Operational Instrument Description and Logfile for FARLAB water vapour isotope instrument HIDS2380

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Date	Description
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Contents

This document documents the properties, calibration, events, and usage of instrument HIDS2380 owned by GFI within ERC project ISLAS, and operated according to principles set up by FARLAB at the Geophysical Institute (GFI) and the Department of Geosciences (GEO), University of Bergen (UiB), Norway. This particular instrument has been in use since 14.03.2019 for water vapour measurements at the GFI tower, and for some periods at FARLAB with the Microdrop and crusher device.

1 Instrument properties

The Picarro L2130-i with serial number HIDS2380 (Picarro Inc, Sunnyvale, USA) records at a data rate of ∼1.25 Hz or 5 Hz, and with a air flow of ∼35 to 300/420 sccm through the cavity for min/max setting of the flight pump. To minimize instrument drift and errors from the spectral fitting, these CRDS systems precisely control the pressure and temperature of their cavities to be at 80 ± 0.02°C and 50 ± 0.1 Torr. The flow rate through the cavity can vary because this instrument has a so-called flux mode, and is equipped with a mass flow regulator for flight mode that enables constant mass flow rates through the instrument at varying ambient pressure. This L2130-i therefore also reports atmospheric pressure readings. The L2130-i for FARLAB has a so-called low humidity option, which means its cavity should be able to take measurements down to 200 ppmv, and a rack mount brackets for standard 19 inch racks.

For the spectral fitting, the instruments target three absorption lines of water vapour in the region 7199-7200 cm^{-1} (Steig et al., 2014). In CRDS, a laser saturates the measurement cavity at one of the selected absorption wavelengths. After switching the laser off, a photodetector measures the decay (ring-down) of photons leaving the cavity through the semi-transparent mirrors (slightly less than 100% reflectivity). The ring-down time is inversely related to the total optical loss in the cavity. For an empty cavity, the ring-down time is determined solely by the reflectivity of the mirrors. For a cavity containing gas that absorbs light, the ring-down time will be shorter due to the additional absorption from the gas. The absorption intensity at a particular wavelength can be determined by comparing the ring-down time of an empty cavity to the ring-down time of a cavity that contains gas. The absorption intensities at all measured wavelengths generate an optical spectrum, where the height or underlying area of each absorption peak is proportional to the concentration of molecule that generated the signal. The height or underlying area of each absorption peak is calculated based on the proper fitting of the absorption baseline. At lower water vapour concentrations, the signal-to-noise ratio decreases, and fitting algorithms are affected by various error sources (Weng et al., 2020).

2 Instrument calibration

This section summarises calibration experiments for the individual measurement parameters of the instrument.

2.1 Mixing ratio calibration for specific humidity

A calibration of the mixing ratio will be performed with a dew point hygrometer.

2.2 Pressure calibration

TBD with pressure metre or aircraft data

2.3 Isotope ratio - humidity dependency calibration

The Picarro L2130-i CRDS analysers have an optimal performance within a water vapour mixing ratio of 19000 – 21000 ppmv (parts per million by volume), where high signal-to-noise ratios enable precise measurements, such as for liquid sample analysis. In-situ measurements of the atmospheric water vapour isotopes vary widely, from 200 ppmv to more than 25000 ppmv. At low water vapour mixing ratios, the measurement uncertainty increases due to weaker absorption, and thus lower signal-to-noise ratios. Additionally, outside of this range, the measurement suffers from a mixing ratio-dependent deviation of the isotope composition. Since atmospheric mixing ratios can vary from below 500 ppmv in dry regions (e.g., polar regions or the middle and upper troposphere) to 30000 ppmv or more in humid regions (e.g., tropics), an appropriate correction to this mixing ratio dependency for high-quality in situ measurements of atmospheric water vapour is required (Weng et al., 2020).

This particular instrument had a unusual high sensitivity to water vapour mixing ratios upon arrival (see "Maintenance and repair"). After some back and fourth with Picarro, and a systematic analysis using the Microdrop, a manual tuning of the fitting parameters provided a much improved linearity of the signal with mixing ratio. The remaining sensitivity resembles that of the other analyzers in use at FARLAB. A final calibration of the isotope composition – mixing ratio dependency will be performed with the Microdrop calibration device.

The Microdrop experiments documented in a separate report (FARLAB report 2020-01).

3 Instrument events log

3.1 Fieldwork and locations

So far instrument was either in GFI tower or at FARLAB. Field deployment or lab operations had been postponed until the instrument performed according to specifications. Planned operations where instead carried out with the HIDS2254.

3.2 Maintenance and repair

This instrument has shortly after operational use been observed to have a much stronger dependency than other instruments we have at FARLAB. The issue has been examined by Picarro technicians, and they attempted a recalibration of the pressure dependency on 17.01.2020. However, no change could be observed after the modifications.

Using instructions from Picarro on how to calibrate the humidity dependency, we have changed the fitting parameters on 14-15.05.2020 in the instrument as detailed below. This results in a much more linear response of the instrument between to far separated humidities (20'000 and 3200 ppmv).

We use the results from the respective calibration report for the HIDS2380 (FARLAB report 2020-01) to correct the previous measurement data obtained from this analyzer during side-by-side measurements at the GFI tower observatory, and since 15.05.2020 we will use a correction, that will have to be determined using the microdrop calibration device.

The adjusted parameters are AIR_offset1 for δ^{18}O and AIR_offset2 for δD, as well as the respective parameters AIR_G1_quadratic and AIR_G3_quadratic which have been set to their default values.

```
AIR_offset1 = -1.88
AIR_offset3 = 1.32
AIR_G1_quadratic = -1.1E-06
AIR_G3_quadratic = -9.7E-07
```

4 Data access, curation, use

Data is available with a Creative Commons license (attribution, access, re-use) after a 2-year carence period. Data are archived on the Bjerknes Centre Data Centre (BCDc, `https://www.bcdc.no`). The contact persons for data access are the data collectors stated above.

Further details on data storage, backup, processing and calibration is available in FARLAB report 2020-02 (`https://wiki.uib.no/farlabprotocols/index.php/Main_Page`).

5 References

- Weng, Y.: Instrument calibration of Picarro L2130-i (HIDS2254), FARLAB report 03-2017, 4 July 2017 (Version 2), 7 pp.

- Steig, E., Gkinis, V., Schauer, A., Schoenemann, S., Samek, K., Hoffnagle, J., Dennis, K., and Tan, S.: Calibrated high-precision 17O-excess measurements using cavity ring-down spectroscopy with laser-current-tuned cavity resonance, Meas. Tech, 7, 2421-2435, 2014.

- Weng, Y., Touzeau, A. and Sodemann, H., 2020: Correcting the impact of the isotope composition on the mixing ratio dependency of water vapour isotope measurements with cavity ring-down spectrometers, Atmos. Meas. Techn., accepted.

6 Instrument usage

This section gives an overview over special event for the instrument, including relocations and field deployments. More specific events and an overview over data availability are given as standardised overview figures. Raw data before July 2019 have unfortunately been lost due to default settings to delete files after a certain space limit. Some brief periods in June to August of the data set could be recovered from the SDM calibration log files with a special FaVaCal option.

Table 1: Relocation and field deployment log

2019-03-14 to 2019-04-03	Instrument arrived, initial function test at GFI basement
2019-04-03 to 2019-04-04	Instrument installed at GFI tower, measuring at PTFE tubing
2019-04-04 to 2019-05-29	Both instruments attached to same heated inlet with 1/8 inch tubing
2019-05-29 to 2019-06-07	Instrument installed at basement for box testing
2019-06-07 to 2019-09-12	Instrument installed at GFI tower to replace HIDS2254
2019-09-16 to 2019-11-01	Instrument transferred to FARLAB DI lab for calibration with microdrop
2019-11-02 to 2019-11-05	Instrument used in box tests
2019-11-05 to 2019-01-28	Instrument used with Microdrop
2020-01-28 to ongoing	Instrument transferred to GFI tower
2020-03-05 15:20	Installed for manual injection mode
2020-05-xx	correction of parameters to rectify humidity dependency

6.1 Events log for 2019

The standardised event log for 2019 is show in Fig. 1

Table 2: Events log for 2019

2019-04-03	Instrument arrived and installed at GFI tower, measuring at PTFE tubing
2019-04-04	Both instruments attached to same heated inlet with 1/8 inch tubing
2019-05-01	Installed SDM and vapourizer
2019-05-23	CRDS data viewer froze
2019-05-10	Installed synchronisation scripts
2019-05-29	Moved instrument to basement for box testing
2019-06-07	Instrument transferred to GFI tower to replace HIDS2254
2019-06-18	Turned off SDM and vapourizer
2019-06-26	Air cylinder change and restart of calibrations
2019-06-29	Analyzer turned off due to power outage at 00:40 UTC
2019-08-26	Set correct data limits and initiated data sync
2019-09-12	Instrument transferred to FARLAB DI lab for calibration with microdrop
2019-09-16 to 2020-11-01	Instrument at FARLAB with Microdrop
2019-10-22	Installed LabJack software and python 2.7.14
2019-11-02 to 2020-11-05	Instrument used in box tests
2019-11-05	Instrument returned to Microdrop

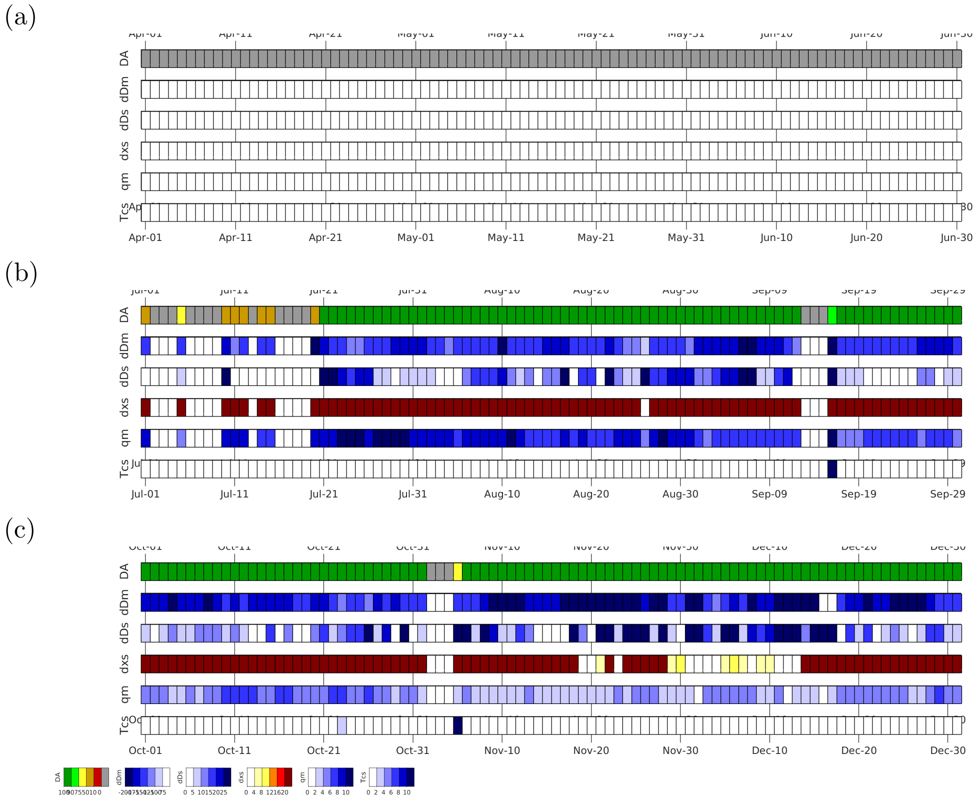

Figure 1: Data availability for the HIDS2380 during 2019 for (a) AMJ (b) JAS (c) OND.

6.2 Events log for 2020

The standardised event log for 2020 is show in Fig. 2

Table 3: Events log for 2020

2020-01-28 14:30	Instrument transferred to GFI tower
2020-01-29 08:54 to 2020-01-29 22:20	Modifications of parts on inlet line
2020-03-05 15:20	Installed for manual injection mode
2020-03-10 to 2020-03-15	No calibrations due to COVID-19 closure
2020-04-14 to 2020-04-17	Instrument off due to power break
2020-05-11 14:15	Reinstallation of SDM
2020-05-14 to 2020-05-15	correction of parameters to rectify mixing ratio dependency

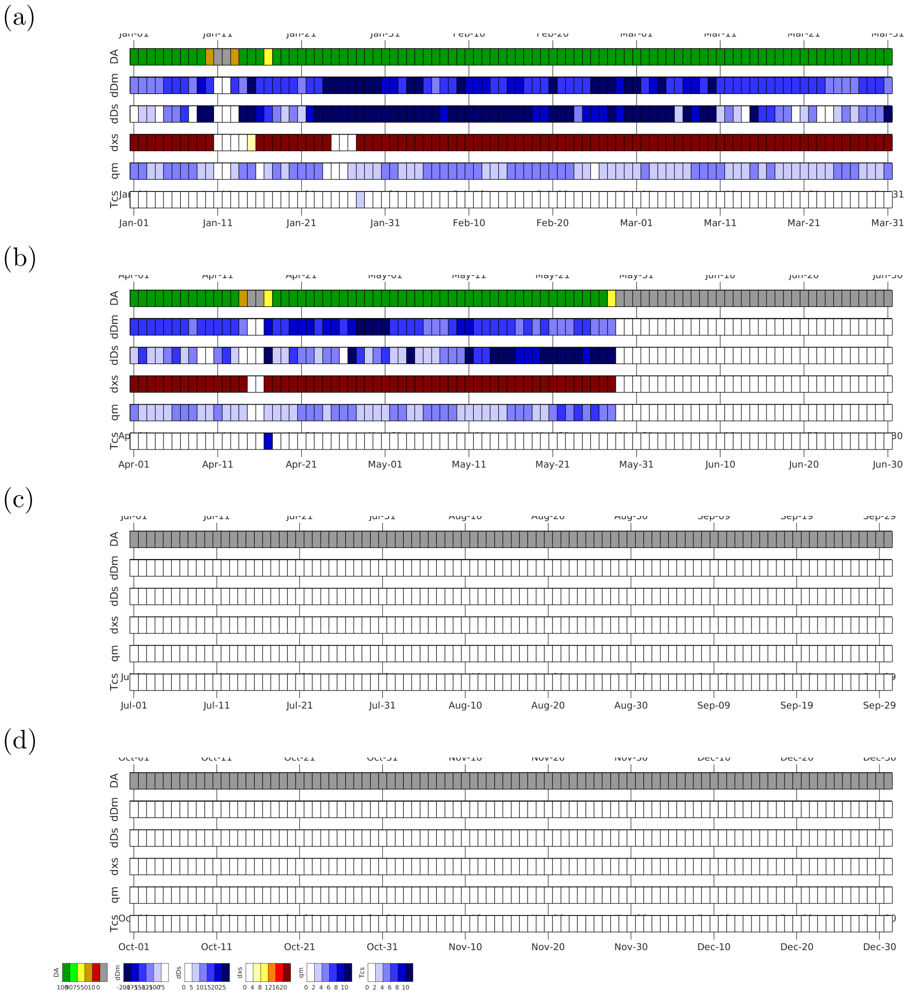

Figure 2: Data availability for the HIDS2380 during 2020 for (a) JFM (b) AMJ (c) JAS (d) OND.