

The Aerosol Modeling Testbed (AMT): A Community Tool Proposed for Coordinating the Development of Aerosol Treatments using WRF-chem

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with support from

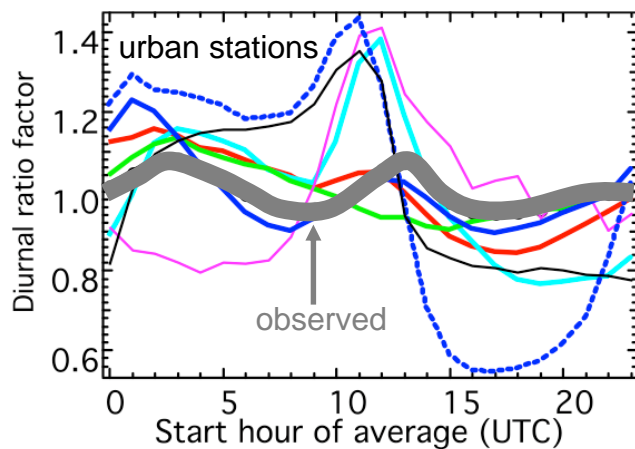


What is the Problem?

There are large uncertainties in the prediction of aerosols and their effect on direct and indirect forcing

- Current comparisons of global models represent a *range of uncertainty*, therefore, difficult to determine the impact of a specific treatment for an aerosol process on the overall uncertainty
- Need greater efficiency in evaluating aerosol treatments because of the timeframe of potential climate change

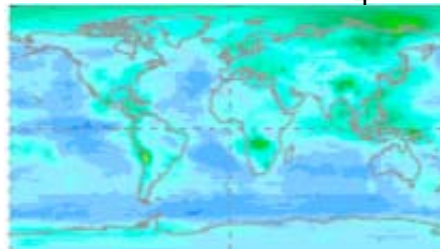
Range of Regional Model Predictions



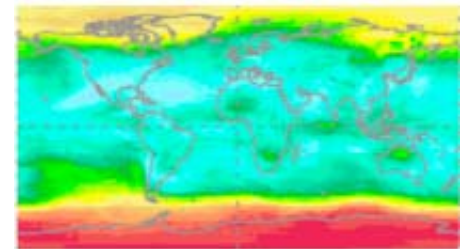
(from McKeen et al., 2007, JGR)

Range of Global Model Predictions

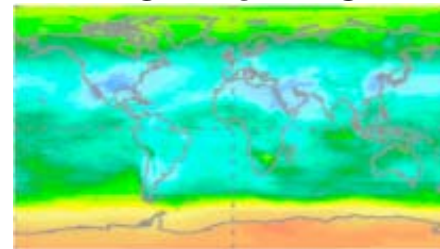
AOD from SO_4



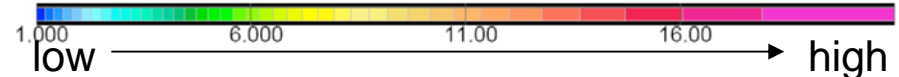
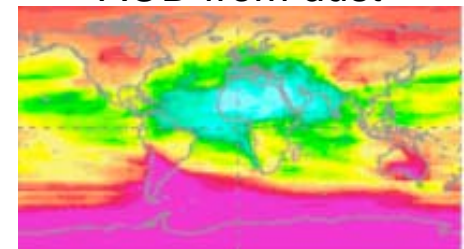
AOD from OC



AOD from BC



AOD from dust



(from Kinne et al., 2006, ACP)

How can this Problem be Addressed?

An *Aerosol Modeling Testbed* is being developed that is a computational framework that streamlines the process of testing and evaluating refined aerosol process modules over a wide range of spatial and temporal scales

Proposed to:

- Provide a more rational approach of evaluating aerosol modules
 - *Treat other processes, such as emission rates, meteorology, trace gas chemistry, and other aerosol processes the same (as much as possible)*
 - *Systematically target specific aerosol processes*
 - *Utilize all measurements (not select set) from field campaigns*
 - *Provide tools to facilitate science by minimizing redundant tedious work*
- Documentation of performance and computational expense
- Foster collaboration among aerosol modelers
 - *Facilitate testing of 0-D, 1-D, and cloud-resolving modules*
 - *Obtain more useful information regarding performance for GCMs*

Modeling Framework

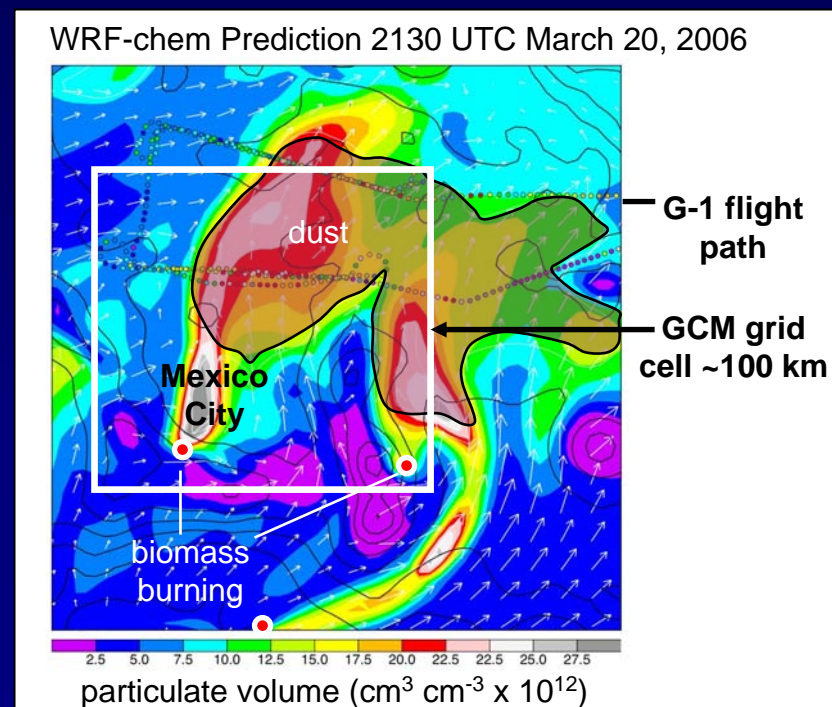
Why base the *AMT* on the chemistry version of the WRF model ?

Rationale:

- Community model framework
- Ability to include aerosol-radiation-cloud-chemistry feedbacks
- Increasing use of WRF-chem by aerosol modeling community
- Continued developments useful for aerosol modeling, such as
 - *Global WRF*
 - *Physics and Data Assimilation*
 - *Chemistry*

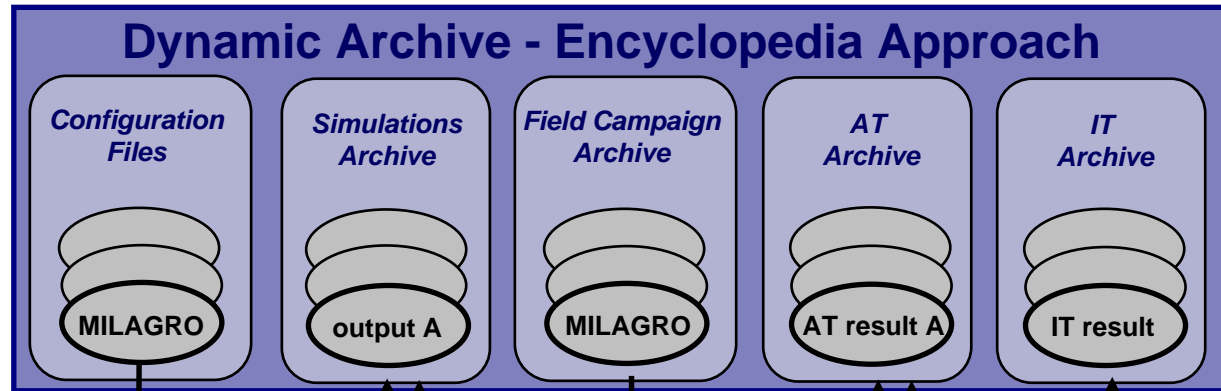
Local - Regional Scales:

- Examine processes that are sub-grid scale for global models
- Evaluate aerosol process modules at scales compatible with field data
- Then, test at coarser resolutions compatible with global models

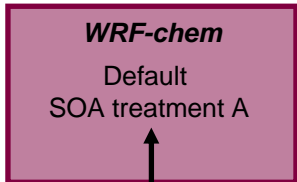


Schematic Diagram

Aerosol Modeling Testbed



Code Repository



New SOA treatment B
New SOA treatment C



output B

output C



AT result B

AT result C



Execution Script

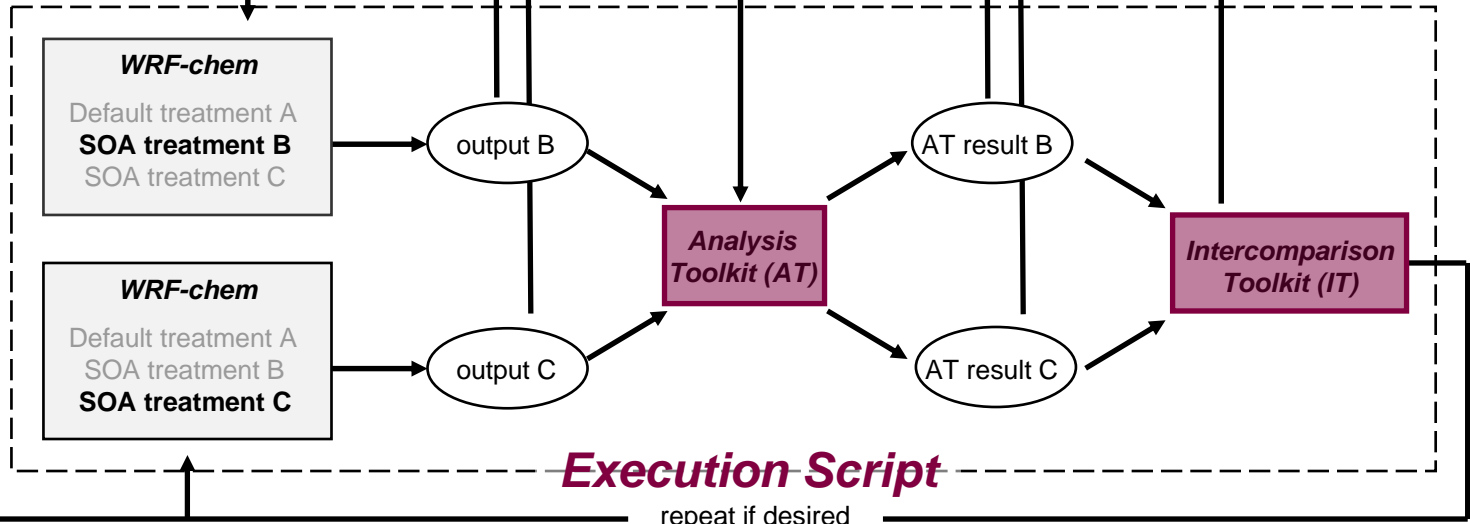
repeat if desired

Step 1

Step 2

Step 3

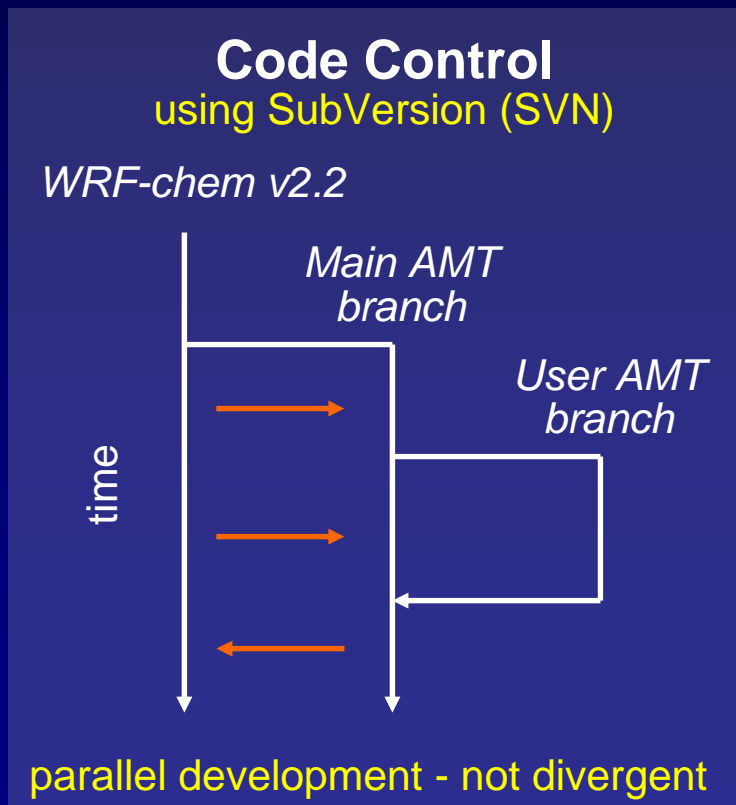
Step 4



Modularity

Why more modularity?

- WRF-chem is suitable in its present form to study a wide range of issues associated with aerosol evolution and radiative forcing, but ...
- Additional work is needed to isolate specific aerosol processes and make the code useful for long-term use

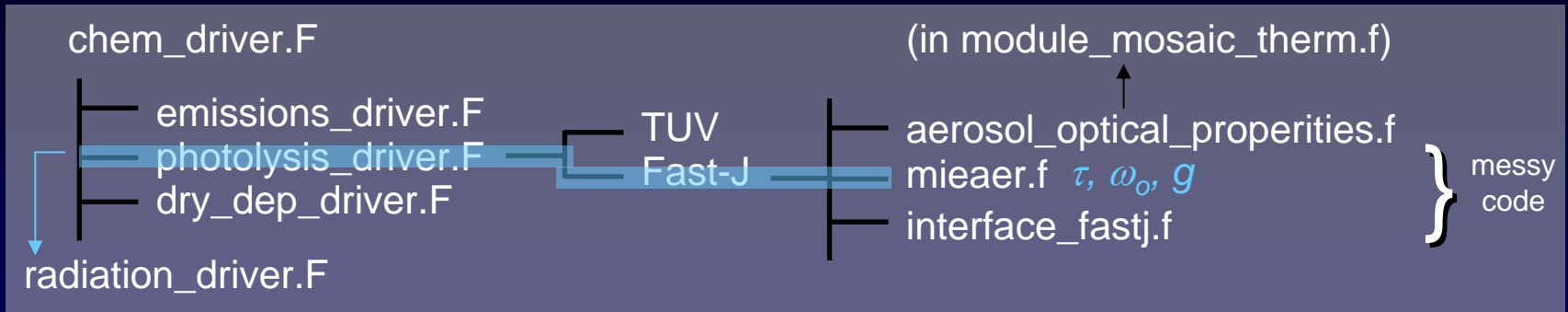


Examples

- *Interchangeable gas aerosol mechanisms*
- *Interchangeable aerosol processes (e.g. nucleation, deposition)*
- *Flexible # size bins*
- *Direct and indirect effects for other aerosol models (not just MOSAIC)*
- *Extend direct and indirect effects to other radiation schemes (e.g. CAM) and micro-physics schemes*

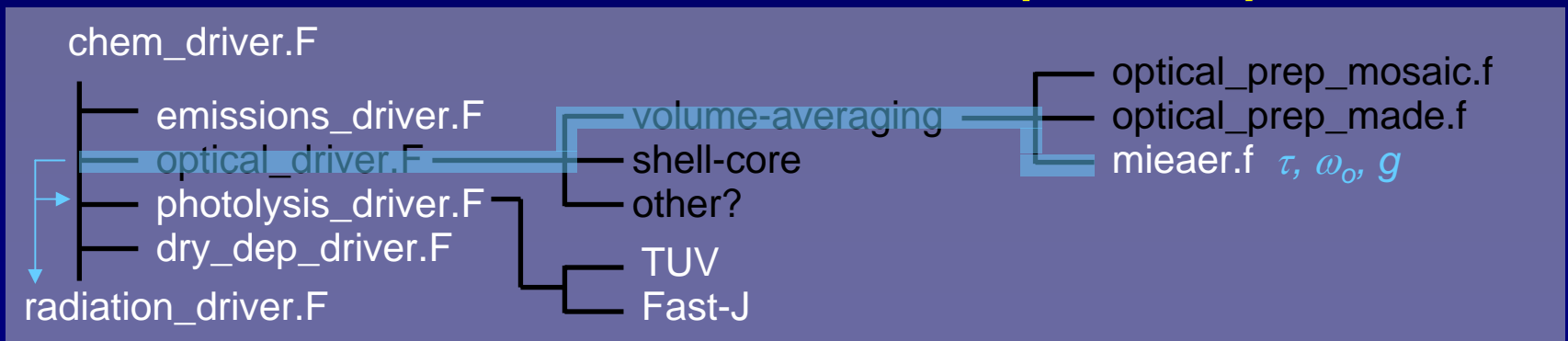
Example of Modularization

Current Treatment of Aerosol Optical Properties for MOSAIC



- Currently, optical properties buried code in Fast-J and tightly coupled with MOSAIC

Solution for More Generic Aerosol Optical Properties

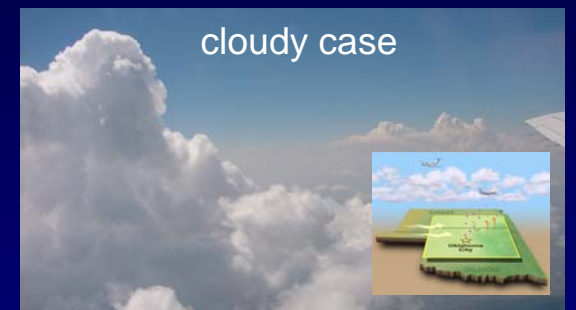


- Now, new driver that enables multiple treatments for aerosol optical properties that are used by photolysis and radiation schemes

Datasets and Toolkits

Assemble Datasets in an Archive:

- Process files into an appropriate format
- QA checks and document data uncertainties
- Dataset types:
 - *idealized 2-D and 3-D cases*
 - *aerosol aging, e.g. MILAGRO*
 - *cloud-interaction, e.g. CLASIC / CHAPS*
 - *Other suggestions from community*



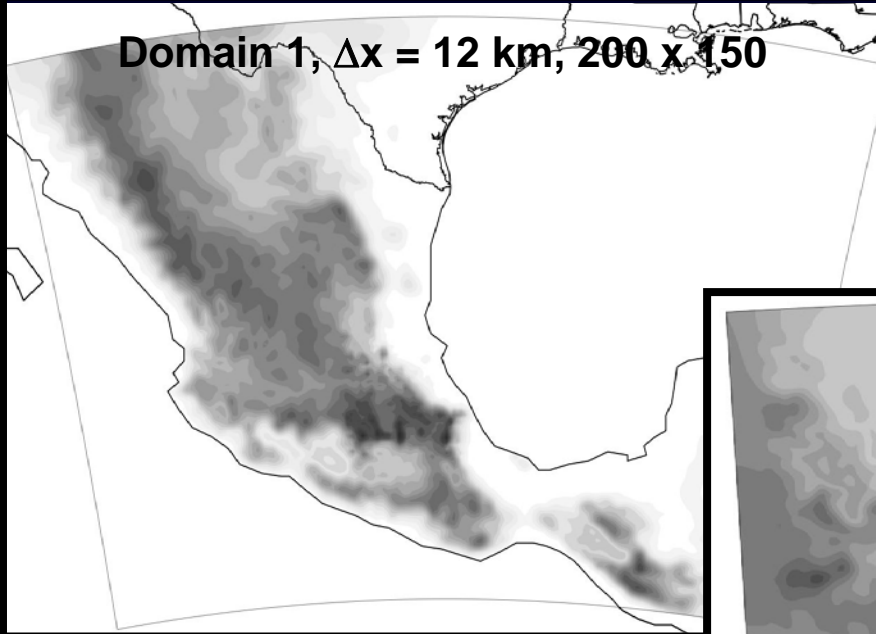
Develop Toolkits to Evaluate Model Performance:

- Analysis Toolkit: Compares model predictions with field data using statistical and graphical methods
- Inter-Comparison Toolkit: Compares predictions that use various aerosol treatments with one another and field measurements
- Archive of toolkit output to document performance

Example Dataset and Domain

2388 km

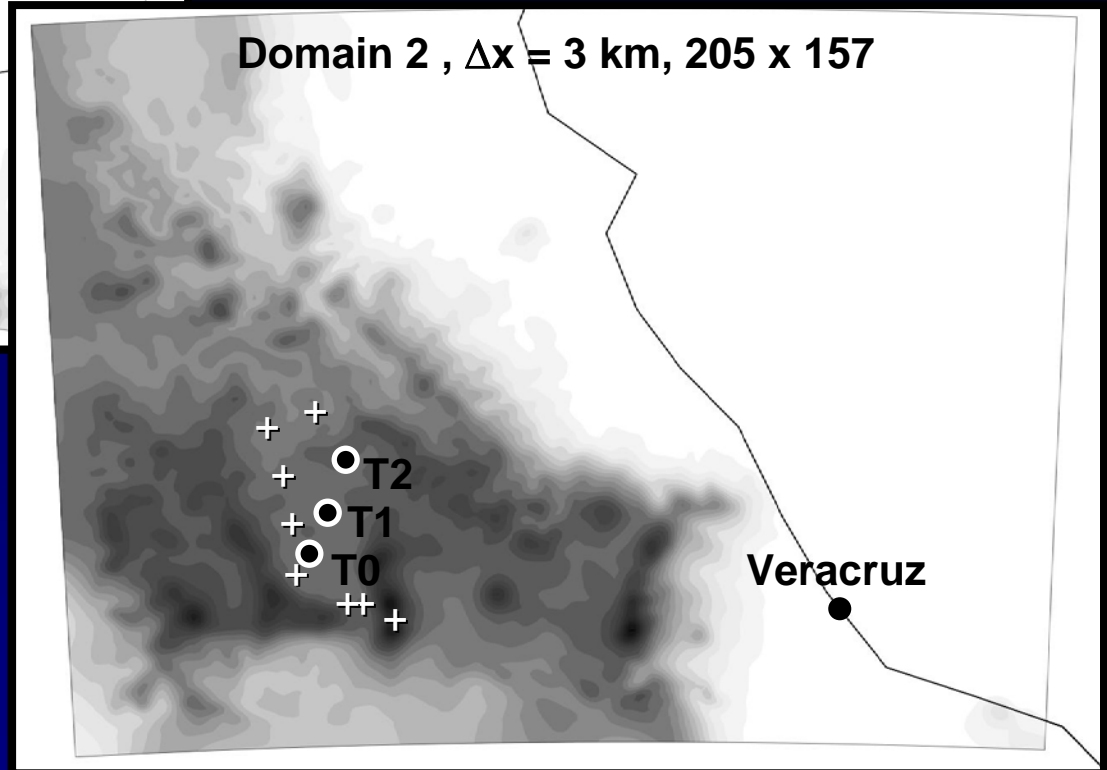
Domain 1, $\Delta x = 12$ km, 200 x 150



Wide range of meteorological, chemical, and particulate measurements

- Primary Surface Sites: T0, T1, T2
- + Secondary Surface Sites

Domain 2, $\Delta x = 3$ km, 205 x 157



612 km

G-1 (DOE)



DC-8 (NASA)



C-130 (NCAR)



King-Air (UM)



J-31 (NASA)



King-Air (NASA)



Computational Aspects

Resources:

- Range of memory and CPU requirements that depends on spatial / temporal scales and aerosol treatment
- **Full AMT**
 - *supercomputer for computational expensive runs*
 - *large storage required for “encyclopedia”*
- **Limited AMT**
 - *downloadable code, input, and Toolkit output*
 - *upload to full AMT at a later date*
- Home for **AMT** has not been determined yet
 - *PNNL’s 1900-processor machine is a candidate*
 - *but, other platforms may be more appropriate*

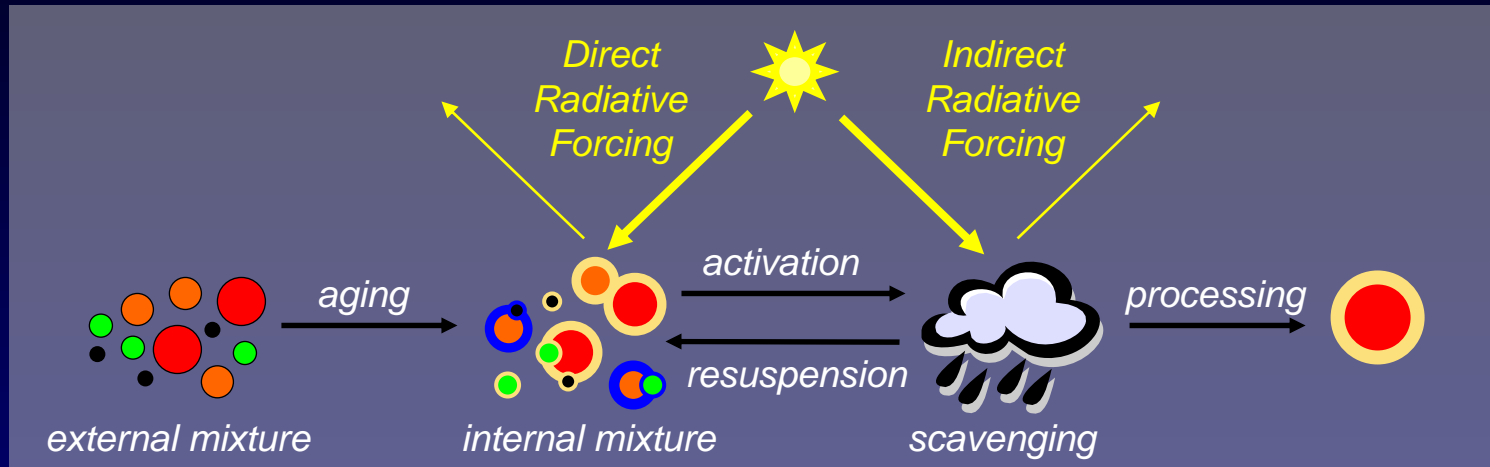


User Access:

- Code freely available, CPU cycles freely available
- Basic support service from *AMT*

Implementation of New Treatments (1)

Seeking Collaborators Interested in Using the *AMT*



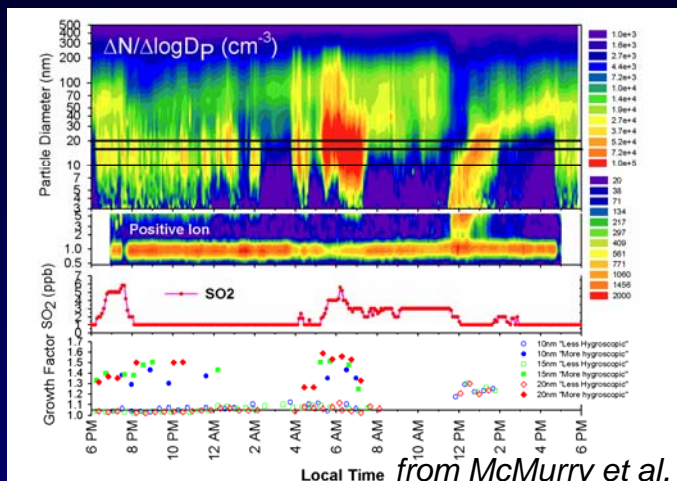
- **Aerosol Models:** evaluate new models and new treatments of specific processes coupled to existing models in WRF-chem
- **On-line emissions:** fluxes of dust & sea-salt coupled to surface layer; treatments available - but they contain large uncertainties

- *MADRID*
- *QMOM*
- *extensions of current models (MADE / SORGAM, MOSAIC)*

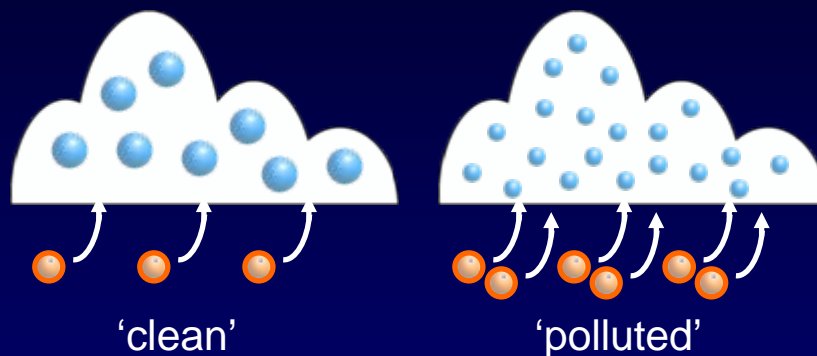


Implementation of New Treatments (2)

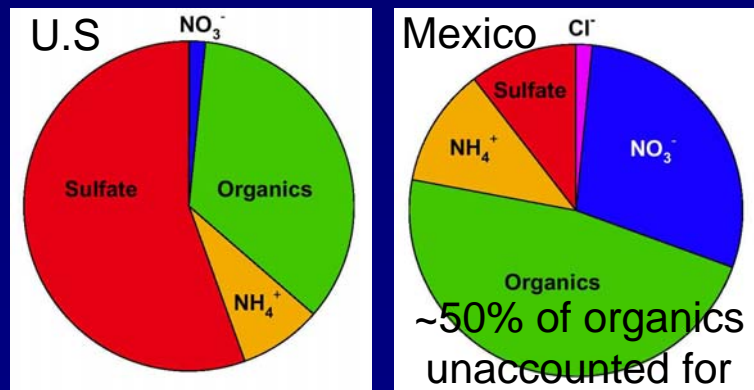
- **Nucleation:** new data available to evaluate new particle formation



- **Cloud-aerosol interactions:** treatments are available, but limited evaluations with data



- **SOA formation:** all treatments under-predict organic mass, poorly understood process



- **Ice-aerosol interactions:** few treatments available & limited data, no treatments yet in WRF-chem



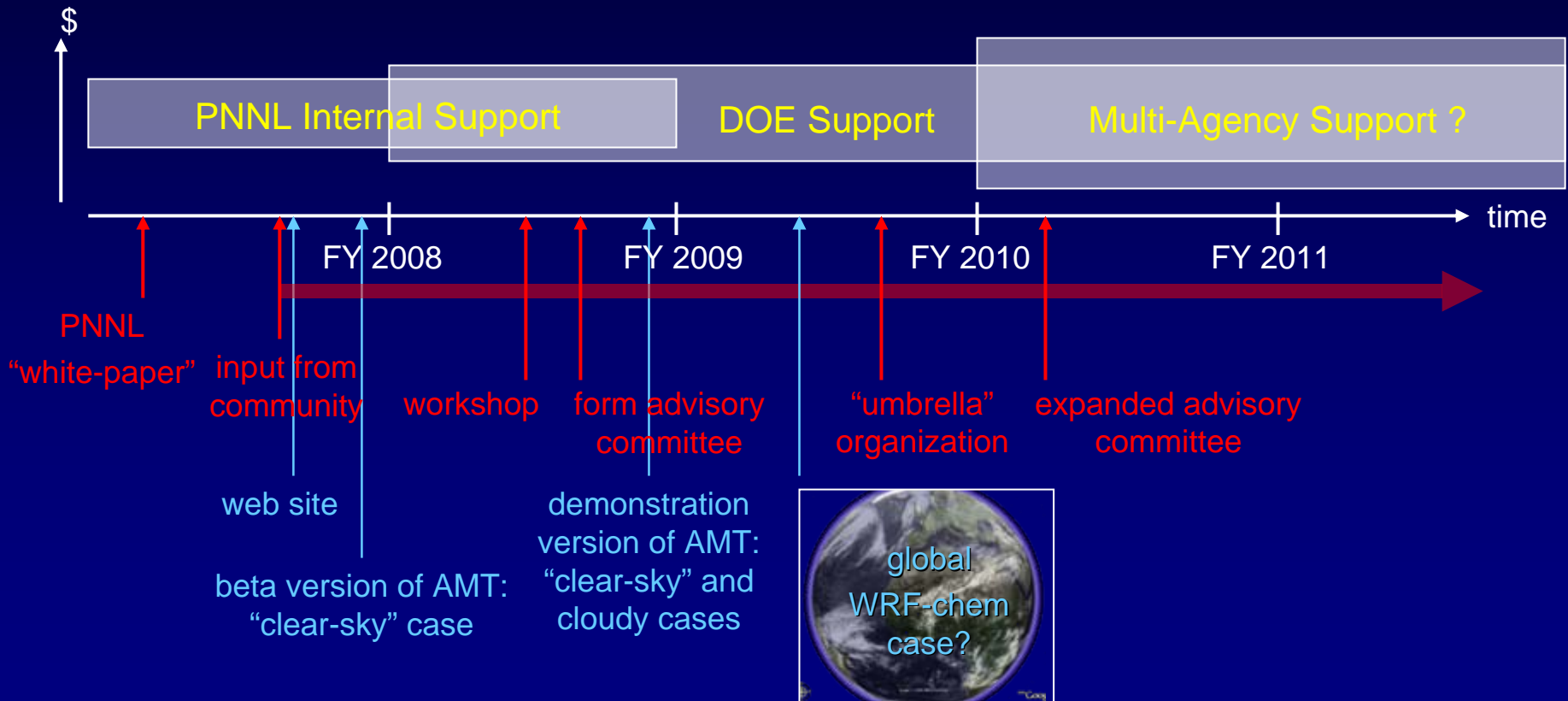
Proposed Path Forward

Core Infrastructure Support, Scientific Community Input, and Milestones

Model for Funding Research using the **AMT**

1) Funding agency supports investigator's proposal, with AMT use at no cost

2) Pool of funds set aside specifically for AMT-related research



Your comments are needed and welcome !