Woods Hole Oceanographic Institution

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Technical Report

September 1994

Calibration History of Some Rotronic MP-100 and Vaisala Humicap Relative Humidity Sensors

by

Richard E. Payne

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UOP Technical Report 94-3

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Abstract

An analysis has been made of the calibrations done during 1990 through 1994 on Rotronic MP-100 relative humidity sensors (used in the Improved METeorological (IMET) system) and sensors built at the Woods Hole Oceanographic Institution (WHOI) with the Vaisala Humicap sensing element (used in the Vector Averaging Wind Recorder (VAWR)). The shift from one calibration to the next is, typically, 2–3% RH which represents the major uncertainty in relative humidity with either of these sensors. The direction of each shift appears to be random; thus, there does not appear to be any long-term drifts.

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1. Introduction

The IMET package was developed by the Upper Ocean Processes Group (UOP) at WHOI for measuring the surface meteorological parameters required for the computation of heat and momentum fluxes at sea surface from buoys (Hosom *et al.*, 1994). These measured variables include wind velocity, air temperature, sea temperature, relative humidity, barometric pressure, shortwave and longwave radiation and precipitation. Of all these variables, relative humidity is a significant parameter since it is required for the calculation of latent heat flux, which is generally the largest heat flux from the sea to the atmosphere. After testing several prospective sensors, the Rotronic MP-100F was selected for use in the IMET relative humidity module (Crescenti *et al.*, 1990), because of its accuracy and reliability.

The VAWR measures a similar set of parameters, except precipitation, and has been used by the UOP group for a number of years. Its conversion from the Vector Averaging Current Meter (VACM) was first accomplished for the JASIN-72 experiment (Payne, 1974), and its present form is described in Dean and Beardsley (1988) and Trask *et al.* (1989). Its success has been due to its very high reliability and very low power consumption. The relative humidity sensor used with it has a Vaisala Humicap sensor element with electronics developed at WHOI (Trask *et al.*, 1989). As with the IMET relative humidity sensor, this sensor has proved accurate and reliable, consistent with the required specifications needed for measuring meteorological parameters.

2. Description of Sensors

The Rotronic MP-100F sensor has a thin film polymer capacitative relative humidity element and a platinum film temperature element. The sensor electronics provide a nominal 0–1 volt output for each, corresponding to 0 to 100% RH and -30 to $+70$°C, respectively. The manufacturer's accuracy specifications are ±2.0% RH from 0 to 100% RH and ±0.5°C. Each relative humidity IMET module has had a Rotronic sensor dedicated to it. No exchanges of sensors have been made in any of the modules analyzed nor have any adjustments been made to the Rotronic sensors or module A/Ds unless there was some kind of failure. In the case of such a failure, the calibration data prior to the failure have been deleted from the results.

The voltages from the Rotronic sensor are digitized in the IMET module by a 15 bit A/D. Testing of these shows that they are extremely stable and precise so the error contributed to the relative humidity measurement by the A/D or associated electronics is an insignificant part of the total error.

For the VAWR sensor, the sensor electronics convert the capacitance of the thin film polymer capacitative Humicap element into a frequency which is an analog of relative humidity. The frequency output is much more convenient to handle in the VAWR than an analog voltage. Until now, the sensor has had no provision for measuring air temperature.

3. Data

Each IMET relative humidity sensor and module has been calibrated as a unit before and after each deployment. Over the three years since deployments began we have accumulated a sufficiently substantial body of successive calibrations on the modules to make a meaningful examination of the results. The VAWR sensors are also calibrated before and after each deployment. In their case, however, the sensor is calibrated alone with the period of the output recorded. High-quality calibrations of the VAWR sensors also began in early 1991. Since they have been used more frequently, we have more calibration data for them.

Both IMET modules and VAWR sensors are calibrated in a Tecnequip relative humidity chamber using, as a standard, a General Eastern Model 1500 Hygrocomputer with a Model 1211 HX optical sensor and air temperature sensor attached (and in the chamber). The chamber is microprocessor controlled and settings are repeatable to a few percent RH and 1°C. The chamber holds constant to 0.1% RH and 0.1°C for long periods of time. The General Eastern combination measures air and dew point temperatures to 0.1°C accuracy and computes relative humidity as well as temperature. The General Eastern Model 1500 and sensors are calibrated annually and have shown no signs of drift beyond the 0.1°C.

The error in measuring temperature leads to an error in the calculated RH which varies with relataive humidity. Figure 1 shows the error in %RH to be expected from a 0.1°C error in dew point temperature for three ambient temperatures. It is apparent that it varies from about 0.2 to about 0.6% RH over the range of relative humidities we may expect to see but varies slowly with air temperature at a given RH value. Since relative humidity is computed from both air and dew point temperatures and both have the same uncertainty, the possible error in the chamber relative humidities is double the graph values, or 0.4 to 1.2% RH. This represents the calibration accuracy of the sensors.

Since we have not used the air temperature measured at the Rotronic sensor in the past, only a rough calibration check has been made on this parameter. We are continually refining our methods, however, and will, in the immediate future, begin using these temperatures to correct the relative humidity values to the ambient temperature as measured by the IMET or VAWR air temperature sensor. Because of this, we are modifying the VAWR sensors to measure temperature and have begun making precise calibrations, in a water bath, of the relative humidity air temperature measurements. Since these calibrations have only recently begun, we have nothing to report on yet.

4. IMET Calibration Data

Table 1 is the report from a recent calibration of one of the IMET modules. Figure 2 is a plot of the data and the curve fitted to it. Note that the fit is done for the counts out of the A/D. At the bottom of Table 1 is a table of standard outputs for all the calibrations which have been done on the sensor. The first column is a standard set of count values used for every module. The rest of the table is the result of substituting these count values into the equation under the heading "FIT STATISTICS" for each of the calibrations. Although the absolute value of each individual table entry has little meaning, the variation from one to another across the table gives a quantitative measure of how much the calibration curve of the sensor has shifted between calibrations as a function of relative humidity.

Table 2 is a distillation of the standard output table from all the IMET modules. Listed are the module number, the number of days since the previous calibration, and the differences between the standard output table value for a given count value and date and the previous calibration set of these numbers for relative humidities of 20–90% RH. Thus, this is a history of the calibration shifts of all the modules. At the bottom of the table are the mean value for each nominal RH value and the standard deviation about that mean for all the sensors in the table. Figures 3 to 10 are plots of the table values for nominal relative humidities of 20–90% RH at 10% RH intervals. From these figures and Table 2 it is apparent that most of the differences are within $\pm$ 3% RH of zero and are nearly independent of the actual relative humidity value. We would expect to see a positive correlation between the RH differences and time if the sensors tended to drift steadily with time, *i.e.*, a longer time between successive calibrations would yield a larger shift. Since none is apparent, we conclude that the differences between calibrations are random and represent the true uncertainty in relative humidity measurements with these sensors. From the standard deviations, the uncertainty ranges from $\pm$ 2% RH at low relative humidities to $\pm$ 3% RH at high values. Since this uncertainty is a factor of 6 larger than the uncertainty in our calibrations, we conclude that this is the limit of accuracy of the Rotronic sensors and the source of the dominant error in each measurement.

5. VAWR Calibration Data

Table 3 is the report from a VAWR sensor calibration study. In this case the fit is done to the period of the output of the sensor. Figure 11 is a plot of the data and the curve fitted to it. The quantities in both Table 3 and Figure 11 are analogous to those for the IMET sensors in Table 1 and Figure 2.

Table 4 is a compilation of all the calibration data from the VAWR sensors similar to that for the IMET modules in Table 2. Figures 12 to 19 are plots of the table values for nominal relative humidities of 20–90% RH at 10 % RH intervals. For the VAWR sensors there is a much larger variation of calibration shift with relative humidity although the maximum values are similar in magnitude. The values are quite small at low relative humidities and of a size similar to those of the IMET at high humidities. Since relative humidity values at sea are rarely below 50% RH, the uncertainty in values measured by the VAWR in typical conditions is ±2 to 3% RH, equivalent to that of the IMET.

6. Temperature Dependence of Relative Humidity Sensors

Table 5 shows the differences between calibrations at 10°C and 20°C on successive days at a variety of nominal relative humidity values for six IMET modules. It is apparent that a temperature shift of 10°C causes a shift of the order of − 2% RH in the output of the sensor at low relative humidities and + 1–2% RH at high humidities. Again, because of the A/D design, this temperature dependence is very likely in the Rotronic sensor.

Table 6 shows the equivalent temperature effect in the VAWR relative humidity sensor. In the relative humidity region that most interests us the magnitude of the effect is of order 1% RH or less for the 10°C difference.

Both the IMET and VAWR show a temperature dependence which should be accounted for in the use of data from them.

7. Summary and Conclusion

Analysis of calibration results for both IMET modules and the VAWR sensors designed and built at WHOI shows that both have random shifts in their calibrations of ±2 to 3% RH in the range of humidities usually experienced at sea. This represents the major uncertainty in measurements made with the sensors. A smaller, and undetermined, error results from the uncorrected temperature dependence of both type of sensors.

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Acknowledgments

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Table 1: Example of report of IMET sensor calibration

OUTPUT OF FITHRH.FOR (11/26/91) 13:26:12 EST 04/13/94
LEAST SQUARES THIRD DEGREE FIT

S/N HRH005 CAL: 04-12-1994 10:05:00

INPUT DATA: Means and SDs of 5 points per RH value

NRH MEAN	NRH STD	RH	NAT MEAN	NAT STD	AT
7291.6	1.2	22.1	13356.0	.6	20.2
8902.0	1.3	27.6	13381.6	1.2	20.1
10257.8	.7	32.1	13502.8	.4	20.3
11352.0	3.1	35.8	13549.0	.9	20.3
13027.2	2.3	40.6	13564.2	.7	20.3
14721.8	2.1	45.7	13567.2	.7	20.4
16368.0	.6	50.5	13578.0	1.1	20.4
17989.0	.9	55.6	13587.2	.4	20.3
19659.6	3.0	60.5	13595.2	.7	20.4
21245.0	1.1	65.7	13605.6	.5	20.4
23202.4	3.0	71.4	13631.0	.9	20.4
24788.4	2.2	76.3	13668.6	.5	20.4
26364.6	2.4	81.0	13690.0	.6	20.5
27815.2	1.5	85.7	13657.0	.6	20.4
29200.8	1.0	90.3	13692.4	.5	20.4
29805.8	1.6	92.1	13684.4	.5	20.4

FIT STATISTICS

RH = -4.120 + 0.0039403*N - 0.5036E-07*N**2 + 0.8918E-12*N**3

RH	NRH	RHCALC	RH-RHC
22.10	7291.6	22.28	-.18
27.60	8902.0	27.60	.00
32.10	10257.8	31.96	.14
35.80	11352.0	35.43	.37
40.60	13027.2	40.64	-.04
45.70	14721.8	45.82	-.12
50.50	16368.0	50.79	-.29
55.60	17989.0	55.66	-.06
60.50	19659.6	60.66	-.16
65.70	21245.0	65.41	.29
71.40	23202.4	71.33	.07
76.30	24788.4	76.19	.11
81.00	26364.6	81.10	-.10
85.70	27815.2	85.71	-.01
90.30	29200.8	90.21	.09
92.10	29805.8	92.20	-.10

RHSTD = .17
Number of data points = 16

Standard outputs using cal equation

N	RH 4/12/94	9/14/93	7/14/93	2/12/92	9/16/91	2/27/91
6000.	17.90	15.92	23.51	18.26	21.05	18.64
9000.	27.91	27.48	30.47	27.99	28.64	29.54
12000.	37.45	38.10	38.52	37.23	36.83	39.36
15000.	46.66	48.03	47.38	46.15	45.52	48.29
18000.	55.69	57.50	56.78	54.91	54.61	56.53
21000.	64.68	66.76	66.44	63.68	64.01	64.26
24000.	73.77	76.04	76.08	72.64	73.60	71.67
27000.	83.11	85.58	85.42	81.94	83.30	78.95
30000.	92.85	95.61	94.19	91.76	93.01	86.30

Table 2: Summary of IMET shifts between calibrations

MOD	DYD	20	30	40	50	60	70	80	90 %RH
HRH001	436.0	2.96	3.08	2.93	2.58	2.10	1.59	-6.88	.79
HRH001	480.0	-.93	-.83	-.71	-.58	-.43	-.28	-.13	.02
HRH002	436.0	-1.83	-1.89	-2.01	-2.12	-2.13	-1.96	-1.53	-.76
HRH002	480.0	-3.78	-4.55	-4.86	-4.82	-4.55	-4.17	-3.79	-3.52
HRH003	514.0	-.60	-.87	-.62	-.02	.76	1.56	2.23	2.58
HRH004	74.0	-1.76	-1.35	-.72	.02	.80	1.52	2.08	2.40
HRH004	129.0	1.48	.10	-.38	-.22	.30	.92	1.35	1.33
HRH004	70.0	-.62	.40	.98	1.22	1.17	.92	.55	.12
HRH004	198.0	-1.58	-1.38	-1.52	-1.82	-2.10	-2.20	-1.94	-1.12
HRH004	78.0	2.89	2.84	2.80	2.73	2.62	2.42	2.12	1.67
HRH004	180.0	-.72	-.13	.11	.07	-.12	-.37	-.55	-.56
HRH004	329.0	1.90	1.81	1.81	1.97	2.27	2.79	3.52	4.51
HRH005	201.0	-.90	-2.53	-2.77	-1.92	-.25	1.93	4.35	6.71
HRH005	149.0	-.65	.40	.63	.30	-.33	-.96	-1.36	-1.25
HRH005	518.0	2.48	1.29	1.23	1.87	2.76	3.44	3.48	2.43
HRH005	62.0	-2.99	-.42	.65	.72	.32	-.04	.16	1.42
HRH005	210.0	.43	-.65	-1.37	-1.81	-2.08	-2.27	-2.47	-2.76
HRH006	271.0	-1.35	-1.94	-2.19	-2.15	-1.90	-1.50	-1.03	-.54
HRH006	456.0	-.67	.27	.77	.95	.91	.75	.60	.54
HRH006	329.0	2.58	2.46	2.43	2.48	2.58	2.73	2.88	3.04
HRH101	78.0	2.89	2.84	2.80	2.73	2.62	2.42	2.12	1.67
HRH101	181.0	-1.45	-1.48	-1.83	-2.29	-2.70	-2.85	-2.56	-1.63
HRH101	328.0	-.01	-.65	-.79	-.60	-.20	.26	.63	.76
HRH102	39.0	.22	.71	.91	.93	.87	.81	.84	1.08
HRH102	202.0	-2.25	-1.85	-1.66	-1.60	-1.59	-1.54	-1.38	-1.02
HRH102	238.0	-1.00	-.97	-1.23	-1.69	-2.23	-2.78	-3.23	-3.49
HRH102	292.0	1.72	1.80	2.05	2.40	2.78	3.13	3.41	3.53
HRH103	481.0	-1.72	-2.21	-2.59	-2.82	-2.89	-2.81	-2.55	-2.11
HRH104	458.0	-.66	-.37	-.68	-1.32	-1.99	-2.42	-2.35	-1.51
HRH106	458.0	-.49	-.29	-.56	-1.11	-1.74	-2.26	-2.46	-5.16
HRH107	591.0	-1.57	-1.17	-.85	-.61	-.42	-.25	-.09	.08
HRH107	225.0	1.27	1.62	1.63	1.34	.96	.56	.50	1.48
HRH108	202.0	-.92	-.47	-.20	-.07	-.03	-.03	-.02	.04
HRH108	587.0	-1.67	-2.92	-3.90	-4.71	-5.45	-6.25	-7.20	-8.40
HRH110	170.0	-1.53	-1.85	-1.94	-1.84	-1.64	-1.37	-1.09	-.86
HRH110	244.0	-2.69	-2.75	-2.90	-3.09	-3.23	-3.28	-3.19	-2.88
HRH110	180.0	.47	.79	.94	.98	1.02	1.15	1.45	2.03
HRH111	620.0	.08	.40	.68	.79	.75	.46	.10	.14
HRH115	42.0	-.43	-.96	-1.13	-1.05	-.85	-.64	-.53	-.64
MEANS		-.34	-.35	-.38	-.38	-.37	-.37	-.36	-.37
STD DEVS		1.68	1.71	1.84	1.92	2.02	2.18	2.58	2.69

Table 3: Example of report of VAWR sensor calibration

```
OUTPUT OF RHPFIT3.FOR
LEAST SQUARES THIRD DEGREE FIT TO

BUOY GROUP SENSOR V-021-001    CAL 22 Feb 1994   COMP 22 Feb 1994
 CAL TEMP 20 C

  RH = (  .116313E+05) + ( -.1635142E+03)*P
       + ( .7444493E+00)*P**2 + (-.1092602E-02)*P**3

  RH = 20.0 +  4.9250*(P-P20) +   .04575*(P-P20)**2
          +  -.0010926*(P-P20)**3
       P20 =  213.16        P in microseconds

INPUT DATA

    RH         P      RHCALC    RH-RHC

   19.88   213.182    20.12     -.24
   25.41   214.208    25.22      .19
   30.26   215.162    30.05      .21
   34.50   216.014    34.42      .08
   40.41   217.177    40.46     -.05
   45.33   218.133    45.50     -.17
   50.40   219.072    50.50     -.10
   55.59   220.008    55.53      .06
   60.40   220.914    60.44     -.04
   65.37   221.815    65.36      .01
   70.26   222.736    70.41     -.15
   76.30   223.768    76.10      .20
   80.99   224.643    80.95      .04
   90.70   226.372    90.55      .15
   94.81   227.169    94.98     -.17

                     RHSDRH =       .14
Number of data points =    15

Standard outputs using curve
   P        RH
         2/22/94  2/93 11/91  2/91 12/90
 212.00    14.4   12.5  16.1  16.8  18.5
 214.00    24.2   22.8  25.4  26.1  27.3
 216.00    34.3   33.2  35.4  36.2  37.1
 218.00    44.8   43.6  46.1  46.7  47.8
 220.00    55.5   54.1  57.1  57.3  59.0
 222.00    66.4   64.8  68.3  68.0  70.5
 224.00    77.4   75.6  79.3  78.3  81.9
 226.00    88.5   86.6  90.1  88.1  92.9
 228.00    99.6
```

Table 4: Summary of VAWR shifts between calibraitons

FILE: DIFSTATV.OUT OUTPUT OF DIFSTATV.FOR (8/24/94)

SENSOR	DYD	20	30	40	50	60	70	80	90 %RH
V-021	1.	.18	-.99	-1.52	-1.56	-1.26	-.77	-.26	.13
V-021	50.	.06	-.36	-.63	-.85	-1.10	-1.50	-2.12	-3.07
V-021	283.	.07	-.37	-.54	-.52	-.38	-.20	-.05	-.02
V-021	463.	-.07	.30	.27	.00	-.32	-.54	-.48	.02
V-021	364.	-.01	-.01	-.15	-.34	-.50	-.53	-.33	.17
V-022	181.	-.04	.72	1.44	2.12	2.79	3.46	4.13	4.82
V-022	39.	.03	-.37	-.46	-.29	.09	.62	1.26	1.96
V-022	149.	.03	-.30	-.34	-.15	.21	.65	1.10	1.51
V-022	65.	-.01	.25	.52	.80	1.10	1.42	1.77	2.16
V-022	725.	.00	-.07	-.11	-.06	.14	.55	1.23	2.24
V-023	59.	-.03	.17	.18	.08	-.02	-.03	.14	.58
V-023	395.	.00	-.01	-.05	-.04	.10	.45	1.10	2.13
V-023	329.	-.02	.17	.23	.28	.46	.89	1.70	3.03
V-023	376.	-.05	.41	.61	.71	.84	1.15	1.78	2.87
V-024	1.	.09	-.24	-.14	.22	.69	1.13	1.39	1.31
V-024	41.	-.01	.00	-.13	-.32	-.49	-.56	-.46	-.10
V-024	395.	.04	-.16	-.26	-.23	-.09	.18	.57	1.09
V-024	480.	.21	-.80	-1.22	-1.18	-.79	-.16	.60	1.38
V-025	652.	.02	-.13	-.25	-.30	-.22	.01	.45	1.14
V-026	1.	.14	-.25	-.15	.28	.87	1.44	1.83	1.87
V-026	41.	.03	-.10	-.22	-.33	-.44	-.56	-.68	-.83
V-026	224.	-.05	.29	.84	1.49	2.13	2.65	2.95	2.90
V-026	464.	.13	-.46	-1.04	-1.53	-1.88	-2.04	-1.95	-1.54
V-026	363.	-.08	.26	.56	.84	1.13	1.44	1.79	2.21
V-027	1.	.04	-.06	.18	.63	1.20	1.75	2.19	2.39
V-027	42.	.04	-.18	-.26	-.24	-.13	.02	.19	.35
V-027	223.	.04	-.18	-.18	-.04	.21	.49	.75	.92
V-027	464.	.02	-.24	-.62	-1.00	-1.29	-1.35	-1.09	-.39
V-027	363.	-.02	.12	.25	.41	.61	.88	1.23	1.69
V-028	1.	.11	-.27	-.07	.51	1.22	1.85	2.17	1.94
V-028	265.	.02	.07	.42	.93	1.51	2.03	2.38	2.45
V-028	262.	-.50	1.82	2.97	3.86	5.37	8.42	13.90	22.72
V-028	21.	.27	-.95	-1.34	-1.16	-.66	-.10	.27	.19
V-028	180.	-.18	.79	1.46	1.89	2.15	2.31	2.42	2.58
V-028	364.	-.05	.31	.72	1.16	1.59	1.96	2.24	2.41
V-029	1.	.07	-.15	.08	.61	1.28	1.95	2.44	2.62
V-029	42.	.06	-.24	-.38	-.40	-.36	-.27	-.20	-.18
V-029	394.	.01	-.04	-.06	-.02	.12	.37	.79	1.39
V-029	91.	.10	-.34	-.41	-.21	.18	.69	1.23	1.72
V-029	202.	.05	-.30	-.67	-.99	-1.19	-1.19	-.93	-.33
V-029	363.	-.23	.93	1.57	1.87	2.02	2.22	2.64	3.47
V-030	1.	.00	.14	.43	.82	1.25	1.67	2.01	2.23
V-030	42.	.00	-.14	-.32	-.52	-.68	-.77	-.76	-.59
V-031	223.	.00	-.12	-.21	-.28	-.30	-.30	-.26	-.19
V-031	151.	.01	.39	.45	.31	.07	-.13	-.20	.01
V-031	313.	.00	.06	-.03	-.19	-.35	-.46	-.43	-.19
V-031	412.	.01	.32	.42	.41	.41	.51	.83	1.48
V-032	223.	.04	-.31	-.51	-.59	-.58	-.51	-.42	-.33
V-032	151.	-.19	1.33	1.96	2.23	2.71	3.96	6.54	11.00
V-032	105.	.00	-.01	-.04	-.01	.11	.38	.85	1.57
V-032	620.	-.03	.18	.22	.14	-.01	-.15	-.24	-.21
V-033	102.	.00	-.53	-.63	-.44	-.10	.26	.48	.43
V-033	827.	.00	-.07	-.03	.11	.34	.64	1.02	1.45
V-034	312.	-.01	.66	1.09	1.34	1.50	1.62	1.78	2.04
V-034	364.	-.01	.57	1.13	1.67	2.23	2.82	3.46	4.16
MEANS		.01	.03	.09	.22	.43	.74	1.18	1.76
STD DEVS		.11	.49	.79	.99	1.23	1.62	2.29	3.45

Table 5: Summary of IMET shifts due to 10°C temperature difference

MOD	20	30	40	50	60	70	80	90 %RH
HRH001	-2.40	-2.04	-1.34	-.48	.38	1.07	1.45	1.36
HRH002	-1.81	-1.22	-.41	.45	1.20	1.70	1.77	1.25
HRH003	-.77	-.23	.44	1.13	1.71	2.03	1.99	1.44
HRH004	-2.70	-2.22	-1.45	-.54	.35	1.05	1.39	1.22
HRH005	-1.31	-.87	.08	1.29	2.52	3.54	4.11	3.98
HRH006	-1.67	-1.21	-.56	.18	.88	1.40	1.61	1.39
MEANS	-1.78	-1.30	-.54	.34	1.17	1.80	2.05	1.77
SD	.64	.68	.69	.71	.76	.85	.94	.99

Table 6: Summary of VAWR shifts due to 10°C temperature difference

SEN	20	30	40	50	60	70	80	90 %RH
V-021	1.2	.2	-.4	-.4	-.2	.4	.9	1.2
V-024	-2.2	-2.8	-2.8	-2.5	-2.1	-1.6	-1.3	1.3
V-026	-1.9	-2.2	-2.0	-1.5	-.9	-.4	.0	.1
V-027	-1.9	-2.4	-2.5	-2.1	-1.6	-1.1	-.6	-.1
V-028	-.8	-1.7	-.9	-1.5	-.8	-.2	.4	.4
V-029	-1.8	-2.1	-2.0	-1.6	-.8	-.2	.3	.5
V-030	-3.0	-3.0	-2.8	-2.5	-2.1	-1.5	-1.1	-.7
MEANS	-1.7	-2.3	-2.2	-2.0	-1.4	-.8	-.2	.5
SD	1.4	1.1	1.0	.8	.8	.8	.8	.7

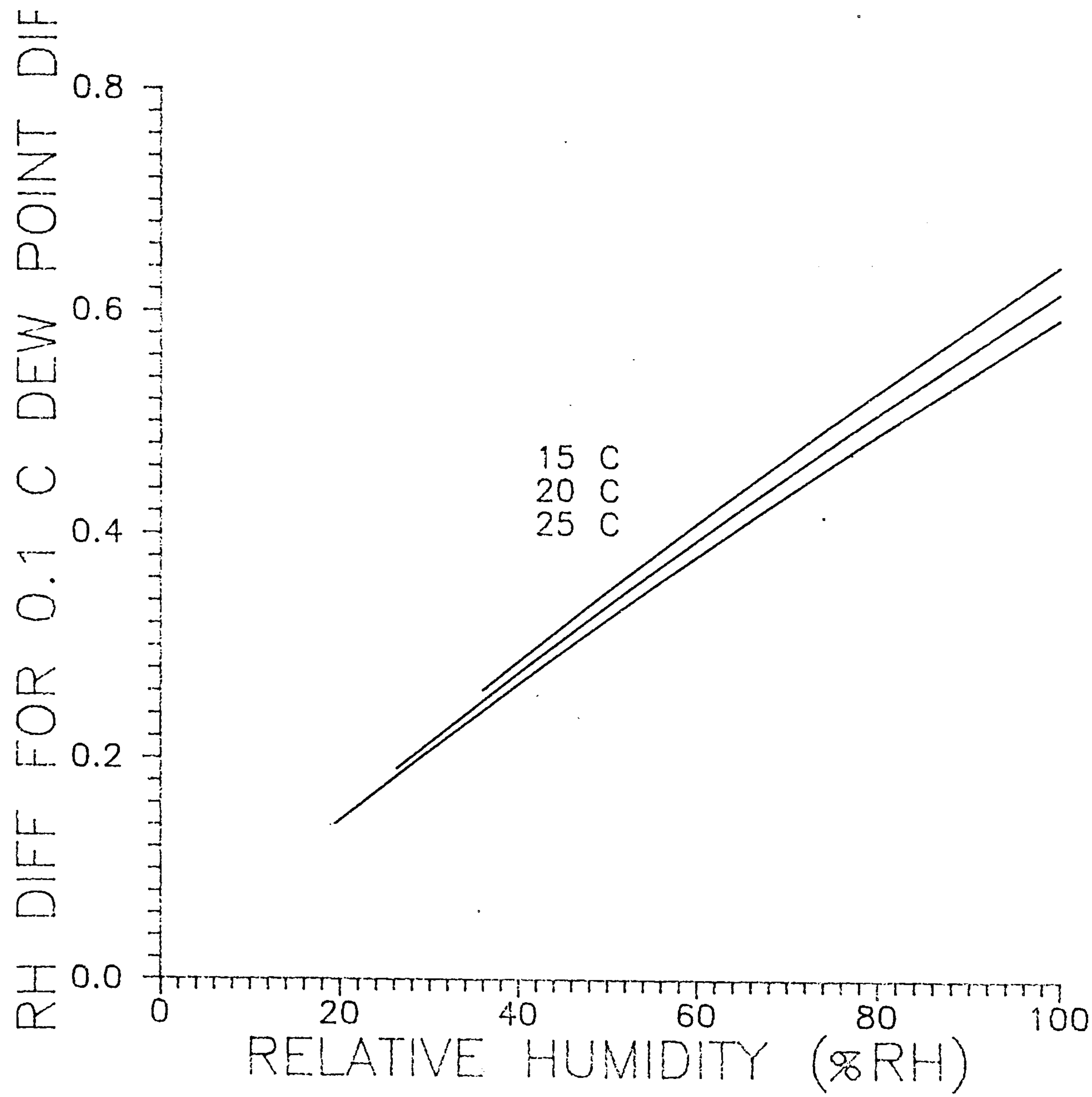

Figure 1: Error in computed relative humidity from 0.1°C error in dew point temperature.

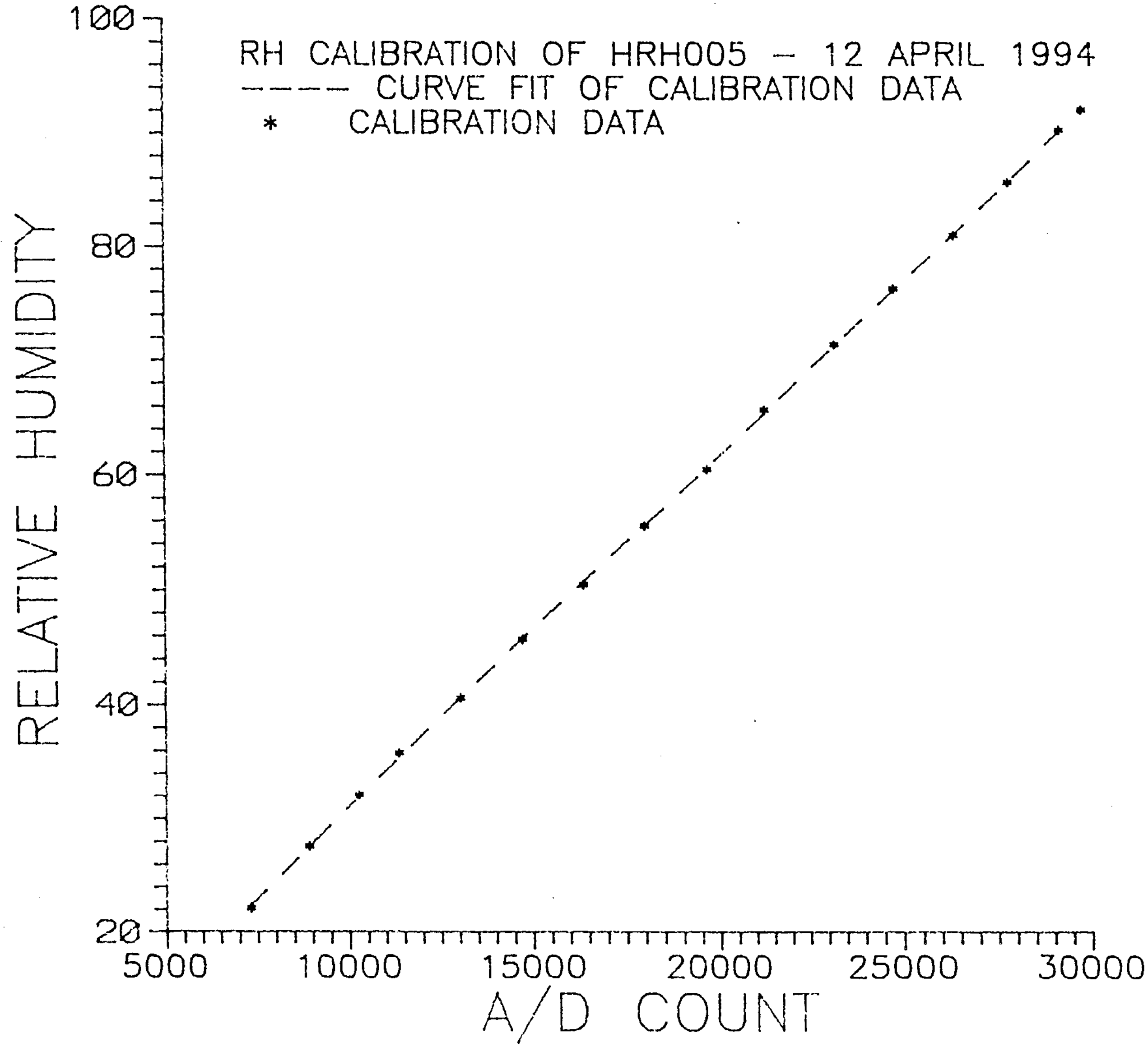

Figure 2: Example of IMET sensor calibration. Asterisks are data points, dashed line is curve fitted to data

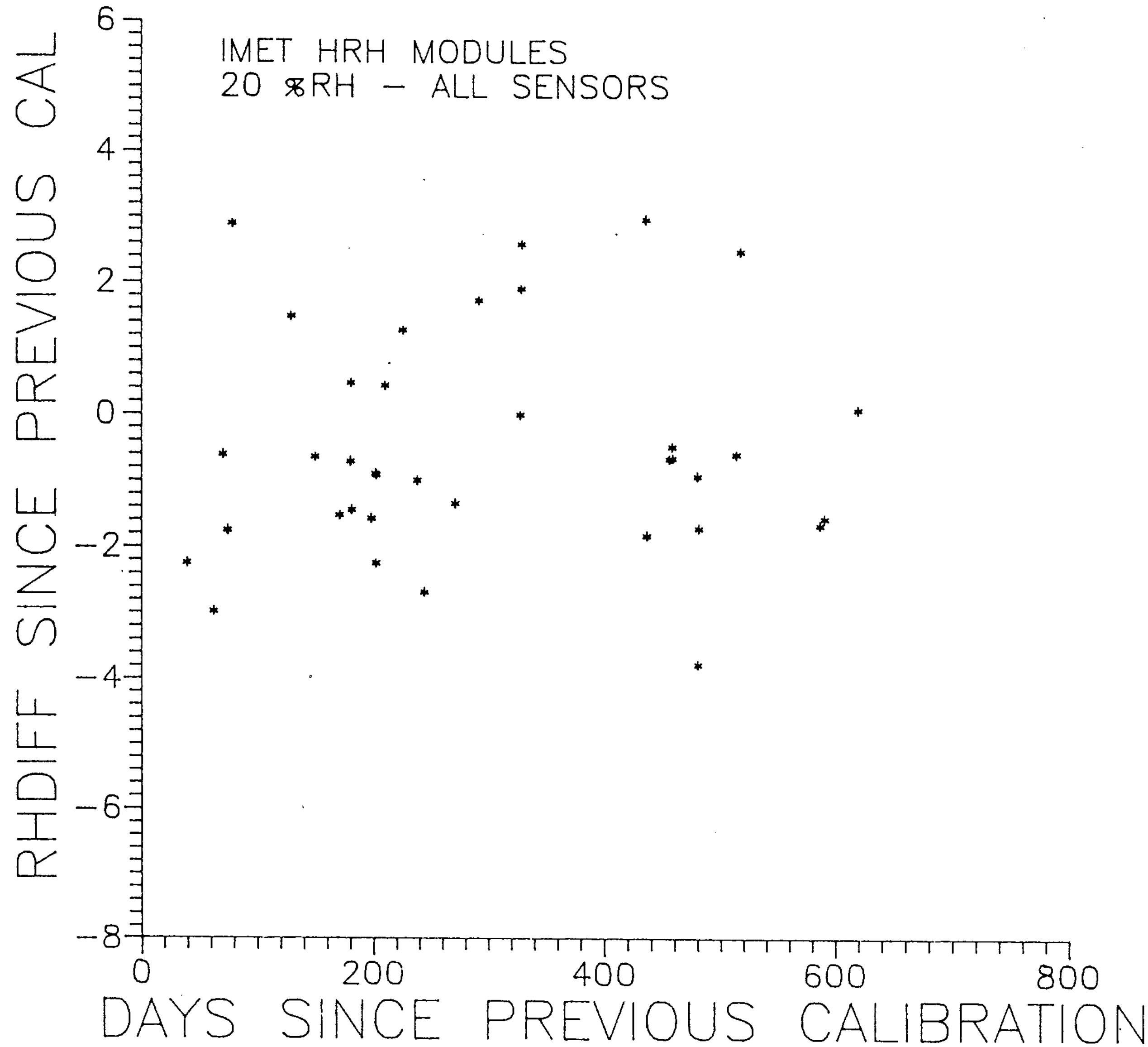

Figure 3: Shifts in IMET sensor calibrations at 20% RH as a function of time since previous calibration.

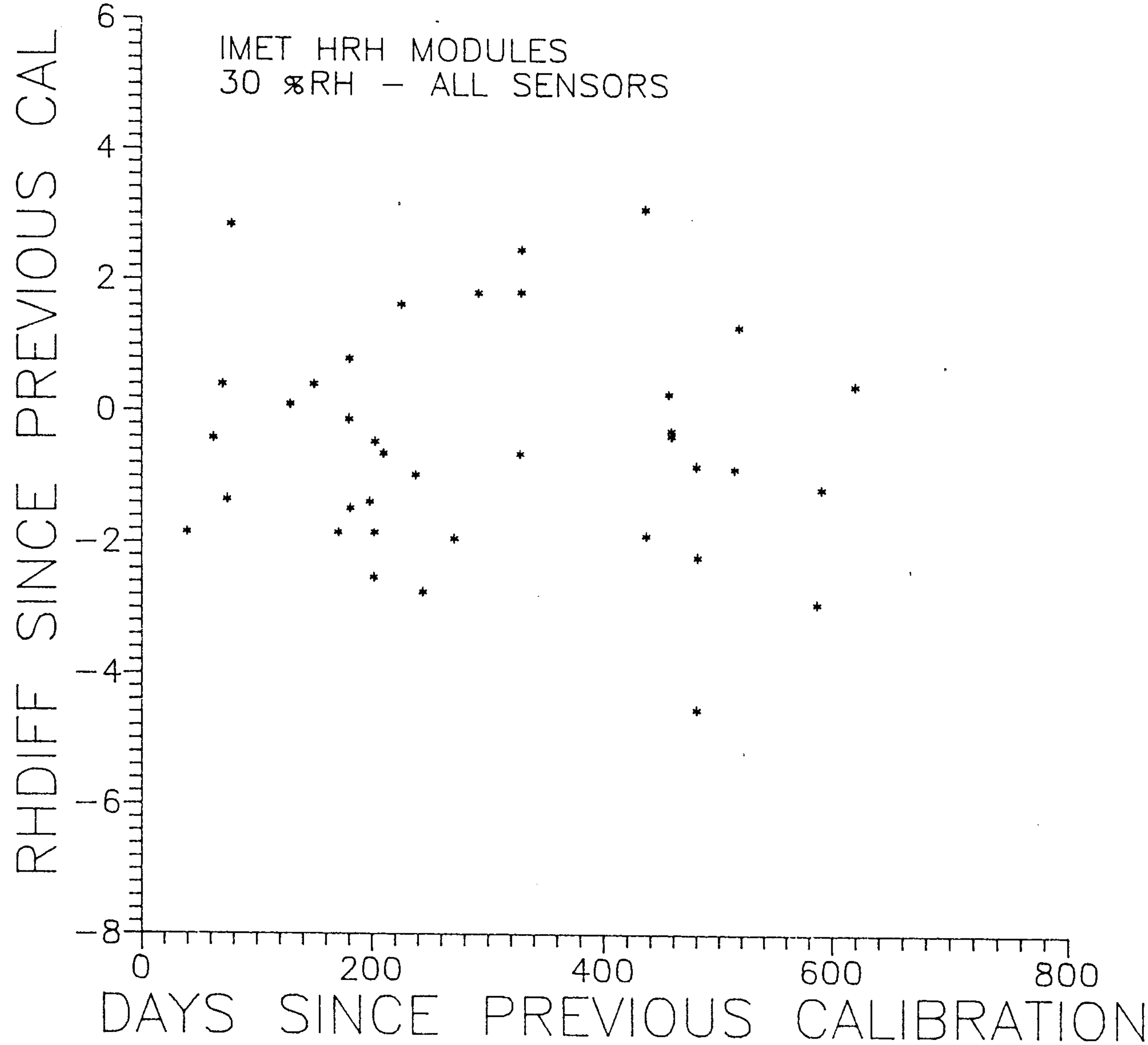

Figure 4: Shifts in IMET sensor calibrations at 30% RH as a function of time since previous calibration.

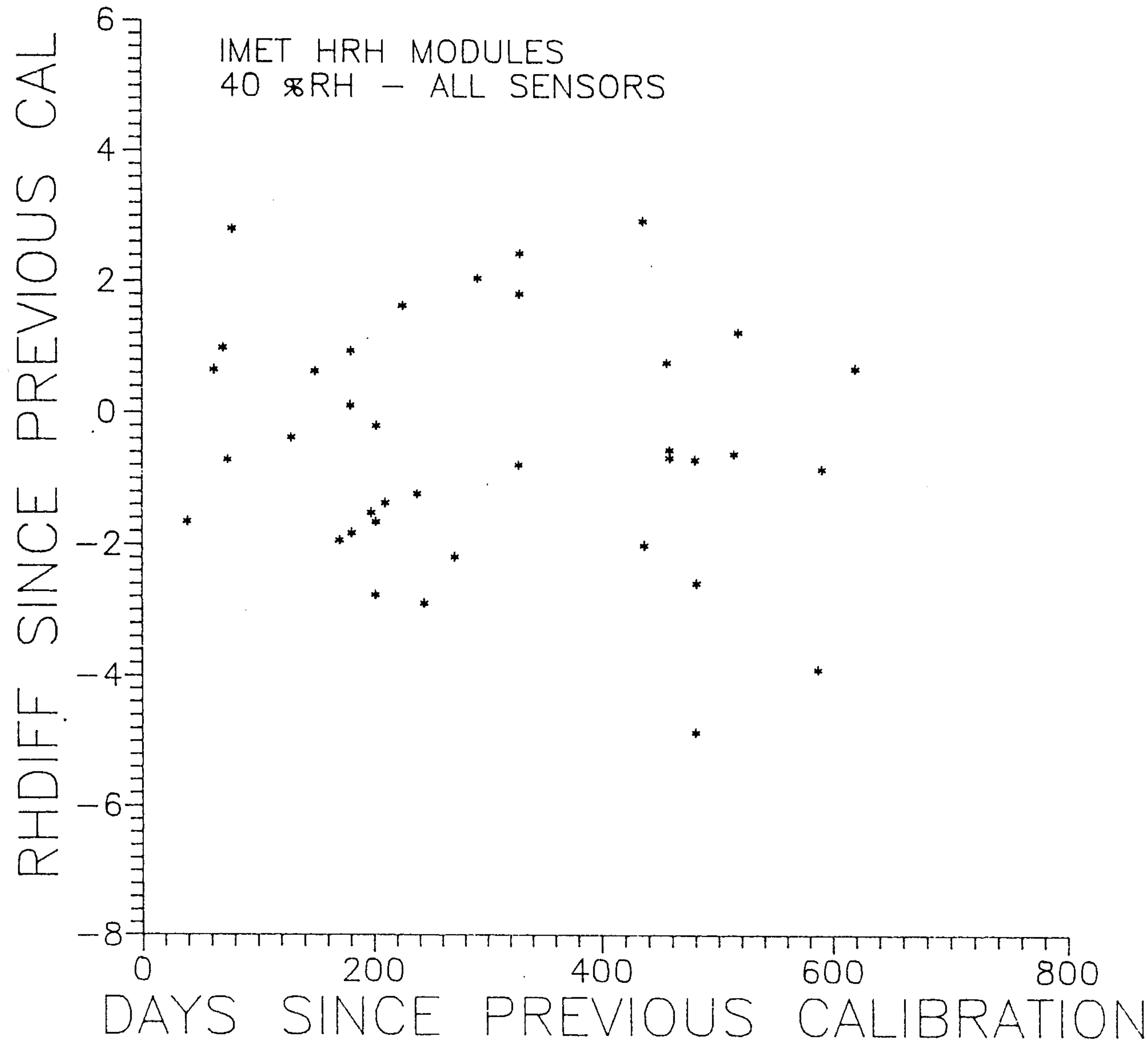

Figure 5: Shifts in IMET sensor calibrations at 40% RH as a function of time since previous calibration.

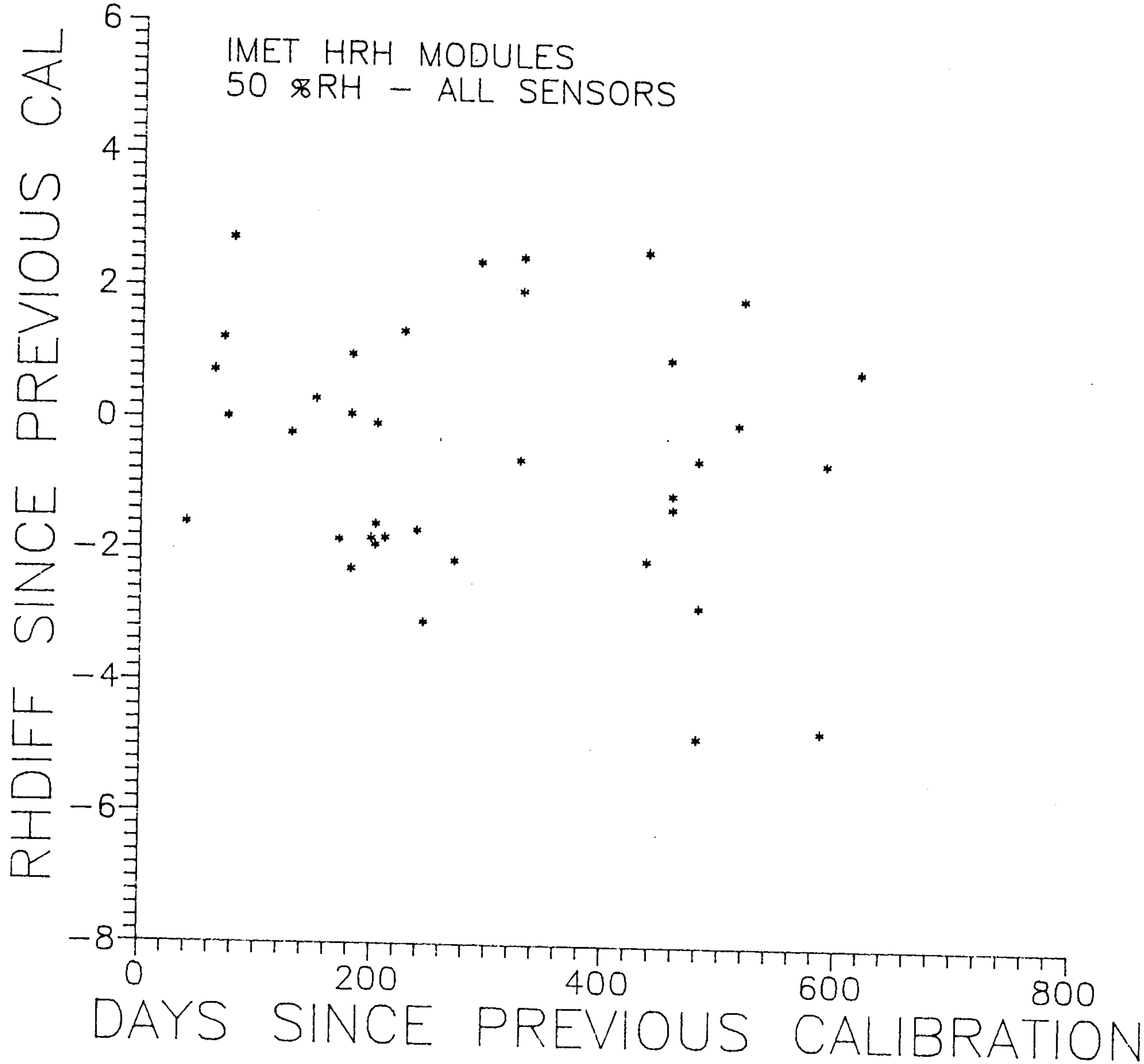

Figure 6: Shifts in IMET sensor calibrations at 50% RH as a function of time since previous calibration.

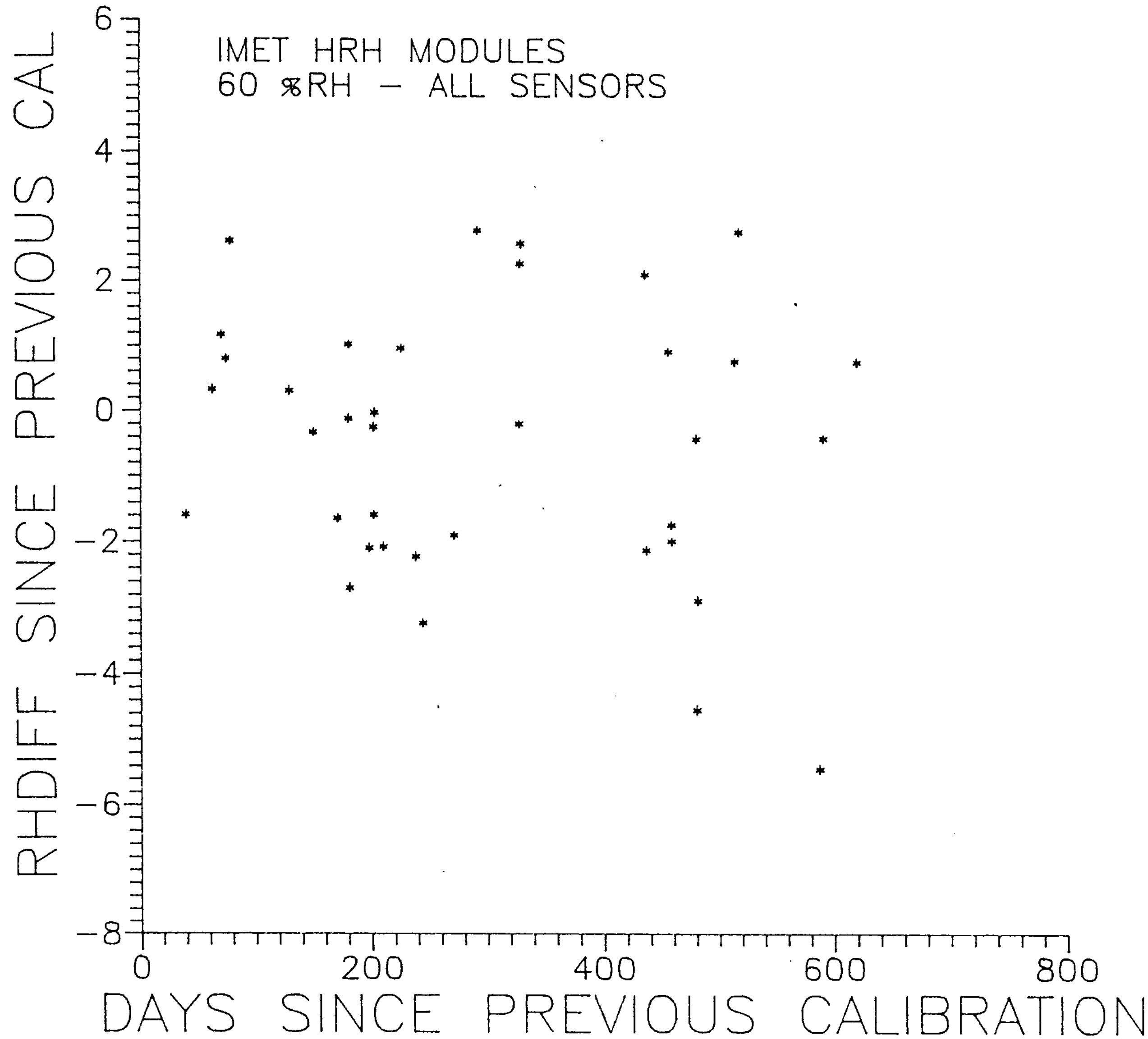

Figure 7: **Shifts in IMET sensor calibrations at 60% RH as a function of time since previous calibration.**

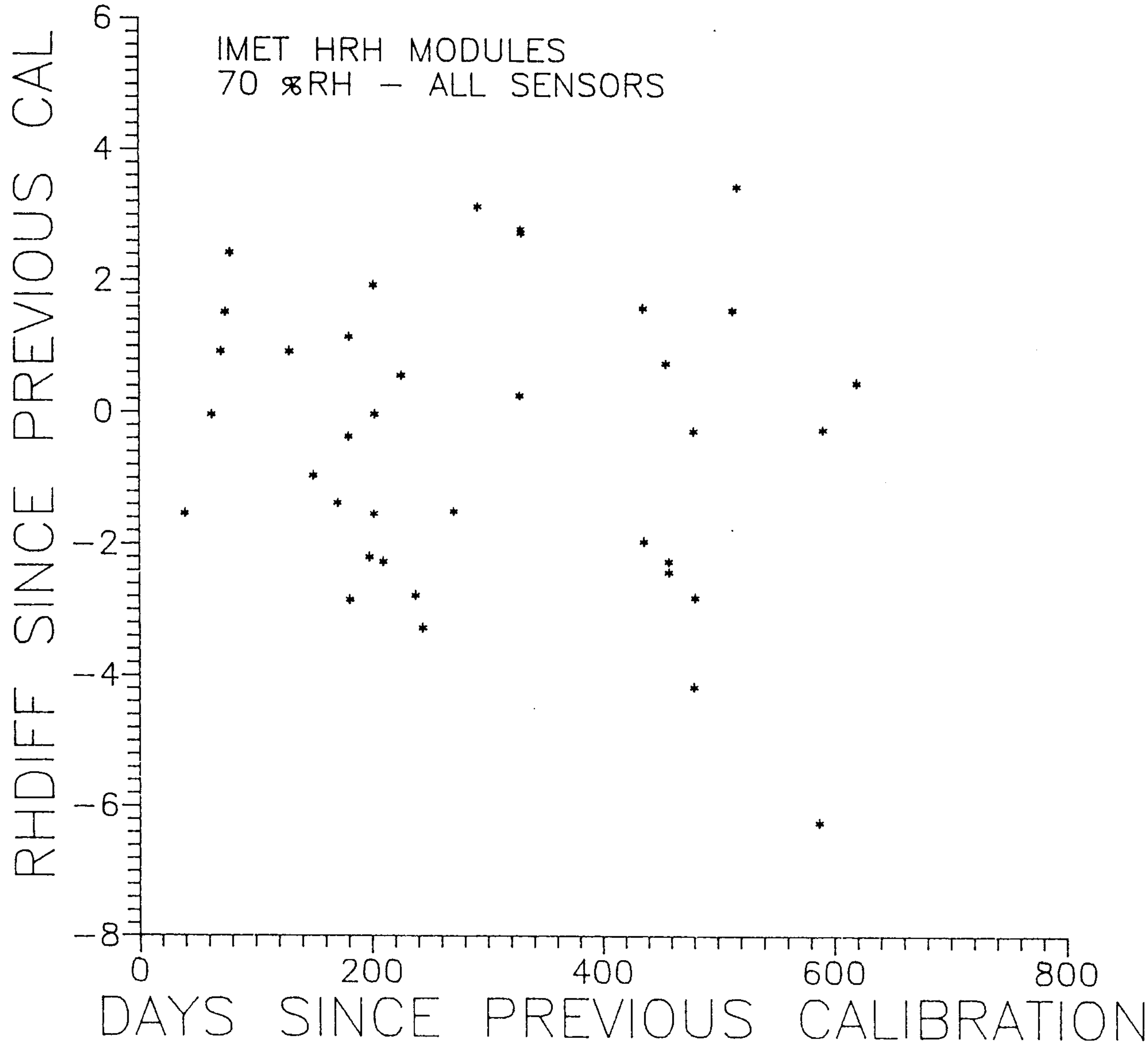

Figure 8: Shifts in IMET sensor calibrations at 70% RH as a function of time since previous calibration.

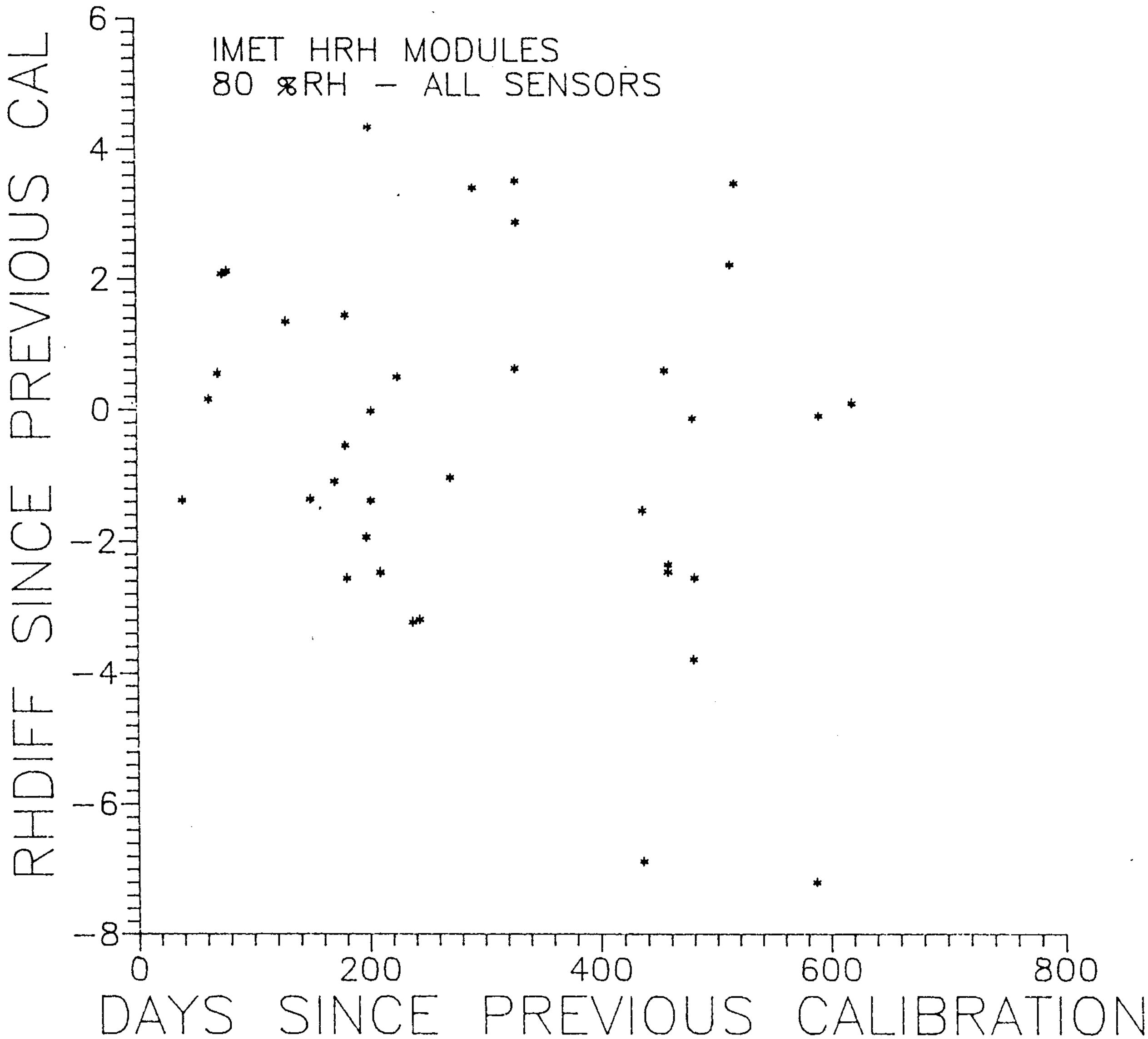

Figure 9: Shifts in IMET sensor calibrations at 80% RH as a function of time since previous calibration.

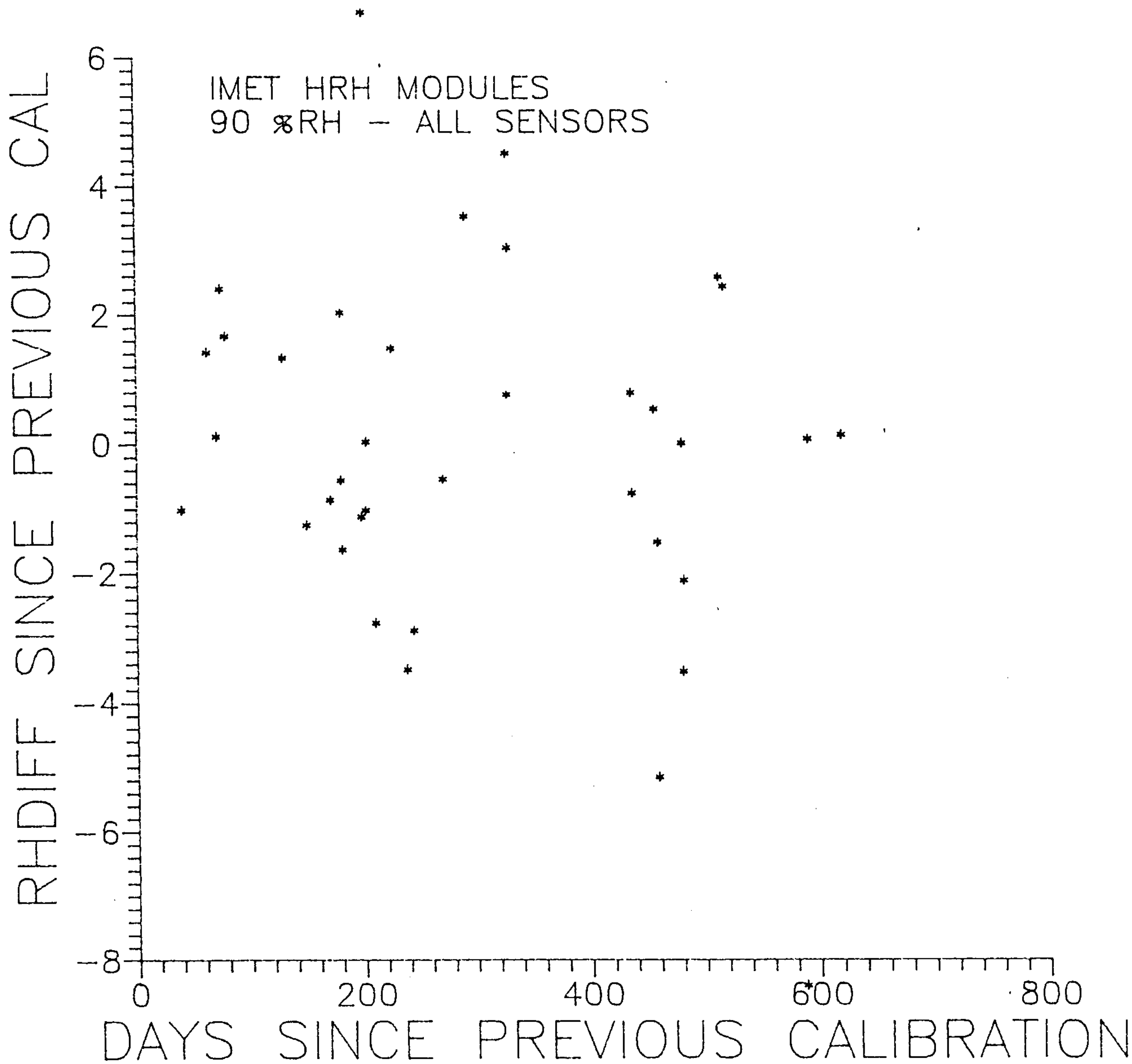

Figure 10: Shifts in IMET sensor calibrations at 90% RH as a function of time since previous calibration.

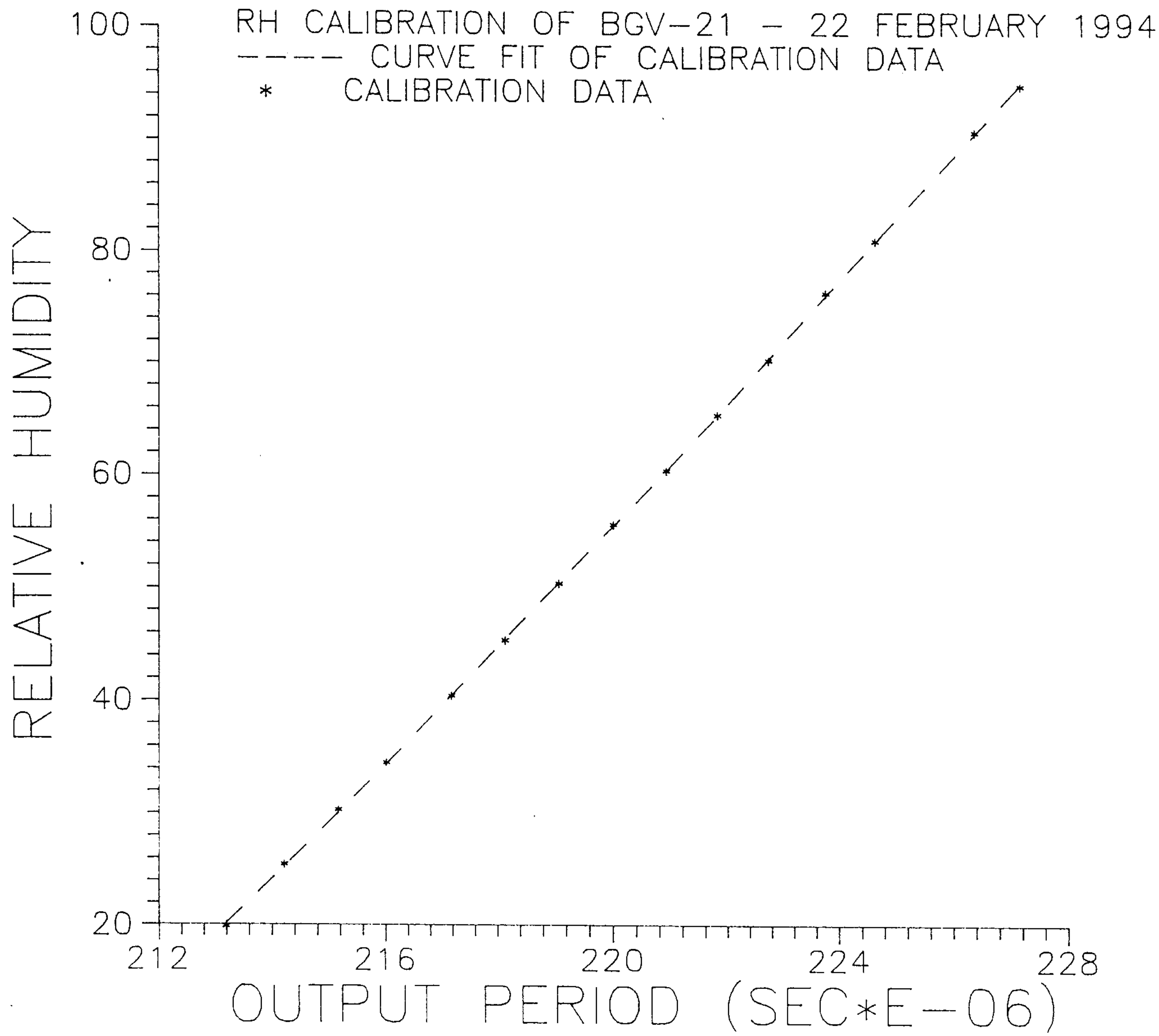

Figure 11: Example of VAWR sensor calibration. Asterisks are data points, dashed line is curve fitted to data.

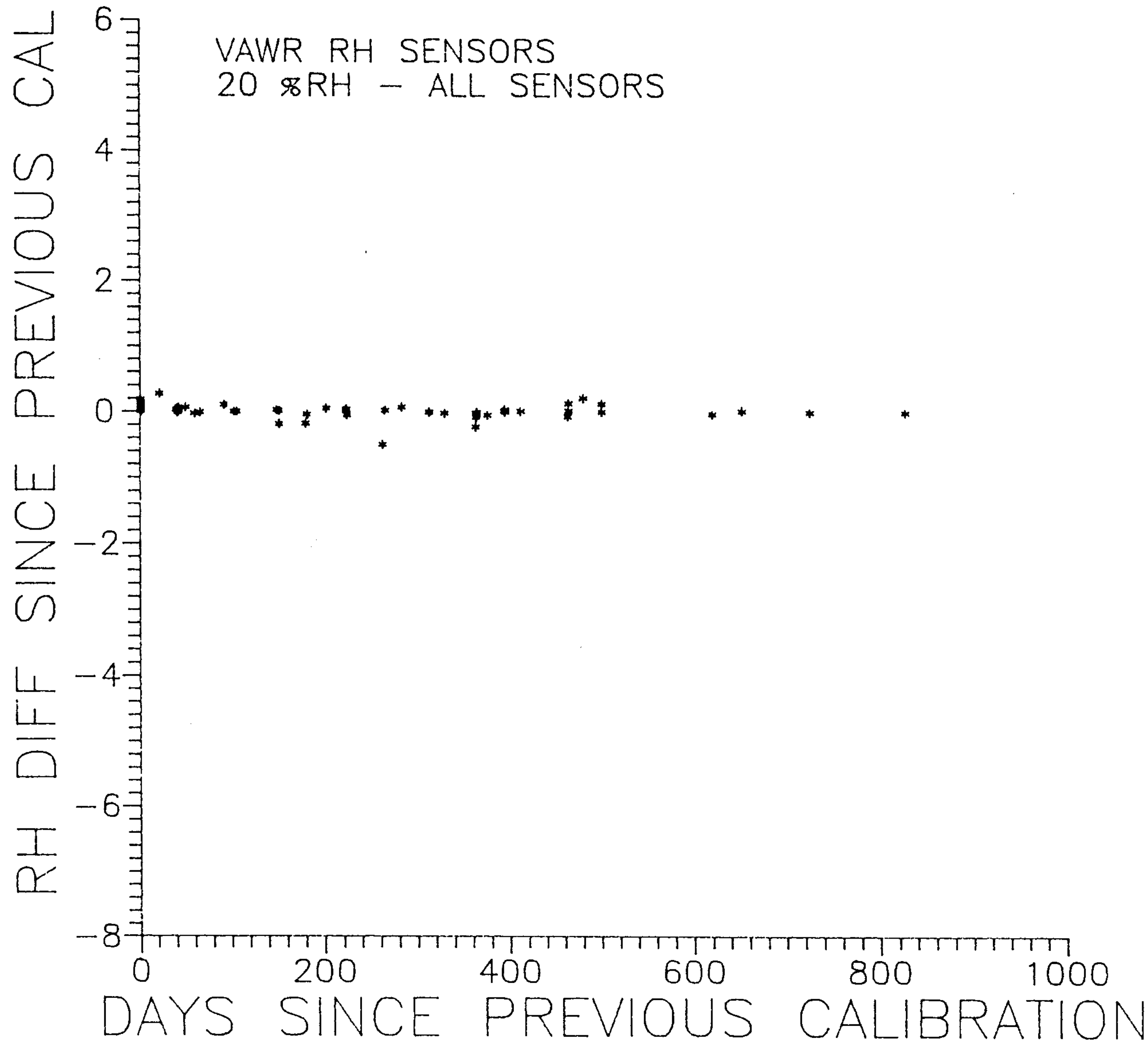

Figure 12: Shifts in VAWR sensor calibrations at 20% RH as a function of time since previous calibration.

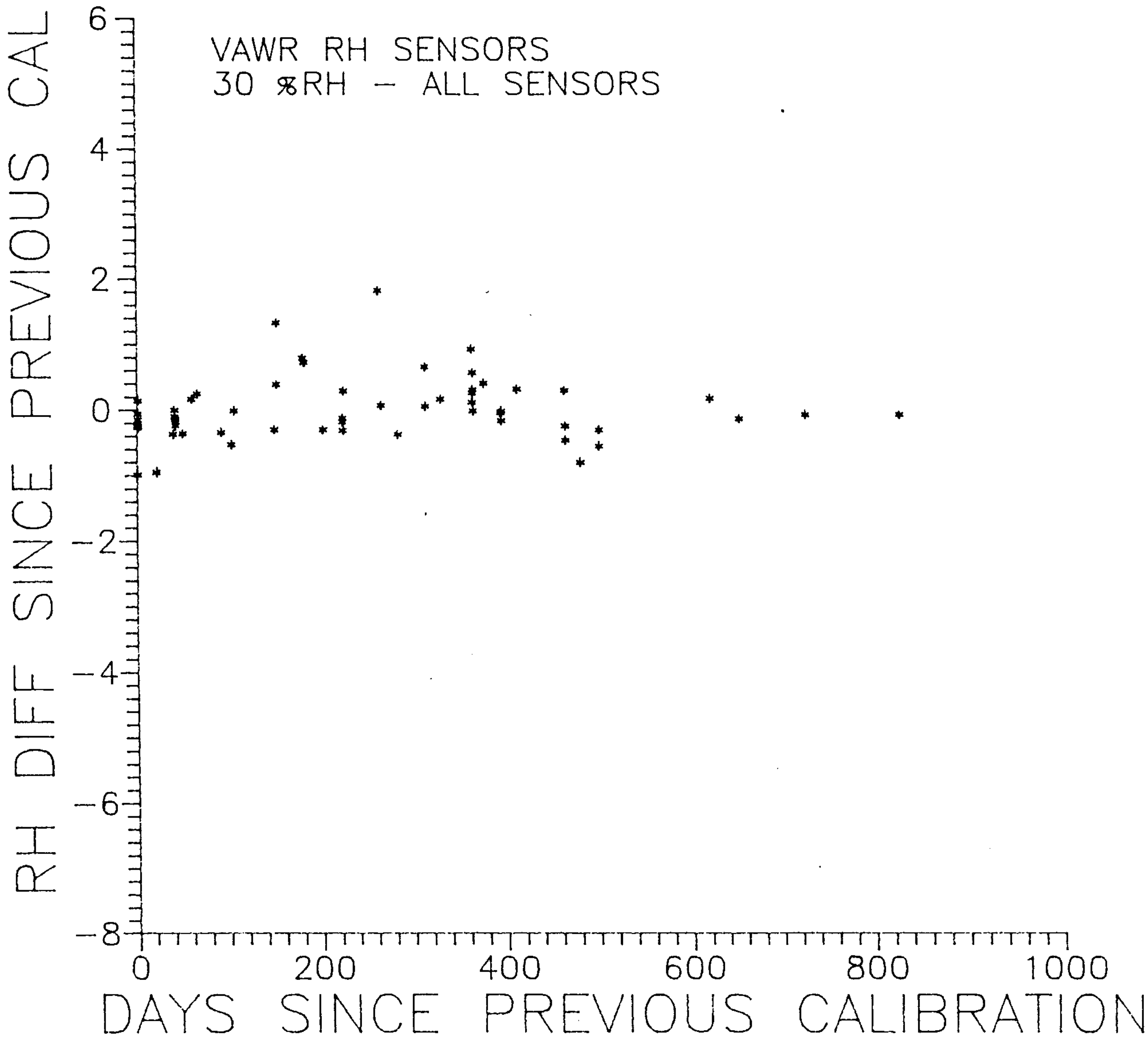

Figure 13: Shifts in VAWR sensor calibrations at 30% RH as a function of time since previous calibration.

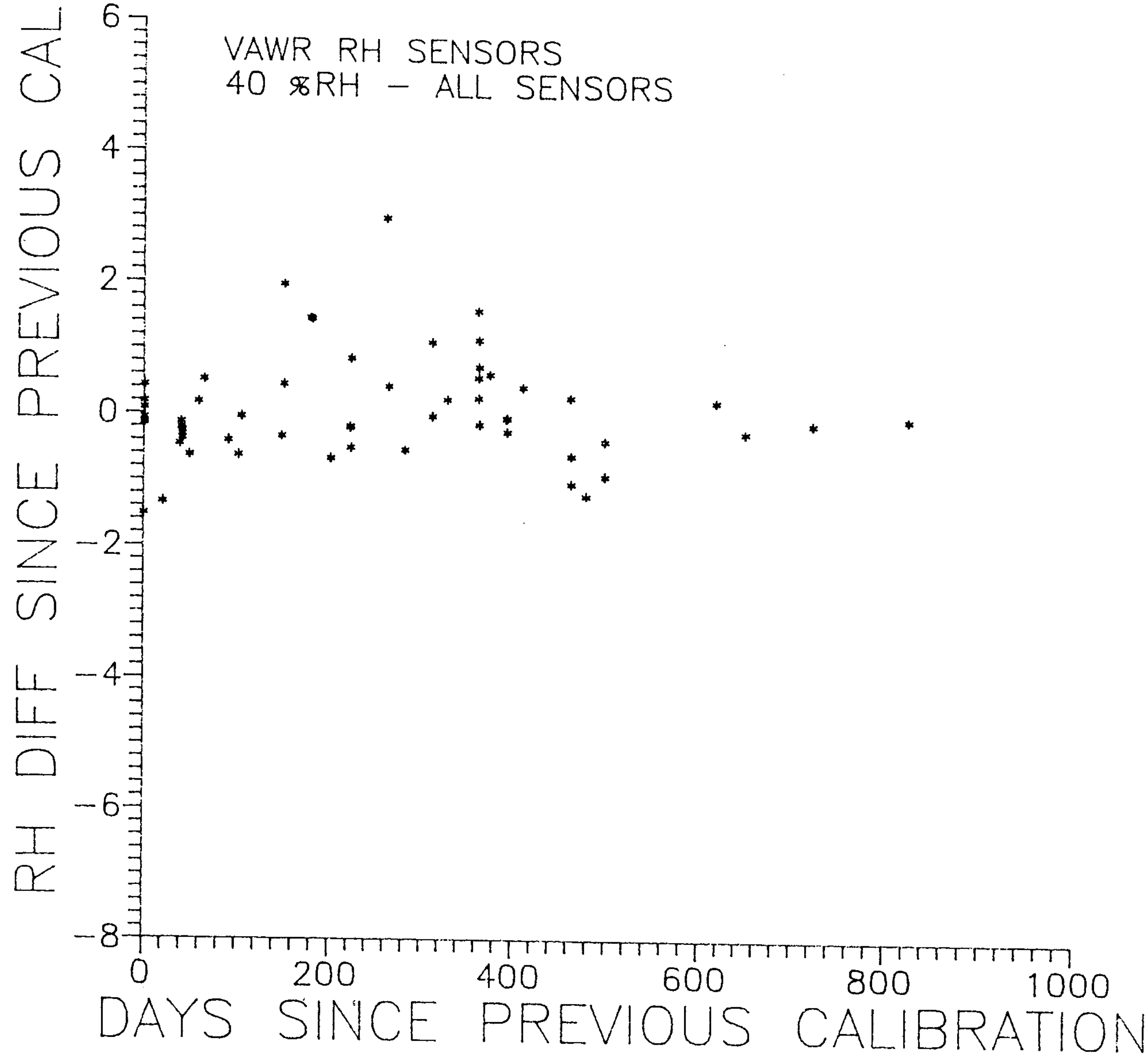

Figure 14: Shifts in VAWR sensor calibrations at 40% RH as a function of time since previous calibration.

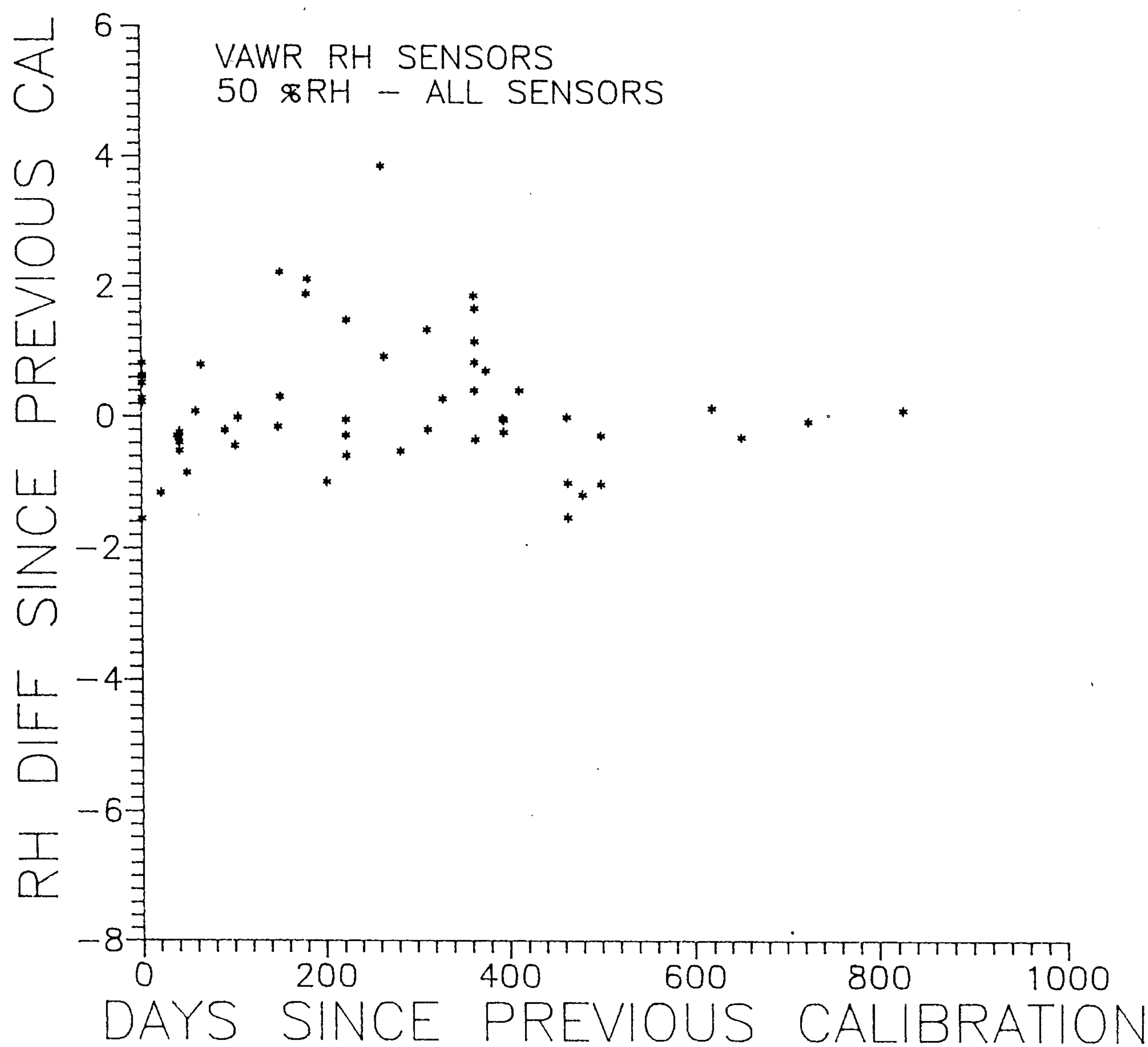

Figure 15: Shifts in VAWR sensor calibrations at 50% RH as a function of time since previous calibration.

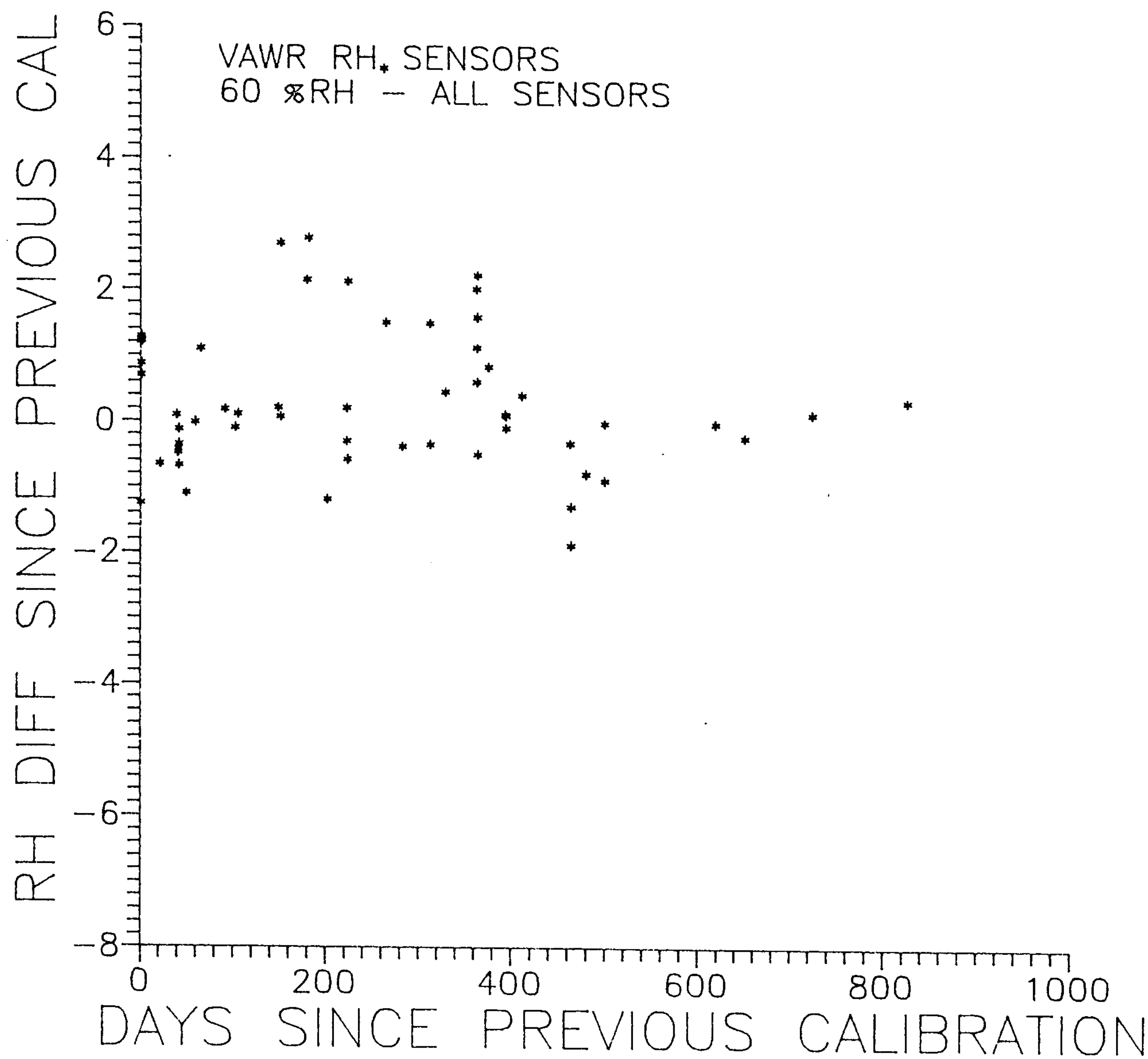

Figure 16: Shifts in VAWR sensor calibrations at 60% RH as a function of time since previous calibration.

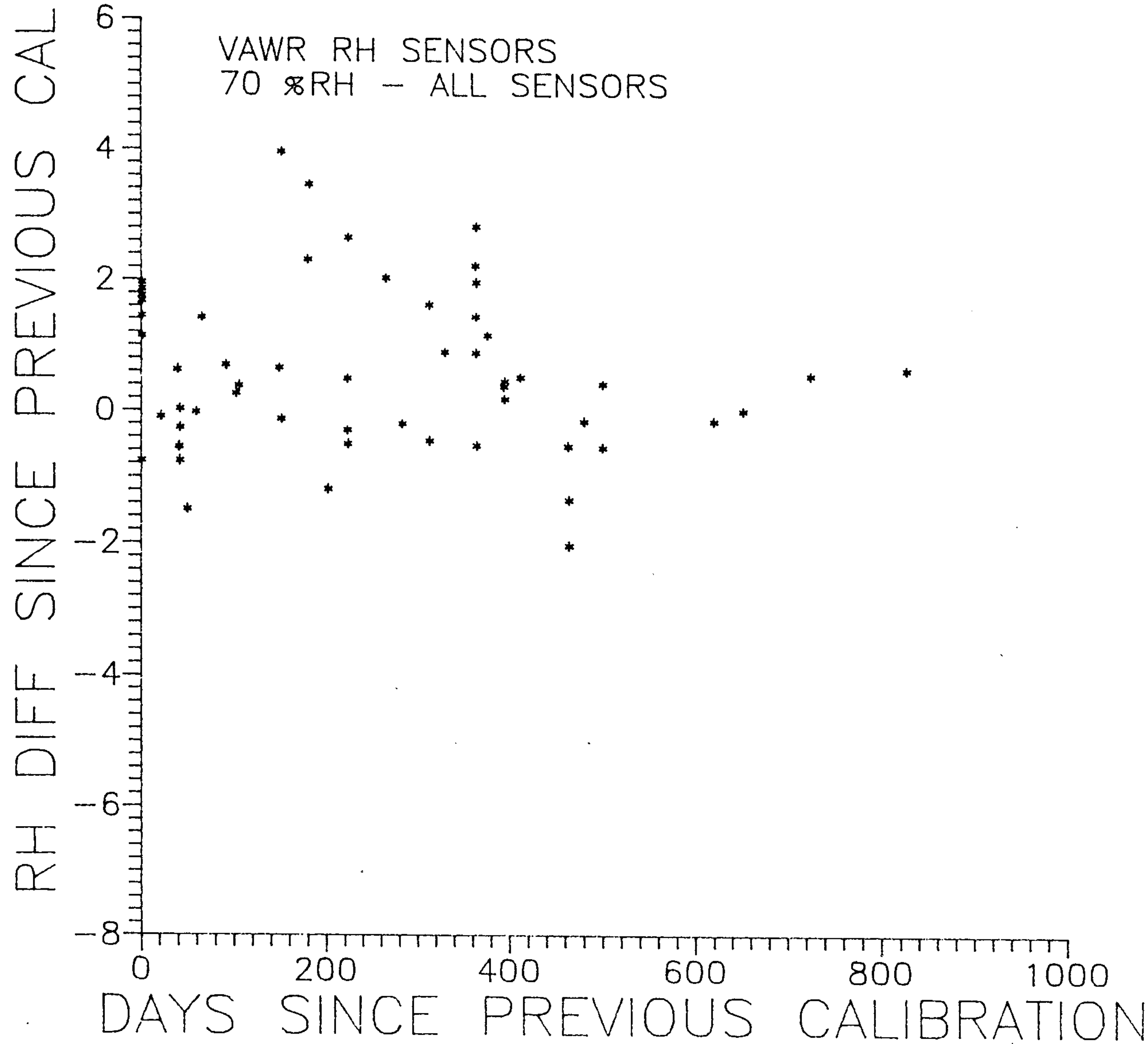

Figure 17: Shifts in VAWR sensor calibrations at 70% RH as a function of time since previous calibration.

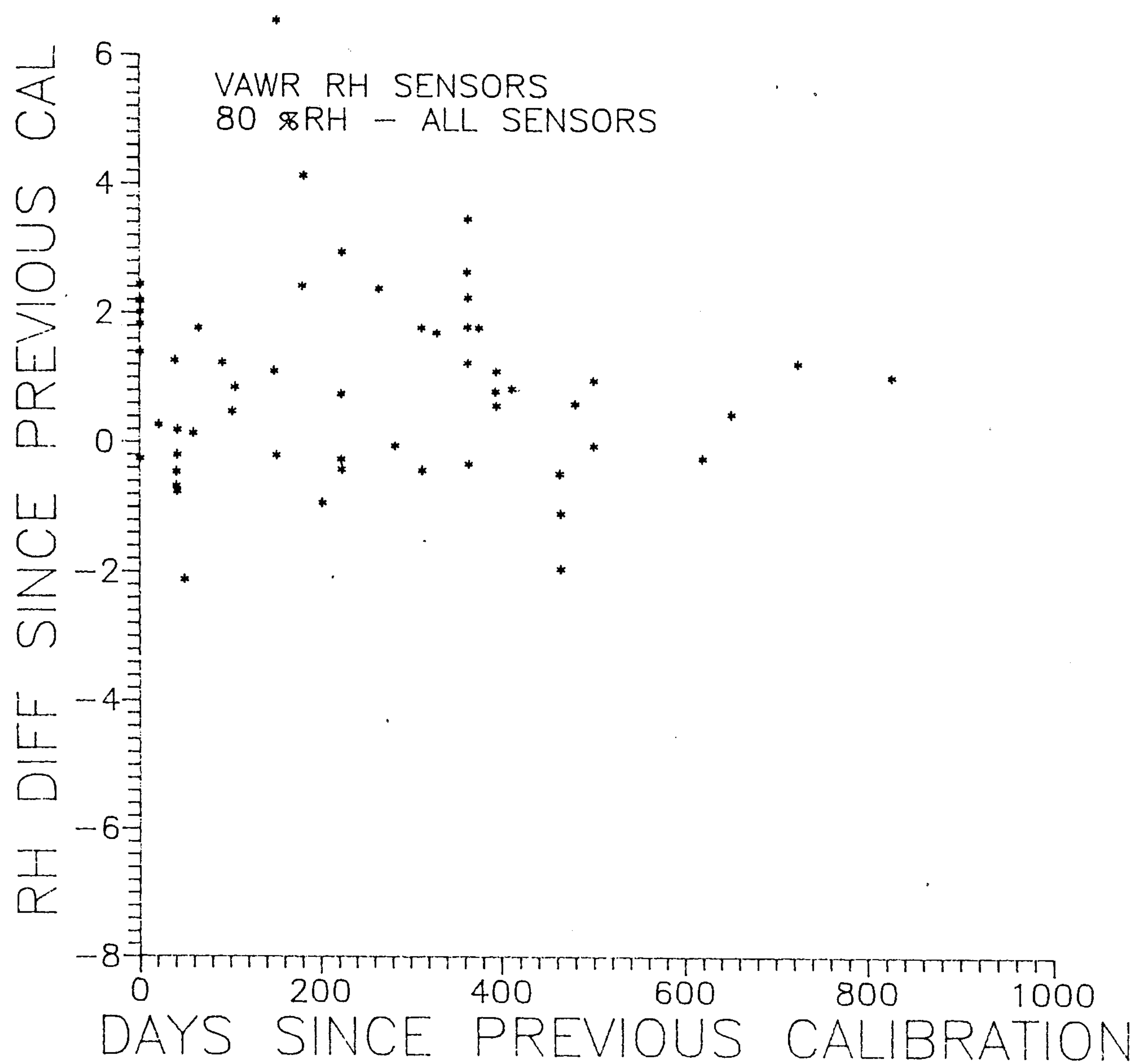

Figure 18: Shifts in VAWR sensor calibrations at 80% RH as a function of time since previous calibration.

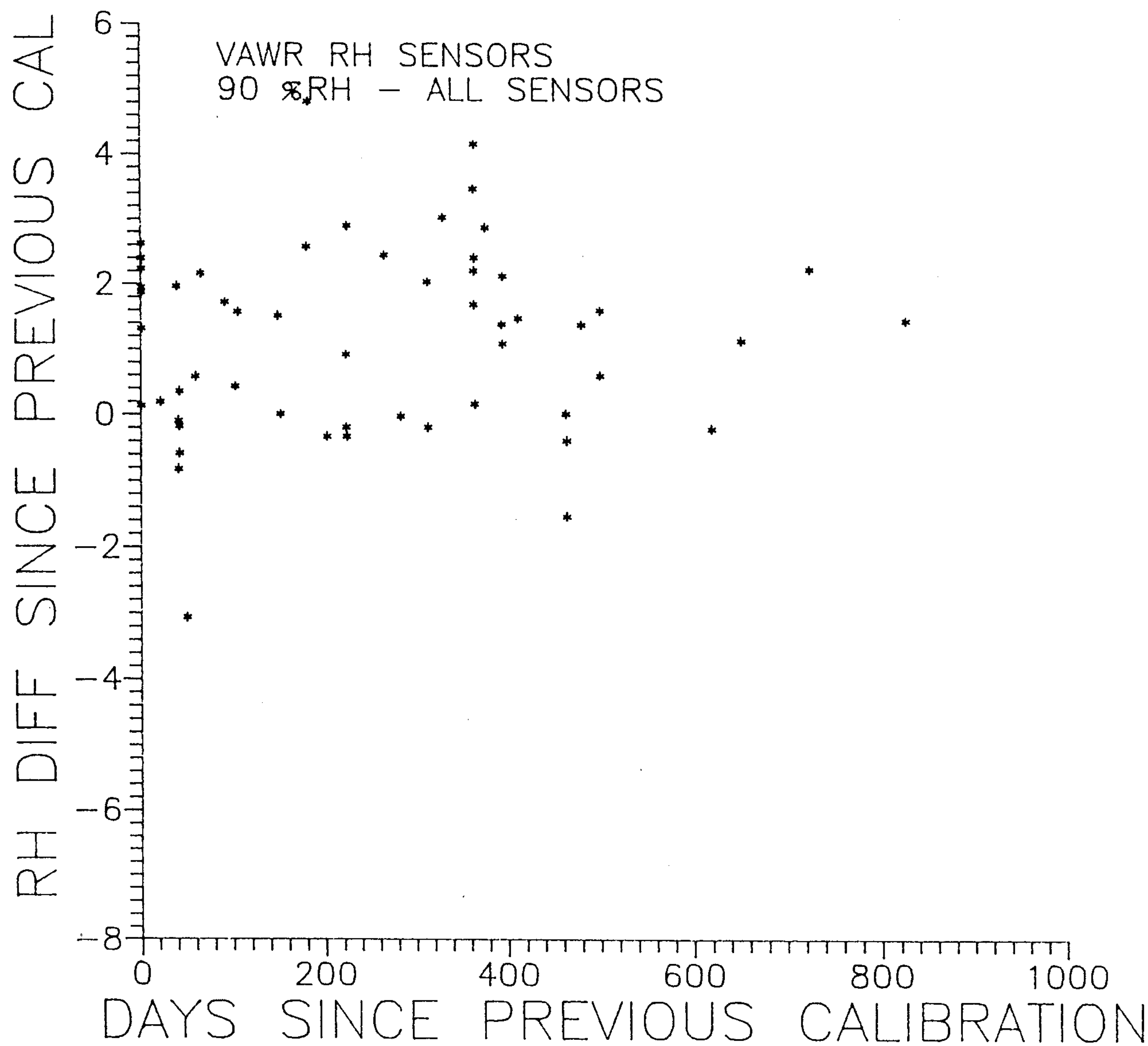

Figure 19: Shifts in VAWR sensor calibrations at 90%RH as a function of time since previous calibration.

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16. Abstract (Limit: 200 words)

An analysis has been made of the calibrations done during 1990 through 1994 on Rotronic MP-100 relative humidity sensors (used in the Improved METeorological (IMET) system and sensors built at the Woods Hole Oceanographic Institution (WHOI) with the Vaisala Humicap sensing element (used in the Vector Averaging Wind Recorder (VAWR)). The shift from one calibration to the next is, typically, 2-3% RH which represents the major uncertainty in relative humidity with either of these sensors. The direction of each shift appears to be random; thus, there does not appear to be any long-term drifts.

17. Document Analysis a. Descriptors

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Vaisala

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