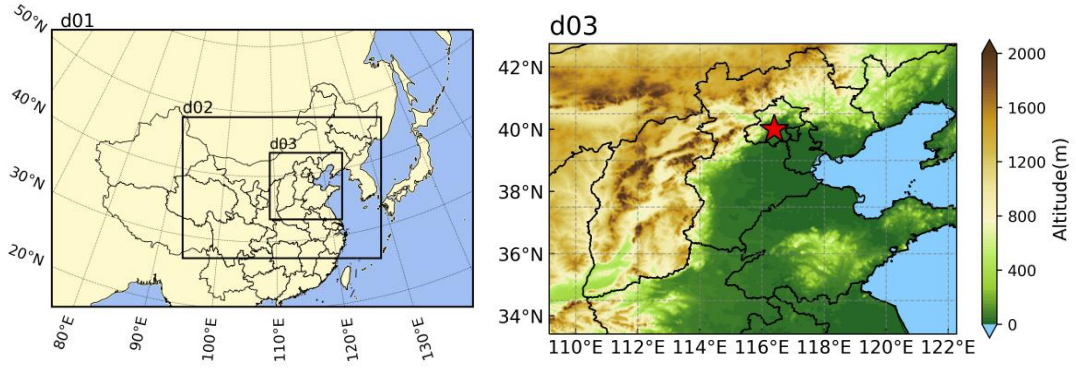

Figure S1: The spatial distributions of three nesting domains d01, d02 and d03 with terrain altitude (m in a.s.l.). The red star represents the capital of China, Beijing.

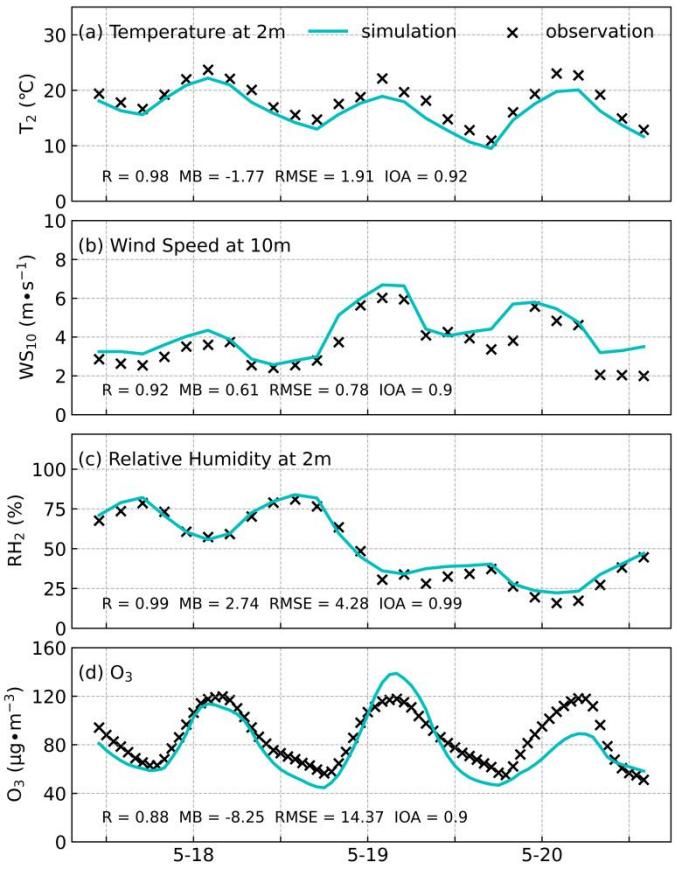

Figure S2: Hourly changes of simulated and observed meteorological elements and near-surface O_3 concentrations during May 18–20, 2019 averaged over North China.

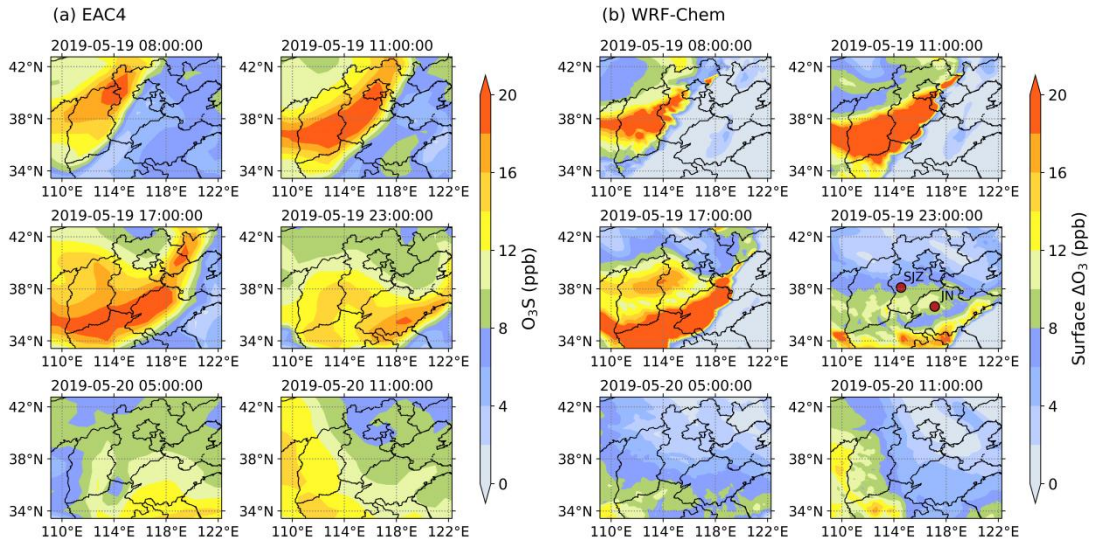

Figure S3: Spatial distribution of (a) the surface O_3S derived from EAC4 data and (b) the differences of surface O_3 between $CASE_{STRO3}$ and $CASE_{noSTRO3}$ simulations of WRF-Chem over the NCP. The red dots in (b) indicate the geographical location of the representative sites SJZ and JN in the NCP.

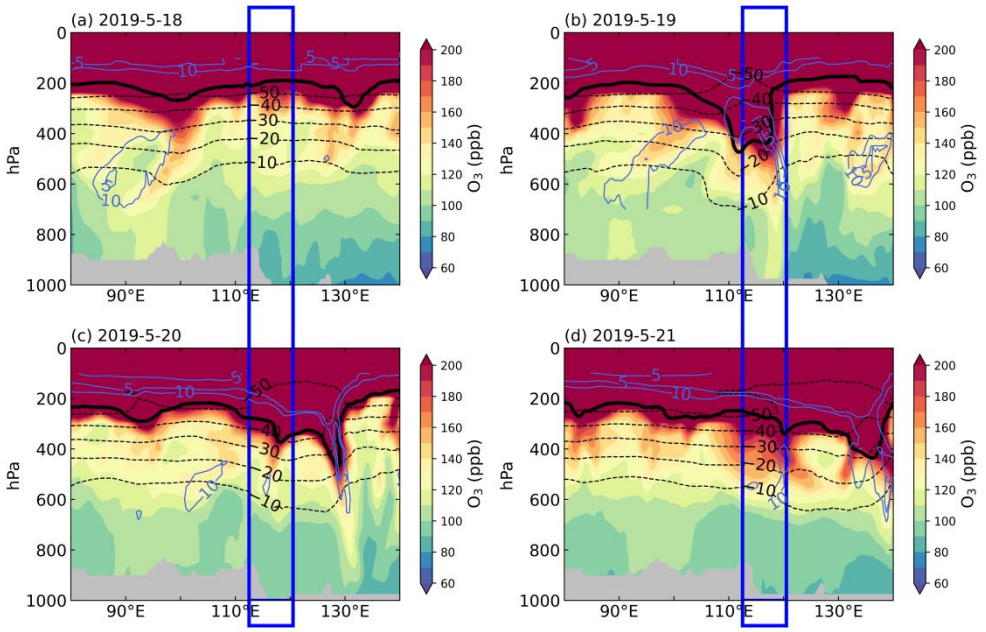

Figure S4: Latitudinal vertical sections of O_3 concentrations (color contours) averaged over 32 °N–40 °N from the MERRA2 data during May 18–21, 2019. Black solid lines indicate the dynamical tropopause labeled by PV=2. The dashed black lines represent air temperature (℃), the solid blue lines represent relative humidity (%), and the blue rectangles mark the NCP region.

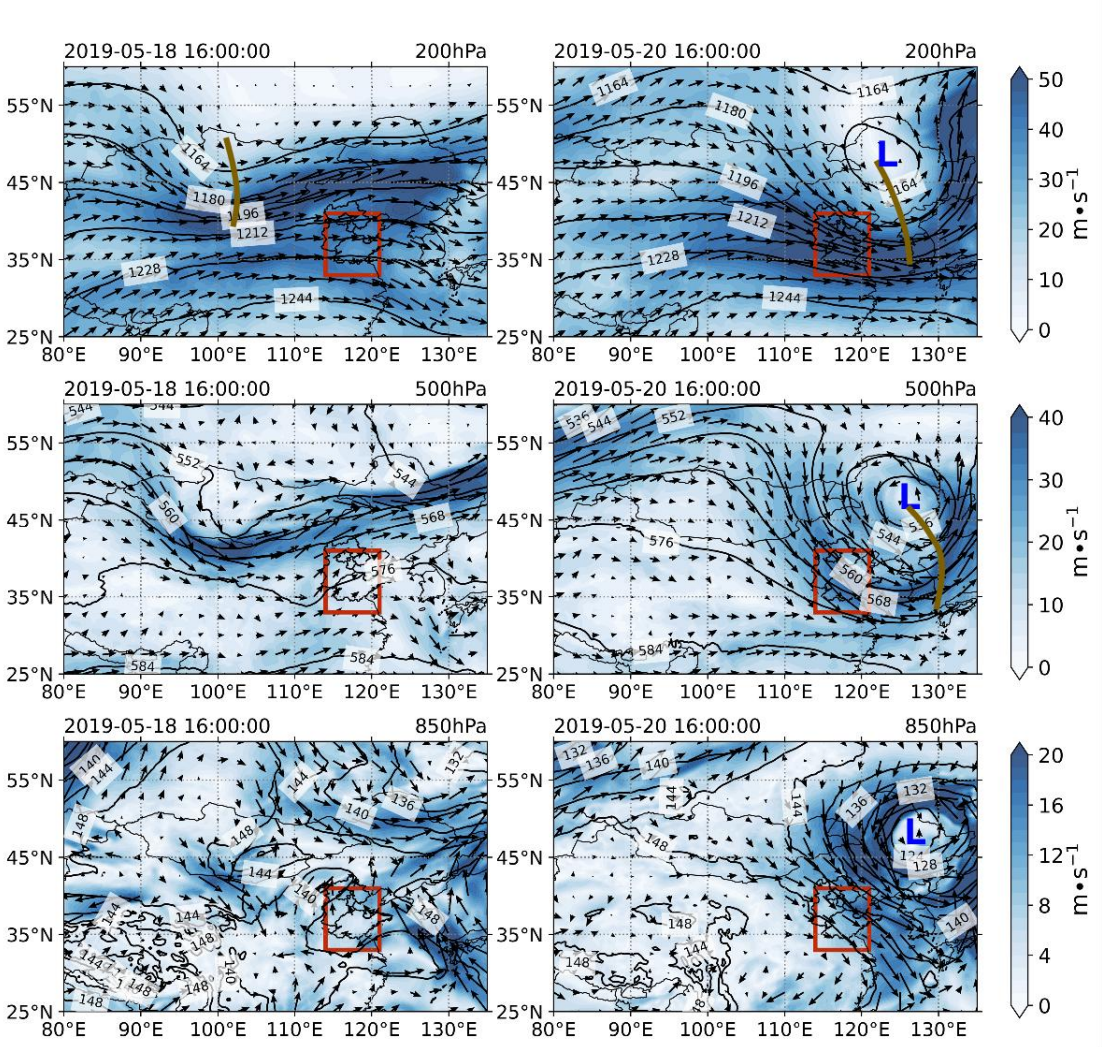

Figure S5: Atmospheric circulation patterns of horizontal wind vectors at 200 hPa, 500 hPa, and 850 hPa at 16:00 LST on May 18 and 20, 2019. The shaded colors and black arrows denote the horizontal wind speed ($m \cdot s^{-1}$), and the black contour lines denote the geopotential height (gpdm). The red solid boxes indicate the scope of the NCP region.

Table S1: Physical and chemical parameterization schemes used in the WRF-Chem simulations.

Process	Parameters	WRF-Chem options
Physical process	Microphysics	Lin scheme
	Longwave radiation	RRTM scheme
	Shortwave radiation	Goddard scheme
	Boundary layer	YSU scheme
	Land surface	unified Noah land-surface model
	Surface layer	MM5 similarity scheme
	Cumulus	Grell 3D ensemble scheme
Chemical process	Gas-phase chemistry	CBMZ
	Aerosol module	MOSAIC_8bins