Ice nucleating properties of bare, coated, coagulated, and thermally treated diesel soot particles

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Motivation: Overview

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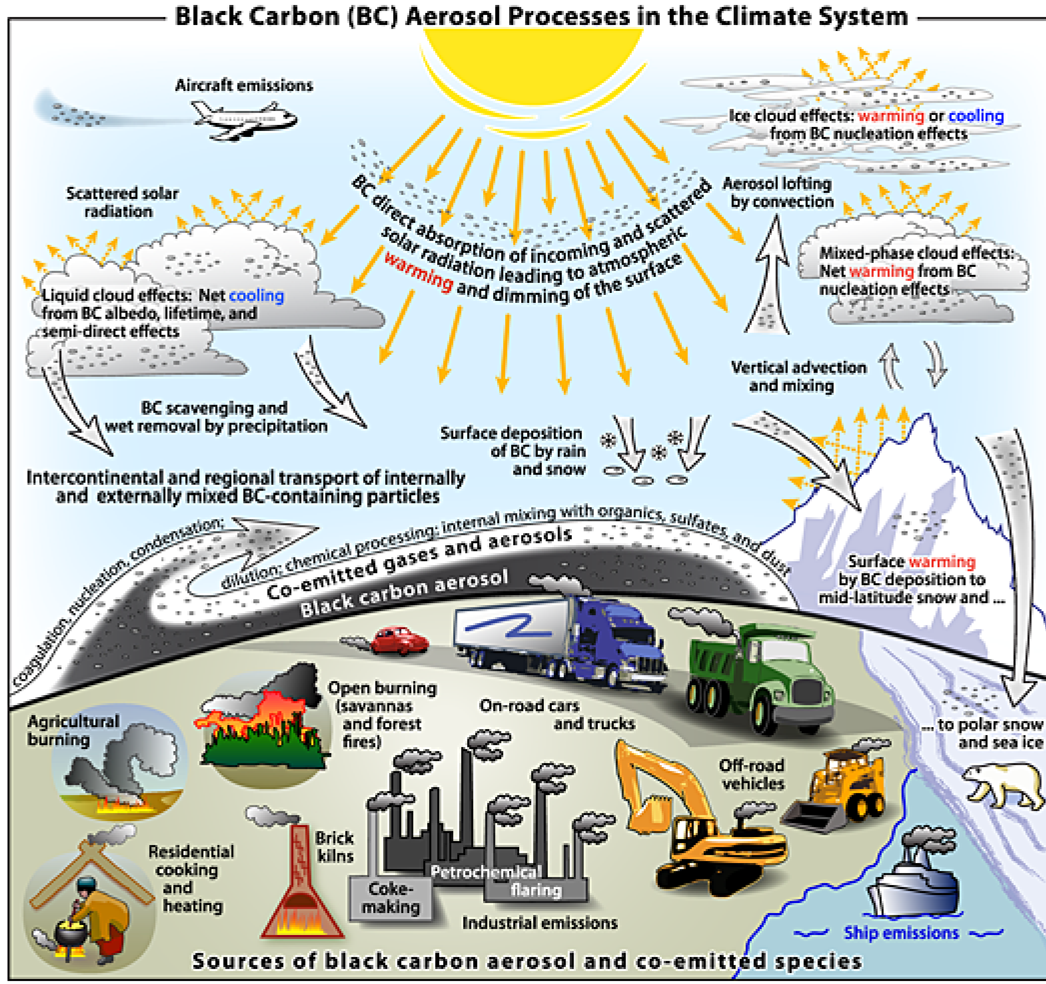
Major sources of soot are:

- Transportation (fossil fuel);
- Industrial and residential (solid fuel);
- Biomass burning.

Why it is challenging?

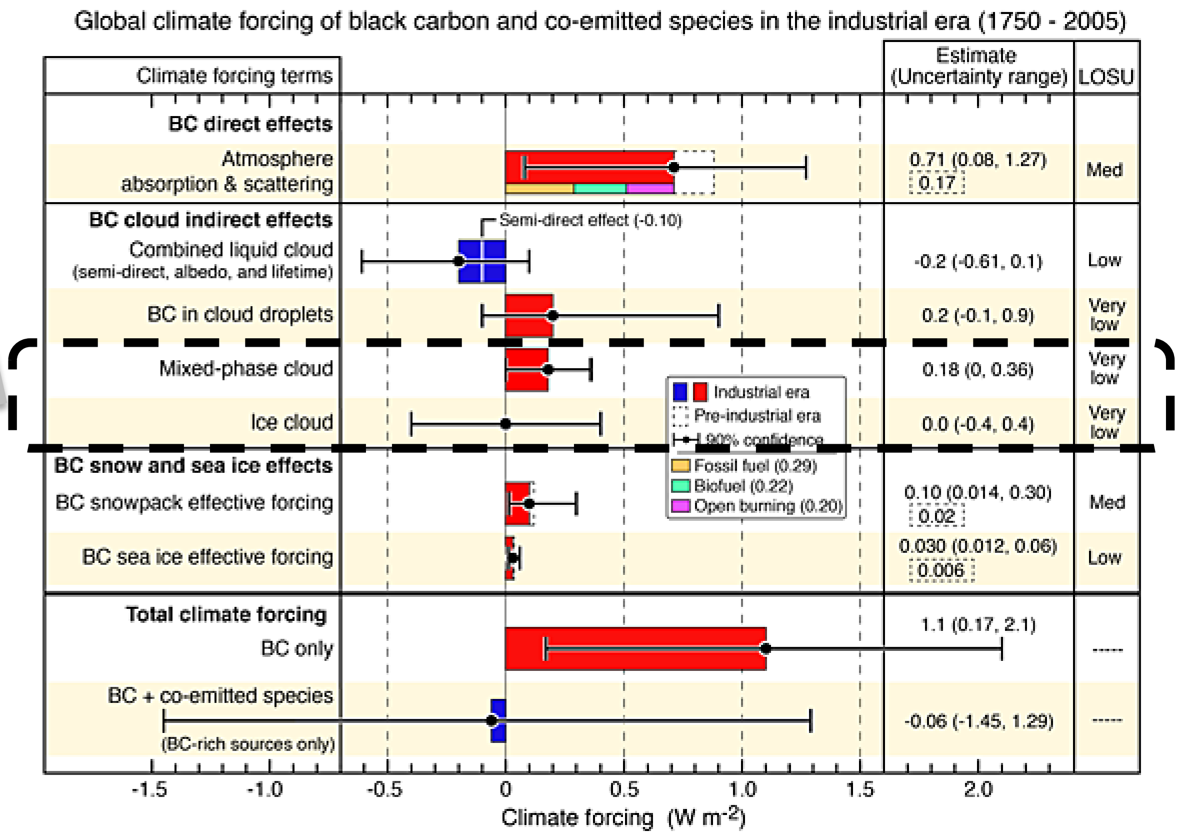
Diverse sources makes it harder to quantify the emissions and understand the effect of soot particles on climate system (aerosol direct and indirect effects).



Bond et al. (2013)

Motivation: Scientific understanding is LOW

Our understanding of how soot particles nucleate ice is very low.

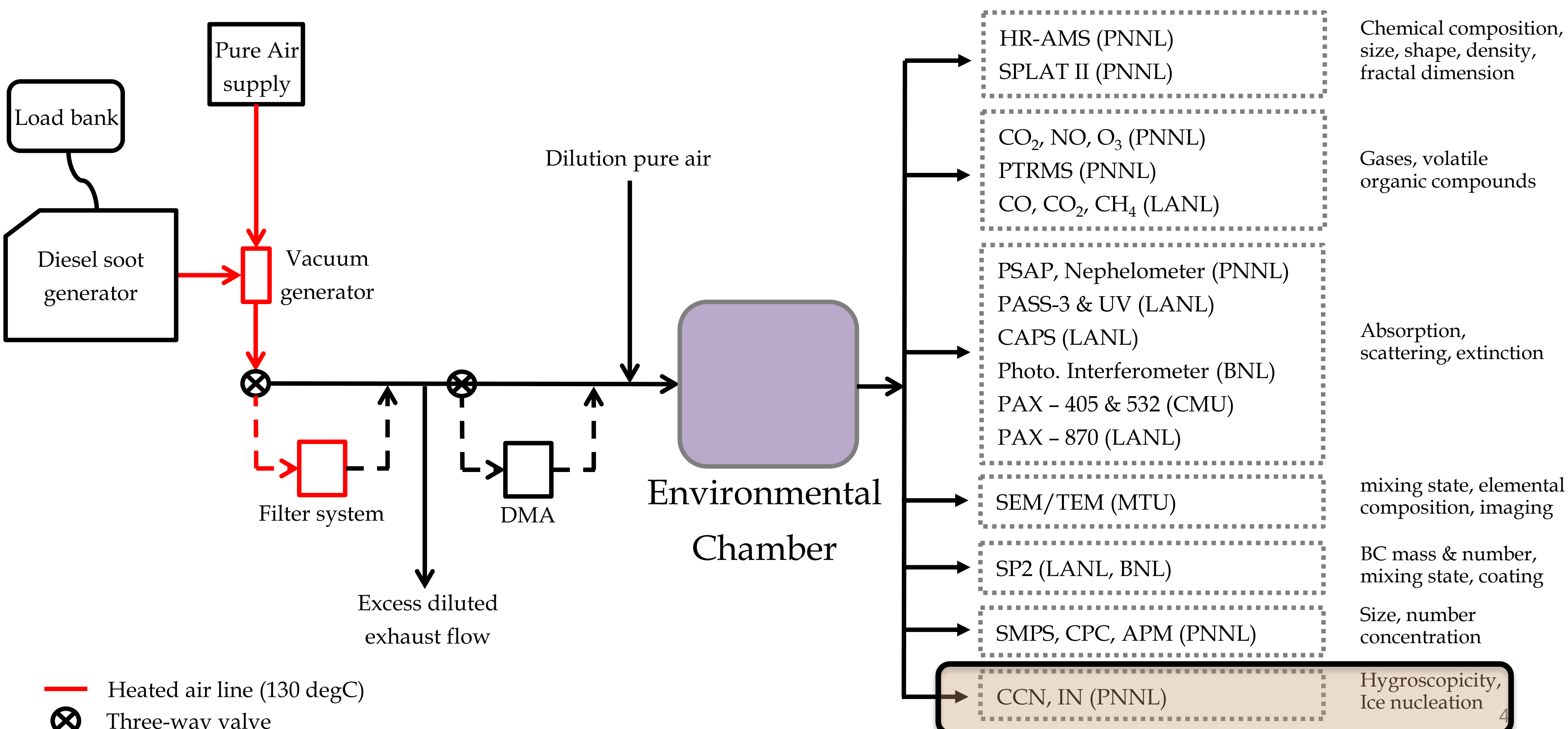


Bond et al. (2013)

Experimental Methodology: Overview

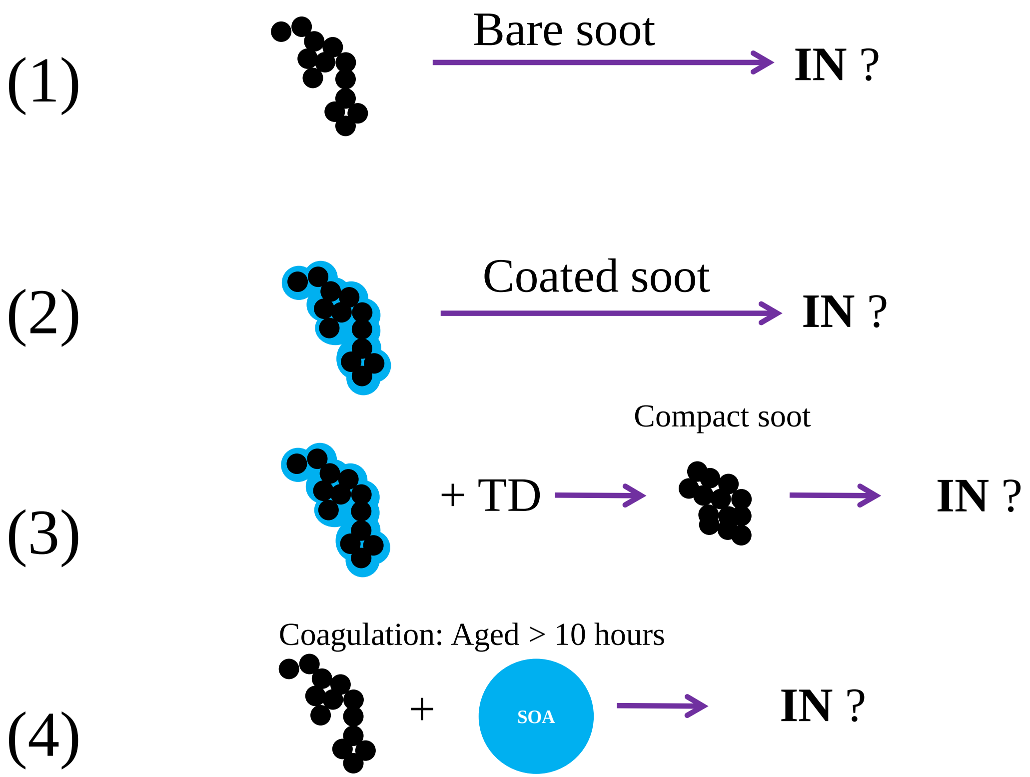
See Rahul's poster for overview results.

Soot generation & dilution → Soot ageing, mixing & coagulation → Soot measurement instrumentation → Soot properties



Objectives

Diesel soot particles were chemically and thermally treated to mimic the atmospheric aging and mixing state.
Four experiments described here.



IN: Ice Nuclei properties
TD: Thermodenuder (heated to 300C to remove coating)

Size distribution and morphology of bare, coated and TD soot particles

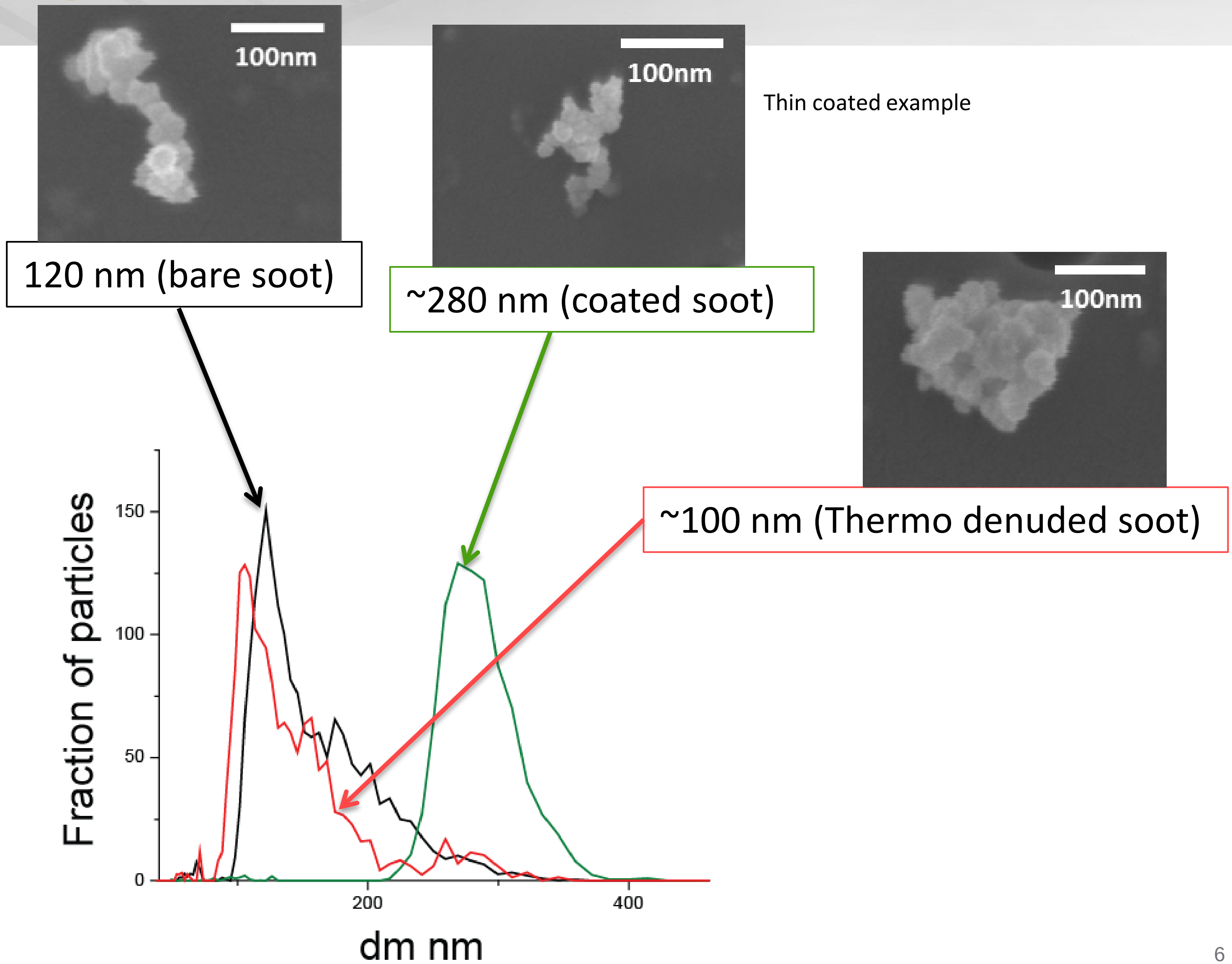


Figure courtesy of Alla Zelenyuk, Michigan Tech U. group, Rahul Zaveri

IN results: -45C

Relative humidity with respect to ice (RH_i) required for detection of 1% of particles as IN for different soot treatments.

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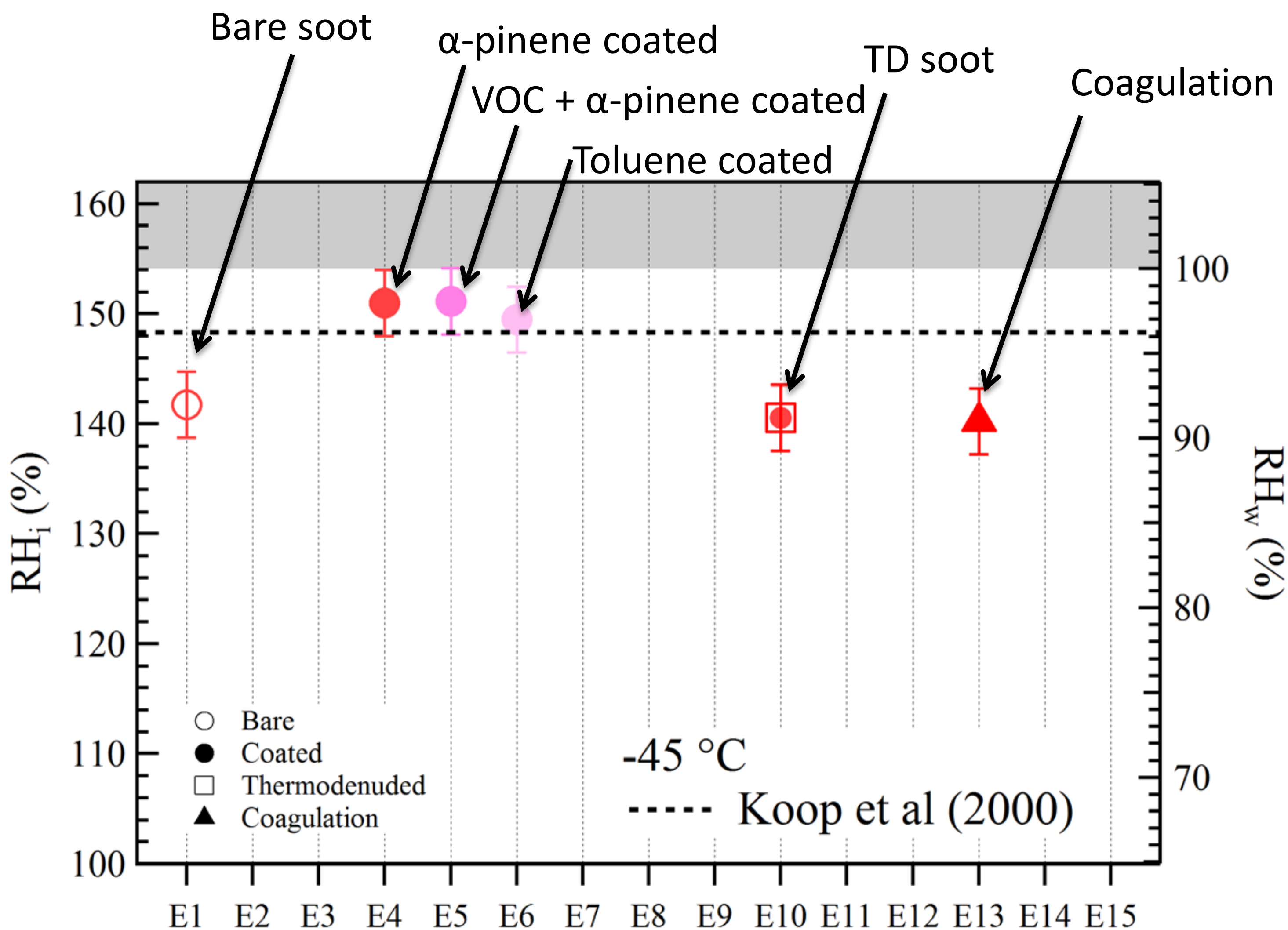
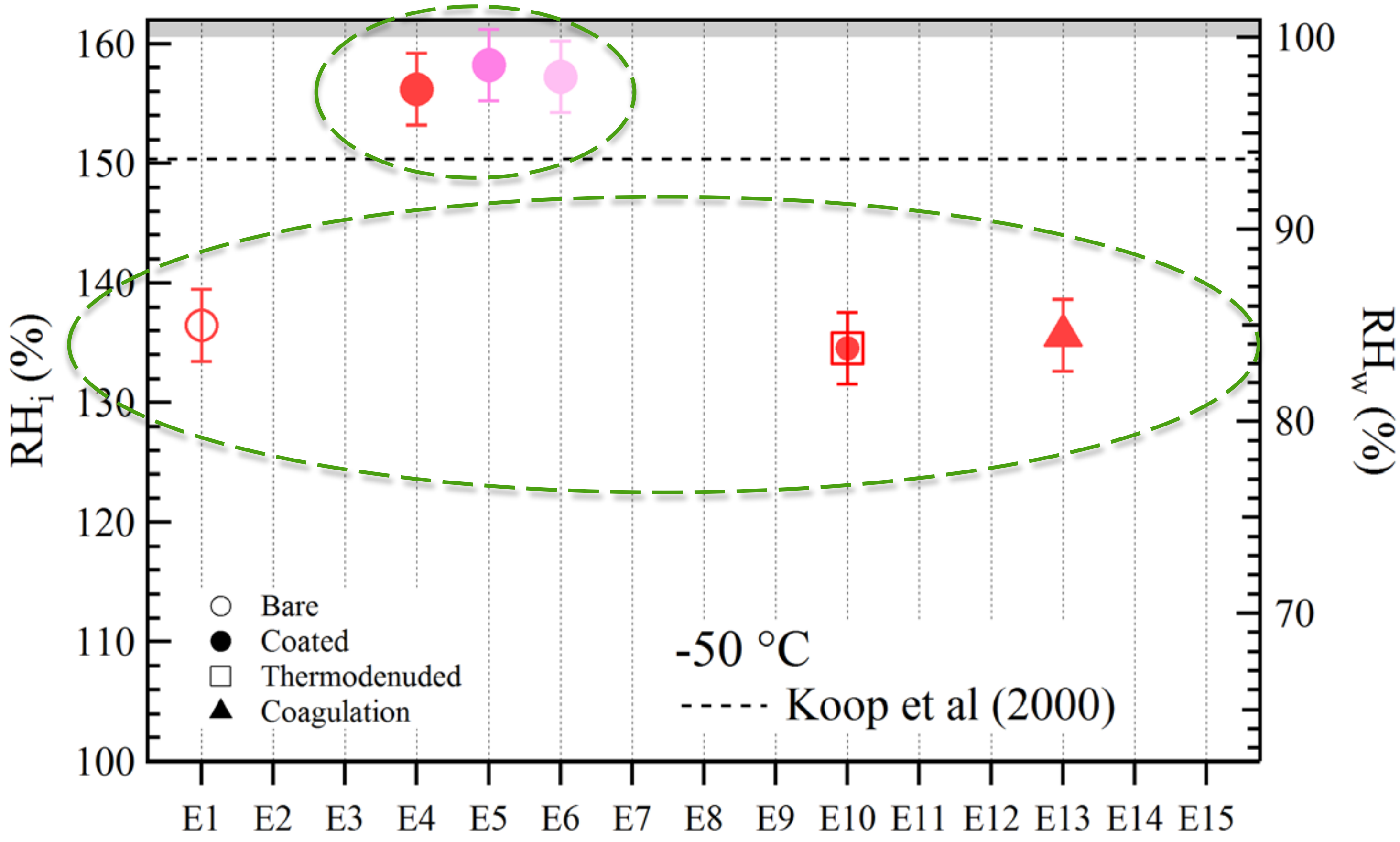
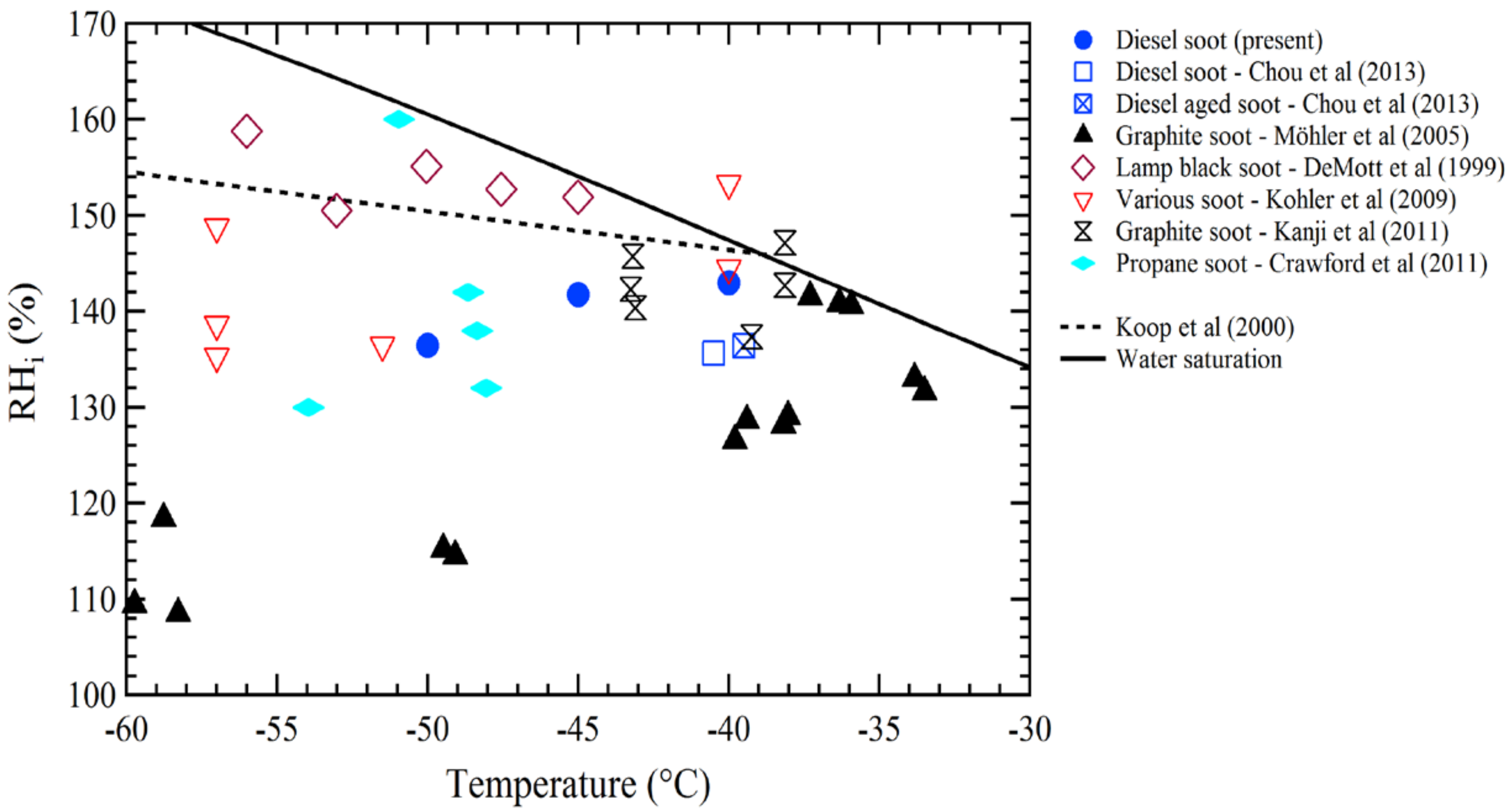


IN results: -50C
Similar story here.



Comparison with other studies (bare only)



IN efficiency depends upon fuel source and combustion technique.

Parameterization using ice active site density approach for cloud model

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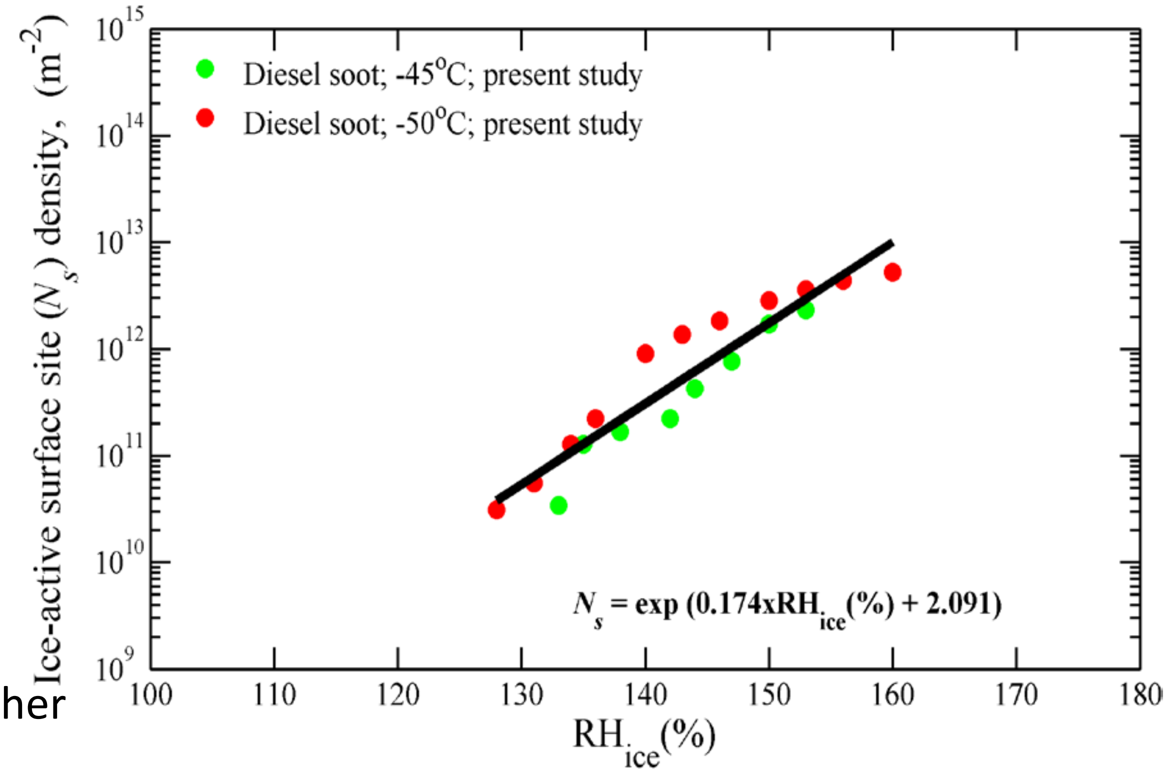
$$N_s = -\frac{1}{A}\ln\{1 - F_{ice}(\mathrm{RH_{ice}})\}$$

Niemand et al. (2012)

Soot surface area (spherical assumption)

From ice chamber measurements.



FW:
Compare with other aerosol Ns fits.

Summary

Ice nucleating properties of bare, coated, thermally, and coagulated diesel soot particles was investigated during recent SAAS (Soot Aerosol Aging Study) campaign.

Preliminary data shows that:

- ✓ Bare soot particles are efficient IN in deposition mode.
- ✓ Coated soot particles require higher RH conditions to classify them as IN.
- ✓ Thermo denuded soot particles show similar IN efficiency as bare particles.
- ✓ Coagulation did not modified the IN efficiency compared to bare particles.

In general, the results suggest that coating reduces IN efficiency and soot morphology plays a small role towards nucleating ice.

Acknowledgments:

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Thank You