2019

HERRAMIENTAS PARA LA INVESTIGACIÓN EN METEOROLOGÍA

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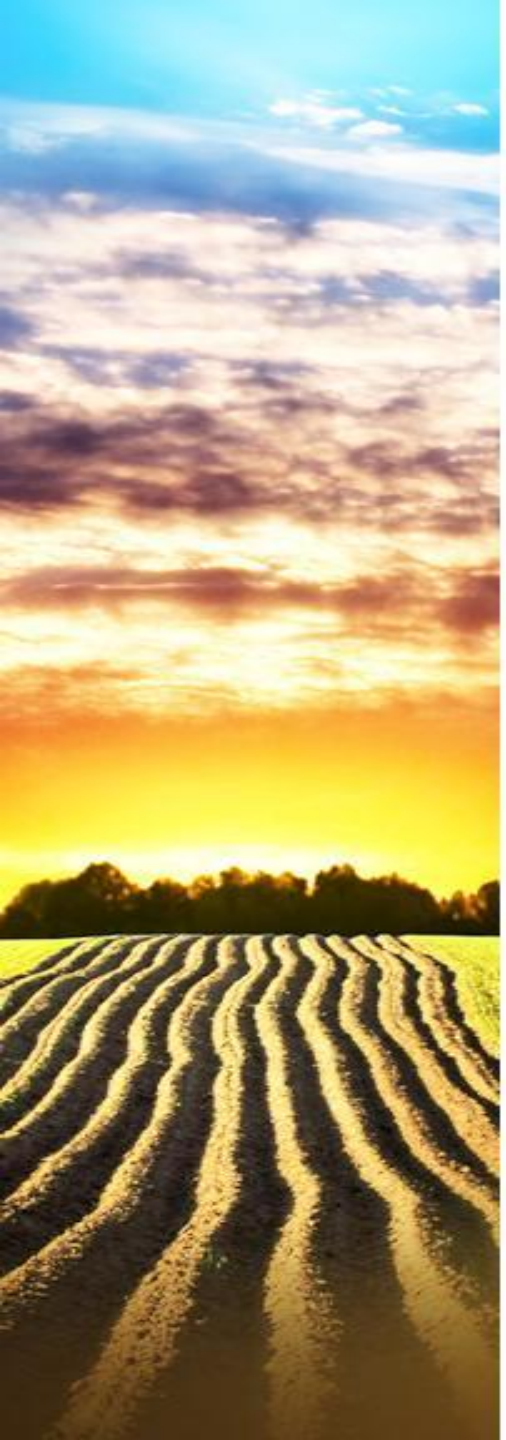
PONENTE EN LA SEMANA CIENTÍFICA DE LA UNALM

Instrumental Agrometeorológico

- **Sensor de Temperatura**
- **Sensor de Humedad**
- **Sensor de Presión**
- **Piranómetro**
- **Pluviómetro**
- **Geotermómetro**
- **Humedad del suelo**
- *** Sensor Infrarrojo**

Objetivo

Elaborar, calibrar y validar una estación agrometeorológica de bajo costo usando la plataforma Arduino



METODOLOGÍA

Área de desarrollo

Datos

instrumental2: Bloc de notas

Archivo Edición Formato Ver Ayuda

```
fecha,BMPTEMP,PRESIONBMP,DHTTEMP,DHTHUMEDAD,PP,HS,valor_sensor,tension_Rs,vo1,res1,temp1,vo2,res2,temp2,vo3,res3,temp3,vo4,res4,temp4
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```
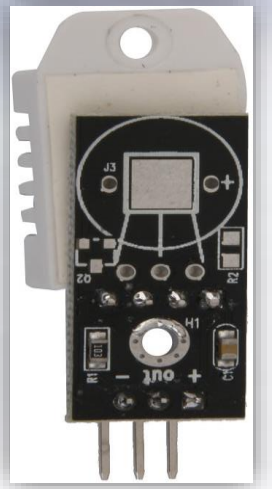
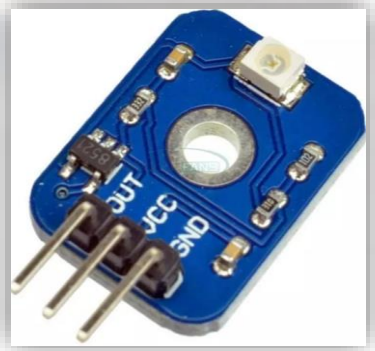

DHT22 (Temperatura y humedad)



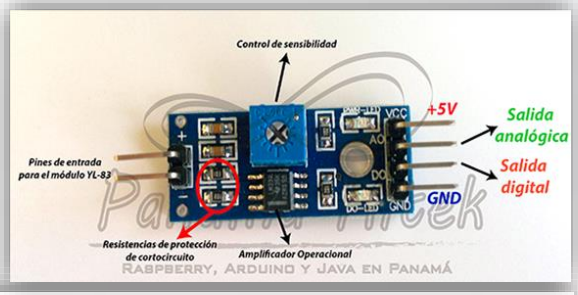
ML8511 (RADIACIÓN*)



Water Sensor SL067 (PRECIPITACIÓN)

4 cm

GEOTERMÓMETRO

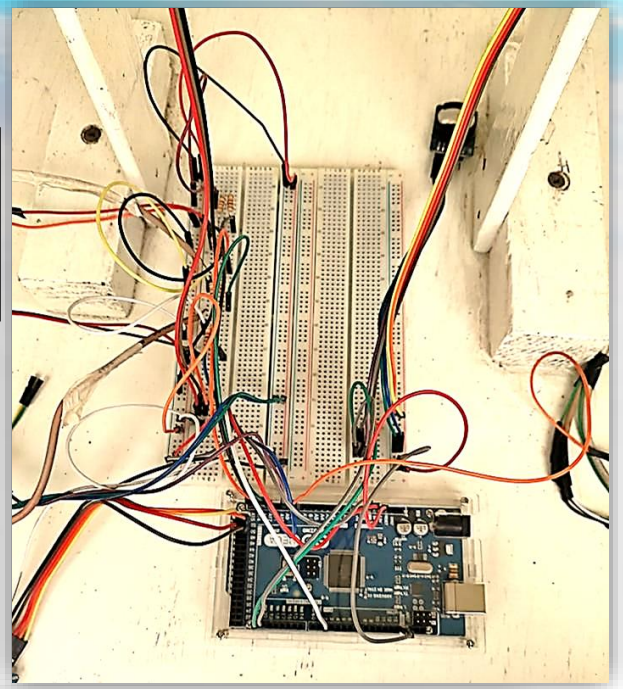


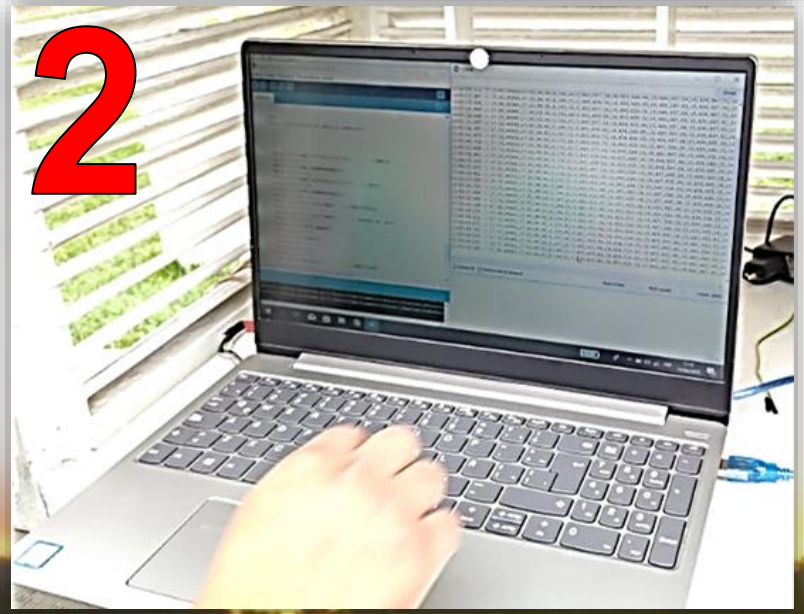
BMP180 (PRESIÓN)

SEN-HUS YL-69 (Higrómetro)

PROCEDIMIENTO

1



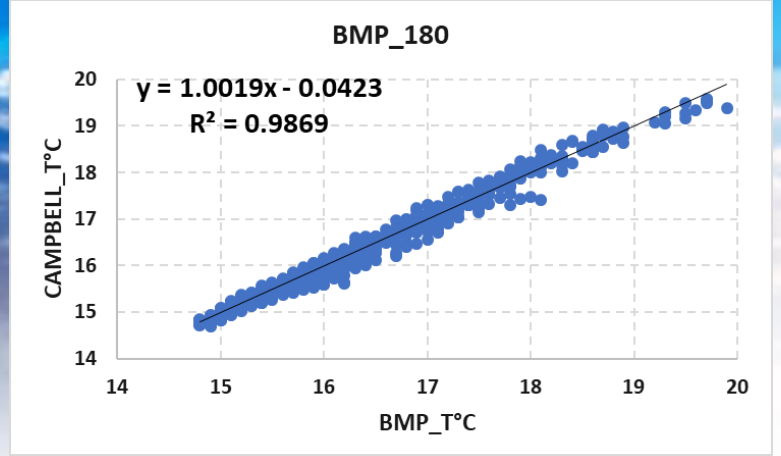


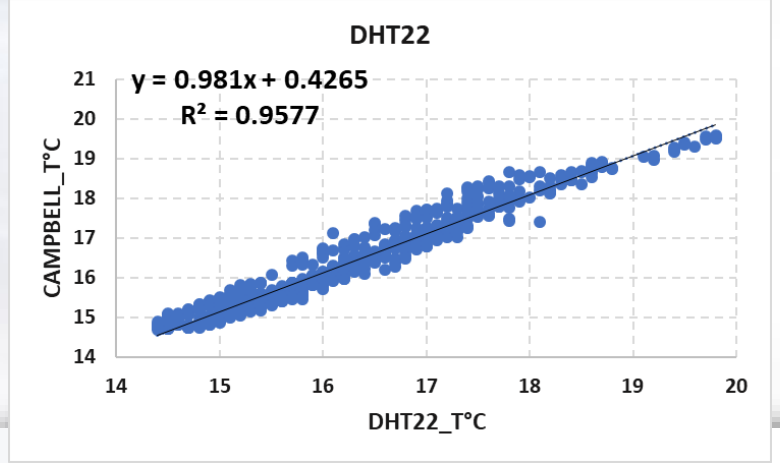
2

3

OBTENCIÓN DE INFORMACIÓN

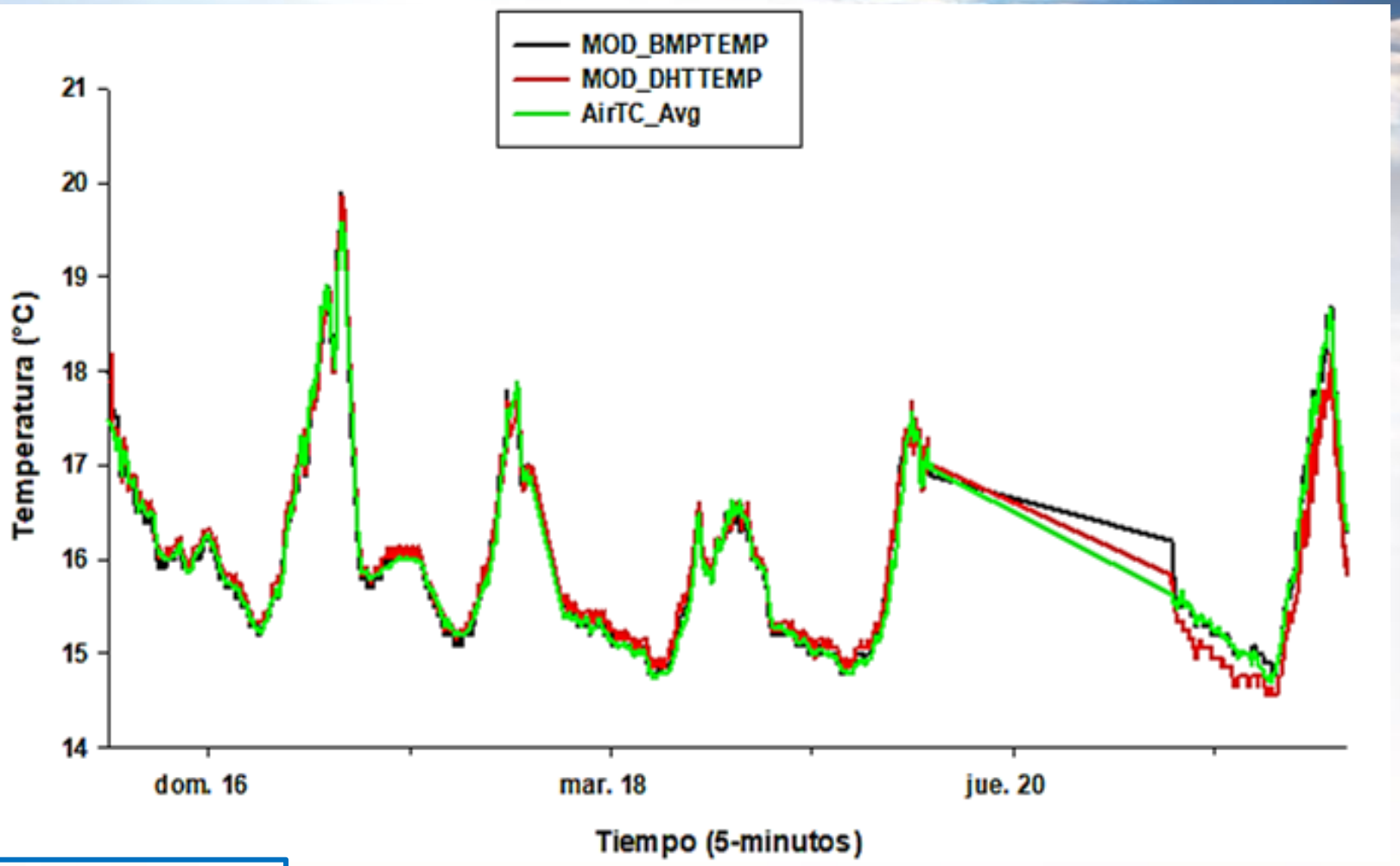
SENSOR DE TEMPERATURA






```
data:  temp$BMPTEMP and temp$AirTC_Avg
t = 321.98, df = 1375, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.9927038 0.9940906
sample estimates:
      cor
0.9934335
```

```
        Pearson's product-moment correlation

data:  temp$DHTTEMP and temp$AirTC_Avg
t = 176.45, df = 1375, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.9762668 0.9807476
sample estimates:
      cor
0.978623
```



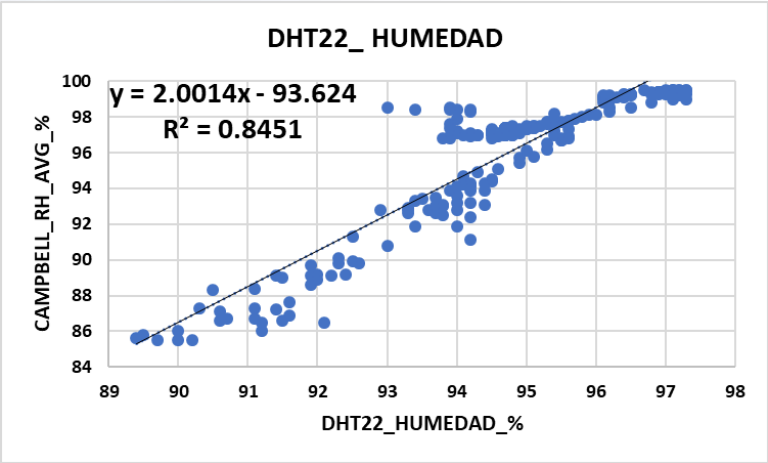
CALIBRACIÓN

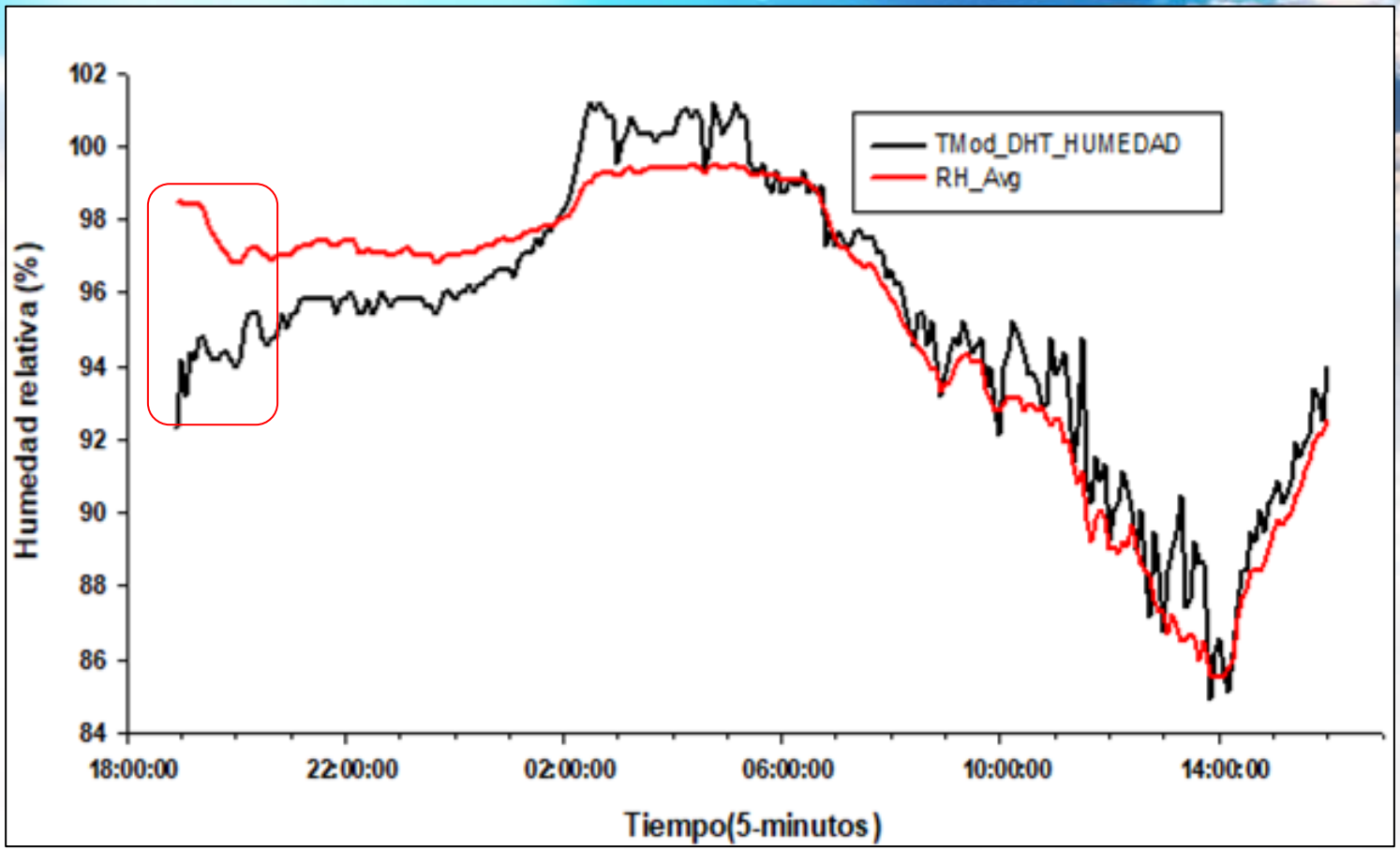
VALIDACIÓN

	BMP_180	DHT22
BIAS	0.03	0.48
RMSE	8.54	2.00
r	0.99	0.99

SENSOR DE HUMEDAD

CALIBRACIÓN






```
> cor.test(humedad$Mod_DHT_HUMEDAD,humedad$RH_Avg, method = "pearson")

        Pearson's product-moment correlation

data:  humedad$Mod_DHT_HUMEDAD and humedad$RH_Avg
t = 35.572, df = 232, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.8967478 0.9370479
sample estimates:
      cor
0.9192734
```

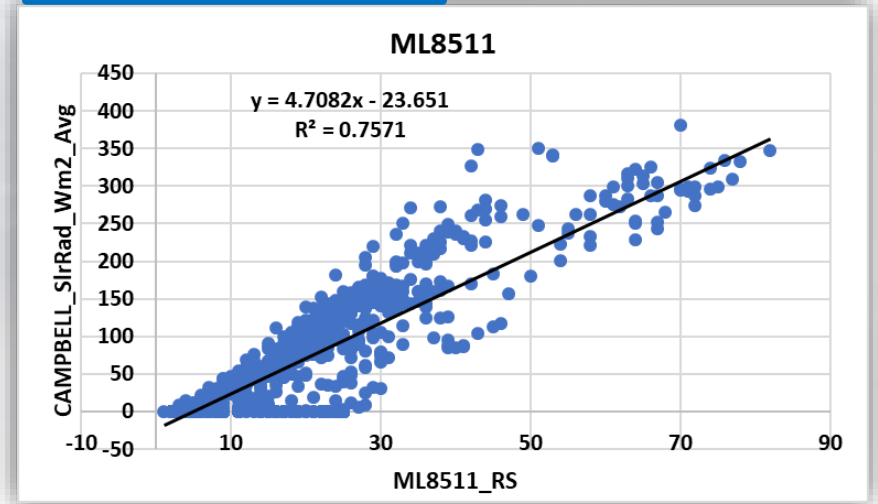
VALIDACIÓN

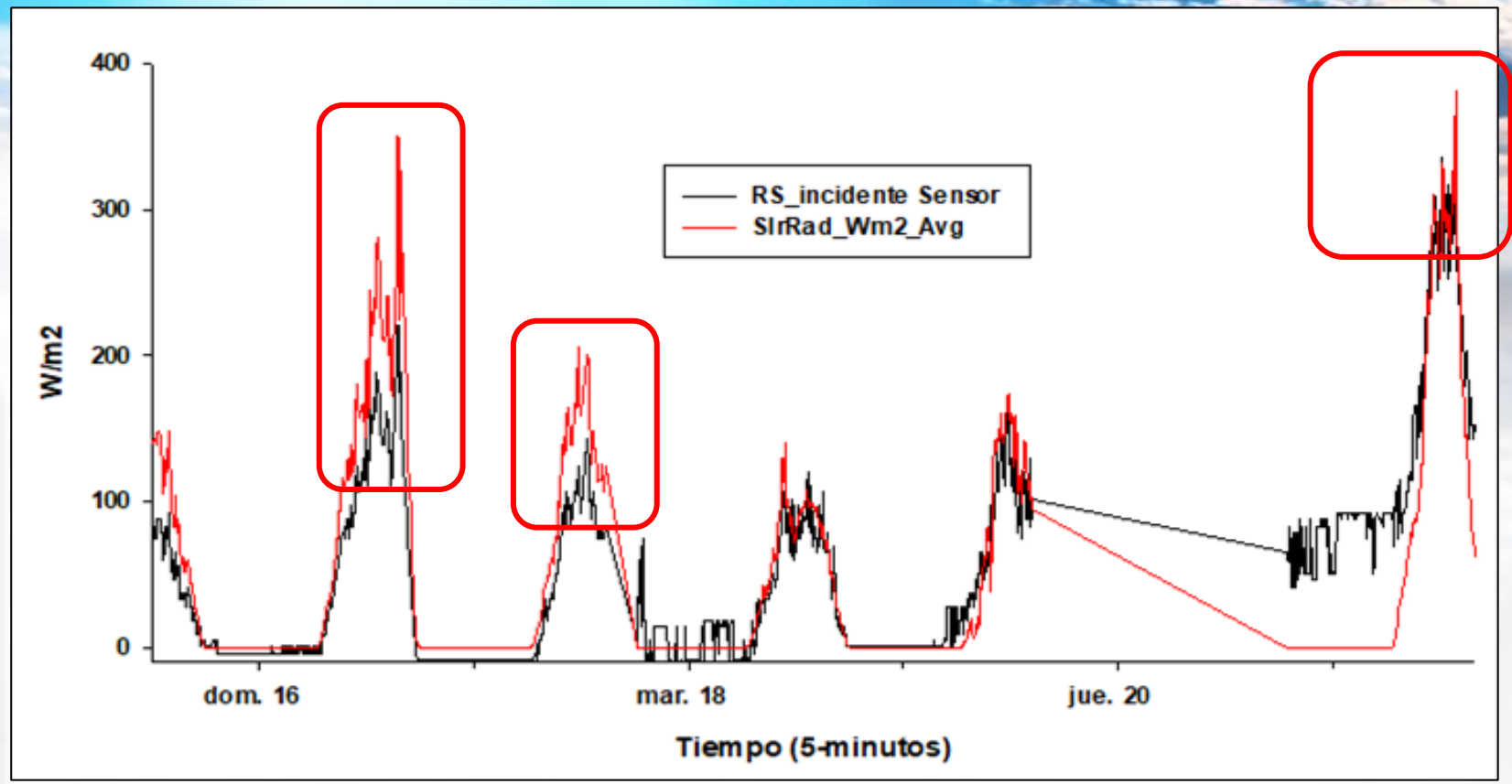
RMSE	1.02
BIAS	1.04
r	0.97

```
> cor.test(hum_val$Mod_DHT_HUMEDAD,hum_val$RH_Avg, method = "pearson")

        Pearson's product-moment correlation

data:  hum_val$Mod_DHT_HUMEDAD and hum_val$RH_Avg
t = 18.558, df = 18, p-value = 3.492e-13
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.9361921 0.9902043
sample estimates:
      cor
0.9748483
```

PIRANÓMETRO

CALIBRACIÓN






```
> cor.test(rad$RS_incidente,rad$SlrRad_Wm2_Avg, method = "pearson")

        Pearson's product-moment correlation

data:  rad$RS_incidente and rad$SlrRad_Wm2_Avg
t = 64.977, df = 1355, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.8565230 0.8824366
sample estimates:
      cor
0.8700797
```

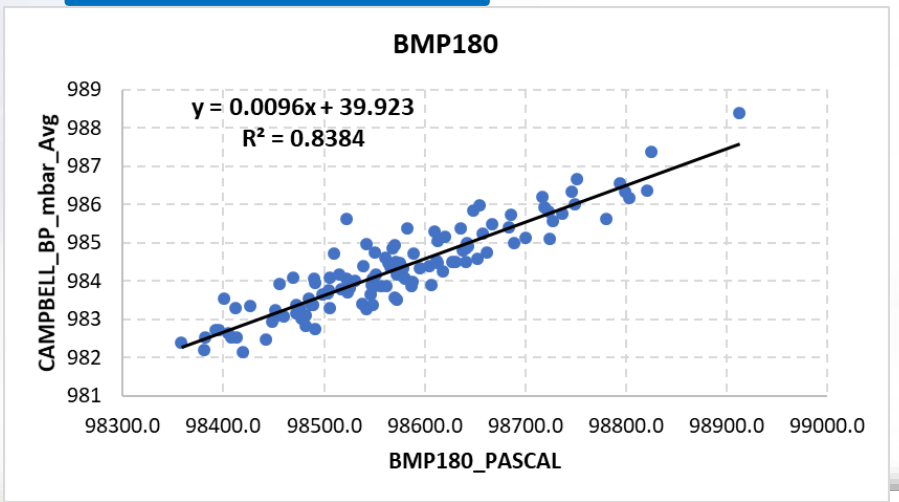
VALIDACIÓN

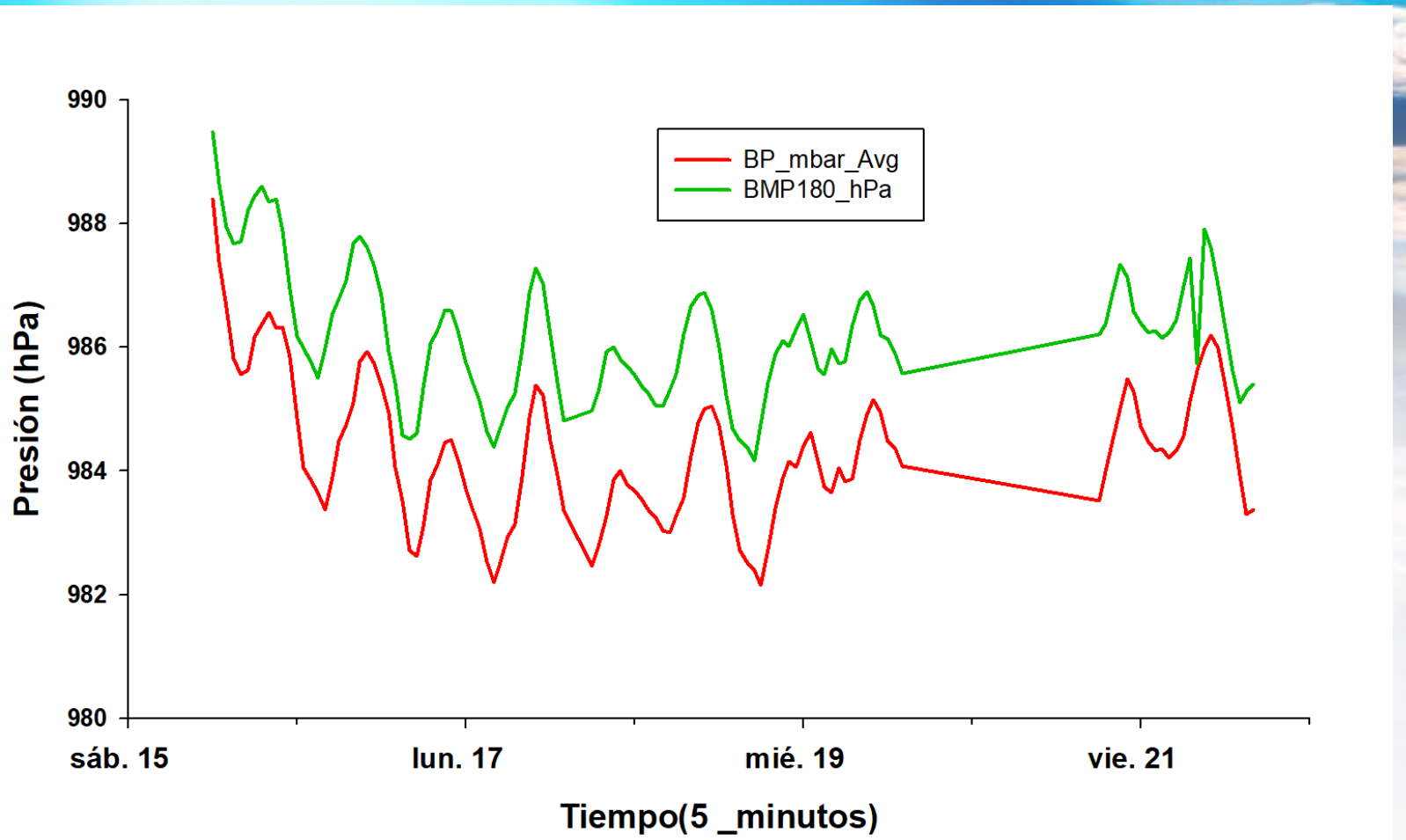
RMSE	0.02
BIAS	-60.28
r	0.91

```
> cor.test(rad$RS_incidente,rad$SlrRad_Wm2_Avg)

        Pearson's product-moment correlation

data:  rad$RS_incidente and rad$SlrRad_Wm2_Avg
t = 9.2915, df = 18, p-value = 2.733e-08
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.7818708 0.9640903
sample estimates:
      cor
0.909656
```

SENSOR DE PRESIÓN ATMOSFÉRICA

CALIBRACIÓN






```
> cor.test(data$PRESIONBMP_promedio,data$presion_sensor, method = 'pearson')

        Pearson's product-moment correlation

data:  data$PRESIONBMP_promedio and data$presion_sensor
t = 24.634, df = 117, p-value < 2.2e-16
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.8807840 0.9405977
sample estimates:
      cor
0.9156197
```

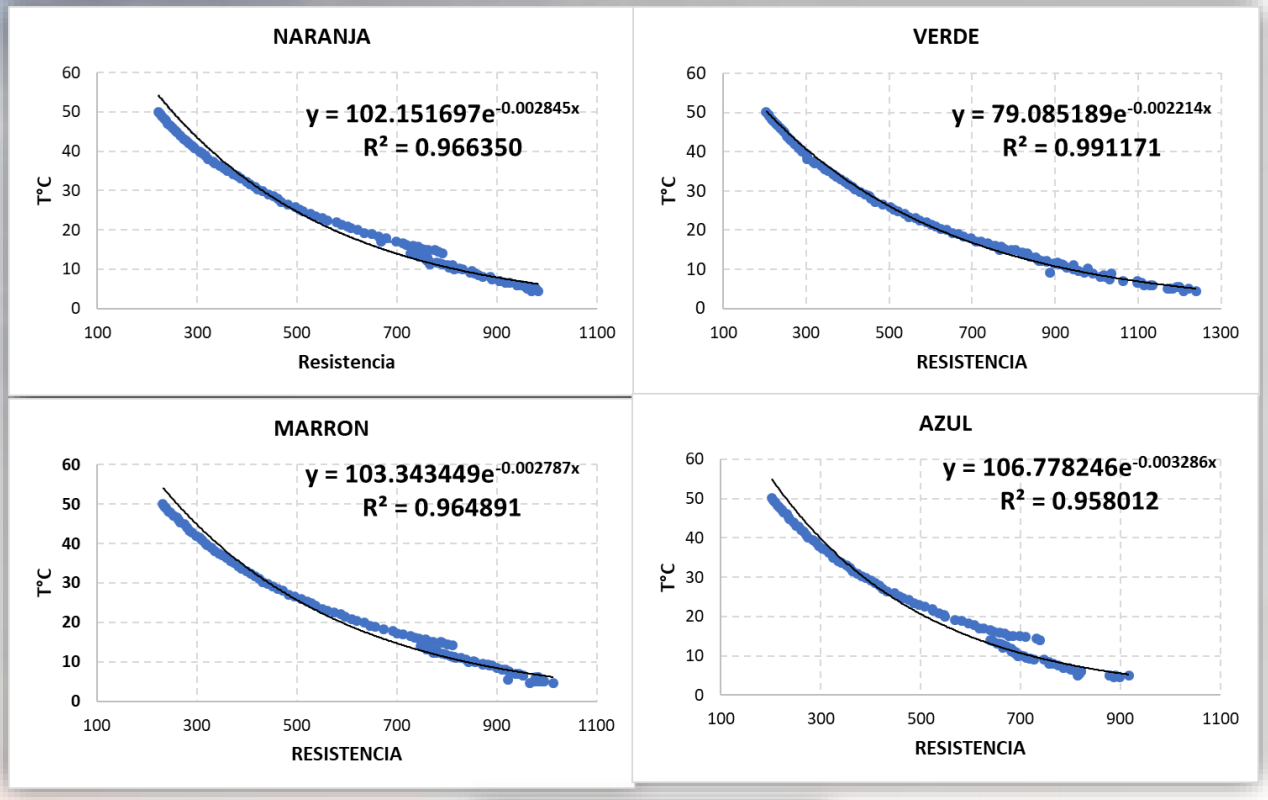
VALIDACIÓN

BIAS	-1.64
RMSE	1.74
r	0.74

```
> cor.test(pre$BP_mbar_Avg,pre$MOD_BMP180)

        Pearson's product-moment correlation

data:  pre$BP_mbar_Avg and pre$MOD_BMP180
t = 3.8402, df = 12, p-value = 0.002352
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.3497405 0.9132976
sample estimates:
      cor
0.7425319
```

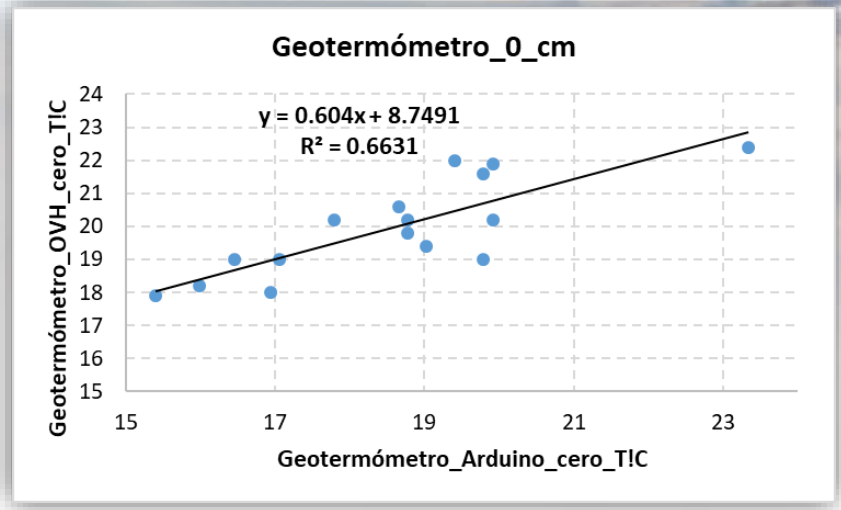
GEOTERMÓMETRO

CALIBRACIÓN EN LABORATORIO

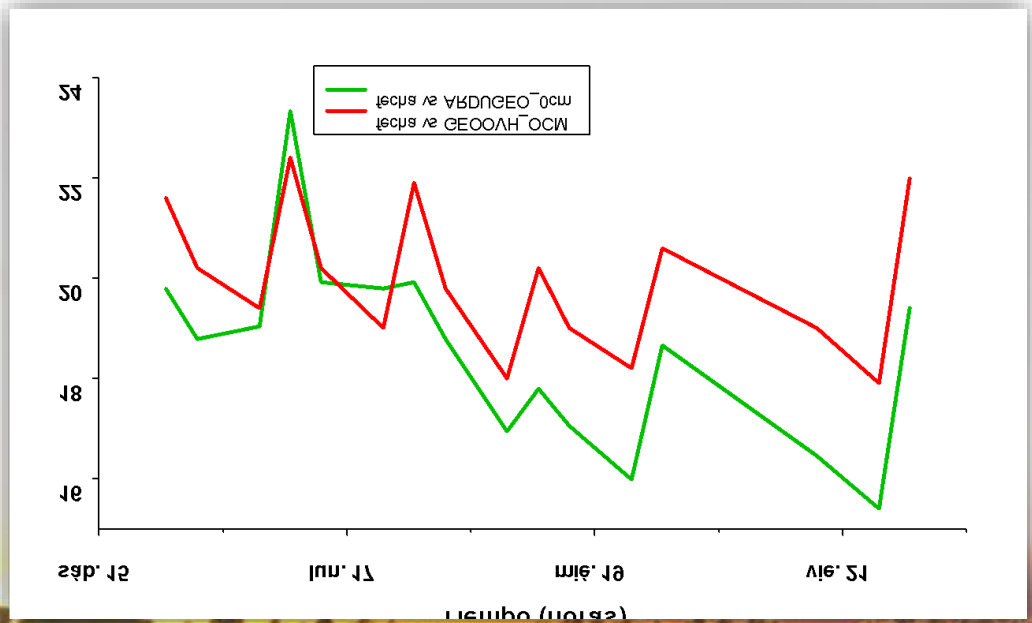


	r
Naranja	0.9931
Verde	0.9985
Marrón	0.9938
Azul	0.9908

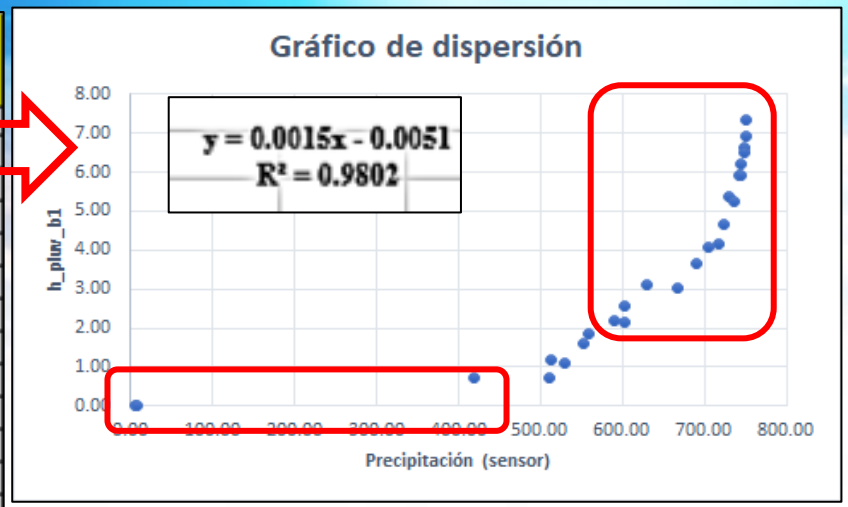
CALIBRACIÓN EN CAMPO



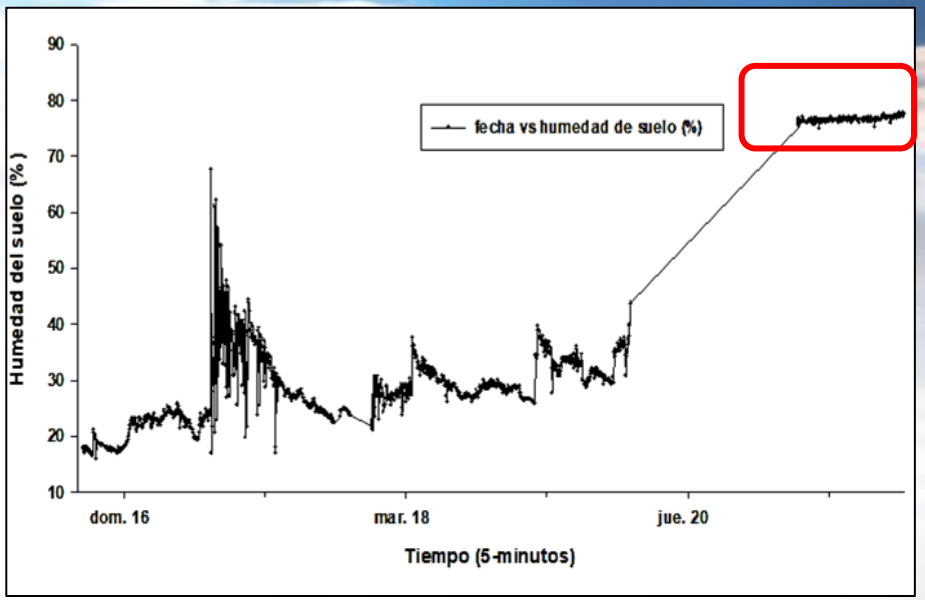
Los siguientes niveles salió erróneo



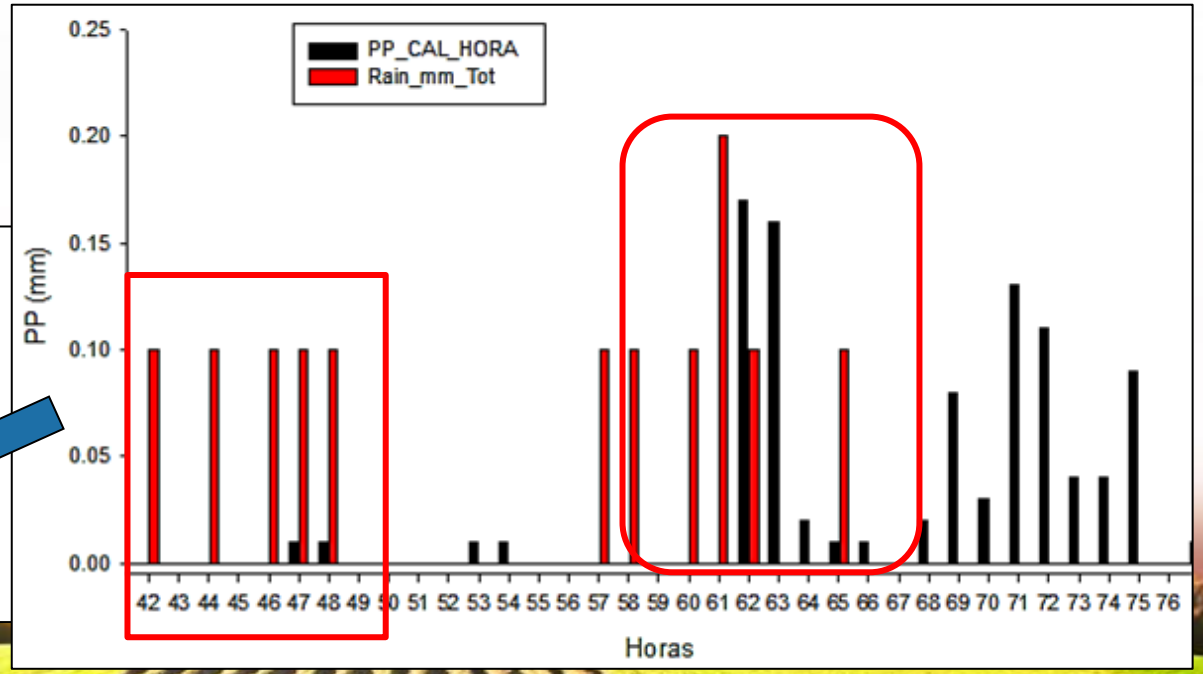
precipitacion	altura mm	h_pluv_b1	h_pluv_b2	Vol_probeta(cm2*mm)
7.00	0.00	0.00	0.00	0.00
9.00	0.00	0.00	0.00	0.00
420.00	1.60	0.71	4.07	320.00
512.00	1.60	0.71	4.07	320.00
514.00	2.70	1.19	6.88	540.00
529.00	2.50	1.11	6.37	500.00
553.00	3.65	1.61	9.29	730.00
559.00	4.20	1.86	10.70	840.00
590.00	5.00	2.21	12.73	1000.00
602.00	5.80	2.56	14.77	1160.00
602.00	4.85	2.14	12.35	970.00
631.00	7.00	3.09	17.83	1400.00
667.00	6.85	3.03	17.44	1370.00
691.00	8.30	3.67	21.14	1660.00
704.00	9.20	4.07	23.43	1840.00
717.00	9.45	4.18	24.06	1890.00
723.00	10.55	4.66	26.87	2110.00
729.00	12.20	5.39	31.07	2440.00
736.00	11.90	5.26	30.30	2380.00
742.00	13.40	5.92	34.12	2680.00
745.00	13.35	5.90	34.00	2670.00
745.00	14.05	6.21	35.78	2810.00
748.00	15.00	6.63	38.20	3000.00
749.00	14.70	6.50	37.43	2940.00
750.00	16.60	7.34	42.27	3320.00
751.00	15.70	6.94	39.98	3140.00



HIGRÓMETRO



Pluviómetro

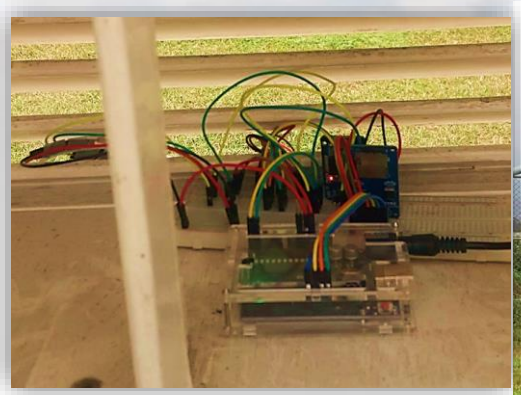



```
> cor.test(precipitacion, h_pluv_b1, method = "spearman")

        Spearman's rank correlation rho

data:  precipitacion and h_pluv_b1
S = 18.012, p-value < 2.2e-16
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.9938419
```

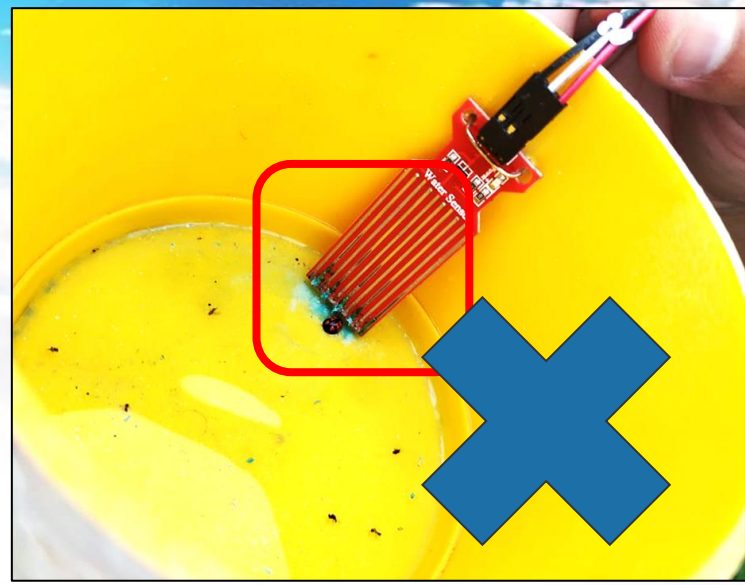
SENSORES INFRARROJOS

Lo que elaboré en prácticas

Lo que desarrollo actualmente



RECOMENDACIONES



CONCLUSIONES

- Los sensores de bajo costo de temperatura, humedad, presión y radiación presentan una alta correlación en comparación con los sensores de la estación automática Campbell CR 300, aunque el geotermómetro en sus cuatro niveles (0cm,5cm,20cm y 40cm) obtuvo una mejor respuesta en el primer nivel.

- El pluviómetro presentó una alta correlación, sin embargo no presentó una óptima respuesta para los eventos de precipitación, por otro lado el sensor de humedad del suelo no presentó el comportamiento esperado.


GRACIAS