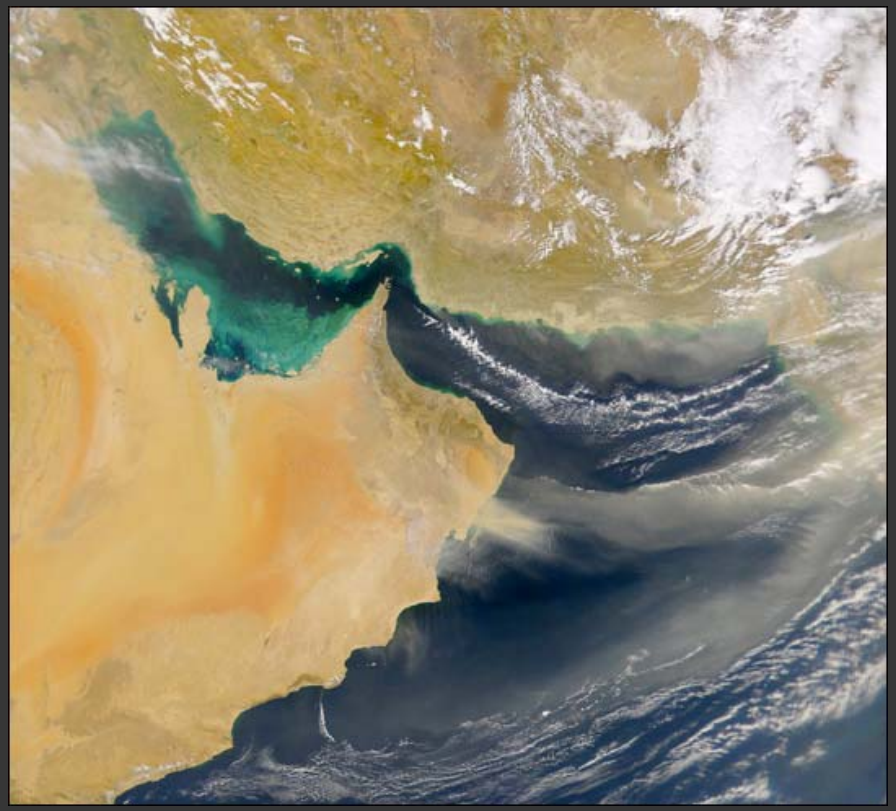
Developing Emissions for Multi-polluant Air Quality Modeling in the Middle East

Zachariah Adelman, Limei Ran, Mohammad Omary, Uma Shankar
Center for Environmental Modeling for Policy Development
University of North Carolina Institute for the Environment
David Streets
Argonne National Laboratory
Argonne, IL

Presented at the 18th International Emission Inventory Conference
April 14-16, 2009 Baltimore, MD

Background

- Middle East significant global source of ozone
- Large and frequent dust events
- Few regional-scale modeling studies
- UAE burden of disease assessment

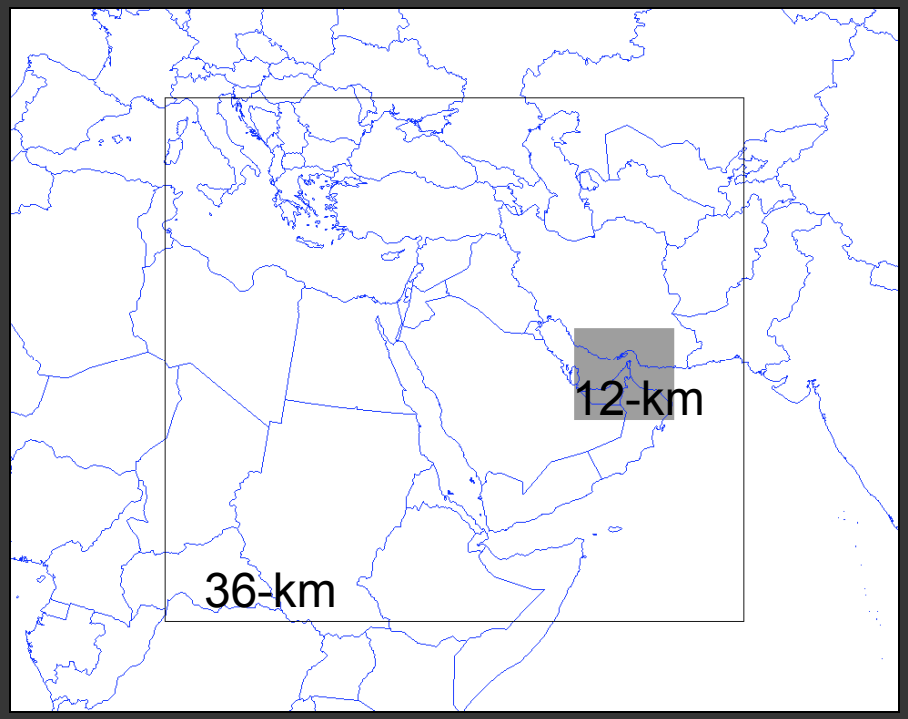


Objective

- Develop emissions to support multi-pollutant CMAQ simulations of air quality in the Middle East
  - Multi-pollutant: ozone, 1º and 2º PM, SOA, acid deposition, air toxics, mercury, chlorine, sea salt
  - Include anthropogenic and natural sources of emissions
  - Appropriate for regional-to-urban spatial scales
  - 2007/08 activities and magnitudes
  - Vertically resolved emissions
  - Source-specific temporal and chemical distributions

Approach

- Middle East Emissions Modeling Platform (ME-EMP) with SMOKEv2.4
- Inventories collected from multiple global/regional/ local sources
- Spatial distribution of pre-gridded and country-total inventories
- Vertical allocation of “area” inventories
- Temporal and chemical allocation using US and European data



UAE 36-km and 12-km CMAQ modeling grids

ME-EMP Inventories

Sector	Europe	Africa	Middle East	Eurasia	UAE
Stationary Area	EMEP	CIRCE+ EDGAR	CIRCE	CIRCE	CIRCE
Onroad Mobile	EMEP	CIRCE+ EDGAR	CIRCE	CIRCE	CIRCE
Nonroad Mobile	EMEP	CIRCE+ EDGAR	CIRCE	CIRCE	CIRCE
Stationary Point	None[1]	None[1]	None[1]	N/A	NILU
Biogenic	MEGAN				
Biomass Burning	GFEDv2				
Commercial Shipping	UD-Ship				
Windblown Dust	SDust				
Mercury	AMAP				

[1] Sources typically treated as point sources contained in stationary area inventory

Spatial Allocation

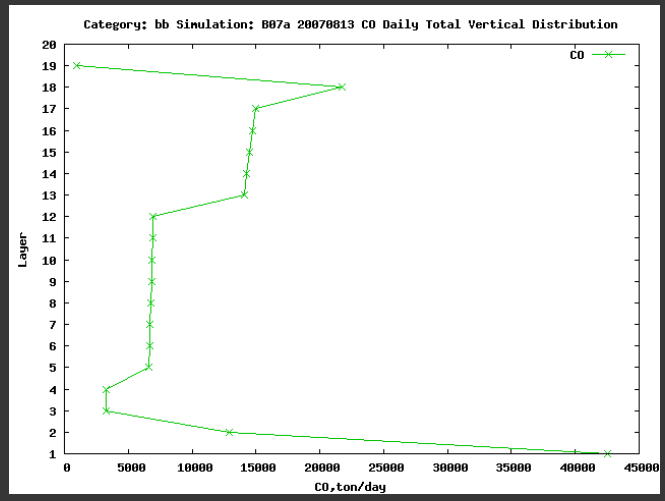
- Pre-gridded Inventories
  - Convert ASCII inventories to netCDF
  - I/O API MTXCALC linear interp. to model grids
- Country-total inventories
  - Global GIS DB, CIESIN, MEGAN, and UAE Shapefiles
  - Spatial Allocator surrogates for the model grids
  - Surrogate assignments by sector descriptions

Spatial Surrogates

- Population
- Roads
- 0.5*Roads+0.5*Pop.
- UAE Roads
- 0.5*UAE Roads+0.5*Pop.
- Crops
- Airports
- Mineral Extraction
- Mines
- Industrial
- Railroads
- Fuel Storage Tanks
- Energy Utilities
- Unpaved Roads
- Nonroad Mobile
- 0.75*Industrial+0.25*Pop.
- Energy Industry
- Heavy Industry
- Water Utilities
- Waste

Vertical Profiles

- EMEP profiles for anthropogenic sources
  - Energy combustion
  - Non-industrial combustion
  - Manufacturing combustion
  - Production processes
  - Fossil fuel extraction
  - Waste
- Prototype profiles for biomass burning sources
  - 0.25%: 0-50m
  - 0.75%: 50-2000m

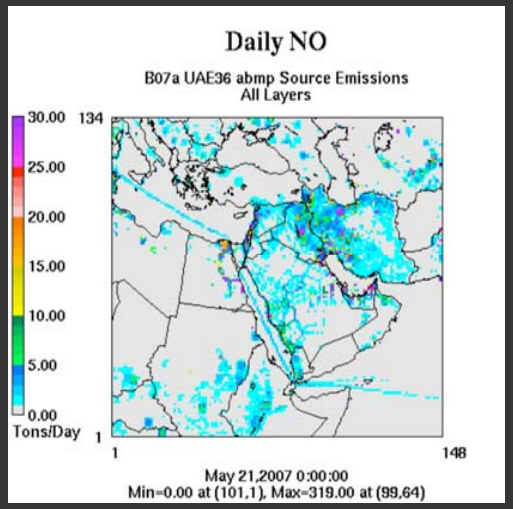


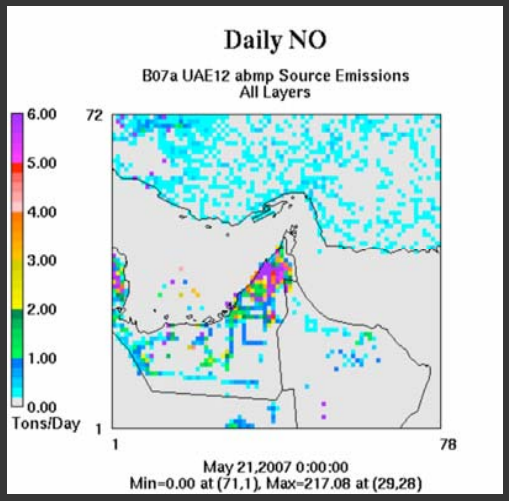
Temporal and Chemical Distributions

- EMEP and USEPA temporal and CB05 speciation profiles
- AMAP speciation for Hg
- SPECIATE mass-fractions for benzene, acetaldehyde, and formaldehyde added to standard CB05 profiles
- Weekday/weekend profiles modified for domain regions
  - Europe: Saturday/Sunday weekend
  - UAE: Friday/Saturday weekend
  - Africa, Middle East, Eurasia: Thursday/Friday weekend
- UAE holidays

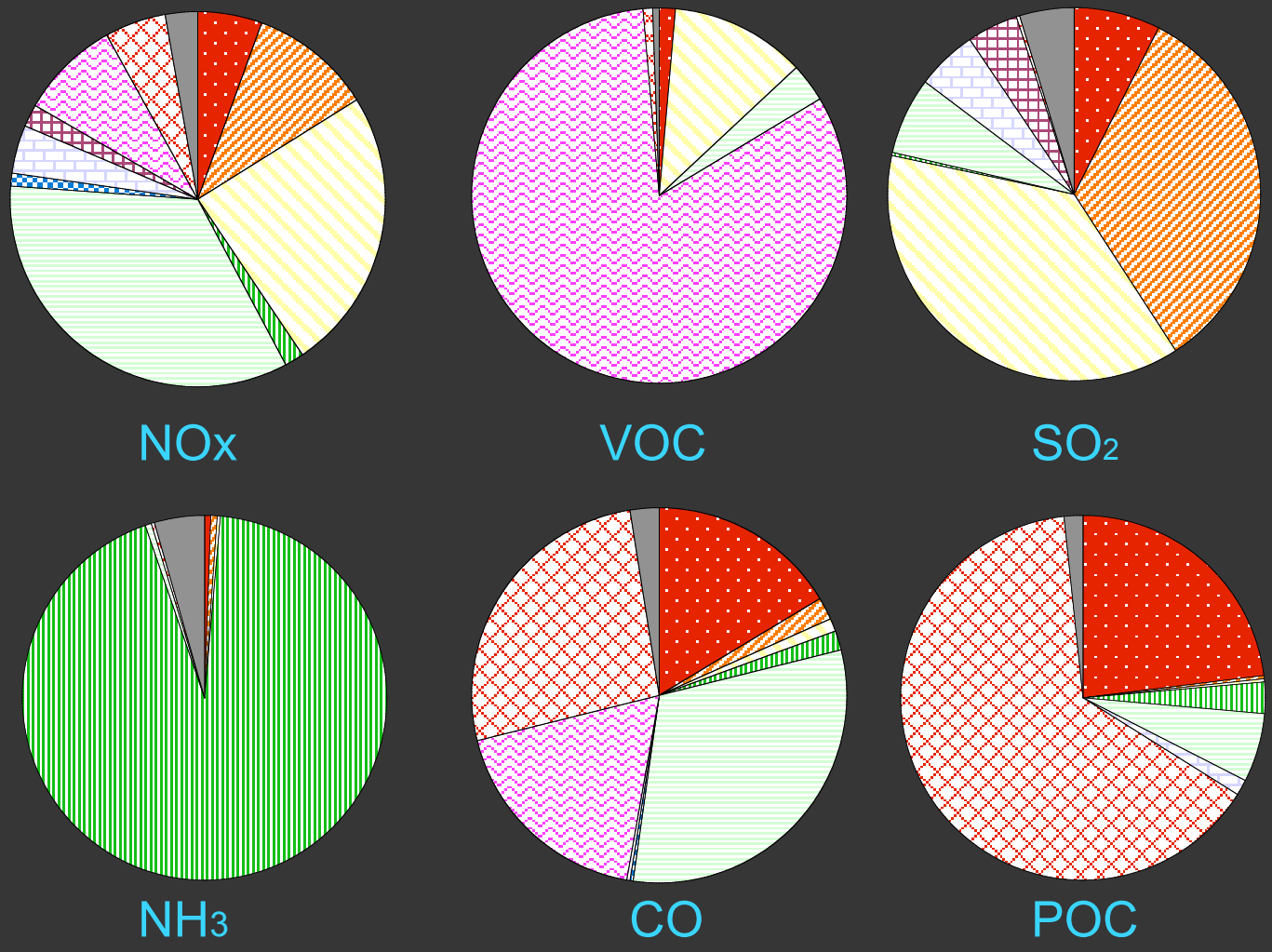
Results

- All emissions results are preliminary and will be evaluated with completion of CMAQ simulations
- Good agreement with the results of global-scale modeling studies (wide-range)
- Qualitative evaluations against satellite observations show strengths and weaknesses in results



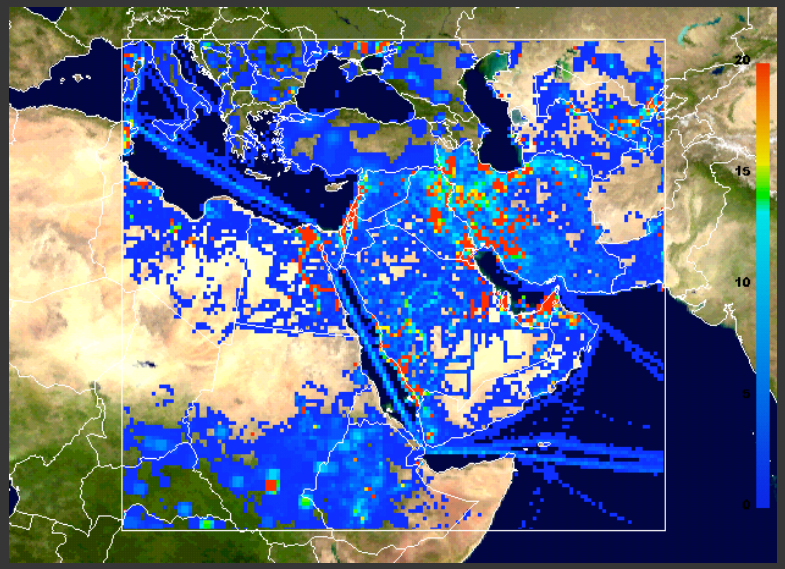


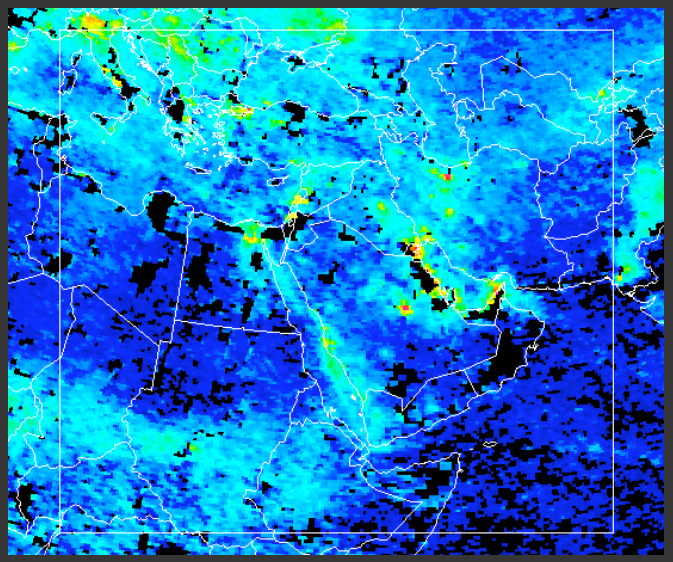
Results


NOx
VOC
SO2
NH3
CO
POC
Area (Res+Solv)
Area (Waste)
Area (Manuf)
Area (Energy)
Agriculture
Onroad
Nonroad
Shipping
Point
Biogenic
Biomass Burning
Windblown Dust
Europe (EMEP)

Results

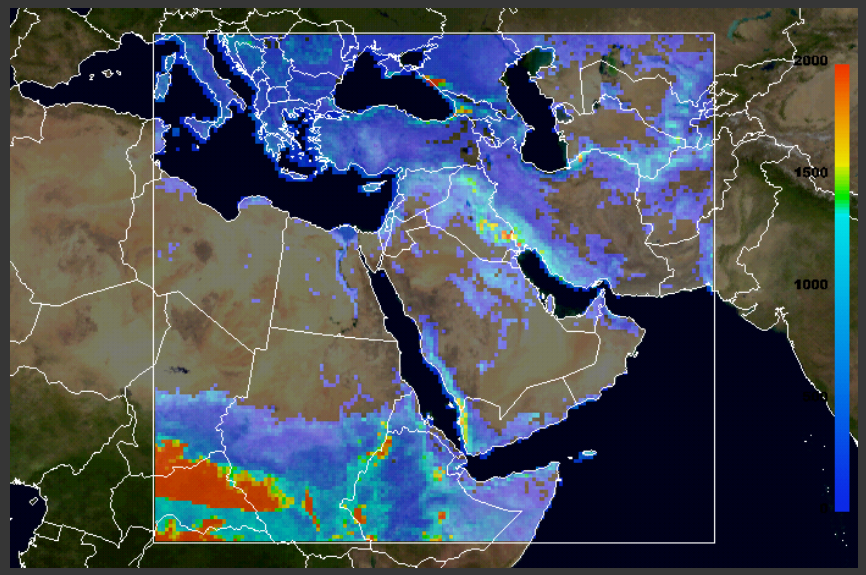
- Monthly total NO_2 emissions (left)
- Monthly average SCIAMACHY NO_2 (right)

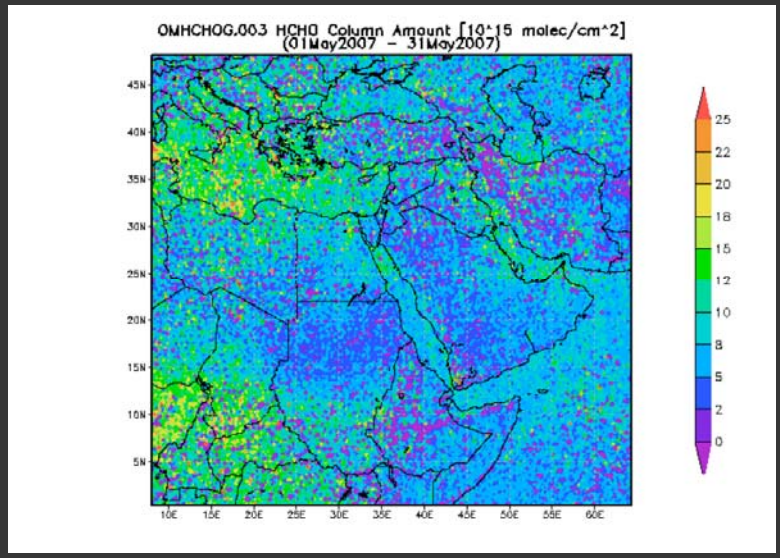




Results

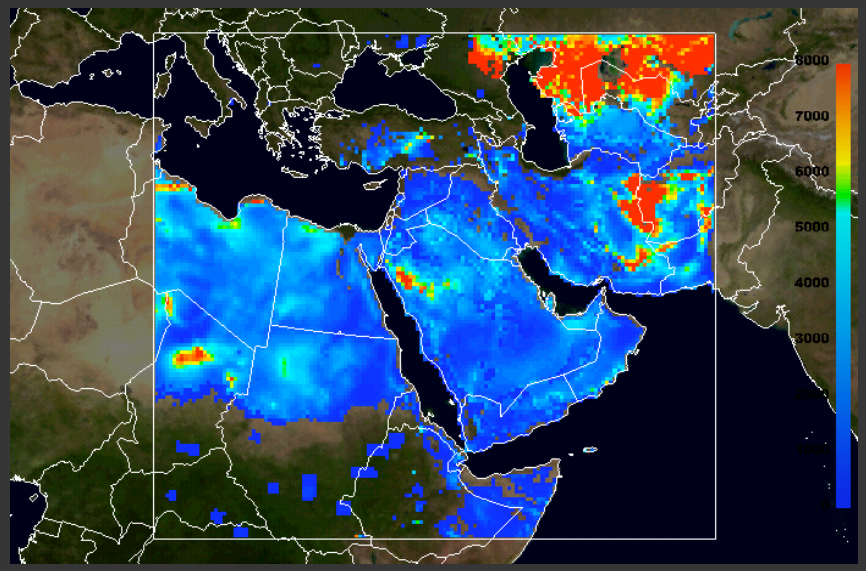
- Monthly total isoprene emissions (left)
- Monthly average OMI HCHO (right)

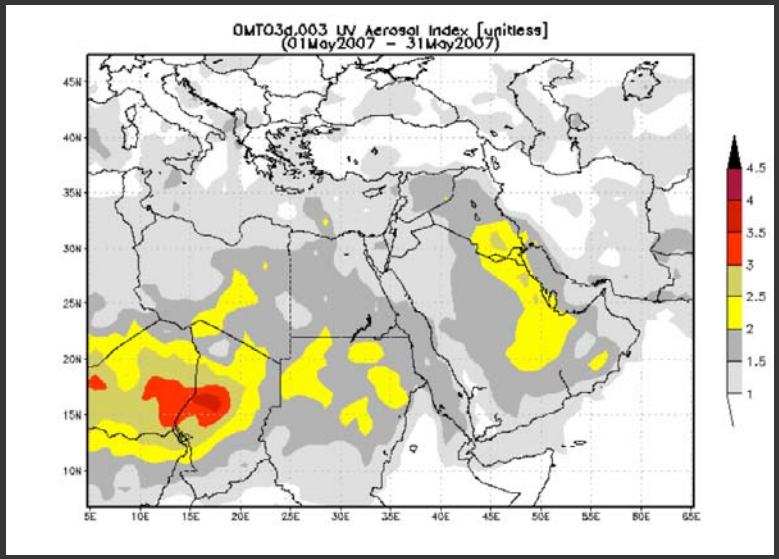




Results

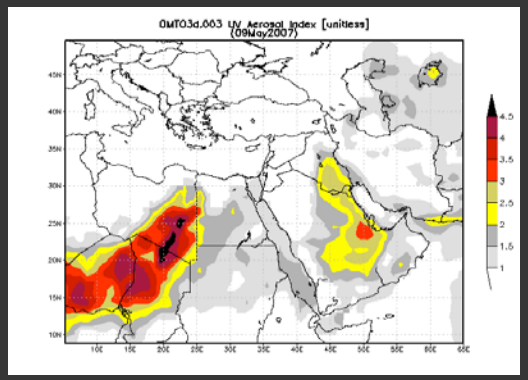
- Monthly total PMC+POC emissions (left)
- Monthly average OMI UV AI (right)

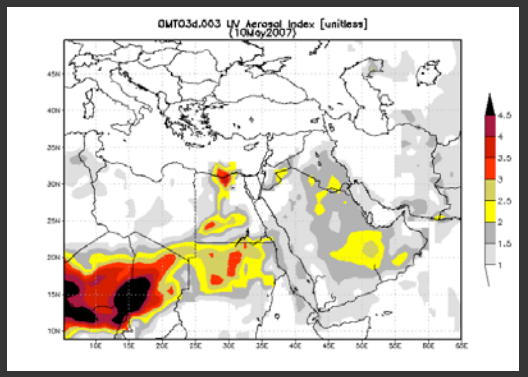


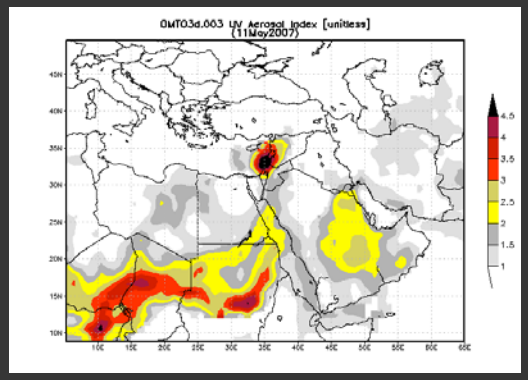


Results

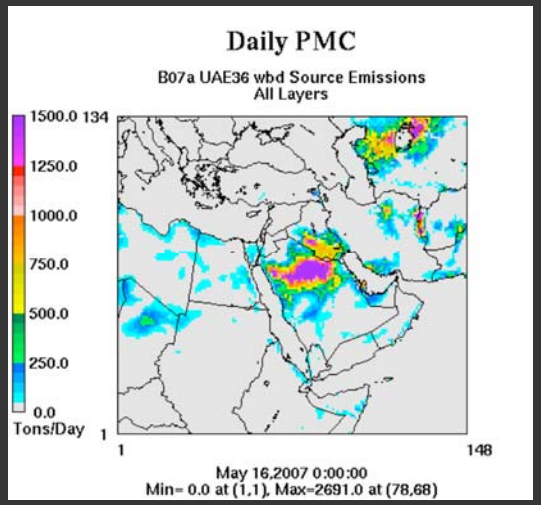
Daily average OMI UV AI, May 9-11, 2007

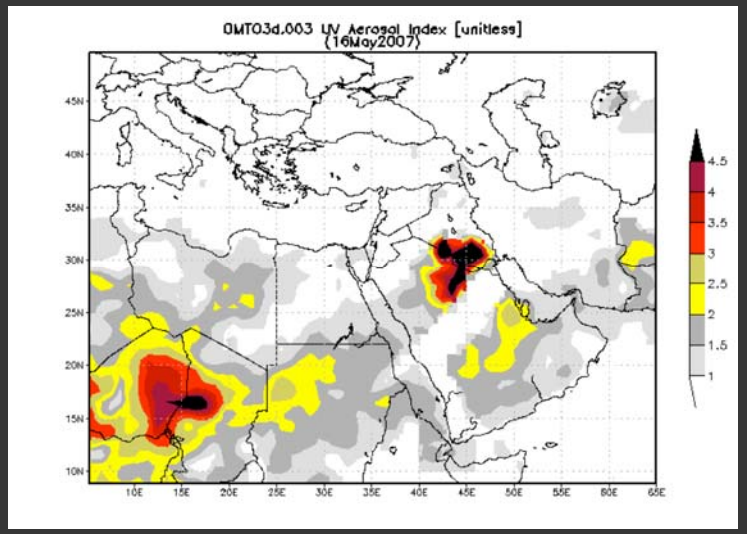






May 16, 2007 SMOKE WBD and OMI UV AI





Conclusions and Future Work

- ME-EMP provides a prototype multi-pollutant emissions framework for domains outside of North America
- Improvements can be made by augmentation with local data
- Full evaluation of the emissions will require completion of CMAQ simulations and diagnostic evaluations
- Future iterations of the ME-EMP will include corrections, replacements, and additions
- On the radar:
  - Vertically resolved lightning NOx emissions
  - Alternative windblown dust emissions
  - Persian Gulf oil and gas inventories
  - Local temporal and chemical speciation data