Improving NAQFC O_3 Predictions over remote sensing-derived chemical regimes

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Goal: Improved ground-level O_3 predictions

▪Various global/regional chemical transport models including Community Multiscale Air Quality Modeling System (CMAQ) overpredict summer daytime O_3 over the eastern US. Peak concentrations predicted by CMAQ are routinely 5-10 ppbv higher than surface EPA Air Quality System (AQS) observations.

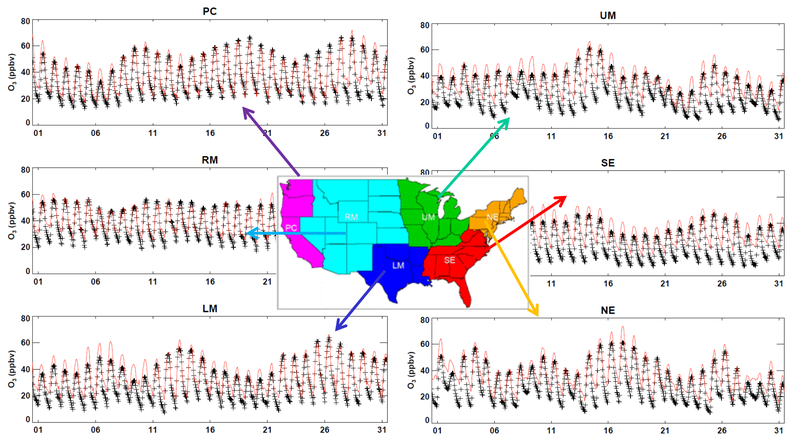


Fig.1 Surface O_3 variation from AQS observations (black) and CMAQ (red) over 6 US regions for August 2009

Approach: Integrate the National Air Quality Forecasting Capability (NAQFC) system with satellite resources

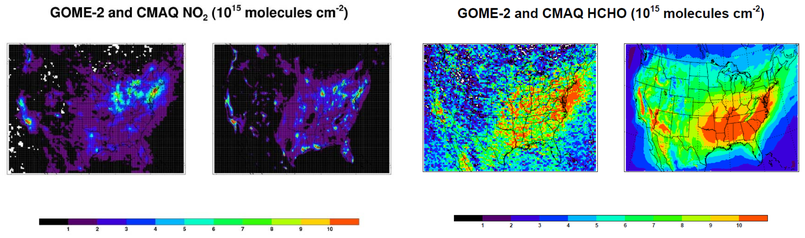
▪Time period: August 2009 with the greatest O_3 biases in NAQFC during 2007-2009

▪The NAQFC system produces 48 hour forecasts of surface O_3 and PM2.5 concentrations over the CONUS. The NAQFC numerical modeling system couples the National Centers for Environmental Prediction (NCEP) Weather Research and Forecasting Non-hydrostatic Mesoscale Model (WRF-NMM) with CMAQ (12km spatial resolution).

▪4 NAQFC setups:

- NAQFC: operational forecasting system based on CMAQ4.6
- NAQFC_2: updating Monin-Obukhov equation using NOAH land surface model variables and implement satellite canopy heights (aerodynamic resistance, Ra update)
- NAQFC_3: updating wet cuticle resistance (canopy resistance, Rc update) from NAQFC_2
- NAQFC_4: CMAQ4.7 with satellite canopy heights

▪Satellite measurements: providing canopy heights and chemical regimes



Accomplishments:

(1) Identification of chemical regimes using satellite (category 1=NOx-saturated regime; category 2=Mixed regime; category 3=NOx-sensitive regime) over the CONUS

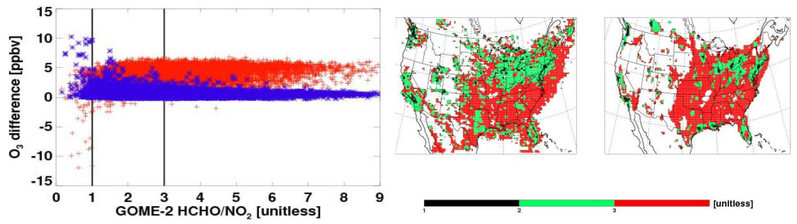


Fig. 2 The surface O_3 changes of CMAQ4.7 by 30% NOx and VOC emissions reductions to the ratio of GOME-2 $HCHO/NO_2$ columns (left panel). The ratio of HCHO versus NO_2 between GOME-2 and CMAQ4.7 (9-10 am, LT) over CONUS for August 2009. Category 1 is for GOME-2 $HCHO/NO_2$ < 1, category 2 is for 1<GOME-2 $HCHO/NO_2$<3, and category 3 is for GOME-2 $HCHO/NO_2$>3 (right panel).

(2) Improved O_3 daily predictions over three chemical regimes in CONUS (applicable to other global/regional models)

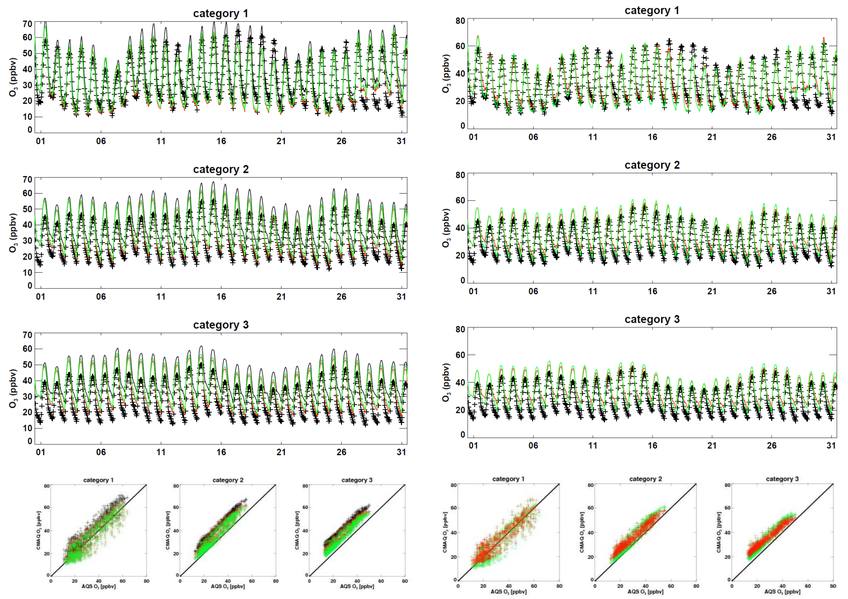


Fig.3 Time series and scatter plots of surface O_3 from NAQFC(black), NAQFC_2(red), and NAQFC_3(green)

Fig.4 Time series and scatter plots of surface O_3 from NAQFC_3(green) and NAQFC_4(red)

(3) Improved weekly anomaly predictions (including "Weekend effects" over category 1) of O_3 in NAQFC over chemical regimes of the CONUS

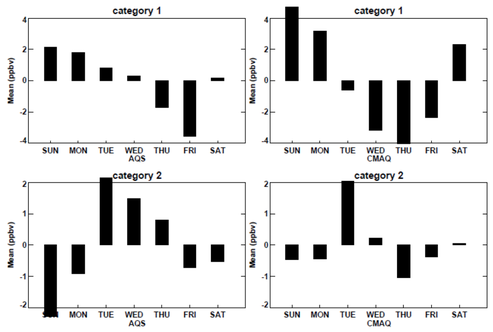


Fig.5 Weekly anomalies of surface O_3 from AQS and NAQFC_4

Indicators of success:

▪Manuscripts in preparation:

-Choi, et al., The impact of satellite-observed canopy heights on improving surface O_3 simulations over the eastern US, will be submitted to Geophysical Research Letters, 2011

-Choi, et al., Weekly variations of the surface NOx and O_3 over the USGS LULC regions and GOME-2-derived chemical regimes of the US: CMAQ4.7 model evaluation and analysis, Atmospheric Chemistry and Physics, 2011, in preparation

-Choi et al., Modeled O_3 and PM2.5 from CMAQ4.6 and CMAQ4.7 over satellite-derived chemical regimes over the US, Atmospheric Environment, 2011, in preparation

▪ Serving the satellite and modeling communities as the science team member of NASA TES project and as a scientific advisory committee of US-Korea geostationary satellite project, GEMS

Collaborators/Partners:

Institute	Group	Lead Scientist
NASA Jet Propulsion Laboratory	OCO-2, TES, and MISR Groups	Dr. Annmarie Eldering, Dr. John Worden, Dr. Dong Wu
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California Institute of Technology	Atmospheric Science Group	Prof. Yuk L. Yung
UCLA	Global/regional Modeling Group	Prof. Qinbin Li
UCLA	Climate Modeling Group	Prof. K.N. Liou and Dr. Jinwon Kim
University of Maryland	Global/regional Modeling Group	Drs. Ken Pickering and Dale Allen
Harvard-Smithonian	Satellite Retrieval Group	Dr. Kelly Chance
PNNL	WRF-Chem Modeling Group	Drs. Chun Zhao and Qing Yang
Dalhousie University	Modeling/Satellite Group	Prof. Randall Martin
Yonsei University (in Korea)	Satellite Retrieval Group	Prof. Jhoon Kim
Laboratoire d'Aerologie (in France)	MOZAIC Group	Dr. Valeri Thouret

Future direction:

-Update NAQFC forecasting system with improved physics and chemistry

-Evaluate current bottom-up emissions inventory using top-down approach (using satellite observations)

-Utilize the data from the forecasting system to establish a long-term monitoring system with corresponding satellite measurements:

Column O_3, NO_2, BrO, OClO from GOME and GOME-2

Column O_3, HCHO and NO_2 from SCIAMACHY

Column O_3, HCHO and NO_2 from OMI

CO profiles from MLS

O_3 and CO profiles, CO_2, H_2O, and CH_4 from TES

Temperature and CO_2 at 8km from AIRS; CO profiles from MAPS

CO profiles, CO column, CH_4 column from MOPITT

Cloud top height and aerosol optical depth from MODIS

DEDICATION:

This presentation is dedicated to the memory of ARL Air Quality Group Lead Dr. Daewon Byun (1955-2011), whose leadership and pursuit of scientific excellence continues to inspire us.

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