MAGIC Aerosol Questions

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Acknowledgements

Gunnar Senum (BNL)
Chongai Kuang (BNL)

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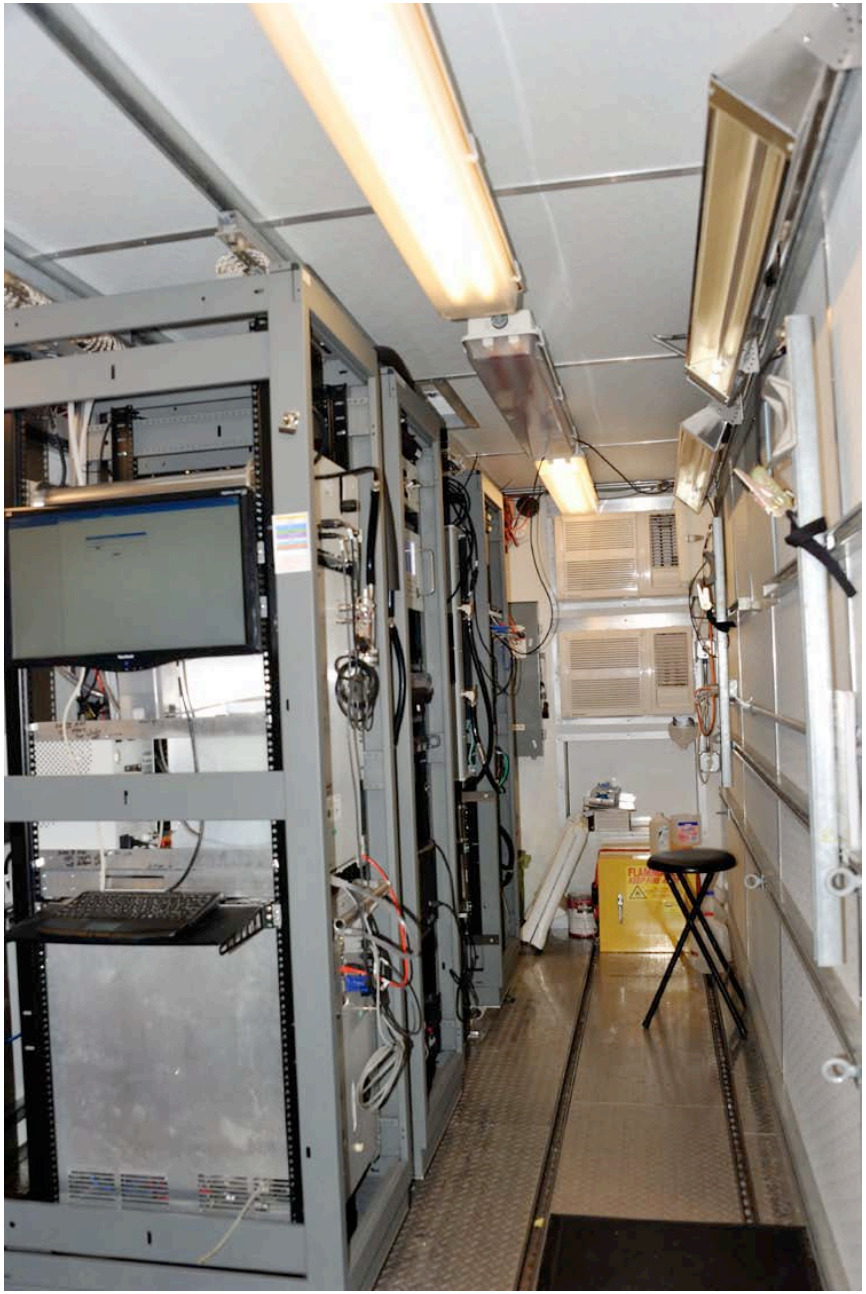
Nicki Hickmon and AMF2 crew and technicians

Horizon Lines & the Captain and crew of the Horizon *Spirit*

Aerosol Observing System (AOS)

Top of stack ~25 m above sea level.

Inside of AOS



It all happens here.

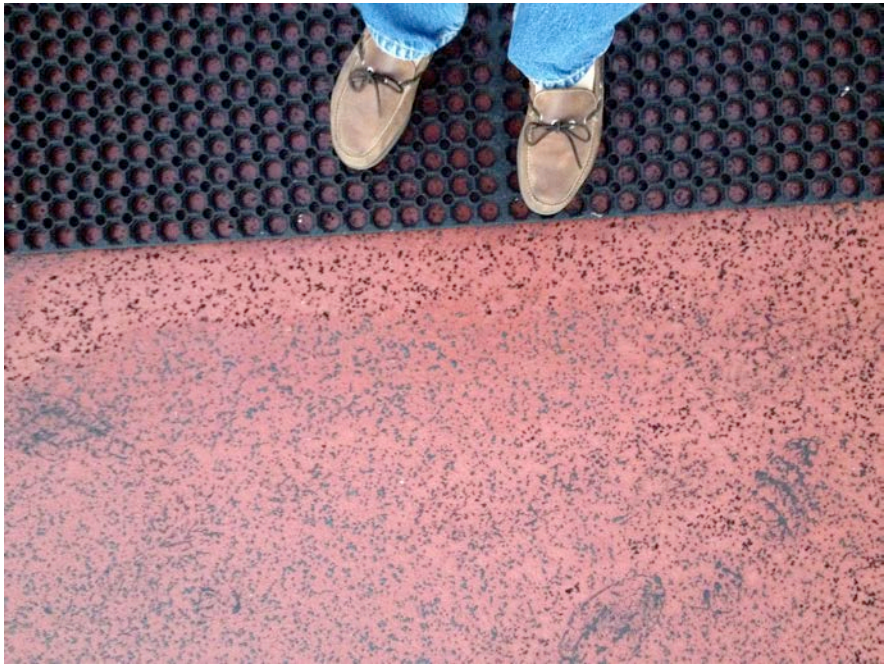
AOS is toward the front of the ship, far ahead of the stacks (white structures ~2/3 the way toward the stern).

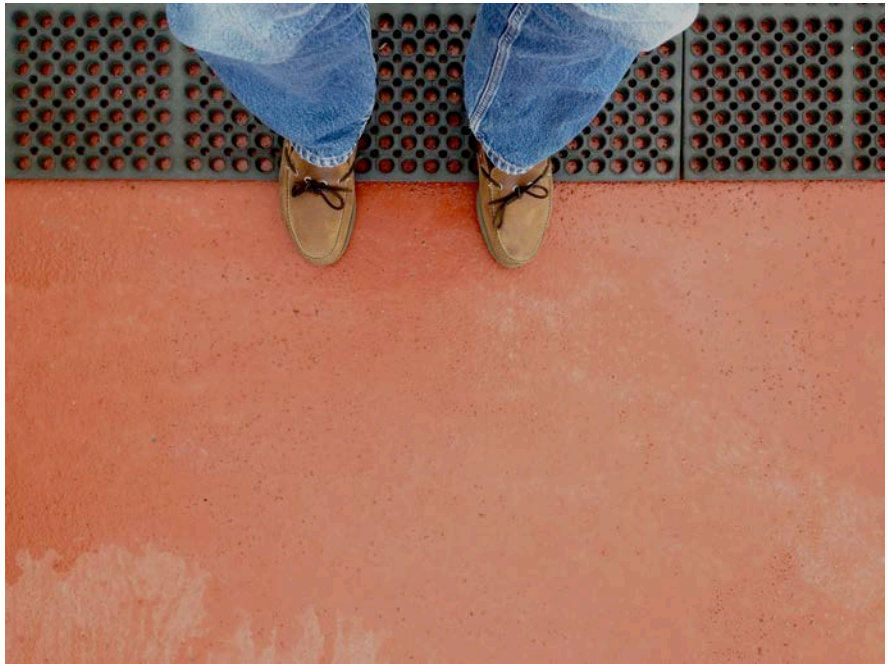
Ship's Stacks Cleaned Daily

sister ship cleaning stack

As ship travels 8-10 m s^{-1}, this typically isn't a problem.

When exhaust is a problem, it's obvious.





Aerosol Measurements

CPC (number concentration, d_p > 10 nm)

CCN (number concentrations, 0.2, 0.4, 0.6, 0.8, 1% supersaturation)

UHSAS (size distribution & number concentration, d_{opt} > 60 nm)

Neph (light scattering, 3λ-rgb; ambient & 30-80% RH scan; 1 & 10 μm cuts)

PSAP (light absorption, 3λ-rgb; 1 & 10 μm cuts)

HTDMA (hygroscopic growth, d_p = 100, 150, 200, 250, 300 nm, dry & 90% RH)

O3

Aerosol sampling (filter samples collected for later analysis)

- bulk & individual particle composition
- individual particle morphology
- Ice Nuclei
- RNA

Aerosol Instrument Status

	Leg												
Instrument	**03A**	**03B**	**04A**	**04B**	**05A**	**05B**	**06A**	**06B**	**07A**	**07B**	**08A**	**08B**	**09A**
CPC													
CCN													
UHSAS													
HTDMA													
Wet/dry nephelometer													
PSAP													
Ozone													
Aerosol sampling													

	LEG																	
Instrument	**10A**	**10B**	**11A**	**11B**	**12A**	**12B**	**13A**	**13B**	**14A**	**14B**	**15A**	**15B**	**16A**	**16B**	**17A**	**17B**	**18A**	**18B**
CPC																		
CCN																		
UHSAS																		
HTDMA																		
Wet/dry nephelometer																		
PSAP																		
Ozone																		
Aerosol sampling																		

No issues	Corrective maintenance or partial data	Questionable data	Instrument down	Not in service

Aerosol instruments "up" most of the time!

Aerosol Sampling

IN (ice nuclei), RNA

- 43 samples (24-hr)
- Paul DeMott, Colorado State

Bulk and individual particle chemical composition, morphology

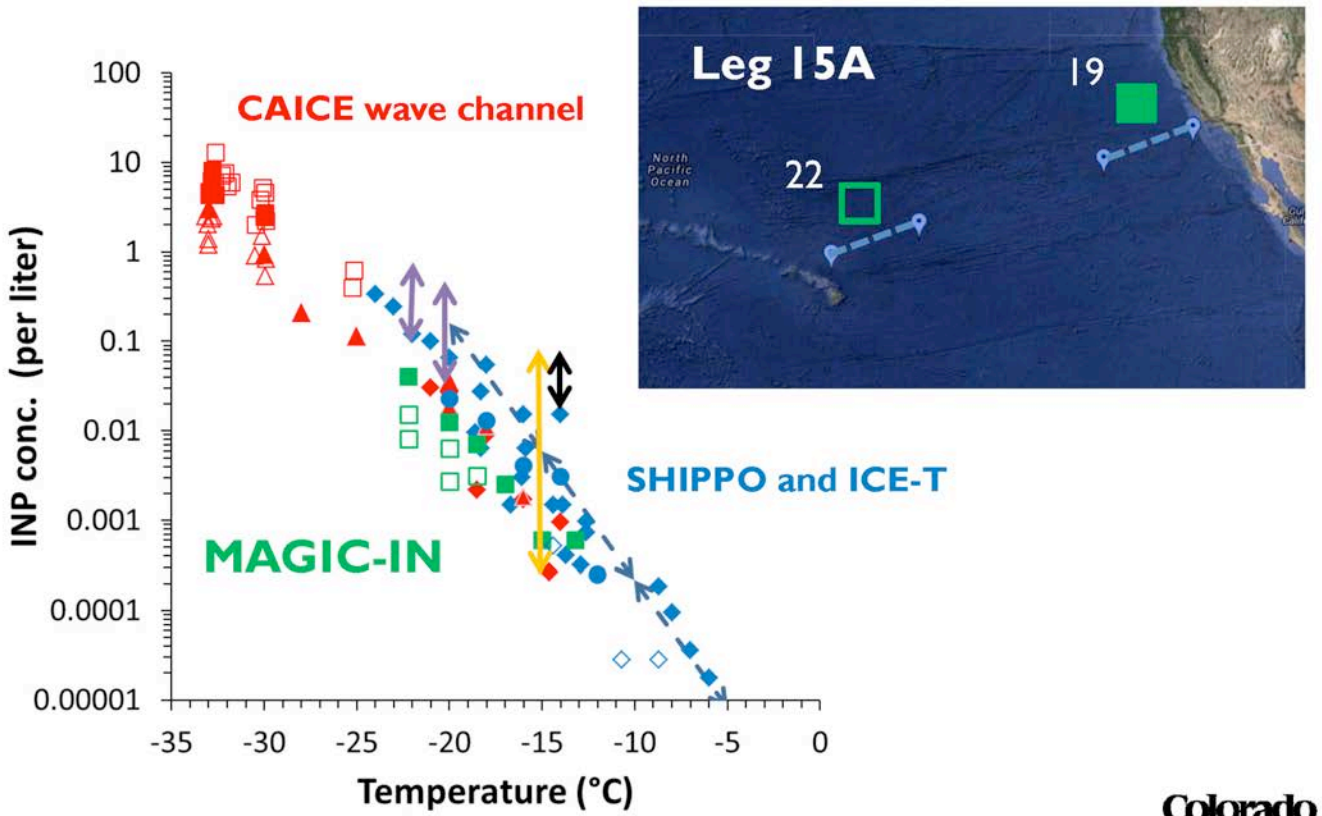
- 139 samples (mostly 24-hr)
- XANES, SEM, ICPMS, IC
- Yuan Gao, Rutgers

Most samples have not yet been analyzed.

THIS IS A PRIORITY!! (all that's needed is $$$)

Some Ice Nuclei Results

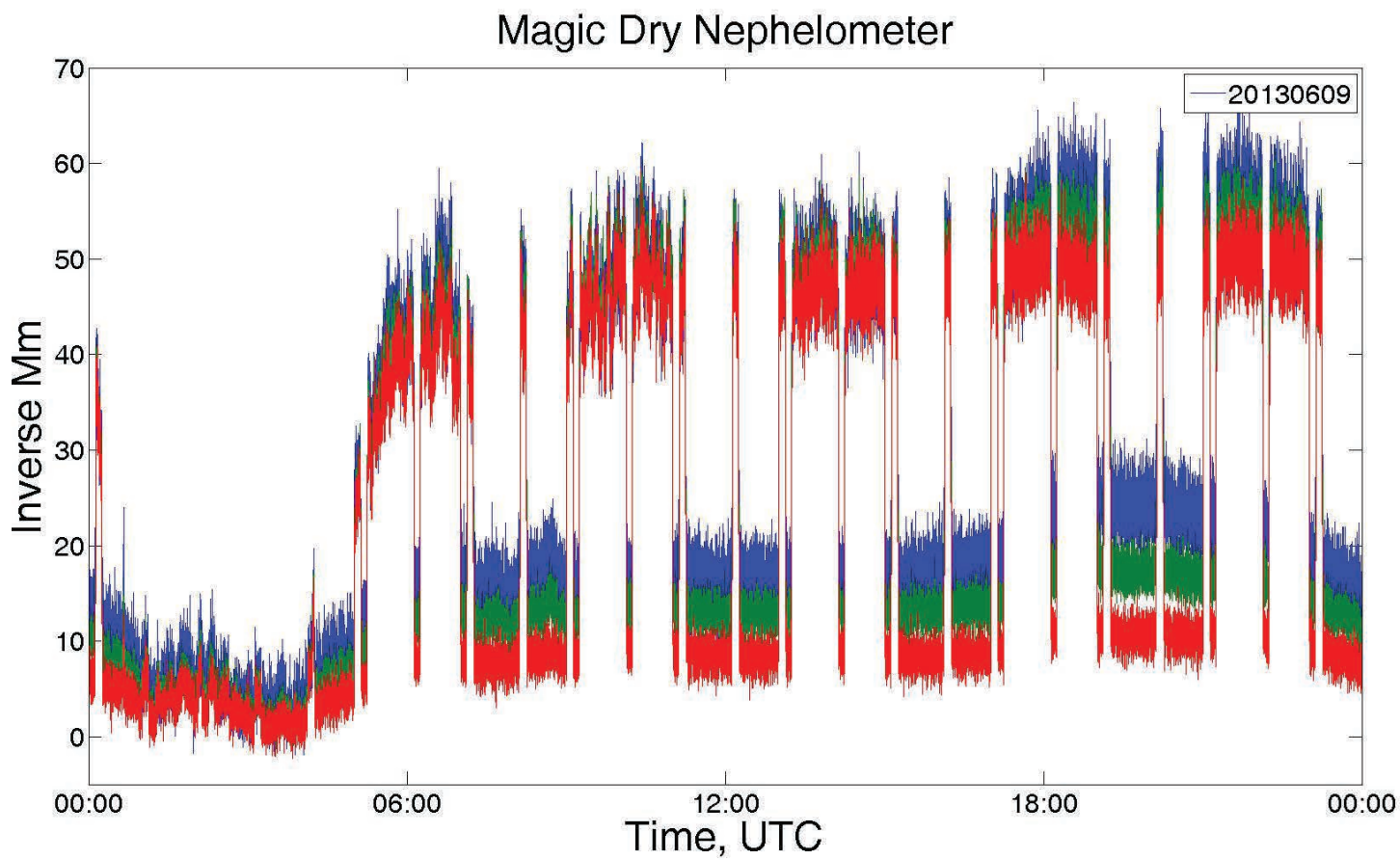
Comparison for a few recent MAGIC samples



Colorado State University

Slide courtesy Paul deMott, CSU

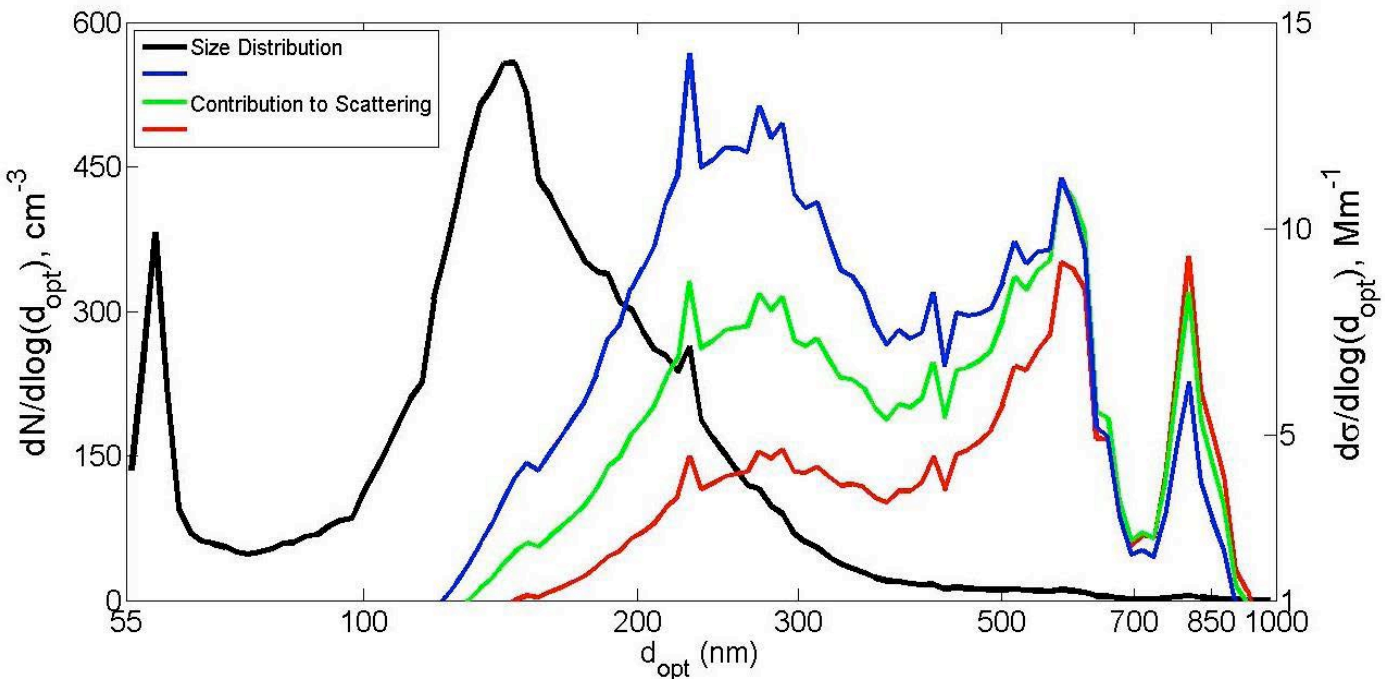
Light Scattering



Different time periods reflect 1 micrometer and 10 micrometer diameter cuts.

More than half the scattering is from 1 μm < d_p < 10 μm.

Most Scattering from Larger Particles



For λ=500 nm, m=1.40:

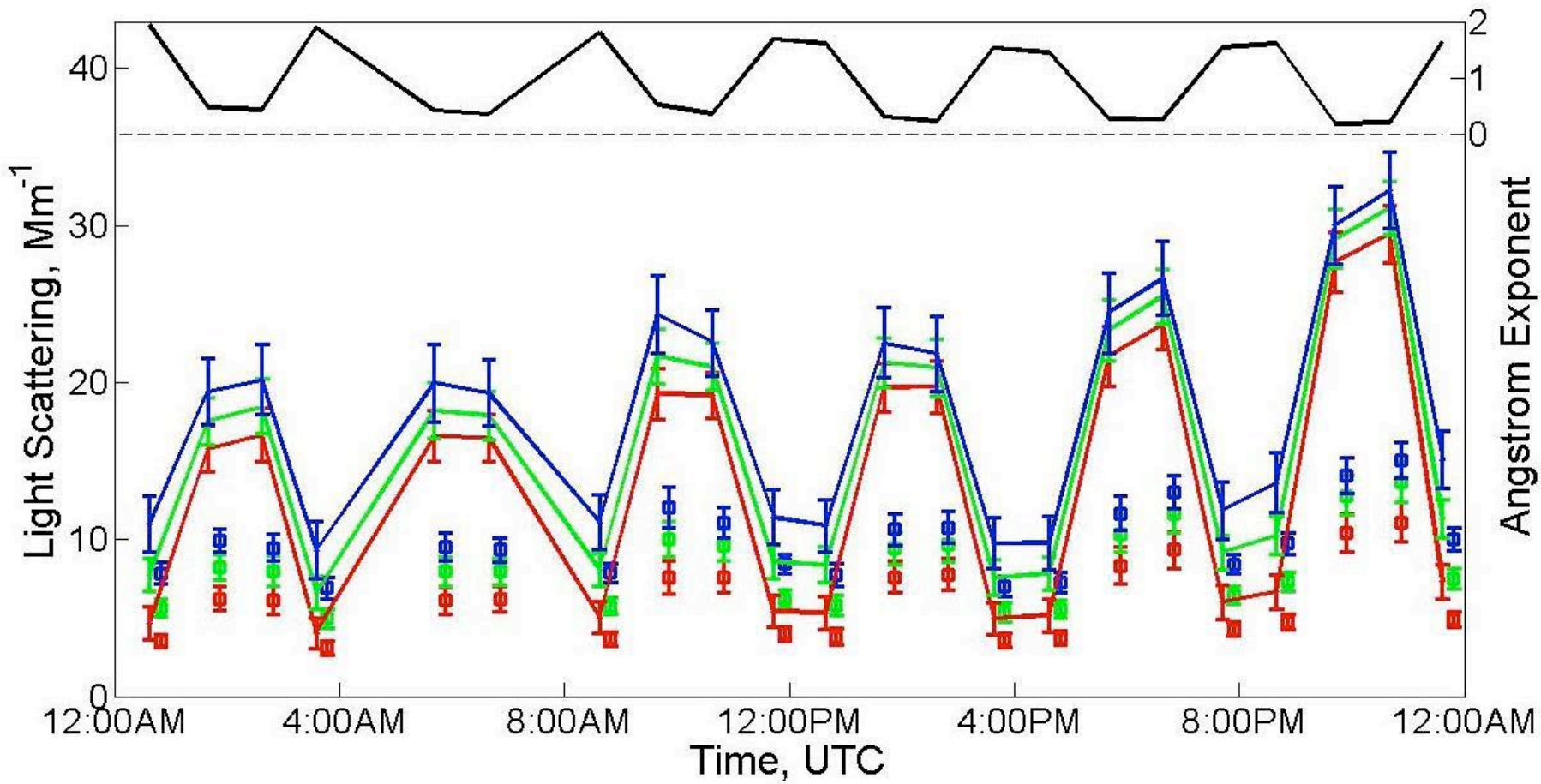
σ(r=500 nm)/σ(r=140 nm)= 65

σ(r=1000 nm)/σ(r=140 nm)=200

σ(r=500 nm)/σ(r=50 nm)=15,000

σ(r=140 nm)/σ(r=50 nm)=230

Measured (Neph) vs. Calculated (UHSAS)



Different time periods reflect 1 μm and 10 μm cuts.

Comparison good for 1 μm cut (UHSAS has upper limit of d_p = 1 μm).

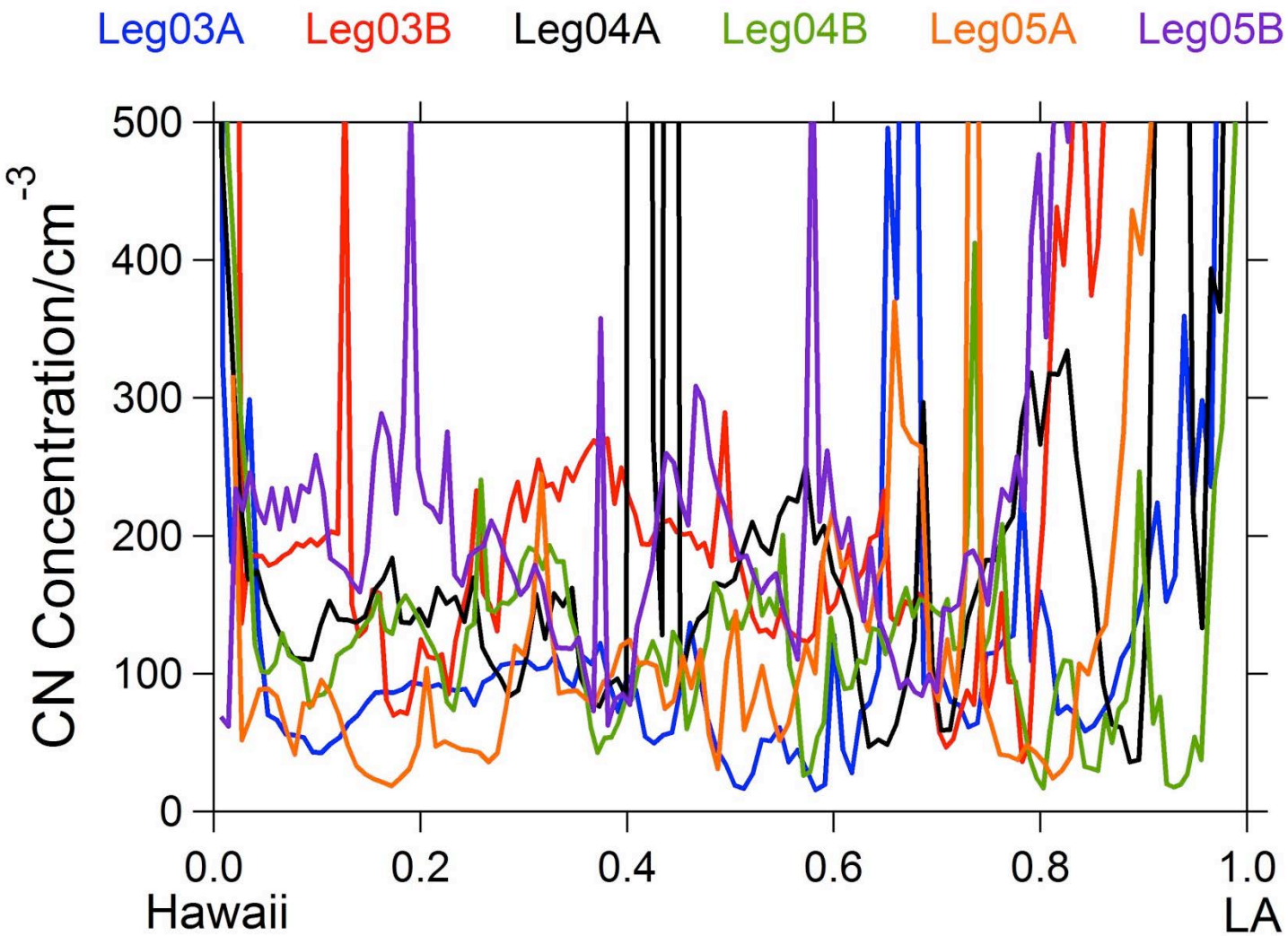
Number Concentrations

CN concentrations (d_p > 10 μm)
UHSAS concentrations (d_{opt} > 60 μm)

1-hr values are shown for various legs.

This analysis is *preliminary*, not comprehensive!

CN Concentration (d_p > 10 nm)



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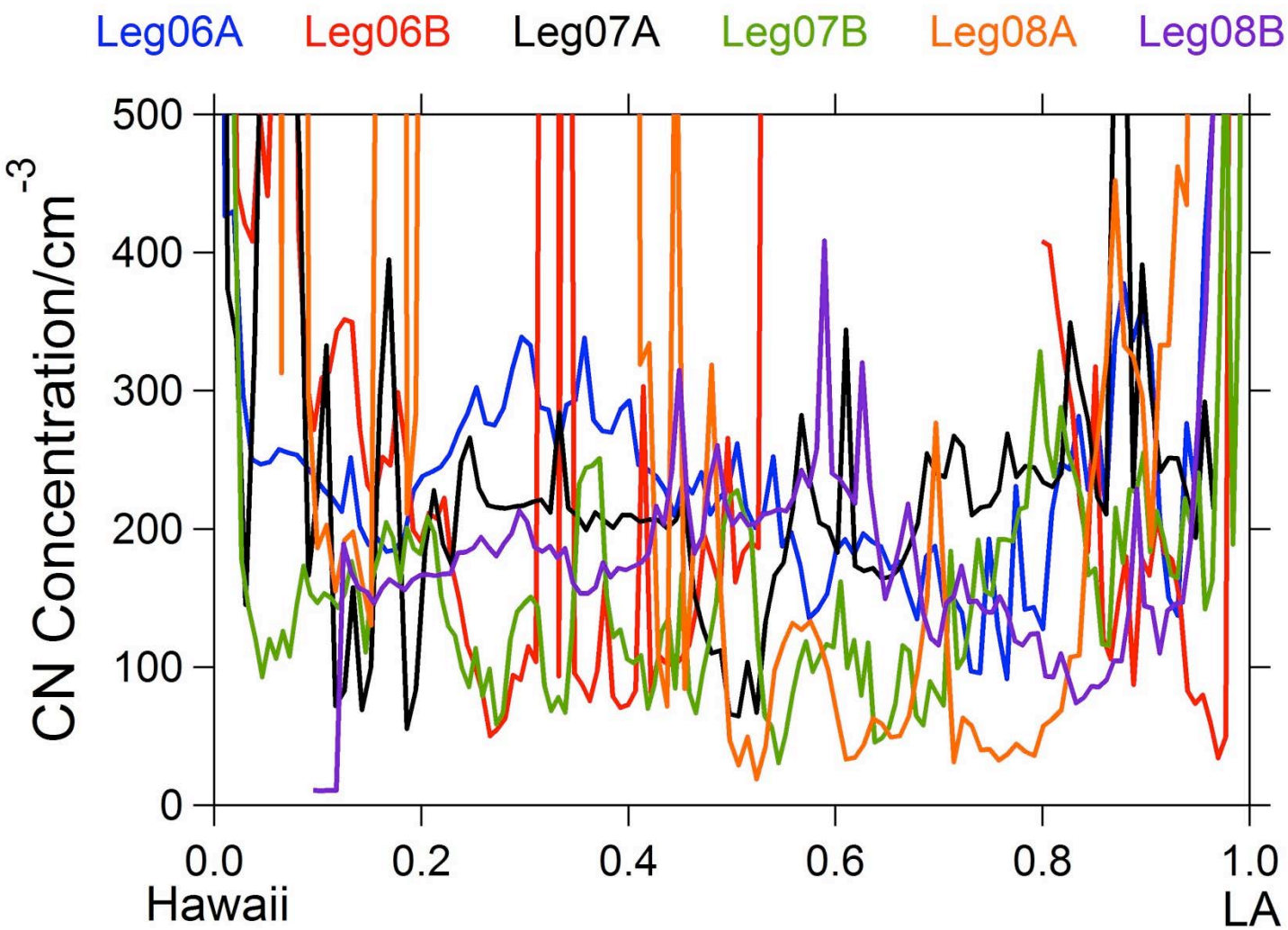
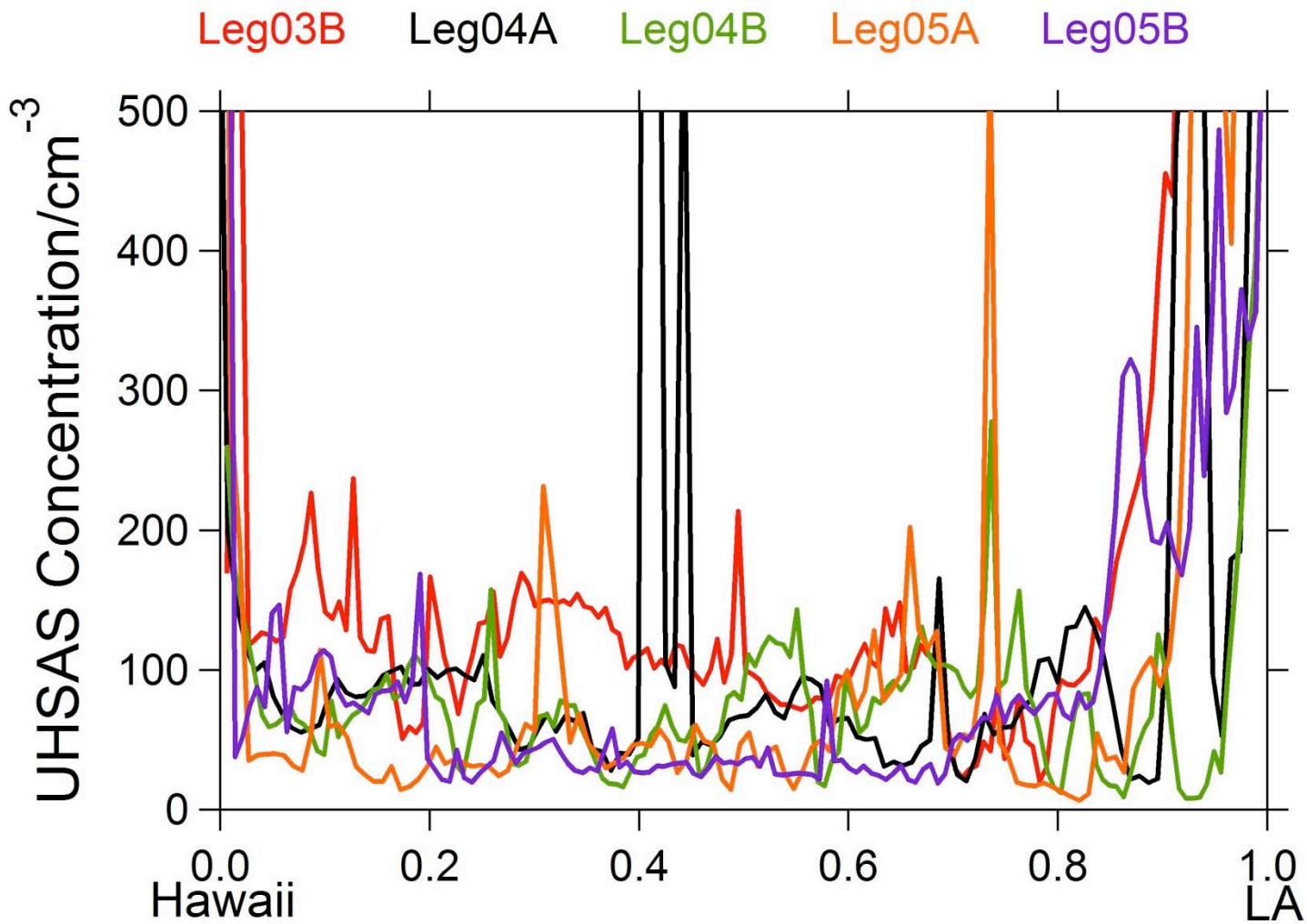
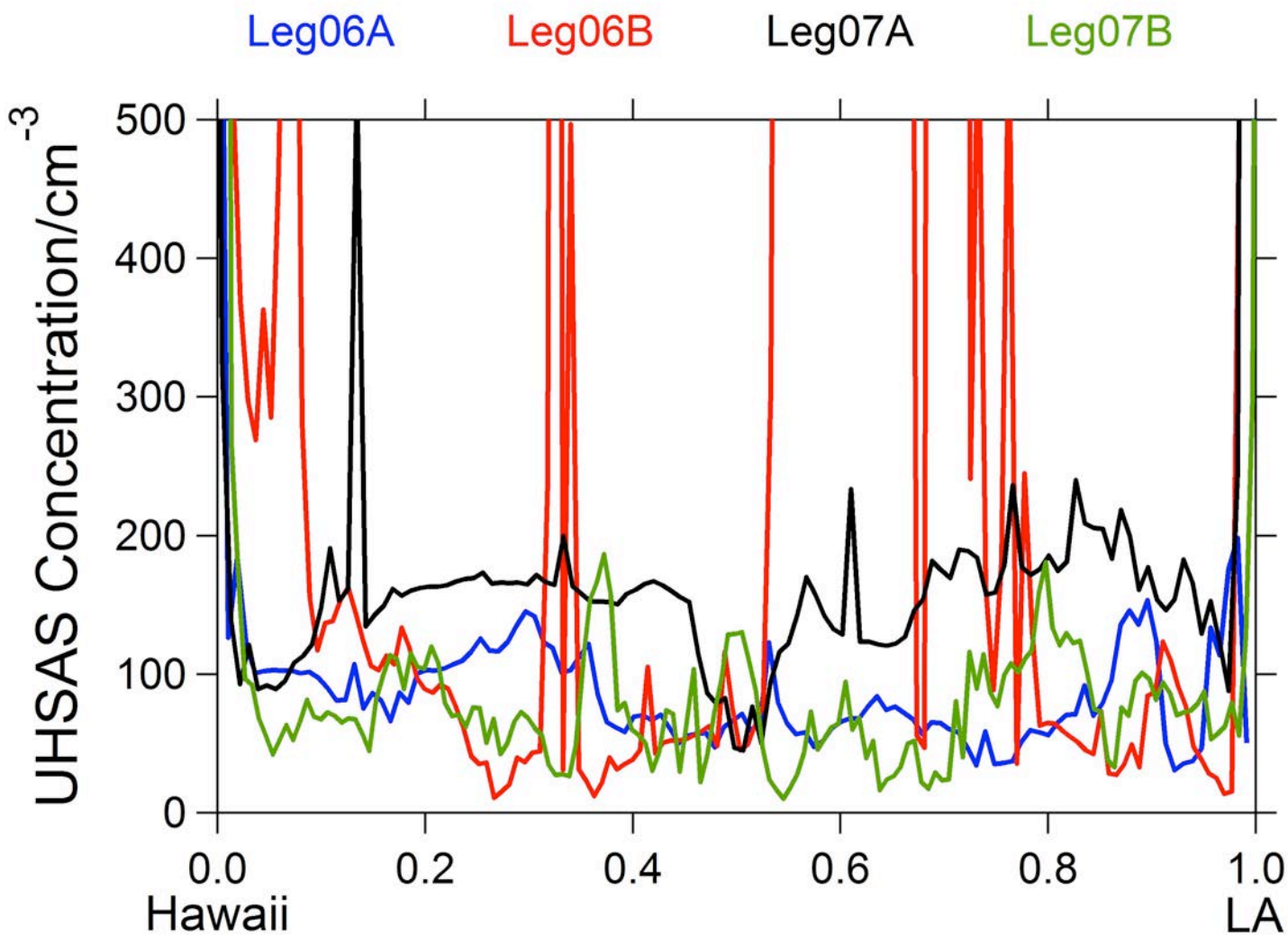


UHSAS Concentration (d_{opt} > 60 nm)



UHSAS Concentration (d_{opt} > 60 nm)



Observations

- Typical values of conc (d_p > 10 nm) are 100-250 cm^{-3}

- Typical values of conc (d_{opt} > 60 nm) are 50-150 cm^{-3}

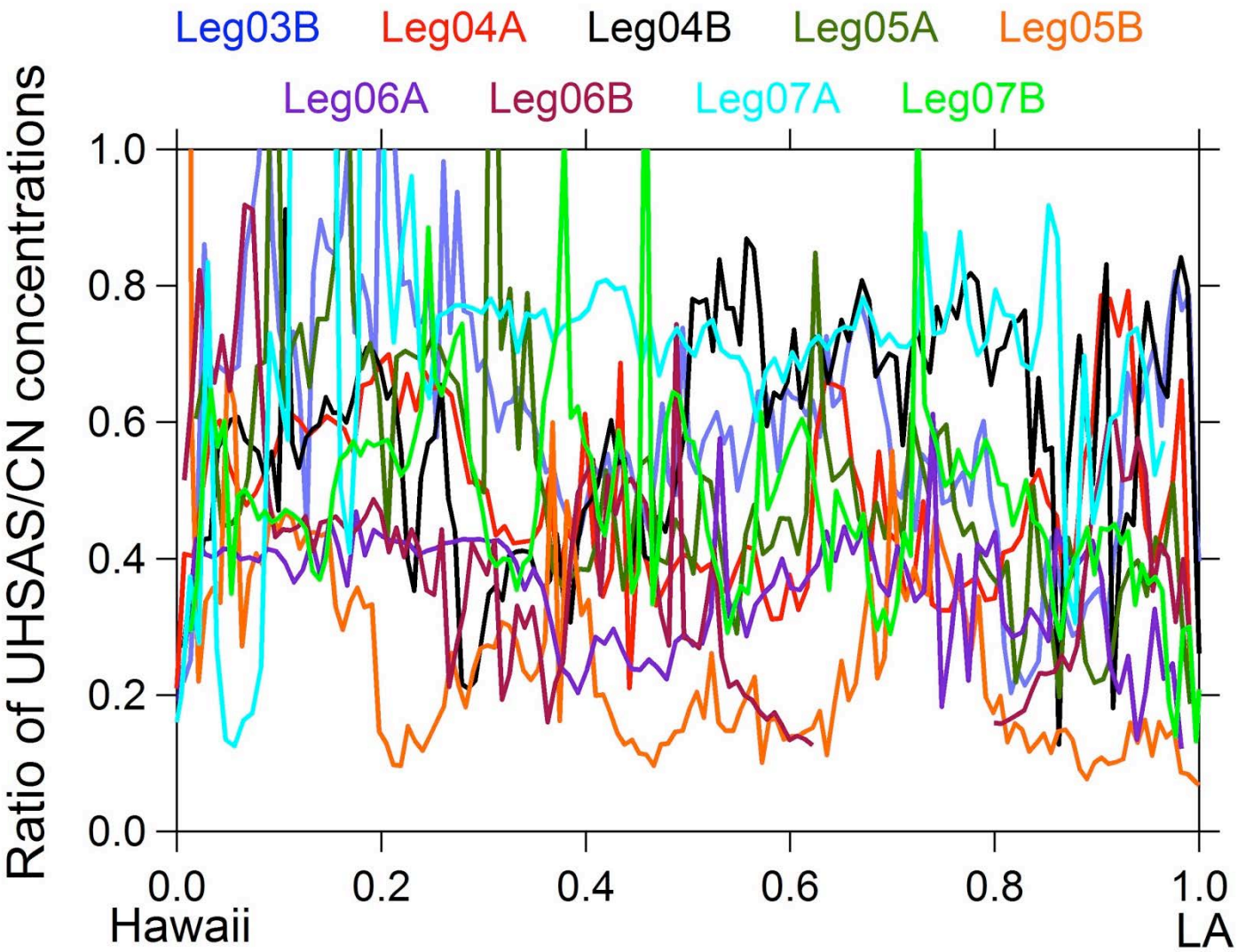
- Much leg-to-leg variability

- No obvious spatial gradients

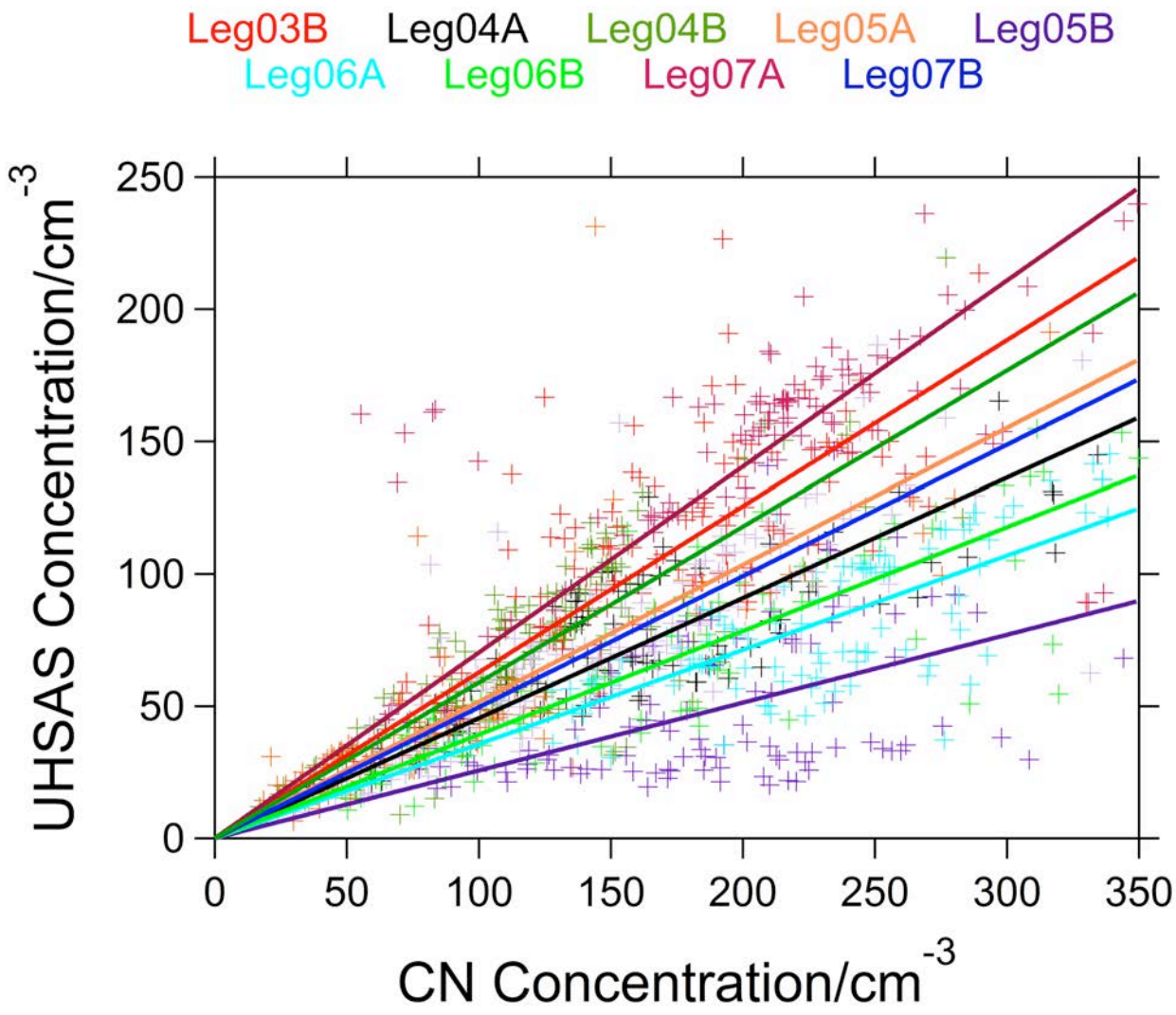
- No obvious diurnal cycle

- Presence of spikes (ship exhaust plumes?)

Ratio of Conc (d_{opt} > 60 nm) to Conc (d_p > 10 nm)



Conc (d_{opt} > 60 nm) vs. Conc (d_p > 10 nm)



Observations

- Two concentrations show good correlation

- Ratio of concentrations shows much variability (~20-80%)

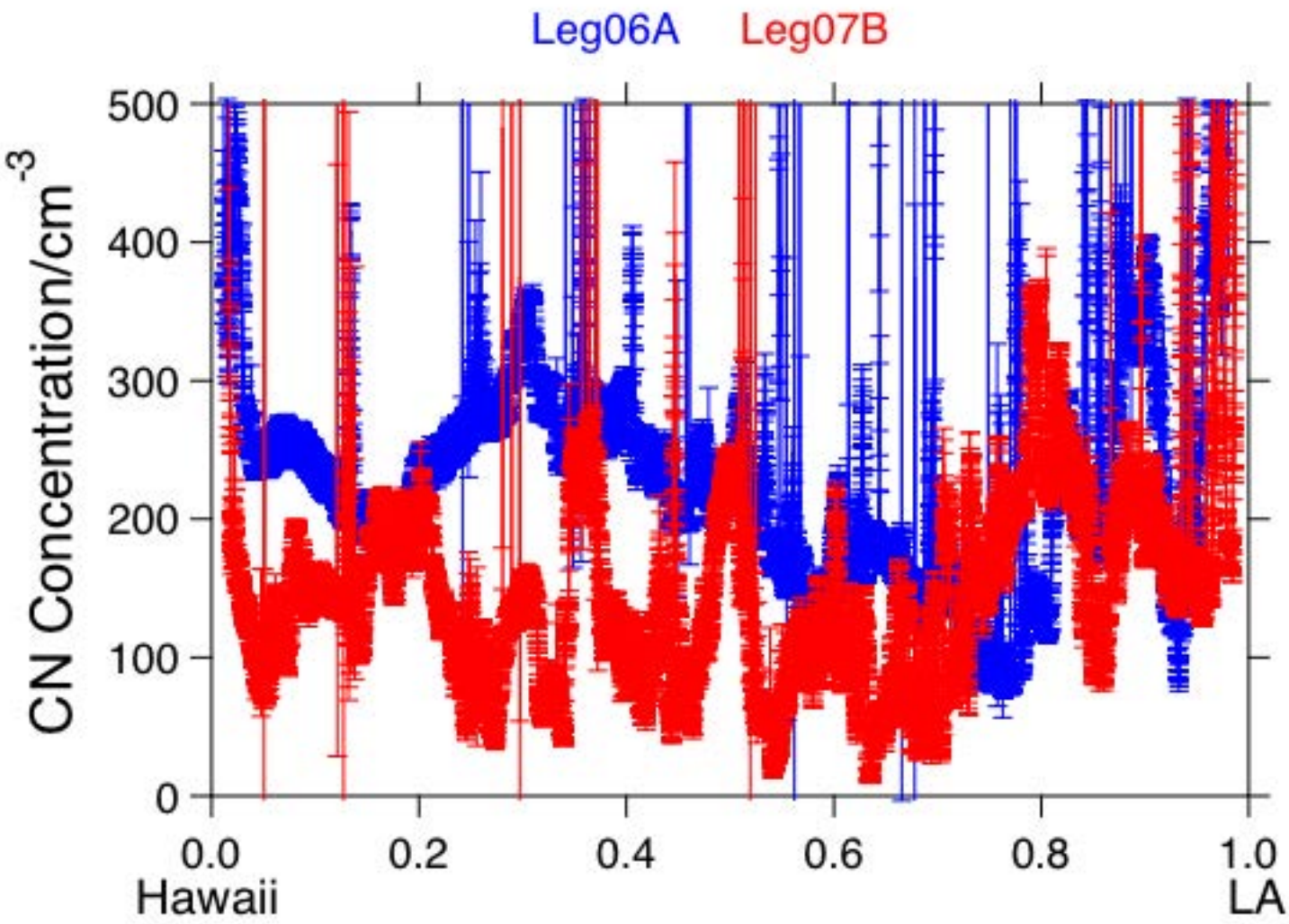
- No obvious spatial gradients

- Instances where ratio > 1 (NOT REALISTIC!)

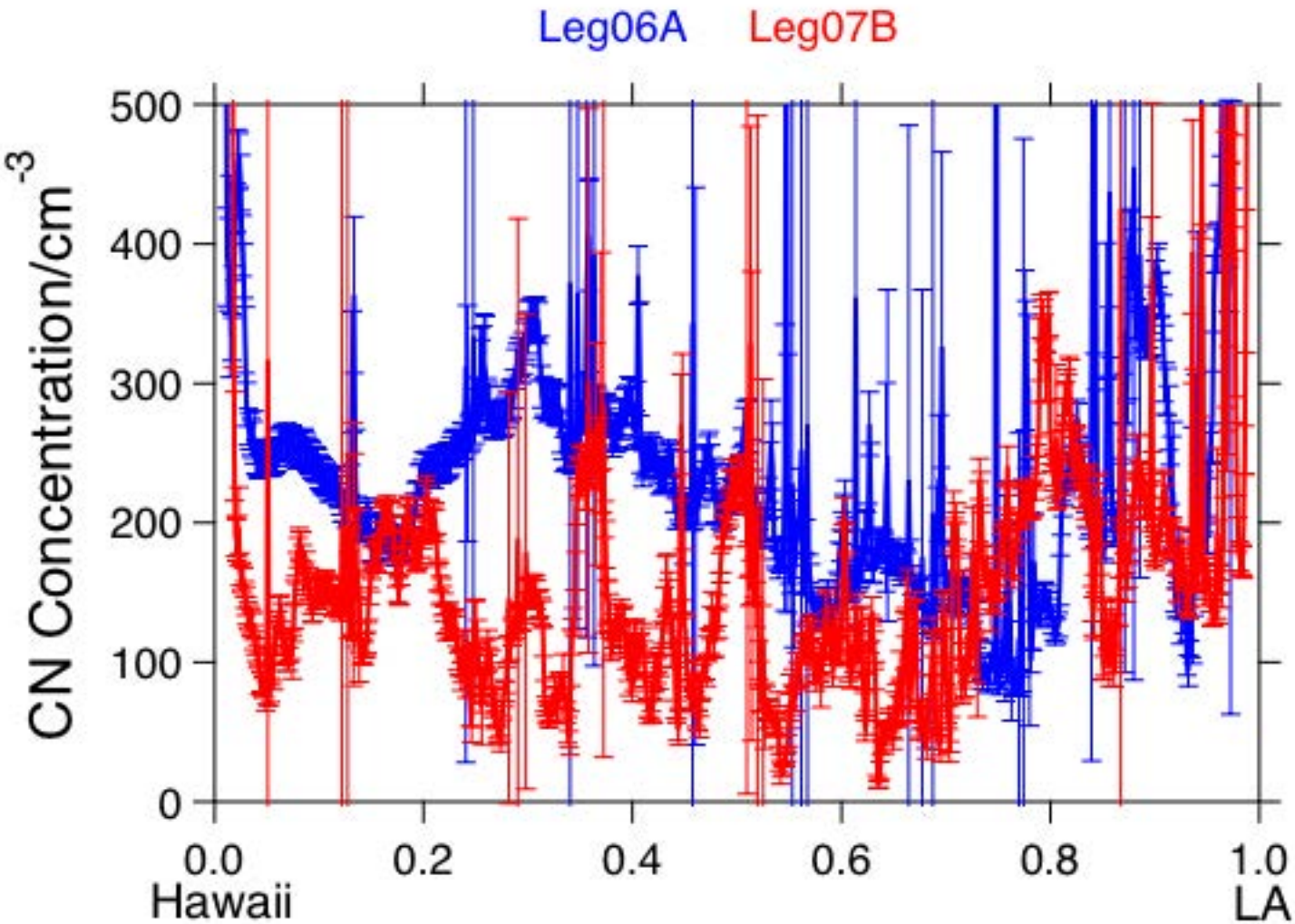
This needs to be investigated further:

- *instrument artifact?*
- *averaging issue?*
- *other?*

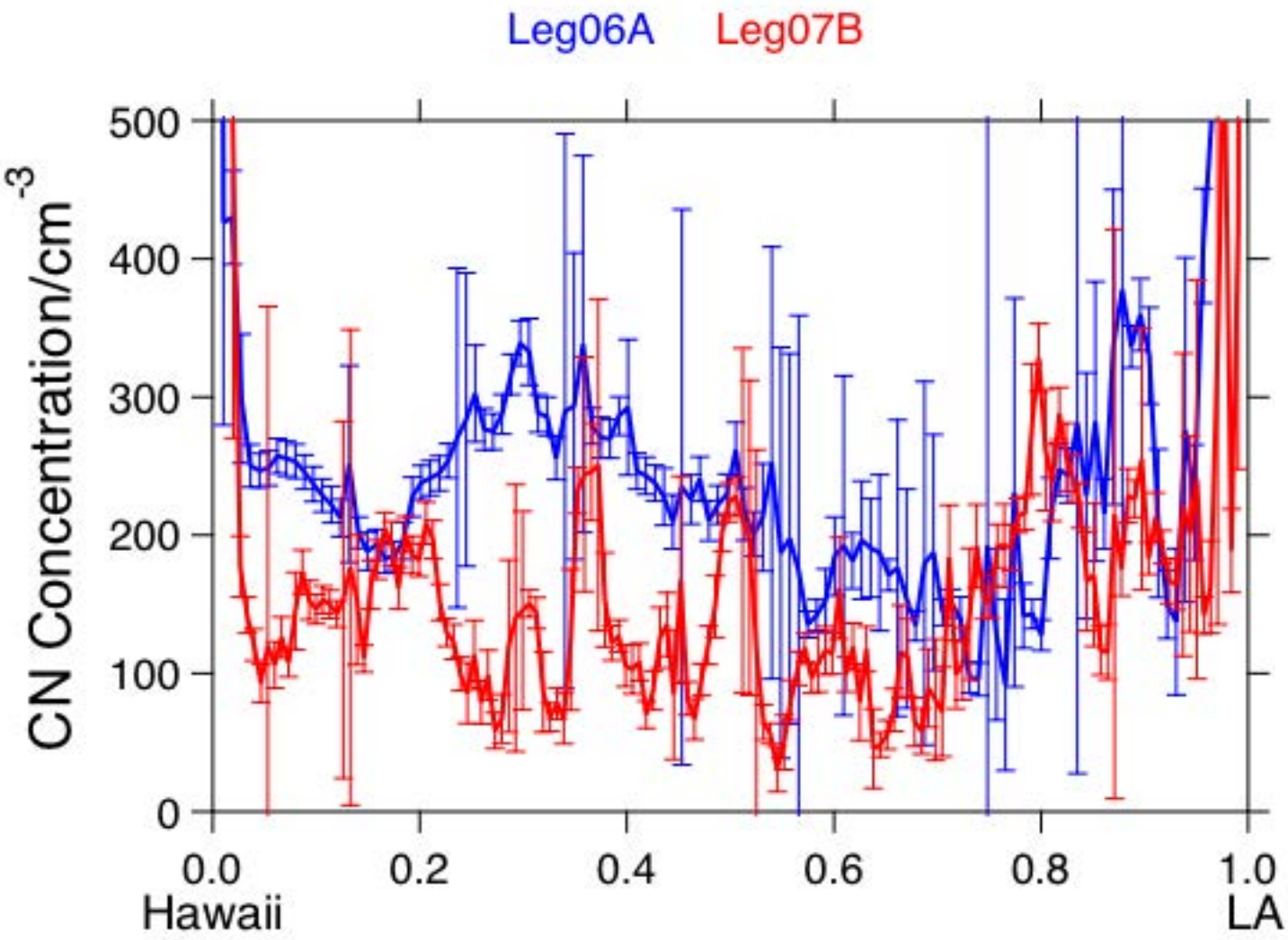
CN Concentration – 1 min average



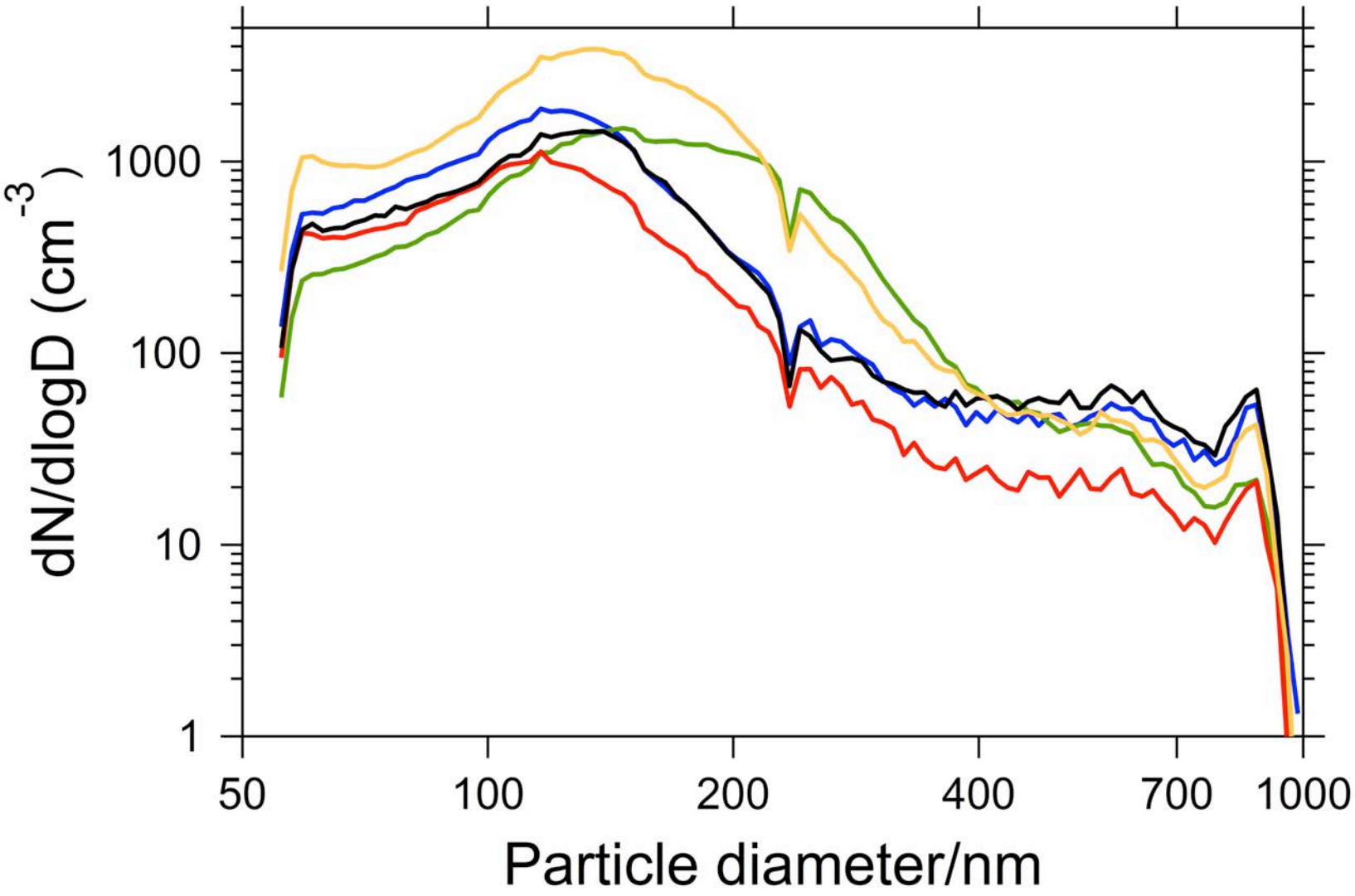
CN Concentration – 10 min average



CN Concentration – 1 hr average



UHSAS Size Distributions



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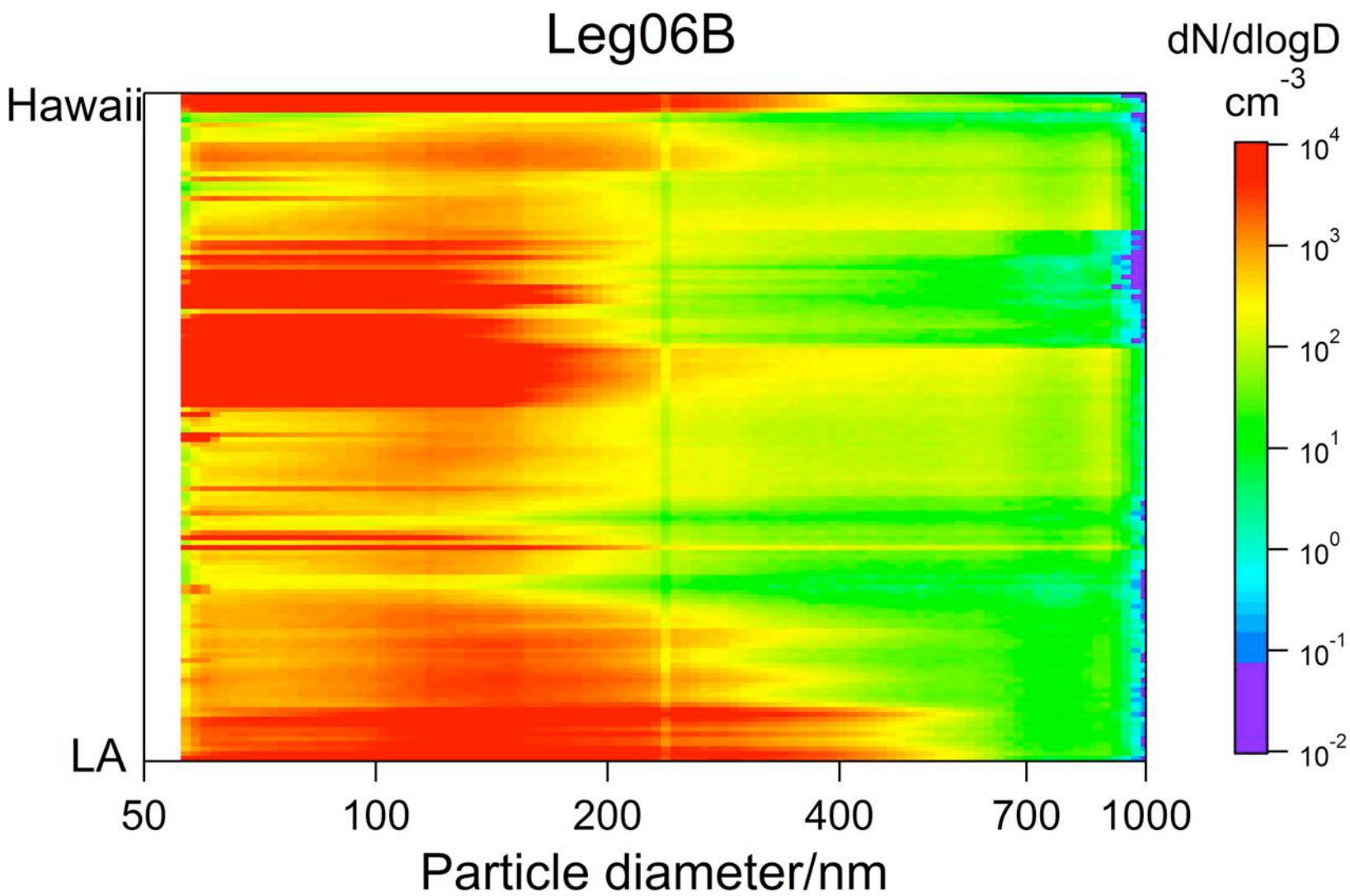


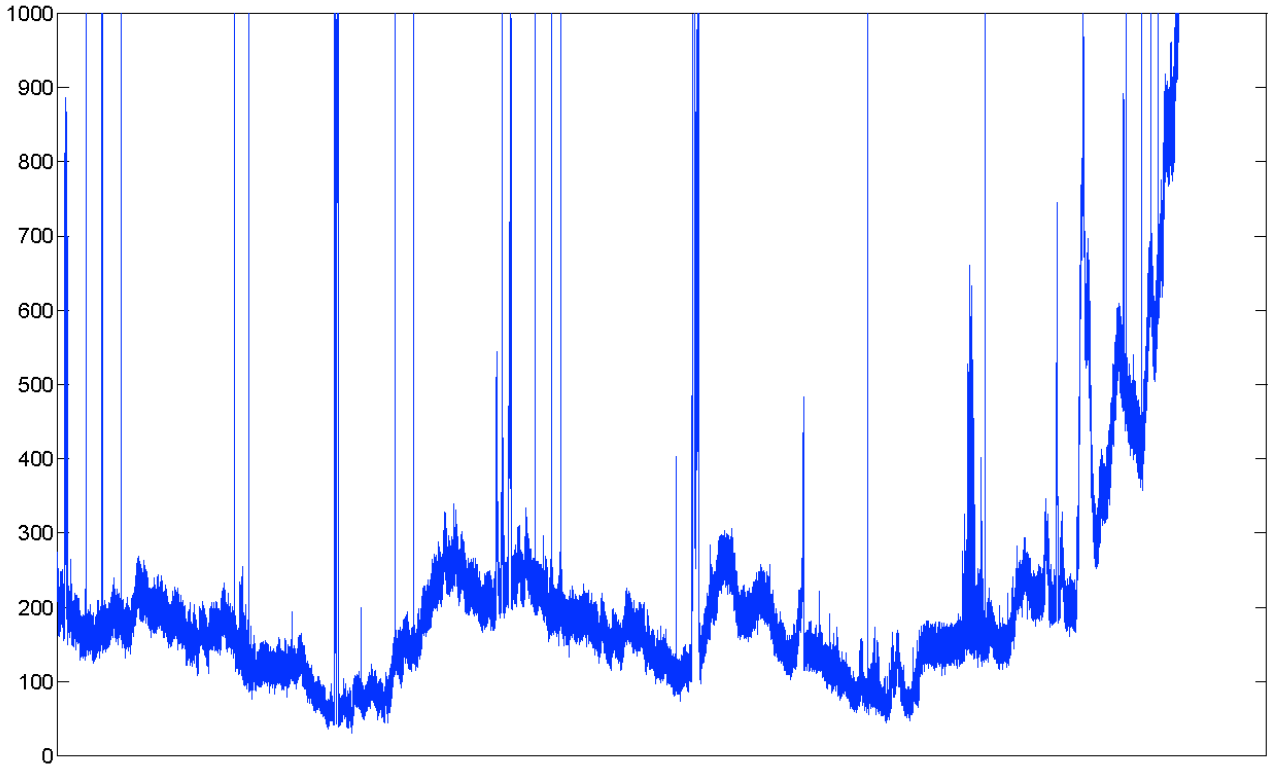
Observations

Number concentration peaks near d_{opt} = 140 nm.

- in representation $dN/d\log d$
- for d_{opt} > 60 nm (there are certainly smaller particles)

But, light scattering dominated by larger particles (from above).

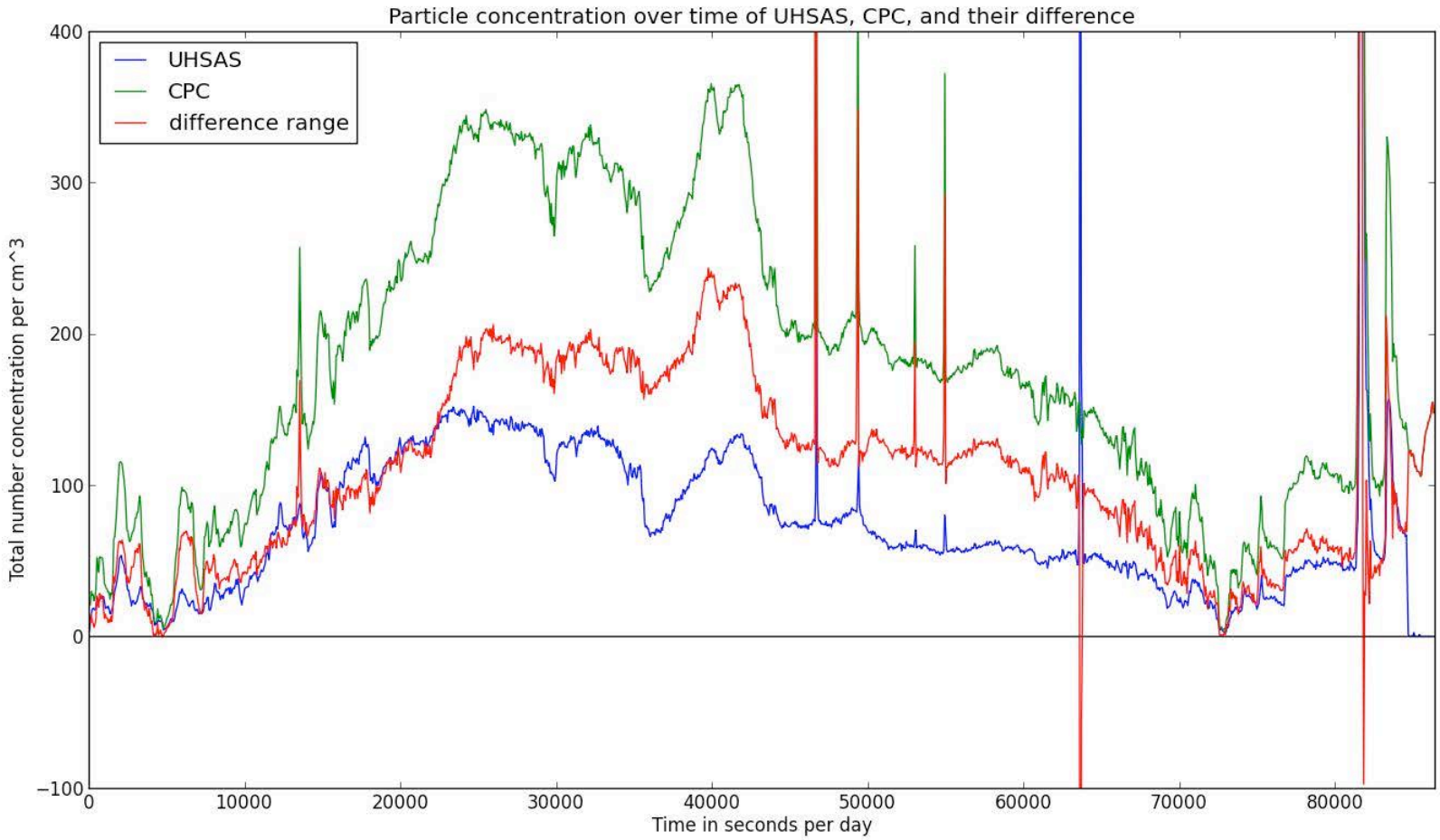
Spikes in Concentrations



Number concentration of particles with d_p > 10 nm

(steady increase at right probably due to coming into port in LA)

Spikes in Concentrations



Increase in conc(d > 10 nm) greater than that in conc(d > 60 nm)

Spikes in Concentrations - Observations

Spikes are prevalent and occur on all legs.

Spikes are of various durations, sometimes very short.

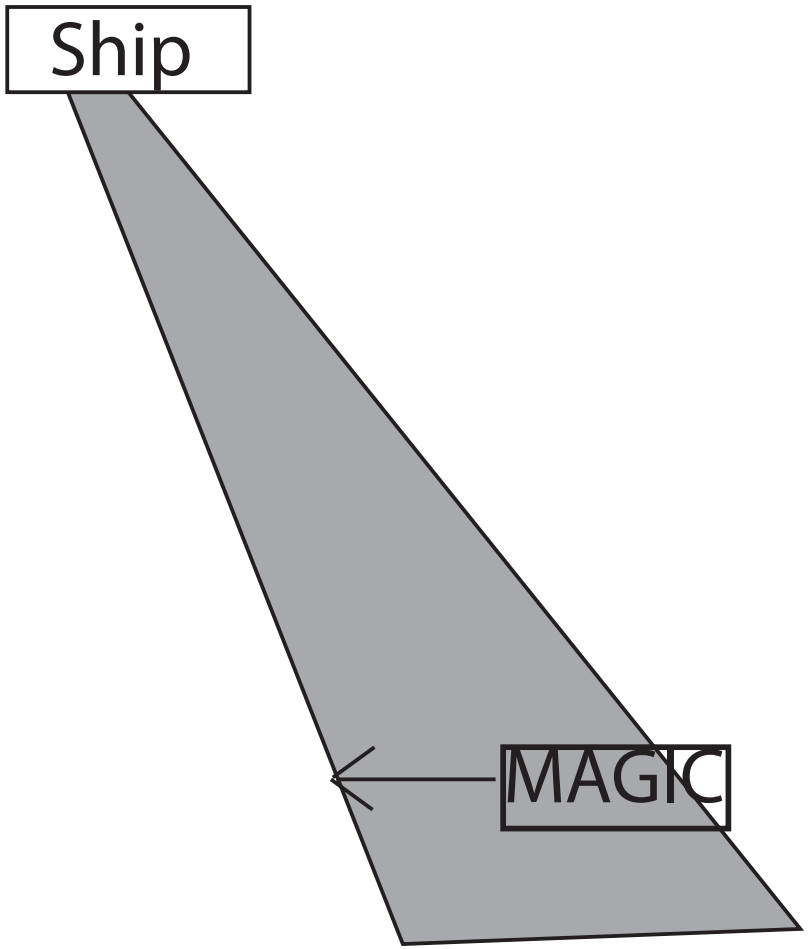
Spikes in CPC concentrations ($d > 10$ nm) occur more often than spikes in UHSAS concentrations ($d > 60$ nm).

Spikes contain more particles with $d > 10$ nm than with $d > 60$ nm (hence most particles in spikes have $10 \text{ nm} < d < 60$ nm).

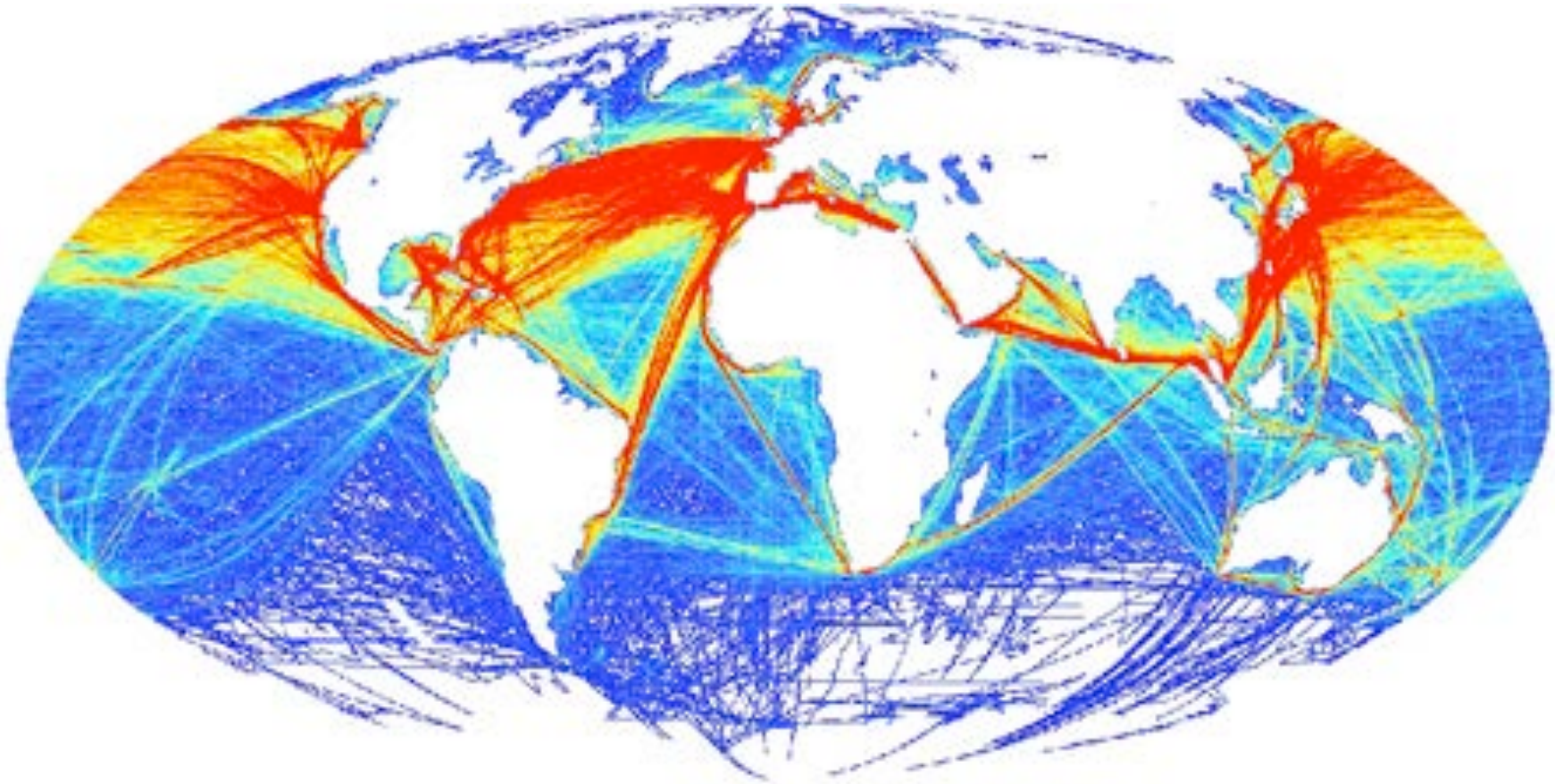
Spikes can make large contribution to total concentrations.

Spikes in Concentrations - Hypothesis

Hypothesis: spikes are exhaust plumes from other ships.



MAGIC Route Near Major Shipping Lanes



How to Test Hypothesis?

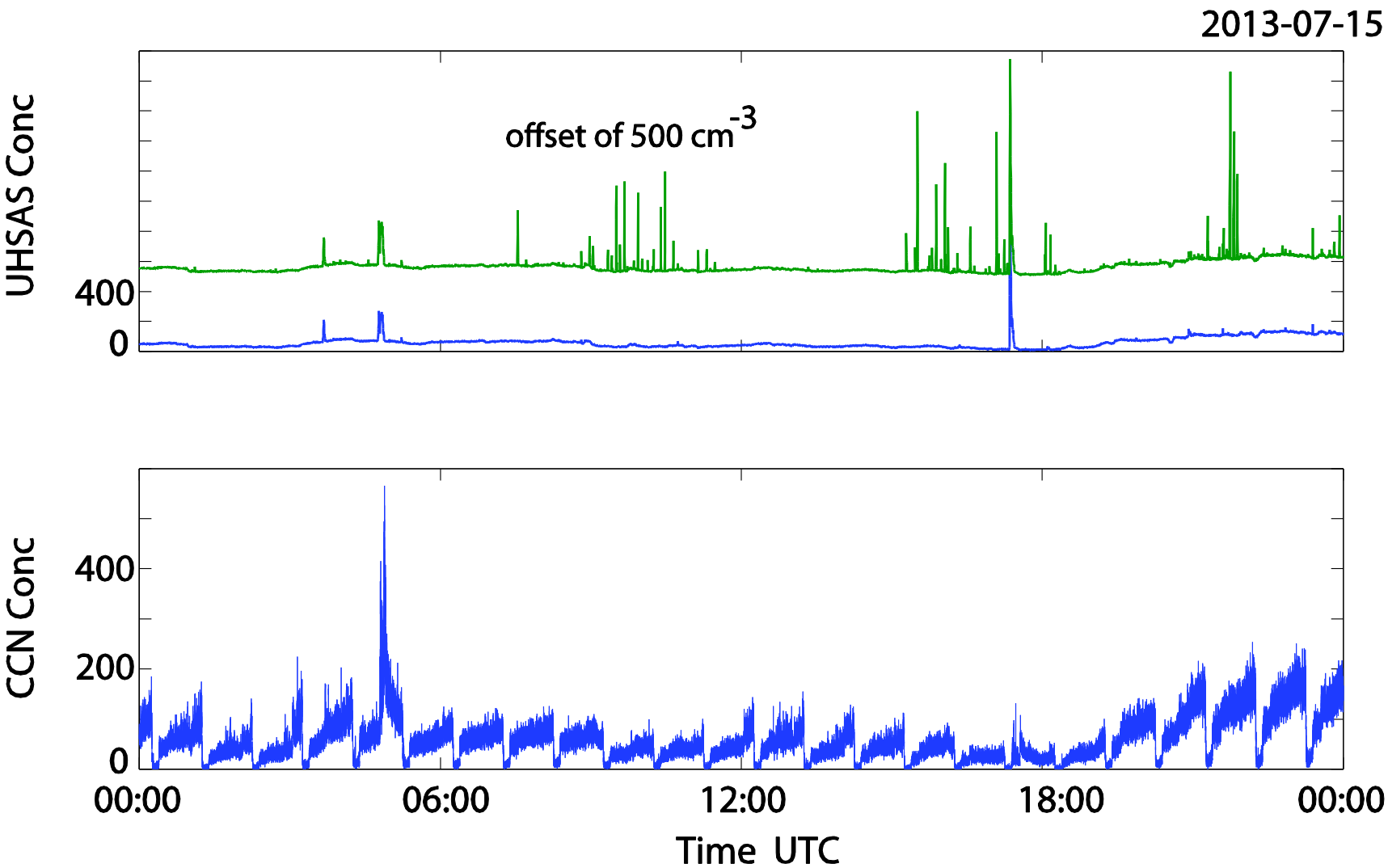
- look at UHSAS and see what channels (sizes) the spikes are in

- look at other data streams such as PSAP, CCN
  (neph probably won't help)

- look at meteorology; correlate with wind speed

- look at filter samples for indications of exhaust particles

Preliminary Work on Filtering Spikes



Future Plans

Look at measurements from other aerosol instruments
(CCN, PSAP, nephelometer)

Correlate with wind speed, precipitation, cloud cover, etc.

Compare with other geographic regions (e.g., N. Atlantic)

Construct aerosol files by leg: leg, date-time, lat-lon, mean, sd
(Chitra volunteered to make these)

Summary

What have I done?

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Pick great students.

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What can I offer?

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What can I share?

Interest. Knowledge. Time. Ideas.

What do I need?

Great people to work on these questions.

Questions:

What is optimal averaging time for aerosol data?

1 s, 10 s, 1 min, 10 min, 1 hr?

low concentrations => low signal-to-noise at shorter times

some instruments don't have 1 s resolution

spikes will be smoothed for longer times (good or bad?)

How should spikes be treated?

- they are real
- at what time resolution should they be filtered?