# Connecting Climate and Health Impacts of Anthropogenic Aerosol


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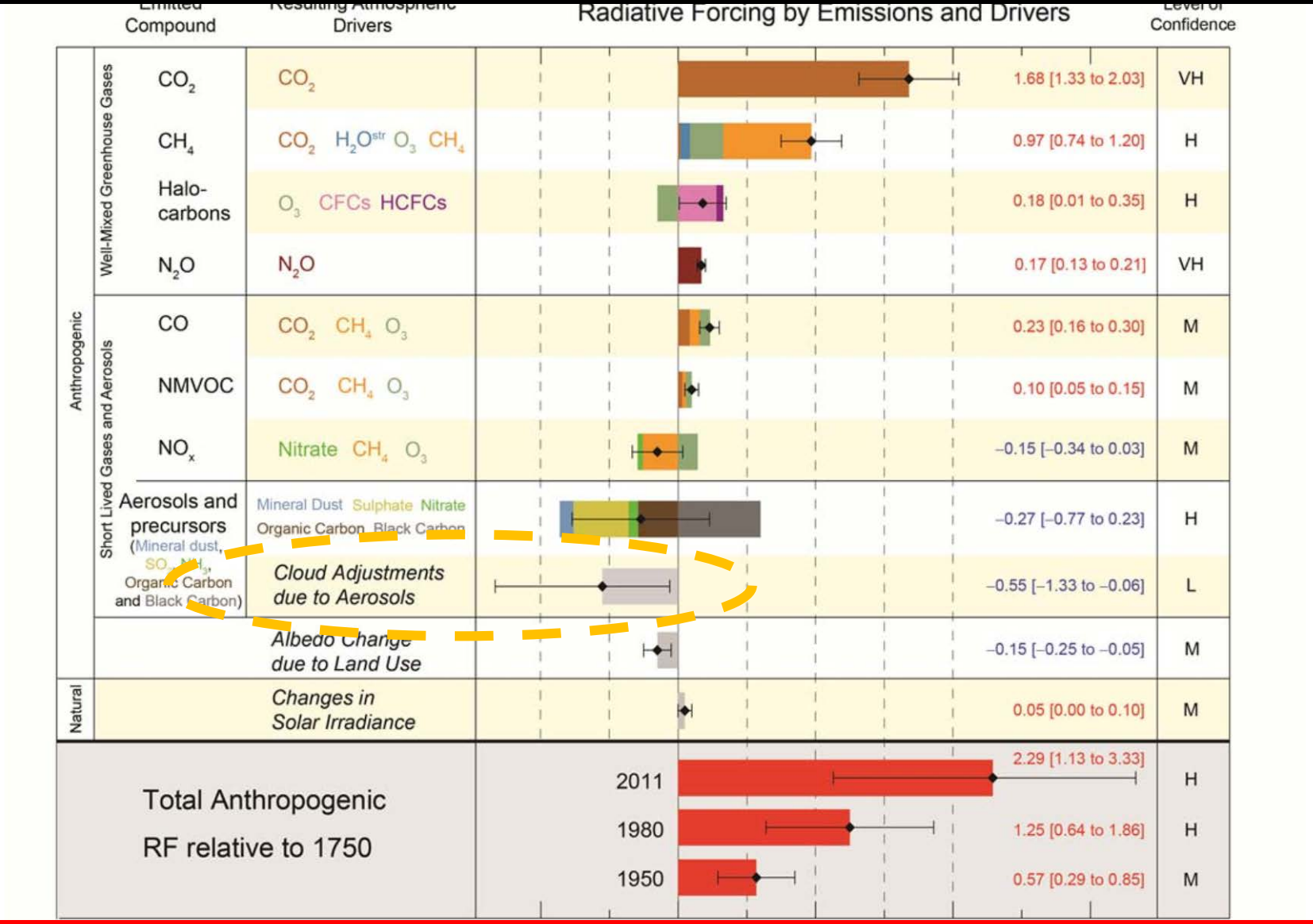
***EPA Black Carbon Webinar Series,***

***Monday, November 21st, 2016***

# Clouds contribute the greatest uncertainty in climate predications

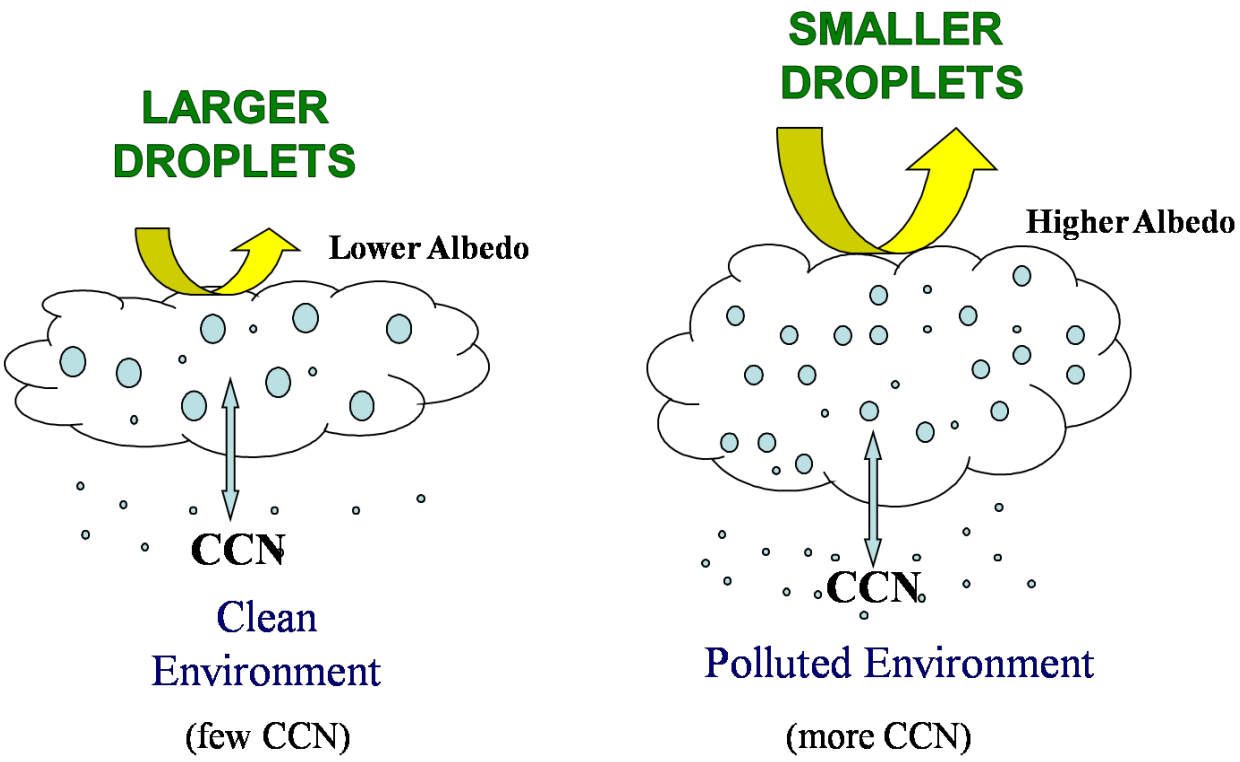



**The interactions of BC with clouds are not well constrained**

# RELEVANT PROPERTIES OF COMPLEX CCN

**Cloud condensation nuclei (CCN)** activate and become cloud droplets.

**The ability to be CCN depends on particle size and composition**



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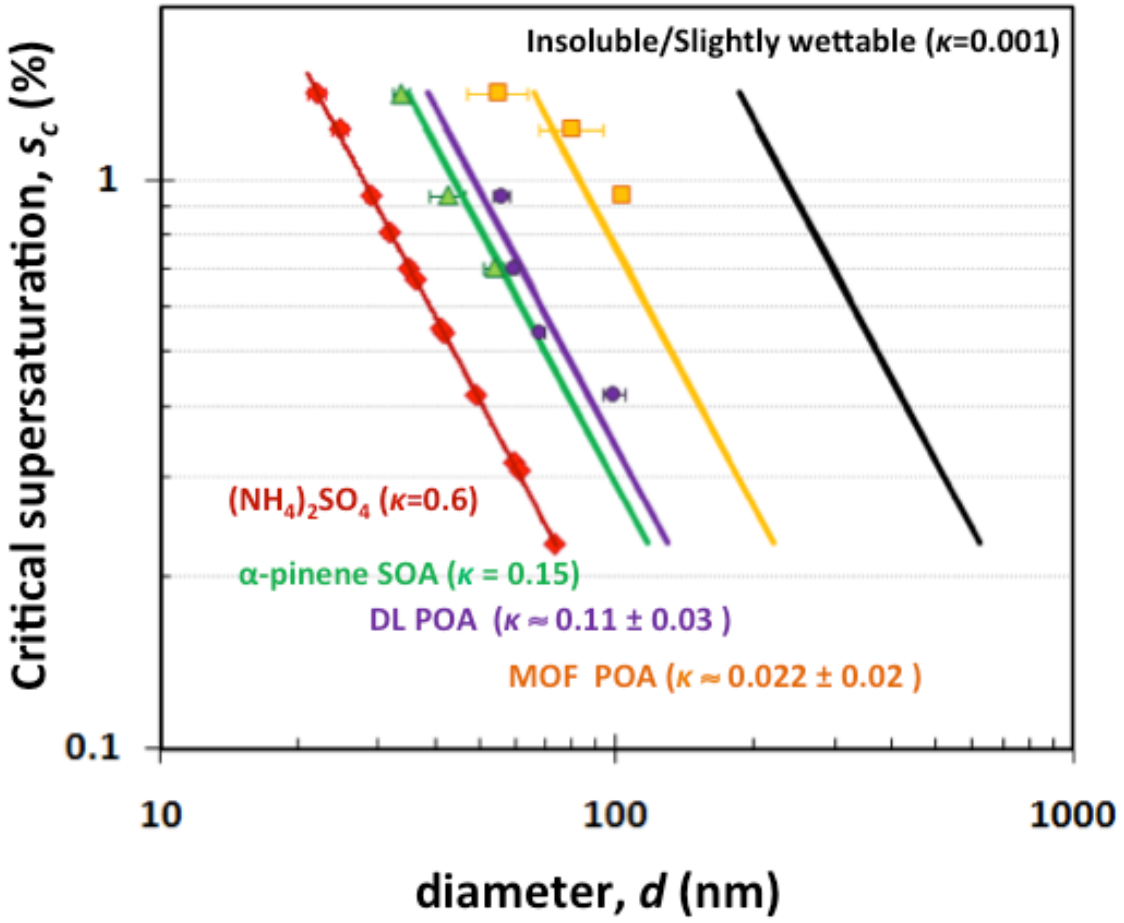
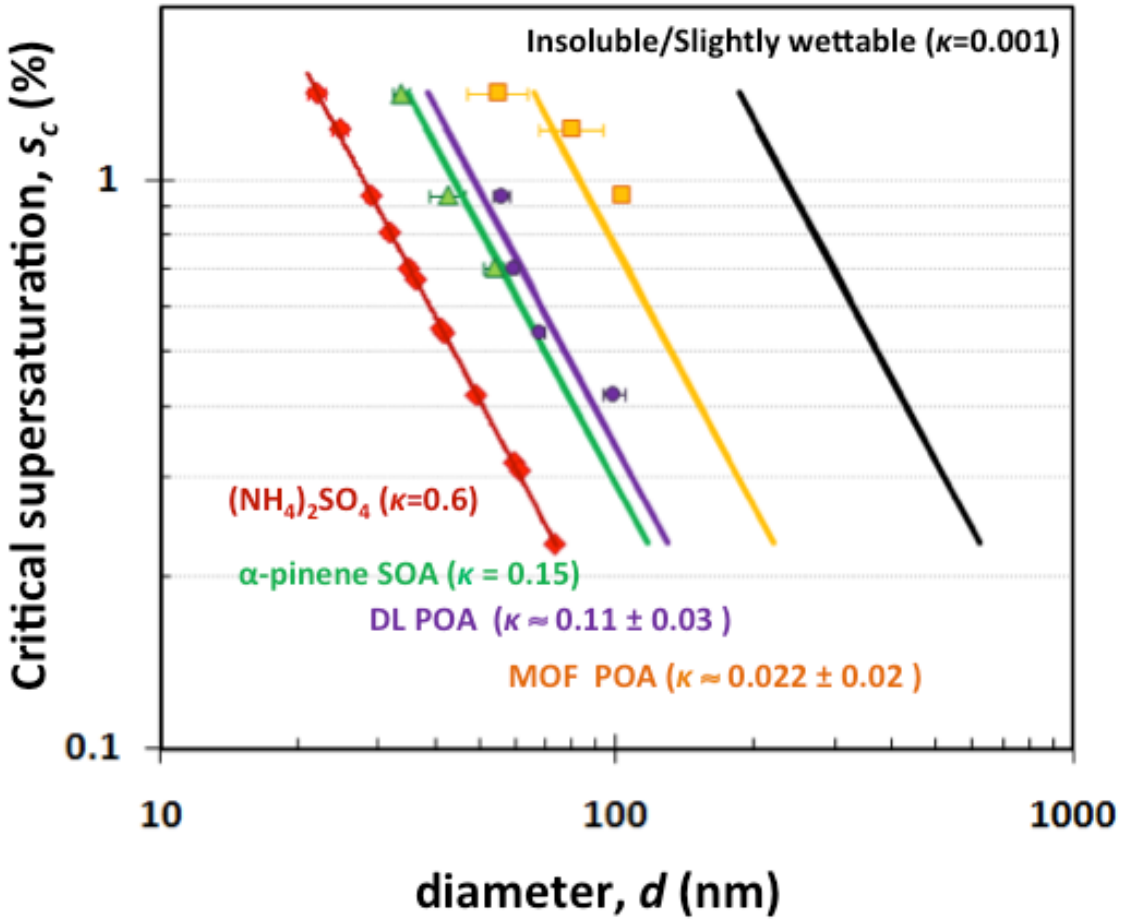
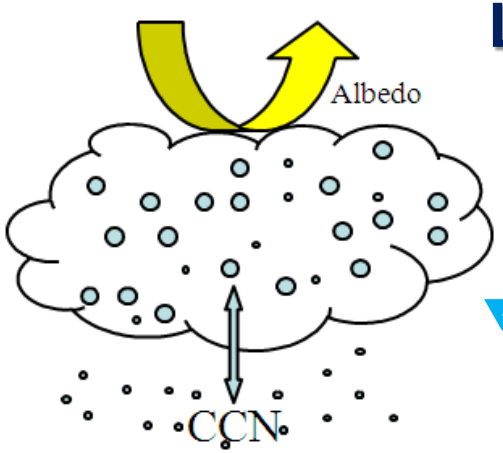


The more complex the aerosol source (as with combustion/BC sources) the more difficult it becomes to characterize the changing chemical and physical properties of the CCN.



# Carbonaceous Aerosol

## Asa-Awuku Research Group
## Linking Climate & Health:

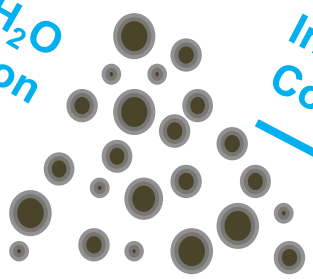



**Aerosols impact cloud formation and climate.**

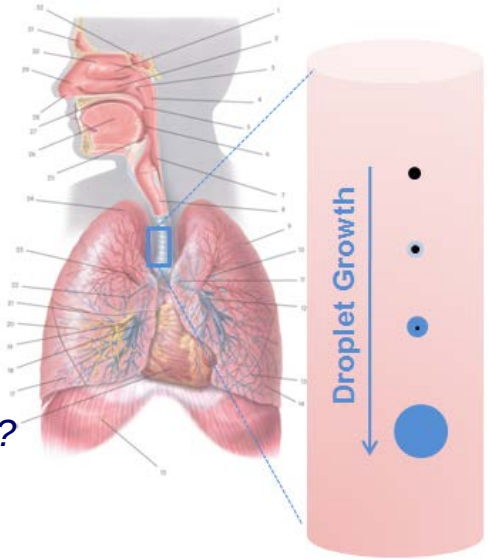
**Aerosol droplet growth affects lung deposition rates and human health**

Ambient $H_2O$ Condensation

Inhalation $H_2O$ Condensation



**Particulate Matter (PM 2.5)**




*Composition? • Sources? • Emission Rates? • Toxicity? • Number Concentration? • Particle Size?*

**The ability of aerosol to uptake water (hygroscopicity) has the potential to impact both climate and health**

Field Testing

Real World Simulations

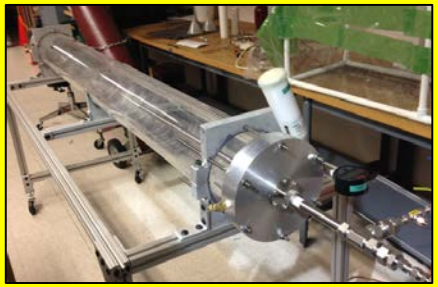
Lab Tests

NEAR-ROAD TESTING

SHIP EMISSIONS

CHASSIS DYNAMOMETER

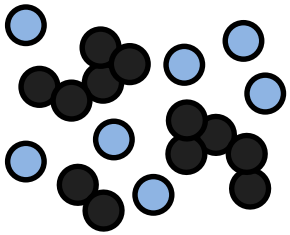
ENVIRONMENTAL CHAMBER



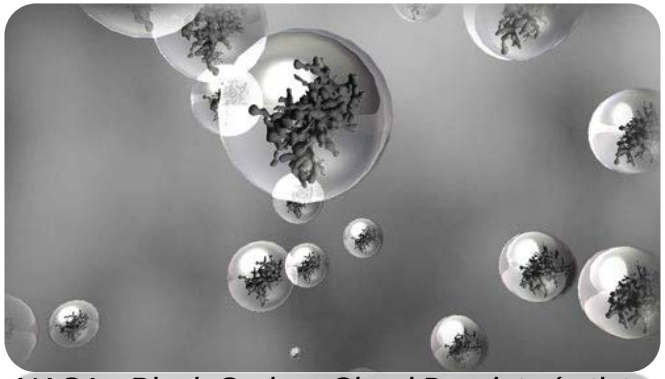
MIXING STATE FLOW TUBE

Increasing Level of Aerosol BC Composition Complexity

# OUR APPROACH TO COMPLEX HYGROSCOPIC PARTICLES



Condensation



Source: NASA : *Black Carbon Cloud Droplets (artist rendition)*

**(1) Provide Quantitative and Fast Measurement Techniques for Real-World Sources**

**(2) Characterize Changes in Physical and Chemical Properties that can alter perceived Hygroscopicity of sources**

**(3) Refine Analysis Methods for complex CCN Mixing States**

ENVIRONMENTAL Science & Technology
Article
pubs.acs.org/est

Atmos. Chem. Phys. Discuss., 14, 12555–12589, 2014
www.atmos-chem-phys-discuss.net/14/12555/2014/
doi:10.5194/acpd-14-12555-2014


Atmospheric Chemistry and Physics Discussions
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# Experimentally measured morphology of biomass burning aerosol and its impacts on CCN ability

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Received: 10 April 2014 – Accepted: 17 April 2014 – Published: 16 May 2014

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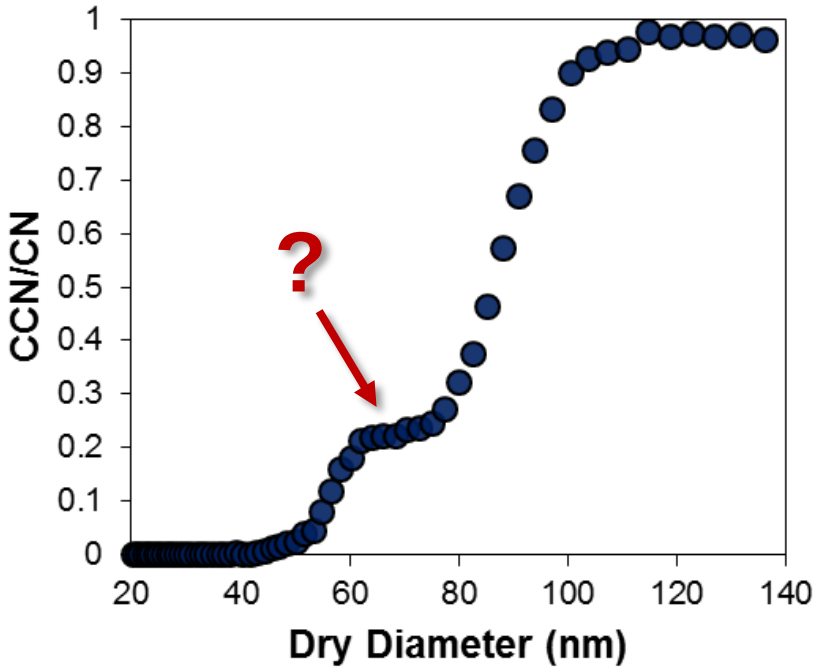
Published by Copernicus Publications on behalf of the European Geosciences Union.

# Mixing State Projects

# Motivation

- **CCN** data sets from ambient and environmental chamber studies can consist of complex mixtures of organic and inorganic aerosols
- **Common assumptions**
  - Doubly charged aerosols
  - Uniform composition

  → Single fit
- **Multiple activation curves**…?
  - Different components?
  - Mixing state? Type / Extent? Complex mixtures?




**α-Pinene / Diesel Exhaust Mixture**

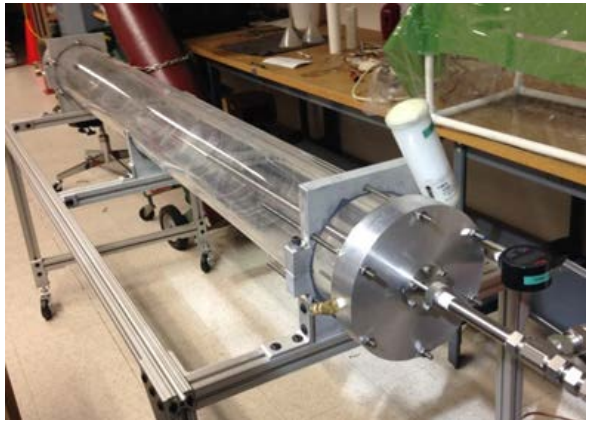
**Environmental Chamber CCN activation data**

data from Asa-Awuku et al. GRL 2009

**GOAL: Improve experimental analysis techniques of CCN of complex mixtures**

# Recreating Activation Curves: Known Mixtures

**CCNC** was operated between **0.2** and **1.1 SS%**



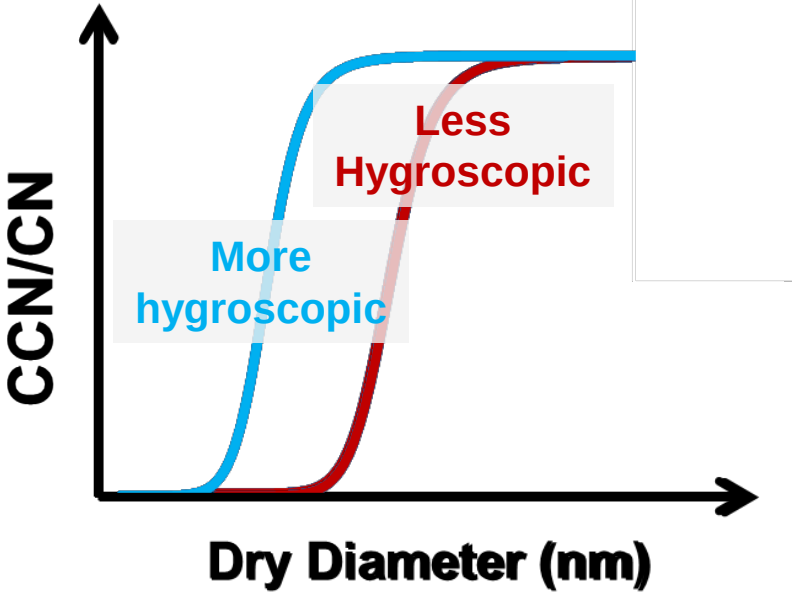


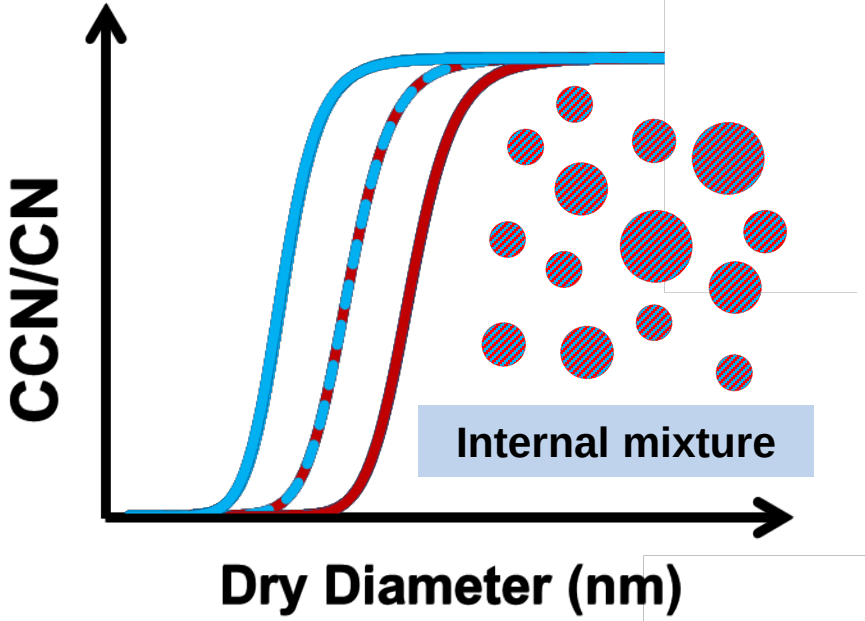

*Vu et al., in prep*

***Organic**: Succinic Acid, $C_4H_6O_4$

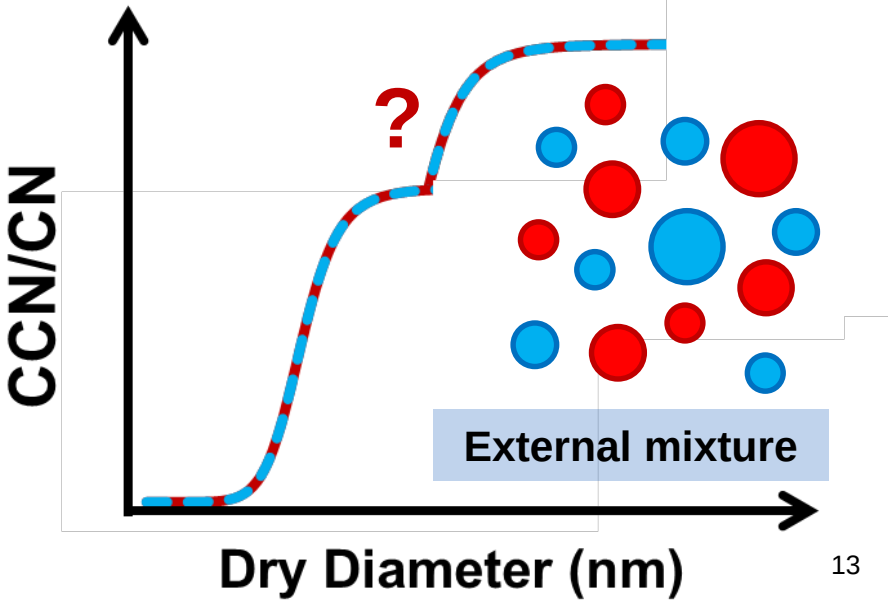
****Inorganic Salt**: Ammonium Sulfate, $(NH_4)_2SO_4$, Sodium Chloride, NaCl

# Mixing States: Internal / External Mixtures



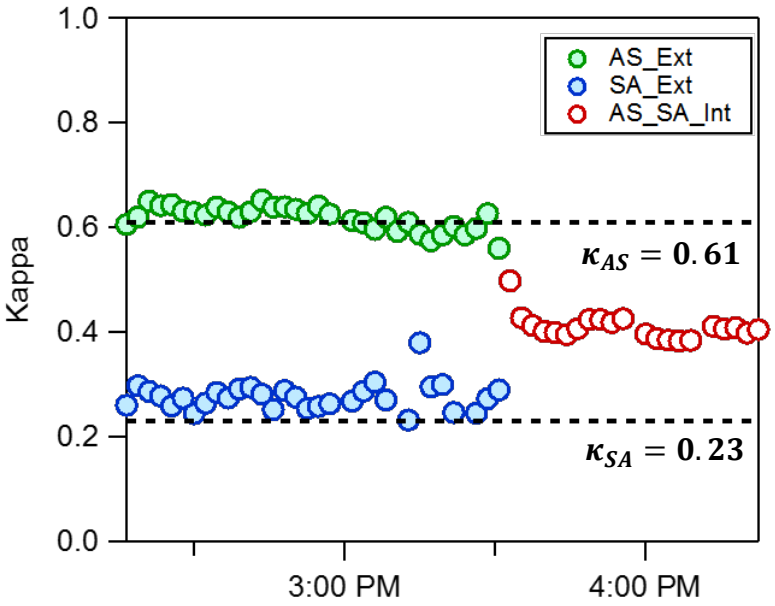

Atmospheric aerosols are often **mixed** and comprised of **multiple components**

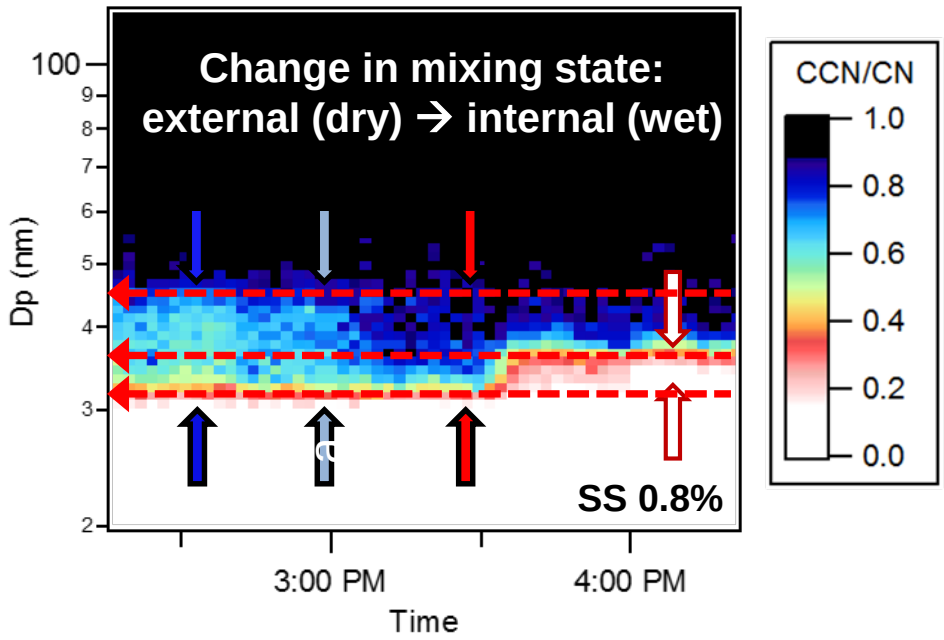


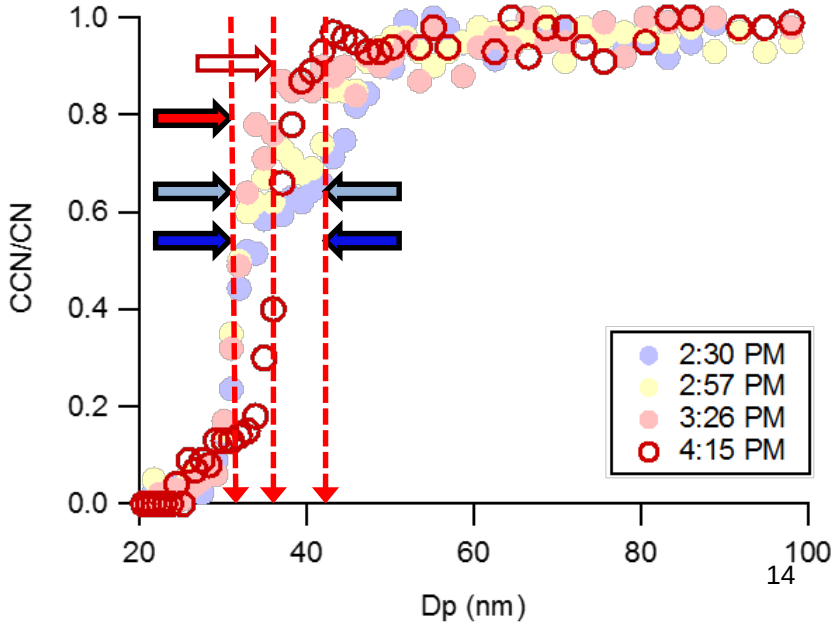
# Modifying Mixing States

- slightly soluble organic: $C_4H_6O_4$ (SA)
- soluble inorganic: $(NH_4)_2SO_4$ (AS)

**Aerosol mixing can be observed in CCN activation data and can be revisited in complex aerosol data sets to understand the extent of mixing**

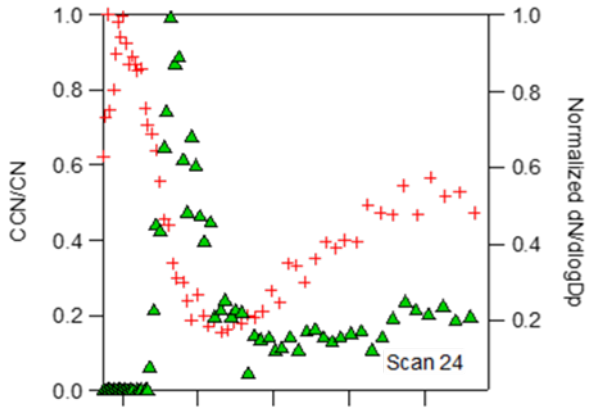


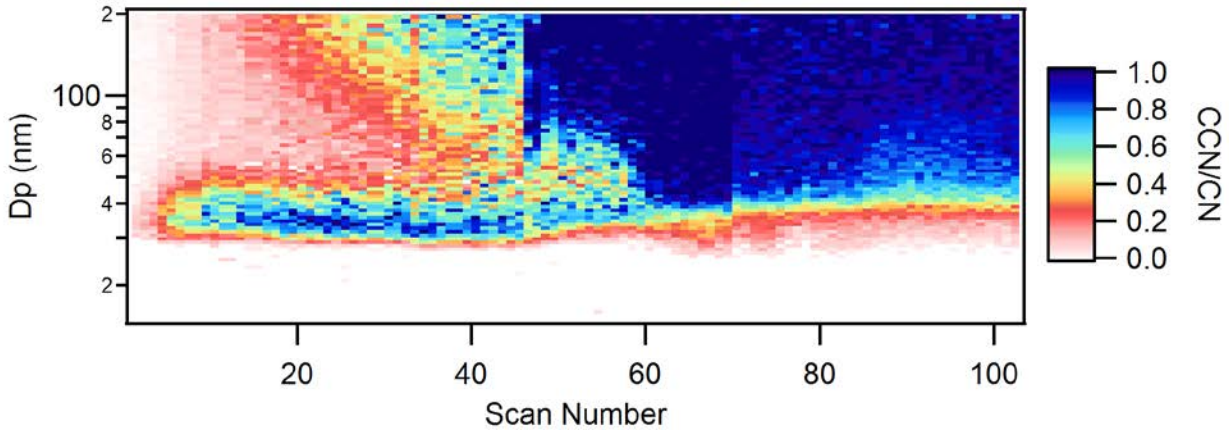



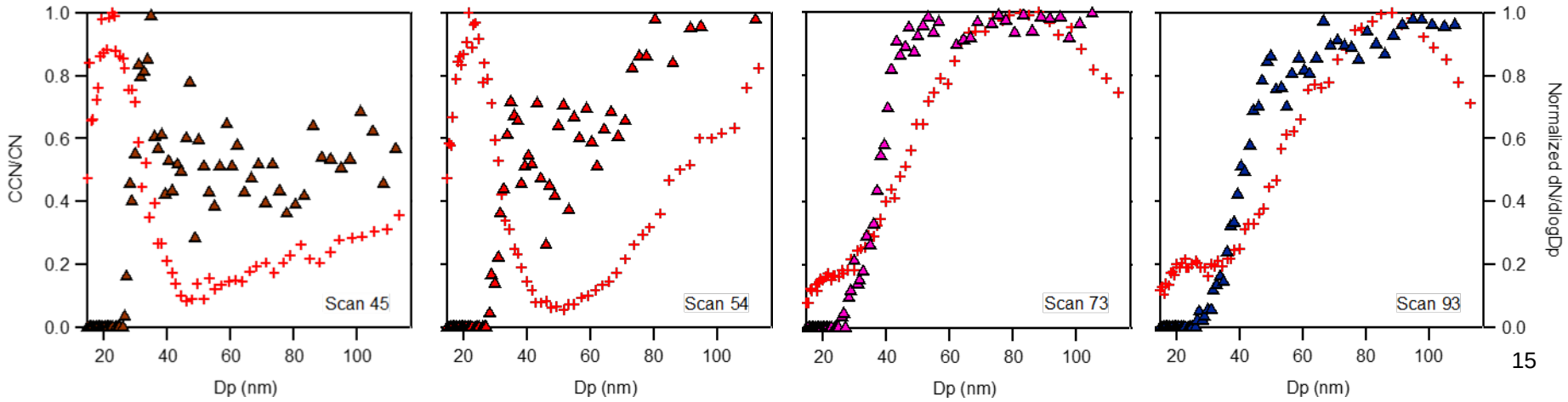



# Organic and Combustion Aerosol Mixtures

- As combustion aerosols internally mixes with the organic material, the BC CCN activity is modified



# Experimental CCN analysis techniques of known mixtures

- **Internal Mixtures**
  - Single activation curve, reflective of internally mixed multicomponent aerosols
- **External Mixtures**
  - Multiple activation curves consistent with externally mixed aerosols of varying solubility, **$\eta$-Kohler** to infer plateau height
- **Flow tube may be used to control mixing states**
  - Results suggest **aerosol water** as a significant factor
  - Under dry conditions, the aerosols maintained an **external** mixture and multiple activation curves were observed to be constant
  - Under humid conditions, external mixing was initially observed; however, the aerosol water promoted **internal** mixing and the activation curves were observed to converge into a single curve

**Aerosol mixing can be observed in CCN activation data and can be revisited in complex aerosol data sets to understand the extent of mixing**

# Emissions Projects

# Higher speeds produce water-soluble particles


**Aerosol Science and Technology**

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uast20

## A Unique Online Method to Infer Water-Insoluble Particle Contributions

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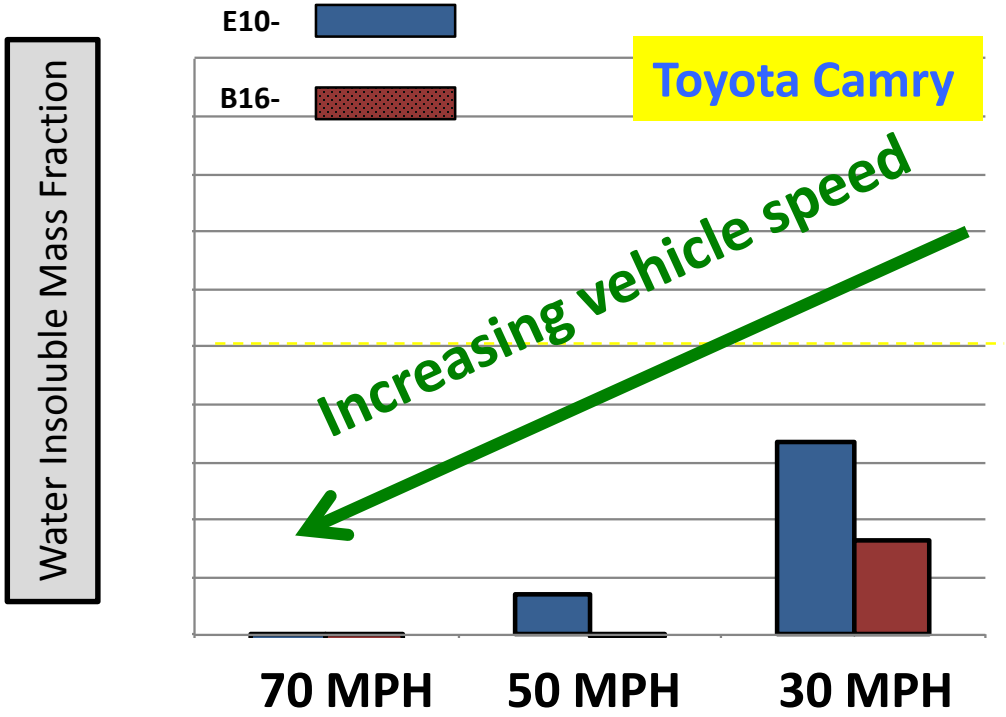
Accepted author version posted online: 23 Apr 2014.Published online: 25 Jun 2014.




- **The chemical composition of aerosol from steady-state emissions is NOT the same as the emissions tested on driving cycles.**
- **This is true for Varying Fuels, Vehicles, and Cycles**

# Mobile Atmospheric Chamber (MACh)

- **Effect of Aging on CCN Activity**
  - Freshly emitted gasoline vehicle exhaust is hydrophobic and not CCN active (Vu et al. AS&T 2015)
  - Physical and chemical changes with atmospheric aging
    - Vehicle emissions are a source of Volatile Organic Compounds (VOCs) that can act as **Secondary Organic Aerosol** (SOA) precursors
  - Effect of photochemical aging of gasoline emissions derived from real world driving conditions on CCN activity is currently not well understood

**<u>Objective</u>: Integrate fresh tailpipe measurements to aged vehicle emissions characterization**

**Aerosol-Cloud-Climate Interactions**

**Vehicle Emissions**

→ **Atmospheric Processes**

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