Hygroscopicity parameter from LASIC observations and comparison to models

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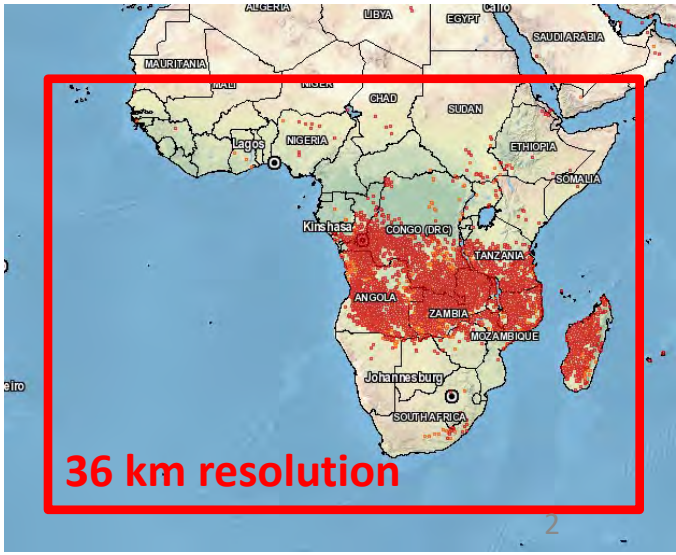
Funding Sources:

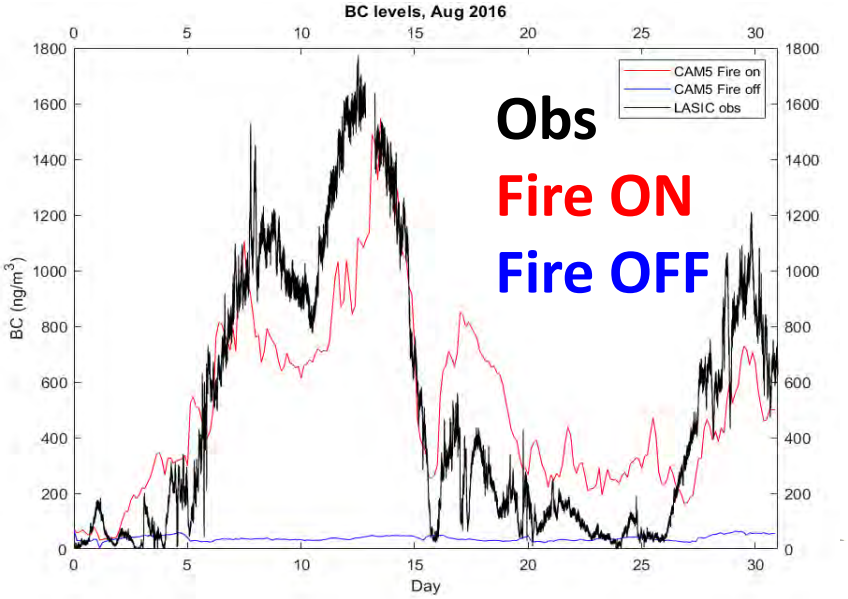
WRF-CAM5

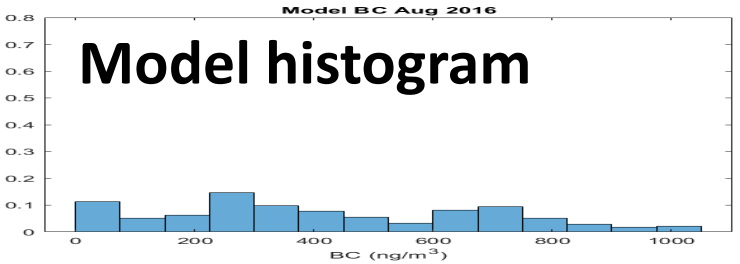
- Obtained through collaboration with Yang Zhang (NC state) and Ruby Leung (PNNL)
- WRF-Chem with CAM5 aerosol and physics:
  - MAM3 aerosols (3 aerosol modes)
  - Fountoukis and Nenes (FN) series cloud droplet activation (includes giant CCN and dust activation), Niemand et al. (2012) ice nucleation
  - UW (Bretherton and Park) Boundary layer scheme
  - CESM cloud microphysics and cumulus scheme, shallow cumulus scheme TURNED OFF
- 36km horizontal, 72 vertical layers, 50 layers below 3km
- QFED Smoke emissions, no inversion, no plume rise
- Started every 5 days from FNL with 3 days of spin-up for each initialization, aerosol initial conditions from previous cycle

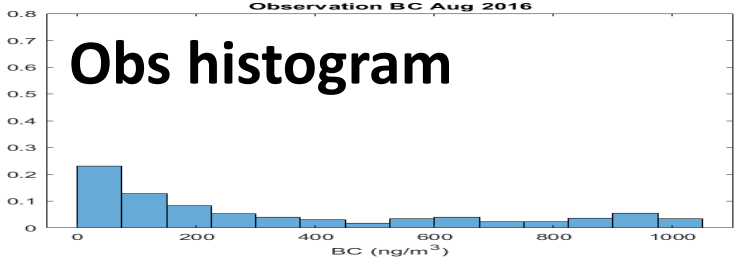


Ascension black carbon during August

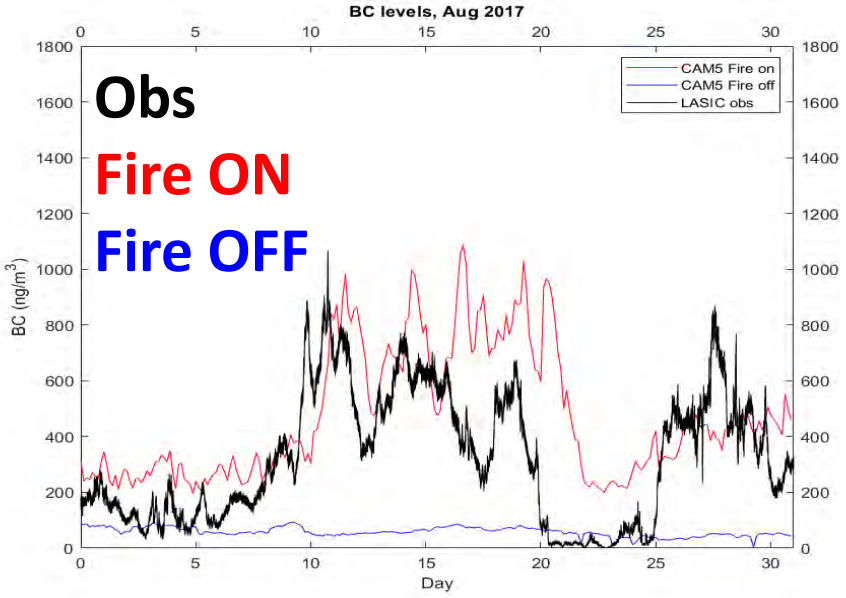
2016

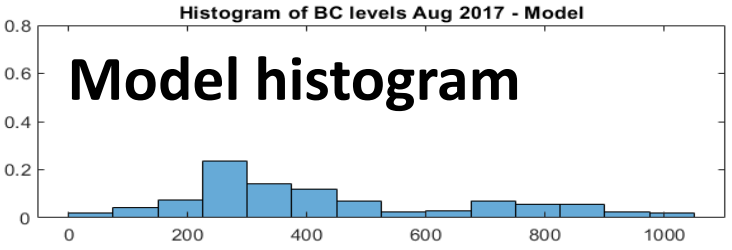


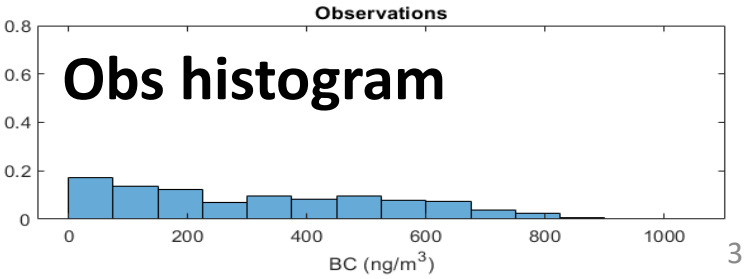




2017

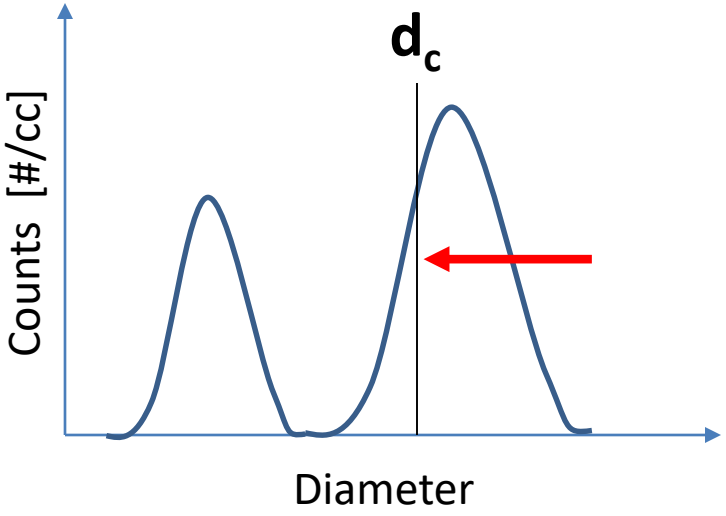


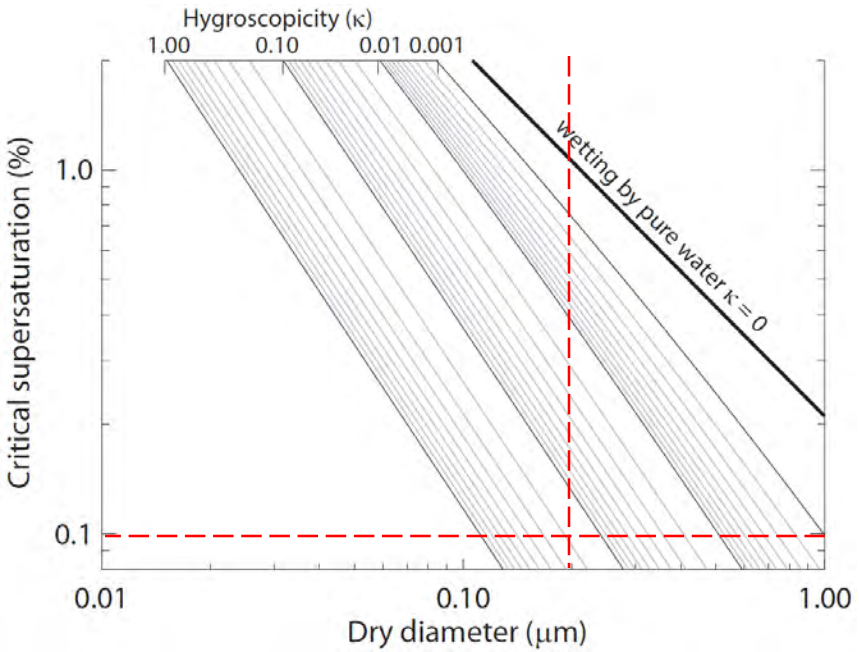




Computing hygroscopicity parameter (κ)

- Need observed CCN and size distribution
- Integrate the size distribution from the largest bin down to the critical diameter (d_c) that matches the measured CCN concentration
- κ can be derived based on CCN supersaturation (SS) and critical diameter

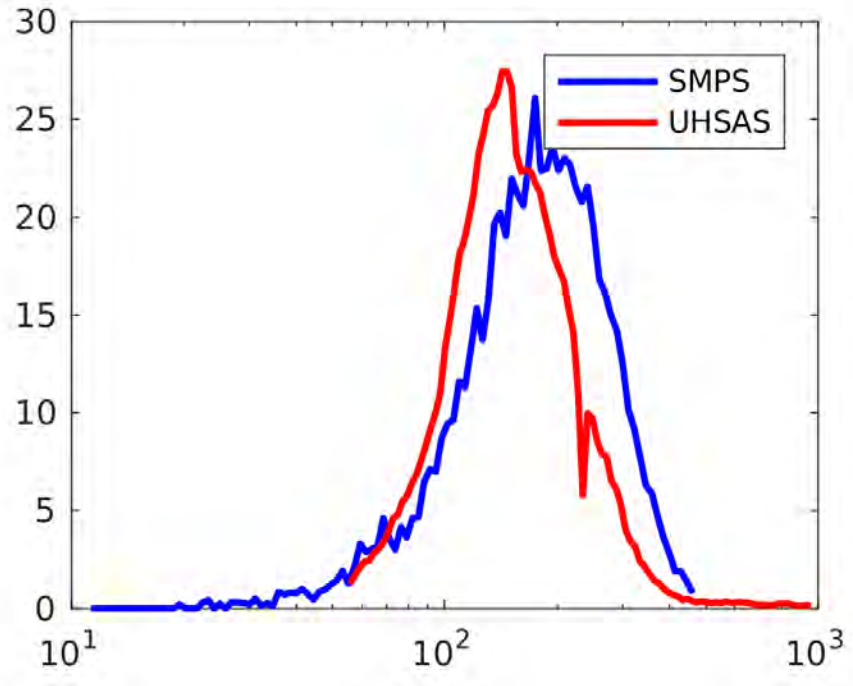


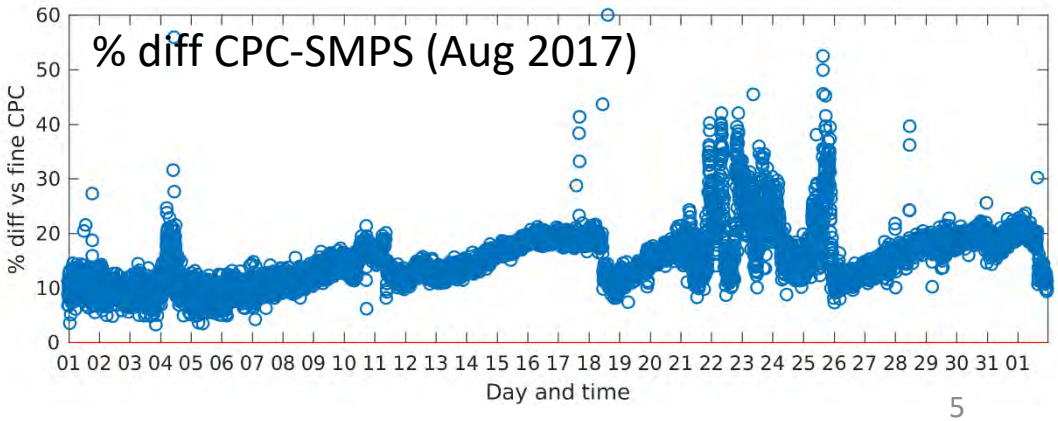


Petters and Kreidenweis, ACP 2007

Size distribution from LASIC

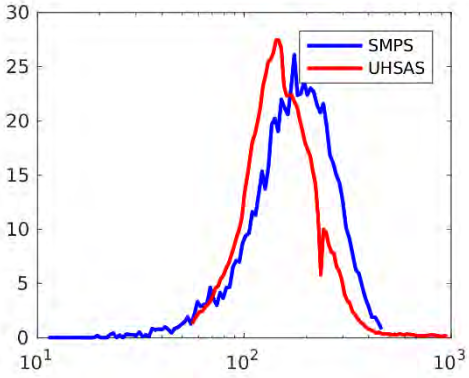
- Can be obtained from SMPS or UHSAS
- UHSAS probably needs diameter correction due to:
  - Different refractive index of aerosol used for calibration (e.g., Brock et al., ACP 2016)
  - Potential evaporation of OA (U of Hawaii findings)
- Use SMPS scaled to total aerosol number concentration from CPC(>10nm) over the SMPS scan

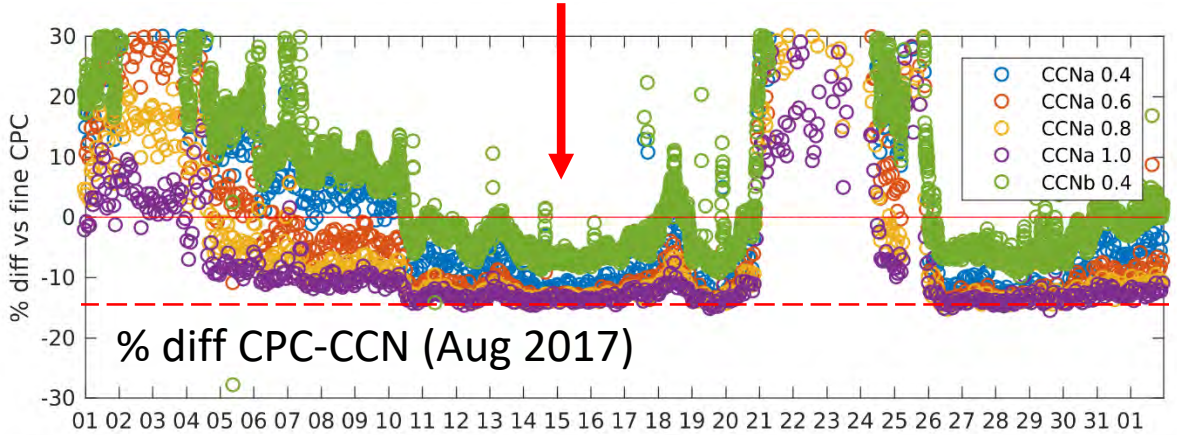


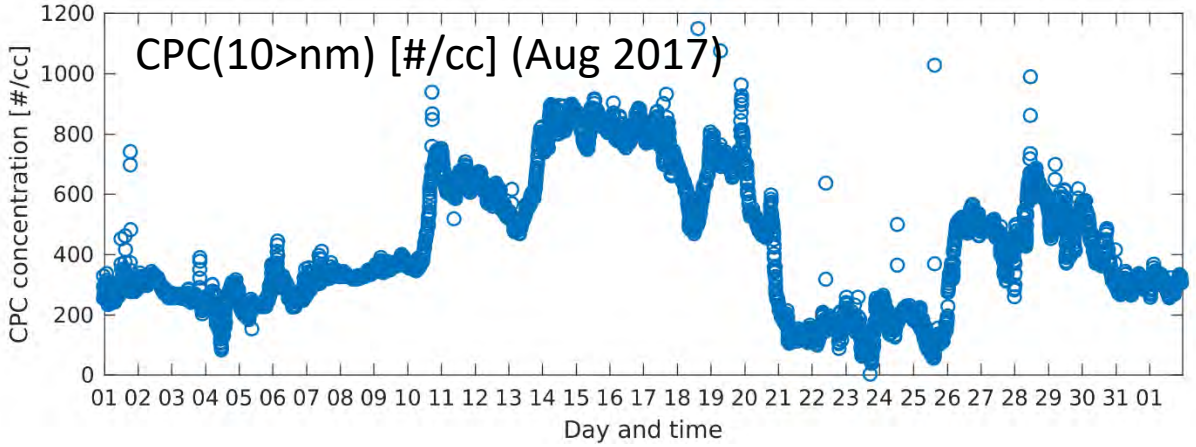


CCN from LASIC

- Two columns
  - CCNa: 0.1-1.0 SS
  - CCNb: 0.4 SS
- CCN is often larger than CPC
- Normalize CCN to match CPC when CCN 0.8 SS ~ CCN 1.0 SS using single correction factor (~12%)

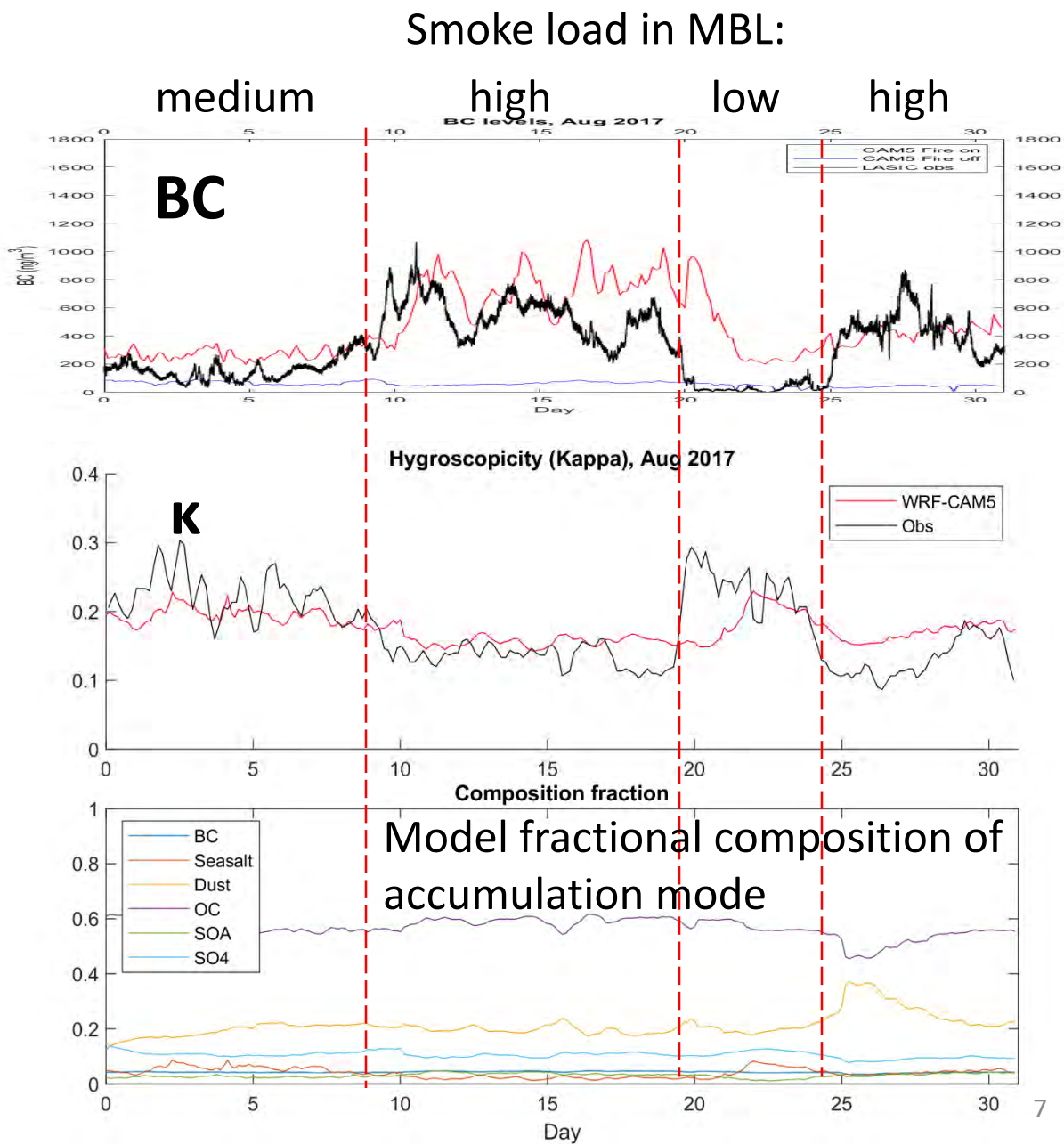






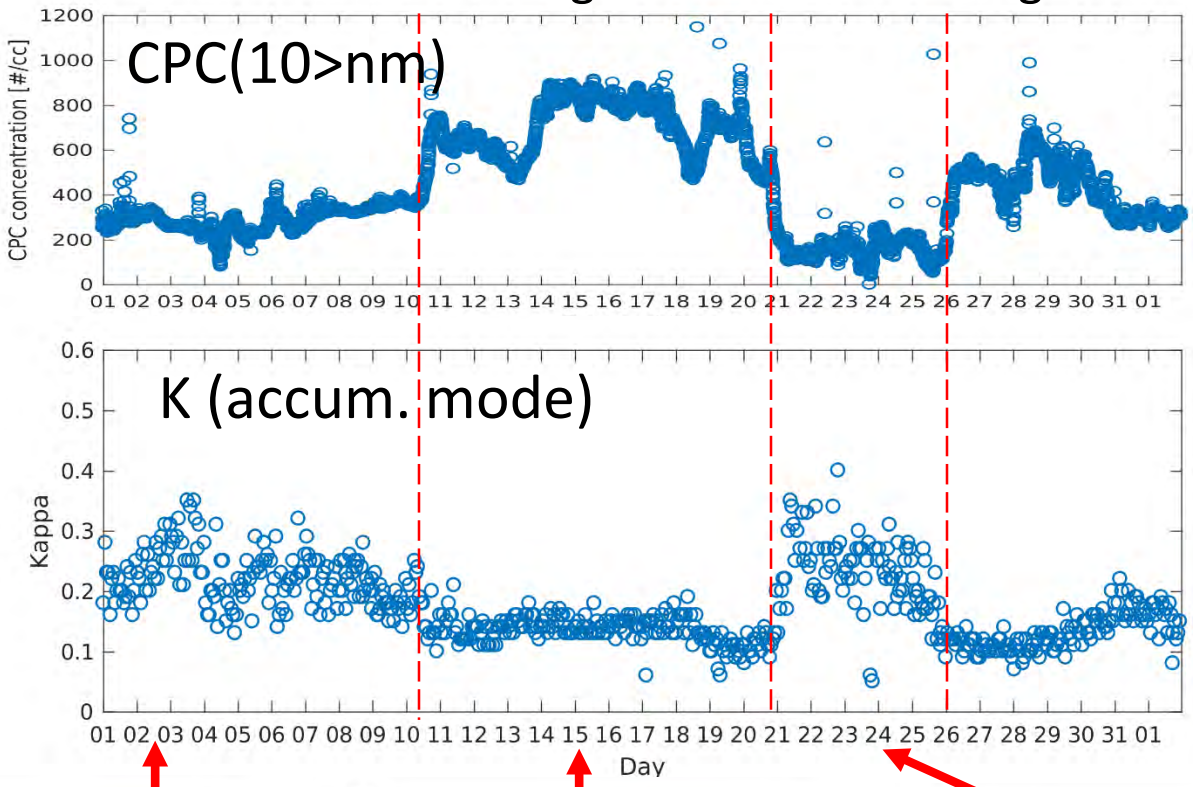
Modeled vs observed κ (accum. mode)

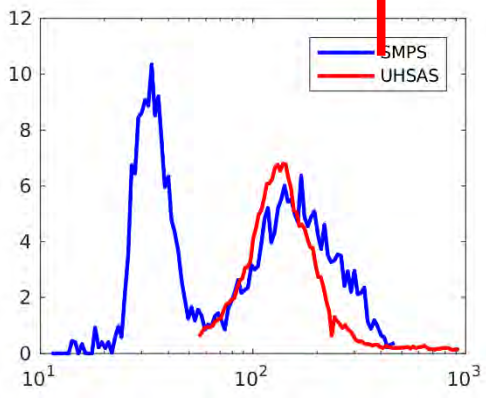
- Range and variability of κ is similar in model and obs
- Modeled increases in κ during high smoke driven by increases in sea salt and sulfate fraction

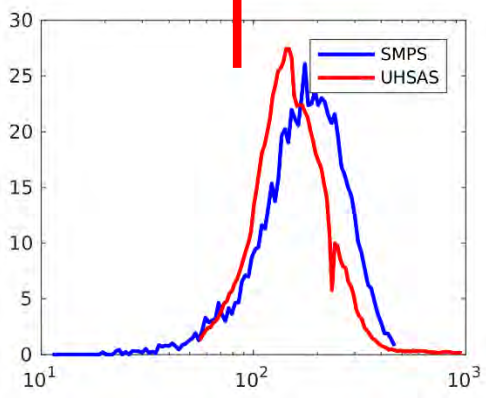


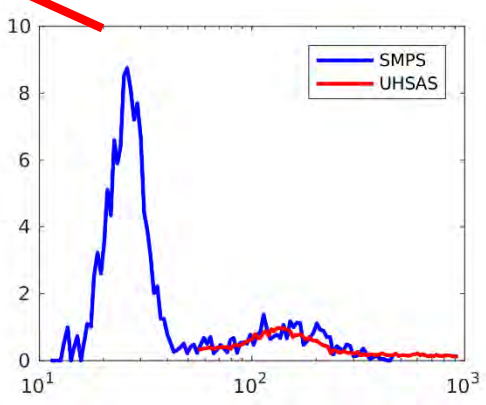
What drives changes in observed κ?

Smoke load in MBL: medium high low high









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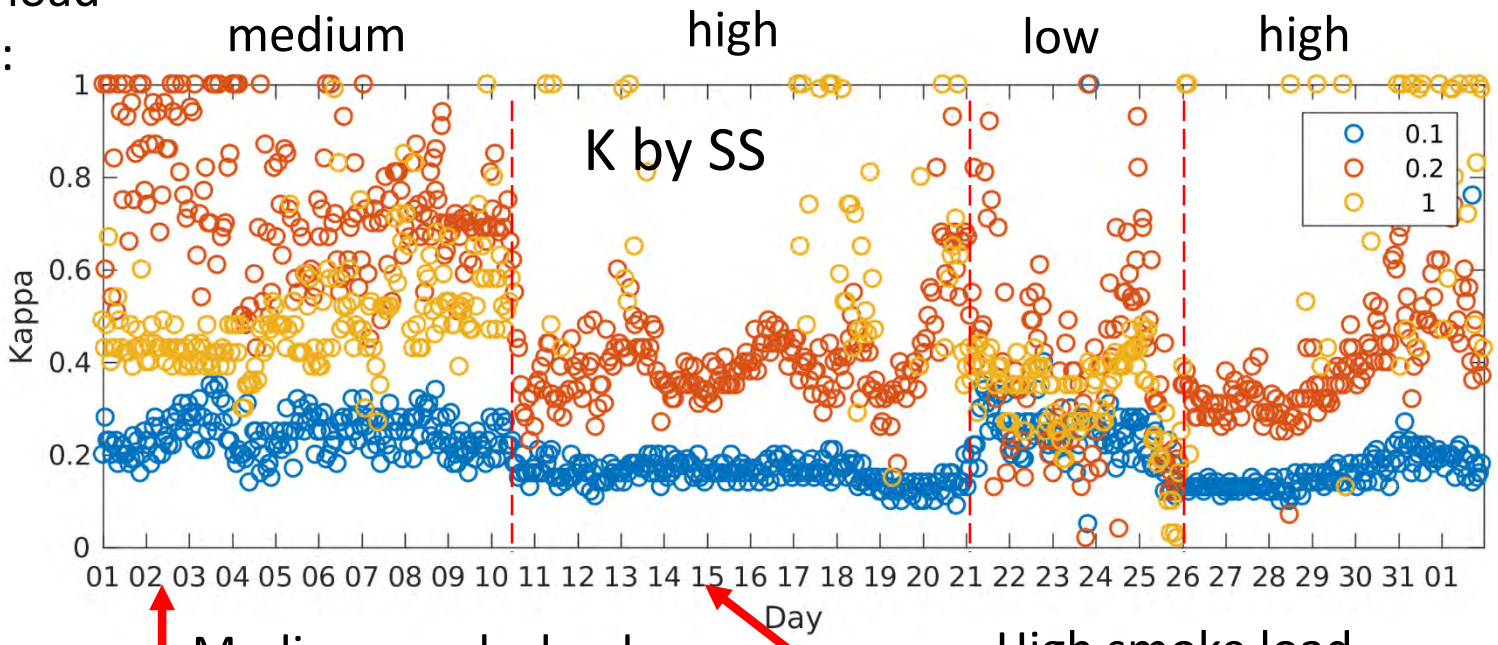
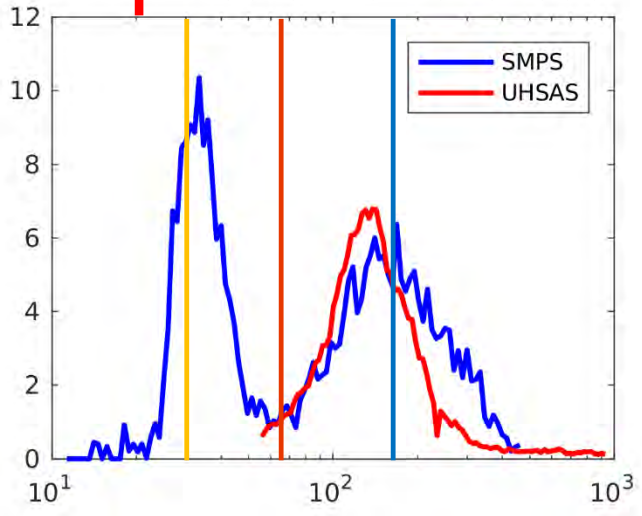
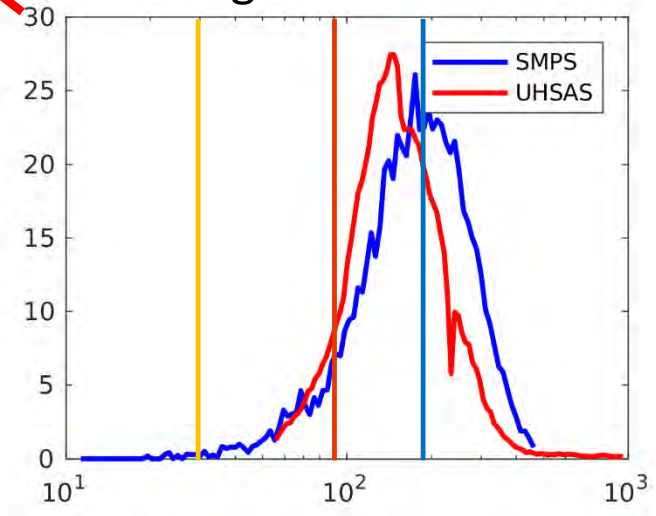


Medium smoke load



High smoke load



Next steps

- Assess model representation of the nucleation mode
- Evaluate the model for other variables related to aerosol-cloud interactions: CCN concentrations, vertical velocities, cloud number droplet concentration
- Compare to observations from ORACLES/CLARIFY that took place in the free-troposphere

Thanks! Questions/comments?

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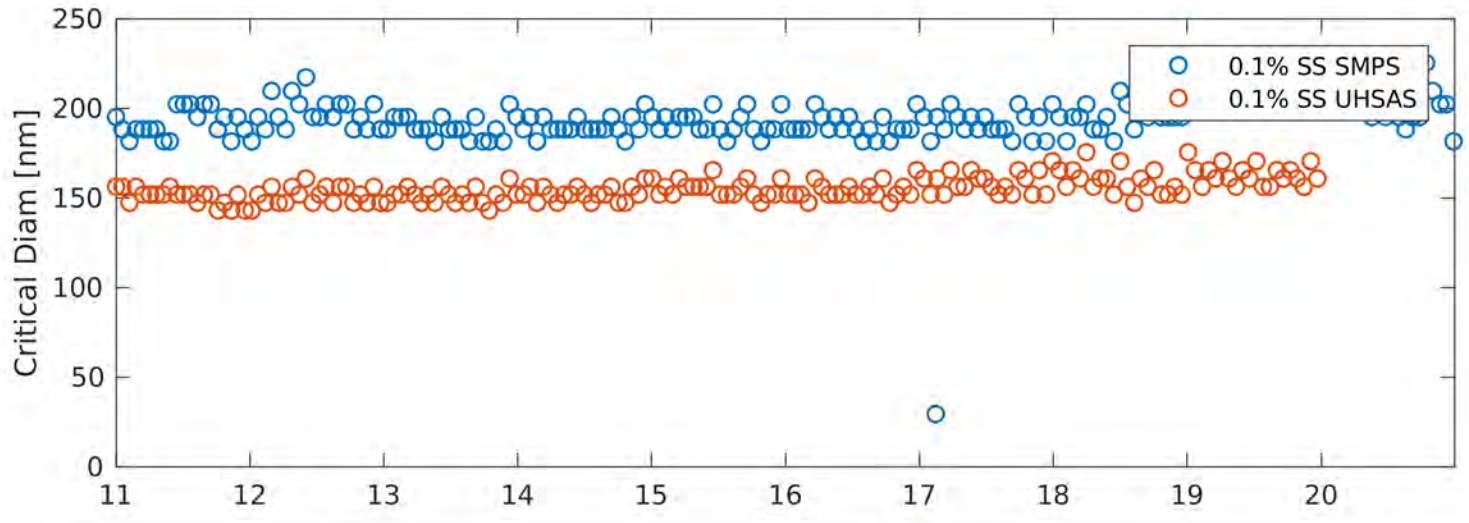
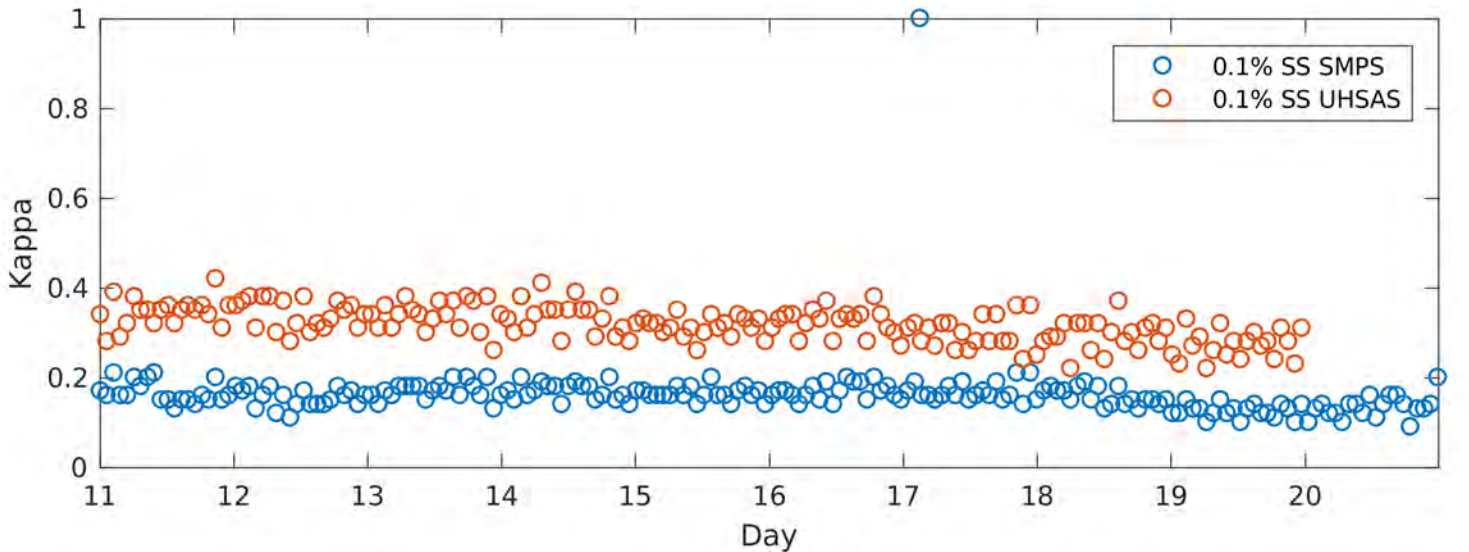
Supporting slides

SMPS vs UHSAS critical diameter and kappa





Mean diameter and GSD evaluation