

# THE DE-ICING COMPARISON EXPERIMENT (D-ICE)

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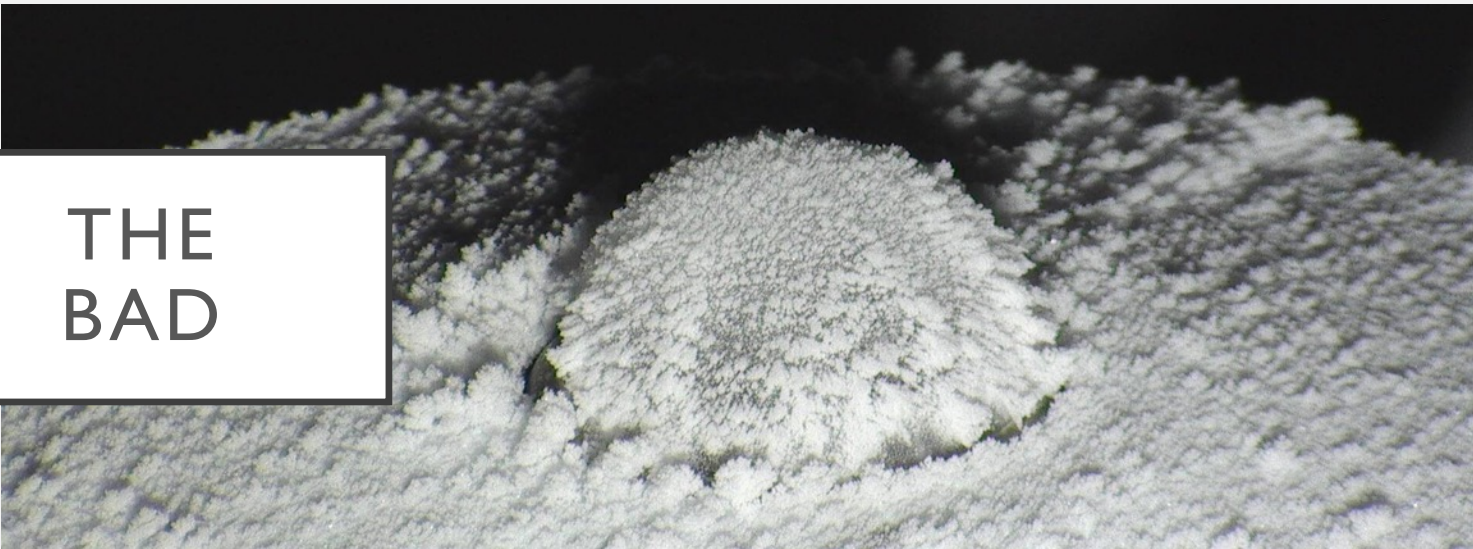
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THE  
GOOD



THE  
BAD



...AND  
THE UGLY

## BSRN INITIATIVE: *COLD CLIMATE ISSUES WG*

- Baseline Surface Radiation Network (BSRN)
  - Product of Global Energy and Water Cycle Experiment (GEWEX)
    - World Climate Research Programme (WCRP)
    - Contribute to Global Atmosphere Watch (GAW)
  - Define protocols for global radiation measurements
    - Monitor global radiative components
    - Provide quality, standard radiation measurements
      - Calibration standards among radiation community
      - Processing techniques



# WELCOME TO D-ICE





# D-ICE De-Icing Comparison Experiment

About | Science Objectives | Experimental Design | Details | Data | Data Browser | Webcam

## 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.

### Project Leads



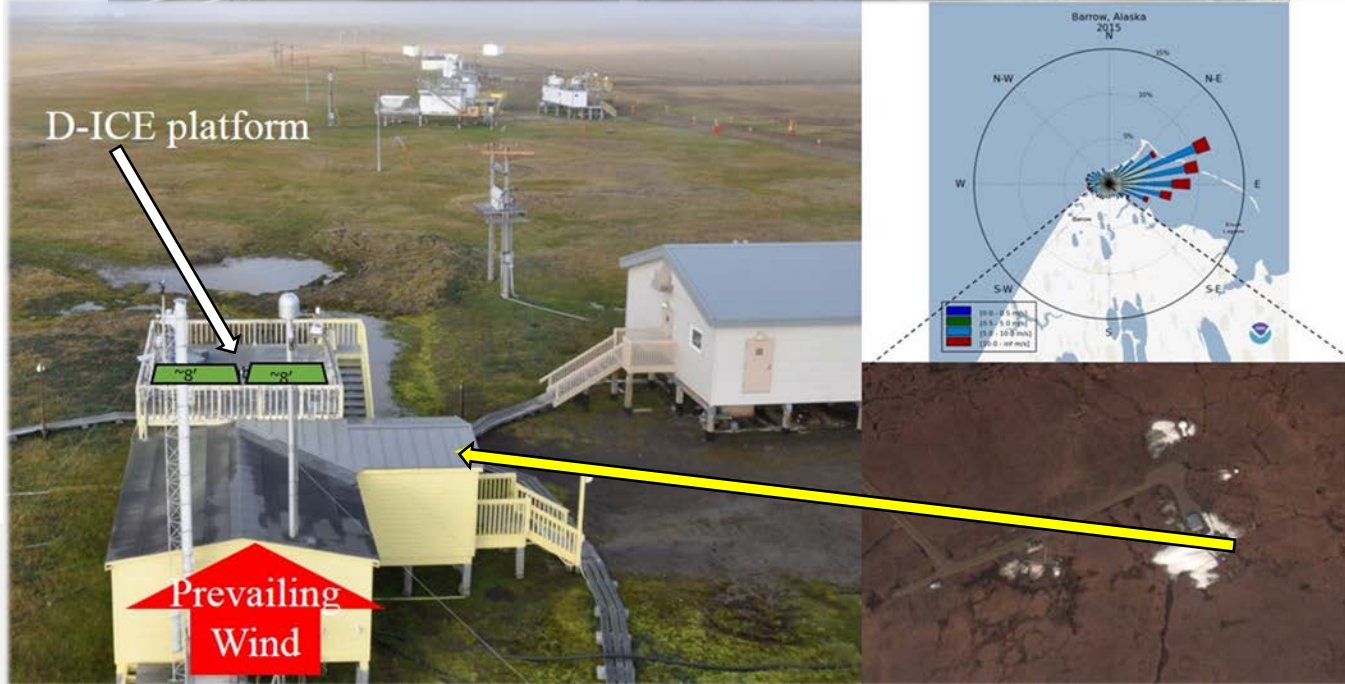
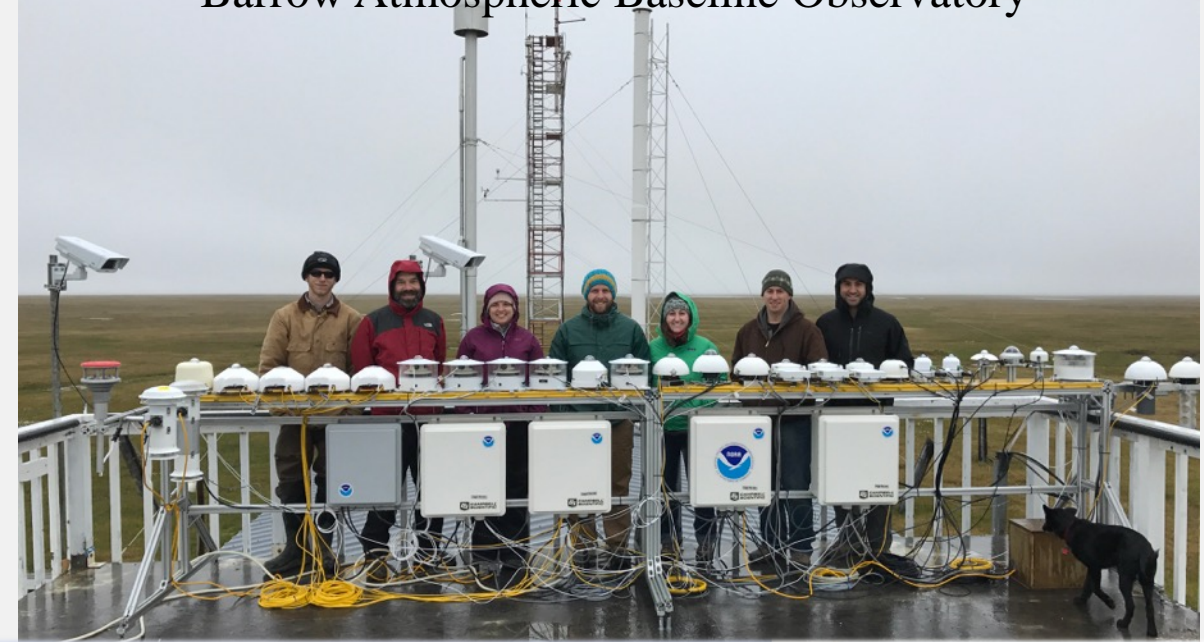
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# NOAA Global Monitoring Division (GMD) Barrow Atmospheric Baseline Observatory



D-ICE Webpage: <https://www.esrl.noaa.gov/psd/arctic/d-ice/>



## Instrument Details

 SW Radiometer: CM11/CM21/ CMP22/SMP22	 LW Radiometer: CGR4/SGR4	 Direct Radiometer: CHP1	 Ventilator: CVF4	 PIR PSP/SPP Ventilator: VEN	 SR30    IR20 SR25    Ventilator: VU01	 MS80/MS80M MS802 Ventilator: MV01	 SPN1	 Ventilator: SBL480 Ventilator: SBL550	 Ventilator: PMOD	 Ventilator: MeteoSwiss					
Kipp & Zonen		Eppley		Hukseflux		EKO		Delta-T		Eigenbrodt		PMOD		MeteoSwiss	

# PARTICIPANTS

Table	Table Position	Radiometer Logger Box #	Radiometer Serial #	Ventilator Logger Box #	Ventilator Model or Serial #	Radiometer Measurement	Radiometer Manufacturer	Radiometer Model	Radiometer Calibrations for D-ICE [ $\mu V/W/m^2$ ]	Previous Factory Calibration ( $\mu V/W/m^2$ )	Ventilation Manufacturer	Ventilation Quality / Quantity	Ventilation Frequency	Heat Applied (y/n)	Heat Quantity (Watts)	Heat Frequency
1	1	7	34231F3	6	ALERT	Shortwave	Eppley	PSP	8.397	8.41	EC, Alert	DC / 80 [cfs]	continuous	no	n/a	n/a
1	2	6	160478	6	171842	Shortwave	Kipp&Zonen	CMP22	9.697	9.74	Kipp&Zonen	DC / 4400 [rpm]	continuous	yes	5.5 [W]	continuous
1	3	6	160183	6	171840	Longwave	Kipp&Zonen	CGR4	$C1 = 9.545$ $C2 = 0.998$	9.4	Kipp&Zonen	DC / 4400 [rpm]	continuous	yes	5.5 [W]	continuous
1	4	6	160002	6	171843	Shortwave	Kipp&Zonen	SMP22	original cal	10.07	Kipp&Zonen	DC / 4400 [rpm]	continuous	yes	5.5 [W]	continuous
1	5	6	160008	6	171841	Longwave	Kipp&Zonen	SGR4	original cal	11.03	Kipp&Zonen	DC / 4400 [rpm]	continuous	yes	5.5 [W]	continuous
1	6	7	26818F3	7	V6 909-12, washers/dome lift	Shortwave	Eppley	PSP	8.449	8.57	Eppley	DC / 80 [cfs]	continuous	no	n/a	n/a
1	7	7	18135F3	7	V6 809	Shortwave	Eppley	PSP	8.556	8.65	Eppley	DC / 80 [cfs]	continuous	no	n/a	n/a
1	8	5	34309F3	7	V6 808, washers/dome lift	Longwave	Eppley, PSD	PIR	$C1 = 3.39$ $K = 3.78$	3.54	Eppley	DC / 80 [cfs]	continuous	no	n/a	n/a
1	9	5	28507F3	7	V6 689	Longwave	Eppley	PIR	$C1 = 3.68$ $K = 3.567$	3.76	Eppley	DC / 80 [cfs]	continuous	no	n/a	n/a
1	10	4	F16305R	4	MS-401FU	Shortwave	EKO	MS-802F	7.056	7.01	EKO	DC / 3000 [rpm]	continuous	no	n/a	n/a
1	11, do NOT clean	7	26214	5	V6 910	Shortwave	Eppley, NCAR	PSP	8.13	8.52	Eppley, lift shield	DC / 80 [cfs]	continuous	no	n/a	n/a
2	12	6	130814	5	PMOD	Shortwave	Kipp&Zonen, GMD	CM11	8.327	8.31	PMOD	DC / 4200 [rpm]	continuous	yes	8.16 [W]	continuous
2	13	5	A1571		GMD PMOD	Total, Diffuse	Delta-T, GMD	SPN	factory set	factory set	GMD, PMOD	DC / 80 [cfs]	continuous	via instrument	20 [W]	continuous
2	14	7	20523F3	5	PMOD	Shortwave	Eppley	PSP	9.433	9.67	PMOD	DC / 4200 [rpm]	continuous	yes	8.16 [W]	continuous
2	15	7	38172F3	4	0932153	Shortwave	Eppley	SPP	7.756	8.05	Eigenbrodt 550	DC / 2500 [rpm]	continuous	yes	14 [W]	n/a
2	16	7	26236	4	0931190	Shortwave	Eppley, NCAR	PSP	8.627	9.07	Eigenbrodt 550	DC / 2500 [rpm]	continuous	no	n/a	n/a
2	17	6	130819	4	0932088	Shortwave	Kipp&Zonen, GMD	CM11	8.681	8.7	Eigenbrodt 550 modified	DC / 2500 [rpm]	continuous	yes	14 [W]	continuous
2	18	4	4037	5	VU01	Longwave	Hukseflux	IR20-T1	$C1 = 10.144$ $C2 = 0.995$	10.13	Hukseflux	DC / 50 [m <sup>2</sup> /hr]	continuous	no	5-10 [W]	optional
2	19	4	S16088025	5	MV0117004	Shortwave	EKO	MS-80	10.616	10.64	EKO	DC / 3000 [rpm]	continuous	yes	7 [W]	continuous
2	20	6	S16090016	5	MV0117003	Shortwave	EKO	MS-80M	10.772	10.76	EKO	DC / 3000 [rpm]	continuous	yes	7 [W]	continuous
2	21	4	2510	none	none	Shortwave	Hukseflux	SR25-T1	14.804	14.87	none	n/a	n/a	no	n/a	n/a
2	22	4	A1338	none	none	Total, Diffuse	Delta-T	SPN	factory set	factory set	none	n/a	n/a	via instrument	20 [W]	continuous
2	23	6	2060	none	none	Shortwave	Hukseflux	SR30-D1	original cal	10.29	none	n/a	n/a	n/a	n/a	n/a
2	24, GMD BSRN	none	none	none	none	Shortwave	Eppley	PSP			Eppley					
2	25	6	130617	4	0932152	Shortwave	Kipp&Zonen, GMD	CM11	8.741	8.79	Eigenbrodt 480	DC / 3300 [rpm]	continuous	yes	25 [W]	continuous
2	26	5	970426	5 = fan 4 = heat	METEOSWISS	Shortwave	Meteo-Swiss	CM21	19.808	19.74	METEOSWISS	DC / 3450 [rpm]	continuous	yes	20 [W]	continuous
n/a	none	5	Icing Probe	none	none	Icing Probe	Anasphere									
n/a	none		9297	none	none	Direct	Hukseflux	DR02-T1-10	original cal	16.5	none	n/a	n/a	no	n/a	n/a
n/a	none	7	26226		SPARE	Shortwave	Eppley, NCAR	PSP	8.053	8.46	none	n/a	n/a	no	n/a	n/a
n/a	none		999991		none	Direct	Kipp&Zonen	CHP1	original cal	7.25	none	n/a	n/a	no	n/a	optional
n/a	none		999992		none	Direct	Kipp&Zonen	CHP1	original cal	7.52	none	n/a	n/a	yes	5.5 [W]	continuous



CAM#1: JANUARY 28, 12 UTC





CAM#2: JANUARY 28, 12 UTC





CAM#3: JANUARY 28, 12 UTC





# IMPACT OF VENTILATION

Ventilators Turned Off

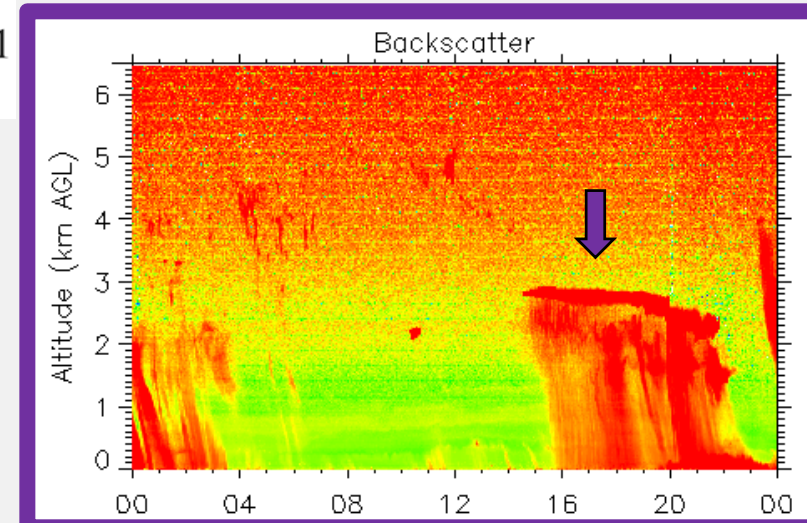
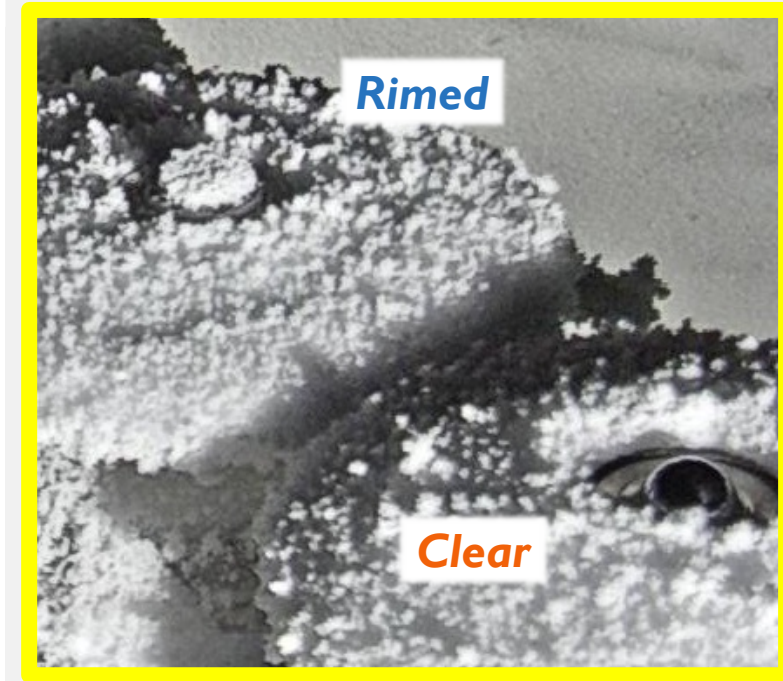
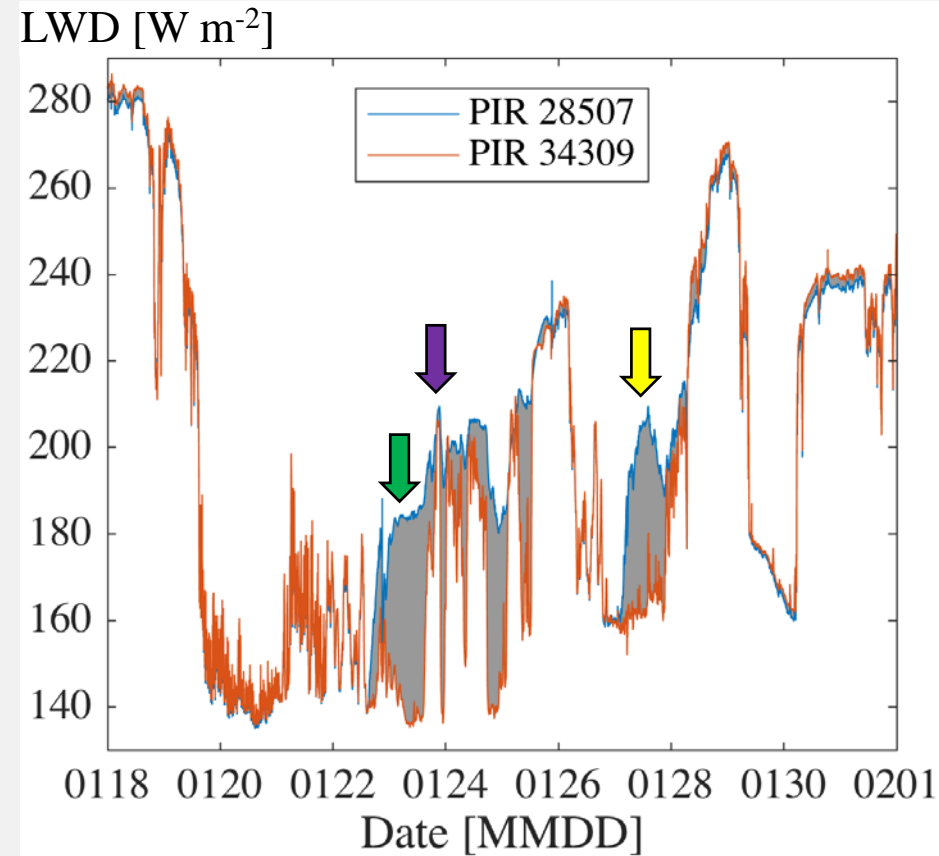
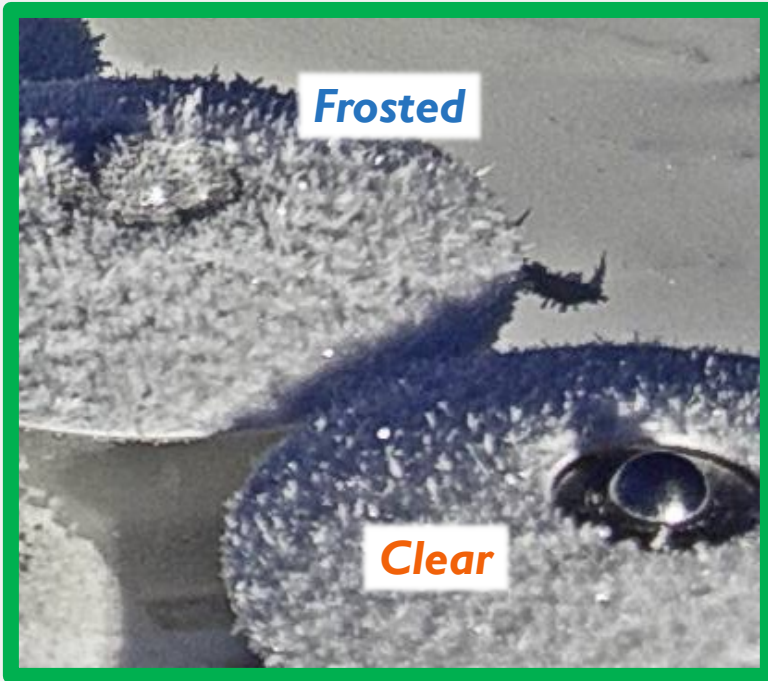


Ventilators Turned On (+8 hrs)





# EXAMPLE FROM JANUARY 2018

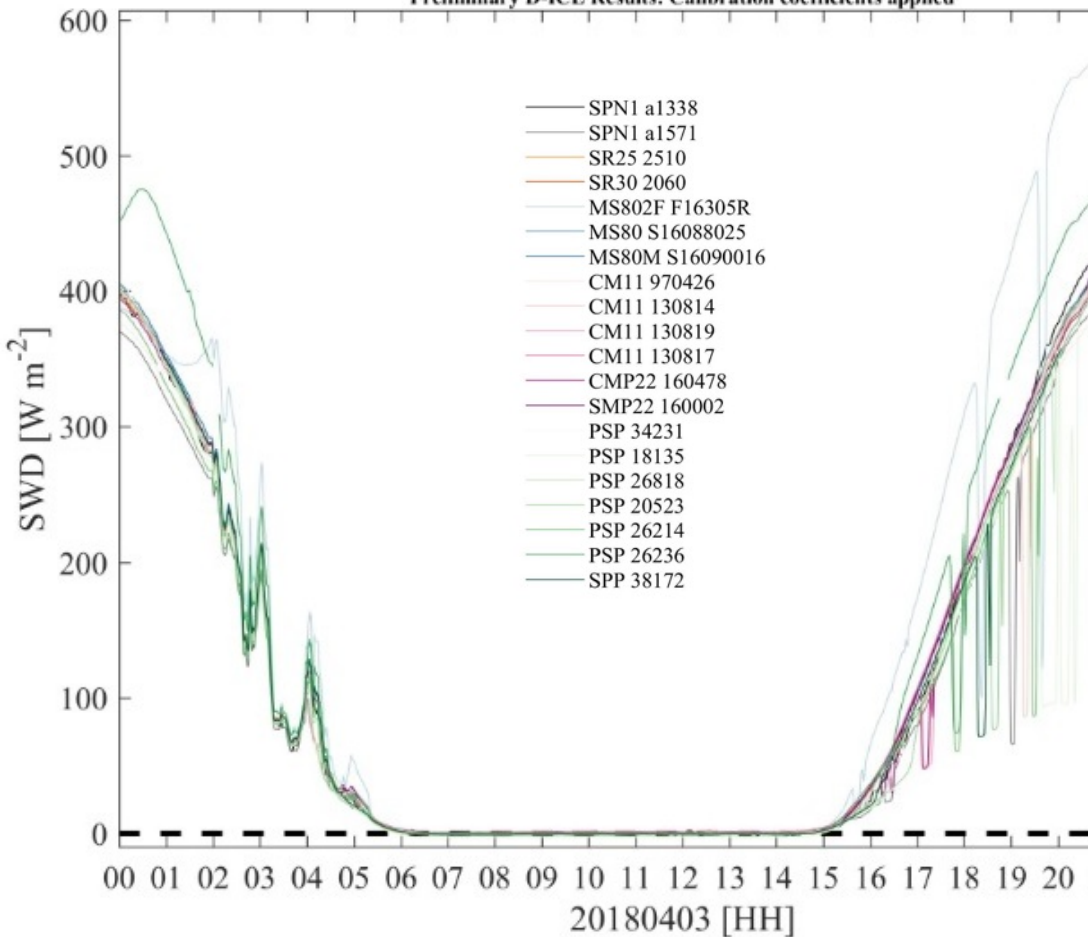


- Biases for iced pyrgometers  $\sim 50 \text{ W m}^{-2}$
- Mean LWD for Jan was  $202 \text{ W m}^{-2}$  and  $198 \text{ W m}^{-2}$ 
  - Small difference as a result of the integrated influence of cloud cover (which reduces the bias, as in the example,  $\sim 63\%$ )

# Shortwave Radiation

NOAA ESRL PSD/POP

Preliminary D-ICE Results: Calibration coefficients applied



MS802F

PSP 26236

PSP 26214

SPN a1571

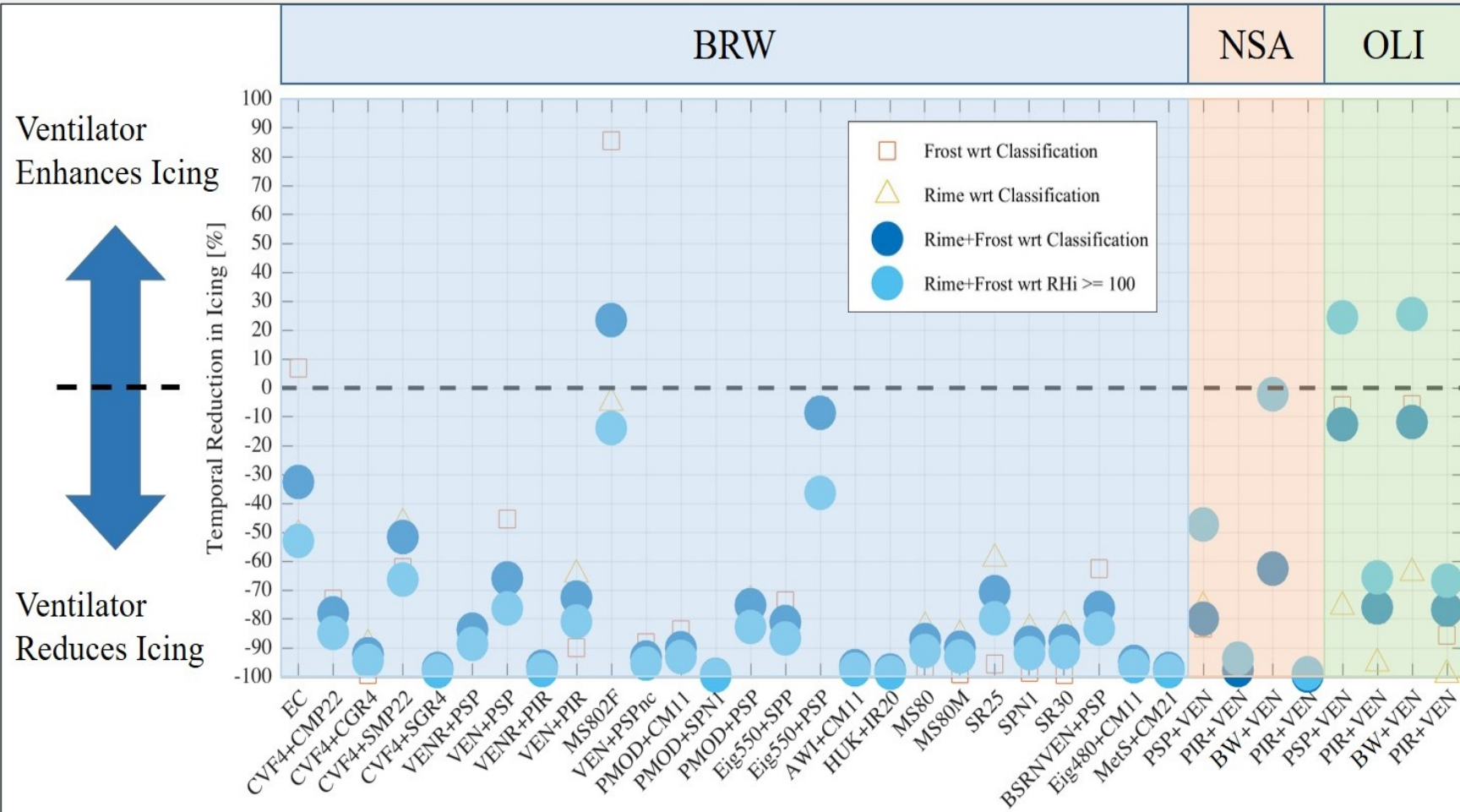
APRIL 3<sup>RD</sup>, 2018



PRELIMINARY  
SWD RESULTS



# VISUAL SCREENING



$$\bullet = \left[ \frac{t_{i\_iced}}{t_{exp\_iced}} \right] - 1$$

$t_{i\_iced}$  is the time radiometer  $i$  was iced

$t_{exp\_iced}$  is the time the natural icing condition was flagged either by classification or RH<sub>i</sub>

Dates analyzed: Nov 2017 – Feb 2018

~ 288,000 radiometer images at D-ICE

~ 53,000 radiometer images at NSA

~ 54,000 radiometer images at OLI

## Visual Screening

- Better at identifying ice on domes than classifying it (rime, frost ...) or when icing conditions occurred
- $t_{i\_iced}$  is pretty good estimate
- $t_{exp\_iced}$  more uncertain (but applied uniformly to all  $i$  at each site)

# CLEANING TECHNIQUES





## PRELIMINARY RESULTS

- Aspiration of ambient air using a ventilator is a viable option for ice mitigation
  - Average improvement against rime/frost was  $73 \pm 31\%$  amongst all systems
    - Better for pyrgeometers than pyranometers, likely due to lower-profile domes
- Additional heating is not a requirement, though effective
- Design matters!

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## **People**

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