

NOAA Pacific Marine Environmental Laboratory
Ocean Climate Stations Project

TECHNICAL NOTE 3

Investigation of Rotronic Hygroclip HC2-S3

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Introduction

The Rotronic Hygroclip HC2-S3 is being considered as a possible replacement to the older Rotronic MP101 air temperature and relative humidity sensor on OCS moorings. The project goal is to find a sensor with low cost, and better stability of the relative humidity sensor, while maintaining or improving on the accuracy specifications of the older instrument.

This experiment was designed to compare the performance of a Hygroclip to the MP101, as well as to a Vaisala WXT 520 combination weather sensor. The comparison was conducted over several months, using the Flex data acquisition system, with the instruments installed on OCS buoy towers at the WRC campus.

Apparatus

- Rotronic Hygroclip HC2-S3 S/N 60194535 (Pre-calibration performed 22 Nov 2011)
- Rotronic MP101 S/N 51042 (Pre-calibration performed 12 Jan 2012)
- Vaisala WXT 520 S/N G4020103 (Pre-calibration performed 31 Oct 2011)
- Flex Data Acquisition System S/N 0002
- Flex Data Acquisition System S/N 0006
- OCS buoy hull and tower

The two Flex data acquisition systems were installed inside the well of an OCS buoy. The test instruments were mounted to the buoy tower, with their pre-calibration coefficients loaded in the Flex systems. The MP101 was considered the “reference sensor” to which all other instruments would be compared. It was connected to Flex 0006, while the Hygroclip and Vaisala were connected to Flex 0002.

Procedure

All ATRH instruments used in this comparison were installed within 3m of each other. They were exposed to outdoor conditions from January 14 to March 9, 2012. During this time, there were periods of cold winter weather, as well as some warmer days. The instruments experienced a broad range of temperatures and humidity levels.

Measurements were logged every 10 minutes by the Flex systems. At the end of the test period, this high-resolution data set was downloaded and analyzed. The values recorded by the test instruments were compared to the measurements recorded simultaneously by the MP101 “reference,” and difference statistics and linear fits were calculated by D. Dougherty.

Post calibrations were also performed on the relative humidity portion of the Hygroclip and the MP101. These were compared to the pre-calibrations, to check for drift in the RH sensor. Post-calibrations were not performed on the temperature sensors.

Results

The statistical analysis of the data is shown in Tables 1 and 2, and the linear fits are shown in Figure 1. Each instrument is identified by serial number. Note that the two designations for the Vaisala G4020103 represent separate time periods. During the period of January 14 – February 6, data

from this sensor were logged with previous calibration coefficients applied. On February 6, the coefficients were removed from the Flex system, so the raw output from the sensor was logged for the remainder of the testing.

The air temperature measurements all compared very well, with the maximum difference between $\pm 2^\circ\text{C}$ for all instruments. The mean differences were even smaller, with the Hygroclip averaging within -0.21°C , and the uncalibrated Vaisala within -0.18°C of the MP101.

The relative humidity measurements were more varied. The mean difference of Hygroclip measurements from MP101 values was the best comparison, at 0.72%. This was an order of magnitude better than the calibrated Vaisala. The maximum differences for the Hygroclip were near $\pm 10\%$, but when viewed graphically, the overall comparison is good.

AT Difference Statistics (Reference Sensor - MP101 51042)

	HC60194535	G4020103(1)	G4020103(2)
N Obs	7681	3263	4392
Mean	-0.21	0.73	-0.18
StdDev	0.17	0.26	0.15
RMS	0.27	0.77	0.24
Min	-1.90	-0.80	-1.40
Max	0.70	1.90	0.60

G4020103(1) : Jan 14 - Feb 06

G4020103(2) : Feb 06 - Mar 09

Table 1: Comparison of air temperatures from Hygroclip (HC60194535) and Vaisala (G4020103), to MP101 (51042).

RH Difference Statistics (Reference Sensor - MP101 51042)

	HC60194535	G4020103(1)	G4020103(2)
N Obs	7947	3401	4520
Mean	0.72	7.00	-2.68
StdDev	1.93	2.09	1.43
RMS	2.06	7.30	3.04
Min	-10.40	-3.50	-10.00
Max	9.10	14.50	2.20

G4020103(1) : Jan 14 - Feb 06

G4020103(2) : Feb 06 - Mar 09

Table 2: Comparison of relative humidities from Hygroclip (HC60194535) and Vaisala (G4020103), to MP101 (51042).

All statistics represent differences between the sensor output and the reference sensor. N Obs = number of observations compared, Mean = mean difference, StdDev = standard deviation, RMS = root-mean-square, Min = minimum difference, Max = maximum difference.

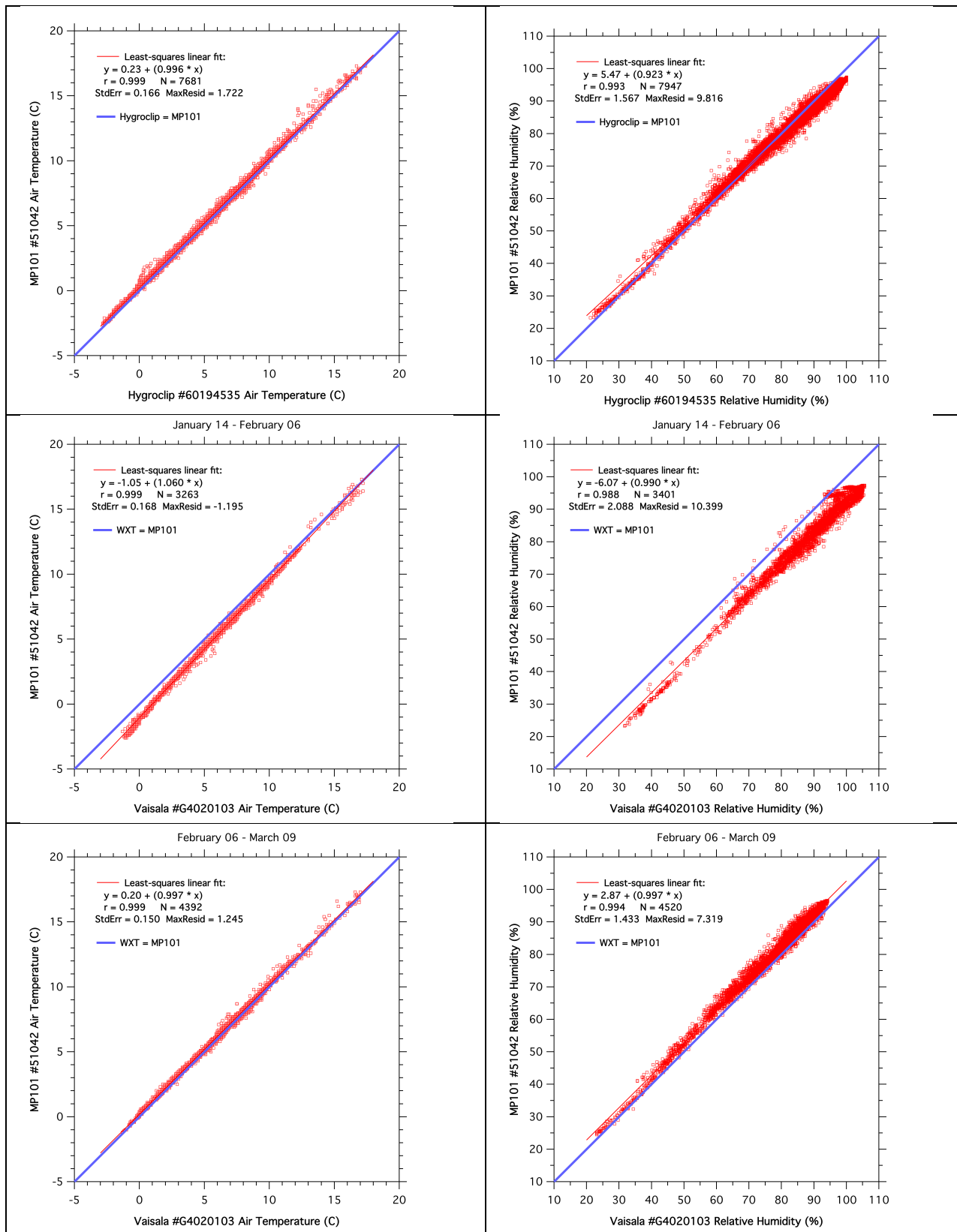


Figure 1: Graphical comparison of instrument performance vs. MP101 standard; air temperature in left column, relative humidity in right column.

The Rotronic MP101 and Hygroclip can be calibrated in a controlled temperature bath, and relative humidity chamber, but the Vaisala WXT cannot. Its “calibration” process is the same comparison-to-reference method described in this report.

Table 3 shows the pre and post RH calibration coefficients for each sensor, and their differences. Coefficient 1 is the slope of a linear fit, and Coefficient 2 is the intercept. The changes in intercept are insignificant for all sensors in this study. The change in slope for the Hygroclip is less than the changes for the MP101 and Vaisala.

Instrument	Pre-Cal Coeff1	Post-Cal Coeff1	Coeff1 Change	Pre-Cal Coeff2	Post-Cal Coeff2	Coeff2 Change
MP101 51042	-0.9064021	0.1431553	+1.0495574	0.9991156	0.9913629	-0.0077527
Hygroclip 60194535	-0.9006464	-0.3279846	+0.5726618	1.007241	0.9937256	-0.0135154
Vaisala G4020103	3.852074	2.871233	-0.980841	1.015677	0.9974941	-0.0181829

Table 3: Pre & post linear fit calibration coefficients for relative humidity. Coeff1 = Slope, Coeff2 = Intercept.

The Standard Error and Maximum Residual for each sensor calibration is calculated, as a measure of quality of fit. These values are shown in Table 4. StdErr is the standard error of the differences between the observed values, and the values given by the least-squares linear fit coefficients. MaxResid is the largest difference between the observed value, and the value predicted based on the fit. The MP101 linear fit actually improved slightly in the post calibration, but the Hygroclip had much lower Standard Errors and Maximum Residuals in both calibrations.

Instrument	Pre-Cal StdErr	Post-Cal StdErr	StdErr Change	Pre-Cal MaxResid	Post-Cal MaxResid	MaxResid Change
MP101 51042	0.276	0.267	0.010 Better	-0.352	-0.297	0.055 Better
Hygroclip 60194535	0.102	0.188	0.086 Worse	-0.108	-0.203	0.095 Worse
Vaisala G4020103	1.224	1.433	0.209 Worse	11.3	7.319	3.981 Better

Table 4: Standard error and maximum residual recorded during calibration procedures.

Recommendations

Based on the findings of this study, the Rotronic Hygroclip HC2-S3 can be recommended as a suitable replacement for the Rotronic MP101 sensors currently used on OCS buoys. The data compared well to the MP101, and the instrument actually calibrated better. In the short term of this study, there was no significant drift of the RH sensor noted in either instrument. Further testing is needed to determine if the Hygroclip has improved accuracy over the MP101. The present testing has shown that it is at least comparable.

The fact that both instruments are made by the same company is beneficial. The manufacturer should be expected, though not guaranteed, to maintain or improve upon their own standards of accuracy. The sensor will also require minimal effort to be integrated into the existing Flex systems and OCS moorings.

The Vaisala is mentioned in this report as a comparison. It is not suggested as a replacement for the MP101. These sensors cannot be calibrated in a controlled and repeatable way.

As an initial field test, the Hygroclip should be deployed on the Flex system, while the MP101 remains on the ATLAS system on an OCS mooring. This will generate a full year of comparison data in the field, for better analysis.

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