Linking Regional and Global Predictions of the Aerosol Lifecycle

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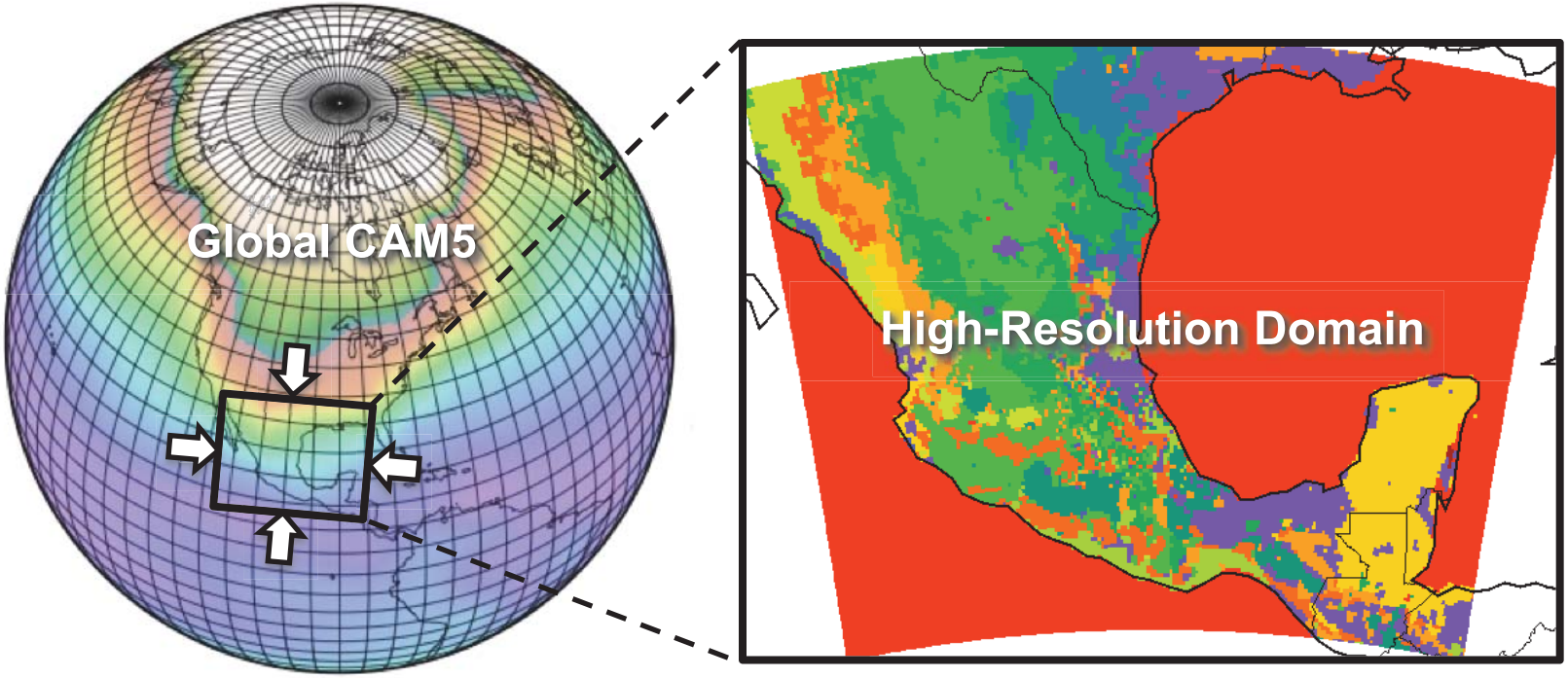
Aerosol Modeling Breakout Session



- Downscaling climate model predictions, using ***consistent physics from global to regional scales***
- Differences in predictions due to resolving atmospheric processes, and not the physics parameterizations

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Motivation

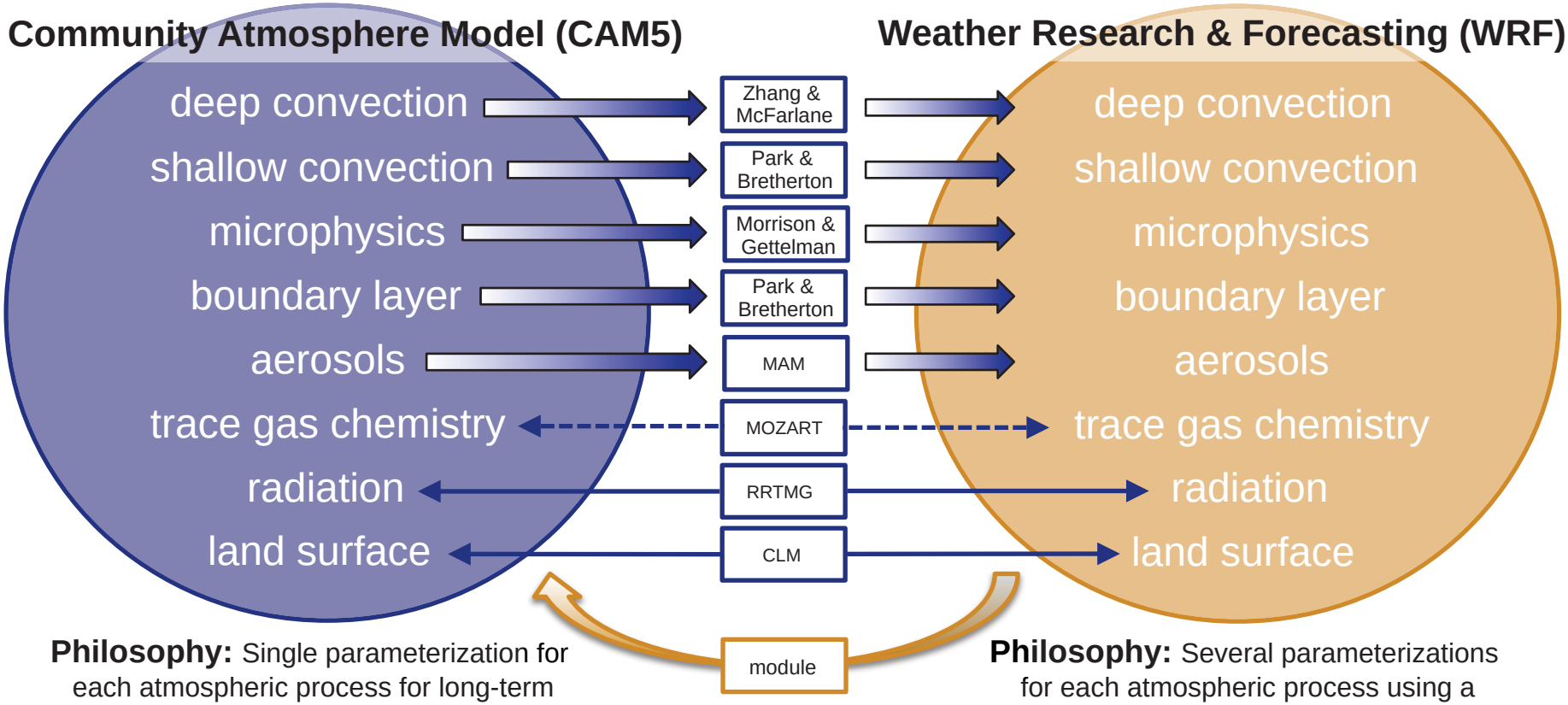
- CAM will be run at higher spatial resolution in the future, but the ***performance of the current suite of physics modules at those scales is not known***

- Current computing capabilities ***do not allow global model domains to be run routinely at mesoscale resolutions***

- Rapid development and evaluation of the next generation suite for CAM requires the ability to ***isolate processes*** as well the ability to test parameterizations across a range of scales

- There has been relatively ***little interaction*** between the WRF (cloud-resolving and mesoscale) and CCSM/CAM (global scale) communities
  - Models optimized for different purposes
  - Lessons learned are not necessarily shared

Approach



Philosophy: Single parameterization for each atmospheric process for long-term climate simulations using a coarse grid

Philosophy: Several parameterizations for each atmospheric process using a wide range of grid spacings

Engineering component: Merge code and ensure code inter-operability

Science component: Evaluate performance of CAM modules at regional scales

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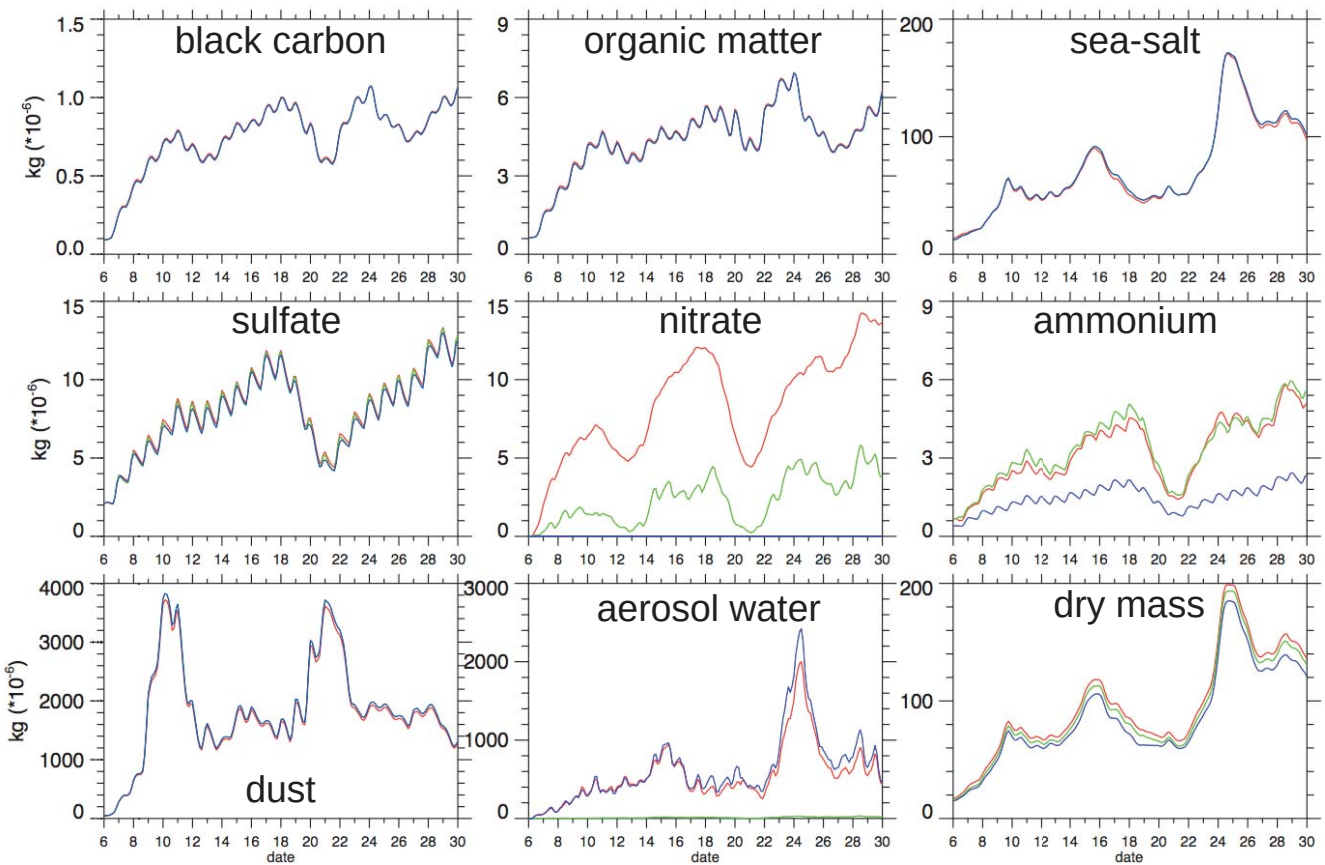
Consistency Checks

- Is total aerosol mass (PM10) from MAM similar to other aerosol models?
- To check, MILAGRO simulations (Δx = 12 km) performed for each model
  - identical emissions, meteorology (feedbacks backs turned off), and chemistry
  - dry deposition and wet removal turned off, fixed boundary conditions (no influx)

Total Mass (PM10) in Domain over 24 Days



MAM
MADE/SORGAM
MOSAIC

- While total mass is similar, there are <u>differences in the aerosol size distribution</u>
- MAM neglects NO_3
- MAM assumes SO_4 is neutralized by NH_4 to form NH_4HSO_4
- MADE/SORGAM produces little aerosol water

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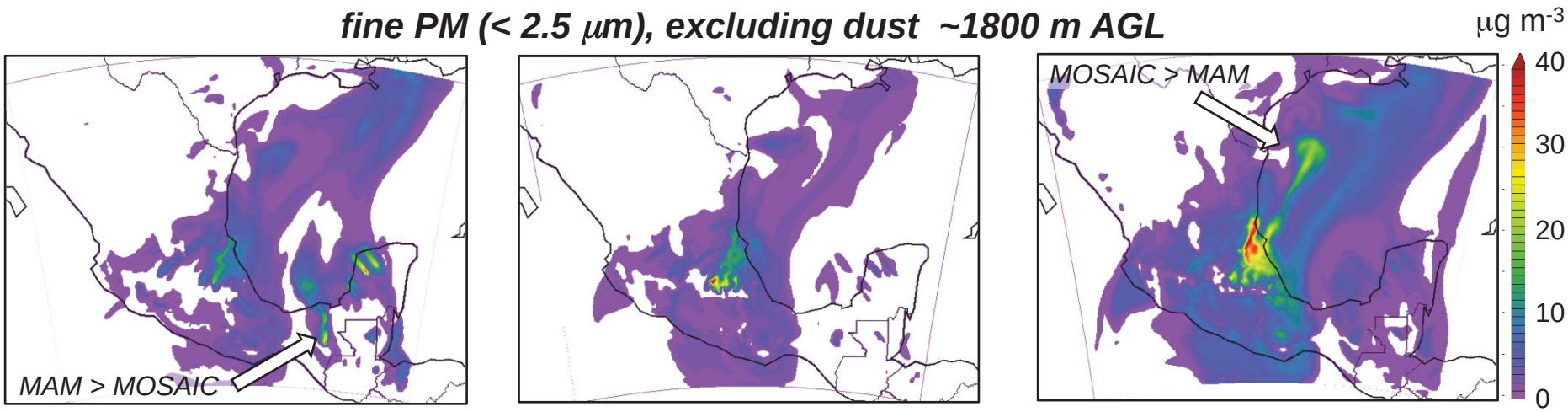
Comparison

- **AMT methodology:** identical emissions, meteorology (aerosol-radiation-cloud feedbacks turned off), chemistry, dry deposition, boundary conditions

MAM (from CAM5)	MADE/SORGAM	MOSAIC
modal – 3 modes, **18** species	modal – 3 modes, **38** species	sectional – 4 bins, **164** species
'simple'	*9 times more species*	**'complex'**
1 simulation day ~ 21 min	*~ 24 min*	*~ 60 min*

fine PM (< 2.5 μm), excluding dust ~1800 m AGL



- Differences due to secondary aerosols (SO_4, NO_3, NH_4, organics)
- Treatment of organics:

  MAM: POA - non-volatile, SOA – simple yields

  MADE/SORGAM: POA - non-volatile, SOA - 2-product approach

  MOSAIC: volatility basis set, non-volatile POA & SOA

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Example

- **AMT methodology:** identical emissions, meteorology (aerosol-radiation-cloud feedbacks turned off), chemistry, dry deposition, boundary conditions

MAM (from CAM5)	MADE/SORGAM	MOSAIC
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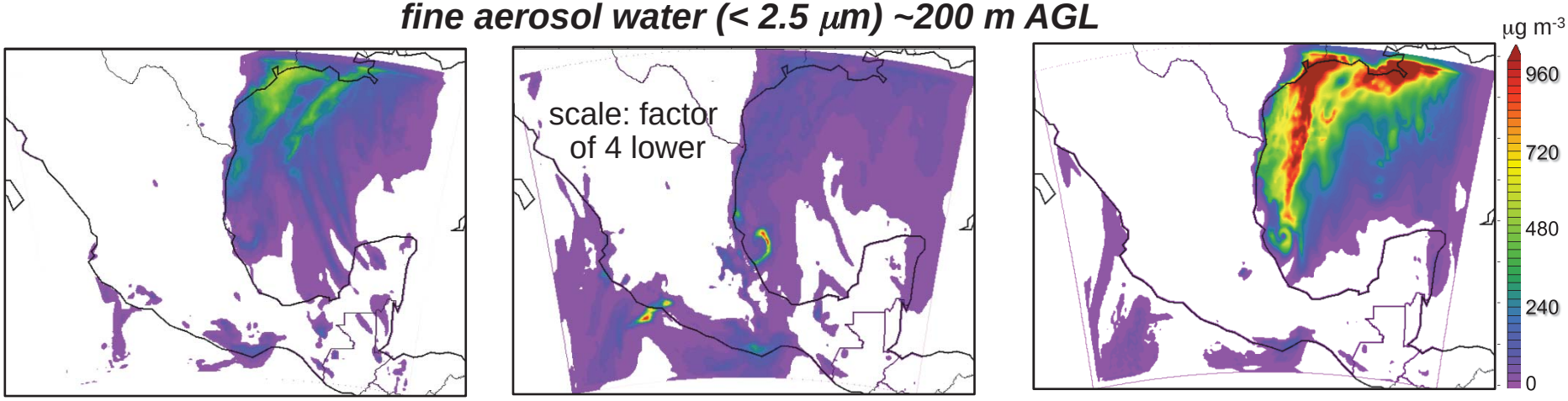
'simple'	*9 times more species*	**'complex'**
1 simulation day ~ 21 min	*~ 24 min*	*~ 60 min*

fine aerosol water (< 2.5 μm) ~200 m AGL



- Differences in secondary aerosols and thermodynamic modules leads to large variations in uptake of water on aerosols
- Differences in H_2O influences aerosol direct effect and hygroscopicity

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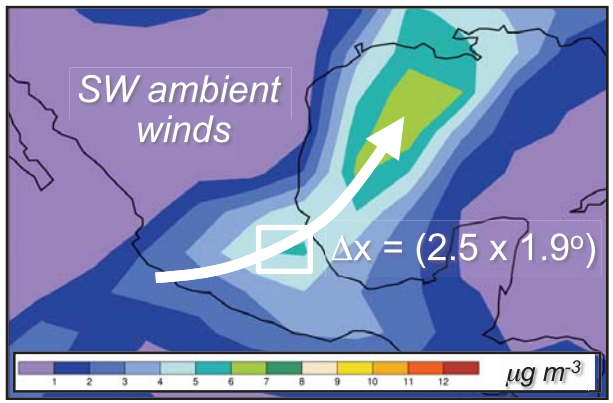
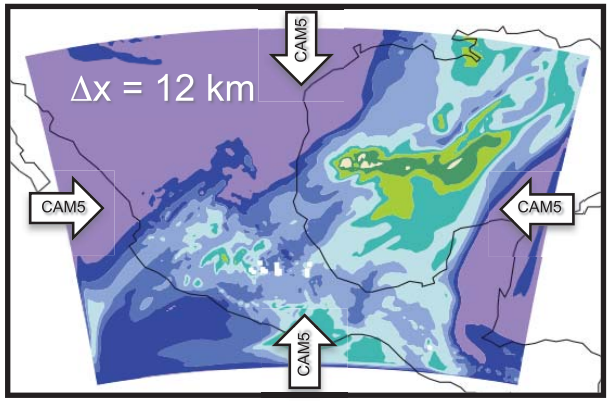
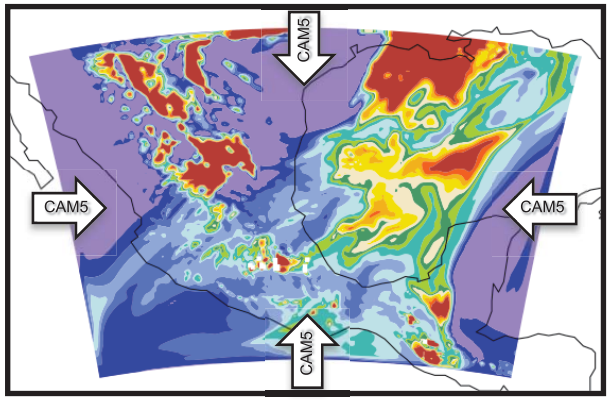
Downscaling

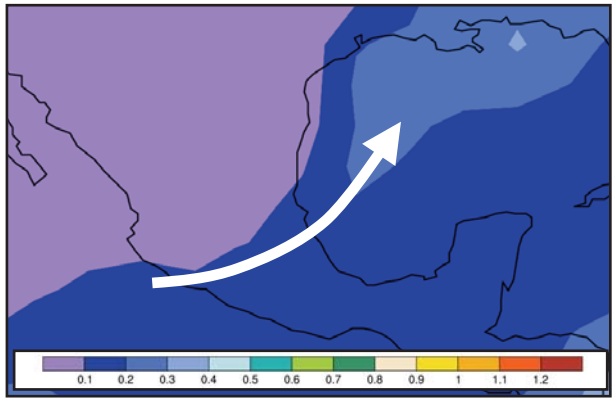
PM2.5 at 700 hPa, 18 UTC 19 March 2006

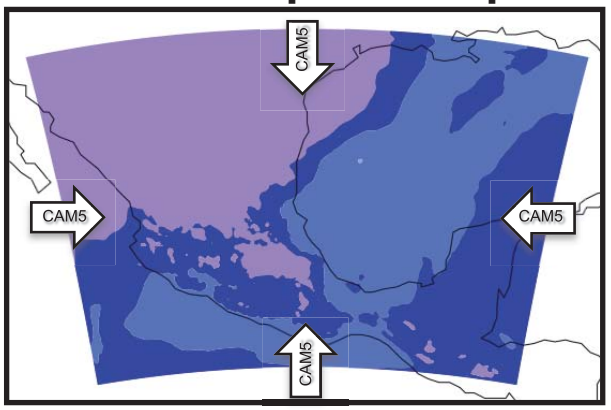


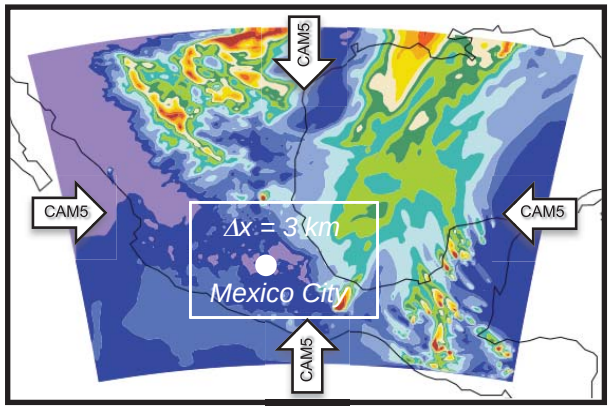




Aerosol Optical Depth







CAM5 + IPCC AR5 emissions

WRF + CAM5 Physics + (IPCC AR5) emissions

WRF + CAM5 Physics + local emissions

- Magnitude similar, but small grid spacing add details
- Differences mostly due to on-line dust calculations

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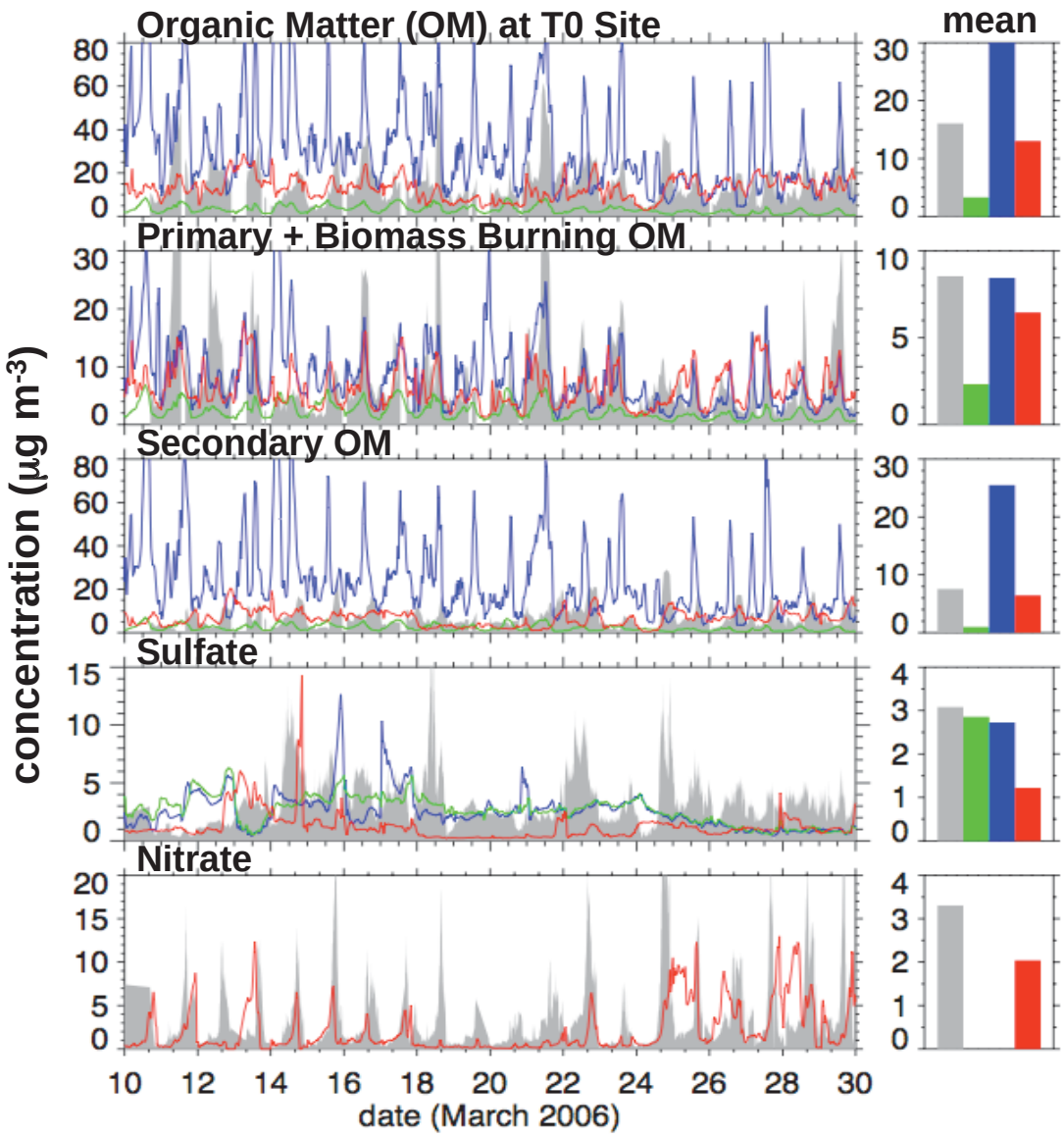
Urban Site



observed: J. Jimenez, A. Aiken
MAM: IPCC AR5 emissions
MAM: local emissions
MOSAIC: local emissions

- SOA from MAM too high, OM from primary + biomass similar between MAM and MOSAIC
- Scale dependance of SOA in MAM needs to be investigated further
- Mean SO_4 from MAM closer to observed than MOSAIC
- 3-mode MAM neglects NO_3

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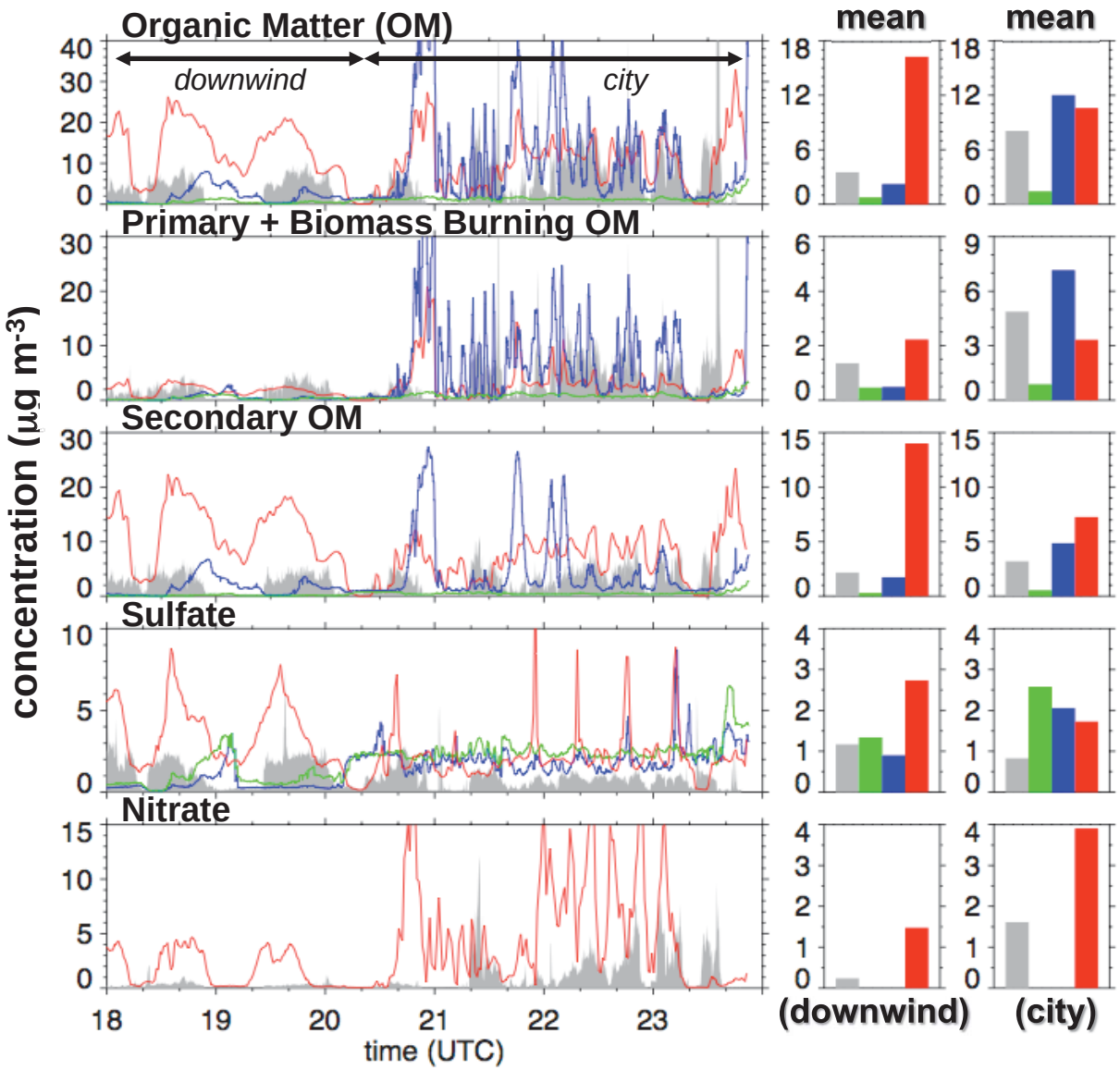
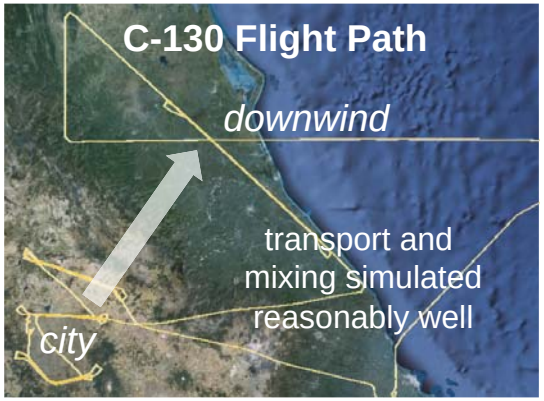
Regional Variations



observed: J. Jimenez, P. DeCarlo
MAM: IPCC AR5 emissions
MAM: local emissions
MOSAIC: local emissions

- MAM and MOSAIC OM similar over city
- SOA from MOSAIC too high everywhere
- Downwind OM from MAM better than MOSAIC



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Summary

- Can now directly evaluate performance of CAM's aerosol model, MAM, using spatial and temporal scales more compatible with field and operational data
- New ability to directly compare performance of MAM and specific aerosol processes contained in CAM (e.g. SOA) against other representations
- By comparing MAM with several ARM field campaign datasets, can better quantify its uncertainties for different locations and times
  - MILAGRO (Mexico)
  - CARES / CalNex (California)
  - BNL (Long Island)
  - GVAX (India)
  - TCAP (Cape Cod)
  - GOAmazon (Brazil)