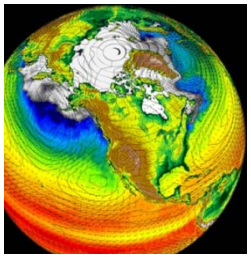


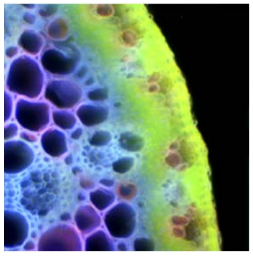
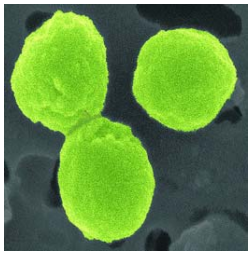

Atmospheric System Research Science Topics

workshop summary for BERAC

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with

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23 March 2016

Motivation – update to ASR science plan

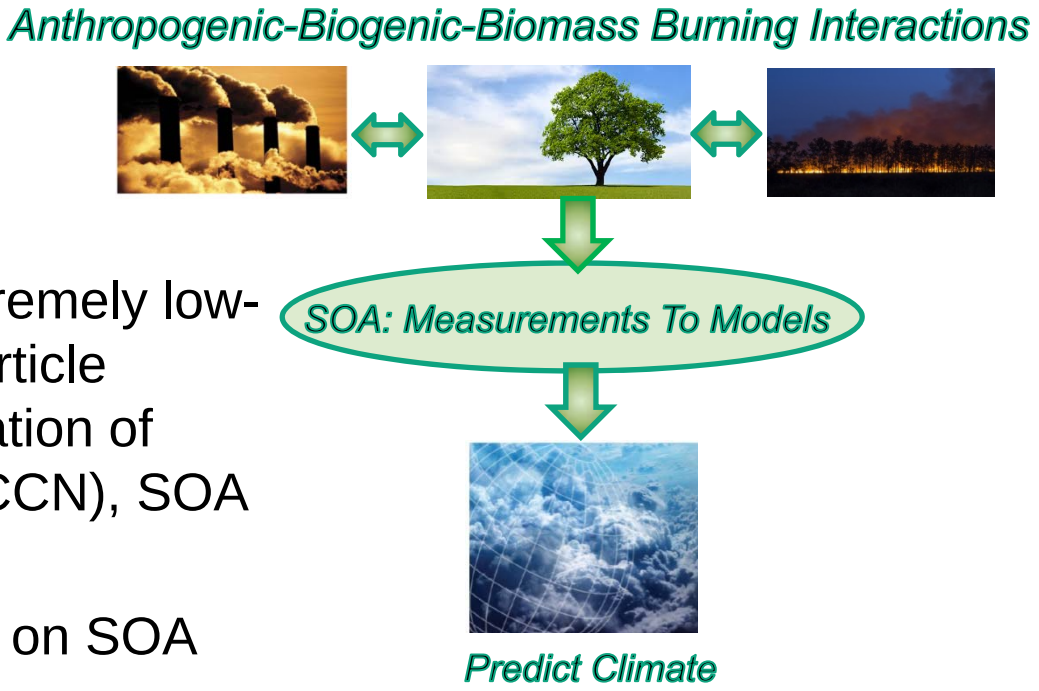
- The Atmospheric System Research program science plan is in the process of being updated
  - Current version is from 2010
- ASR and CESD workshop reports are important sources of input to the science plan
- **4 ASR workshops over the past year**
- Other workshops:
  - ARM/ASR High Resolution Modeling workshop (May 2014)
  - ARM/ASR NSA priorities workshop (Sept. 2014)
  - CESD Aerial Needs workshop (May 2015)
  - ACME-ARM-ASR Coordination workshop (Oct. 2015)

1. Anthropogenic-biogenic interactions of Secondary Organic Aerosols (SOA) in climate models workshop

SOA particles often dominate global fine particle climate impacts but fundamental SOA processes are not yet adequately included in atmospheric models.

- Hosted by PNNL from June 8-9, 2015
- Co-chairs:
  - Manish Shrivastava, Pacific Northwest National Lab
  - Joel Thornton, Univ. of Washington
- 24 participants from DOE labs and universities/research centers
- Remote attendance by ASR program manager
- Workshop report is published

SOA workshop themes



1. Acidity, sulfate, and water effects on isoprene SOA formation
2. Role of low-volatility and extremely low-volatility organics on new particle formation, number concentration of cloud condensation nuclei (CCN), SOA loadings, and lifetimes
3. Role of SOA viscosity/phase on SOA growth and CCN activity
4. Anthropogenic emissions interacting with biogenic SOA
5. Importance of biomass burning for SOA
6. Mechanistic insights from laboratory studies of SOA formation pathways
7. Modeling approaches to represent interactions between aerosols and clouds

SOA workshop take home messages

- Analyses of measurements over the past 5 years, many of which were funded by ASR, have advanced several fundamental insights in key SOA processes that relate to the burden and lifetime of SOA particles and their interaction with clouds and radiation.

But……

- Current climate models do not include these advances, which could make large potential impacts in our understanding of the climate impacts of SOA particles.
- Key advances in the understanding of SOA processes include those associated with isoprene chemistry, reactions producing low volatility products, SOA growth kinetics and mechanisms, anthropogenic-biogenic interaction mechanisms, effects of biomass burning on SOA, and SOA-water interactions.

SOA current and future activities

- Specific feasible activities were discussed which can remedy this deficiency in climate models and reduce the uncertainties in understanding the climate impacts of these particles.
- **Near-term activities**: Develop/improve SOA model parameterizations in earth system models to account for the new process-level understanding of SOA
- **Future activities**: Cross-cutting measurement and modeling activities among the seven themes discussed during the workshop that focus on remaining unknowns
- It was recognized that integrated model-measurement approaches can provide/improve model fidelity in addressing the new processes for both mechanistic accuracy and higher confidence for climate prediction.

2. Absorbing aerosols workshop

Absorbing aerosols (AA) redistribute energy through the atmospheric column via localized heating from absorption and are the source of large uncertainties in climate model predictions

- Hosted by DOE in Germantown from January 20-21, 2015
- Co-chairs:
  - Chris Cappa, Univ. California-Davis
  - Rao Kotamarthi, Argonne National Lab
  - Art Sedlacek, Brookhaven National Lab
- 18 participants from DOE labs, universities/research centers, and federal agencies
- ASR, ARM, and ESM program managers in attendance
- Workshop report is currently in progress

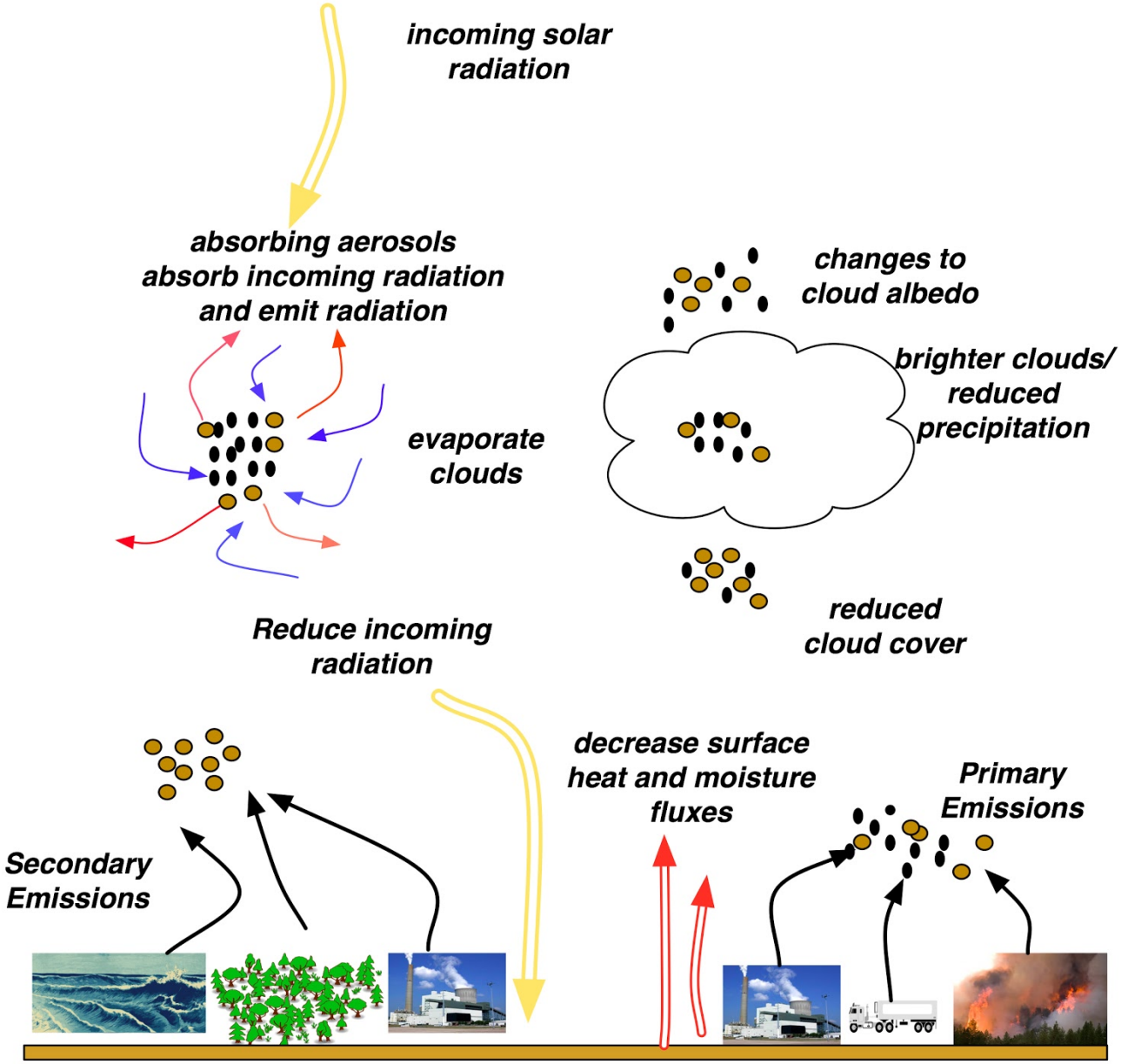
Absorbing aerosols whitepaper questions

1. What absorbing aerosols knowledge gaps limit our understanding of these species and their roles in climate-relevant radiative, thermodynamic, and dynamic processes in the atmosphere?
2. What factors currently limit a robust representation of these absorbing aerosol processes in large-scale models?
3. How may these knowledge gap(s) be addressed with current and feasible new DOE resources, including observations from the ARM facility? What specific additional resources would be appropriate and what value would be added by them?

Absorbing aerosols take home messages

- Biomass and biofuel combustion is a major source of AA that still lacks key understanding.
- Major contributors to model/measurement uncertainty in direct radiative forcing by AA include poor attribution of absorption to different AA types (e.g. black vs. brown carbon) and possible measurement artifacts (column and *in situ*).
- **The contributions of dust, black carbon and brown carbon absorption across the solar and terrestrial spectrum, particularly as a function of altitude and with atmospheric conditions are unknown**.
- High priority: develop an *integrated understanding* of in situ and remote sensing measurements (and limitations) to facilitate improved apportionment and source-specific process-level representation of AA in models

The Varying Influences of Absorbing Aerosols



3. Marine low clouds workshop

Marine low clouds represent one of the largest uncertainties and most important feedback factors in current-generation climate models

- Hosted by BNL during January 27-29, 2015
- Co-chairs:
  - Michael Jensen, Brookhaven National Lab
  - Jian Wang, Brookhaven National Lab
  - Rob Wood, University of Washington
- 17 participants from DOE labs, universities/research centers, and federal agencies
- ASR and ARM program managers in attendance both on site and remotely
- Workshop report is currently in revision

Marine low clouds themes

The workshop was organized around a set of four themes

1. Aerosol indirect effects and the cloud condensation nuclei budget
2. Mesoscale organization
3. Entrainment and mixing
4. Precipitation

A set of science questions and approaches to addressing the questions was developed for each theme (examples follow)

Marine low clouds questions (a subset)

- Why do models produce such a diversity of **aerosol indirect effects** on cloud radiative forcing?
- What do we need to close the **CCN** budget in marine boundary clouds?
- What are the processes that drive **mesoscale organization** in the marine boundary layer?
- What are the roles of mixing, evaporation, wind shear, and radiation on **entrainment** efficiency?
- How much and how frequently do marine low clouds precipitate, and how can we measure this **precipitation** accurately?

Marine low clouds approaches (a subset)

- Constrain the representation of **aerosol-cloud interactions** using comprehensive measurements, especially in regions with greatest model diversity
- Develop a dataset/metric to quantify **mesoscale organization** and associated variables
- Determine the effects of **entrainment and mixing** on cloud liquid water content and particle size distribution (and other microphysical properties)
- Determine the relative importance of autoconversion rate and accretion rate in the marine low clouds **precipitation** process

4. Convection workshop

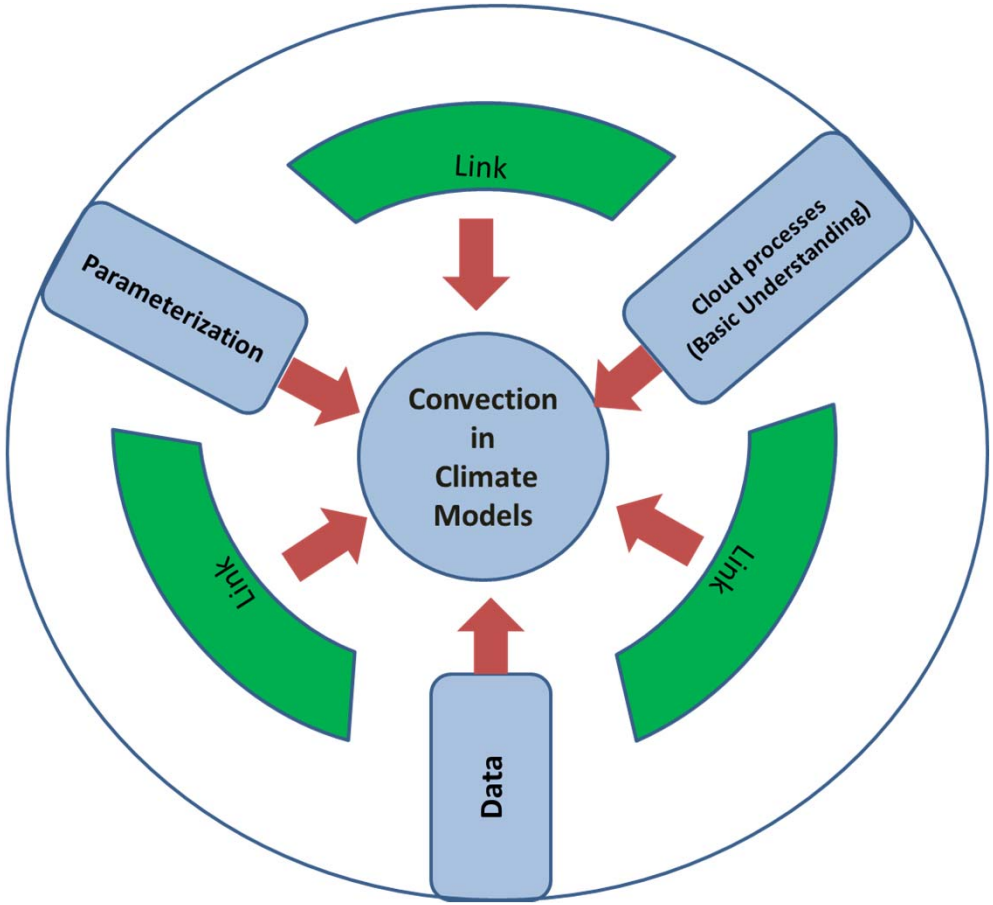
Significant model biases in mean climate and variability are related to problems in representing organized convection

- Hosted by PNNL during February 3-5, 2016
- Co-chairs:
  - Samson Hagos, Pacific Northwest National Lab
  - Bob Houze, Univ. of Washington/Pacific Northwest National Lab
- 28 participants from DOE labs, universities/research centers, and federal agencies (some participants remote)
- ASR and ARM program managers in attendance remotely
- Workshop report is currently in progress

Convection whitepaper themes

Questions for each of the 4 themes and 3 links

- What are the challenges/opportunities?
- How can ASR meet (take advantage of) them given DOE capabilities (ARM, high performance computing) and needs (ACME and other model development efforts)?



Convection take home messages

- Organized convection is part of an entire **sequence of events** that needs to be better understood and better parameterized seamlessly:

  Boundary layer instability → formation of non-precipitating cumulus → development of showers and cold pools → aggregation of developing convection → formation of mesoscale convective systems

- Measurement and parameterization priorities:
  - Boundary-layer instabilities related to cloud growth
  - Widths and intensities of convective updrafts
  - Cold pool dynamics
  - Ice-phase microphysics

Convection strategies

- Observational approaches recognize that different measurements are need for different elements of the convection sequence
  - Short term: develop new weather-based observational strategies for SGP such as a spring storm season IOP
  - Longer term: dual-polarization S-band radar, convection-penetrating aircraft, and tropical ocean IOP
- The importance of hierarchical modeling approaches and built-in scale awareness of parameterizations were emphasized.
- Several paths to representing convection in next generation climate models are identified and assessed.