The De-Icing Comparison Experiment (D-ICE)

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Tysons, Virginia, March 19-23, 2018
Icing of Broadband Radiometers

Could be snow, rime (contact freezing from supercooled liquid) or frost (vapor deposition)
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.

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

Two cameras on the SKYRAD systems at NSA and OLI: 10 min images

North Slope of Alaska (NSA), Oliktok Point (OLI)

Eppley PSP, PIR, BW, PIR
VEN housing
15 W heater coils
3 adhesive pads (on OLI PSP only)
Fans: Delta Electronics 4.1 W (55 cfm)
Biases for iced pyrgeometers were $\sim 50 \text{ W m}^{-2}$, yet the mean LWD for Jan was $202 \text{ W m}^{-2}$ and $198 \text{ W m}^{-2}$, 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!
$y[\%] = \left[ \frac{t_{i,\text{iced}}}{t_{\text{exp,iced}}} - 1 \right] \times 100$

$t_{i,\text{iced}}$ is the time radiometer $i$ was iced.

$t_{\text{exp,iced}}$ is the time the natural icing condition was flagged either by classification or rhi.

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
  - $t_{i,\text{iced}}$ is pretty good estimate
  - $t_{\text{exp,iced}}$ more uncertain (but applied uniformly to all $i$ at each site.)
Preliminary Conclusions

• The data supports the hypothesis that aspiration of ambient air using a ventilator is a viable option for ice mitigation

• Additional heating is not a requirement, though it is effective

• Subtleties in the design matter

• ARM ventilation system:
  • More effective for pyrgeometers than pyranometers
  • OLI system likely less effective than NSA system
Acknowledgements

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 Global Monitoring Division, and PMOD-WRC.

People

Taneil Uttal (NOAA-PSD), Chuck Long (CIRES/NOAA-GMD), Allison McComiskey (NOAA-GMD), Johan Booth (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), Nick Lewis (Univ. Colorado), Meghan Helmberger (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), Ross Burgener (NOAA-GMD) and members of the BSRN Cold Climates Issues Working Group.
Near the peak of an extended freezing fog event ~ -10°C, Rhi > 100%
- During Eureka winter, frost builds on the domes slowly over ~12 hours under radiatively clear skies.
- Growth curves punctuated by daily manual cleaning reveals the iced conditions,
  - 20-30 Wm\(^{-2}\) bias
  - Within the intermediate range of LWD conditions.
Ventilators turned off

Back on + 8 hours
### Instrument Details

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