In-Cloud Icing and Large-Drop Experiment (ICICLE) 2019

G-band radiometer data

Prepared by: N. Bliankinshtein

National Research Council Canada

Contacts: data editor[1] Natalia.Bliankinshtein@nrc-cnrc.gc.ca,

NRC Project PI Mengistu.Wolde@nrc-cnrc.gc.ca

Document last updated: July 9, 2020

Data ver.: 3.0 (July 9, 2020)

Data level: 2 ("final complete data set of measured and retrieved parameters with quality control flag")

General notes

- These are the datasets acquired between January and March 2019 during the ICICLE project based out of Rockford, Illinois (USA).
- The G-band water vapor radiometer (GVR) was designed by ProSensing, its first airborne installation was in 2007 on the NRC Convair-580 (Pazmany and Wolde, 2008). The instrument currently belongs to ECCC.
- During ICICLE, the GVR was installed in the starboard aft wingtip pod on the NRC Convair-580, see Fig 1.
- The GVR primary output are zenith-looking brightness temperatures in four spectral channels (183.31 ±1, ±3, ±7 and ± 14 GHz), from which liquid water path (LWP) and precipitable water vapor (PWV)[2] are retrieved with a Neural Network algorithm (Pazmany, 2007; Cadeddu et. al., 2007).
- The GVR retrieval algorithm is provided by ProSensing and used as a "black box", without modifications from NRC or ECCC. Additionally, the data has been assessed for basic quality by NRC, e.g. to control for periods of instrument power off and thus eliminate meaningless data. Whenever the instrument operates normally, data is presumed of good quality, see *Data quality* section below. No additional processing or correction of the data is planned.
- Basic geolocation information (latitude, longitude, altitude) and aircraft attitude (roll, pitch, and heading) are provided, as well as static temperature and static pressure.

Structure of data files

The data is provided in a NetCDF format, follows NCAR-RAF convention and is compatible with ncplot tool. It is also accompanied by interactive quicklooks in an html format which are generated with Python *plotly* library. For a sample file structure see the accompanying GVR_L2.cdl file.

---

1 As per EOL Archive Authorship guidelines

2 PWV and LWP are integrals over the atmospheric column above the aircraft of the vertical distribution of water vapor density ($PWV=\int \rho_V(z)dz$) and of the vertical distribution of cloud liquid water content ($LWP=\int w(z)dz$) respectively. Here they are normalized by the nominal density of liquid water, 10^6 g/m3, and PWV is expressed in centimeters and LWP in millimeters.

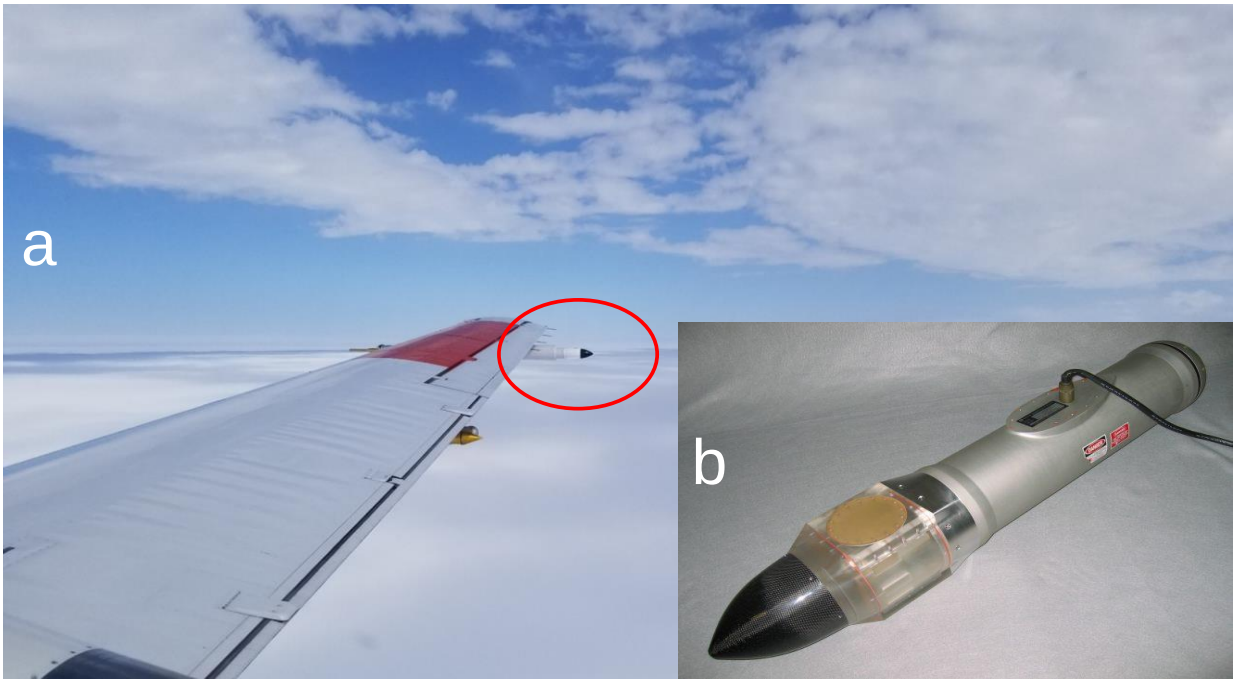

Figure 1. a) GVR installed in the starboard aft wingtip pod on the NRC Convair-580. Photo credit: NRC b) The G-band radiometer (GVR). Photo credit: ProSensing.

Instrument limitations

- The GVR is designed for relatively dry atmospheres because of the high opacity of the 183 GHz absorption line. Therefore GVR is sensitive to PWV up to about 5 mm, after which the spectrum begins to saturate. The Neural Net retrievals extend to LWP up to 0.55 mm and PWV up to 16 mm.
- In the brightness temperature data, unrealistic negative values may appear which are artifacts. These happen, however, under very low water vapor or liquid water amounts and yield negligible error in LWP or PWV. Therefore such instances are deemed of good quality.
- The GVR was found to interfere with avionics equipment and therefore is not operated at take-off and landing as a safety measure. Similarly, GVR is shut down during missed approach maneuvers below certain altitude.
- Additionally, some periods of data during ICICLE were lost due to minor power interruption.

Data availability

The GVR was installed on all flights of the ICICLE mission and operated normally on most of them. The duration of GVR record during ICICLE flights is shown in Table 1.

Flight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Duration	1:37	3:41	3:09	3:44	3:51	3:46	4:01	3:45	3:42	2:10	3:31	3:11	2:26	4:08	4:13	
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total hours:
	4:04	3:49	2:33	4:44	4:08	3:42	4:03	2:24	3:56	4:22	4:12	3:35	4:12	4:51	2:48	108:31

Table 1. ICICLE GVR data record by flight. Green: good quality, no interruptions. Light green: good quality, some interruptions.

For several flights (e.g. 01, 03, 10, 18, 23), GVR power was off at the beginning/end of the flight for longer than necessary. Also, the flights shown in light green in the table experienced power outages of different duration.

Data quality

The data rate of GVR is approximately 1/7 Hz, i.e. one data point every 7 seconds (sometimes 6 or 8 seconds). The NetCDF files are provided at 1 Hz, with missing points indicated as “calibration cycle” (data flag value 4).

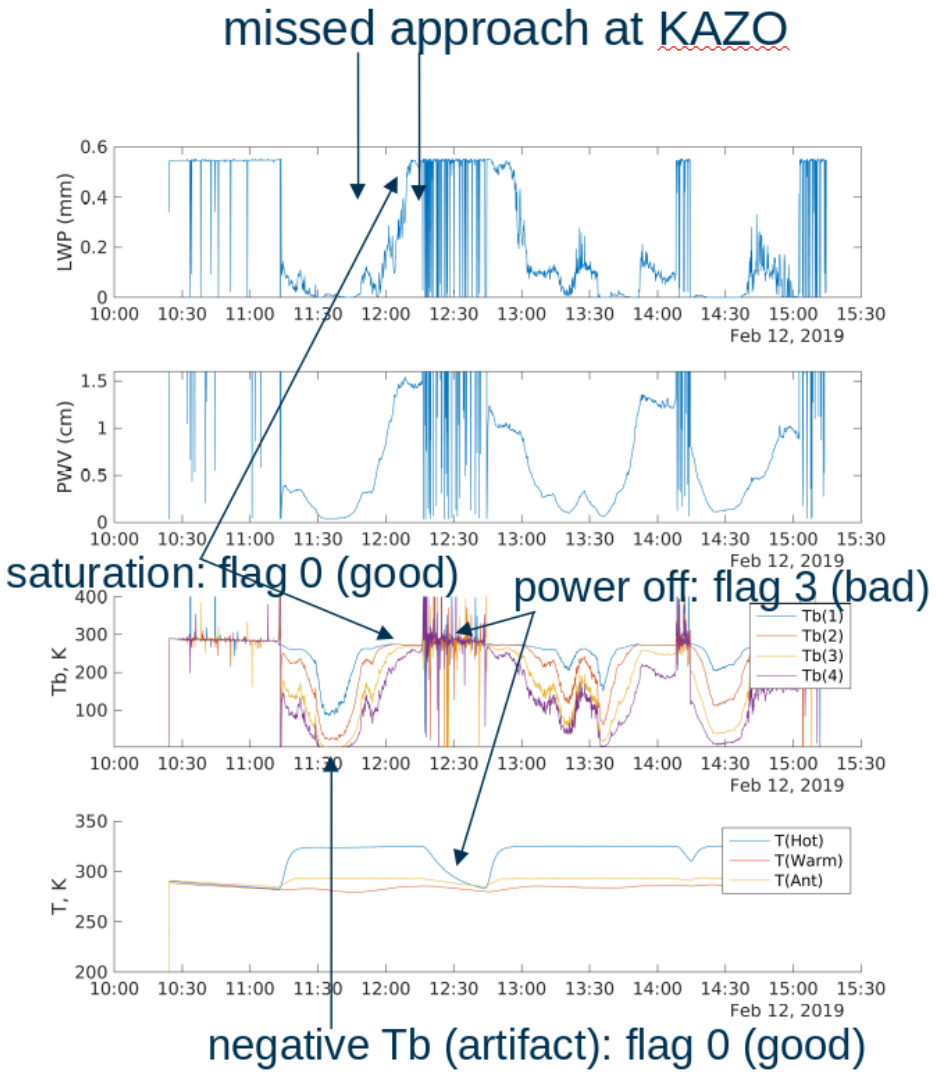

Figure 2a. Example of GVR data during Flight 12 of ICICLE with possible issues labeled.

Brightness temperatures and retrieved quantities are meaningless during power outages and biased for short periods after power recovery (approximately 5 min while the hot calibration load warms up). Such instances are marked as Data flag value 3 - “bad data”.

The rest of the data is deemed of good quality – data flag 0. It should be noted that while “good” retrieved LWP and PWV can be used for qualitative assessment of the environment, specific use of the quantitative values requires a closer scrutiny. For example, the retrievals do not account for varying aircraft attitude (roll and pitch). Also, saturated profiles, where the retrieved LWP and PWV are likely capped, are not labeled in this data product.

Fig. 2a shows examples of saturation, power interruption and recovery, and artificially negative brightness temperatures. Fig. 2b shows an example of plotting LWP and PWV profiles against the altitude data to obtain a (pseudo-) profile, from which the vertical distributions of water vapor density and of cloud liquid water content can be inferred (keeping in mind the aircraft's horizontal displacement and maneuvers during the descent).

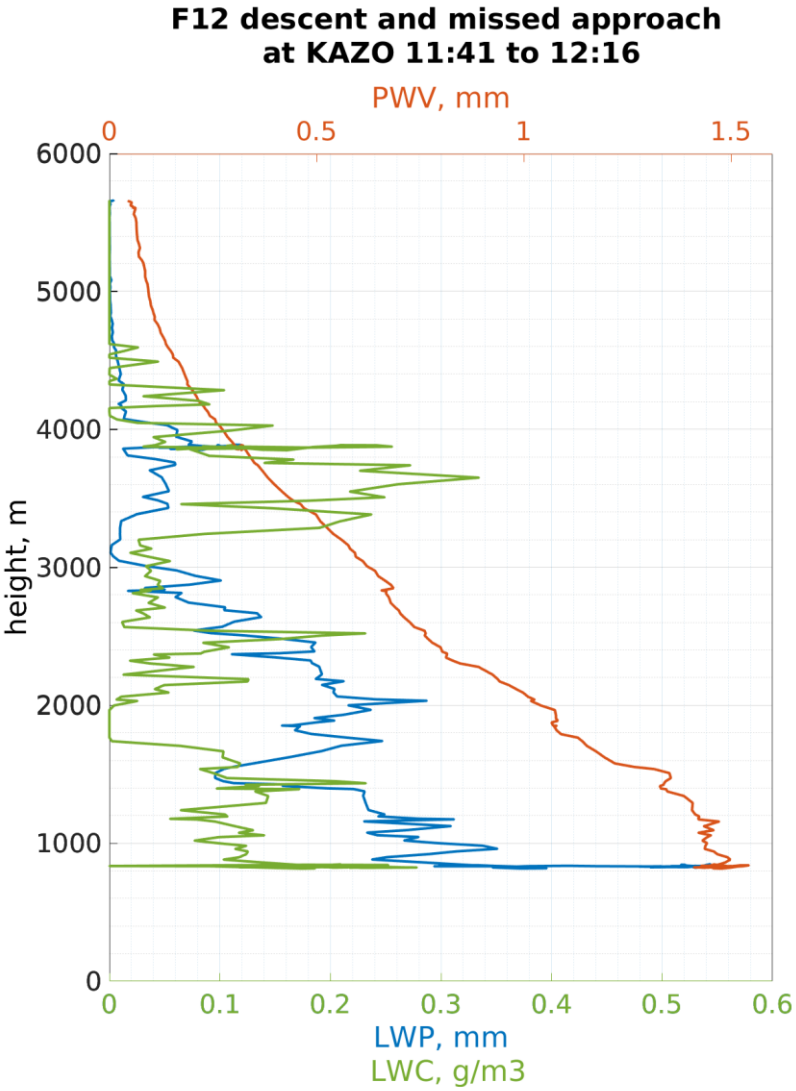

Figure 2b. Example of GVR pseudo-profile data during a missed approach at KAZO in Flight 12. Liquid water content (LWC) profile comes from Nevzorov probe (preliminary quality) data record.

Distribution and Publication

Preliminary data distribution and data use for publications follow the data policy agreed upon by the NRC, ECCC and FAA. We request that the NRC is notified for any data distribution to 3rd parties before the public release. Dr. Mengistu Wolde is the point of contact for such requests.

References

Pazmany, A. L. 2007: **"A compact 183-GHz radiometer for water vapor and liquid water sensing."** IEEE Trans. Geosci.. Remote Sens. Vol. 45, No. 7, pp. 2202-2206, July 2007. https://doi.org/10.1109/TGRS.2006.888104

Pazmany A. L. and M. Wolde 2008: **"A Compact Airborne G-band (183 GHz) Water Vapor Radiometer and Retrievals of Liquid Cloud Parameters from Coincident Radiometer and Millimeter Wave Radar Measurements."** Extended Abstract, Microrad 2008, Florence, Italy.

Cadeddu, M. P., J. C. Liljegren and A. L. Pazmany 2007: **"Measurements and retrievals from a new 183-GHz water-vapor radiometer in the Arctic."** Trans. Geosci. and Remote Sensing, 45, 7, 2207-2215. https://doi.org/10.1109/MICRAD.2006.1677098