



Supplement of

Modeling stratospheric intrusion and trans-Pacific transport on tropospheric ozone using hemispheric CMAQ during April 2010 – Part 2: Examination of emission impacts based on the higher-order decoupled direct method

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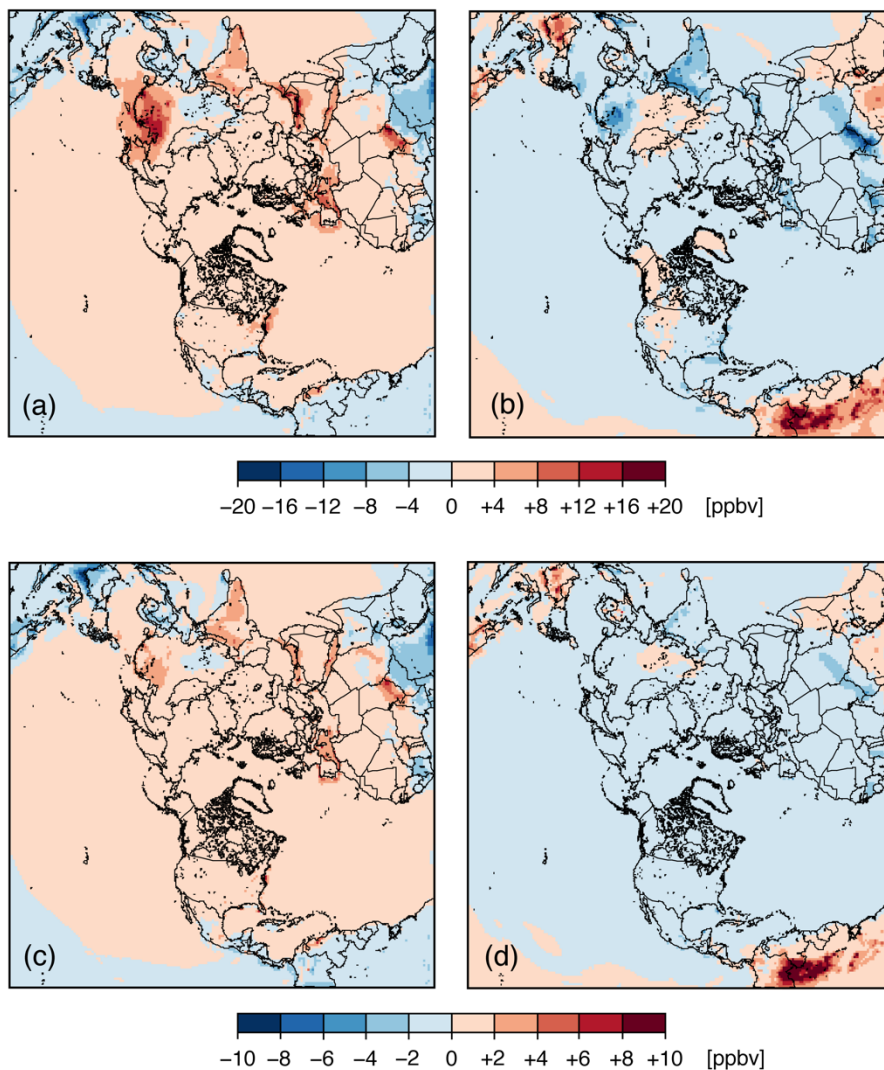


Figure S1. (Top) spatial distribution of the sensitivity coefficients of O_3 to (a) domain-wide VOC emissions as first-order, (b) same as (a) but as second-order during April 2010 (same figure with Fig. 1 (b) and (c)). (Bottom) spatial distribution of the sensitivity coefficients of O_3 to (c) domain-wide isoprene emissions as first-order, (d) same as (c) but as second-order during April 2010. Note the color scale is half of top panel.

Sensitivity coefficient of O₃ to emissions from U.S.A.

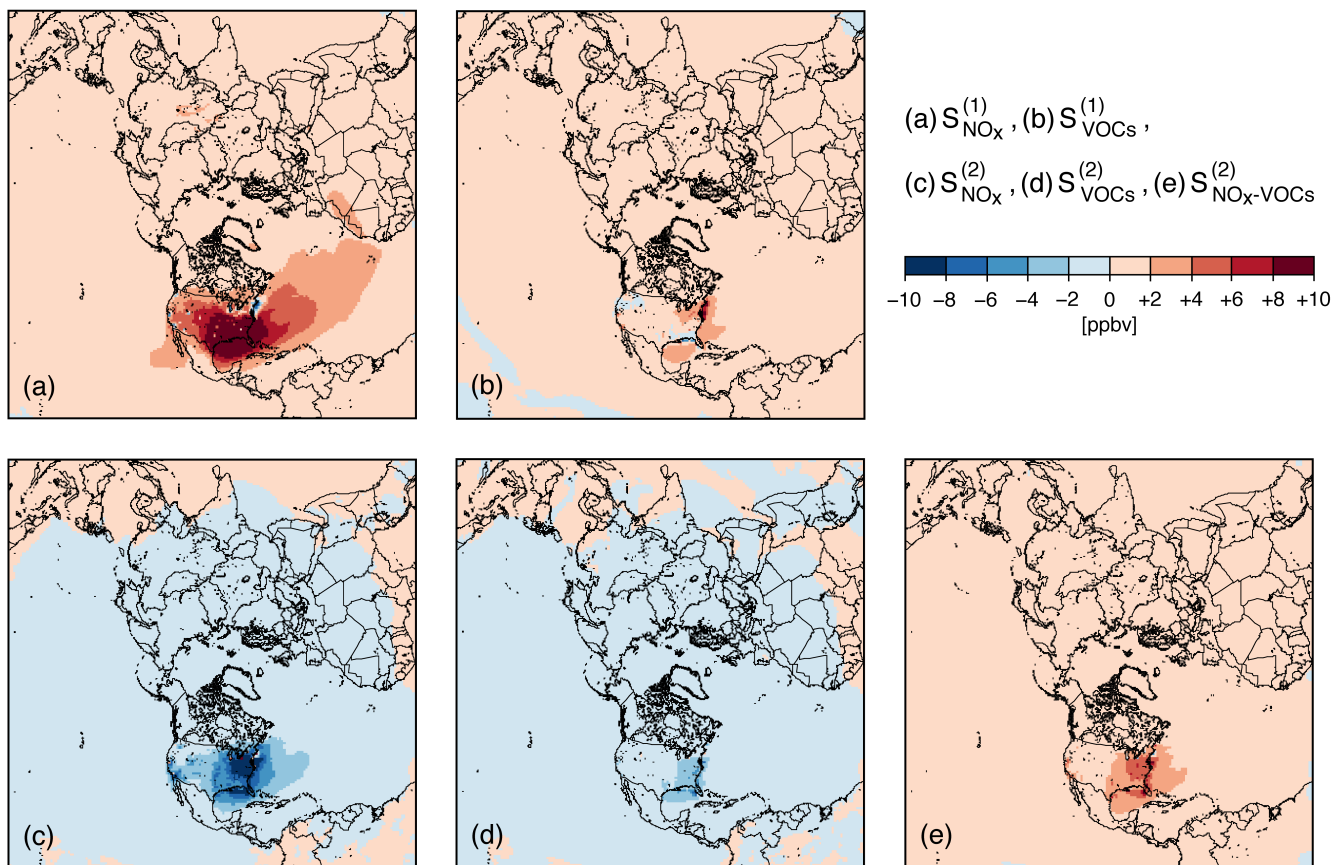


Figure S2. Spatial distribution of the sensitivity coefficients of O₃ to (a) NO_x emissions from U.S.A as first-order, (b) VOC emissions from U.S.A as first-order, (c) same as (a) but as second-order, (d) same as (b) but as second-order, and (e) NO_x and VOC emissions from U.S.A. during April 2010.

Sensitivity coefficient of O₃ to emissions from East Asia

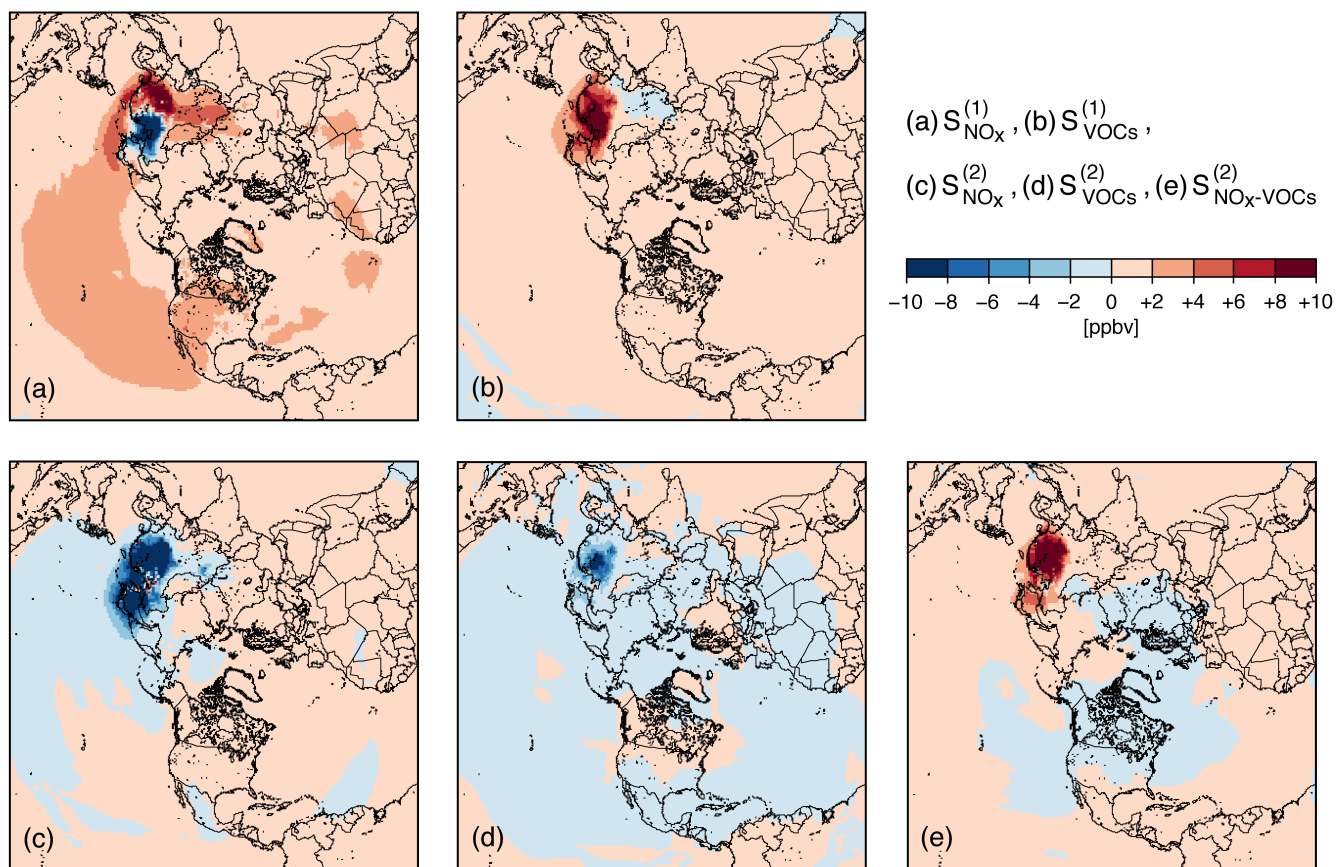


Figure S3. Spatial distribution of the sensitivity coefficients of O₃ to (a) NO_x emissions from East Asia as first-order, (b) VOC emissions from East Asia as first-order, (c) same as (a) but as second-order, (d) same as (b) but as second-order, and (e) NO_x and VOC emissions from East Asia during April 2010.

Sensitivity coefficient of O₃ to emissions from other regions

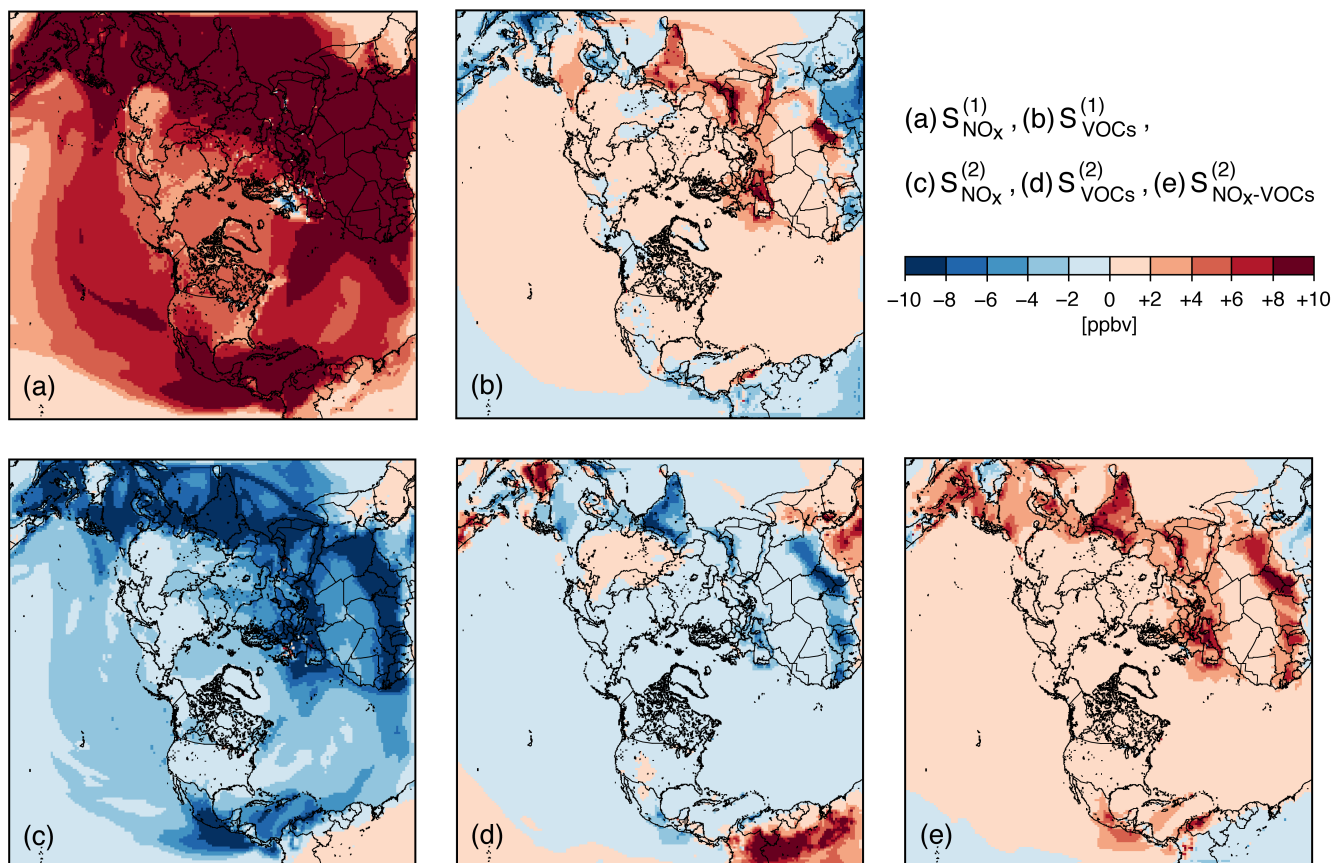


Figure S4. Spatial distribution of the sensitivity coefficients of O₃ to (a) NO_x emissions from East Asia as first-order, (b) VOC emissions from East Asia as first-order, (c) same as (a) but as second-order, (d) same as (b) but as second-order, and (e) NO_x and VOC emissions from other regions except U.S.A. (shown in Fig. S2) and East Asia (shown in Fig. S3) during April 2010.

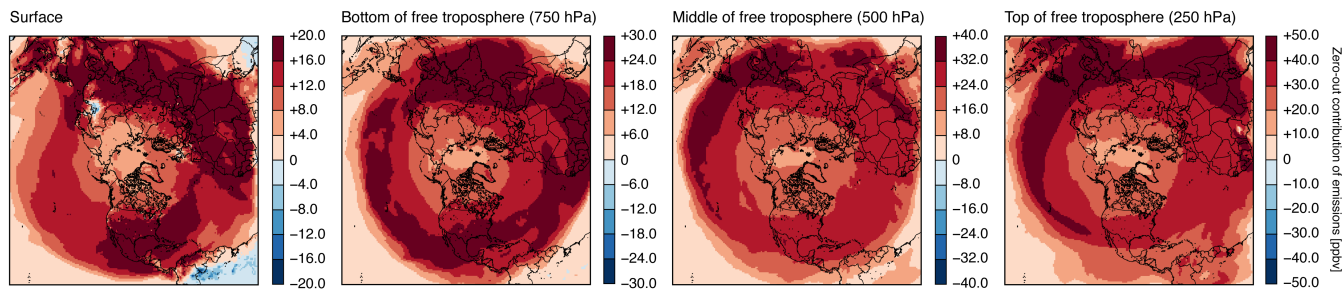


Figure S5. Monthly averaged zero-out contribution from domain-wide emissions at surface, bottom of free troposphere (750 hPa), middle of free troposphere (500 hPa), and top of free troposphere (250 hPa) from left to right.

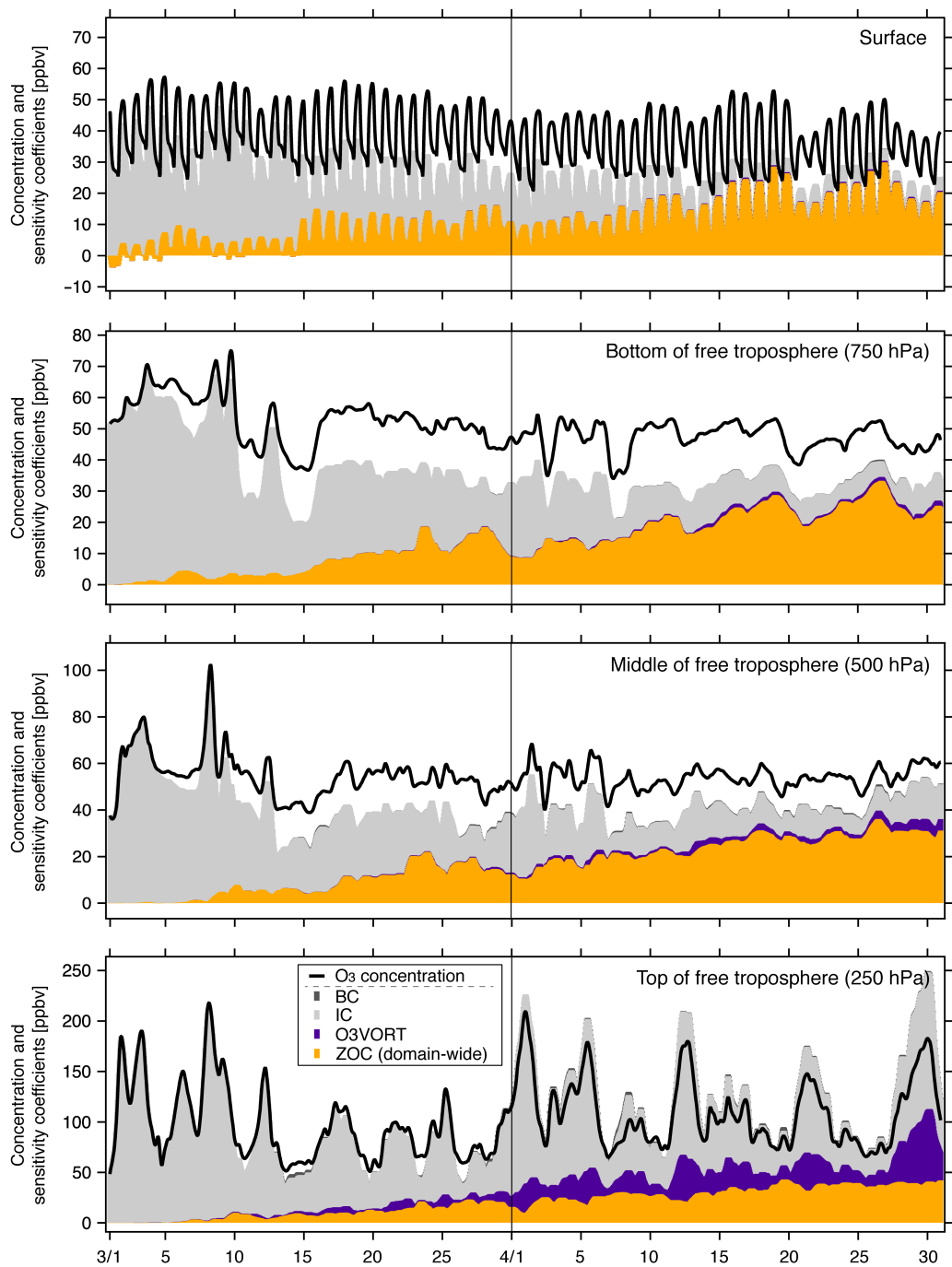


Figure S6. Temporal variation of O₃ concentration and sensitivities O₃ to boundary condition (BC), initial condition (IC), stratospheric O₃ (O3VORT), and emissions (shown as ZOC, see, eq. (5)) over PST in the U.S.A.

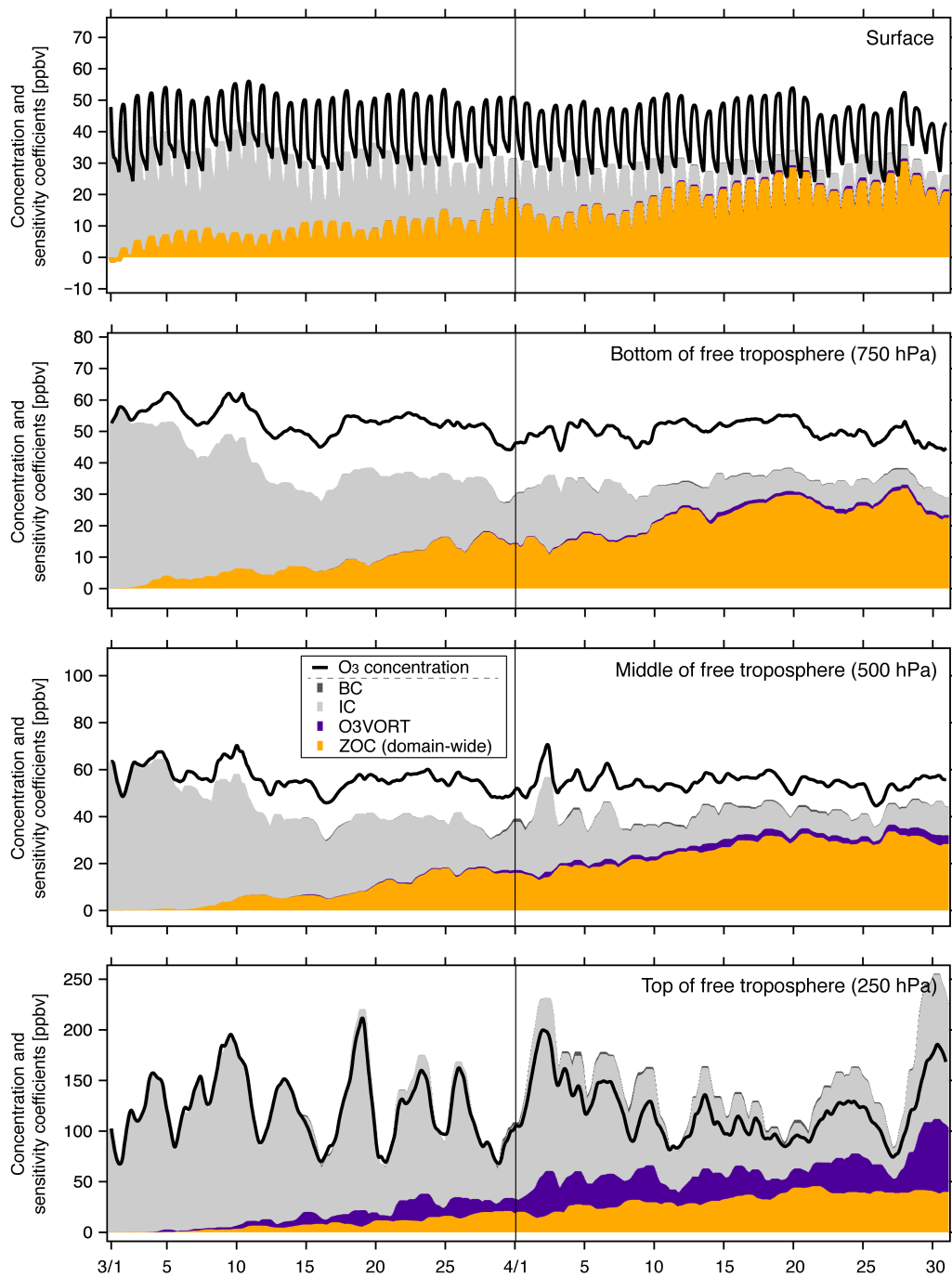


Figure S7. Temporal variation of O₃ concentration and sensitivities O₃ to boundary condition (BC), initial condition (IC), stratospheric O₃ (O3VORT), and emissions (shown as ZOC, see, eq. (5)) over MST in the U.S.A.

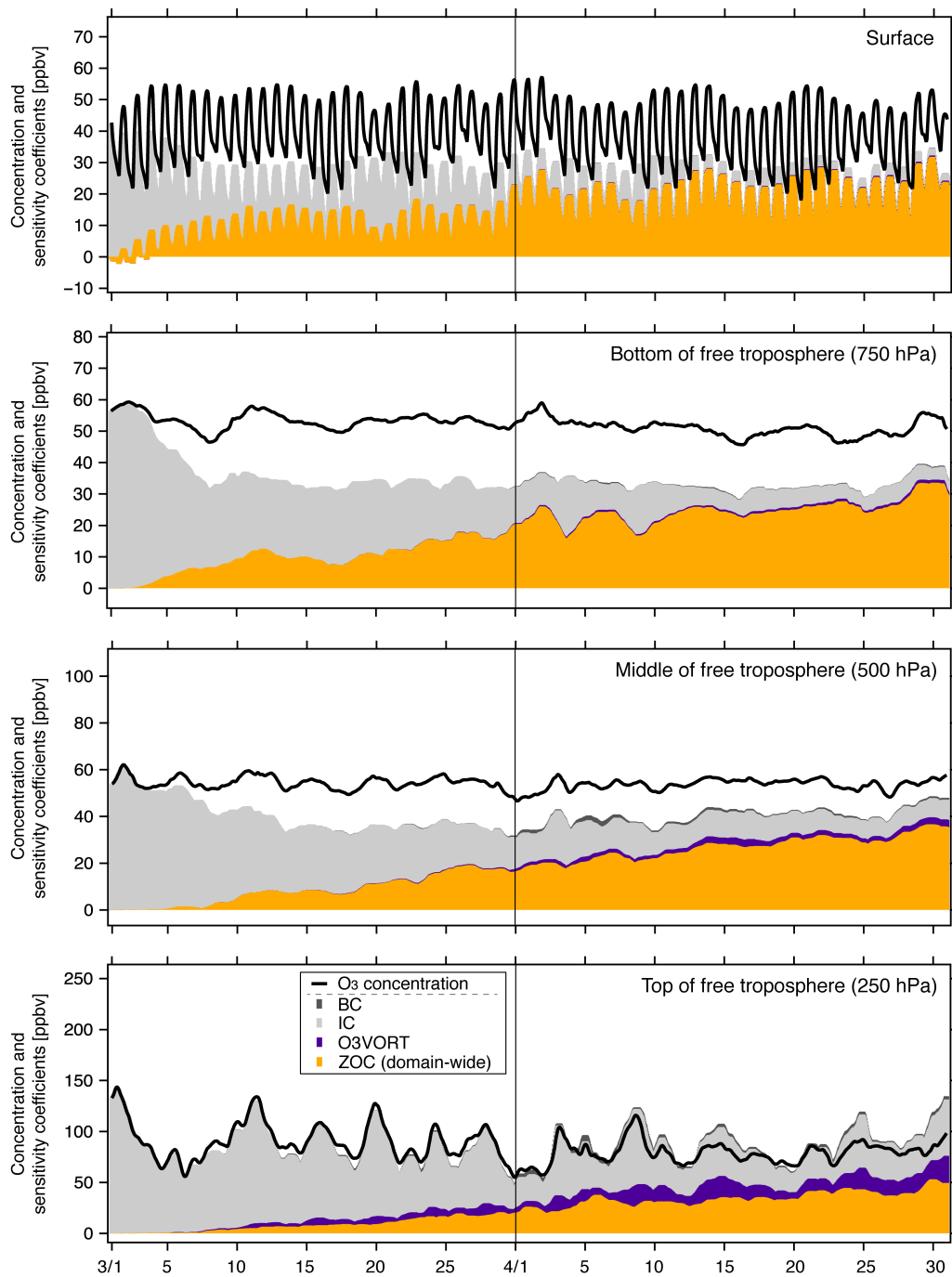


Figure S8. Temporal variation of O₃ concentration and sensitivities O₃ to boundary condition (BC), initial condition (IC), stratospheric O₃ (O₃VORT), and emissions (shown as ZOC, see, eq. (5)) over CST in the U.S.A.

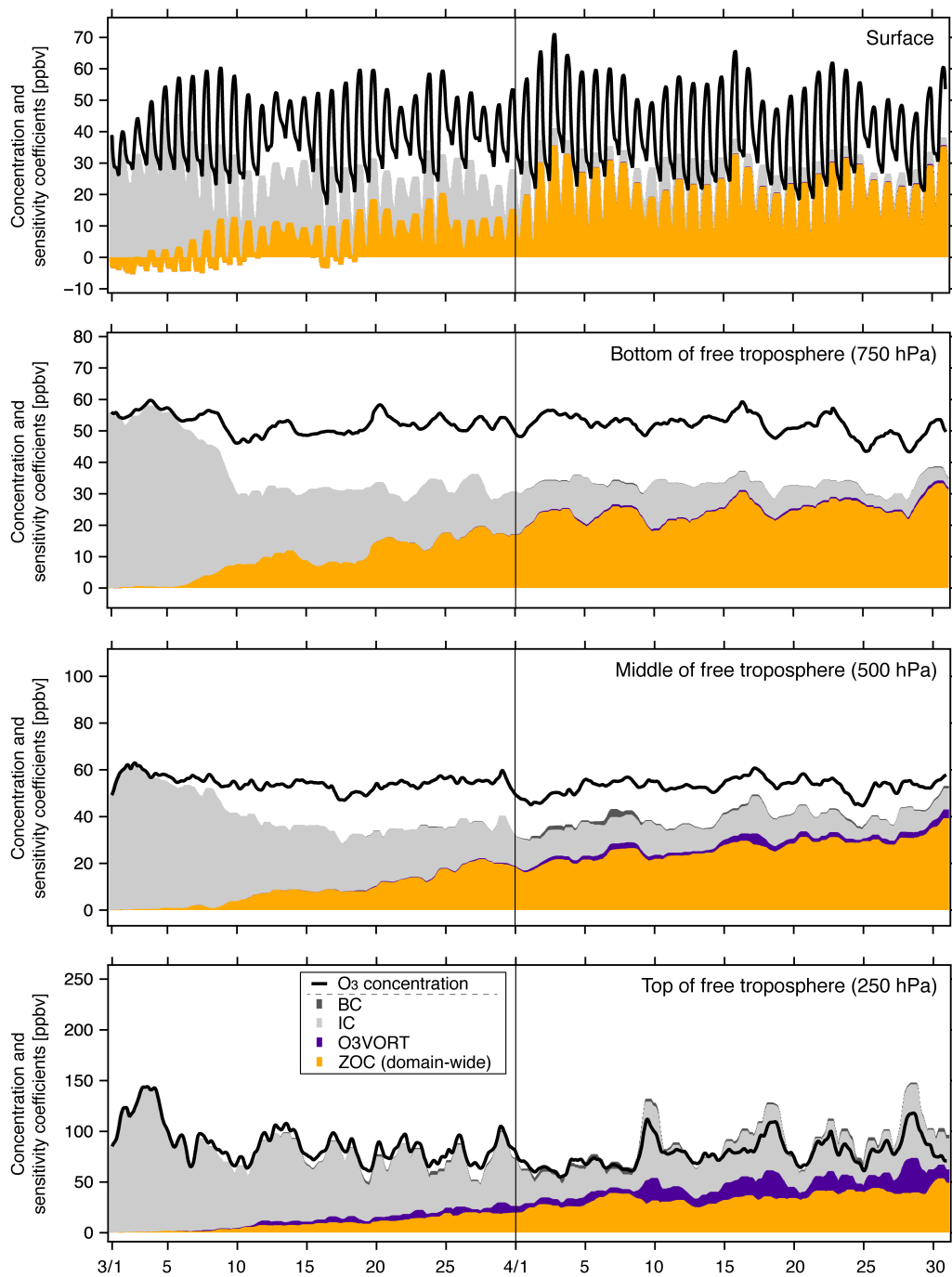


Figure S9. Temporal variation of O₃ concentration and sensitivities O₃ to boundary condition (BC), initial condition (IC), stratospheric O₃ (O₃VORT), and emissions (shown as ZOC, see, eq. (5)) over EST in the U.S.A.

Table S1. Elevated CASTNET sites in an alphabetical order.

ID	Site name	State	Time Zone	Longitude (°)	Latitude (°)	Elevation (m a.s.l.)
BBE401	Big Band NP	TX	CST	-103.178	29.303	1052
CAN407	Canyonlands NP	UT	MST	-109.821	38.458	1809
CHA467	Chiricahua NM	AZ	MST	-109.389	32.009	1570
CNT169	Centennial	WY	MST	-106.240	41.365	3175
CON186	Converse Station	CA	PST	-116.913	34.194	1718
GRB411	Great Basin NP	NV	PST	-114.216	39.005	2060
GRC474	Grand Canyon NP	AZ	MST	-112.184	36.059	2073
GTH161	Gothic	CO	MST	-106.986	38.956	2915
JOT403	Joshua Tree NP	CA	PST	-116.389	34.070	1244
LAV410	Lassen Volcanic NP	CA	PST	-121.576	40.540	1756
MEV405	Mesa Verde NP	CO	MST	-108.490	37.198	2165
PAL190	Palo Duro	TX	CST	-101.665	34.881	1053
PET427	Petrified Forest	AZ	MST	-109.892	34.823	1723
PND165	Pinedake	WY	MST	-109.788	42.929	2386
PNF126	Cranberry	NC	EST	-82.045	36.105	1216
ROM206	Rocky Mountain NP Collocated	CO	MST	-105.546	40.278	2742
ROM406	Rocky Mountain NP	CO	MST	-105.546	40.278	2743
SHN418	Shenandoah NP	VA	EST	-78.435	38.523	1073
WNC429	Wind Cave NP	SD	MST	-103.484	43.558	1292
YEL408	Yellowstone NP	WY	MST	-110.400	44.565	2430
YOS404	Yosemite NP	CA	PST	-119.706	37.713	1605

Note: Elevated sites defined as sites with an elevation higher than 1000 m a.s.l. (above sea level). The available sites during April 2010 are listed. Time zone indicates Pacific, Mountain, Central, and Eastern Standard Time as PST, MST, CST, and EST.