**Documentation for IKP Version 4 Data Set:**

## 1. Introduction

This data set contains a quality controlled data set of the Isokinetic Evaporator probe (IKP2).

The data set includes a number of SAFIRE-provided state parameters for context. The data come from the 1-second files provided by SAFIRE, with the filenames of the form such as the following for flight 6, 23-Jan-14.

F20_1Hz-HAIC_base_aipov_v2_20140123_fs140006.txt

## 2. Variable List

The following describes the variable in the comma-delimited file:

| Variable | Description | Units |
|---|---|---|
| Stimech | Time in hh:mm:ss format | UTC |
| Slat | Latitude | Decimal degrees (south negative) |
| Slong | Longitude | Decimal degrees East |
| SIAltm | SAFIRE-provided Altitude from INS | meters |
| SINShead | SAFIRE-provided heading from INS | Degrees True |
| Spress | Pressure calculated from pressure altitude by M300 | Mb |
| SSAT | SAFIRE-provided Altitude from INS | Degrees C |
| STAT | SAFIRE-provided Static Air Temperature | Degrees C |
| SRHWVSS | SAFIRE-provided Relative Humidity from WVSS-2 | Percent |
| STAS | SAFIRE-provided true air speed | $ms^{-1}$ |
| Szaccg | SAFIRE-provided vertical acceleration from INS | G |
| Swdir | SAFIRE-provided wind direction | Degree True |
| Swspd | SAFIRE-provided wind speed | $ms^{-1}$ |
| XKBZRgm3 | IKP condensed water content, version 4 | $gm^{-3}$ |

## 3. Description of preparation of IKP data set

The IKP data set was prepared between over the months of April-July 2014. The following is a general description of the steps in preparing the data:

- Comma-delimited ASCII files were run by SEA and provided to Strapp. These contained a series of variables calculated by the real-time data system, and re-run in M300 PLAYBACK mode after the project. The file contained all of the data required to recompute the derived parameters independently from the M300 calculations.
- Strapp visited SEA in June 2014 and re-ran the IKP Licor and background Licor highest frequency data (2 Hz), and the WVSS-2 highest frequency data (1 per 2.2 seconds), collectively called hereafter the ‘humidity’ data.
- The humidity data were reprocessed into 1-second interpolated values using user-written computer programs. Since the three humidity systems were not synchronized, the data were first interpolated to one second values starting on the even second. Then, a section of each flight where humidity varied quickly were examined to determine the phase difference between the different humidity measurements. If differences were observed, the WVSS-2 and/or background Licor measurement times were adjusted to coincide in phase as best as possible (1 second) with the IKP Licor measurements.
- The new interpolated 1-second humidity measurements were manually pasted back into the original comma-delimited ASCII files run by SEA using Microsoft EXCEL.
- A user-written program was developed to merge the SEA comma-delimited files with the SAFIRE quality-controlled state parameter files, recalculate IKP values, and various other parameters required for the processing. This will hereafter be referred to as the ‘IKP re-processing’ routine.
- It was necessary to remove background humidity from the IKP measurements. This was the most time consuming part of the effort, and was largely a manual operation. All three humidity measurements (IKP, background LICOR, and WVSS-2) drifted in clear air, or were subject to time-varying baseline signals for a variety of reasons (wetting of air lines, calibration effects at low pressure, etc.)
    - For cloud-free periods, the approach was to observe the ppmw difference between the IKP and the best background humidity measurement (which varied by flight and even during a flight), and apply it to clear-air portions to attempt to ‘zero’ the IKP. These difference-values were taken by manual inspection at time periods when it was concluded that the aircraft was in relatively cloud-free air, and stored in a text file for later reading by the IKP re-processing routine. For times between these discrete values, ppmw differences were inferred by interpolation.
    - For periods when the aircraft was inside significant ice cloud, ice saturation was assumed. Due to some drift in the IKP Licor, again it was necessary to adjust the baseline to ensure that the IKP Licor measured ice saturation in very low IWC cloud . This again was accomplished manually, by observing the peripheral regions of clouds where the IWC was very low, and assuming that the cloud was at ice saturation in those

regions. The IKP Licor measures vapour + condensate, so it was necessary to search for cloud areas where the condensate was negligible to determine the offset of the IKP Licor from the ice saturation value.

  - It was not possible to assume ice saturation in regions between clouds, because the air was often sub-saturated. Doing so would result in negative IKP IWCs between clouds. It was therefore necessary to switch to either the WVSS-2 or the background LICOR between clouds, again applying an estimated offset ppmw correction. Occasionally there are very short periods of out-of-cloud exposures that could not be switched to a background humidity measurement for practical reasons, and negative IWC values may appear in these cases. It is important to note that these are probably not indicative of an unresolved baseline bias in the IWC, but are more likely due to the IKP calculation subtracting too large a background (ice saturation) in sub-saturated air.
  - The reasons for not using background humidity measurements while in cloud are as follows. The WVSS-2 clearly ingests ice crystals and gives erroneously high background humidity readings in cloud. It is not clear yet whether the background Licor is also contaminated by ice crystals, but our preliminary conclusion is that it may be. In order to provide a data set with a defensible definition, it was deemed preferable to assume ice saturation pending further research on the quality of the background Licor measurements in high-IWC cloud. The effect in both cases would be to underestimate the true IWC in cloud, in some cases by a relatively large amount. In general, using ice saturation may over-estimate IWC, but only by a small amount, and only in some vigorous cases where the air exceeds ice saturation.
  - Inexact subtraction of background humidity leads to errors in the IKP TWC. Phase differences between the device measurements caused by different clocks, sampling intervals, air line lengths and sample flows, lead to increasing IKP baseline noise with warmer temperatures. At 0 C, the background vapour is of the order of 5 gm-3, and differences in the response of the IKP Licor and even the same model background Licor, and the inability to exactly phase-lock the two instruments, can lead to unacceptable baseline noise at this temperature. This is particularly true in airmasses where there is significant inhomogeneity in the water vapour field. For this reason, all data at temperatures warmer than 0 C have been excluded from this data set. In addition, the user should be aware of this increasing baseline uncertainty with warmer temperatures in this data set. Fortunately, the background humidity at the coldest temperatures where most of the data were collected is quite low, and background-humidity-removal is only a small correction.

- Once the background humidity offsets and time periods were determined and stored in definition files, the IKP reprocessing program was rerun, and the new IKP values were stored in the comma-delimited output files provided here. A few periods of bad IKP data were set to values of -999. Data at temperatures warmer than 0 C were set to -999. Data were re-checked by graphical inspection.

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