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Supporting Information for

Ozone Pollution Extremes in Southeast China Exacerbated by Reduced Uptake by Vegetation during Hot Droughts

Meiyun Lin[1*], Yuanyu Xie[1,2], Isabelle De Smedt[3], Larry W. Horowitz[1]

[1] NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ, USA
[2] now at Princeton School of Public Policy and International Affairs, Princeton University, Princeton, NJ, USA
[3] Royal Belgian Institute for Space Aeronomy (BIRA-IASB), Brussels, Belgium

*Corresponding author: Meiyun Lin (Meiyun.Lin@noaa.gov)

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Text S1: Surface air quality observations in China.

We obtain hourly measurements of surface ozone, $PM_{2.5}$, NO_2, and SO_2 concentrations from China's national air quality monitoring network from 2014 to 2023. The number of monitoring sites is ~1000 in 2014, ~1600 during 2015-2020, and ~2000 in 2021-2023. Real-time data are available at https://air.cnemc.cn:18007/ and historical data are archived at https://quotsoft.net/air/. Hourly measurements with values exceeding 1,000 μg/m³ or below 0 μg/m³ (<1% of the dataset) are excluded from our analyses. For gas concentrations (ozone, SO_2, and NO_2), we convert original data in microgram per cubic meter (μg/m³) to parts per billion by volume (ppbv) based on the ideal gas law. Raw observations were reported under the reference condition of 273 K and 1013 hPa before September 1 of 2018. After that, observations were reported under 298 K and 1013 hPa. Following the approach of Li et al. (2020), we convert results from observations and model simulations to the reference condition of 273 K and 1013 hPa for the entire study period. For ozone, we calculate 24 rolling 8-hour average concentrations and maximum daily 8-hour average (MDA8) for each day and at each station. A minimum of 4 valid hourly measurements is required for each 8-hour average calculation, and a minimum of 12 valid 8-hour averages is required for computing MDA8 values on each day.

Text S2: AM4_drySoil and AM4_wetSoil experiments

In this study, we perform a set of 16-year hindcast simulations (2008-2023) with the AM4_drySoil and AM4_wetSoil configurations. Both configurations are based on the GFDL LM4.0 dynamic vegetation land model, but there are significant differences in settings related to the soil-type characterization and soil parameters. The AM4_drySoil experiment applies soil properties from the standard version of LM3.0 as used in the Coupled Model Intercomparison Project Phase 5 (CMIP5) [*Milly et al., 2014; Paulot et al., 2018; Lin et al., 2019*]. The AM4_wetSoil experiment applies soil properties from the standard version of LM4.0 as used in the Coupled Model Intercomparison Project Phase 6 (CMIP6) [*Zhao et al., 2018*; *Held et al., 2019*]. There are no changes in soil depth nor in settings related to albedos associated with snow masking of vegetation between the two experiments. There is a slight difference in land cover, with AM4_drySoil inheriting land cover dataset from CMIP5 while AM4_wetSoil inheriting land cover datasets from CMIP6 (**Fig.S4**). Before starting hindcast simulations from 2008 for the present study, land initial conditions for both experiments have been spun up for hundreds of years with the respective soil and land cover settings. For the AM4_drySoil experiment, land initial conditions in 2008 were taken from a standalone (i.e., observation-based atmospheric forcings) LM4.0 configuration with LM3.0 soil settings that have been spun up for 500+ years, as described in *Lin et al.* [2019, 2020]. Land initial conditions in 2008 for the AM4_wetSoil experiment were obtained from a long AM4/LM4 simulation (including a 102-yr potential vegetation spin-up phase, a 120-yr intermediate land use phase, and a 135-yr historical phase) driven by observed sea surface temperatures and sea ice distributions [*Held et al.*, 2019].

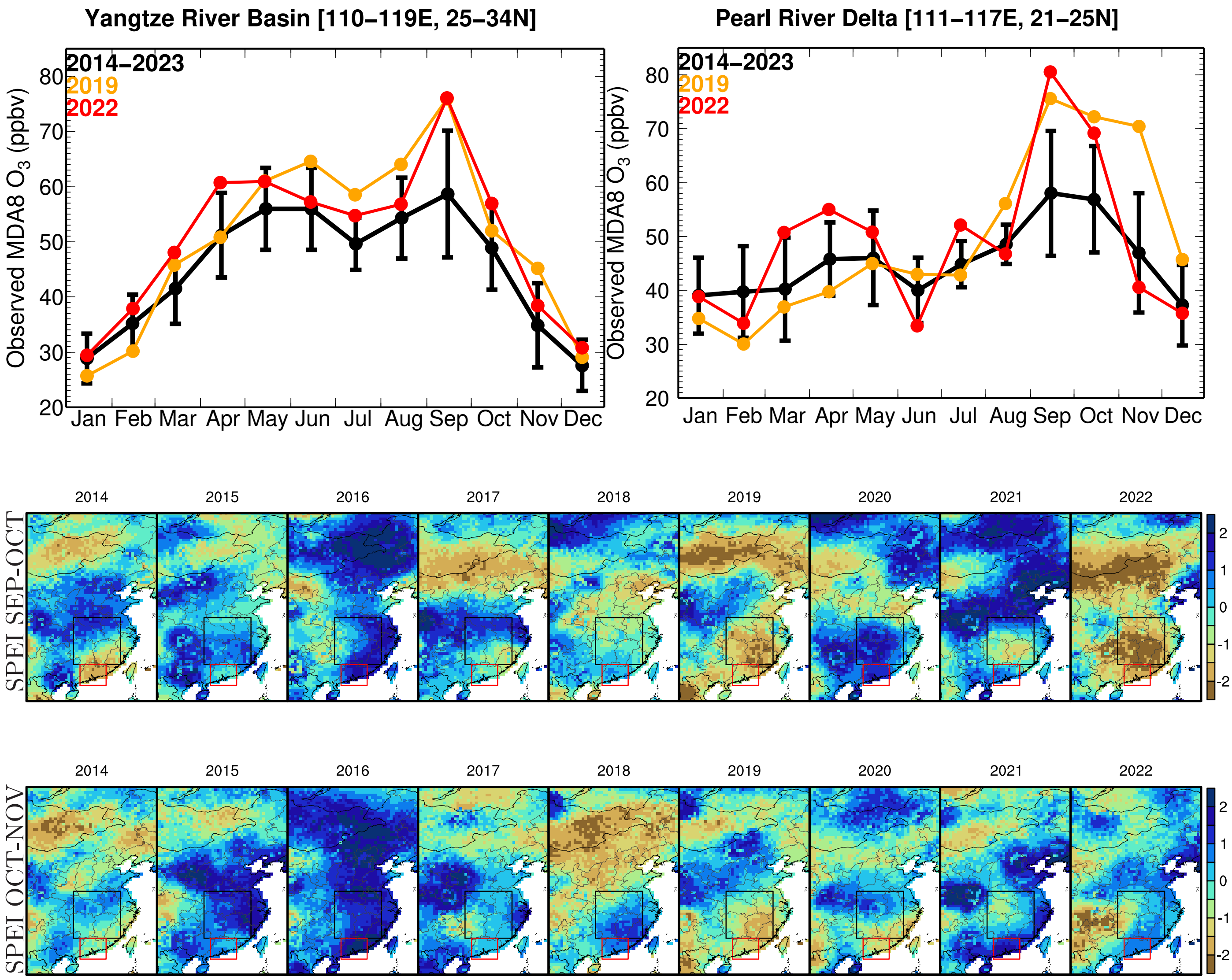

Figure S1. Monthly mean MDA8 ozone in the Yangtze River Basin and the Pearl River Delta in 2019 (orange) and 2022 (red) in contrast to the 2014-2023 monthly climatology (black, with the error bars representing interannual standard deviation). The maps show the Standardized Precipitation Evapotranspiration Index integrating water status over September-October and October-November, respectively. The black box denotes theYangtze River Basin and the red box denotes the Pearl River Delta.

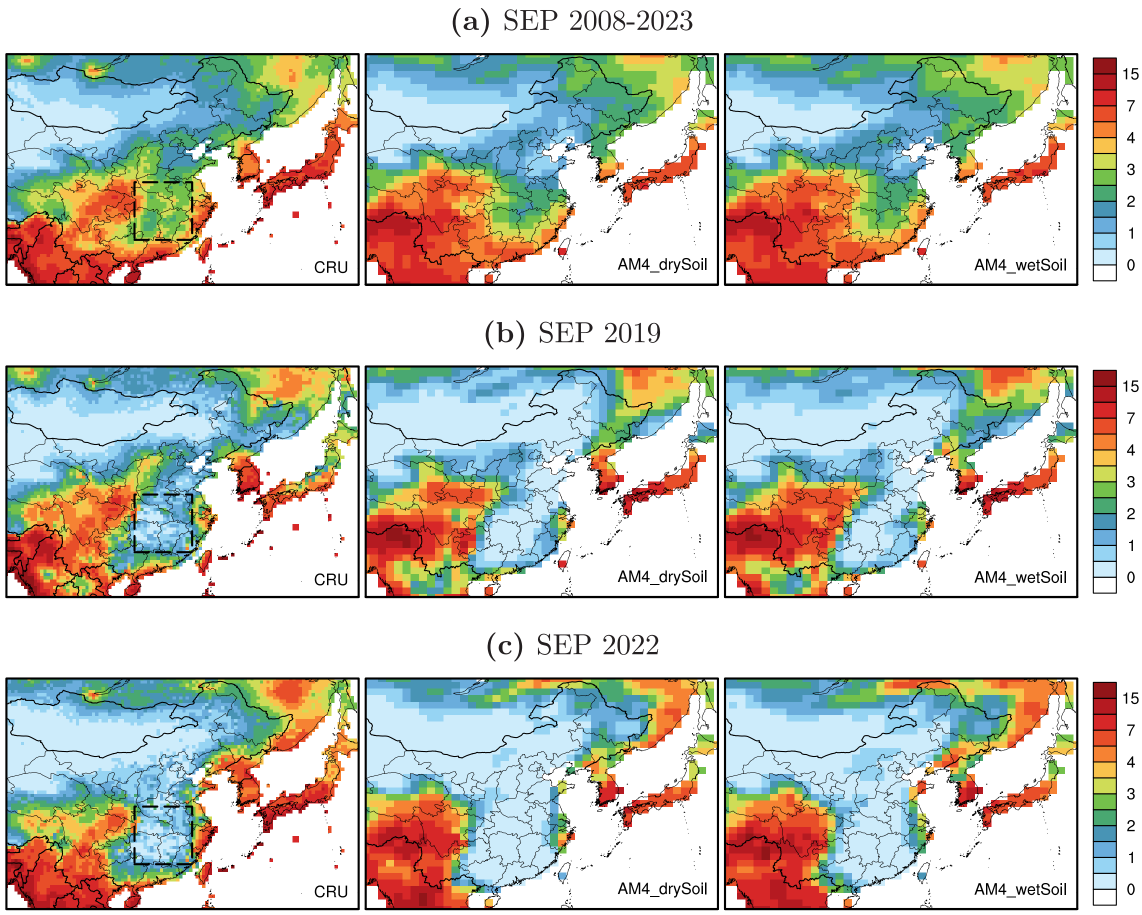

Figure S2. Observed and simulated September mean precipitation (in mm day−1) for the 2008-2023 average, 2019, and 2022. The rectangle denotes the Yangtze River Basin.

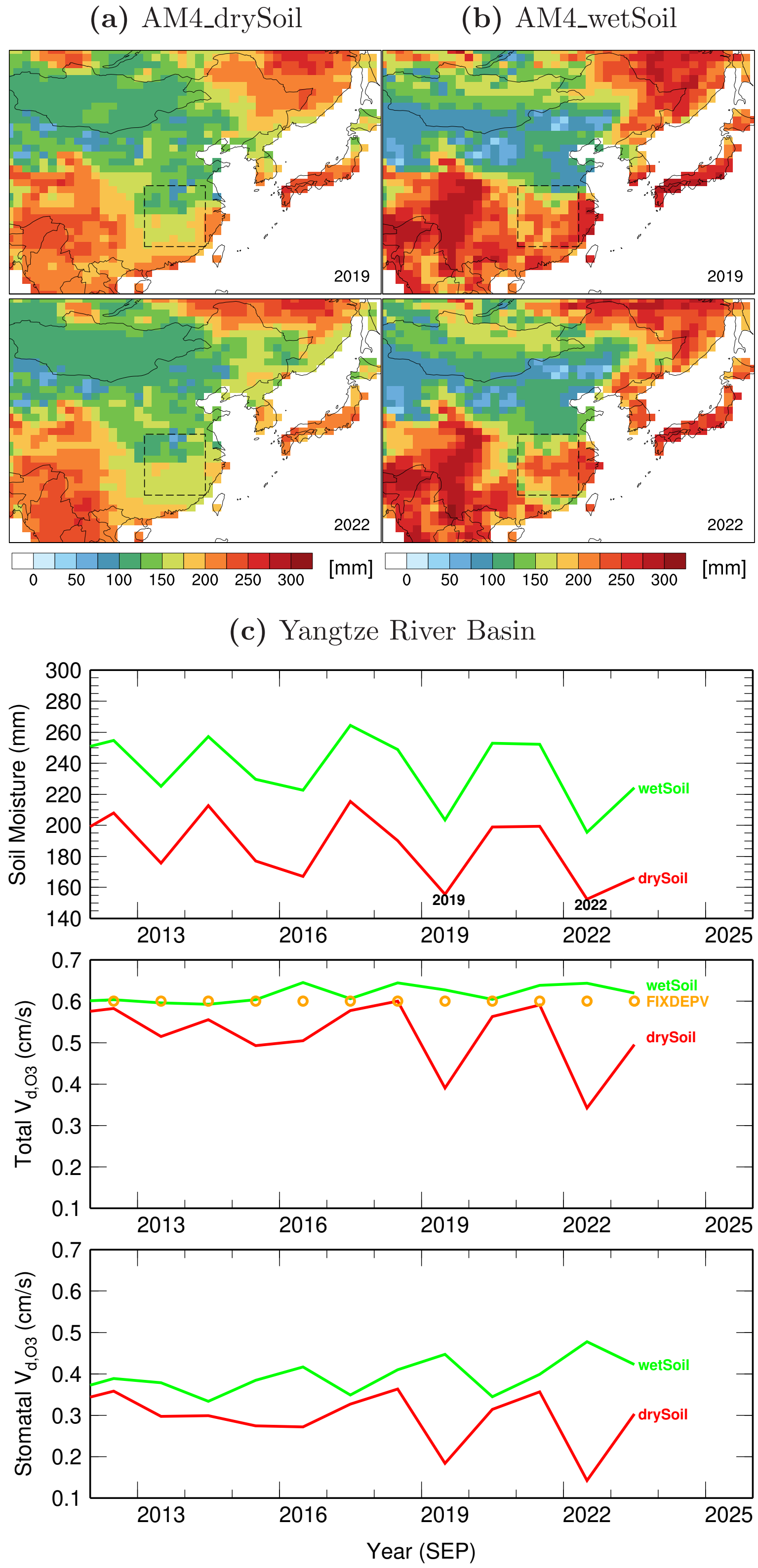

Figure S3. (a) Top 25cm soil moisture in September 2019 and 2022 from AM4_drySoil simulation with soil properties from LM3.0; (b) Same as (a) but for AM4_wetSoil simulation with soil properties from LM4.0; (c) Time series of September mean soil moisture, total and stomatal ozone deposition velocities ($V_{d,O3}$) during daytime (9AM-3PM local time) averaged over all vegetation land areas over the Yangtze River Basin (box on maps). The 2018 $V_{d,O3}$ level prescribed in the FIXDEPV experiment (orange circles) is also shown for comparison.

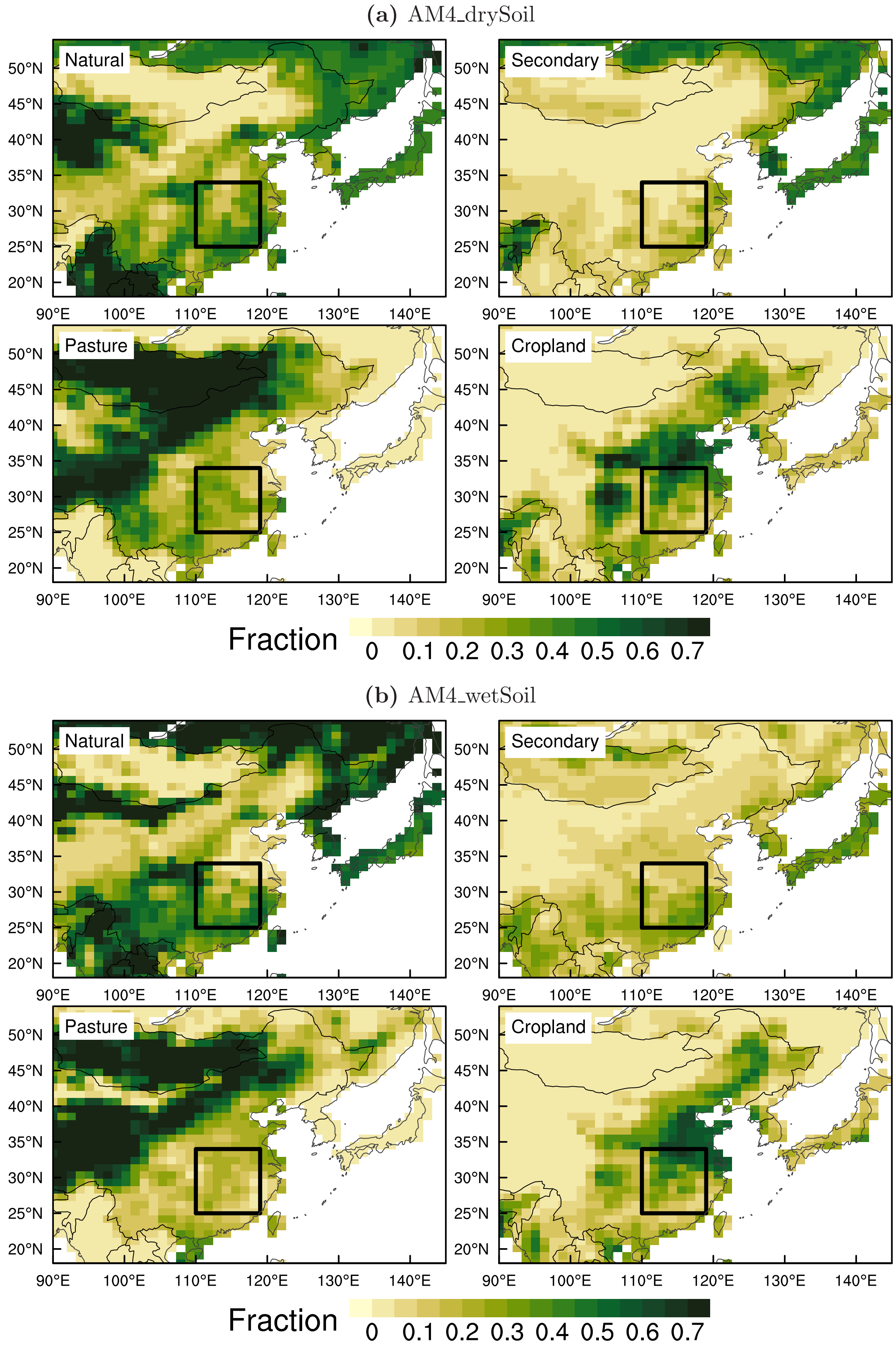

Figure S4. Fraction of the four land use categories in each grid cell: Natural forests (lands undisturbed by human activities), secondary vegetation (lands harvested at least once, including managed forests and abandoned cropland and pasture), pastures, and croplands. Results are averaged over the 2014-2022 period. The rectangles indicate the Yangtze River Basin.

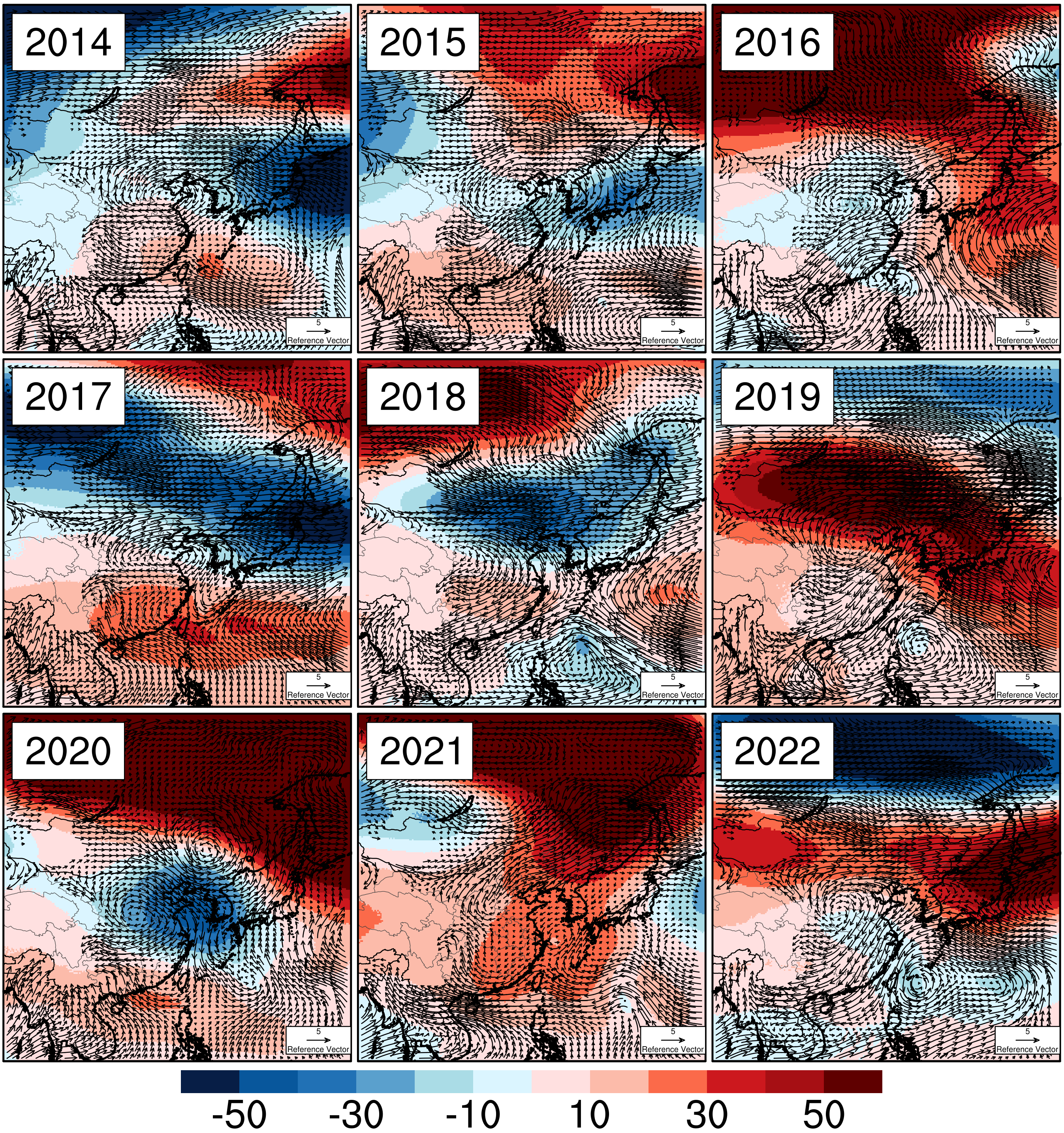

Figure S5. Maps of 500 hPa geopotential height anomalies (m, relative to 1990-2010) overlaid with 850 hPa winds (m/s) in September from 2014 to 2022. Data are based on the ERA5 reanalysis.

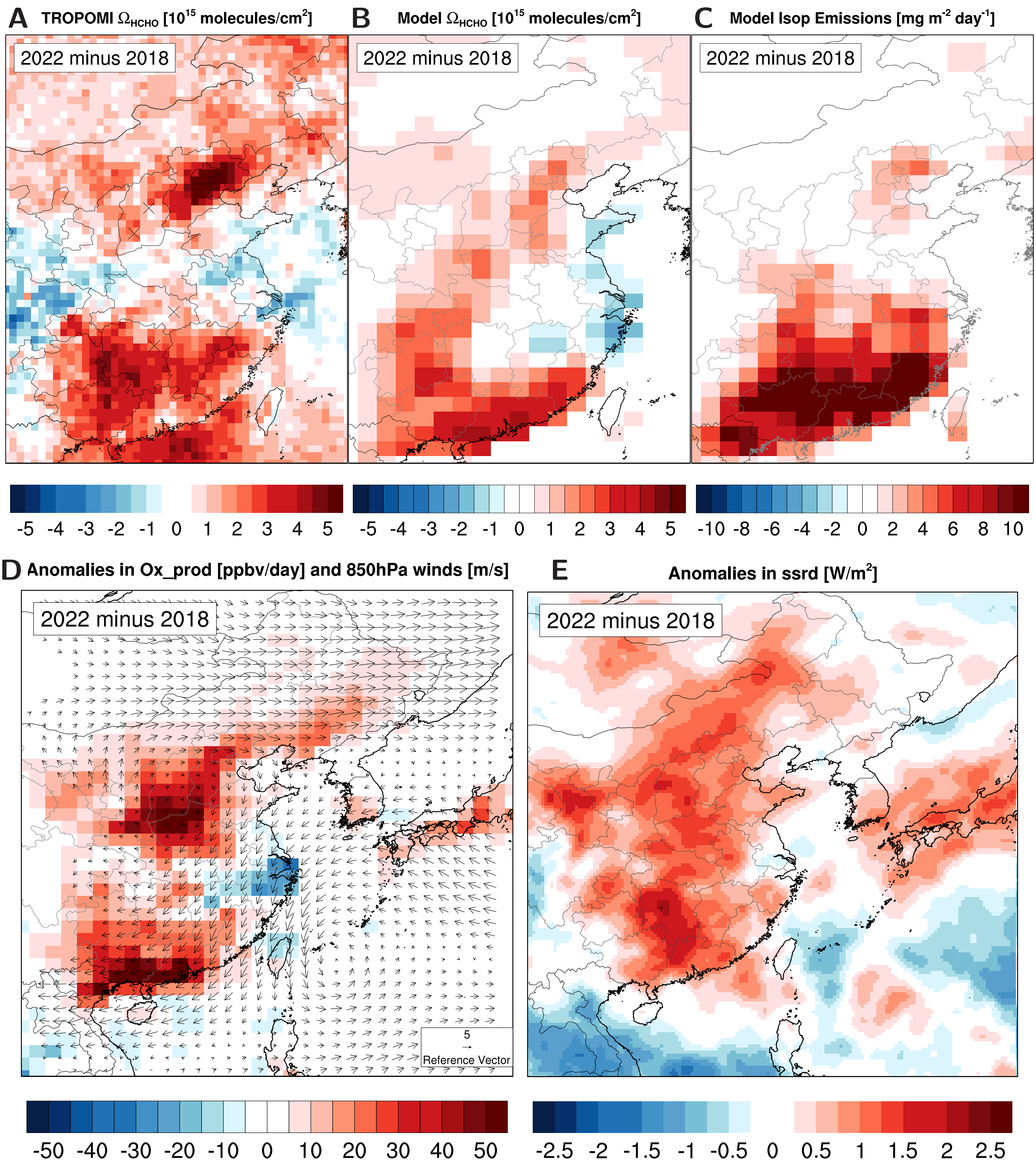

Figure S6. **Same as Fig.3 in the main article, but for anomalies in September 2022 relative to 2018 for:** (A-B) Satellite-retrieved and AM4_drySoil simulated tropospheric column densities of formaldehyde (Ω_{HCHO}); (C) Simulated biogenic isoprene emissions; (D) Simulated ozone (odd oxygen) production rates overlaid with 850 hPa winds; and (E) ERA5-observed surface downward shortwave radiation.

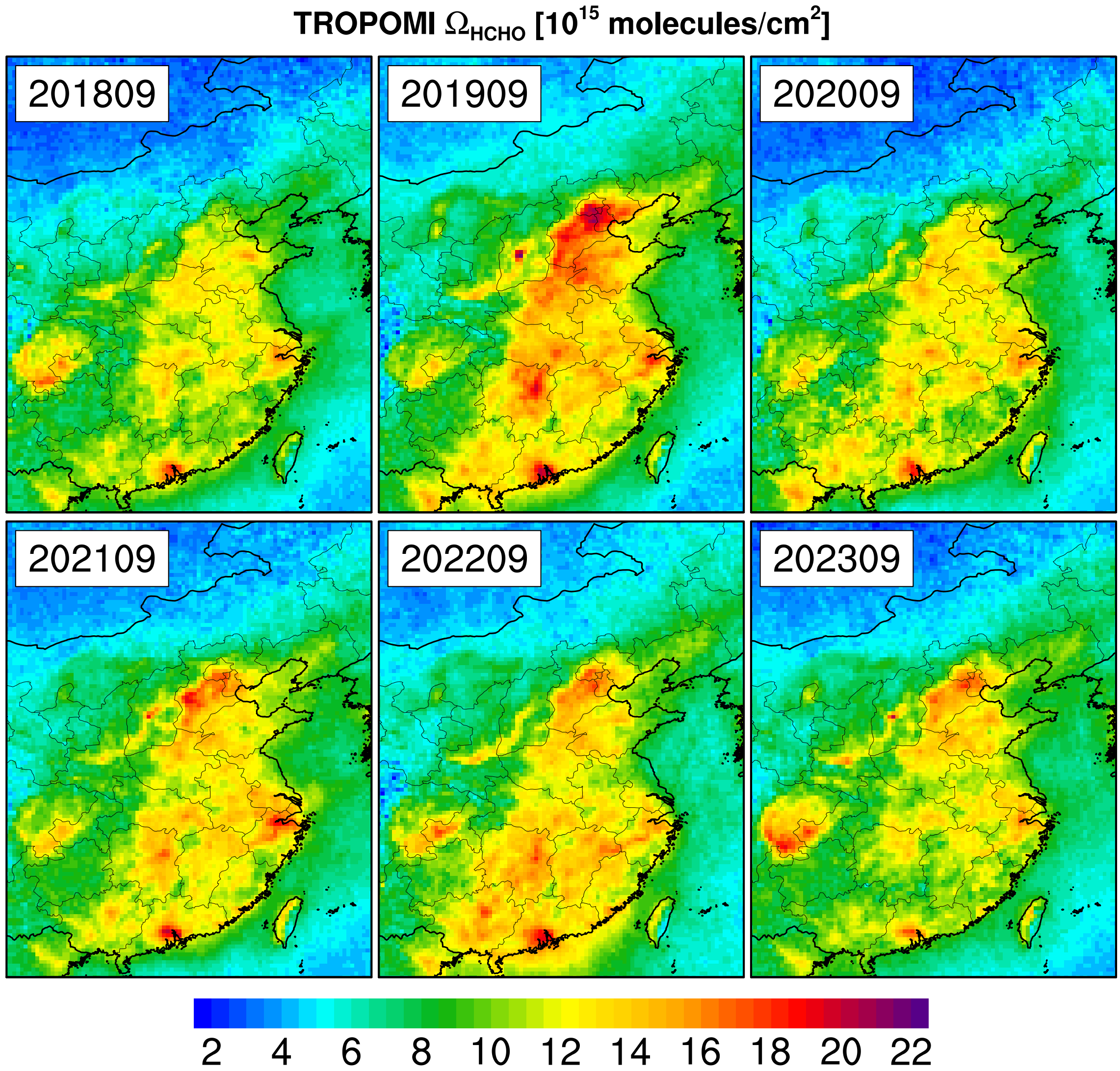

Figure S7. Maps of September mean TROPOMI Ω_{HCHO} from 2018 to 2023. The Ω_{HCHO} retrieval algorithm is as described in De Smedt et al.(2021). Data are regridded to 0.25 x 0.25 degrees.

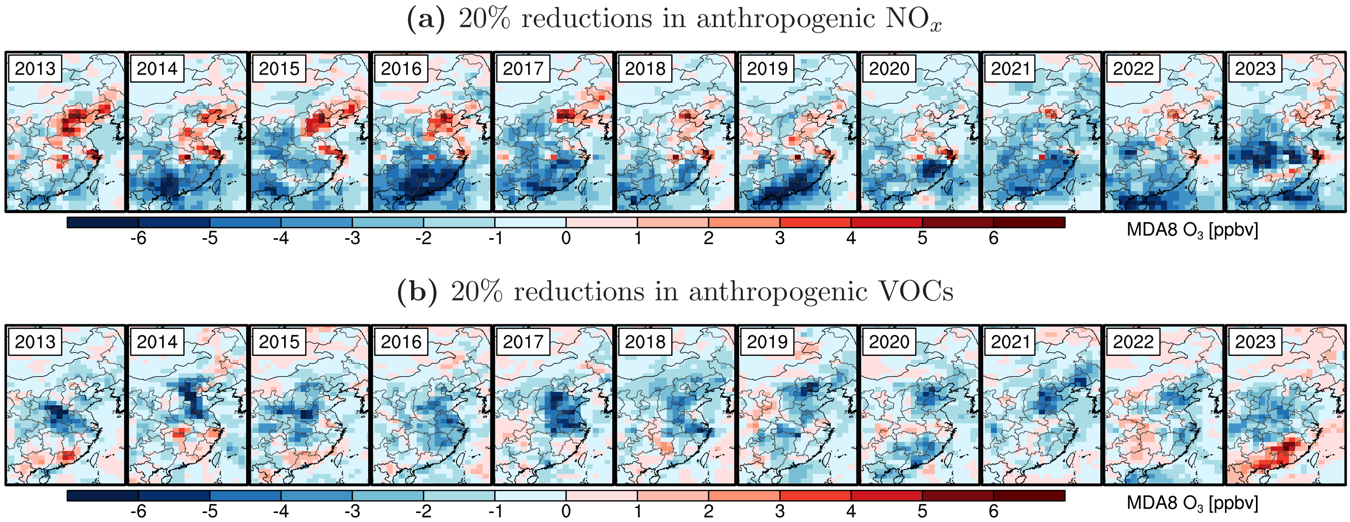

Figure S8. Simulated changes in September mean MDA8 O_3 (ppbv) in response to 20% reductions in anthropogenic NO_x and VOC emissions, respectively.