RHTLogger
Battery operated, 60 euros, modifiable
NOTES

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1   Briefly

The goal of this project is to build a low power Arduino based cheap and reliable data logger and test some sensors.

The total cost of the components should be around 60 euros, accuracy of RH measurements 3% and temperature 0.2C. The logger should last about a year with 3xAA batteries. Taking one measurement per minute, a 1 GB SD card has capacity for about 30 years of data.

No special software is needed to operate the logger. The data is written in a normal text files on the SD card.

An initial two months comparison was made with Rotronic CL11 logger, see Fig. 4. No calibration was made for any of the sensors and the test was conducted on my office desk, see Fig. 2. After offsetting the results, all devices give near identical results. The differences arise from usability, price, and reliability. Rotronic CL11 failed after the two months, most likely due to power grid failure. The Arduino based logger has suffered zero problems in testing.

This project was mainly inspired by an article published in Sensors by Patricia A. Beddrows and Edward K. Mallow in 2018 (https://www.mdpi.com/1424-8220/18/2/530).
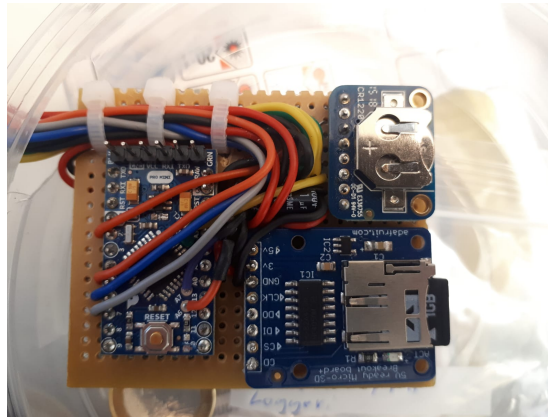

Figure 1: Logger. Left: Arduino Pro Mini. Upper right: Clock. Lower right: SD-card and adapter. Wires go to sensors and LED. Battery back (3xAA) below (not visible). One euro coin in the background.

2   Next generation

For next generation logger I would use a lower power, wireless Arduino compatible board made by Wisen (https://wisen.com.au/store/products/whispernode-avr/). Is costs about 15 euros and should be better than the current board in everyway (ten times more efficient power, wireless, more memory...).

Sensiron SHT 85 seems like a good option for a sensor ($\pm1.5\%$ RH ±0.1°C, PTFE membrane, heater, 22e, https://cdn.sos.sk/productdata/8d/94/c6c9b77b/sht-85.pdf, https://www.soselectronic.com/products/sensirion/sht-85-305843).

3   Comparison with Rotronic CL11

After writing these notes, a two moths test was performed, see Fig. 4 and Table 2. The results were the same as in the shorter test discussed here. Additionally, the Rotronic CL11 failed after about two months of operation. Probably due to power failure (my desktop shut down around the same time for no apparent reason). From this longer test, some educated tests may also be made of the battery life of the Arduino based logger, see Fig. 4.

According to the reported specs, see Tables 3,4, and 1, the Rotronic logger has roughly the same accuracy than the logger build here. The price of the Rotronic logger is about 6 times higher (excluding work). The 1G SD-card used here has about 1500 times the capacity of the Rotronic logger. Rotronic logger requires a special software (free) to access the data. The build logger writes the data on a SD card as a normal txt-file. Rotronic logger requires power from a wall socket and will reset time etc. if power fails. The logger build here is battery operated and has a separated battery for the clock with about 5 years of life time.

	Sensor	**T**	**RH**
	?	0.3C (-20..+60C)	3% (10-95%,25C)
Price	357e (http://www.rotronic-messgeraete.de/de/CL11)		
Memory	10000 data points (about one week with once per minute sampling)		

Table 1: Rotronic CL11

The test was conducted on my office desk and took about a week. Data was sampled once a minute. The clocks were initialize with 0.5 minute accuracy. No senor calibration was made. The sensors were duct taped together, and shielded from radiation and strong advection with some loose fitting papers, see Fig. 2.
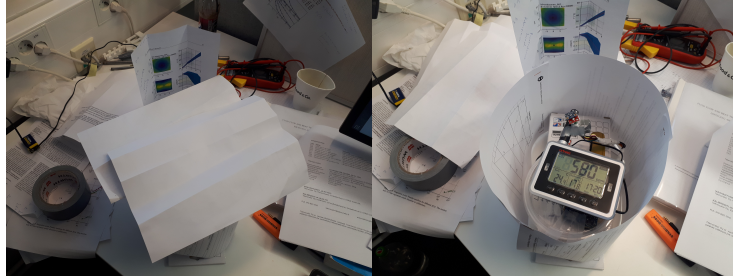
Figure 2: Measurement setup. Radiation / advection shielding using paper.

The results from all the sensors are withing their reported accuracy for temperature, see Fig. 3. Temperatures from Si7021 and Rotronic CL11 are near identical. SHT31 gave a systematically higher temperature. All the temperatures were withing the reported error bands of the sensors.

The relative humidities reported by the different sensors all had the same trends. They also had a near constant offset with each other, see Fig. 3. The values almost fit withing the reported error bands of the sensors. The spikes in the humidity, visible in all the sensors, is likely caused by me opening the paper cover and breathing in.

Considering the imprecise nature of this test, all the sensors give the same results. Next, a more scientific test would be in order.

The RTC temperature is red from the logger clock and is not accurate. It is included for the case of high humidity, when heating circuits are powered up in the sensors to protect them from damage. In that case, the RTC temperature would be the most reliable one.

Logger battery voltage was also logged. The voltage divider used for the measurement was loosely calibrated and the accuracy is probably around 10%.
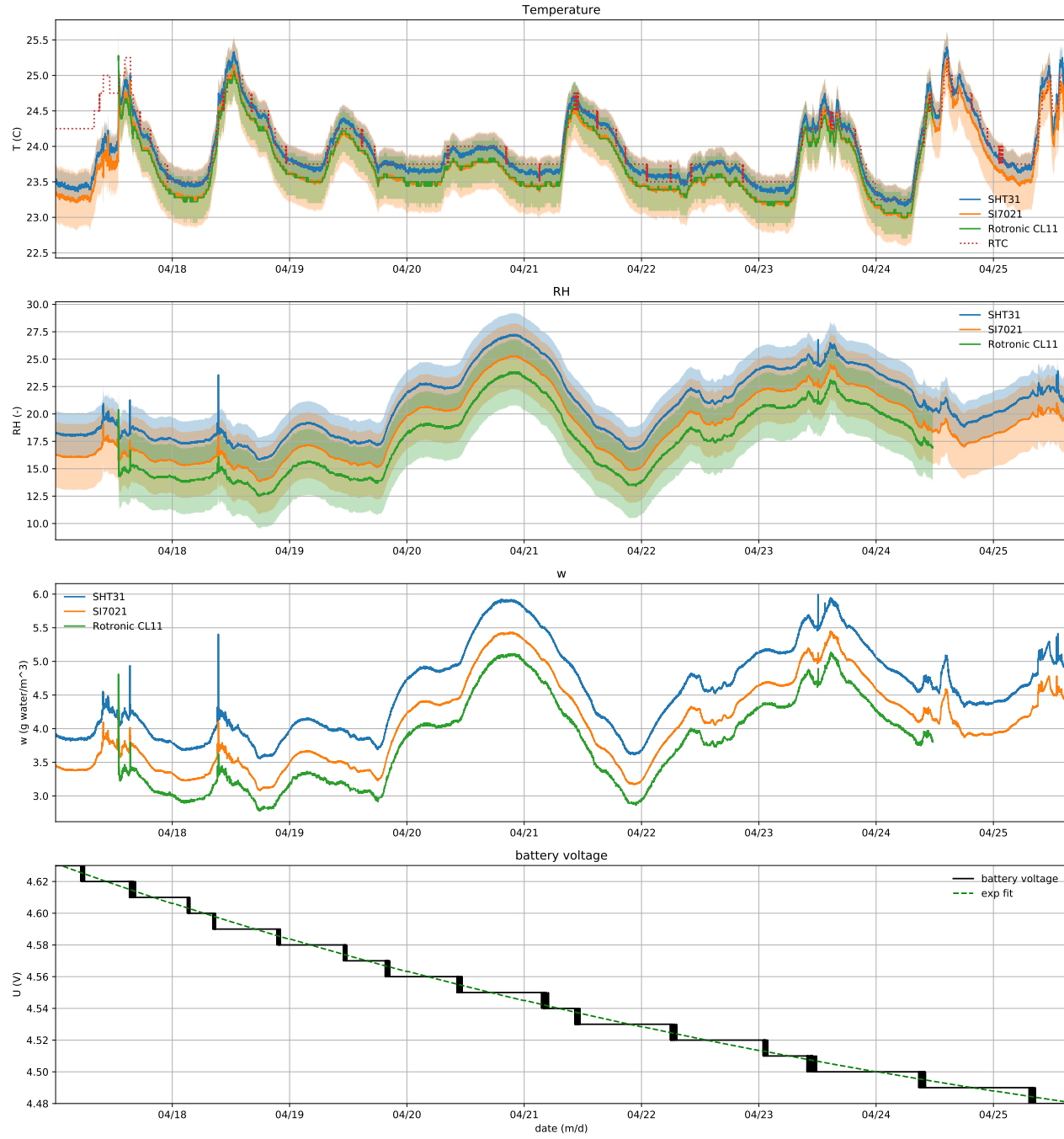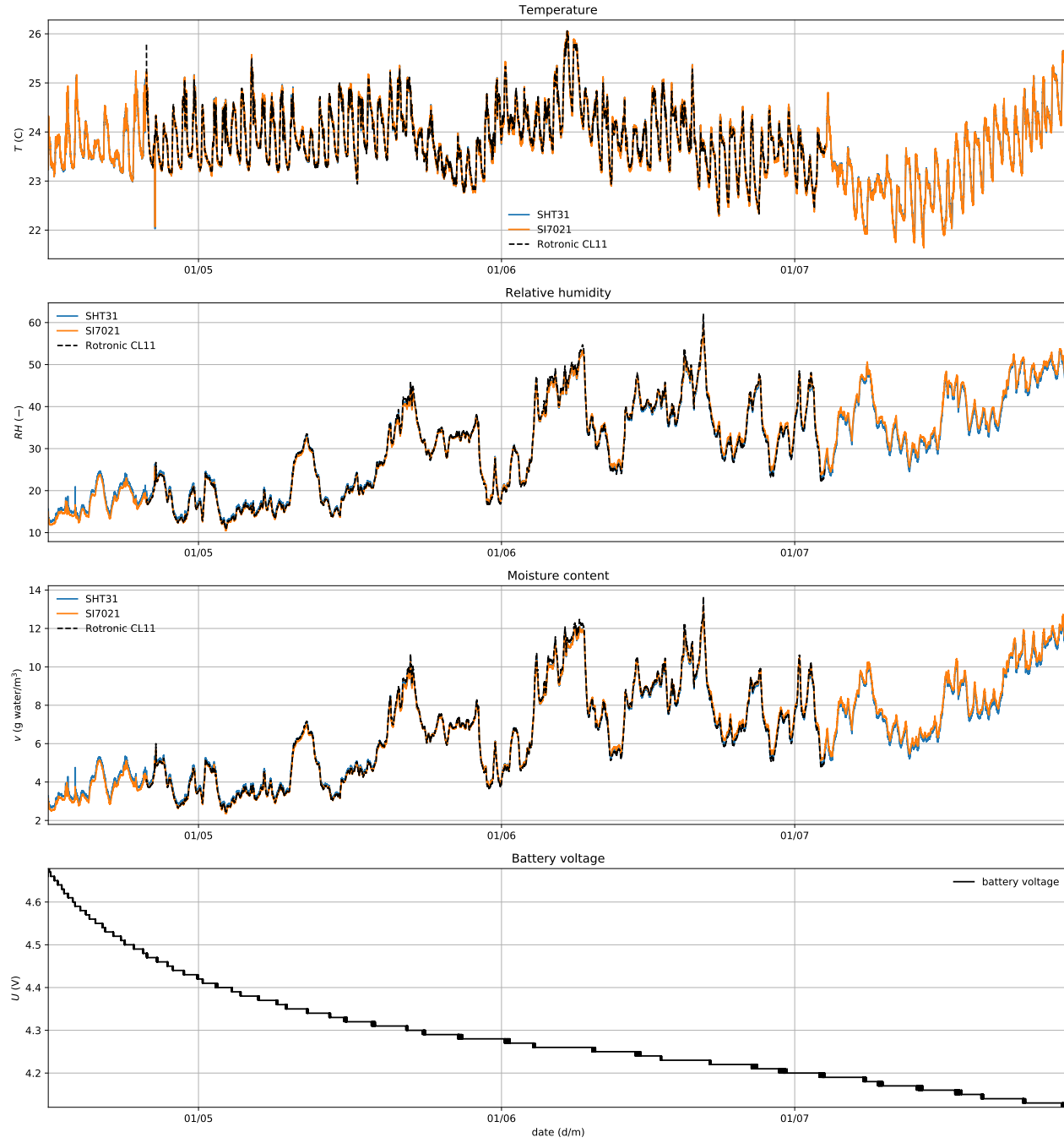
Figure 3: Comparison with Rotronic CL11

Figure 4: 2 Months comparison with Rotronic CL11. SHT31 and SI7021 results offset with constant values to correspond to Rotronic CL11.

Sensor	T	RH
SHT31-D	-0.17C	-2.60%
Si7021	+0.01C	-1.47%

Table 2: Offsets in the two moths test, Fig. 4.

4 Component

Both sensor boards use a Sensiron made sensor with PTFE membrane and heating.

4.1 Reported accuracy

Sensor	T	RH
SHT31-D	0.2C (0..85C)	2% (0-100%)
Si7021	0.4C (-10..85C)	3% (0-80%)

Table 3: Reported accuracy

4.2   Price

LOGGER

Seller	Component	Price
Adafruit	MicroSD card breakout board+[ID:254]	6.63
Adafruit	Adafruit DS3231 Precision RTC Breakout[ID:3013]	12.32
Sparkfun	Arduino Pro Mini 328 – 3.3V/8MHz DEV-11114	8.79
Sparkfun	microSD Card - 1GB (Class 4) COM-15107	4.37
		32.11

SENSORS

Seller	Component	Price
Adafruit	Adafruit Sensirion SHT31-D (Temperature & Humidity Sensor) [ID:2857]	12.32
Sparkfun	SparkFun Humidity and Temperature Sensor Breakout – Si7021 SEN-13763	14.05
		26.37

ELSE

Seller	Component	Price
Ebay	Three colorLED	0.87
	Wires, solder, etc...	1
		1.87

TOTAL

LOGGER	32.11
SENSORS	26.37
ELSE	1.87
	60.36

Table 4: Prices

5 Wire colors etc.

Color	Purposes
red	positive power (3.3V) and raw battery power
black	ground, (NOTE black heat-srink tubing may be misleading)
yellow	serial clock
green	serial data
orange	alarm, ...

Table 5: Wire colors