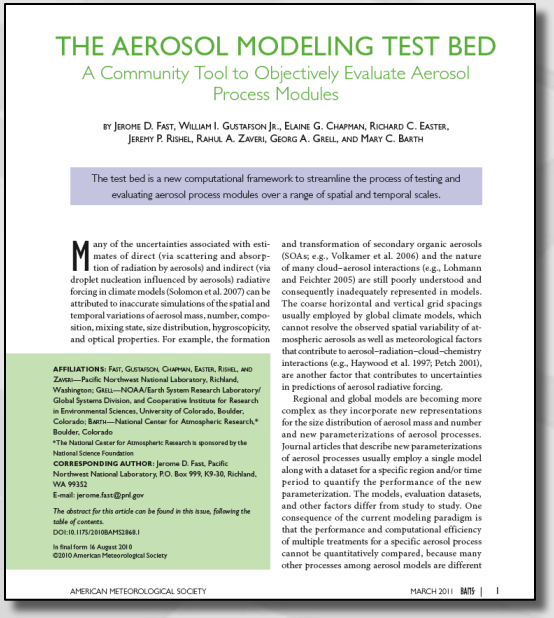
Status and Applications of the Aerosol Modeling Testbed

Development Team: **Jerome Fast, William Gustafson Jr., Elaine Chapman, Richard Easter, Jeremy Rishel, Brody Borque, Balwinder Singh**

Overview of Concept and Demonstration



THE AEROSOL MODELING TEST BED

A Community Tool to Objectively Evaluate Aerosol Process Modules

BY JEROME D. FAST, WILLIAM I. GUSTAFSON JR., ELAINE G. CHAPMAN, RICHARD C. EASTER, JEREMY P. RISHEL, RAHUL A. ZAVERI, GEORG A. GRELL, AND MARY C. BARTH

The test bed is a new computational framework to streamline the process of testing and evaluating aerosol process modules over a range of spatial and temporal scales.

Many of the uncertainties associated with estimates of direct (via scattering and absorption of radiation by aerosols) and indirect (via droplet nucleation influenced by aerosols) radiative forcing in climate models (Solomon et al. 2007) can be attributed to inaccurate simulations of the spatial and temporal variations of aerosol mass, number, composition, mixing state, size distribution, hygroscopicity, and optical properties. For example, the formation and transformation of secondary organic aerosols (SOAs; e.g., Volkamer et al. 2006) and the nature of many cloud–aerosol interactions (e.g., Lohmann and Feichter 2005) are still poorly understood and consequently inadequately represented in models. The coarse horizontal and vertical grid spacings usually employed by global climate models, which cannot resolve the observed spatial variability of atmospheric aerosols as well as meteorological factors that contribute to aerosol–radiation–cloud–chemistry interactions (e.g., Haywood et al. 1997; Petch 2001), are another factor that contributes to uncertainties in predictions of aerosol radiative forcing.

Regional and global models are becoming more complex as they incorporate new representations for the size distribution of aerosol mass and number and new parameterizations of aerosol processes. Journal articles that describe new parameterizations of aerosol processes usually employ a single model along with a dataset for a specific region and/or time period to quantify the performance of the new parameterization. The models, evaluation datasets, and other factors differ from study to study. One consequence of the current modeling paradigm is that the performance and computational efficiency of multiple treatments for a specific aerosol process cannot be quantitatively compared, because many other processes among aerosol models are different

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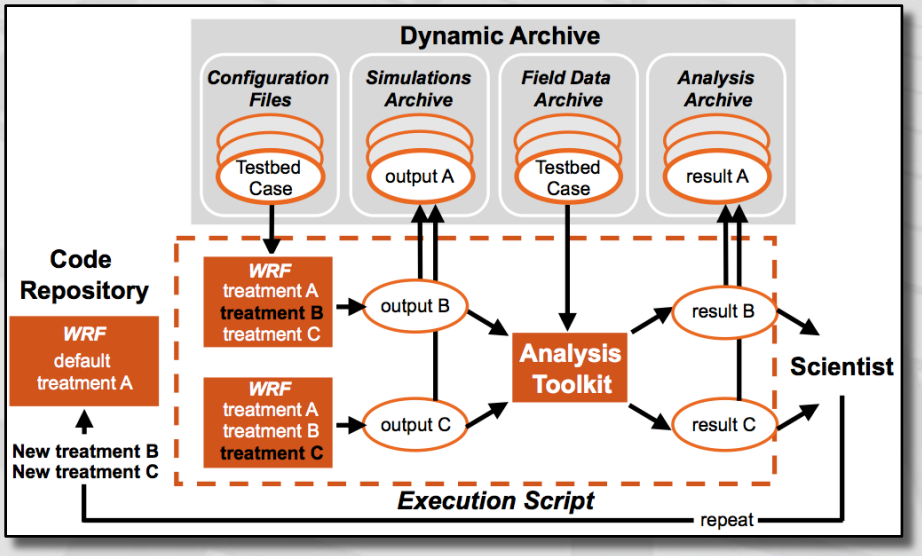
BAMS March Issue

Schematic Diagram



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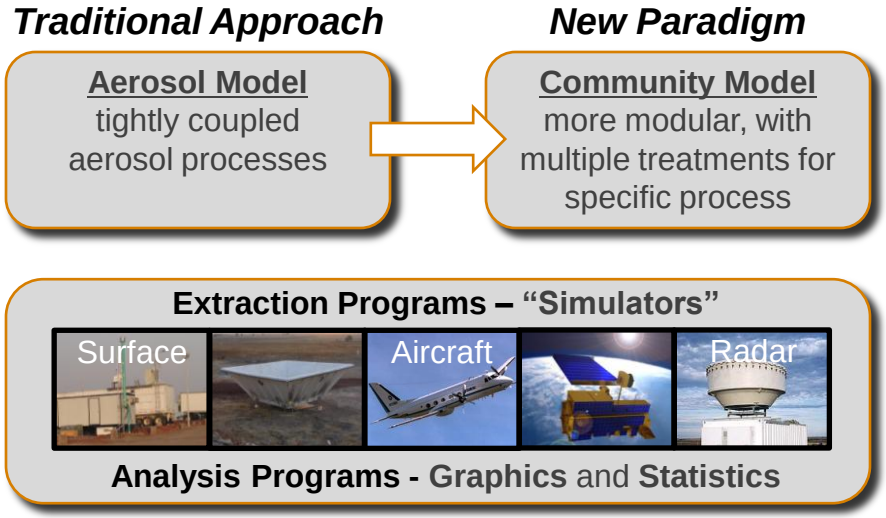
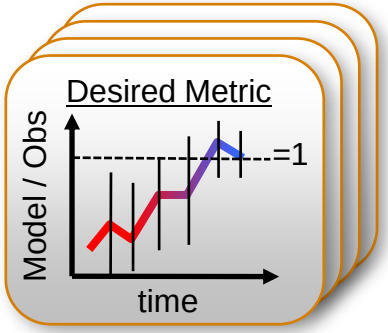
What is the AMT ?

Aerosol Modeling Testbed: A computational framework that streamlines the process of testing and evaluating aerosol and clouds process modules over a range of spatial scales

- **Systematically and objectively** evaluate aerosol process modules
- Better **quantify uncertainties** by targeting specific processes
- Provide **tools** that facilitate science by minimizing redundant tasks
- **Document** performance and computational expense
- Build an **international-recognized capability** that fosters collaboration





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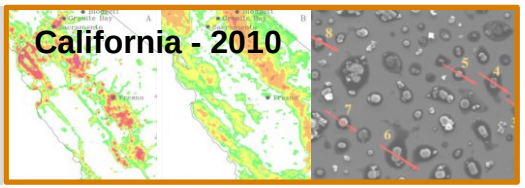
Testbed Case Development

Multiple Cases Needed for Wide Range of Conditions

MILAGRO: secondary organic aerosols, aerosol aging over multiple spatial scales		**completed**
CHAPS: processing of anthropogenic aerosols in shallow continental cumulus		**in progress**
ISDAC / ARCTAS: processing of aged aerosols in Arctic mixed-phase clouds		**in progress**
VOCALS: processing of natural and anthropogenic aerosols in shallow marine stratocumulus		**in progress**
CARES / CalNex: secondary organic aerosols, black carbon mixing state, and their optical properties		**to be started this spring**

Users are free to develop their own cases for all to use

How the AMT is Being Used

ASR: Research associated with aerosol lifecycle and cloud-aerosol Interactions

- MILAGRO: Assessing the performance of predicted aerosol mass, composition, and size, as well as performance of SOA treatments
  - *Fast et al*. 2009; *Shrivastava et al.* 2011; *Qian et al.* 2010; *Gustafson et al.* 2011
  - **Collaborators:** NCSU – SOA treatment in MADRID, JPL?, SUNY – Albany?
- CHAPS: Coupling aerosol aging and cloud processing via CuP parameterization
- CARES: Assessing the performance of SOA treatments, testing new treatment of aerosol mixing state, and evaluating simulated aerosol optical properties
  - **Collaborators:** several, but awaiting decisions for FY11 ASR proposals

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ESM: Test CAM5 physics parameterizations at regional spatial scales and compare their performance with more computationally expensive parameterizations

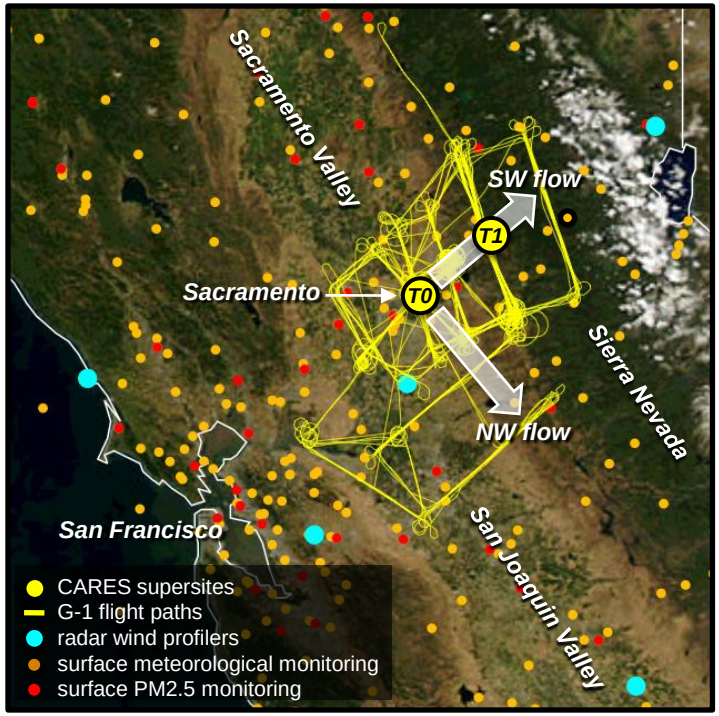
- ISDAC /ARCTAS: Assessing the performance of cloud-aerosol interactions and SOA treatments
  - **Collaborations:** LATMOS – expanding testbed case to include POLARCAT

NOAA: Evaluating treatments of cloud-aerosol interactions

- VOCALS: Determining whether treatment of aerosol activation is consistent with measurements, assessing role of anthropogenic and natural emissions
  - *Yang et al.*, 2011 (in preparation)

CARES Testbed Case

Central California



Field Data

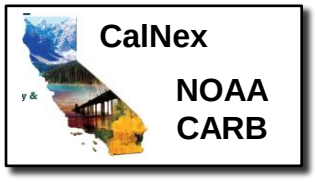
PI products

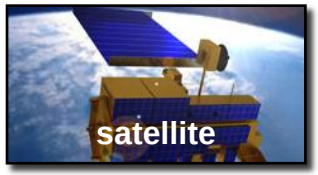
Value-Added Product
via Aerosol Modeling Translator
(to be started this spring)

ACRF Archive

CARES Testbed Case

P3-B, NOAA Twin Otter, CIRPAS Twin Otter, Research Vessel Atlantis, Pasadena surface site





NOAA proposal

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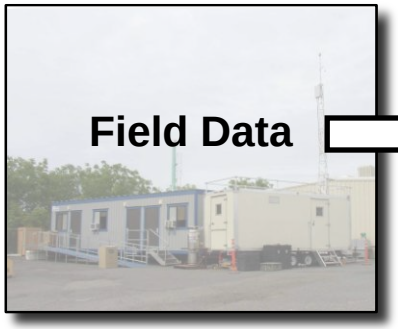
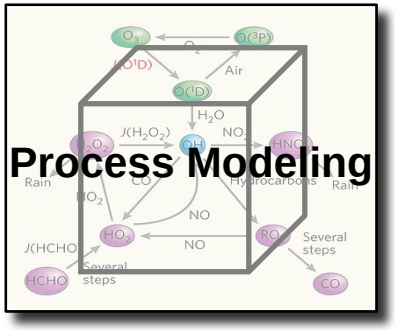
Linking Measurements and Modeling: SOA

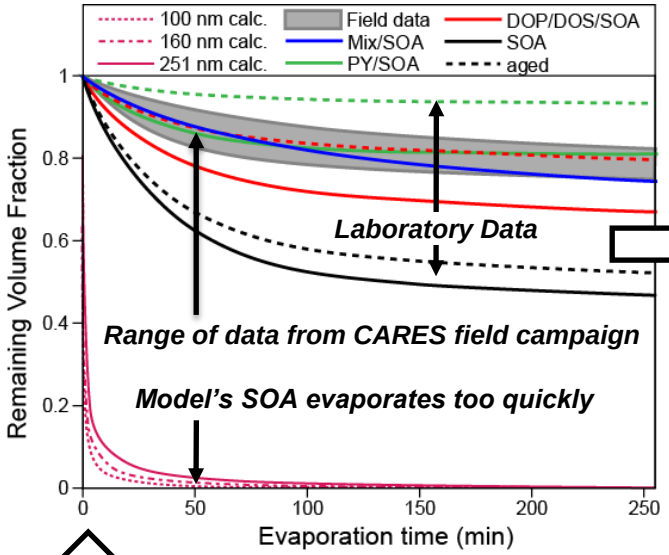
- *Vaden et al., PNAS, (2011)*
- *Shrivastava et al., submitted to Nature Geosciences (2011)*

CARES Testbed Case

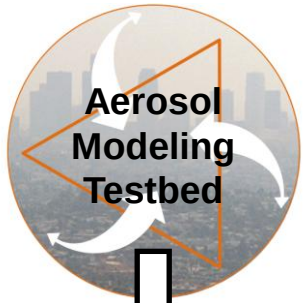


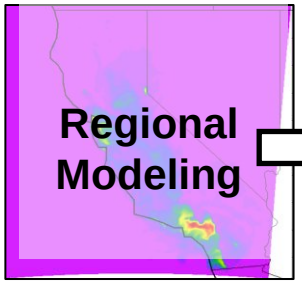


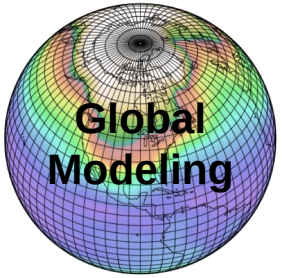
Perform new experiments to define physical relationships



Revise process model of SOA based on new data







Collaborators

Very important – problem too big and complex for one group to solve

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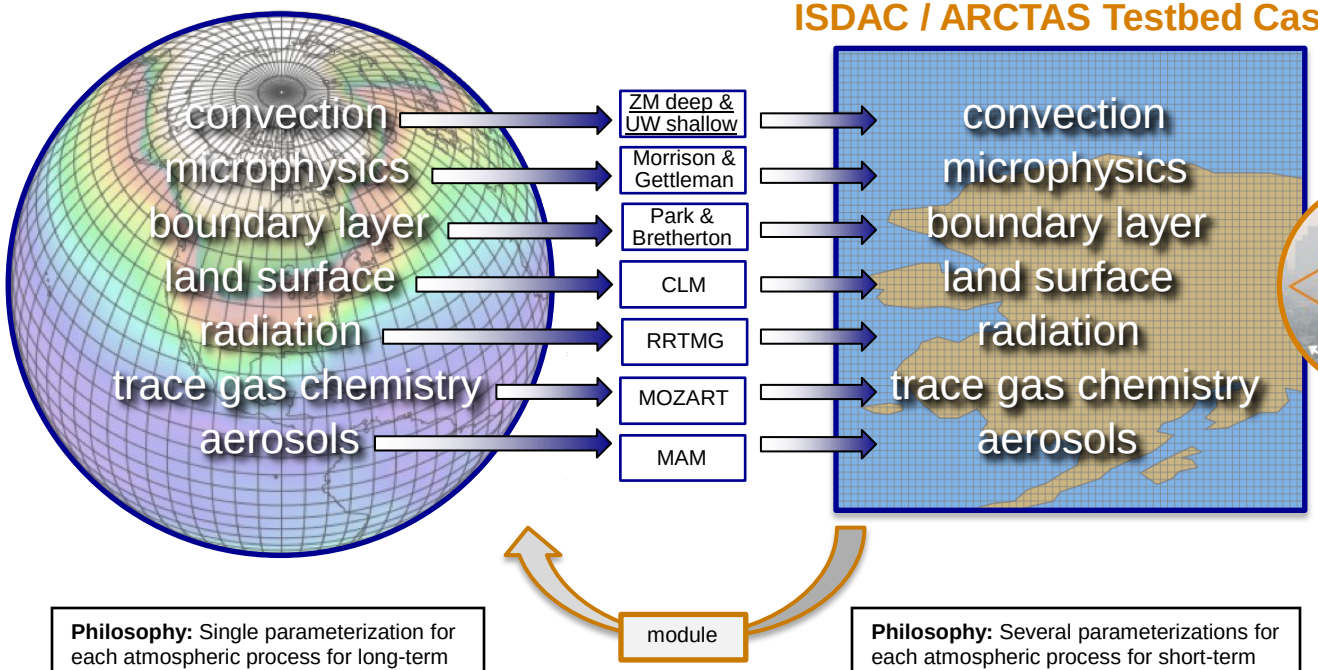
Testing CAM5 Physics at Regional Scales

Community Atmosphere Model (CAM5)

Weather Research & Forecasting (WRF)

ISDAC / ARCTAS Testbed Case

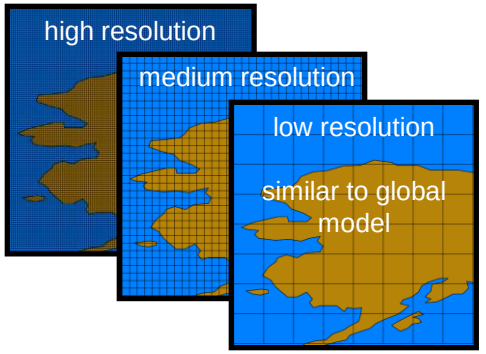


Philosophy: Single parameterization for each atmospheric process for long-term climate simulations using a coarse grid

Philosophy: Several parameterizations for each atmospheric process for short-term simulations using range of grid spacings

POLARCAT Data
(LATMOS collaboration)

Testbed Case Data



Evaluate CAM5 Physics Suite at Higher Spatial Resolution

boundary conditions

downscaling with consistent physics

POLar Model Intercomparison Program (POLMIP)

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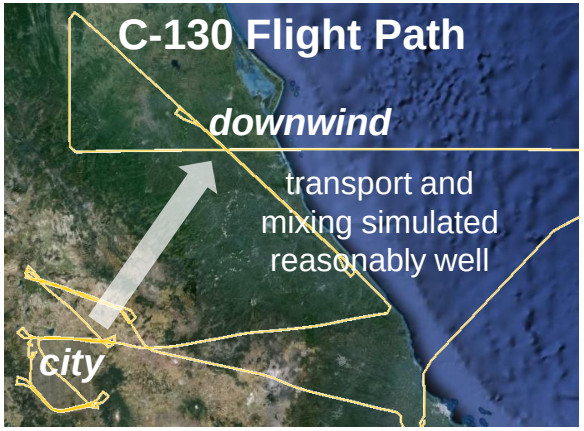
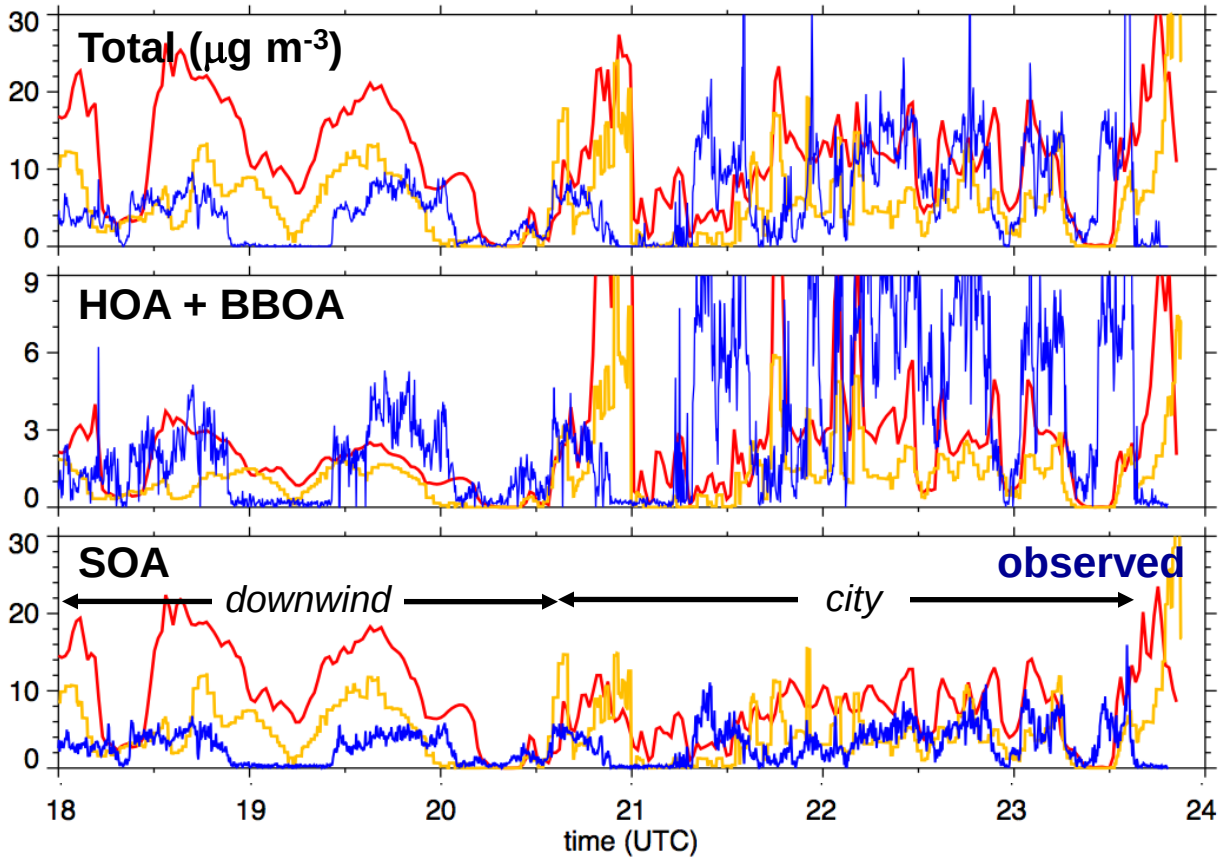
Organic Matter Predictions in the AMT

AMT Methodology:

Identical emissions, boundary conditions, meteorology, trace gas chemistry, dry deposition



Volatility Basis Set (VBS) from *Shrivastava et al.*, ACP, 2011



MAM (from CAM5)
modal – 3 modes, 11 species
'simple'
1 simulation day ~ 21 min (128 processors)

MADE/SORGAM
modal – 3 modes, 38 species
~ 24 min

MOSAIC +VBS
sectional – 4 bins, 164 species
'complex'
~ 60 min

15 times more species

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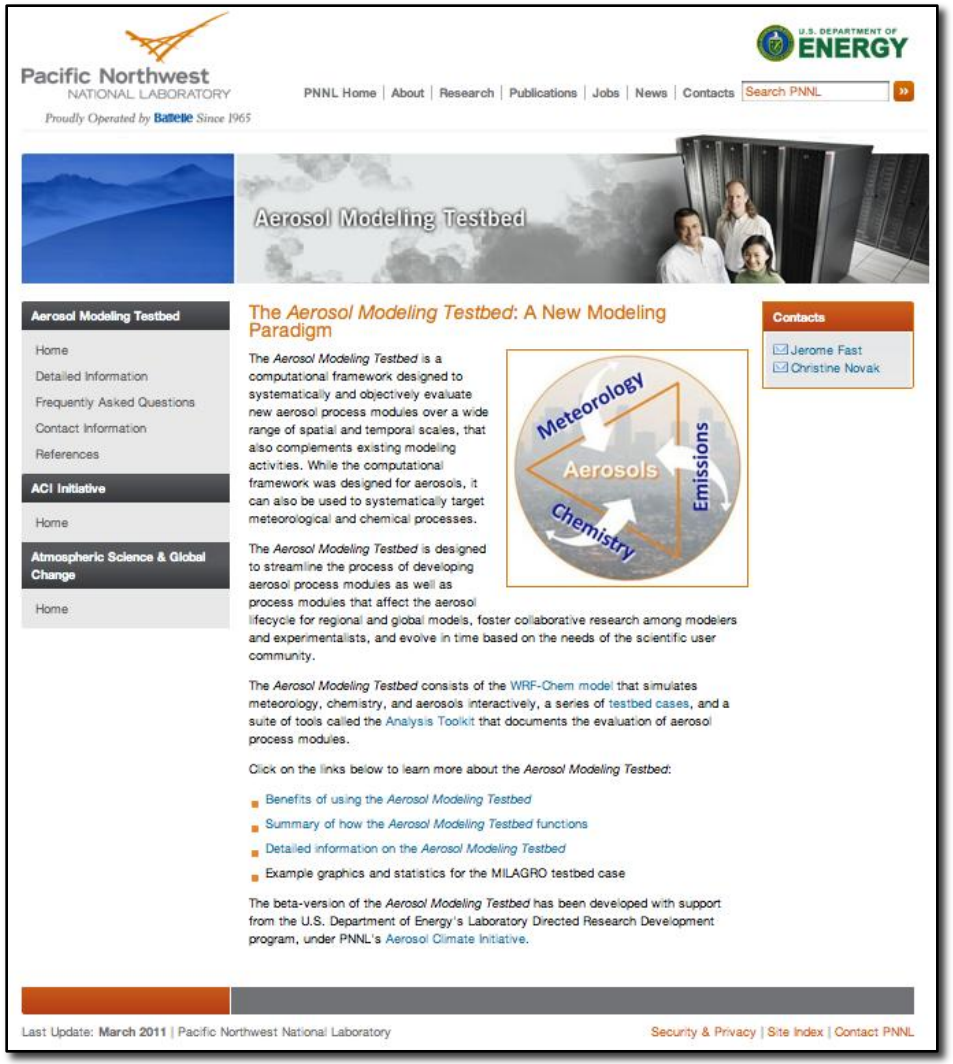
Web Page

http://www.pnl.gov/atmospheric/research/aci/amt/index.stm



- Description and vision of the AMT
- PDF files that document data format employed by AMT testbed cases and describe how to use software tools
- Status of testbed case development based on field campaigns
- How to access software and testbed cases

- Collaborators and users are welcome !
- AMT useful for future model inter-comparison studies conducted by the Aerosol Lifecycle Working Group

Aerosol Modeling Breakout Session

Summary

Objective: Provide information on the priorities and interests of aerosol modelers for the AL and CAPI Working Groups; 5 talks and discussion session

Interests: Similar to those described in ASR Science Plan, e.g. SOA, mixing state, new particle formation, optical properties, direct radiative forcing

Aerosol Representations used by Modelers:

- Modal (CAM, CMAQ)
- Quadrature Method of Moments (e.g. MATRIX)
- Sectional (WRF-Chem)
- Particle-Resolved (PARTMC-MOSAIC)

varying levels of complexity available

Measurement Needs (improved instrument and/or more routine sampling)**:**

- Sized-resolved composition
- Absorption

Focus Groups:

- Current and near-future research fits into proposed Aerosol Lifecycle Focus groups
- Aerosol process module development and evaluation addresses needs of global climate models

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