Operational Instrument Description and Logfile for FARLAB water vapour isotope instrument HIDS2254

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2020-06-02

Date	Description
02.06.2020	First release, including data up to May 2020

Contents

This document documents the properties, calibration, events, and usage of instrument HIDS2254 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, several aircraft and ship measurements, Finse station, and for tests with the Microdrop device at FARLAB.

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 $80 \pm 0.02°$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. It is noteworthy that the HIDS2254 is about 2 kg lighter than the HIDS2380 with otherwise same specifications.

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

Water concentration measured by Picarro L2130-i was calibrated against dew point generator (DPG) on 2016-06-03 at FARLAB, UiB. The model used is LI-610, LI-COR Inc., Lincoln, NE, USA). The results have been fitted with a simple linear regression function and a quadratic function with an extra constraint point (0 ppmv,0 ppmv). The fitting results show systematic variation of the residuals and suggest a square-root relation or power law as a more appropriate fit (FARLAB report 01-2018). So far, the linear correction is being used.

$$
\begin{aligned}
y &= 1.0678(\pm 0.003)x - 511.9837(\pm 40.425) \\
y &= 3.3331 \times 10^{-6}(\pm 1.7800 \times 10^{-7}) \times 2 - 0.9788(\pm 0.0029)x
\end{aligned}
$$

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

2.2 Pressure calibration

Pressure calibration has been performed with pressure metre at the lab over ambient pressure values at sea level (Farlab report 01-2018). For this range, a simple offset correction can be applied ($y = x - 0.31$). A pressure calibration over a more complete range of values will be done with aircraft data from the IGP campaign.

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).

So far there has not yet been done a systematic analysis for synthetic air as matrix gas, but for N_2 there is a systematic study by Weng et al., 2020 (Fig. 1; their Figure A2).

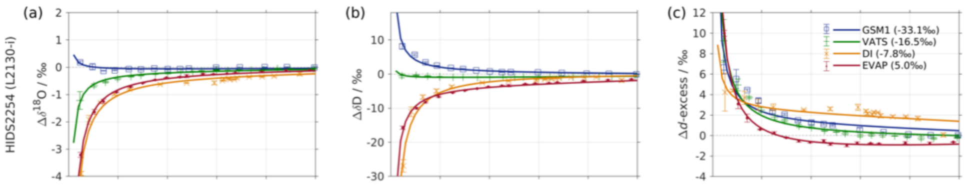

Figure 1: Isotope-composition mixing ratio dependency for instrument HIDS2254 determined with matrix gas N_2 using liquid injections (Weng et al., 2020, their Fig. A2).

3 Instrument events

3.1 Fieldwork and locations

So far instrument has taken part in an aircraft campaign (2018), a ship deployment (2018), an Alpine station (2018/2019), and ultralight aircraft (2019) and a mobile box setup in the Arctic (2020). Otherwise the instrument was either in GFI tower or at FARLAB, where it is becoming part of the crushing line.

3.2 Maintenance and repair

So far this instrument has not had maintenance or repair. During aircraft installation, we encountered problems where the instrument would not reach operating temperature during flight, this was however due to insufficient heatup time before flying. Heating thresholds are DAS 20C - Warm box starts heating, WB 40C - Hot box starts heating. If the DAS does not reach 20C, the instrument takes a long time to get warm and may need external heat.

The instrument has sometimes had difficulty in getting the high flow mode (air) running as expected. In these cases, the cavity pressure either stops before reaching down to 50 Torr, or reaches below 50 Torr and bounces back up again. Reducing the flow at the inlet in some way can help the instrument to stabilize flow rates and get the needed cavity pressure.

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. Some raw data files are missing before January 2016 and between 2016-07-09 and 2016-10-01.

Table 1: Relocation and field deployment log

2015-12-21	Preliminary instrument testing
2016-05-03 to 2016-11-xx	Inlet to outside in FARLAB
2016-12-06 21:40 to 2018-02-10 12:00 (?)	Instrument at GFI tower
2018-02-15 16:40 to 2018-03-19	Instrument at IGP campaign 2018 (Twin Otter), Akureyri
2018-06-08 15:20 to 2018-12-18 13:00	Instrument at GFI tower
2018-12-18 18:30 to 2019-02-05 10:00	Instrument at Finse for SNOWPACE
2019-02-08 09:16 to 2019-06-07 11:50	Instrument at GFI tower
2019-06-07 11:52 to 2019-06-22	Instrument at WaViL campaign, Annecy (ULA)
2019-07-17 to 2019-09-12	Installation of instrument onboard KV Svalbard for CAATEX/INTAROS
2019-09-12 15:35 to 2020-01-28 14:00	Instrument at GFI tower
2020-02-21 to 2020-03-15	Instrument at ISLAS2020 campaign (Ny Alesund)
2020-05-04 to ongoing	Instrument installed at FARLAB with crusher and Microdrop

6.1 Events log for 2016

The standardised event log for 2016 is show in Fig. 2

Table 2: Events log for 2016

2016-01-08	Installation and tests
2016-03-03	Water concentration dependency test setup
2016-05-04 to 2016-05-15	Instrument measuring from outside at FARLAB
2016-05-23 to 2016-06-10	Dew point generator calibration tests
2016-06-29	Installation of SDM
2016-07-08	Isotope composition dependency tests with SDM
2016-09-30 to 2016-11-15	Ambient air measurements at FARLAB window
2016-12-06 UTC 21:40	Instrument at GFI tower on unheated PTFE inlet

(a)

(b)

(c)

(d)

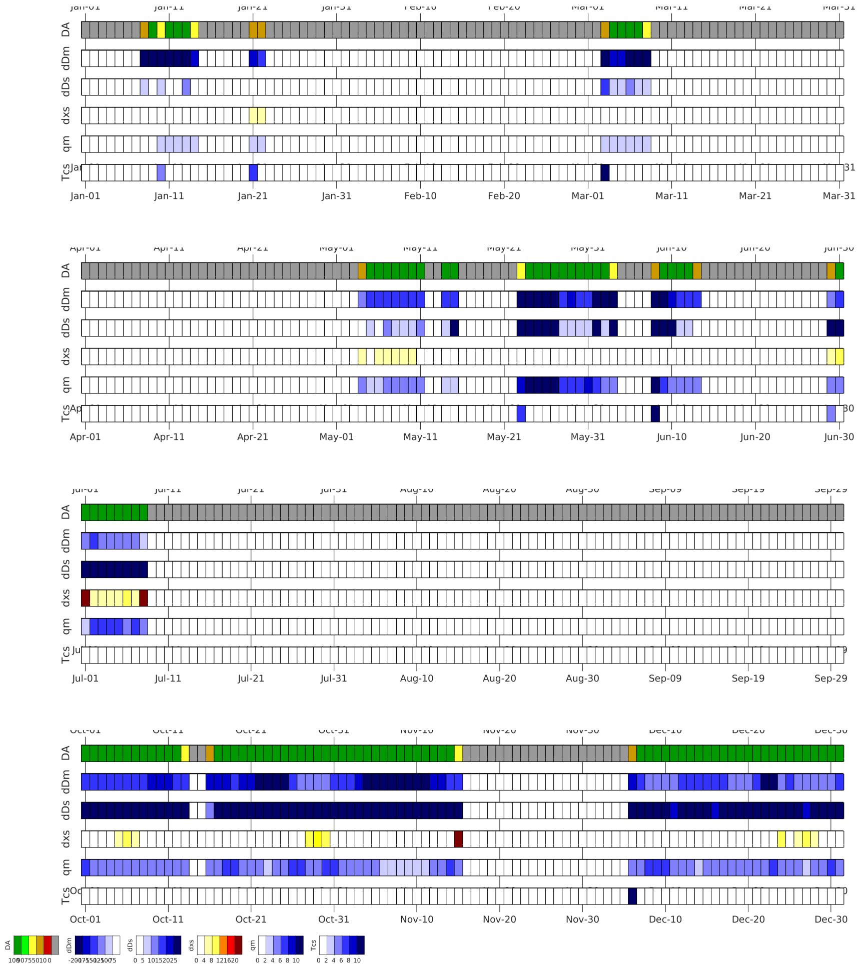

Figure 2: Data availability for the HIDS2254 during 2016 for (a) JFM (b) AMJ (c) JAS (d) OND.

6.2 Events log for 2017

The standardised event log for 2017 is show in Fig. 3

Table 3: Events log for 2017

2017-02-16 to 2017-03-17	Humidity dependency tests with autosampler
2017-03-17	Resume vapour measurements
2017-04-05	Set larger user quota to avoid file deletion
2017-03-28	Installation of first inlet pump
2017-05-10(?)	Inlet pump with start/stop cycle due to overheating
2017-06-01	New inlet installation, without flush pump
2017-06-07	Reinstalled flush pump
2017-06-08	Heat trace installation at 50C
2017-06-19	Picarro measured room air when pump was failing, closed valve now
2017-06-23	Installed Vaccubrand MD1 as flush pump, 13 lpm
2017-07-20 to 2017-07-21	Inlet experiments heated/unheated
2017-08-25	Calibration sequence now 23h instead of 11h
2017-09-07	Power outage
2017-09-11	SDM calibration with dry air from bottle
2017-10-12 21:30 to 2017-10-13 14:46	Broken tubing in inlet, replaced
2017-11-22 15:30	Installation of KNF inlet pump, 10 lpm

(a)

(b)

(c)

(d)

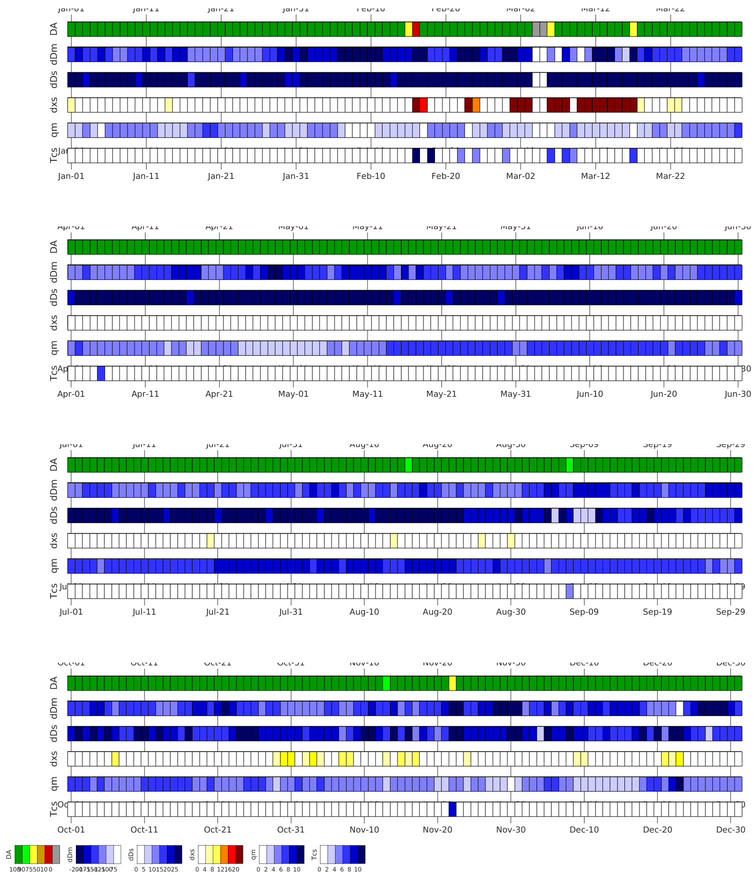

Figure 3: Data availability for the HIDS2254 during 2017 for (a) JFM (b) AMJ (c) JAS (d) OND.

6.3 Events log for 2018

Table 4: Events log for 2018

2018-01-04	Foam insulation on 1/8 inch tubing
2018-01-11 to 2018-01-29	Bubbler tests, water in inlet?
2018-02-10 to 2018-02-12	HC tests calibration system
2018-02-15 16:40	Instrument shut down for shipping to Iceland (IGP campaign)
2018-03-08 08:00 to 2018-03-18	Installation in MASIN for IGP, Akureyri
2018-04-25	Installed at FARLAB with A7 for liquid measurements and vapour calibration
2018-06-08 15:10	Instrument at GFI tower, connected to inlet (unprotected)
2018-07-27 to 2018-08-27	Instrument running without vapourizer
2018-09-12	Swapping vapourizer 1 (coated) to vapourizer 2.
2018-10-23	Taping of inlet to prevent water in the tubing
2018-12-18 13:00	Instrument shut down for transport to Finse (SNOWPACE 2018)

(a)

(b)

(c)

(d)

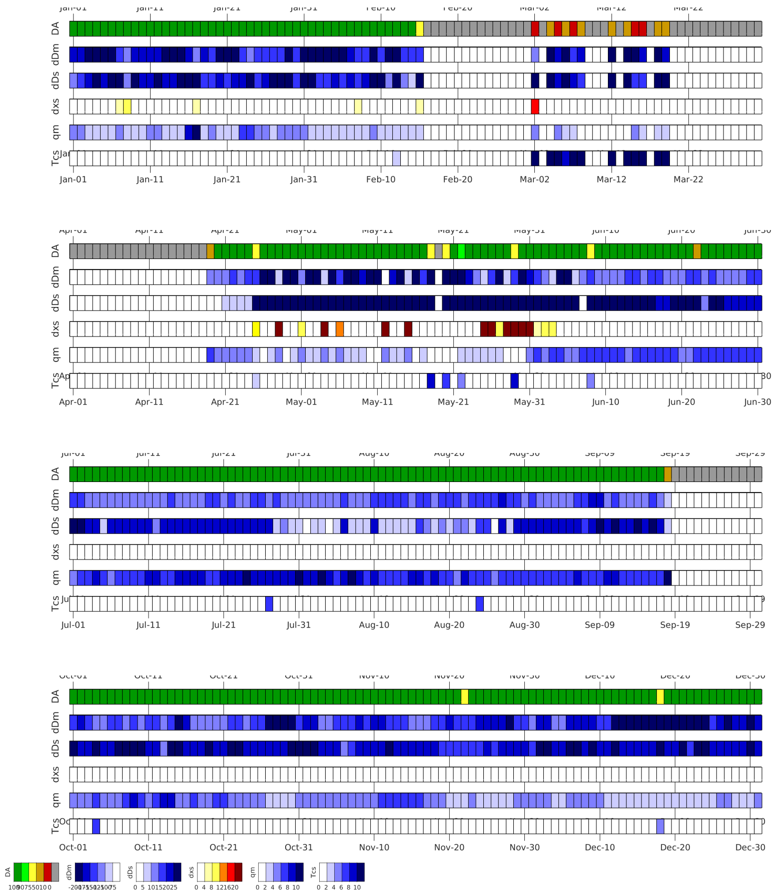

Figure 4: Data availability for the HIDS2254 during 2018 for (a) JFM (b) AMJ (c) JAS (d) OND.

6.4 Events log for 2019

The standardised event log for 2019 is show in Fig. 5

Table 5: Events log for 2019

2019-02-05 10:00	Instrument shut down for transport to Finse (SNOWPACE 2018)
2019-02-08 08:15	Analyzer set up in GFI tower on vapour inlet
2019-02-08 09:16	Starting calibration sequence 20/20/1440 with DI in pump 1 and GSM1 in pump2
2019-02-08 13:38 to 2019-02-09	1/16 inlet tubing on vapourizer broke, fixing poorly with aluminium tape
2019-02-14 21:00	Installed coated 1/16 inlet tubing
2019-05-01 10:30	Connected HIDS2380 on same line
2019-06-07 11:52	Shutdown and packing of instrument for shipping WaViL, Annecy
2019-06-22	Last operations before packing at WaViL
2019-06-27 08:00	Calibration tests at GFI basement
2019-06-28 06:25	Shutdown and packing of instrument for shipping to INTAROS CAATEX
2019-07-17 to 2019-09-12	Installation of instrument onboard KV Svalbard for CAATEX/INTAROS
2019-09-12 14:18	Instrument installed in tower with FARLABBAK2
2019-09-12 15:35	Start calibration with injection volume 0.062 for DI and GSM1

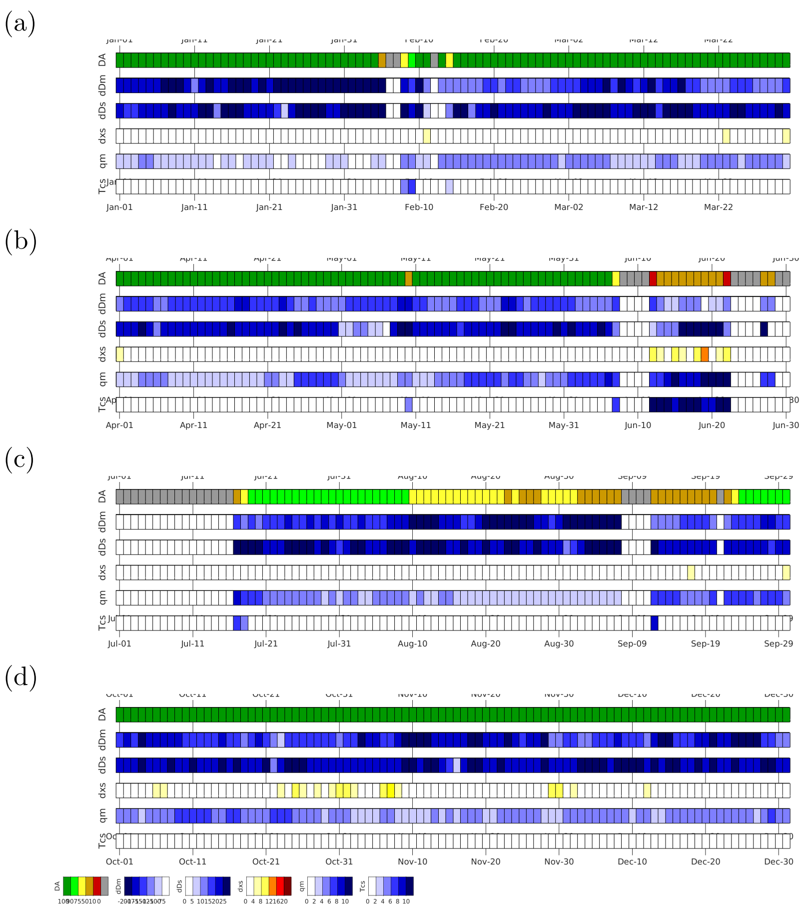

Figure 5: Data availability for the HIDS2254 during 2019 for (a) JFM (b) AMJ (c) JAS (d) OND.

6.5 Events log for 2020

The standardised event log for 2020 is show in Fig. 6

Table 6: Events log for 2020

2020-01-29 14:02 to 2020-01-30	Tests with sample arm at Marineholmen
2020-02-21 14:02	Install instrument for ISLAS2020 campaign (Ny Alesund)
2020-02-22 to 2020-03-15	Measurements in Ny Alesund
2020-05-04	Instrument installed at FARLAB with crusher
2020-05-05	Python and LabJack installation

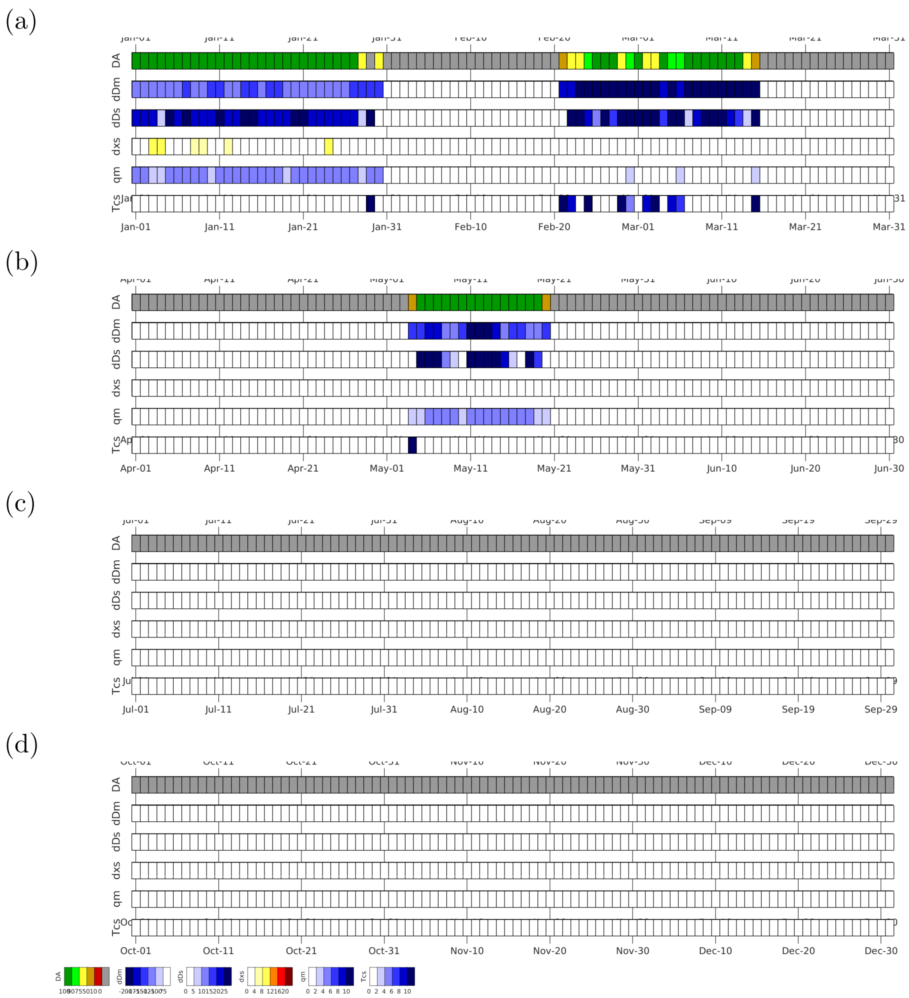

Figure 6: Data availability for the HIDS2254 during 2020 for (a) JFM (b) AMJ (c) JAS (d) OND.