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Supplement of

Decadal evaluation of regional climate, air quality, and their interactions using WRF/Chem Version 3.6.1

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1. Mapping of RCP Emissions to CB05 species

Table S1 summarizes the mapping of species from RCP emissions to CB05 species for input into the model. The explanation for the mapping process can be found in the main text.

Table S1. CB05 emissions species for WRF/Chem, their associated long names, their availability in regards to the RCP emissions dataset, and the lumped RCP group species.

CB05 Species WRF/Chem	Species Long name	RCP Species Available	RCP Group
E_ALD2	Acetaldehyde	Group	Other Alkanals
E_ALDX	Higher Aldehydes	Group	Hexanes and Higher Alkanes
E_BENZENE	Benzene	Yes	
E_CH4	Methane	Yes	
E_CL2	Chlorine	No	
E_CO	Carbon Monoxide	Yes	
E_ECI, E_ECJ, E_ECC	Elemental Carbon - Nuclei, Accumulation, Coarse Modes	No, Group, No	Black Carbon
E_ETH	Ethene	Yes	
E_ETHA	Ethane	Yes	
E_ETOH	Ethanol	Group	Alcohols
E_FORM	Formaldehyde	Yes	
E_HCL	Hydrogen Chloride	No	
E_HONO	Nitrous Acid	No	
E_IOLE	Internal Olefin Carbon Bond	Group	Other Alkenes and Alkynes
E_ISOP	Isoprene	No	
E_MEOH	Methanol	Group	Alcohols
E_NH3	Ammonia	Yes	
E_NH4I, E_NH4J	Ammonium – Nuclei, Accumulation Modes	No	
E_NO	Nitrogen Oxides	Yes	
E_NO2	Nitrogen Dioxide	No	
E_NO3I, E_NO3J, E_NO3C	Nitrate – Nuclei, Accumulation, Coarse Modes	No	
E_OLE	Terminal Olefin Carbon Bond	Group	Other Alkenes and Alkynes
E_ORGI, E_ORGJ, E_ORGC	Organics – Nuclei, Accumulation, Coarse Modes	No, Group, No	Organic Carbon
E_PAR	Paraffin Carbon Bond	No	
E_PM10	Unspeciated PM ₁₀	No	
E_PM25	Unspeciated PM _{2.5}	No	
E_PM25I, E_PM25J	Unspeciated PM _{2.5} – Nuclei, Accumulation Modes	No, No	
E_PSULF	Sulfuric Acid	No	
E_SO2	Sulfur Dioxide	Yes	
E_SO4I, E_SO4J, E_SO4C	Sulfate – Nuclei, Accumulation, Coarse Modes	No, No, No	
E_TERP	Terpene	No	
E_TOL	Toluene	Yes	
E_XYL	Xylene	Yes	

2. Observational Datasets for Model Evaluation and Operational Evaluation

Table S2 summarizes the observational databases and the variables evaluated in this work. For evaluation of chemical concentrations and meteorological variables, the surface networks include the National Climatic Data Center (NCDC) Quality Controlled Local Climatological Data (QCLCD), Clean Air Status and Trends Network (CASTNET), the Aerometric Information Retrieval System (AIRS) – Air Quality System (AQS), the Interagency Monitoring of Protected Visual Environments (IMPROVE), the Speciated Trends Network (STN), the Southeastern Aerosol Research and Characterization (SEARCH), and the National Atmospheric Deposition Network (NADP). Several aerosol-cloud-radiation variables are also evaluated against satellite retrievals including the Clouds and the Earth’s Radiant Energy System (CERES) and the Moderate Resolution Imaging Spectroradiometer (MODIS).

NCDC QCLCD data contains data over 700 U.S. locations from July 1996 to December 2004, and over 1600 locations from 2005 onwards (<http://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/quality-controlled-local-climatological-data-qclcd>). CASTNET observations have been collected in a range of rural environments, from desert to agricultural locations, and from flat to complex terrains (http://java.epa.gov/castnet/epa_jsp/sites.jsp). It contains measurement data for meteorological variables and chemical concentrations. AIRS-AQS is the U.S. EPA’s repository for ambient air quality data from over 5000 active monitors (<http://www.epa.gov/ttn/airs/airsaqs/>). While IMPROVE observations have been collected in protected visual environments, i.e., in National Parks and Wilderness Areas (<http://vista.cira.colostate.edu/improve/>), STN sites are located in a range of locations from urban

to rural areas (<http://www.epa.gov/ttnamti1/specgen.html>). Both networks contain data for PM_{2.5} and major PM_{2.5} species. NADP contains precipitation data from rain gauges.

Table S2. Observational datasets and variables evaluated in this study.

Gases and PM Species			
Observational database	Variables evaluated	Sampling Frequency	Number of Sites
CASTNET	Max 1-hr and 8-hr O ₃	Daily for O ₃	~90
AIRS–AQS	O ₃	Hourly	~1150
IMPROVE	PM _{2.5} , SO ₄ ²⁻ , NO ₃ ⁻ , NH ₄ ⁺ , EC, OC	24-hour data. Data availability once every 3 days	~160
STN	PM _{2.5} , SO ₄ ²⁻ , NO ₃ ⁻ , NH ₄ ⁺ , EC, TC	24-hour data. Data availability once every 3 days	~200
Meteorology			
<i>Observational Database</i>	<i>Variables evaluated</i>	<i>Temporal Resolution</i>	<i>Spatial Resolution</i>
NCDC QCLCD	T2, RH, WS10, WD10	Hourly	~700 before 2005 ~1600 after 2005
NADP	Precipitation	Weekly	255
Radiation and other Aerosol/Cloud variables			
<i>Observational Database/ Satellite</i>	<i>Variables evaluated</i>	<i>Temporal Resolution</i>	<i>Number of sites/ Spatial Resolution</i>
CERES	SWDOWN	Monthly	1° × 1°
MODIS	AOD, CF, COT, CWP, QVAPOR, CCN	Monthly	1° × 1°
MODIS derived based on Bennartz (2007)	CDNC	Monthly	1° × 1°

3. List of Acronyms

Table S3. List of Acronyms used in the paper

Acronym	Full Name
AER/AFWA	The Atmospheric and Environmental Research Inc. and Air Force Weather Agency scheme
AERONET	The Aerosol Robotic Network
AIRS-AQS	the Aerometric Information Retrieval System– Air Quality System
AOD	Aerosol optical depth
BCs	Boundary Conditions
CAM5	The Community Atmosphere Model version 5
CASTNET	The Clean Air Status and Trends Network
CALIOP	The Cloud-Aerosol Lidar with Orthogonal Polarization
CB05	The Carbon Bond 2005
CCN	Cloud condensation nuclei
CDNC	Cloud droplet number concentration
CERES	The Clouds and the Earth’s Radiant Energy System
CESM	The Community Earth System Model
CESM_NCSU	CESM/CAM5 developed at the North Carolina State University
CLDFRA	Cloud fraction
CMAQ	The Community Multiscale Air Quality Model
CMIP5	The Coupled Model Intercomparison Project Phase 5
CONUS	Continental U.S.
COT	Cloud optical thickness
CRU	Climatic Research Unit
CWP	Cloud water path
EC	Elemental carbon
GCMs	General circulation models
GCTMs	Global chemical transport models
GLW	Longwave radiation
GSW	Net shortwave radiation
ICs	Initial Conditions
IMPROVE	The Interagency Monitoring of Protected Visual Environments
IOA	Index of Agreement
IPCC	The Intergovernmental Panel on Climate Change
JFD	January, February and December
JJA	June, July, and August
LSM	Land Surface Model
LST	local standard time
LWCF	Longwave cloud forcing
MADE/VBS	The Modal for Aerosol Dynamics in Europe / Volatility Basis Set
MAM	March, April, and May
MAN	The Maritime Aerosol Network
MB	Mean bias
MEGAN2	The Model of Emissions of Gases and Aerosols from Nature version 2

MODIS	The Moderate Resolution Imaging Spectroradiometer
NADP	The National Atmospheric Deposition Network
NARR	The North American Regional Reanalyses
NCDC	The National Climatic Data Center
NCEP	The National Centers for Environmental Prediction
NCEP FNL	The NCEP Final Reanalyses
NEI	The National Emission Inventory
NH ₄ ⁺	Ammonium
NMB	Normalized mean bias
NME	Normalized mean error
NO ₃ ⁻	Nitrate
NO	Nitric oxide
NO ₂	Nitrogen dioxide
NO _x	Nitrogen oxide
NOAH	The National Center for Environmental Prediction, Oregon State University, Air Force and Hydrologic Research Lab
O ₃	Ozone
OA	Organic aerosol
OC	Organic carbon
OMI	The Ozone Monitoring Instrument
PM _{2.5} and PM ₁₀	Particulate matter with diameter less than and equal to 2.5 and 10 μm
POA	Primary organic aerosol
PRECIS	Providing Regional Climates for Impacts Studies
R	Correlation coefficient
RCMs	Regional climate models
RCP	The Representative Concentration Pathway
RH2	Relative humidity at 2-m
RRTMG	The Rapid and accurate Radiative Transfer Model for GCM
SEARCH	The Southeastern Aerosol Research and Characterization
SMOKE	The Sparse Matrix Operator Kernel Emissions model
SOA	Secondary organic aerosol
SO ₂	Sulfur dioxide
SO ₄ ²⁻	Sulfate
SON	September, October, and November
STN	The Speciated Trends Network
SWCF	Shortwave cloud forcing
SWDOWN	Downward shortwave radiation
T2	Temperature at 2-m
TC	Total carbon, = EC + OC
WD10	Wind direction at 10-m
WRF	Weather Research and Forecasting model
WRF/Chem	The Weather Research and Forecasting model with Chemistry
WS10	Wind speed at 10-m

References

Bennartz, R. (2007), Global assessment of marine boundary layer cloud droplet number concentration from satellite, *J. Geophys. Res.*, 112, D02201, doi:10.1029/2006JD007547.