

Evaluating Ultrafine Aerosol Nucleation Mode in E3SM with in- situ Aircraft measurements at SGP and ENA

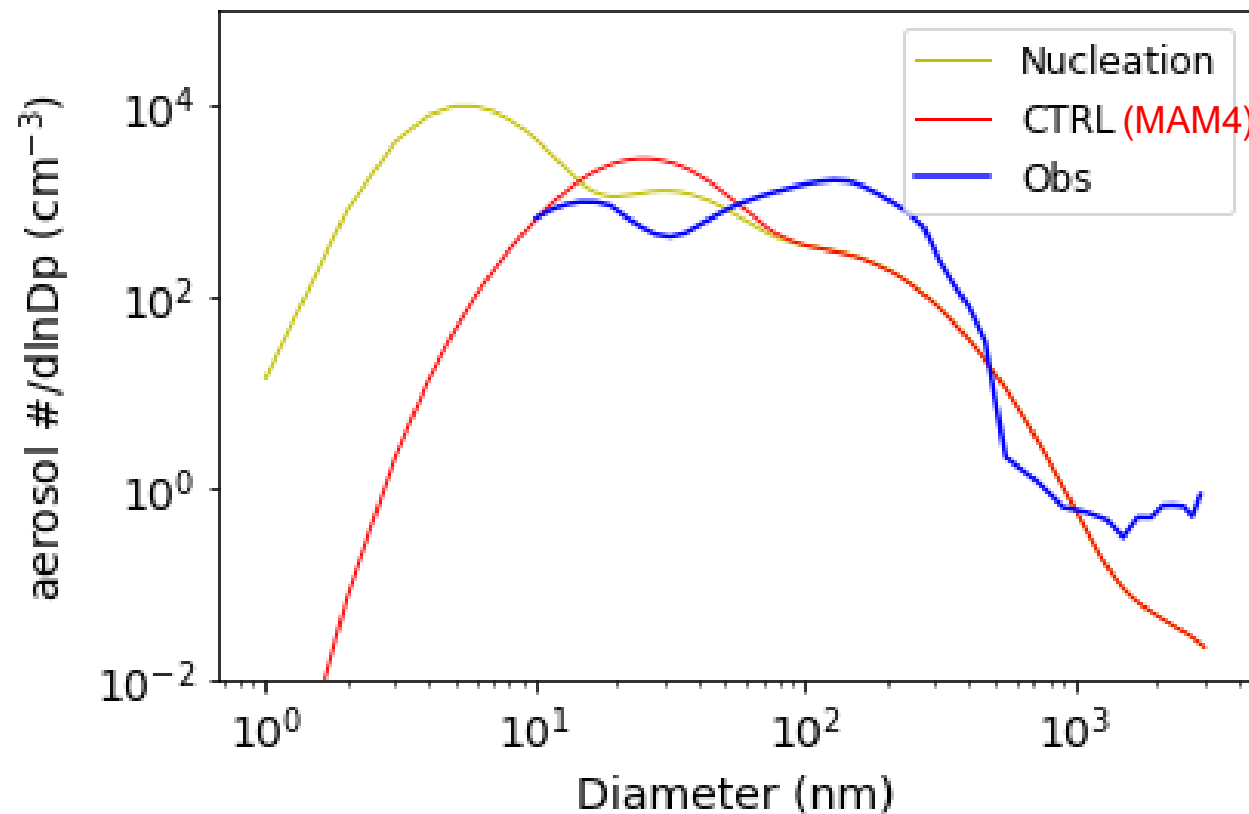
October 21, 2020

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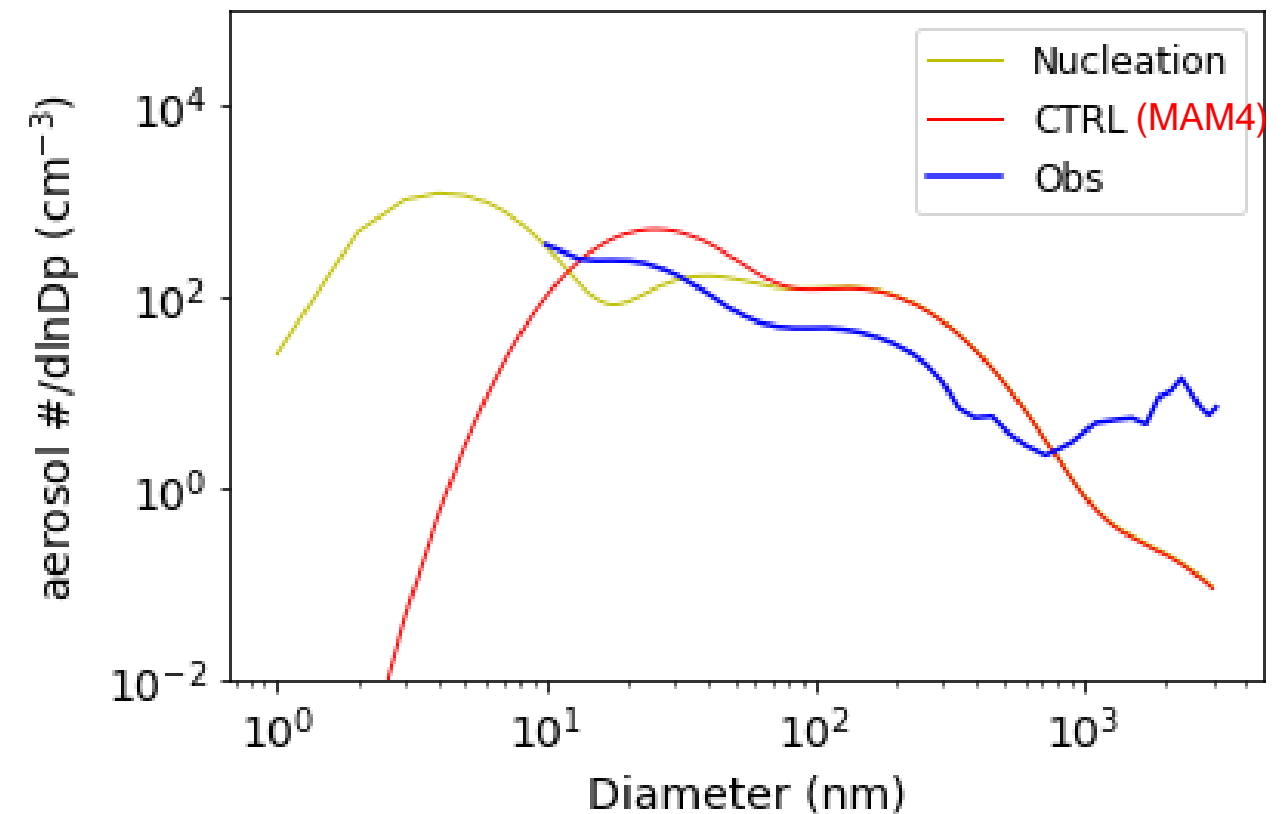
EAGLES is Developing Aerosol and ACI Treatments in E3SM Suitable for Cloud-Resolving Scales

A **nucleation mode (3-10nm)** has been added in MAM to explicitly represent new particle formation, condensational growth, and coagulation processes for ultrafine particles that could influence CCN concentrations and cloud properties.

Hi-Scale @ SGP



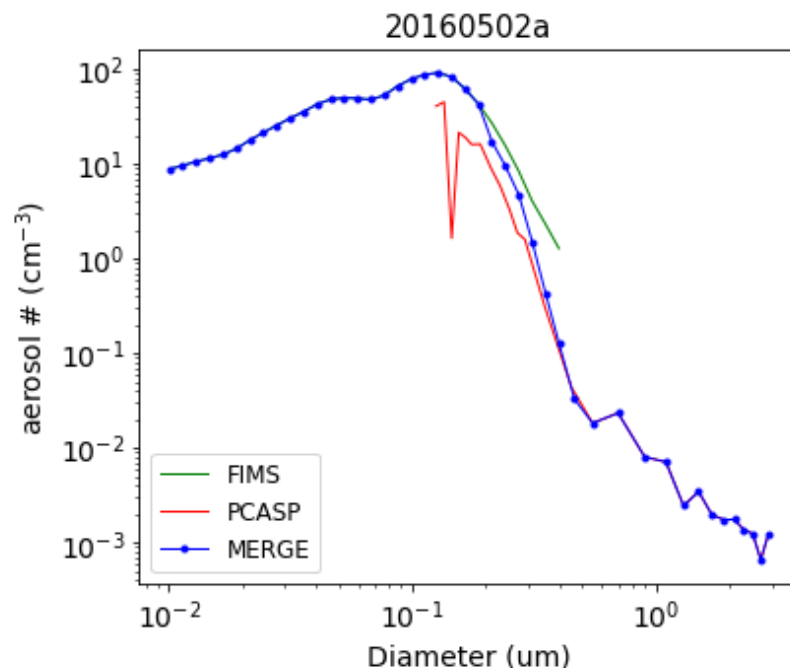
ACE-ENA @ ENA



Measurements and Diagnostics

One objective of EAGLES is the development of new metrics using in-situ ARM measurements from surface and aircraft platforms to quantify the performance of aerosol and aerosol-cloud interaction (ACI) predictions.

Creation of a merged size distribution using FIMS and PCASP data to account for ultrafine, Aiken, and accumulation mode aerosol concentrations

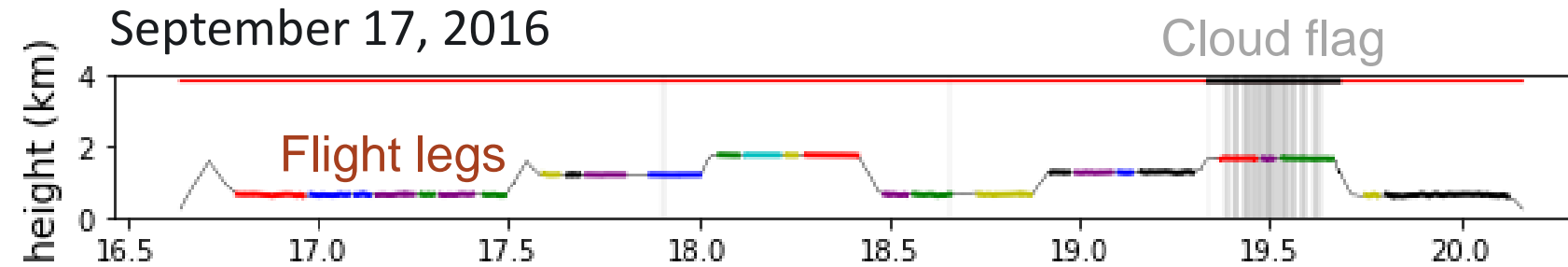


MAM mode information is converted into size ranges comparable to observations

Aircraft-measured aerosol size distribution data used in this work:

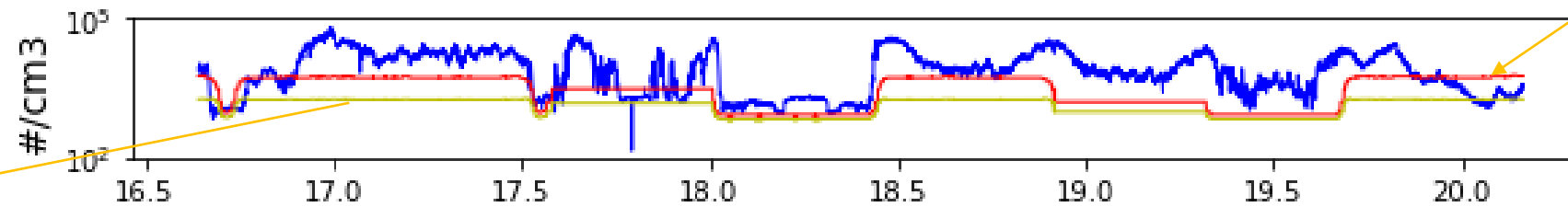
- Field campaigns:
 - **Hi-Scale @SGP**: Apr-May, Aug-Sep 2016. (38 flights)
 - **ACE-ENA @ENA**: Jun-Jul 2017, Jan-Feb 2018. (39 flights)
- Instruments:
 - CPC/CPCU: CN# (CPC: >10nm, CPCU: >3nm)
 - CCN counter: SS=0.24% and 0.46%
 - FIMS: size distribution between 10-425nm
 - PCASP: size distribution between 120-3000nm
 - UHSAS: size distribution between 70-700nm (only for Hi-Scale IOP1)

Particle Number and CCN For One Flight

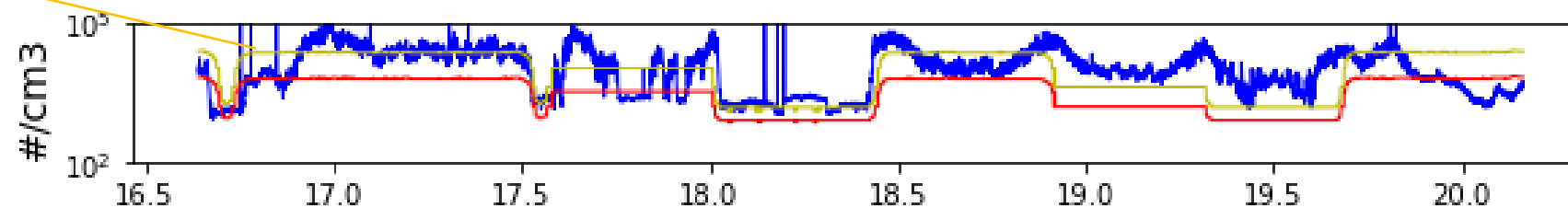


Coarse 1-degree grid spacing does not resolve spatial variability, but new comparisons can be made as E3SM resolution increases

decreases in Aiken mode and # increases in nucleation mode

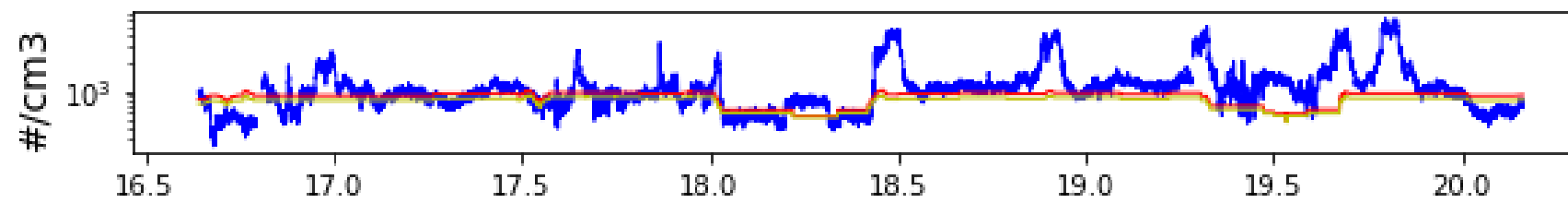


— CPC(>10nm)
— CTRL
— Nucleation

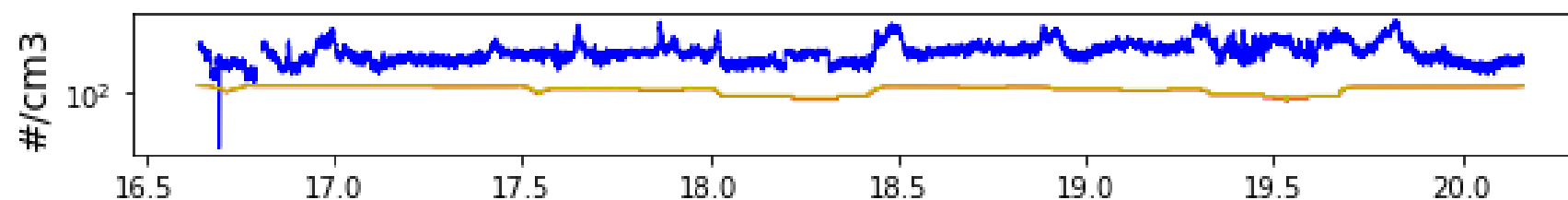


— CPC(>3nm)
— CTRL
— Nucleation

CCN# increases with higher SS. Nucleation increases less than CTRL.



— CCN(0.5%)
— CTRL
— Nucleation

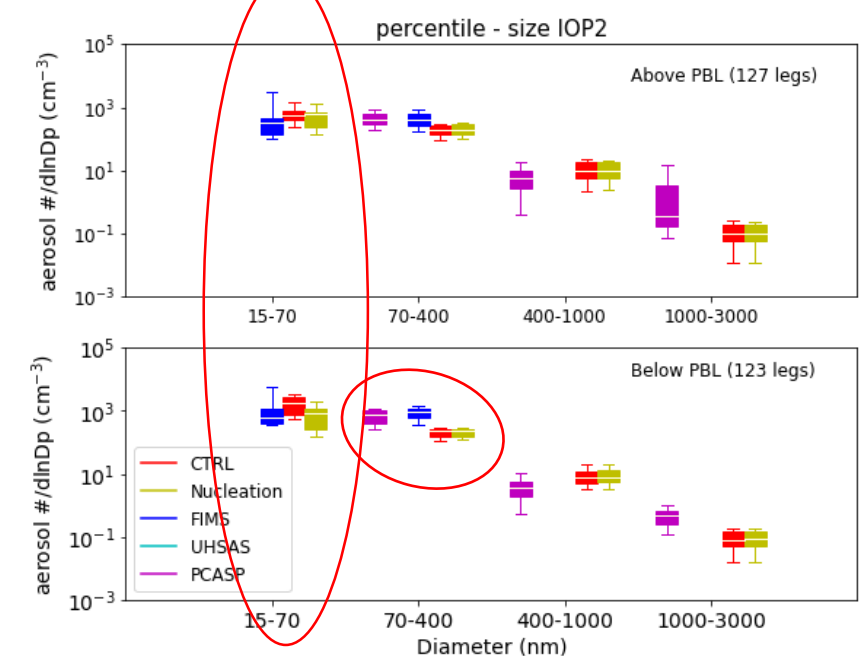
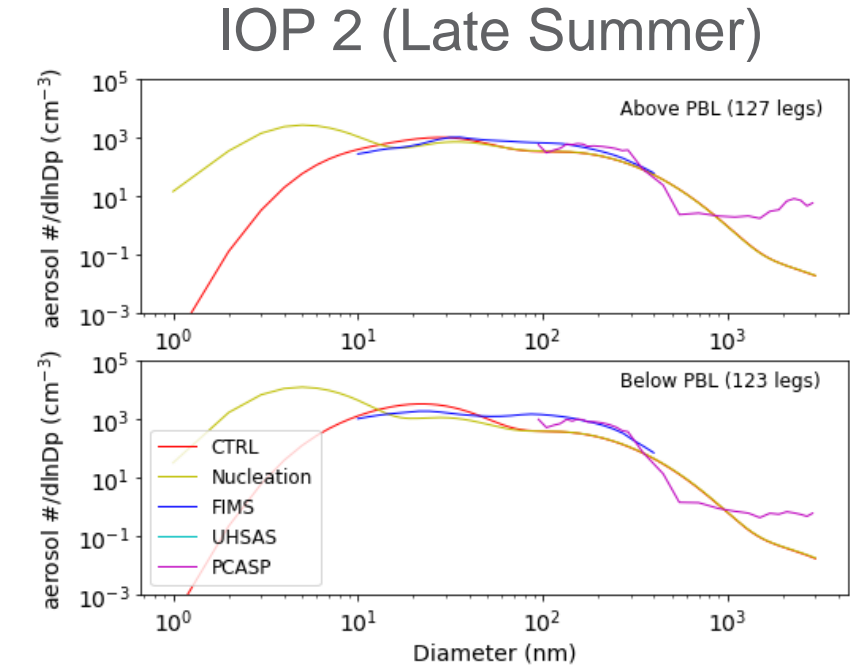
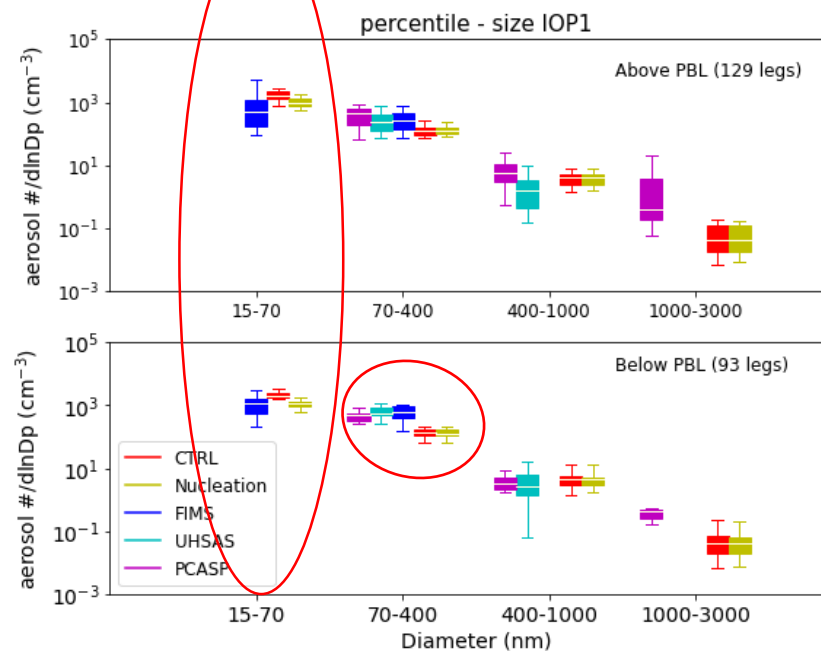
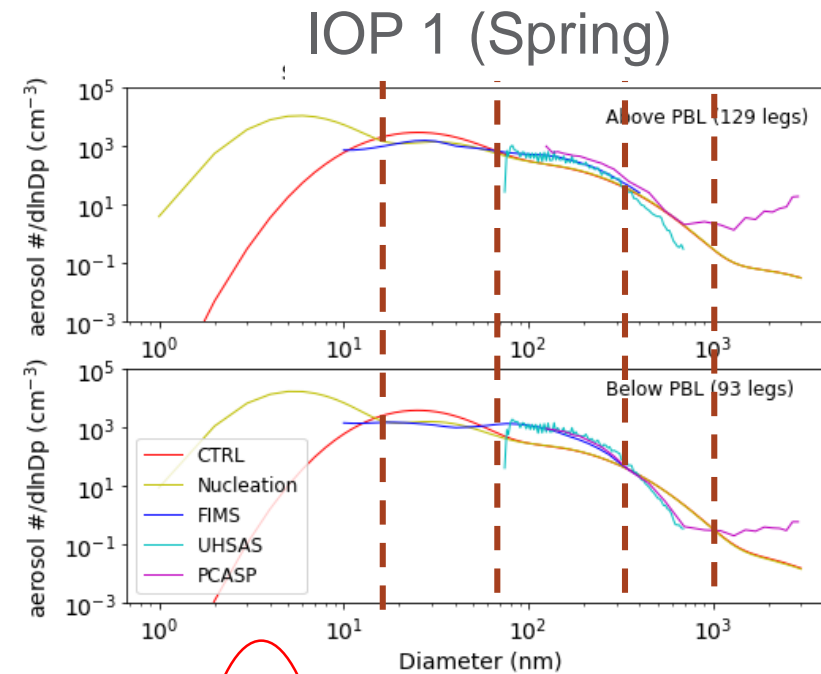


— CCN(0.3%)
— CTRL
— Nucleation

time (hour UTC)

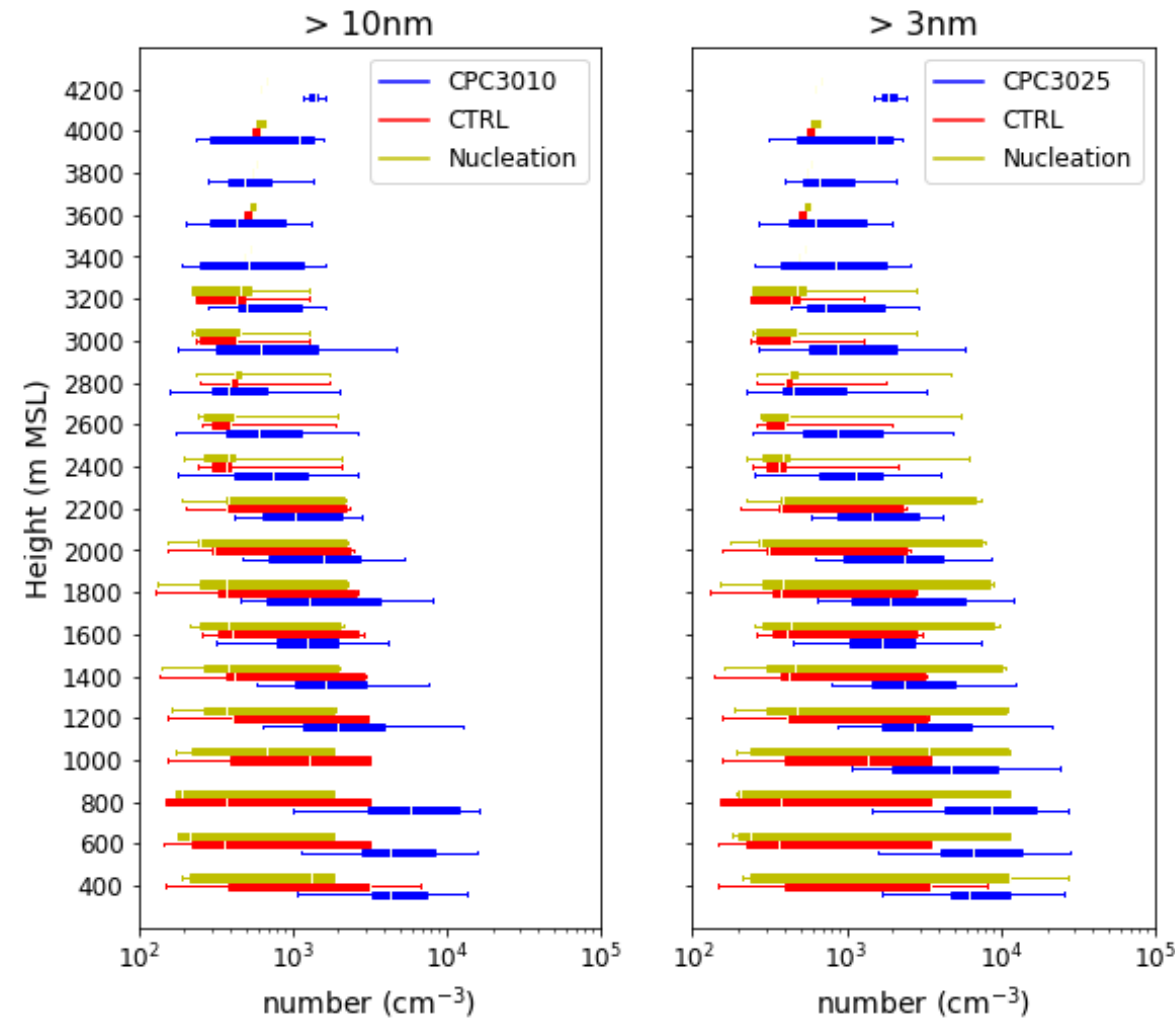
Size Distribution Above/Within PBL

- CTRL overestimates smaller size (15-70nm) particles. New scheme performs better
- Both CTRL and Nucleation underestimate 70-400nm aerosols, especially within PBL.
- CTRL and Nucleation are similar for particles >100nm

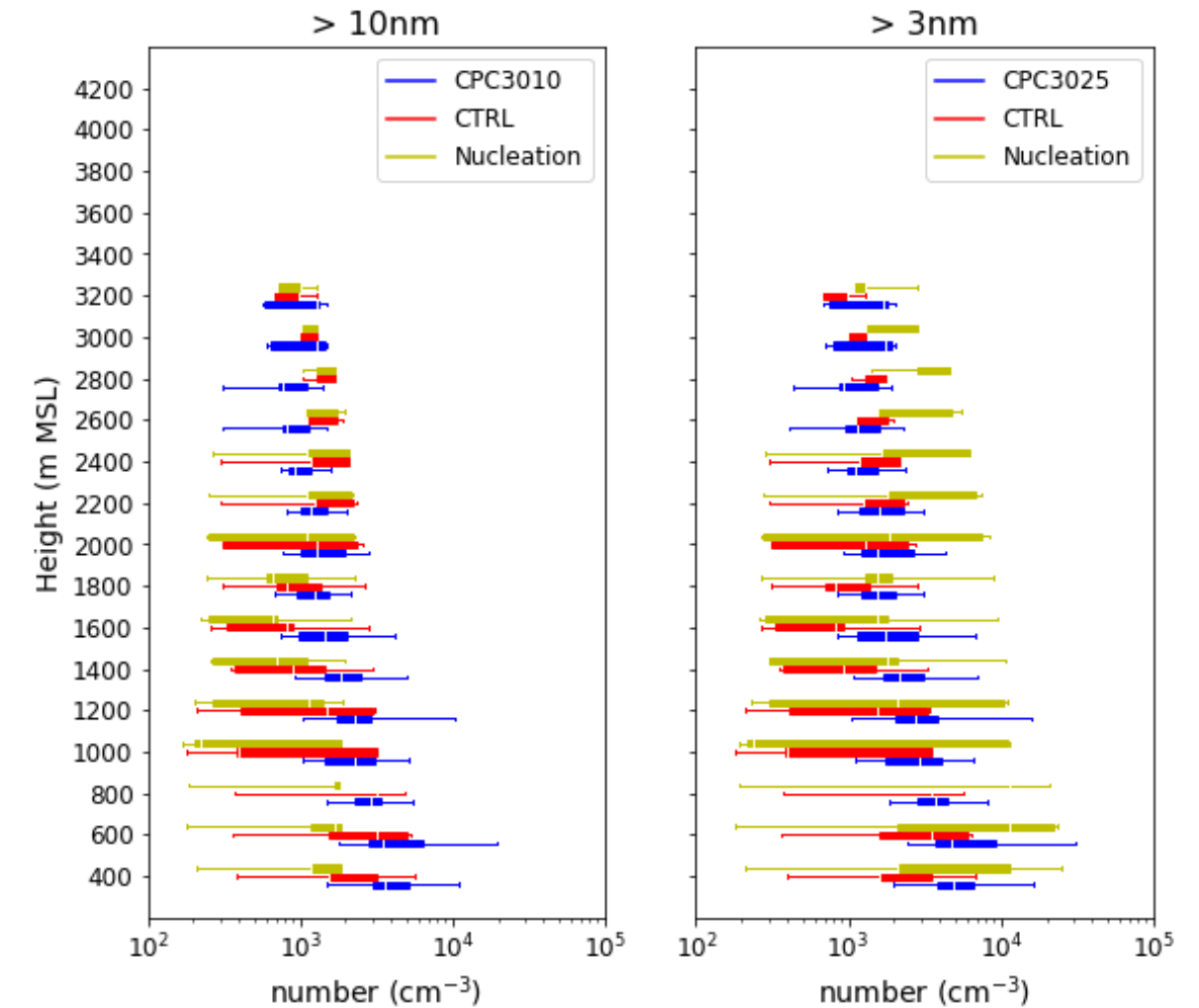


Seasonal Variation in Particle Number

IOP 1 (Spring)



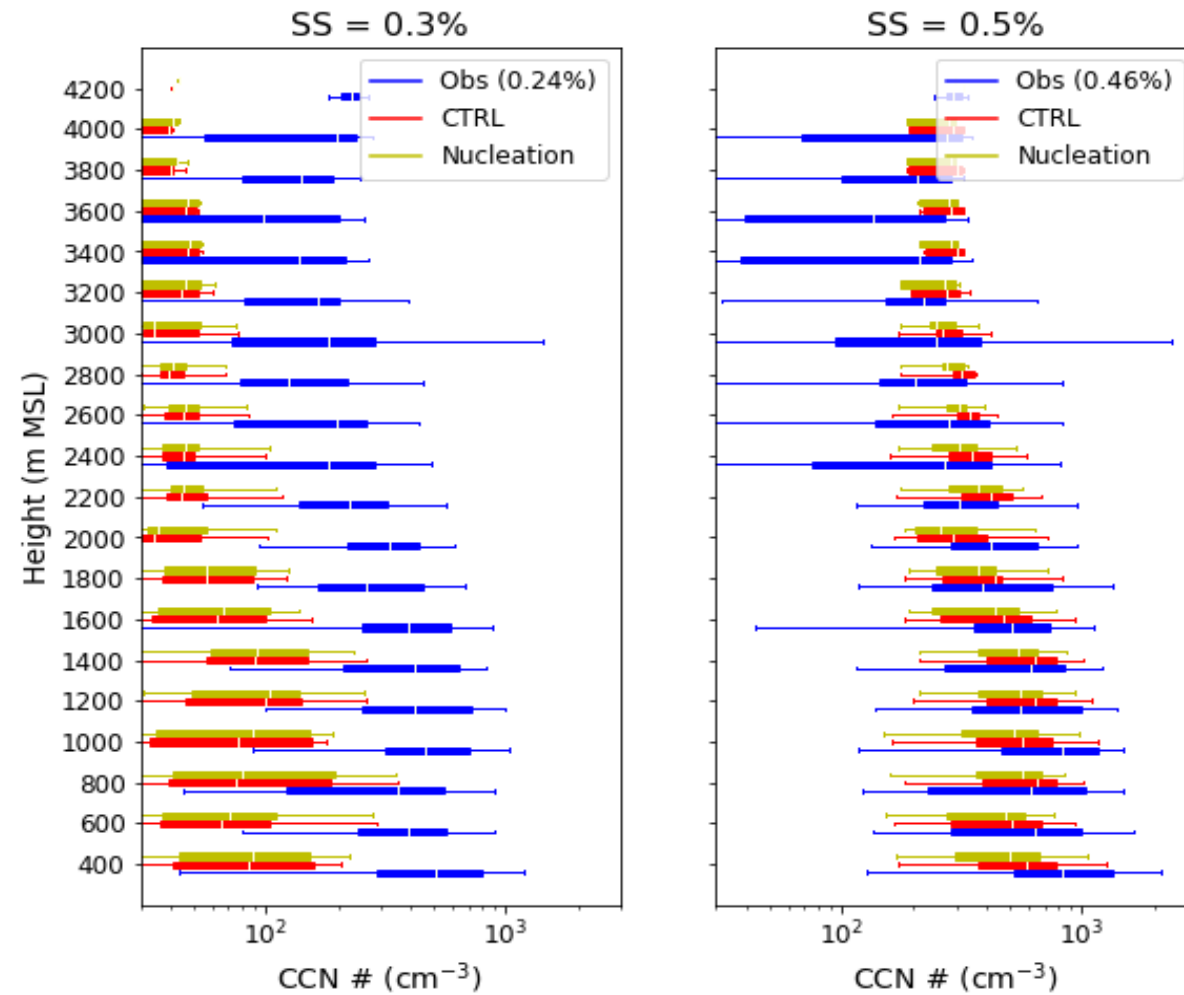
IOP (Late Summer)



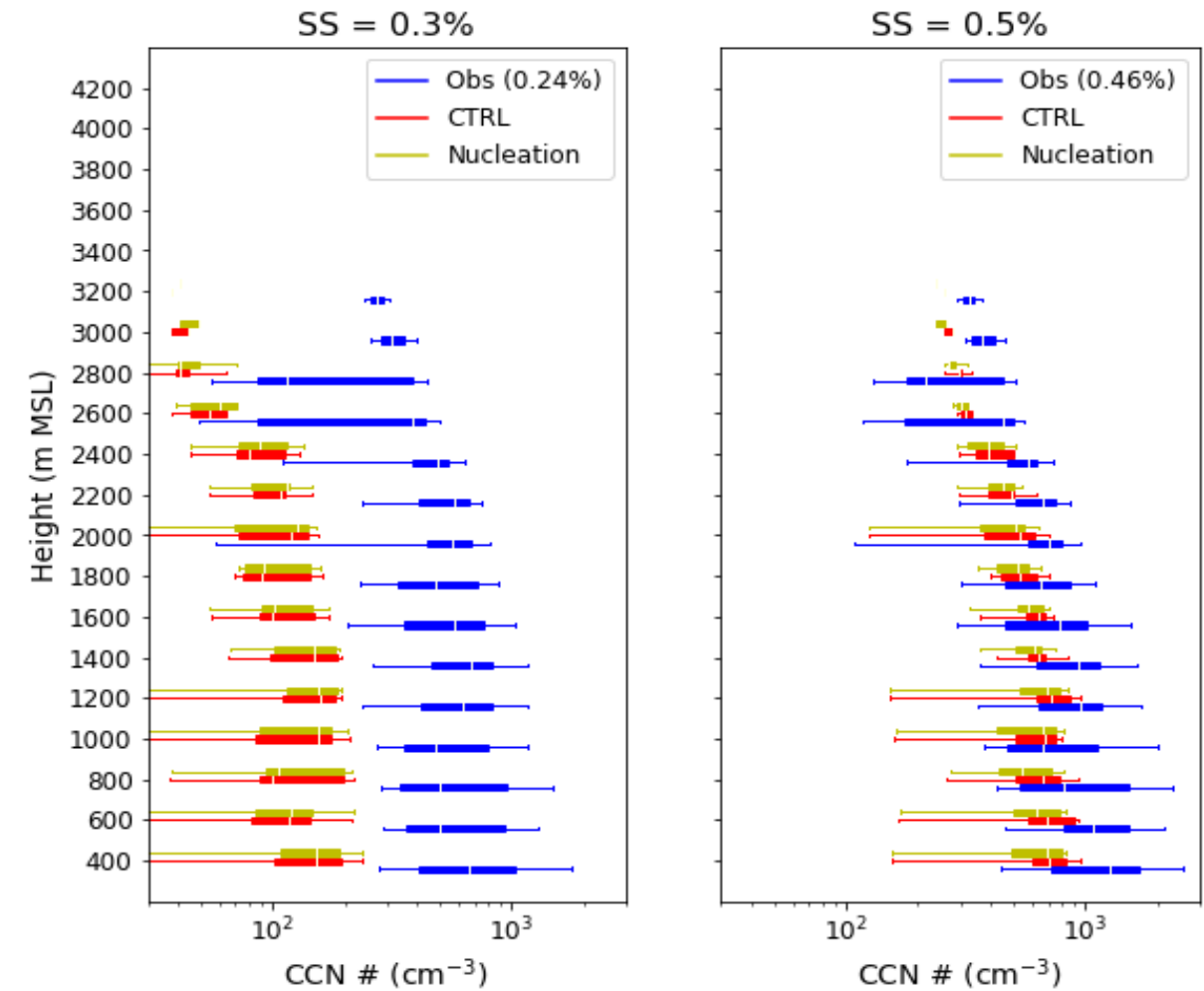
The new model has large number of nucleation mode particles
Both Nucleation and CTRL underestimate near-surface aerosol number

Seasonal Variations in CCN

IOP 1 (Spring)



IOP 2 (Late Summer)



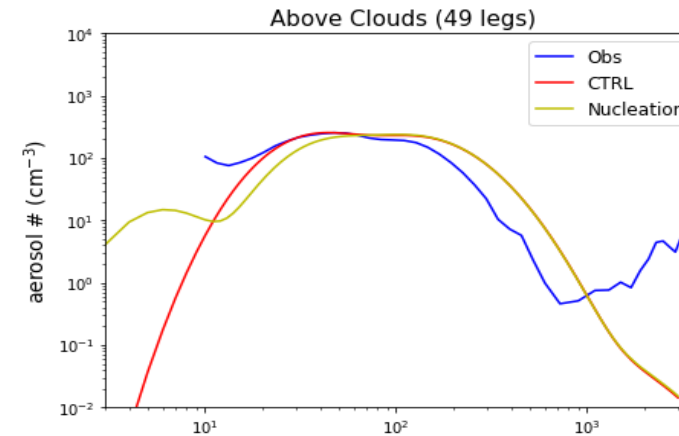
Model underestimates CCN for SS=0.3%
 Model underestimates CCN for SS=0.5% in IOP2
 Small difference between Nucleation and CTRL

Size Distribution At Different Altitudes

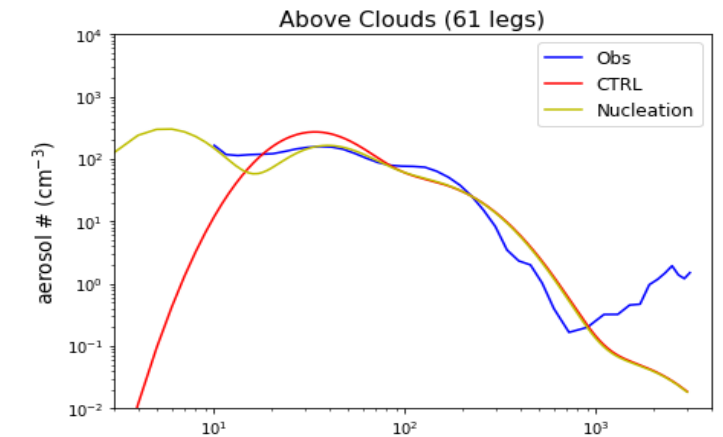
- Both CTRL and Nucleation overestimates small (15-80nm) particle concentrations near the surface. CTRL also overestimates small particles near clouds and above clouds in IOP2.
- Both CTRL and Nucleation overestimate 400-1000nm aerosols.
- Need to remove cloud/rain contamination at large size range in the observations.

Above
Clouds

IOP1 (Summer)

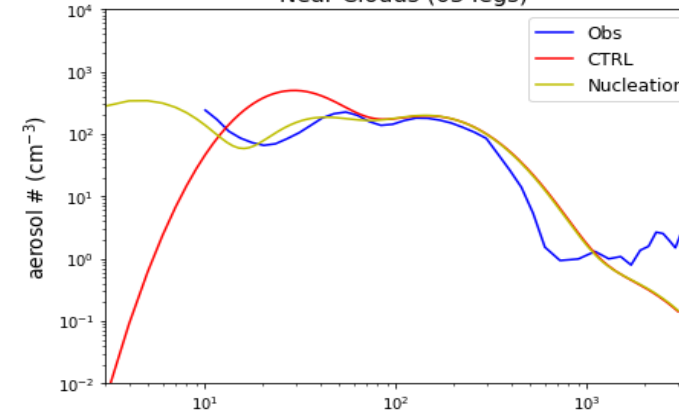


IOP2 (Winter)

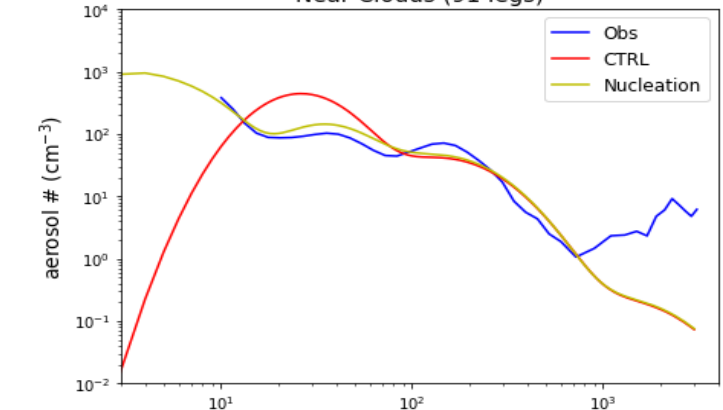


Near
Clouds

Near Clouds (63 legs)

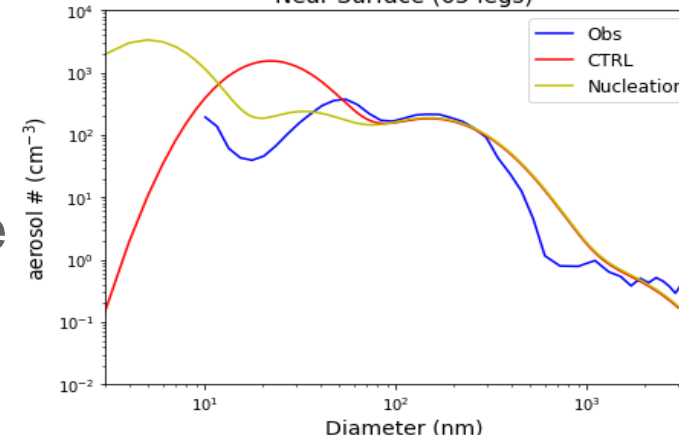


Near Clouds (91 legs)

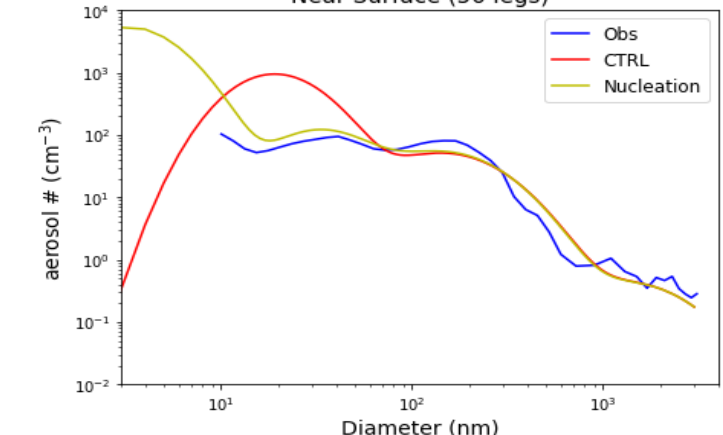


Near
Surface

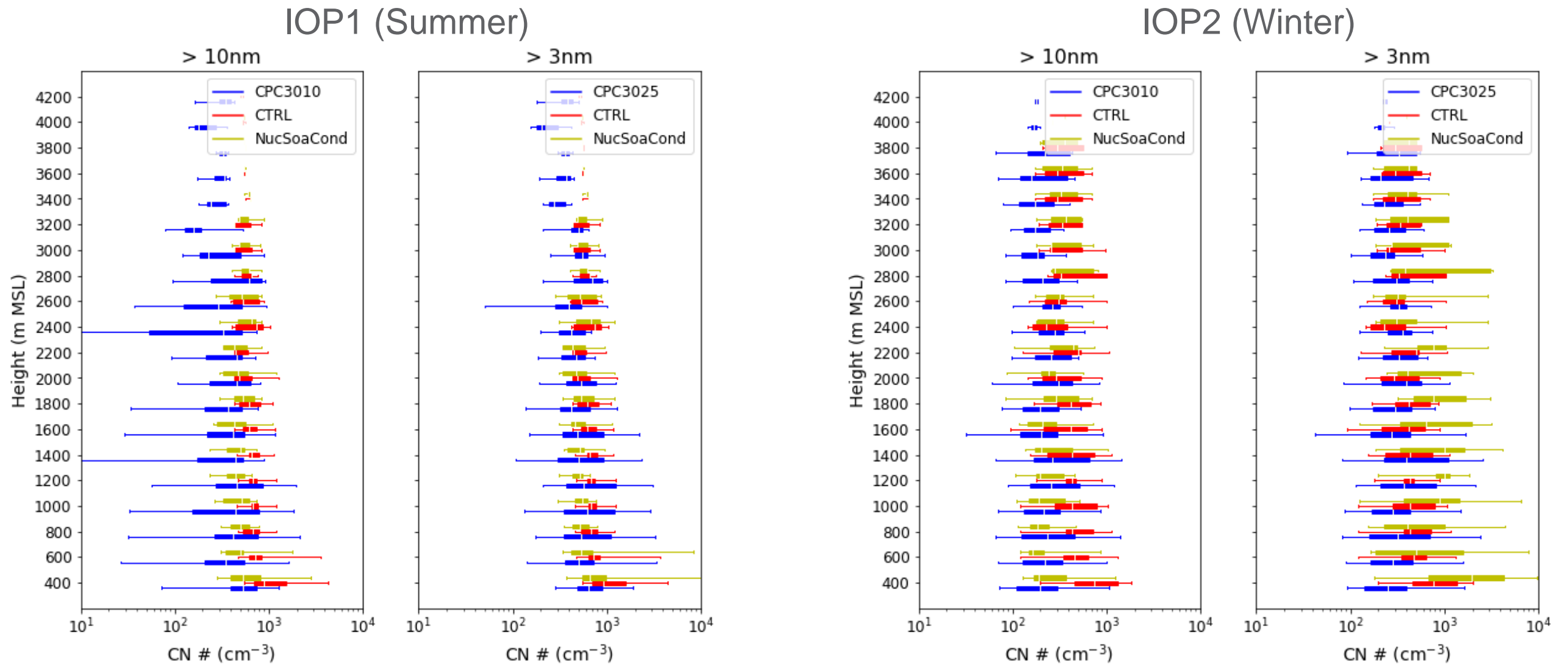
Near Surface (65 legs)



Near Surface (56 legs)



Seasonal Variation in Particle Number



The new model has much more nucleation mode particles in IOP2 than IOP1
 Model overestimates aerosol number at most levels <2000m and >3000m.
 Nucleation performs better than CTRL except for >3nm size in IOP2

Summary and Ongoing Work

- The newly added aerosol nucleation mode improves the prediction of aerosol number concentration and size distribution when compared with ARM aircraft measurements at two locations.
- Model still underestimates near-surface aerosol number concentration at SGP and overestimates at ENA. There are still room for improvement.
- The interaction between aerosol size, composition, CCN concentration and cloud properties need further investigation.
- Comparisons using long-term ARM surface measurements underway.
- Observational data need additional quality checks to remove cloud/rain contamination.
- Python code being written to automate statistical evaluation of MAM species using ARM observations.