Evaluation of the Performance of a Rosemount Icing Detector During IMPACTS 2020

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Introduction

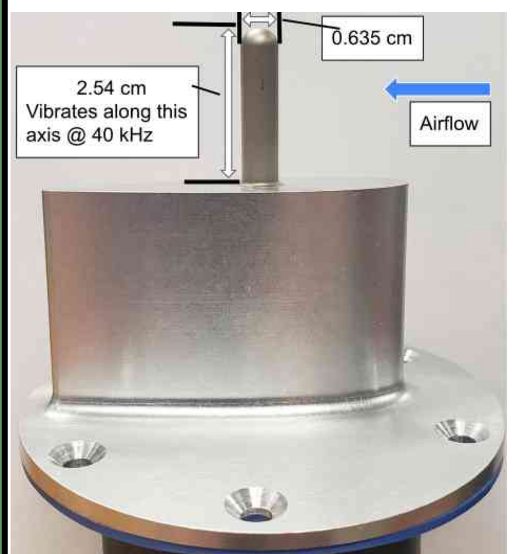
The Rosemount Icing Detector (RICE) is an oscillating icing rod that was deployed on the fuselage of the NASA P-3 during IMPACTS 2020. During the project, flight scientists had real time access to the raw frequency plot as a qualitative measure of the presence of supercooled liquid water (SLW). For quantitative liquid water content (LWC) measurements, flight scientists had to rely on the King Liquid Water Sensor (King Probe) and the Cloud Droplet Probe (CDP). A derived supercooled liquid water content (SLWC) product is generated for the first time with the model 0871ND4 RICE. The derived SLWC product is then analyzed under a variety of conditions to evaluate the performance of the product.

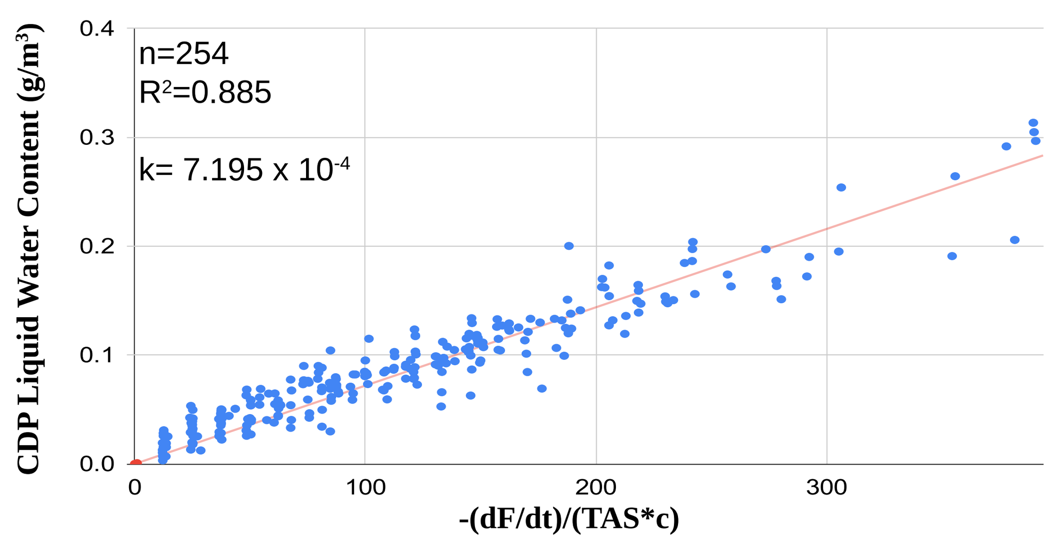
SLWC Product Generation

The RICE Probe (shown below, left) SLWC product is derived by comparing the change in frequency to the liquid water content from the CDP in ice-free conditions. The times that the RICE Probe's deicing heater was tripped were recorded, and initial cases were defined as the time before the heater trip when the frequency dropped below 40 kHz until 3 seconds before the frequency sharply returned to 40 kHz. The initial cases were narrowed down to SLW-only cases by assuming SLW phase when the 2D-S images were mostly spherical, particles >100 µm in diameter were at concentrations <10^4 m^{-3}, mean volume diameter was under 50 µm, and temperatures were <-5 ℃. With the remaining cases assumed to be SLW only, the CDP LWC is smoothed over 3 second time periods and the RICE Probe's derived SLWC is calculated by the following equation from Mazin et al. (2001):

$$SLWC = \frac{\frac{-dF}{dt} \cdot k}{2 \cdot R_c \cdot l \cdot TAS}, \qquad (1)$$

where -dF/dt is the negative change in frequency over time, TAS is the True Air Speed, and R_c and l are the radius and the length of the RICE Probe respectively. The k constant is found by making a scatter plot of the RICE Probe signal and CDP LWC and forcing a trend line through the origin, with k being the slope of that trend line (plot below, right).



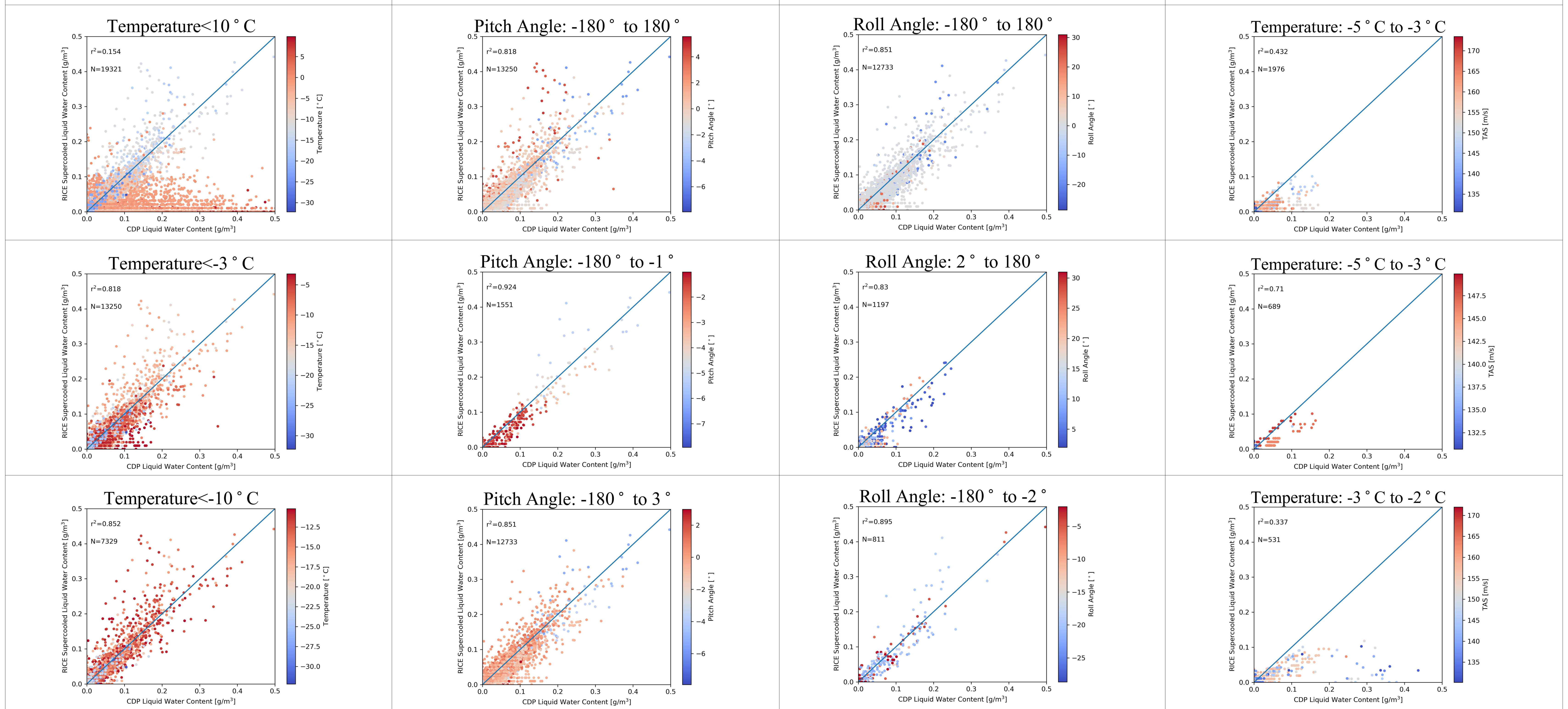


Objective: The RICE Probe's derived SLWC product is evaluated for different environments.

Conclusions

The RICE Probe derived SLWC product is a valid product when operating at temperatures colder than -3 ℃ and with a pitch angle less than 3°. The addition of the RICE Probe derived SLWC product adds redundancy in case of instrument failure from other LWC probes. Additionally, the RICE Probe has potential to perform better in mixed phase conditions because the RICE Probe is insensitive to ice particles.

Environment Analysis



Data gathered over the four flights where both the CDP and RICE Probe were fully operational from 01/25/20 to 02/07/20.

Future Work

Future work in the coming months will focus on the effect of total concentration and mean volume diameter in order to test if the RICE Probe has a reduction in performance with varying particle concentrations or with varying particle sizes.

Acknowledgments and References

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Mazin, I. P., A. V. Korolev, A. Heymsfield, G. A. Isaac, and S. G. Cober, 2001: Thermodynamics of Icing Cylinder for Measurements of Liquid Water Content in Supercooled Clouds. J. Atmospheric Ocean. Technol., 18, 543–558, https://doi.org/10.1175/1520-0426(2001)018<0543:TOICFM>2.0.CO;2.