

# The De-Icing Comparison Experiment (D-ICE):

## A Campaign for Improving Data Retention Rates of Radiometric Measurements Under Icing Conditions in Cold Regions

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**Earth System Research Laboratory**  
 Physical Sciences Division

**D-ICE De-Icing Comparison Experiment**

**About this Project**  
 August 2017–August 2018 | Utqiagvik, Alaska

Measurements of longwave (terrestrial) and shortwave (solar) radiation are fundamental environmental quantities and are regularly observed around the world using broadband radiometers. Because of the sensitivity of these instruments to internal temperature instabilities, there are limitations to using heat as a method for preventing the build-up of ice on the sensor windows. Consequently, substantial amounts of data are lost in regions conducive to frost, rime and snow, such as the polar regions.

The purpose of the D-ICE campaign is to test strategies developed by research institutes and industry for preventing radiometer icing. Specifically, we aim to identify a method to be adopted by the research community that is effective at mitigating ice while also minimizing adverse effects on measurement quality, and to serve the needs of the community best, while also being energy efficient. Following the experience of the contributing institutes, the guiding hypothesis is that ventilation of ambient air alone, if properly applied, is sufficient to maintain ice-free radiometers without increasing measurement uncertainty during icing conditions. Other methods, including applying heat to the housing and/or circulating heated air across the dome as well as manual cleanings by on-site technicians will also be evaluated. The project is being led by the NOAA Physical Sciences Division and the Baseline Surface Radiation Network Cold Climates Issues Working Group. The project will be carried out at the NOAA Global Monitoring Division Atmospheric Baseline Observatory in Utqiagvik (formerly Barrow), Alaska, from August 2017 through summer 2018.

<https://www.esrl.noaa.gov/psd/arctic/d-ice/>  
<https://www.arm.gov/research/campaigns/nsa2017dicexaco>

**Project Leads**  
 Sara Morris  
 Christopher Cox

### Details from the main platform

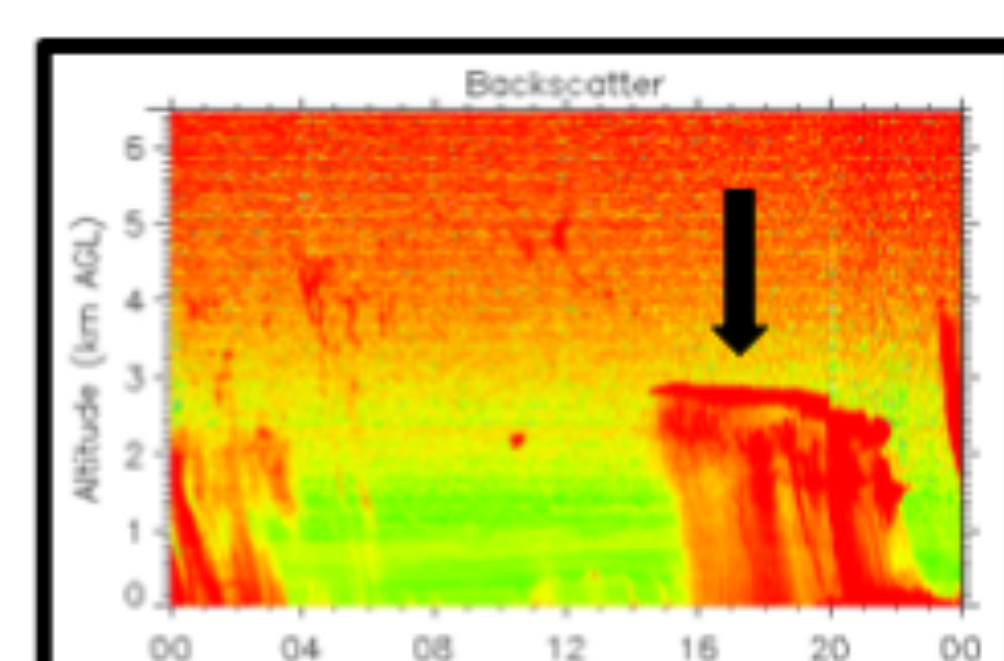
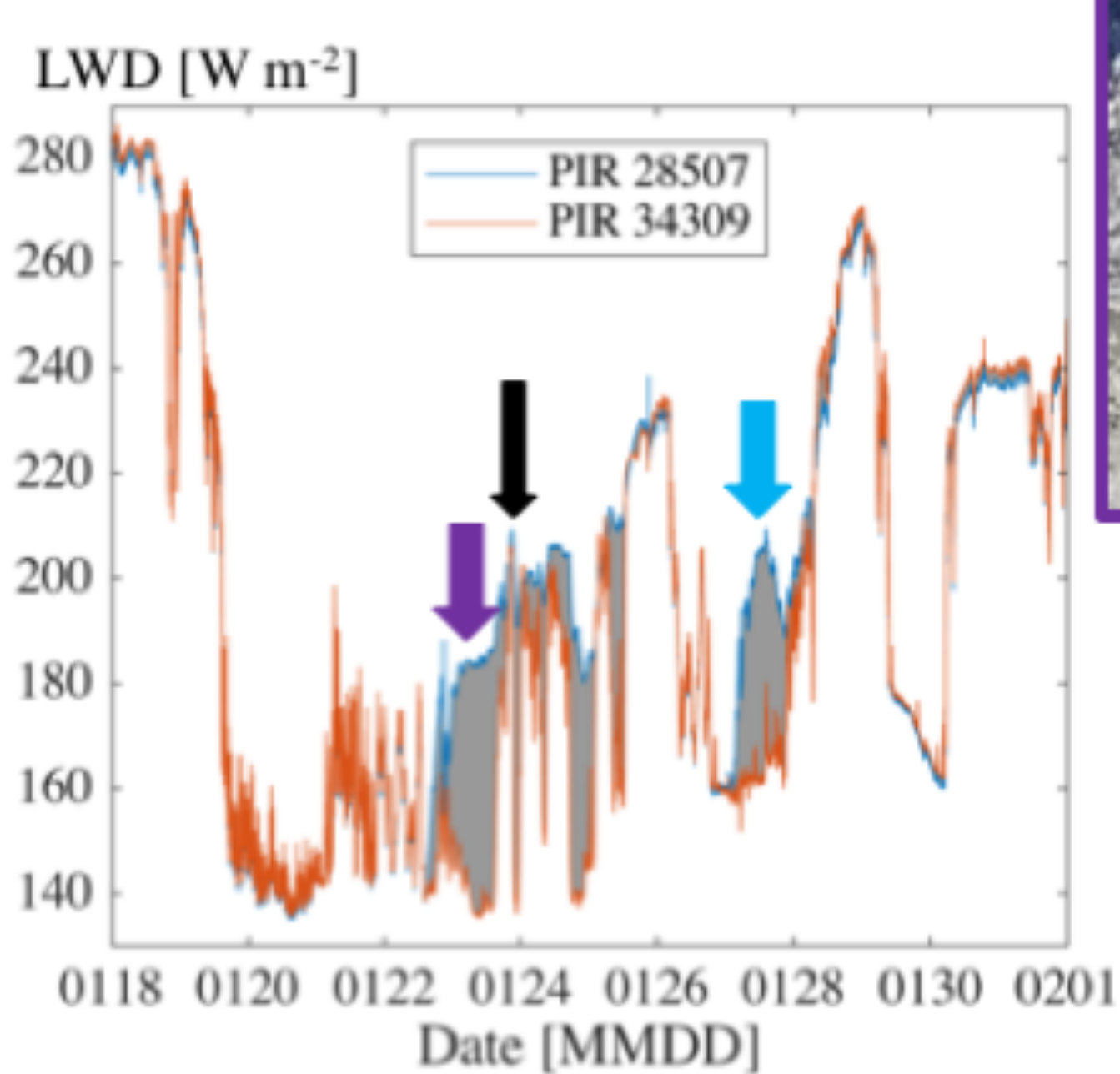
<b>#2-5</b> SW Radiometer: CM11/CM21/CMP22/SMP22 LW Radiometer: CGR4/SGR4 Direct Radiometer: CHP1 Ventilator: CVF4 Kipp & Zonen	<b>#6-9,11</b> PIR PSP/SPP Ventilator: VEN Eppley	<b>#21</b> SR30 <b>#23</b> SR25 Ventilator: VU01 Hukseflux	<b>#10</b> MS80/MS80M <b>#19, 20</b> MS802 Ventilator: MV01 EKO	<b>#13, 22</b> SPN1 Delta-T	<b>#25</b> Ventilator: SBL480 <b>#15-17</b> Ventilator: SBL550 Eigenbrodt	<b>#12-14</b> Ventilator: PMOD PMOD	<b>#26</b> Ventilator: MeteoSwiss MeteoSwiss
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ARM operates PIRs and PSPs in VENS similar to #6-9, 11, but with lower power DC fans (4.1 W / 55 cfm compared to 10.3 W / 80 cfm). ARM also adds 10-15 W of heating from a heating coil located beneath the radiation shield. Several heating and power adjustments have recently been at both sites, but have not yet been considered in the analysis.

**The Problem:** Biased broadband radiometric measurements when ice builds on instrument domes. The biases are + or -, affect SW and LW and have signals similar to clouds. D-ICE is evaluating ventilation and heating technology designed to mitigate icing at Barrow: data and images of 26 radiometers. Also, all 4 upward-facing radiometers at both NSA and OLI (ARM campaign "DICEXACO").



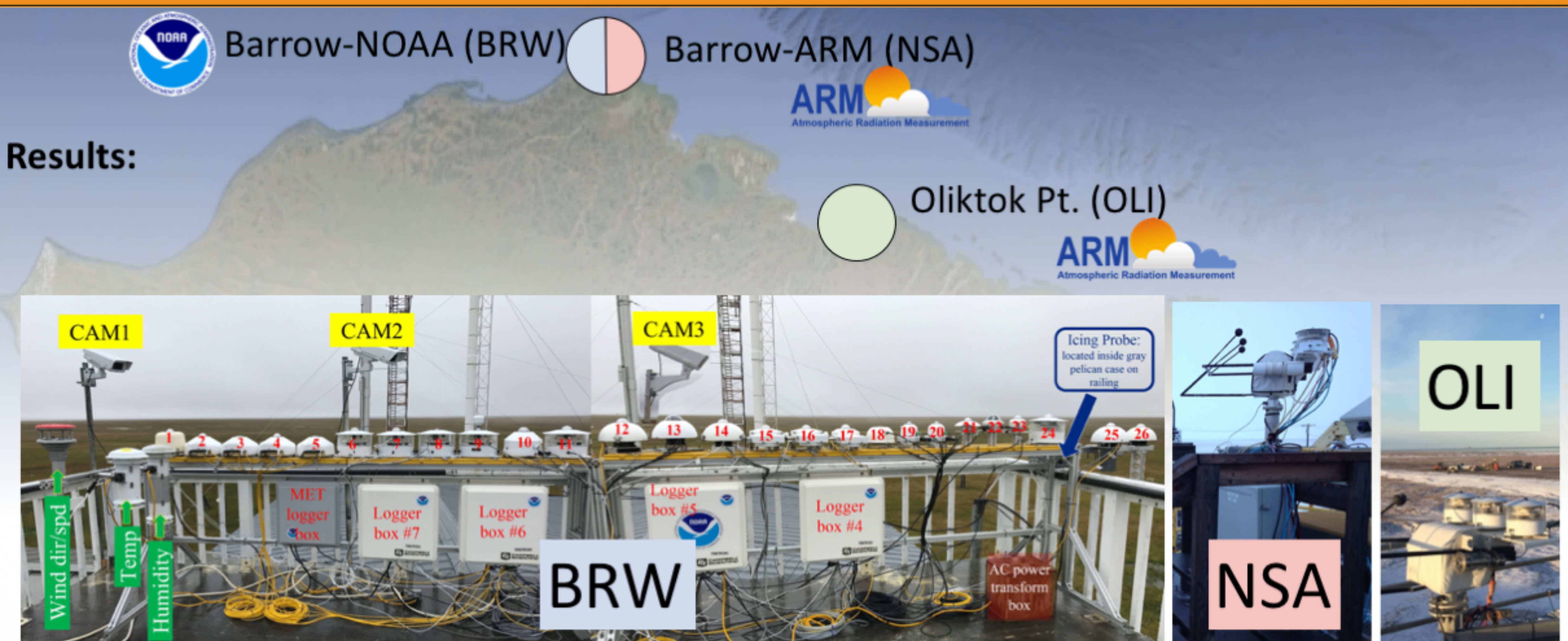
Example from D-ICE: January 2018



Biases for iced pyrgeometers were  $\sim 50 W m^{-2}$ , yet the mean LWD for Jan was  $202 W m^{-2}$  and  $198 W m^{-2}$ , a relatively small difference that is the result of the integrated influence of cloud cover (which reduces the bias, as in the example,  $\sim 63\%$  in Jan [CEILO]), in addition to the frequency (4.7% vs 34.5%) and severity of icing. PIR 34309 was iced less frequently because of a very subtle ventilator variation – just a 2 mm lift in the radiation shield!

### Preliminary Results:

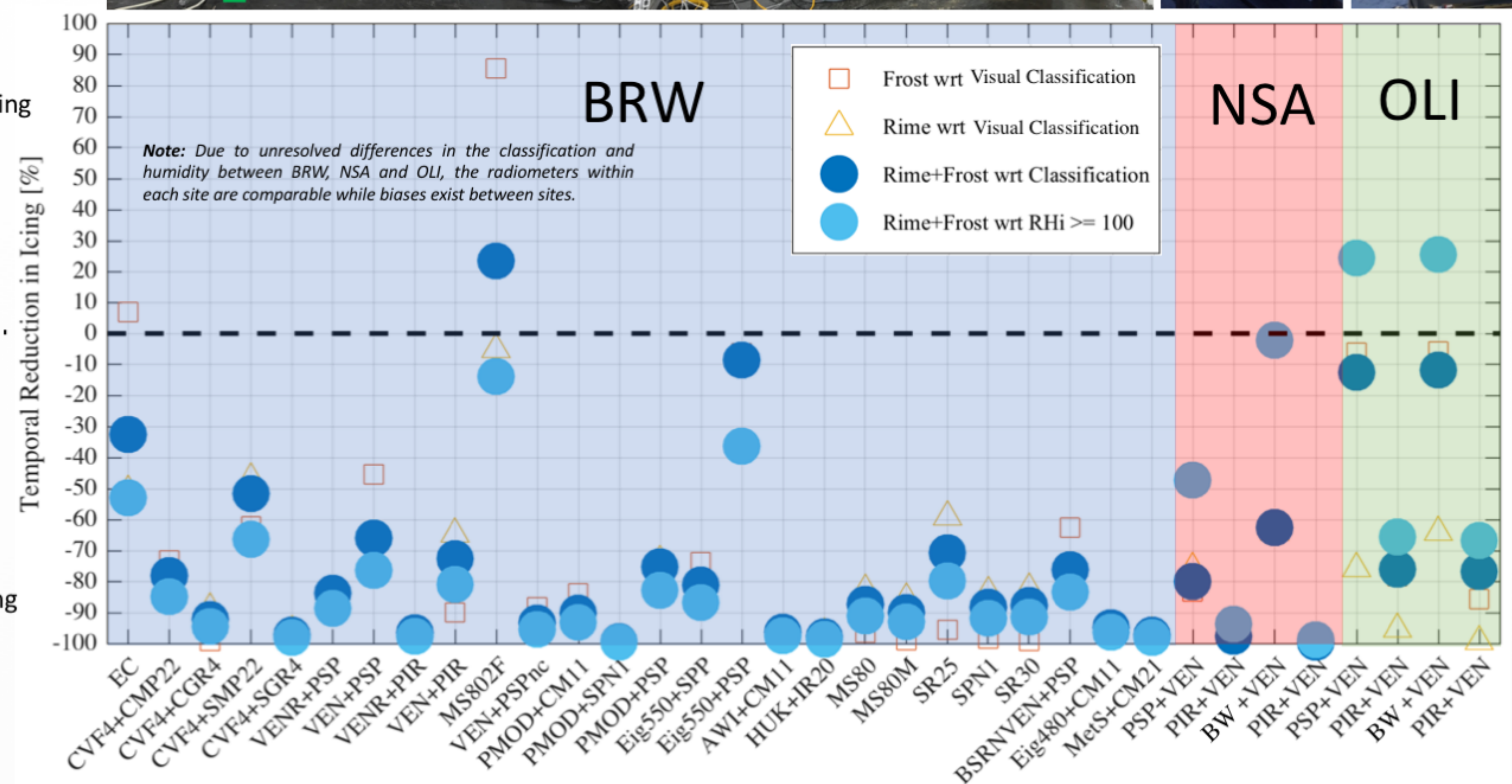
Radiometers



Ventilator enhances icing



Ventilator reduces icing



Analysis of > 400,000 images of radiometer domes acquired November 2017 through February 2018:  $76 \pm 29\%$  reduction in ice caused by rime and frost when averaged across 26 BRW systems;  $85\% \pm 17\%$  at NSA and  $44\% \pm 37\%$  at OLI.

### Conclusions:

- Initial results support anecdotal reports that ventilation without additional heating is a viable option for preventing ice from developing on radiometer domes.
- The average improvement against rime/frost was  $73 \pm 31\%$  amongst all systems; better for pyrgeometers than pyranometers, likely due to lower-profile domes.
- Monthly mean downwelling longwave flux (Jan 2018) using a common pyrgeometer setup was biased high by only  $\sim 4 W m^{-2}$  compared to ice-free measurements.
- PSPs at NSA and OLI are frequently iced, but PIRs perform well in the current system.
- Compared to a best-estimate downwelling longwave flux derived from the five D-ICE pyrgeometers, the NSA "iced" qcrad LW fluxes, are unbiased ( $-0.2 \pm 1.4 W m^{-2}$ ).
- We consider all results to be preliminary.

### Acknowledgments



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