What's the bee-weather & how-to correct particulate-matter readings

(in Grafana, of course)

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The Hiveeyes Project

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part #1: what's the (bee-)weather?

meteogram: past & future

how are the bees?

how is the weather for bees?

part #2: particulate matter:
official vs. low-cost sensors

compare nearby stations

compensation at high humidities
part #1: what's the (bee-)weather?
meteograms (future only)
my first meteogram (past only)
combining past & future
1st challenge: two station-lists, no common ID

solution: manually generate a combined-list (using lon/lat) to access different station-IDs with consecutive variable-queries
"nesting" of dashboard templating variables

$COMMON_CDC_NAME (cdc_name)
$COMMON_CDC_ID (cdc_staq_id) || $COMMON_MOSMIX_ID (mosmix_id)

Wetter: DWD > CDC & MOSMIX: selection of a station...

<table>
<thead>
<tr>
<th>Time</th>
<th>cdc_lat</th>
<th>cdc_lon</th>
<th>cdc_name</th>
<th>cdc_staq_id</th>
<th>mosmix_id</th>
<th>mosmix_lat</th>
<th>mosmix_lon</th>
<th>mosmix_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>50.7983</td>
<td>6.0244</td>
<td>Aachen-Orsbach</td>
<td>15000</td>
<td>10505</td>
<td>50.8</td>
<td>6.03</td>
<td>AACHEN-ORSBACH</td>
</tr>
<tr>
<td>-</td>
<td>48.2155</td>
<td>8.9784</td>
<td>Albstadt-Badkap</td>
<td>00071</td>
<td>0751</td>
<td>48.22</td>
<td>8.98</td>
<td>ALBSTADT-BADKAP</td>
</tr>
<tr>
<td>-</td>
<td>51.9644</td>
<td>9.8072</td>
<td>Alfeld</td>
<td>07367</td>
<td>10442</td>
<td>51.97</td>
<td>9.8</td>
<td>ALFELD</td>
</tr>
<tr>
<td>-</td>
<td>52.4853</td>
<td>7.9126</td>
<td>Alfeld</td>
<td>00078</td>
<td>E626</td>
<td>52.48</td>
<td>7.92</td>
<td>ALFHAUSEN</td>
</tr>
<tr>
<td>-</td>
<td>43.1470</td>
<td>4.4506</td>
<td>Altheim-Kreis Rheinbach</td>
<td>04190</td>
<td>0771</td>
<td>42.15</td>
<td>0.47</td>
<td>RIEDKINSENM</td>
</tr>
</tbody>
</table>

variable COMMON_CDC_NAME=="Berlin-Tegel" variable COMMON_MOSMIX_ID=="10382"
2nd challenge: (no) two equals are the same

°C ≠ K -- but + 273.15 is

m/s ≠ km/h -- but × 3.6 is

sec/1hr ≠ min/10min -- but ÷ 3600 is
meteogram: past & future

- Temperature:
  - Last: 11:20:00 - 18.4 °C
  - Current: 15.06.2020 13:02:24 - 16 °C

- Humidity:
  - Last: 11:20:00 - 44 %

- Precipitation:
  - Last: 5cm
  - Current: 23.0 °C - 0 L/24h

- Taupoint:
  - Last: 11 km/h
  - Current: 5.9 °C - 1015 mbar

- Wind:
  - Last: 18 km/h max.
how are the bees?

measured elements & what they indicate
hive's weight

does nectar/pollen get harvested or eaten?

drying of nectar

in winter: will feed last until spring?

controlling population/size of hive

swarm-alarm

detection if honey flow stalls

planning of harvest

theft and other horseplays
scale and hive by karsten
latest swarm event

Gewicht und stündliche Änderung

- Gewicht Total (temp.komp.): 45.89 kg, 50.20 kg, 47.39 kg
- Gewicht Total (gl. Mittelwert): 45.51 kg, 50.26 kg, 47.41 kg
- Gewicht Total (Rohdaten): 45.51 kg, 292.00 g, 50.00 g
- Stündliche Gewichtsdifferenz (right-y)
weight of an untouched bee-hive

hive: Zentrum für Urbanistik, Berlin (no harvesting), 2019
temperatures & humidities

35±1°C inside hive? Brood: ✓! Queen: ✓!

multiple sensors: position and size of brood-nest planning of medical treatment
bee-weather: pre-flight conditions
as studied by german weather-service DWD

enough temperature, sun
not too much wind, rain
bee-hive & weather dashboard

Statista: Hive overview & bee-weather [test-hive ZK/U]

- **BeeKlopper**
- **hiveeyes_open_hive_test_statista**
- **DWD-Station**
- **Berlin-Tegel**

**Current Values**
- **Last 24h**:
  - Weight: -1 kg
- **Time range**:
  - Weight: +27 kg
- **Swarm**:
  - Weight: -1 g/30m
- **Weight**:
  - 52.12 kg
- **Volts**:
  - 4.32 V
- **Hive°C**:
  - 30.3 °C
- **Rein**:
  - 0 mm/10m
- **Sun**:
  - 0 J/cm²
- **Wind**:
  - 2.0 m/s

**Weight & Daily Difference**

**Temperature & Humidity in and around the Hive**

**Temperature around hive**

**Battery, Power & Sunshine**

**Diffuse Solar Radiation**

**Hourly Weight Difference**
bee-hive & weather dashboard
queen's egg laying rate
from temperature, according to Bretschko & Bergemann
research: thermal image

SVG-plugin by Marco Warm
research: thermal image

SVG-plugin by Marco Warm
coming up: sound

Fast Fourier transform (FFT) < 1kHz of hive-sound with heatmap-plugin, by Diren
part #2: particulate matter (PM) comparing official and low-cost sensors
luftdaten.info (LDI) import & worldmap panel
<table>
<thead>
<tr>
<th>official</th>
<th>low-cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. Grimm EDM180</td>
<td>e.g. Nova SDS011</td>
</tr>
</tbody>
</table>

![Official Device](image1.png) ![Low-Cost Device](image2.png)
VMM/IRCELINNE (Belgium): SOS Import
combined overview of both networks
compare view across both networks
bias of laser-scatter sensors for PM
vapour-particles are detected, too
assumption: values need compensation at high humidities
obviously underestimates, too
common low-cost humidity-sensors

DHT22

BME280
Humidity data comparison: official with low-cost

Humidity-compare: DWD ./ LDI's BME280 & DHT22. last 2h

Germany: Deutscher Wetterdienst (DWD) ./ lufdaten.info (LDI). Alle Einzelwerte werden über die Zeit von 115 bis 130min vor Ende des ausgewählten Zeitraums gebildet, um eine vergleichbare "Live"-Ansicht mit den bis zu 2h verzögerten Daten des DWDs zu erhalten.

LDI: benutzte Feinstaub-Sensoren

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDS011</td>
<td>15971</td>
<td>97.1%</td>
</tr>
<tr>
<td>PMS5003</td>
<td>299</td>
<td>1.8%</td>
</tr>
<tr>
<td>PMS7003</td>
<td>148</td>
<td>0.9%</td>
</tr>
<tr>
<td>PMS3603</td>
<td>8</td>
<td>0.0%</td>
</tr>
<tr>
<td>PPD42NS</td>
<td>7</td>
<td>0.0%</td>
</tr>
<tr>
<td>SDS021</td>
<td>7</td>
<td>0.0%</td>
</tr>
<tr>
<td>PMS1030</td>
<td>7</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

LDI: benutzte Temperatur/Feuchtigkeit-Sensoren

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHT22</td>
<td>10486</td>
<td>69%</td>
</tr>
<tr>
<td>BME280</td>
<td>4269</td>
<td>28%</td>
</tr>
<tr>
<td>BMP180</td>
<td>153</td>
<td>1%</td>
</tr>
<tr>
<td>BMP280</td>
<td>139</td>
<td>1%</td>
</tr>
<tr>
<td>HTU21D</td>
<td>29</td>
<td>0%</td>
</tr>
<tr>
<td>DS18B20</td>
<td>17</td>
<td>0%</td>
</tr>
<tr>
<td>DHT11</td>
<td>1</td>
<td>0%</td>
</tr>
</tbody>
</table>
conclusio

let's use official humidity data

using PostGIS for meta-data due to nearest-neighbour-search

SELECT station_id FROM ldi_network WHERE sensor_type_name = 'SDS011' ORDER BY geopoint <-> 'POINT($ircceline_station_lon $ircceline_station_lat)' LIMIT $limit;
actual compensation done in InfluxDB/flux-lang

```flux
import "math"

PM2.5 = from(bucket:"luftdaten_info")
  |> range(start:-7d)
  |> filter(fn: (r) =>
          r._measurement == "ldi_readings" and
          r._field == "pm-2-5" and
          r.stat_name == "$ldi_id"
    )
  |> aggregateWindow(every: 1h, fn: mean)

humidity = from(bucket:"vmm")
  |> range(start:-7d)
  |> filter(fn: (r) =>
           r._measurement == "irceline_readings" and
```

actual compensation done in InfluxDB/flux-lang

```flux
|> range(start:-7d)
|> filter(fn: (r) =>
    r._measurement == "irceline_readings" and
    r._field == "humidity" and
    r.sta_name == "$irceline_id"
  )
|> aggregateWindow(every: 1h, fn: mean)

join(tables: {pm: PM2.5, hum: humidity}, on: ["_time"])
|> map(fn: (r) => {
    _time: r._time,
    _value: r.value_pm / math.pow(x: 1.0-(r.value_hum*0.01), y: -0.3),
    _field: "PM2.5 (luftdaten.info), humidity-corrected with Hänel-formula"
})
```
expert-view with humidity-compensation
ideas & wishes
Thanks.

The Hiveeyes Project
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image credits
- https://unsplash.com/photos/jv9ATyWT0Bw
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