Southern New Mexico Ozone Modeling Study

Summary of Results: Tasks 4-6

Ramboll-Environ (RE)
University of North Carolina (UNC-IE)

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SNMOS Background and Objectives

- The southern Doña Ana County region has the highest ozone levels of any area in New Mexico
  - The southern Doña Ana County area is within 95% of the federal standard for ozone
  - The New Mexico Air Quality Control Act requires the New Mexico Environment Department to develop a plan for reducing ozone levels in areas that are within 95% of the ozone standard
- The first step towards developing the plan is to understand the causes of high ozone in Doña Ana County
- SNMOS objectives:
  - Study the factors contributing to high ozone in Doña Ana County
  - Investigate future emissions scenarios that will produce attainment of the ozone standard

Overview of Approach

- SNMOS builds off of the Western Air Quality Study (WAQS)
  - WAQS 2011 modeling platform: WRF/SMOKE/CAMx
  - Adjustments to the meteorology and modeling domains to optimize for southern New Mexico
- Modeling 2011 New Mexico ozone season: May 1 – September 30
- Modeling Plan
  - Prepare base year emission inventories
  - Run WRF/SMOKE/CAMx for 2011 base year
    - Evaluate 2011 base year model against observations, refine model if needed
  - Prepare future year emission inventories, year TBD
  - Run SMOKE/CAMx for future year
    - Modeled Attainment Test
    - Emissions sensitivity/control runs
    - Source apportionment to diagnose causes of high ozone in Doña Ana County
  - Reporting

SNMOS Tasks

- **Task 1**: 2011 WRF 36/12/4 km with 4 km focus on Dona Ana/El Paso/Juarez and Work Plan
- **Task 2**: 2011 update Permian Basin O&G
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- **Task 12**: FY 4 km source apportionment run
- **Task 13**: Air Quality Technical Support Document (AQTSD)

Outline of Today's Presentation

Task 4-6 Deliverables

4. SMOKE modeling of 4 km grid emissions (Technical Memorandum)
5. Natural Emissions: Gridded 2011 biogenic, fires, lightning emissions for 12/4 km domain (This Presentation)
   - Wind-blown dust not required for this study, which focuses on ozone
6. 2011 base year air quality modeling (This Presentation)

Task 4: 2011 Base Case Emissions Modeling

SNMOS Emissions on 4 km Grid

Lead: University of North Carolina

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Task 4: SNMOS 2011 Emissions Memo

- Introduction
- SNMOS 2011 Emissions Modeling Platform
  - Emissions Modeling Software
  - 2011 Emissions Data
- 2011 Emissions Summary
  - Dona Ana and Surrounding Counties
  - New Mexico Counties
  - Mexico Border States
- URL: ftp://ftp.unc.edu/pub/empd/SNMOS/SNMOS_Emissions_Modeling_Memo_v17Feb2016_FINAL.pdf

Task 5: Natural Emissions for the 12/4 km Domain

SNMOS Emissions from Biogenics, Fires and Lightning

Lead: Ramboll Environ

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Task 5 Objectives and Deliverables

- Objective
  - Prepare natural emissions for the SNMOS 2011 Base Case CAMx modeling
- Deliverables
  - PowerPoint presentation on results of natural emissions modeling. (**Completed 2/16/2016**)
  - Provide natural emissions on the 12/4 km grids to UNC for SMOKE emissions modeling/merge (**Completed 1/18/2016**)
- Tasks
  - Prepare gridded, CAMx ready MEGAN version 2.10 biogenic emissions. (**Completed 1/12/2016**)
  - Prepare gridded, CAMx ready lightning NOx emissions. (**Completed 1/15/2016**)
  - Prepare gridded, CAMx ready PMDETAIL fire emissions. (**Completed 1/18/2016**)
  - Develop initial PowerPoint presentation. (**Completed 1/27/2016**)
  - Prepare documentation and model performance information for Task 13.

CAMx Modeling Domains

- Develop natural emissions for 12/4 km domains
  - Biogenics, fires, LNOx
- Process through SMOKE
- Merge with anthropogenic emissions

Biogenic Emissions Modeling

MEGAN v2.10

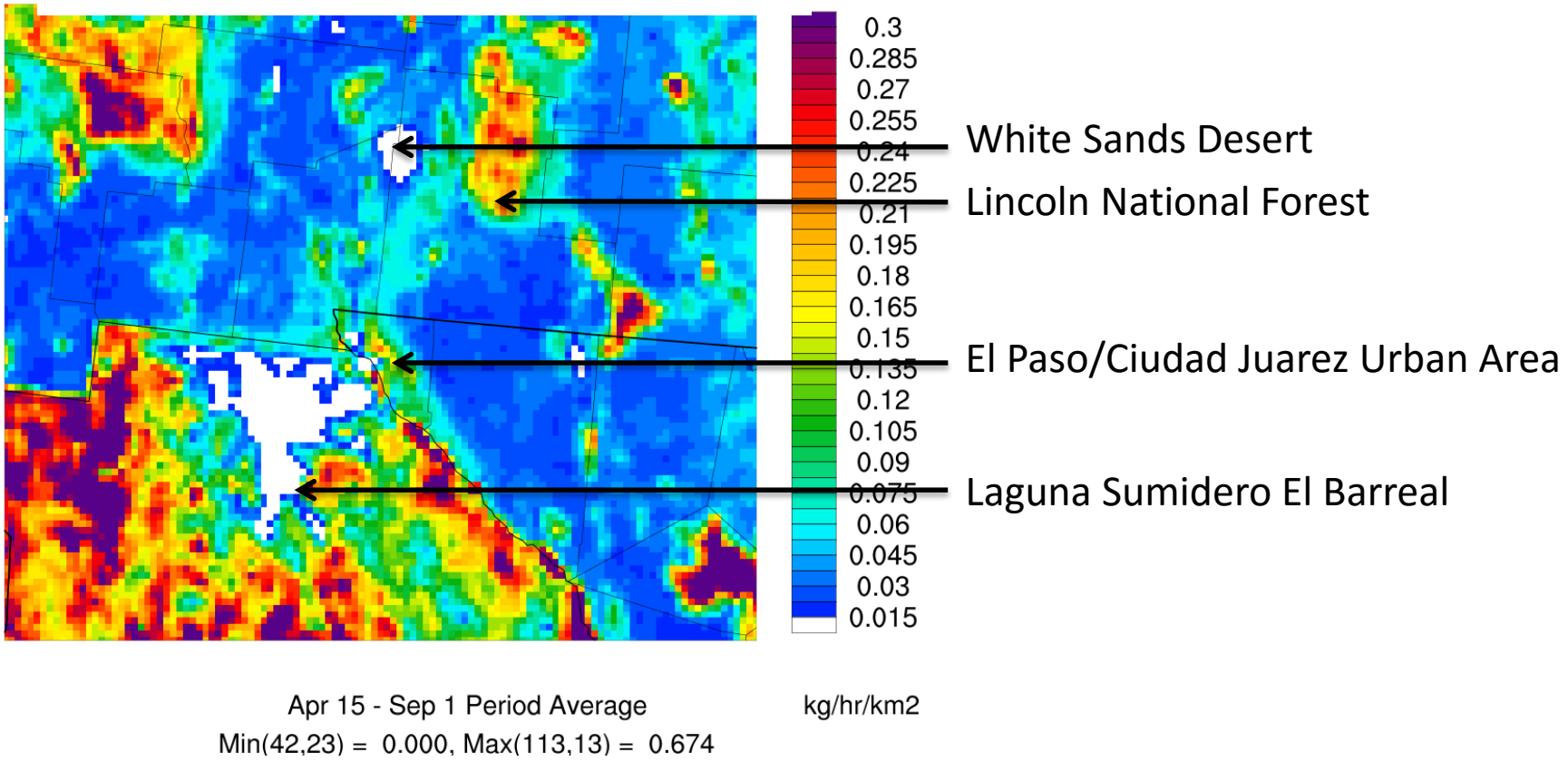
1. ***MEGAN generates hourly, gridded biogenic emissions***
2. ***Requires gridded inputs***
   - ***Land Cover Data (What type of plants? How dense is the foliage?)***
     - Plant Functional Types: Developed from high resolution satellite land cover/crop data
     - Species composition averaged over ecoregions
     - Leaf Area Index: based on MODIS satellite observations
   - ***Weather Data (How active are the plants?)***
     - 2011 meteorology from the MSKF NAM WRF model run
     - Gridded, hourly temperature, solar radiation, and soil moisture
   - ***Emission Factor Data (How much do they emit?)***
     - Emission factor maps based on vegetation species composition
3. ***Ramboll Environ ran MEGAN for the SNMOS 2011 Episode***

Biogenic Emissions Quality Assurance

- Emissions tables
  - County-level emission summaries for NOx, CO and VOC
- Spatial evaluation
  - Is the pattern of emissions reasonable?
    - Expect higher emissions over heavily vegetated regions
    - Urban areas and deserts should have lower biogenic emissions

Biogenic Emissions Evaluation

MEGAN v2.10 Episode Average Isoprene Emissions on 4 km Grid



- Checked LAI and emission factor maps against final emissions maps and satellite imagery; note abrupt change at Mexico-U.S. border

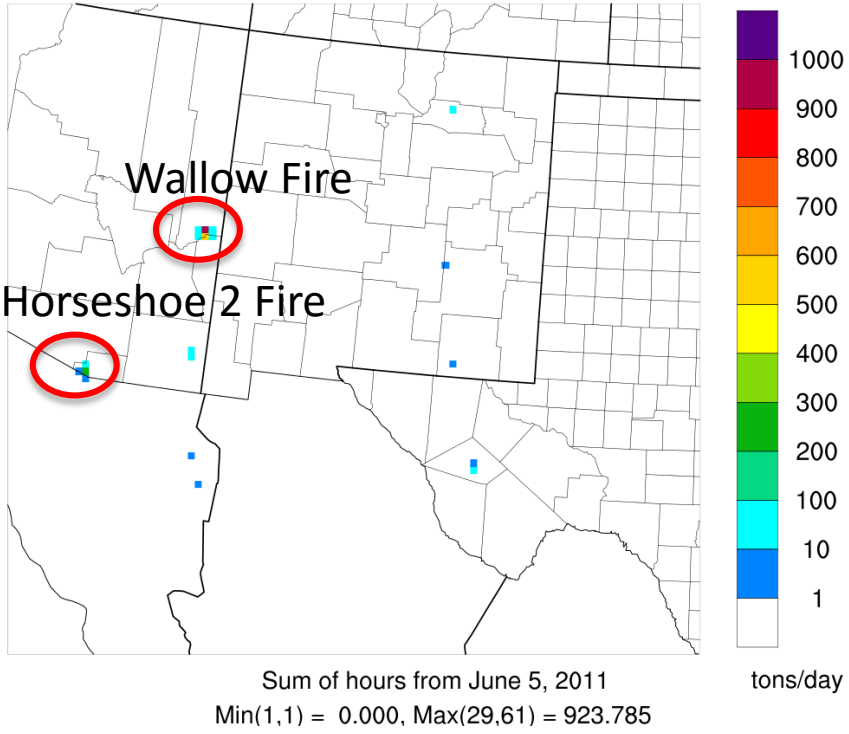
Fire Emissions Modeling

PMDETAIL FIRES

1. ***Day-specific wildfire, ag, and prescribed fire data*** – FETS fire activity data for all fires within modeling domain (size, location, timing, fuel loading, moisture, and emission fluxes, chemical parameters)
2. ***Gridding*** – fires gridded to SNMOS modeling domains
3. ***Speciation*** – emissions adapted to CAMx chemical mechanism
4. ***Plume Rise*** - plume characteristics for each fire event prescribed based on fire type and size
   - Plume rise is weather-dependent
   - Plume characterized by smoldering fraction, plume bottom and plume top
5. ***Ramboll Environ developed PMDETAIL fire emissions for SNMOS base case episode***
   - Quality assurance of emissions
     - County-level emissions summaries for ag burns, wildfires, prescribed fires
     - Spatial plots

Fire Emissions Evaluation: June 5, 2011

PMDETAIL $PM_{2.5}$ Daily Total Fire Emissions



NOAA HMS Satellite Fire Detections and Smoke Extent

- Spot checks to ensure fire locations match satellite fire detections

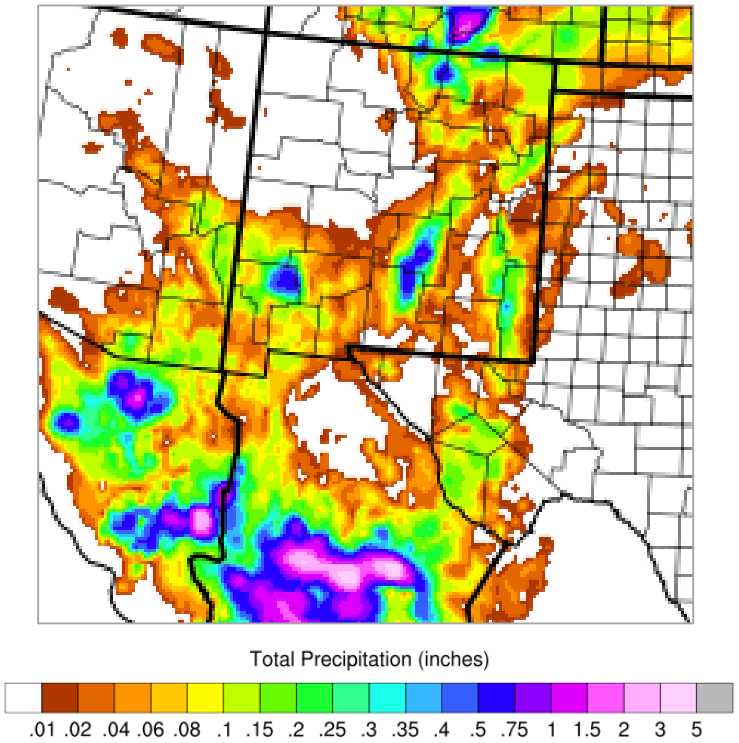
Lightning Emissions Modeling

1. ***NOx is formed in lightning channels***
    - Heat released by the electrical discharge causes the conversion of N_2 and O_2 to NO
2. ***Formation of LNOx is associated with deep convection; LNOx production is typically parameterized in terms of the modeled convection.***
    - Koo et al. (2010) parameterization estimates annual total LNOx emissions for North America using NLDN flash data and NO emission factor (NO generated per flash of lightning)
    - Allocate LNOx emissions to WRF grid columns where modeled convection occurred using WRF convective precipitation as a proxy for lightning activity
    - LNOx distributed in the vertical using profiles derived from aircraft measurements and cloud-resolving models
    - LNOx modeled as point sources with zero plume rise in appropriate layer

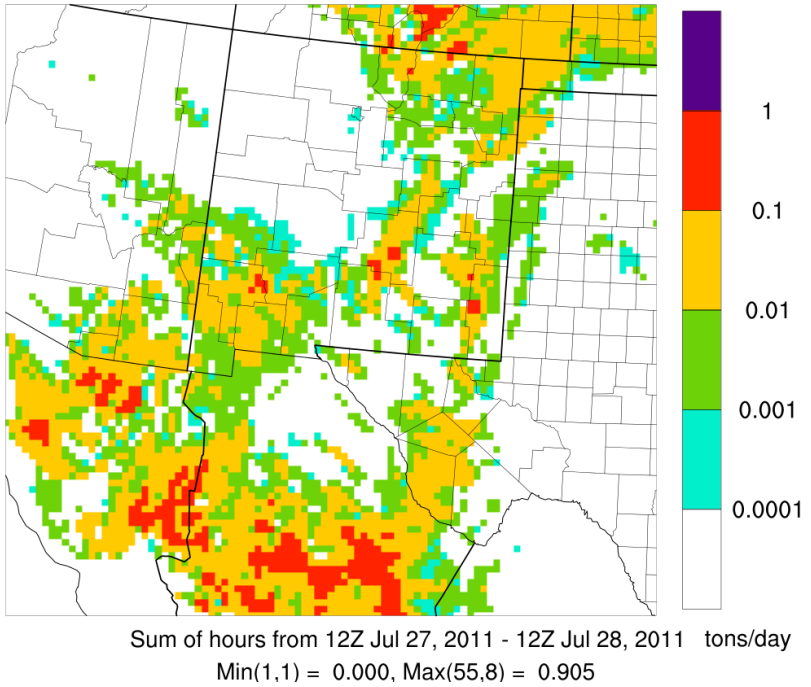
Lightning Emissions Evaluation

July 27-28, 2011

WRF MSKF NAM Run Precipitation



Column-Integrated LNOx Emissions



- Match locations of locally intense (convective) rainfall with LNOx maxima

Task 6: 2011 Base Case Air Quality Modeling

SNMOS Modeling on the 12/4 km Domain

Lead: Ramboll Environ

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CAMx Air Quality Modeling

- CAMx configured as in WAQS 2011b study
  - Modeling ozone, PM, N and S deposition
  - CAMx v6.20
  - CB6r2 chemical mechanism, EBI solver
  - Zhang dry deposition scheme
  - WRF meteorology
    - WRFCAMx with CMAQ-like Kv
- CAMx run for April–October, 2011

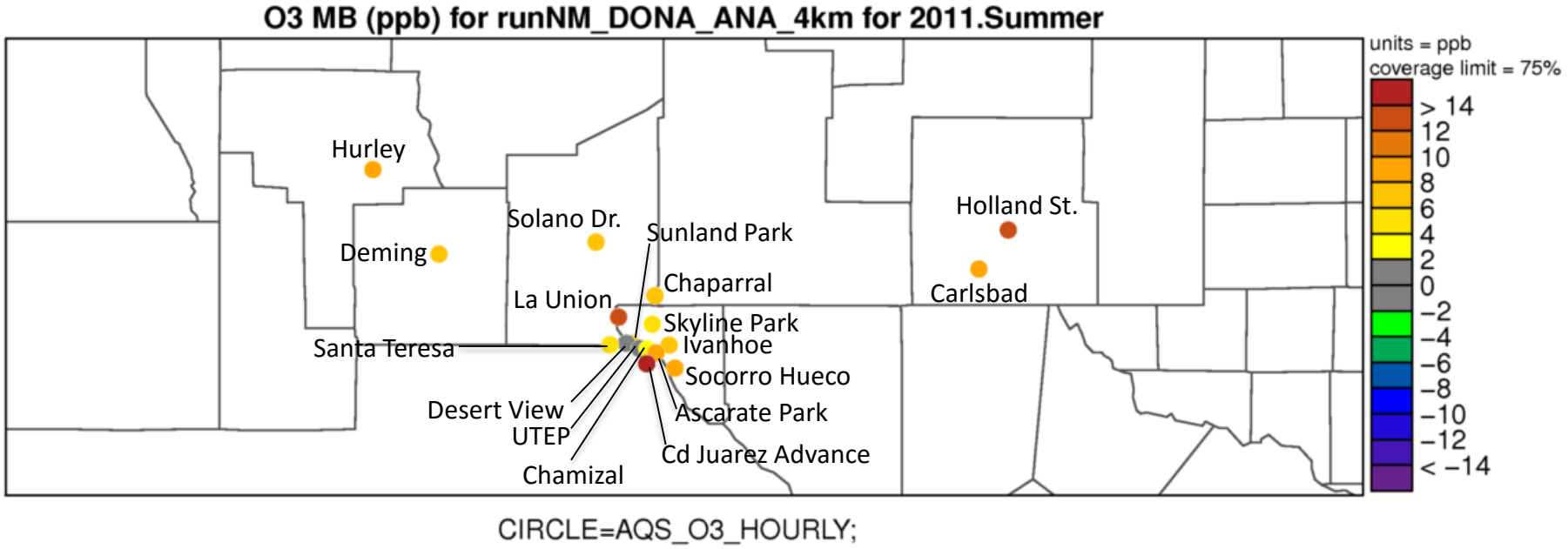
CAMx Boundary Conditions

- 3SAQS 36 km grid 3D output fields used as BCs for the Dona Ana 12 km grid
- 12/4 km grids run in 2-way nested mode

CAMx Model Performance Evaluation

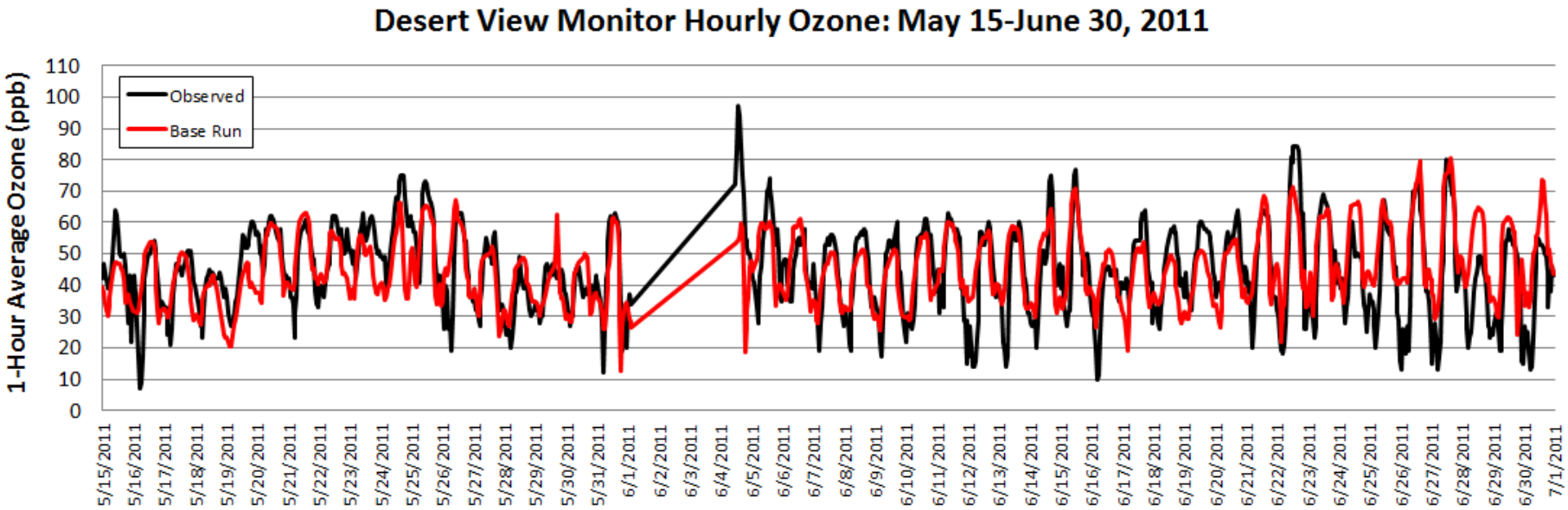
- Evaluate model on 12/4 km grid
  - Compare ozone, CO, NO_2, total $PM_{2.5}$ mass and speciated $PM_{2.5}$ concentrations against observed values, paired in time and space
  - Procedures follow EPA's 2014 modeling guidance[1] and WAQS 2011b modeling
- Performance statistics (bias, error, etc.) and spatial plots using AMET
  - Compare model performance with results of other modeling efforts (Simon et al., 2012)
- Perform sensitivity tests as needed if aspects of model performance need improvement

CAMx Mean Bias for 1-hr Ozone



- Overall high bias for ozone
  - Smallest bias at Desert View and UTEP
  - Investigating reasons for high bias at Ciudad Juarez Advance and La Union monitors

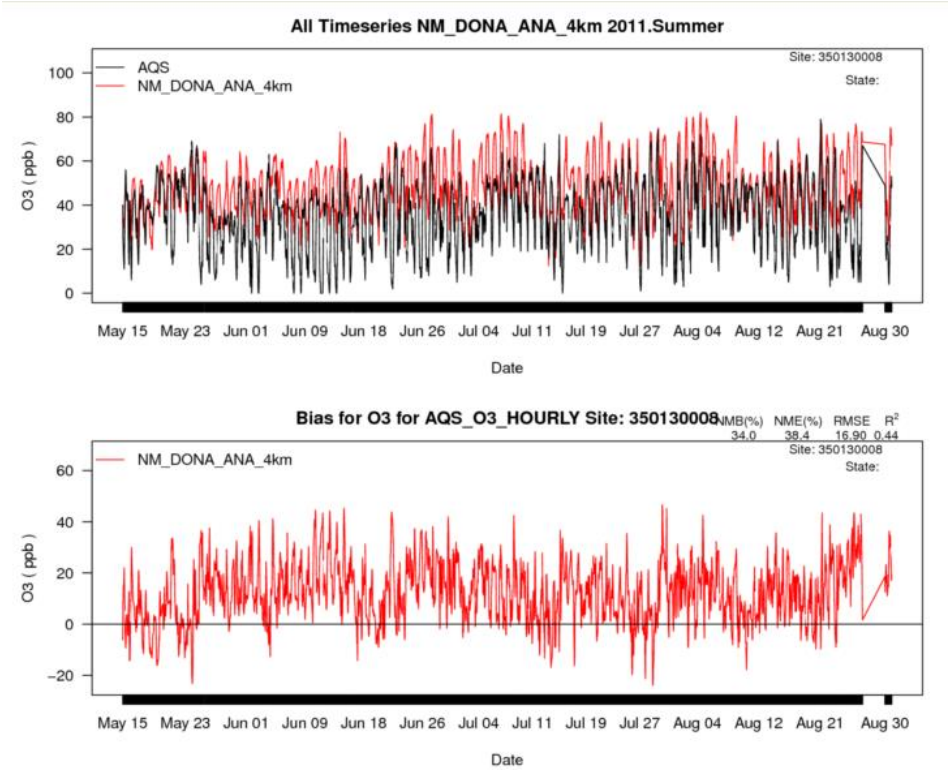
Desert View: May-June Ozone Episodes



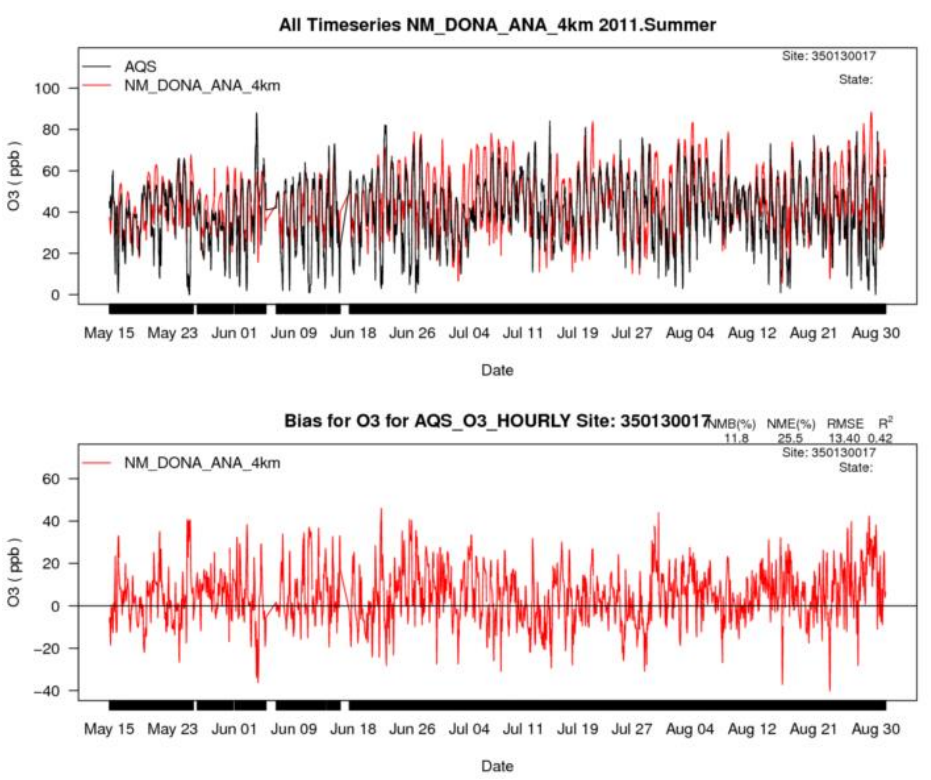
- High MDA8 ozone episodes May 24-25, June 4, 22, 27
- Model underestimates ozone on days with highest observed ozone

Ozone Time Series

La Union Monitor



Sunland Park Monitor



- 4 km grid monitors overestimated ozone in late June/early July

Task 4-6 Summary

- Anthropogenic emission inventory completed
- Natural emission inventory completed
- Emissions merging completed
- CAMx modeling of 2011 completed
  - Full model performance evaluation underway

Next Steps

Tasks to be Completed by April 30, 2016

- **Task 1**: 2011 WRF 36/12/4 km with 4 km focus on Dona Ana/El Paso/Juarez and Work Plan (Completed)
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