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National Research Council Canada Status Update

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lational Research Conseil national de Council Canada recherches Canada WINTRE-MIX project meeting



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Outline

- Data updates
- Calibration updates
- NRC research
 - NAWX
 - Aerosol
 - Icing conditions
 - Image analysis

Data Delivery

- All preliminary aircraft data delivered to co-PIs
- Detailed flight reports linked on EOL
- Most of 'final' aircraft datasets uploaded to EOL
 - 'Microphysics' dataset uploaded
 - Radar dataset will be uploaded this month as its structure was decided last week
- Dataset corrections will be uploaded in the coming months.

Some minor errors has been identified and will be fixed in the next version. <u>If you find any errors please let us know!</u>

Aerosol Calibration updates

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outstanding calibrations were completed with Fullerene sootstandard aerosol for SP2 Dec 2022

and with ammonium sulphate aerosol for CCNc





Single Particle Soot Photometer (SP2)

Cloud Condensation Nuclei Counter

Intercomparison analyses at the NRC Altitude Icing Wind Tunnel (AIWT) Nov 2022



Next month NRC will be releasing a Laboratory Technical Report on Hot-Wire probe data analysis.

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Research progress, plans, ideas for collaboration

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Radar waveforms used in WINTRE-MIX



Doppler unfolding processing

- Use of external wind data (need high temporal/spatial data and closely coincident with NAWX data)
- Apply Chinese Remainder Theorem (CRT) to NAW and NAX data



- NAW aft antenna polarimetric staggered-PRT 2/3: 19.9 m/s
- NAW aft stg-PRT (up position) (19.9 m/s) and NAX zenith (13.26 m/s) (~ 2/3 PRT): 40 m/s
- NAW nadir (9.9 m/s) and NAX nadir (13.26 m/s) (~ 3/4 PRT): 39.68 m/s

$$v_a = \frac{v_a^{f1} v_a^{f2}}{\left|v_a^{f1} - v_a^{f2}\right|}$$



Example: RF04 (IOP05)





Example: RF04 (IOP05)



Example: RF06 (IOP08)

15:08:00

15:09:00

15:10:00

15:11:00

15:12:00

Date 03/06/2022, UTC time

15:04:00



15:14:00

15:13:00

15:15:00

15:16:00

15:17:00

15:18:00 15:19:00

15:20:00



Example: RF06 (IOP08)



Future research topics

 Investigate the use of W-band Polarization Diversity Pulse Pair (PDPP) technique to measure very high Doppler velocity at off nadir direction and its use in dual-Doppler technique.



- W-band radar attenuation in midlatitude snowstorm.
 - Taking the advantages of WINTRE-MIX flight patterns and dual antenna beams (nadir and down-fore) configuration





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Aerosol

CVI (Counter-flow Virtual Impactor) for residual aerosol characterization





Critical to the examination of field data is the quantification of the "enhancement factor" (EF) as a result of the ambient aerosol concentration in the CVI inlet according to the following equation: (Shingler, et al., 2012)

$$EF = A_{tip} [m^2] \times TAS_{aircraft} [m/s] / q_{sample} [L/min]$$

 $N_{true} = N_{meas} \times Transms_eff(D) / EF$

How drop breakup and transmission efficiency affect the measurements?

Aerosol measurements

- F01-F04 (IOP1-IOP5) only wing UHSAS aerosol data were collected
- CVI became operational starting from F05 (IOP7) till the last flight (IOP10)
- Due to the high interest in precipitation and clouds, we had a tiny portion of clear-air flight time and in most of the flights only residual aerosol data were collected.



Aerosol to Hazardous icing (app. C)

A case of aerosol activation/growth into hazardous (*appendix C*/small drops/ MVD<50 µm) icing conditions observed just outside of the ROI on RTB (F05 00:30-01:00).

Project:WINTRF-MIX NRC Convair-580 F#:05 Probe:2DS-H Sample Images 2022-03-02Scale: 100µ: ↦ 1mm:

2DS: 10 µm images only (single pixel) CVI inlet: hydrometeors are just above the cut-off diameter (8 µm) of the CVI. (i.e. not all sampled)



RID detected the most intense portion of icing in this flight segment (Dither algorithm)

- At ~2.5 km (8 kft) altitude (i.e. CPC readings are still valid)
- Ts ~ -15 °C, 100% saturated air
- LWC up to 0.3 g m⁻³

Heavy icing observed on PICTUR



Aerosol activation

The size of the residual aerosol from droplets (CVI) was twice bigger than the ۲ interstitial aerosol measured with wing-UHSAS.



Sample flow

- The smaller aerosol, if activated, did not grow droplets above the CVI cut-off diameter (8 µm) and therefore was not sampled.
- With this dried aerosol residuals we observed ~50% reactivation in CCNc @SS_w 0.3%

 $(CCN/UHSAS=50xP_{out}/P_{CPI}/120=50*720/600/120 = ~50\%)$

Aerosol sampling Enhancement factor



- The cloud scattering probes indicate Median Volume Diameter (MVD) of ~10 µm,
 i.e. ~60% of droplets are sized between 2 to 8 µm and therefore were not sampled via the CVI but contributed to Appendix C icing.
- Enhancement factor calculated using parameterization is ~5.4 close to the factor observed comparing the sampled small SLD vs. residual aerosol.

Icing Research update

NRC PICTUR (Platform for Ice-accretion and Coatings Tests with Ultrasonic Readings)



Testing of NRC icing detection technologies and anti-icing solutions on a new platform (planned in the NSF proposal)





20:39:50

20:42:43

20:31:12

20:34:05

20:36:58





Higher efficiency in FZRA

Leonid Nichman, Dan Fuleki, Naiheng Song, Ali Benmeddour, Mengistu Wolde, David Orchard, Edgar Matida, Kenny Bala, Zhigang Sun, Natalia Bliankinshtein, Keyvan Ranjbar, Stephanie DiVito: Airborne Platform for Ice-accretion and Coatings Tests with Ultrasonic Readings (PICTUR), SAE Icing conference, Vienna, submitted, 2023.



Software development for Microphysics data analysis

- Bala, K., Freer, M., Bliankinshtein, N., Nichman, L., Shilin, S. and Wolde, M.: Standardized Imaging Probe Format and Algorithms: Implementation and Applications, 18th International Conference on Clouds and Precipitation (ICCP), Pune, India, 2-6 August, (2021), https://iccp2021.ipostersessions.com/?s=7A-38-B1-D9-4B-35-A1-44-9F-91-65-67-63-C3-06-88.
- NRC Single Particle Image Format (SPIF) conversion utility, <u>https://doi.org/10.4224/40002712</u>, 2021
- Image classification (CNN / unsupervised ML /classical Holroyd etc.)
- Development of tools with a user friendly GUI for data viewing

Thank you

