THE DE-ICING COMPARISON EXPERIMENT (D-ICE)

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Recognition of icing as a problem for radiometric measurements and attempts to mitigate go back at least to the 1960s (e.g., Koerner et al. 1963)

Within BSRN this came up at the 2012 (Potsdam), 2014 (Bologna) and 2016 (Canberra)

And there has been previous work (DoE ARM NSA Radiometer Campaign, efforts by individual institutions and commercial firms) largely focused on ventilation/heating, though largely also independently and in parallel

Chris/Taneil and CIRES/NOAA volunteered to lead a CCIWG effort

After Canberra, in August 2016 an internal organizational meeting was held within CIRES/NOAA

- Resources (personnel, funds), location (Barrow, AK), tentative dates (2017-2018)
- In November 2016, CCIWG, BSRN and others were contacted about participation
COLLABORATORS

Institutes

Alfred Wegener Institute (AWI), Hukseflux, MeteoSwiss, EKO Instruments, Eppley, Kipp and Zonen, Delta-T, U.S. DoE Atmospheric Radiation Measurement (ARM) Program, NCAR, NOAA PSD/POP, NOAA GMD/G-Rad, and PMOD-WRC.

People

Taneil Uttal (NOAA-PSD), Chuck Long (CIRES/NOAA-GMD), Allison McComiskey (NOAA-GMD), Jim Wendell (NOAA-GMD), Emiel Hall (CIRES/NOAA-GMD), Brian Vasel (NOAA-GMD), Christine Schultz (NOAA-GMD), Andy Clarke (NOAA-GMD), Robert Albee (NOAA-PSD), Ola Persson (NOAA-PSD), Bernd Loose (AWI), Gert König-Lango (AWI, retired), Holger Schmithüsen (AWI), Jörgen Konings (Hukseflux), Matt Martinsen (NOAA-GMD), Tom Kirk (Eppley), Julian Groebner (PMOD-WRC), Steven Semmer (NCAR), Steve Oncley (NCAR), Kurt Knudeson (NCAR), Victor Cassella (Kipp & Zonen), Dick Jenkins (Delta-T), Laurent Vuilleumier (MeteoSwiss), Matt Shupe (NOAA-PSD), Will Beuttell (EKO), Johan Booth (NOAA-GMD), Nick Lewis (Univ. Colorado), Meghan Helmerger (Univ. Colorado), Martin Stuefer (UAF), Fred Helsel (Sandia), David Oaks (Sandia), Ben Bishop (Sandia), Jim Mather (PNNL), Mark Ivey (Sandia), Walter Brower (ARM), Bryan Thomas (NOAA-GMD), Kevin Olivas (STC), Amanda Looze (NOAA), Ross Burgener (NOAA-GMD) and members of the BSRN Cold Climates Issues Working Group.
De-Icing Comparison Experiment (D-ICE)
Utiqivik, Alaska: August 2017 — August 2018

About this Project

Project Leads: Christopher Cox (Phone: 303-497-4516) and John Moore (Phone: 303-497-4453)

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 using an automated alcohol washer system and 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 Utiqivik (formerly Barrow), Alaska, from August 2017 through summer 2018.

Website: https://www.esrl.noaa.gov/psd/arctic/d-ice/

Data Management Plan

- Logger #4
- Logger #5
- Logger #6
- Logger #7
- CAM#1: NW of table
- CAM#2: SE of table
- CAM #3: tracker
- Temperature
- Relative Humidity
- Wind Spd/Dir
- Icing Probe??

- “Field” computer located in Boulder
- All data types (raw, product, etc.) publically available
- Raw data/images transferred daily to webpage
- Product (cal/QC) data transferred monthly to webpage
- DICE Datagrams (metadata) available on webpage
- Archive data/images to NCEI at end of campaign
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.

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D-ICE Webpage: https://www.esrl.noaa.gov/psd/arctic/d-ice/
WELCOME TO D-ICE
CAM#2: JANUARY 28, 12 UTC
CAM#3: JANUARY 28, 12 UTC
IMPACT OF VENTILATION

Ventilators Turned Off

Ventilators Turned On (+8 hrs)
- Small modification to Eppley VEN significantly increases ice mitigation efficiency
- Biases for frosted or rimed pyrgeometers $\sim +50 \text{ W m}^{-2}$
- Reduces to near 0 W m$^{-2}$ under optically thick clouds (FCC $\sim 63\%$ during this period)
LWD icing biases: Smaller than expected!

**Unattended**
D-ICE 28507: 203.5 Wm\(^{-2}\)

**Operational**
BSRN: 202.0 Wm\(^{-2}\)
ARM-NSA: 199.5 Wm\(^{-2}\)

**Best Estimate Ice-Free**
all D-ICE: 200.1 Wm\(^{-2}\)
Shortwave Radiation
NOAA ESRL PSD/POP
Preliminary DICE Results: Calibration coefficients applied

PRELIMINARY SWD RESULTS

APRIL 3RD, 2018
Visual Screening

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

Visual Screening

$\bullet$ Better at identifying ice on domes than classifying it (rime, frost ...) or when icing conditions occurred
$\bullet$ $t_{iced}$ is pretty good estimate
$\bullet$ $t_{exp.iced}$ more uncertain (but applied uniformly to all $i$ at each site)
Aspiration of ambient air using a ventilator is a viable option for ice mitigation

- Average improvement against rime/frost was 73 ± 31% amongst all systems
- Need to identify the attributes of ventilators yield high performance
  - e.g., geometry: Better performance for pyrgeometers than pyranometers
- Need to explain the physical mechanism
- Additional heating is not likely necessary, though it is effective

- Instantaneous biases from ice of ~+50 Wm\(^{-2}\) observed in LWD and ~+150 Wm\(^{-2}\) in SWD
  - For LW, the bias in operational systems is small when averaged over time at BRW, in part because of high cloud cover
  - For SW??? TBD
- Cameras can provide useful real-time documentation of station status
CLEANING TECHNIQUES