Title: Final Ice Water Content from the Isokinetic Probe (IKP2)

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Data Set Description:

The data for 10 HIWC-2022 flights are provided to NASA as per the contract, as the intended final IKP2 TWC dataset for use by the community. The data are provided in a similar format as was used for HIWC RADAR 2. Each file contains the IKP2 5-second center averaged TWC data for each second of each flight, restricted to times containing data of acceptable quality (usually for all data colder than -10 C). The increase in the IKP2 out-of-cloud noise level due to the fore-mentioned issues with BWV removal is usually the limiting factor (Strapp et al. 2016). This revision of data is version 6. The ten data file names are:

220708-HIWC2022-DC8-IKPTWC-v6.csv
220710-HIWC2022-DC8-IKPTWC-v6.csv
220714-HIWC2022-DC8-IKPTWC-v6.csv
220716-HIWC2022-DC8-IKPTWC-v6.csv
220718-HIWC2022-DC8-IKPTWC-v6.csv
220722-HIWC2022-DC8-IKPTWC-v6.csv
220724-HIWC2022-DC8-IKPTWC-v6.csv
220726-HIWC2022-DC8-IKPTWC-v6.csv
220727-HIWC2022-DC8-IKPTWC-v6.csv
220730-HIWC2022-DC8-IKPTWC-v6.csv

Instrument Description:
The Isokinetic Evaporator (IKP2) was the reference instrument for cloud TWC measurements for the two HAIC-HIWC campaigns and the two HIWC-RADAR campaigns. Details can be found in Strapp et al (2016).

Data Collection and Processing:

During the period of 8-Jul-2022 to 30-Jul-2022 the NASA/FAA HIWC-2022 flight campaign collected data during 10 flights over 10 different days. The numbering of the flights delivered starts at flight three, with flight one being a test flight out of Palmdale, and flight two being the transit to Jacksonville. Neither of these first two flights collected data useful for the campaign analysis. All flight focused on measurements in and around deep convective clouds and surrounding towering cumulus. The NASA DC-8 aircraft was instrumented with a variety of cloud measuring instruments that included the Isokinetic Evaporator (IKP2), which was also the reference instrument for cloud TWC measurements for the two HAIC-HIWC campaigns and the two HIWC-RADAR campaigns.

The IKP2 TWC values were recalculated postflight from the aircraft state parameters, the synchronized and normalized WV concentrations, and IKP2 raw measurements. The aircraft state parameters were edited by Tom Ratvasky of the NASA Glenn Research Center (GRC), and pasted into the existing dataset for IKP2 TWC analysis. These values were corrected GRC

during the several pitot anomalies. Similarly, updated post campaign DLH data were pasted into the existing dataset. The DLH was used exclusively as the BWV value in the earlier draft data distribution Version 5c of the IKP2 dataset. For this final dataset, the method of background water vapour (BWV) subtraction for the IKP2 TWC analysis was compatible with the HAIC-HIWC and HIWC RADAR I datasets. The best hygrometer BWV was used at the edges of cloud, and calculations of ice saturation vapour concentrations were used in the interior of the cloud. This hybrid BWV is explained in more detail in Strapp (2023). Since DLH in-cloud concentrations were very close to ice saturation values, an alternate calculation based on the DLH BWV through the entire cloud would yield almost the same IKP2 TWC values. This will be quantified in a future report.

The equations used to derive IKP2 TWC have been summarized in Davison et al. (2016). For IKP2 flowrate calculation, the temperature, static pressure, and airspeed values were those selected to be free of anomalies, as noted above. TWC values were corrected for the ratio of measured to isokinetic flow (XKF). LiCor water vapour values were those output by the instruments in units of ppmw.

Although one-second IKP2 TWC values were computed for the campaign, these will not be distributed, and the five-second centered-average values provided should be the values used by the HIWC team. This is due to an overshoot/undershoot issue with the Licors during large step changes.

Data Format:

The data are in comma-delimited text format. At the beginning each file and there is a 20-line header, such as the following from Flight #3:

Flight Date: 08-Jul-22
Flight 3
Project Name: HIWC-2022
Version 6
Intended Final IKP2 TWC distribution release 6-Jun-2023
M300time =IRIGB time recorded on M300 data system in hh:mm:ss
M300Timesecs= M300time expressed as seconds since midnight
Paltftuse=final campaign pressure altitude in feet
Psmbuse= final campaign static pressure in mb
SATCuse= final campaign static air temperature in degrees C
TATCuse= final campaign total air temperature in degrees C
TASmpsuse= final campaign true airspeed in meters per second
IKPTWC5s= final campaign IKP TWC values, 5 second centered-average every 1 second, Strapp variable name is XKIDALT05s
Notes on IKP2 TWC:
IKPTWC5sgm3 filtered using to include values when SAT < ~-10 C due to increasing baseline noise for warmer temperatures
Uses hybrid BWV from final DLH and ice saturation background water vapours (BWVs) as per previous Appendix D datasets.
Cloud edge switchover from DLH to ice saturation for hybrid BWV at ~0.2 gm-3
No surrogate IKP TWC values required for HIWC2022. IKP2 always functioned in cloud.

M300Time,M300Timesecs,Paltftuse,Psmbuse,SATCuse,TATCuse,TASmpsuse,IKPTWC5sgm3

The legend for each column (parameter) in the files is given in Table 1.

Table 1. Summary of parameters provided in HIWC-2022 Draft IKP2 TWC data set distribution, version 5c.

Parameter	Units	Description
M300time	UTC	IRIGB time recorded on M300 data system in hh:mm:ss
M300Timesecs	Seconds	M300time expressed as seconds after midnight
Paltftuse	Ft	Official campaign Pressure Altitude, from post-campaign MetNav dataset, or as fixed by NASA GRC for anomalies
Psmbuse	Mb	Official campaign Static Pressure chosen to circumvent anomalies (usually MetNav ADC2)
SATCuse	C	Official campaign Static Air Temperature, calculated post-campaign by NASA GRC from Boeing probe measurements. Free from anomalies
TATCuse	C	Official campaign Total Air Temperature, calculated post-campaign by NASA GRC from Boeing probe measurements. Free from anomalies
TASmpsuse	m/s	Official campaign True airspeed (usually ADC2), with special treatment by NASA GRC during anomalies
IKPTWC5sgm3	gm^{-3}	Final IKP2 TWC, 5 second center averaged value at 1 second intervals. Low-altitude value blanked out due to increasing background water vapour noise at warmer temperatures.

Data Remarks: This is intended as the final IKP2 TWC dataset.

References:

- Davison, C. R., Strapp, J. W., Lilie, L., Ratvasky, T. P., and Dumont, C., " Isokinetic TWC Evaporator Probe: Calculations and Systemic Error Analysis", 2016, *8th AIAA Atmospheric and Space Environments Conference*, June 17, 2016, Washington, DC. AIAA-4060. http://dx.doi.org/10.2514/6.2016-4060

- Diskin, G.S.; Podolske, J.R.; Sachse, G.W.; and Slate, T.A.: "Open-Path Airborne Tunable Diode Laser Hygrometer," in Diode Lasers and Applications in Atmospheric Sensing, SPIE Proceedings 4817, A. Fried, editor, 196-204 (2002).

- Strapp, J.W., Lilie, L.E., Ratvasky, T.P., Davison, C.R., and C. Dumont, 2016. Isokinetic TWC Evaporator Probe: Development of the IKP2 and Performance Testing for the

HAIC-HIWC Darwin 2014 and Cayenne Field Campaigns, *8th AIAA Atmospheric and Space Environments Conference, AIAA*

- Strapp, J.W., "Delivery of HIWC-2022 Post-Campaign DC-8 Final IKP2 Total Water Content Data Set", unpublished FAA contract report, 7-Jun-2023, 114 pp, 2023.

Appendix: None