Role of Surface Pressure Variability on the Ground-Level Ice-Nucleating Particle (INP) Abundance on the North Slope of Alaska

Naruki Hiranuma[1], Stephanie R. Simonsen[1], Aidan Pantoya[1], Bryan D. Thomas[2], Ross Burgener[2], Christopher Cox[3], and Gijs de Boer[3]

[1]West Texas A&M University, Canyon TX, USA,
[2]NOAA Global Monitoring Laboratory, Boulder CO, USA
[3]NOAA Physical Sciences Laboratory, Boulder CO, USA

Acknowledgement: This research is in part supported by the US Department of Energy, Office of Science, Office of Biological and Environmental Research (grant no. DE-SC-0018979).

Summary:
The presence of high pressure cores in the East and South of Aleutian Islands triggers the transport of warm North Pacific air to the NSA area, possibly delivering air mass containing freezing active marine biogenic and Eurasian continental aerosols or local dust.

https://asr.science.energy.gov/meetings/stm/posters/abstract/3260

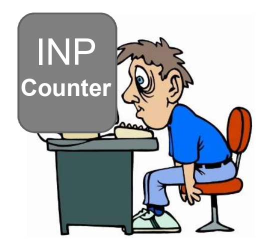
Problems & Motivation

- The Arctic is warming up to 6 times faster than the rest of the world [1]

- The increase in ice-nucleating particles (INPs), in part driven by **atmospheric pressure gradients**, can accelerate the warming BUT the impact remains quantitatively uncertain [2]

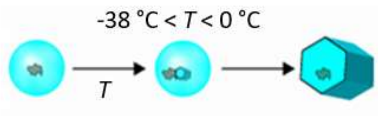
- INPs represent **a few in a million aerosol particles** producing ice crystals at ~ -20 °C [3]

- Reducing **labor intensity** of INP monitoring & analyses (increasing **consistency**) is necessary, AND we need more INP data across the world.

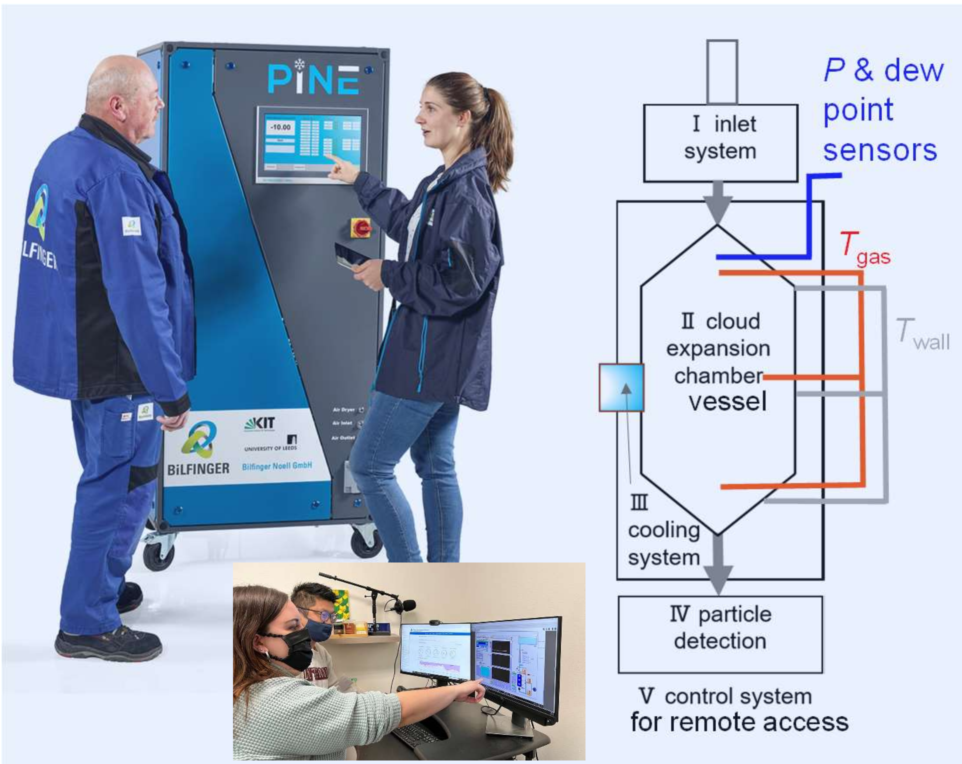


[1] Hanssen-Bauer, I. et al.: Climate in Svalbard 2100 - a Knowledge Base for Climate Adaptation, doi:10.13140/RG.2.2.10183.75687, 2019;
[2] Murray, B. J. et al.: Atmos. Chem. Phys., 21, 665–679, 2021; [3] DeMott, P. J. et al.: PNAS, 107, 11217–11222, 2010.

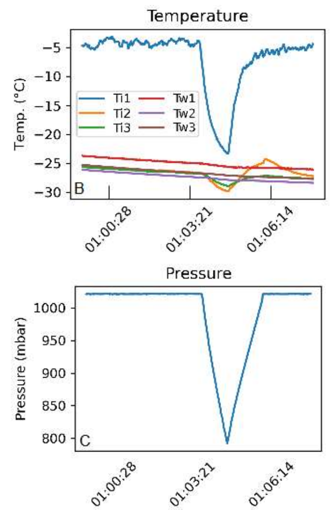
Portable Ice Nucleation Experiment Chamber (PINE-3)

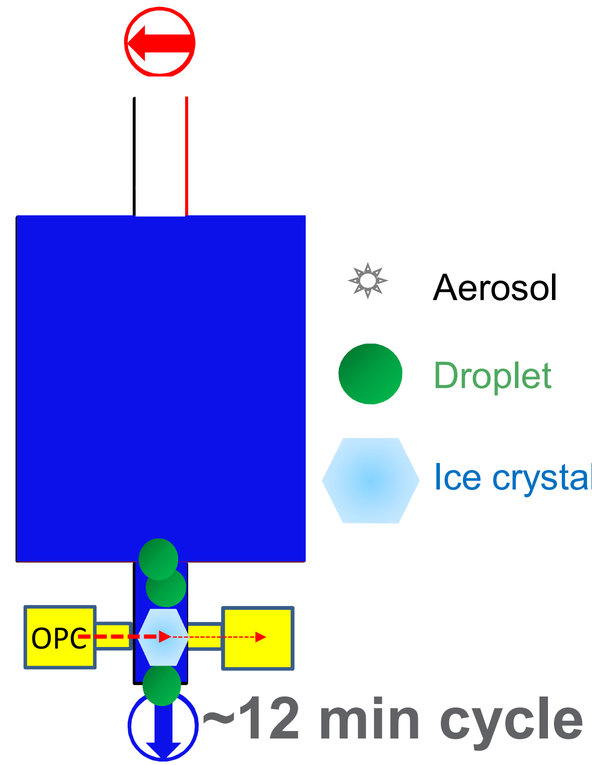


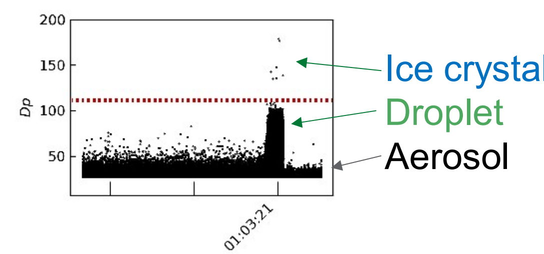
Immersion freezing ≈ 85-99% of ambient ice nucleation – e.g., *Hande and Hoose* (2017, ACP, 17, 14105–14118)



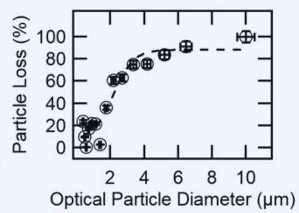
Ref.: Möhler, O. et al.: Atmos. Meas. Tech., 14, 1143–1166, 2021.



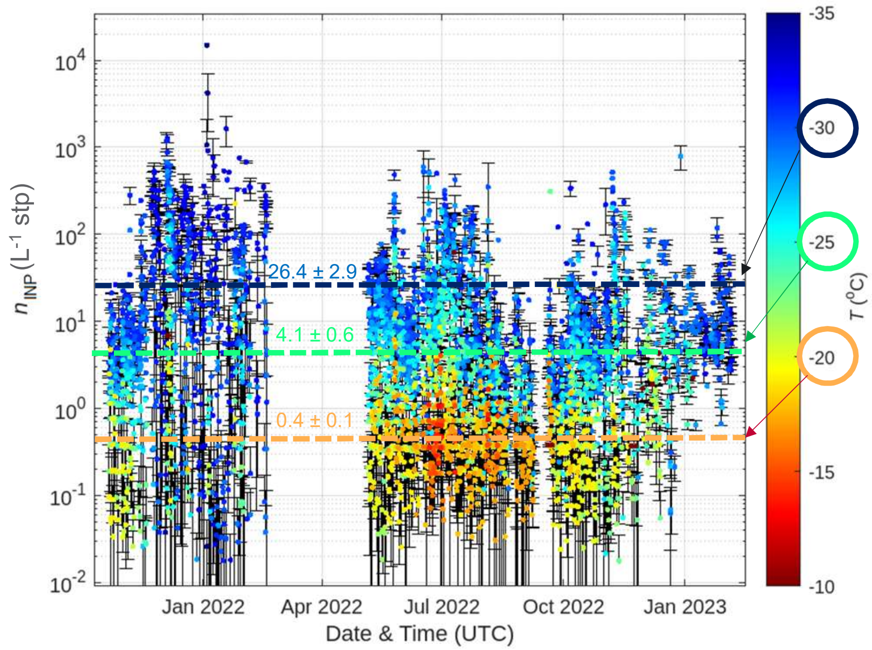


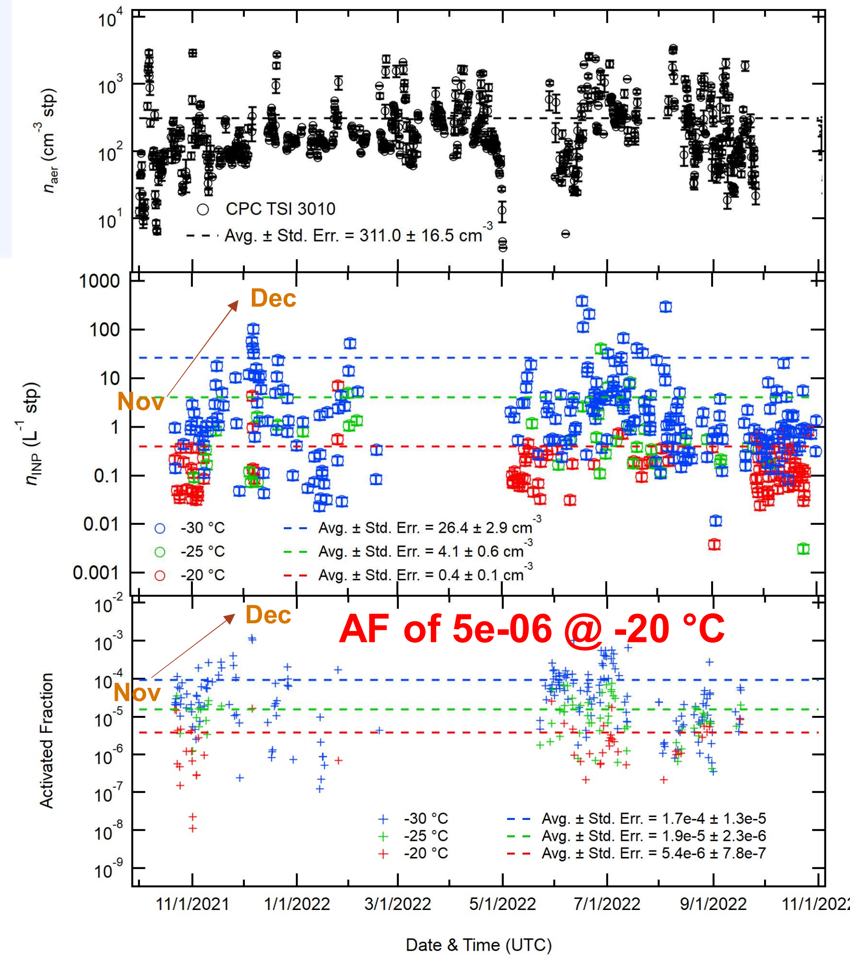


INP Abundance in North Slope of Alaska



Oct 21' - Oct 22' (Avg. ± Std. Error)





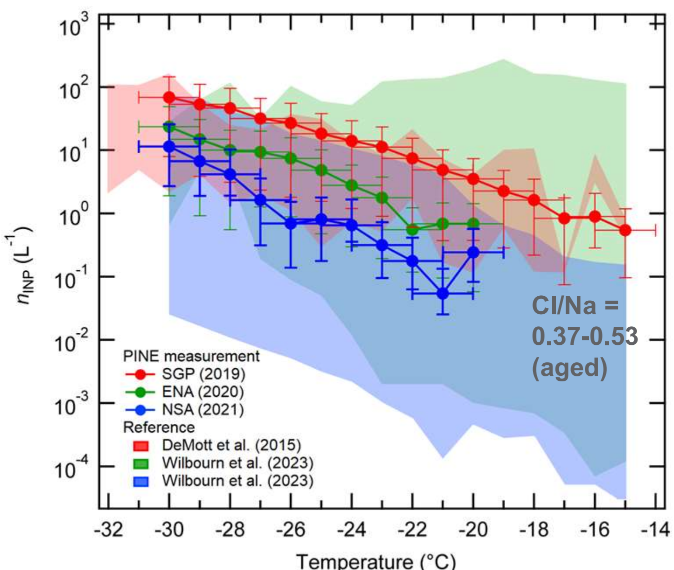
INP Abundance in North Slope of Alaska

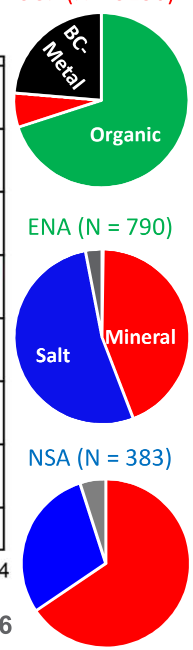
We find notably high ice activated fraction at NSA

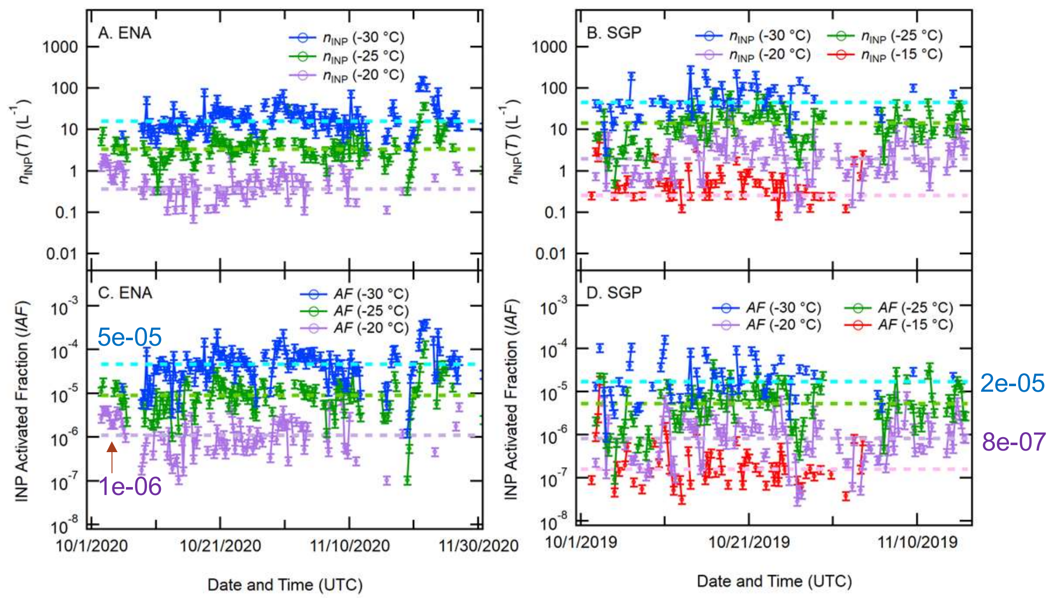
- ❑ AF of 5e-06 @ -20 °C
- ❑ AF of 2e-04 @ -30 °C

NSA particles contain more mineral dust mixed with aged sea salt

Oct - Nov (Avg. ± Std. Error)

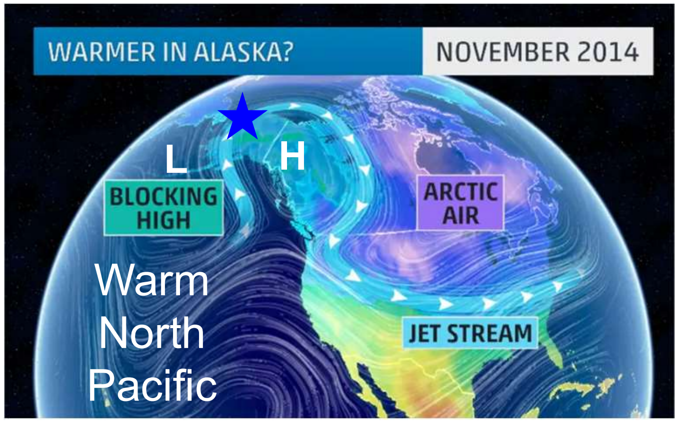






Ref. Wilbourn, E. K. et al.: A comparison of ice-nucleating particle and cloud condensation nuclei sources and properties during autumn at contrasting marine and terrestrial locations, Atmos. Chem. & Phys., submitted, 2023

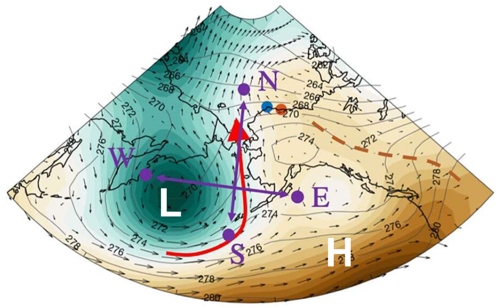
The Source of INPs @ NSA



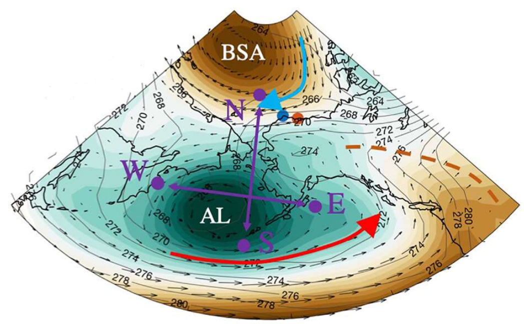
- The presence of high pressure cores in the Eastern and Southern regions over Aleutian Islands creates the Omega shape Jetstream over NSA.
- Warm North Pacific air advection into NSA can bring air mass containing freezing active marine biogenic plus long-range transported continental aerosols or local soil dust.

850 mb geopotential height under **high *P* gradient**

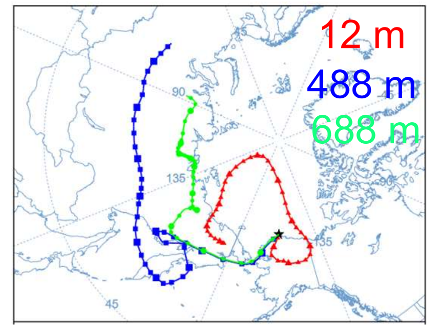
ALBSA = (P_E – P_W) – (P_N – P_S)



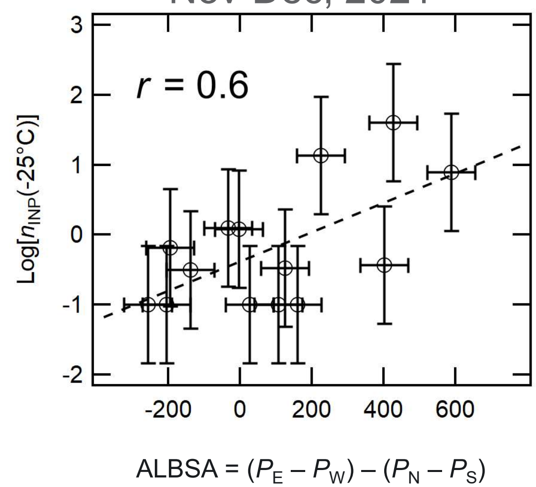
850 mb geopotential height under **low *P* gradient**



10-day back trajectory of **High n_{INP}** condition 12/5/2021



Nov-Dec, 2021



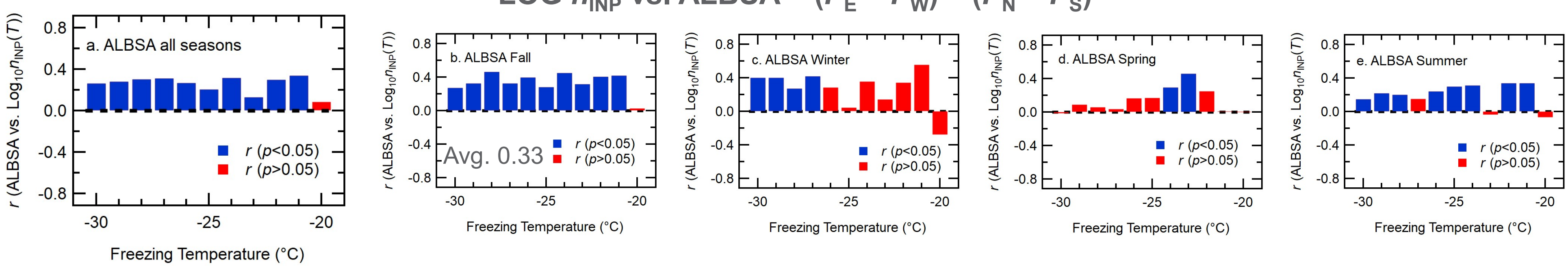
Ref: Cox, et al. (2019) Geophysical Research Letters, 46, 7476-7473.

Graphic: https://weather.com/storms/winter/news/warmer-alaska-texas-contiguous-united-states-artic-blast-20141115

Summary & Outlook

- We find a slight positive correlation between INP abundance and the pressure variability over NSA (i.e., Aleutian Low - Beaufort High).
- The presence of high pressure cores in the East and South of Aleutian Islands triggers the transport of warm North Pacific air to the NSA area, possibly delivering air mass containing freezing active marine biogenic and Eurasian continental aerosols or local dust.
- Air mass fractions over land vs. ocean, as well as local atmospheric stability (e.g., Bulk Richardson Number), surface turbulence, and vertical mixing, must be looked into for local vs. transported dust contributions.

LOG n_{INP} vs. ALBSA = $(P_E - P_W) - (P_N - P_S)$

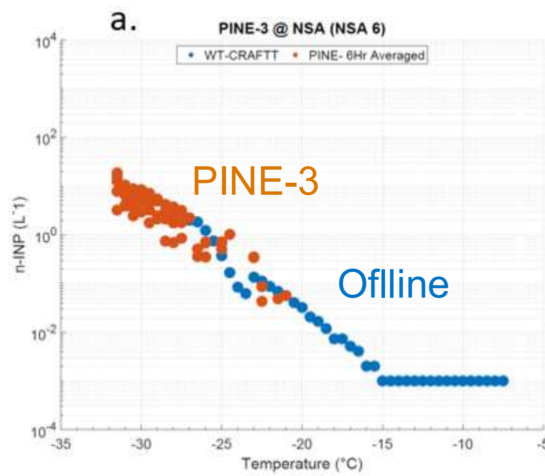


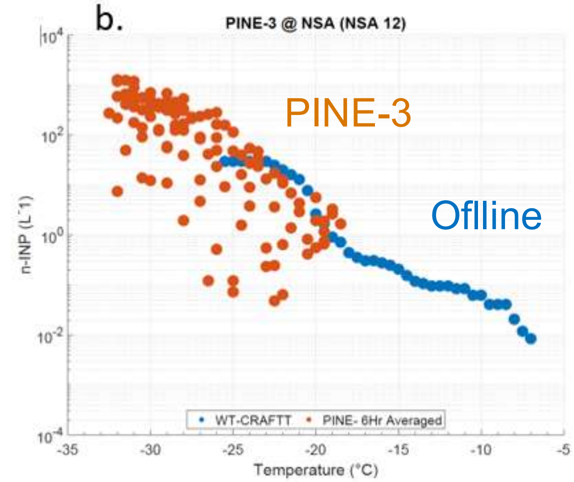
THANK YOU

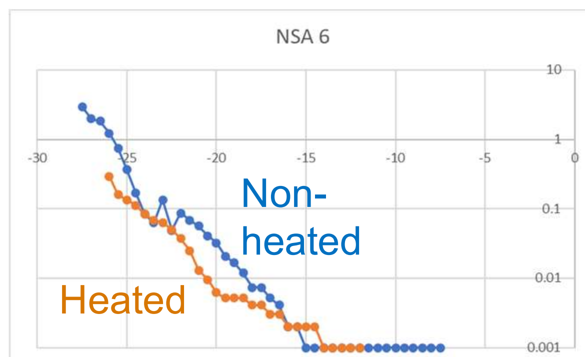
Contact: Naruki (Poster #3260)
nhiranuma@wtamu.edu

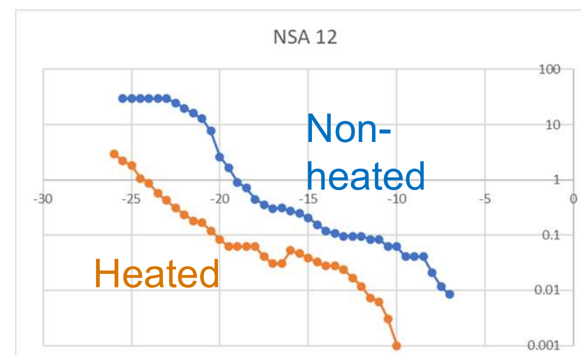
Filter ID	Initial Freezing T (°C)	n_{INP} @ -25 °C (L^{-1})	Ice nucleation active*?	Heat-sensitive**?
NSA4	-12	0.4	no	☑
NSA5	-5.5	0.3	no	☑
NSA6	-7.5	0.4	*no*	*no*
NSA7	-17	0.3	no	☑
NSA8	-16	0.2	*no*	*no*
NSA9	-11.5	0.1	*no*	*no*
NSA10	-17	0.3	*no*	*no*
NSA11	-17.5	0.3	*no*	*no*
NSA12	-7	**29.5**	☑	☑
NSA13	-7	2.8	☑	☑
NSA14	-14	0.9	☑	no
NSA15	-11	0.3	no	no
NSA16	-9	0.3	no	☑
NSA17	-15.5	0.3	no	☑

Filter ID	Start Date (UTC)	End Date (UTC)	*Sampled Air Vol. (L)	**Suspension Vol. (mL)
NSA4	11/1/2021 22:12	11/5/2021 17:05	9665.4	2.0
NSA5	11/5/2021 17:23	11/8/2021 22:41	8394.8	1.8
NSA6	11/8/2021 23:00	11/12/2021 19:38	10004	2.1
NSA7	11/12/2021 19:55	11/15/2021 21:02	8455.9	1.8
NSA8	11/15/2021 21:13	11/22/2021 21:06	9921.9	2.1
NSA9	11/22/2021 21:18	11/26/2021 23:32	11493	2.4
NSA10	11/26/2021 23:39	11/29/2021 21:23	8263.4	1.7
NSA11	11/29/2021 21:31	12/3/2021 21:11	5008.2	1.0
NSA12	12/3/2021 21:18	12/6/2021 23:41	9149.2	1.9
NSA13	12/6/2021 23:48	12/10/2021 21:46	11431	2.4
NSA14	12/10/2021 21:55	12/13/2021 21:25	8837.4	1.8
NSA15	12/13/2021 21:32	12/18/2021 0:32	12014	2.5
NSA16	12/18/2021 0:36	12/20/2021 21:06	8035.1	1.7
NSA17	12/20/2021 21:11	12/31/2021 23:00	29585	6.2



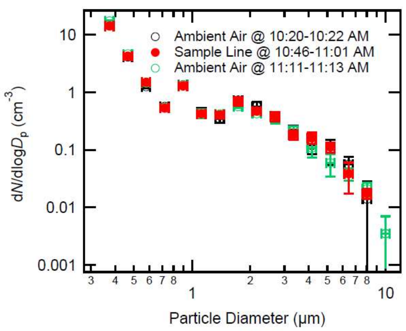


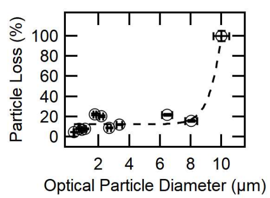




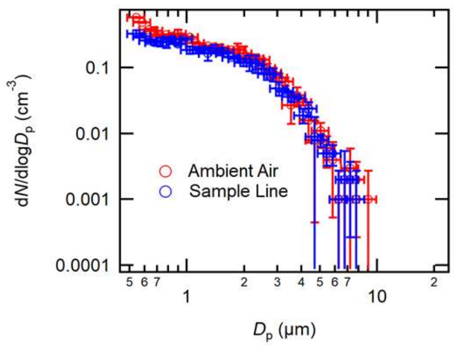
Inlet Particle Loss

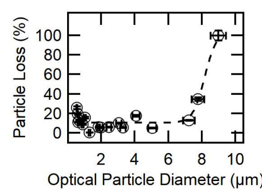
SGP



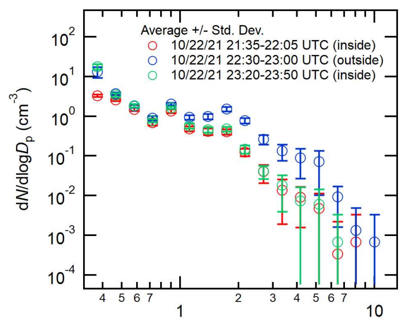


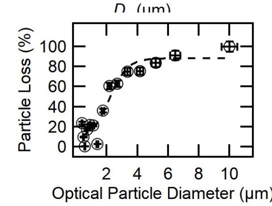
ENA





NSA-BRW





West Texas A&M

Naruki Hiranuma
nhiranuma@wtamu.edu