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Supplement of

Quantifying the emission changes and associated air quality impacts during the COVID-19 pandemic on the North China Plain: a response modeling study

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Figure S1 Comparison of the simulated average concentrations of NO$_2$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; Grey dots: original simulation without assimilation; unit: μg m$^{-3}$)
Figure S2 Same as Figure S1 but in 2020
Figure S3 Comparison of the simulated average concentrations of O$_3$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; Green dots: simulations using adjusted emission with consideration of shut-down influences but without VOC; Grey dots: original simulation without assimilation; unit: $\mu$g m$^{-3}$.)
Figure S4 Same as Figure S3 but in 2020
Figure S5 Comparison of the simulated average concentrations of NO$_3^-$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; Green dots: simulations using adjusted emission with consideration of shut-down influences but without NH$_3$; Grey dots: original simulation without assimilation; unit: $\mu$g m$^{-3}$).
**Figure S6** Same as Figure S5 but in 2020
Figure S7 Comparison of the simulated average concentrations of SO$_2$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; unit: Grey dots: original simulation without assimilation; $\mu g$ m$^{-3}$).
**Figure S8** Same as Figure S7 but in 2020
**Figure S9** Comparison of the simulated average concentrations of $\text{SO}_4^{2-}$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; Green dots: simulations using adjusted emission with consideration of shut-down influences but without $\text{SO}_2$; Grey dots: original simulation without assimilation; unit: $\mu g \text{ m}^{-3}$)
Figure S10 Same as Figure S9 but in 2020
**Figure S11** Comparison of the simulated average concentrations of PM$_{2.5}$ in NCP (the percentage numbers indicate the normalized mean biases in hypothesis and actual simulations respectively for Period 2. Blue dots: observations; Black dots: simulations using adjusted emission with no consideration of shutdown influences; Red dots: simulations using adjusted emission with consideration of shutdown influences; Green dots: simulations using adjusted emission with consideration of shut-down influences but without primary PM$_{2.5}$; Grey dots: original simulation without assimilation; unit: $\mu$g m$^{-3}$).
Figure S12 Same as Figure S11 but in 2020
Figure S13. Comparison of estimated percent changes in emissions due to the shutdown in Period 2 from cross-validation (cv1-cross validation #1 by using randomly selected half of the observation sites in each province for correction; cv2-cross validation #2 by using the rest half of the observation sites in cv1 for correction; all-used all observation sites).