

# A Ten-Month Comparison of Pyrheliometers

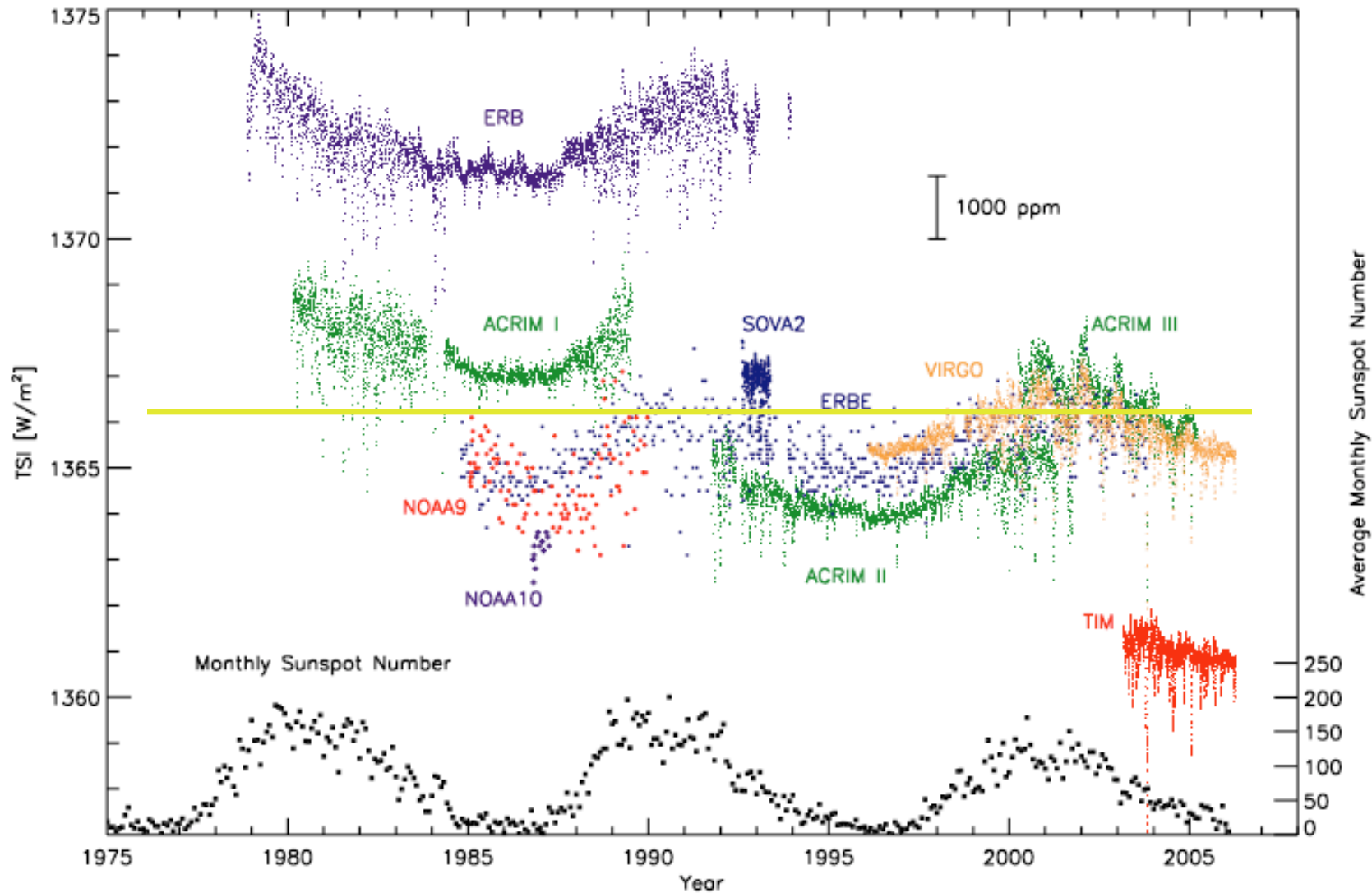
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- Why should this be of interest?
- Direct normal irradiance is the largest source of uncertainty in shortwave radiation measurements
- Baseline Surface Radiation Network had the goal to measure direct normal irradiance with an open cavity radiometer (with a 95% uncertainty of  $< 4 \text{ Wm}^{-2}$ )
- How well are we doing with the field instruments we are using instead of open cavities

# The Status of the Solar Reference, or How Well Do We Do in Space?



8.339	9.043	13.757	9.613	8.105	7.873	8.362	10.932	8.238	8.186	7.312	8.117	15.241	9.037	9.612	10.396	5.839
8.280	8.940	13.790	8.550	8.240	7.860	8.290	10.850	8.312	7.920	7.500	8.080	13.590	7.960	8.750	9.070	6.170
6.4	10.3	-2.2	99.5	-15.0	1.5	7.7	6.8	-8.1	29.2	-23.1	4.1	97.5	107.3	80.7	114.8	-51.0

7.945	7.972	9.850	8.032	7.719	5.900	7.927	8.117	10.879	10.530	8.091
7.940	8.050	9.830	8.050	7.670	6.150	7.890	8.135	10.760	10.340	8.137
0.6	-8.8	1.8	-2.0	5.7	-38.1	4.2	-2.0	9.8	16.2	-5.1

Top row: Absolute Cavity Calibration for Study

Middle row: Manufacturer's Sticker Calibration

Bottom row: Difference for average clear sky  
of  $903 \text{ Wm}^{-2}$  (Red > 1%)

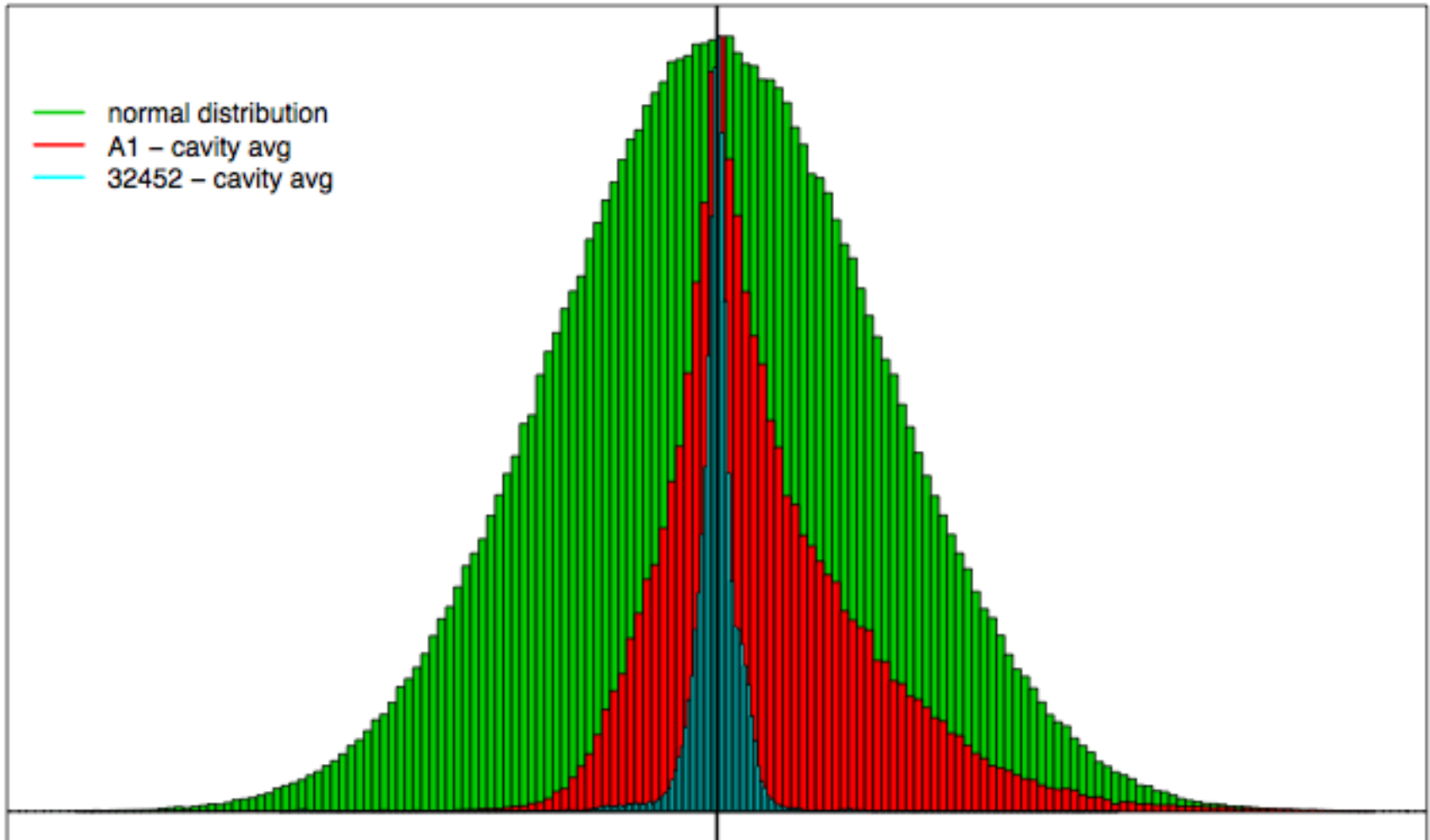
# Various Conditions Pyrheliometer Comparison - VCPC

- Ten-month comparison of almost all commercial pyrheliometers
- Site was NREL's Solar Radiation Research Laboratory
- Cleaned on weekdays (which is practice at well-run sites)
- One-minute averages (of 2-sec samples) are compared
- 29 pyrheliometers compared to three windowed cavities during comparison
- Monthly calibrations of windowed cavities is tied to WRR

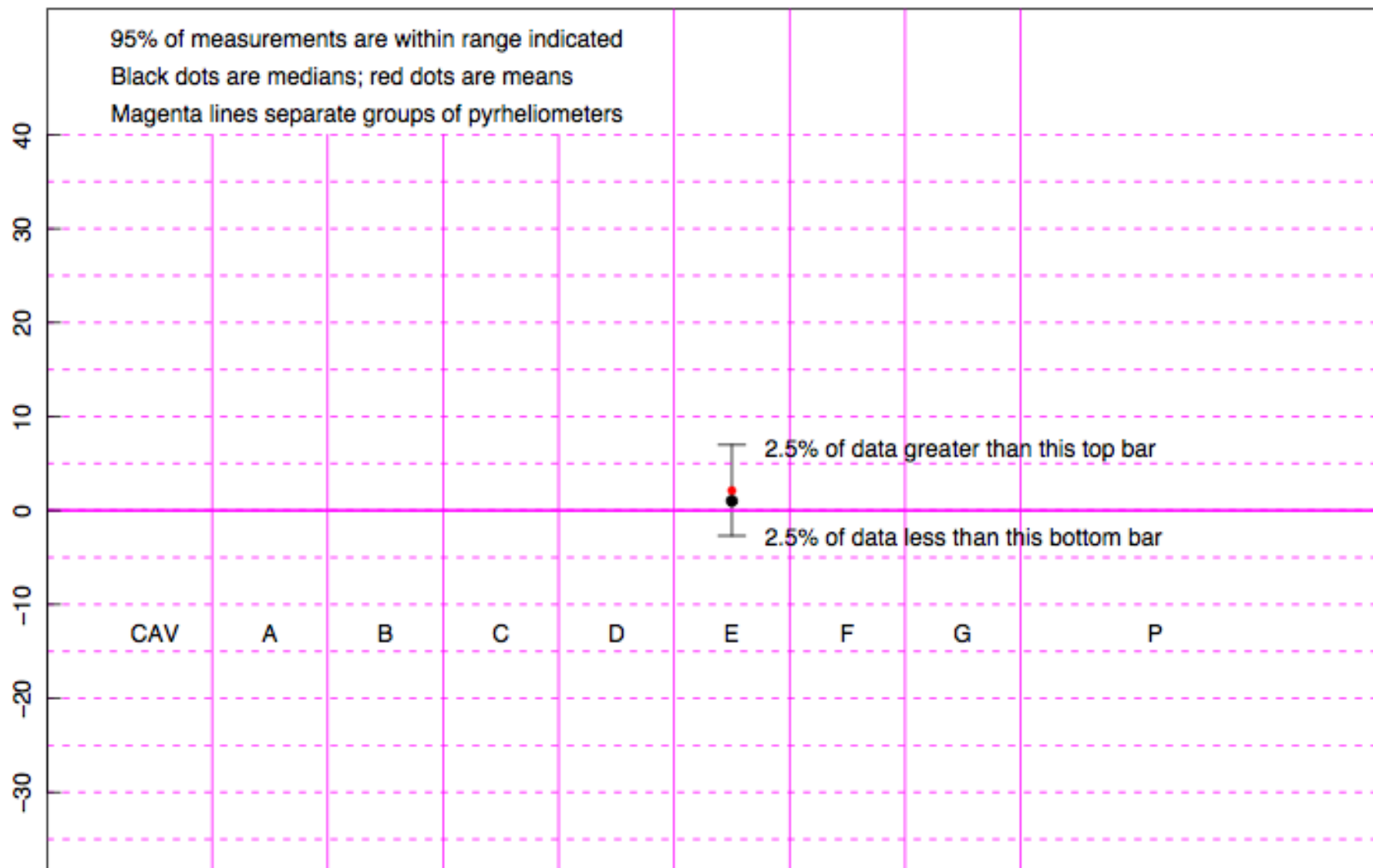
# How is this different from other comparisons (IPC's and NPC's)?

- IPCs are clear (direct  $> 700 \text{ W/m}^2$ ), calm, and with no hint of clouds for two or three weeks
- VCPC was all-sky conditions (clear  $\rightarrow$  cloudy, calm  $\rightarrow$  windy, hot  $\rightarrow$  cold) typical of high, mid-latitude, continental conditions
- **Blind analysis**





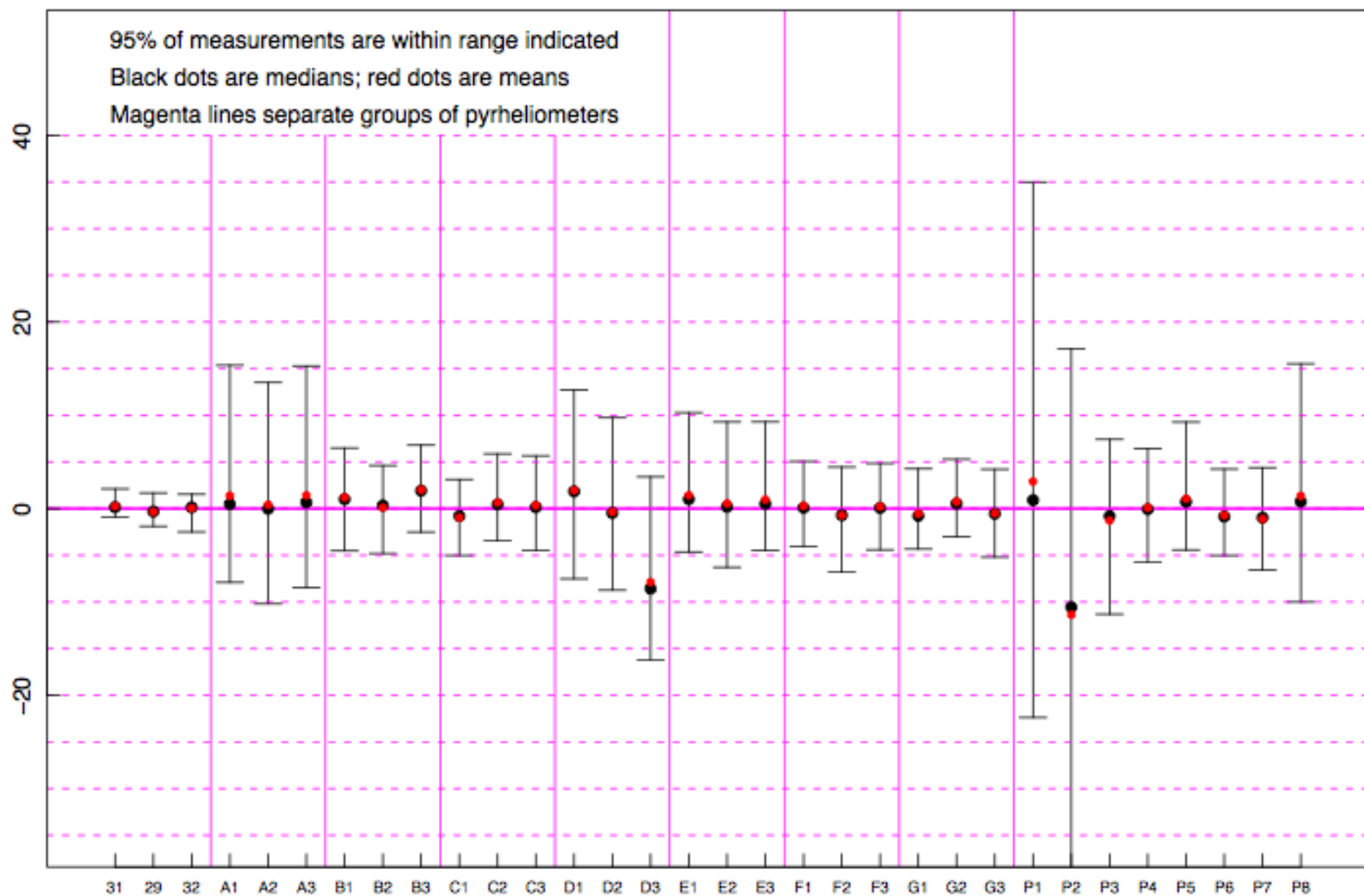
### Test Instrument Minus 3-Cavity Average



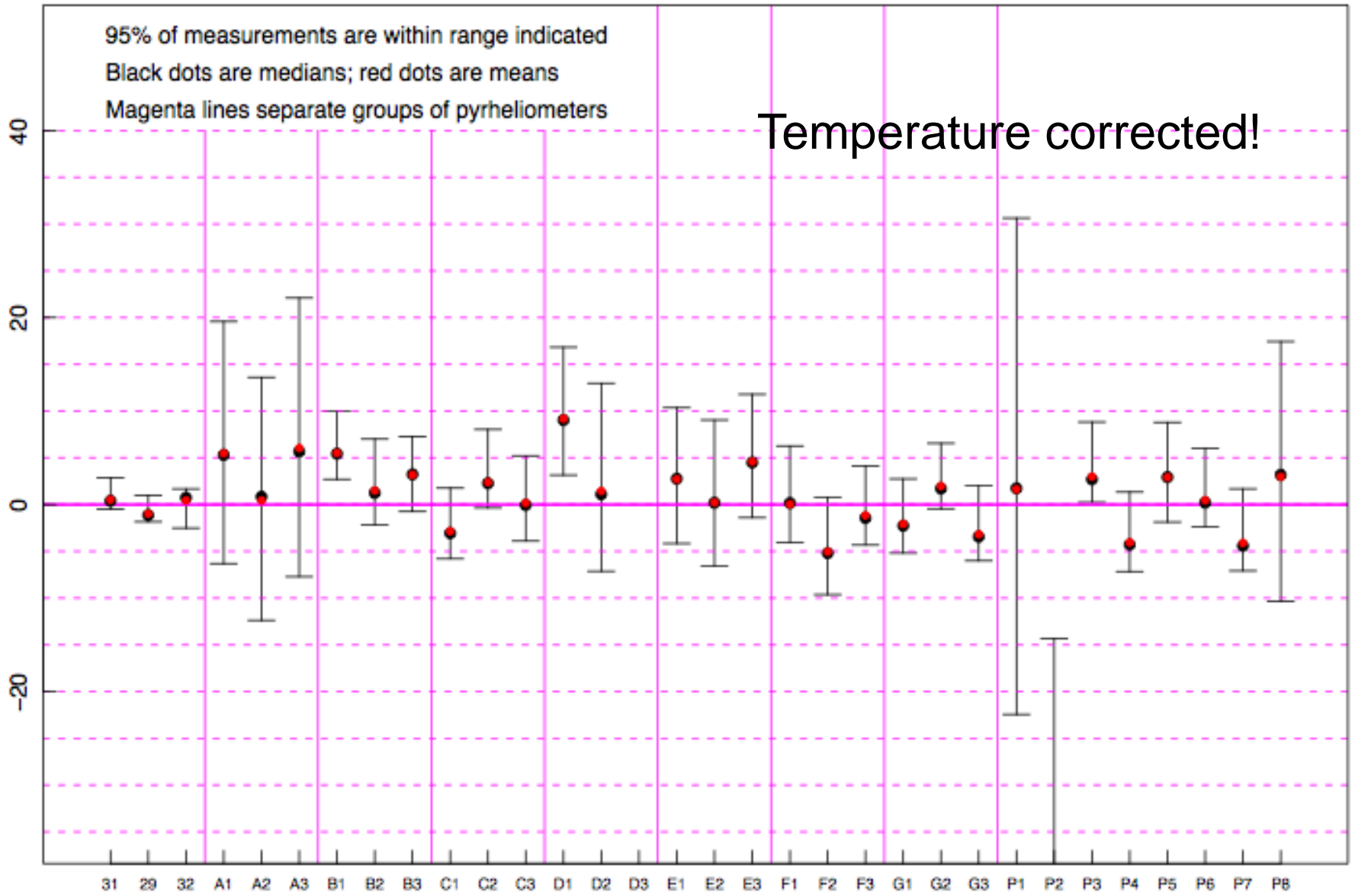


Conditions	Criteria	313000	Mean Direct
Night	sza > 91.2 degs	160000	< 1 W/m <sup>2</sup>
Cloudy	sza < 91.2 degs & direct < 4 W/m <sup>2</sup>	44000	< 1 W/m <sup>2</sup>
Daytime	sza < 91.2 degs	154000	410 W/m <sup>2</sup>
Passing clouds	sza < 91.2 & direct > 50 & stddev > 10	23000	476 W/m <sup>2</sup>
<b>Clear</b>	<b>sza &lt; 91.2 &amp; direct &gt; 700</b>	<b>56000</b>	<b>903 W/m<sup>2</sup></b>
Very Clear	sza < 91.2 & direct > 700 & stddev < 2 W/m <sup>2</sup>	41000	918 W/m <sup>2</sup>
Clear/Calm	sza < 91.2 & direct > 700 & ws < 2 m/s	39000	894 W/m <sup>2</sup>
Clear/Windy	sza < 91.2 & direct > 700 & ws > 5 m/s	3900	952 W/m <sup>2</sup>
Clear/Cold	sza < 91.2 & direct > 700 & temp < 0 degs	3300	896 W/m <sup>2</sup>
Clear/Moderate	sza < 91.2 & direct > 700 & temp > 10 & < 20 degs	16500	905 W/m <sup>2</sup>
Clear/Hot	sza < 91.2 & direct > 700 & temp > 30 degs	3300	899 W/m <sup>2</sup>

### Uncertainty Estimates for VCPC – Clear

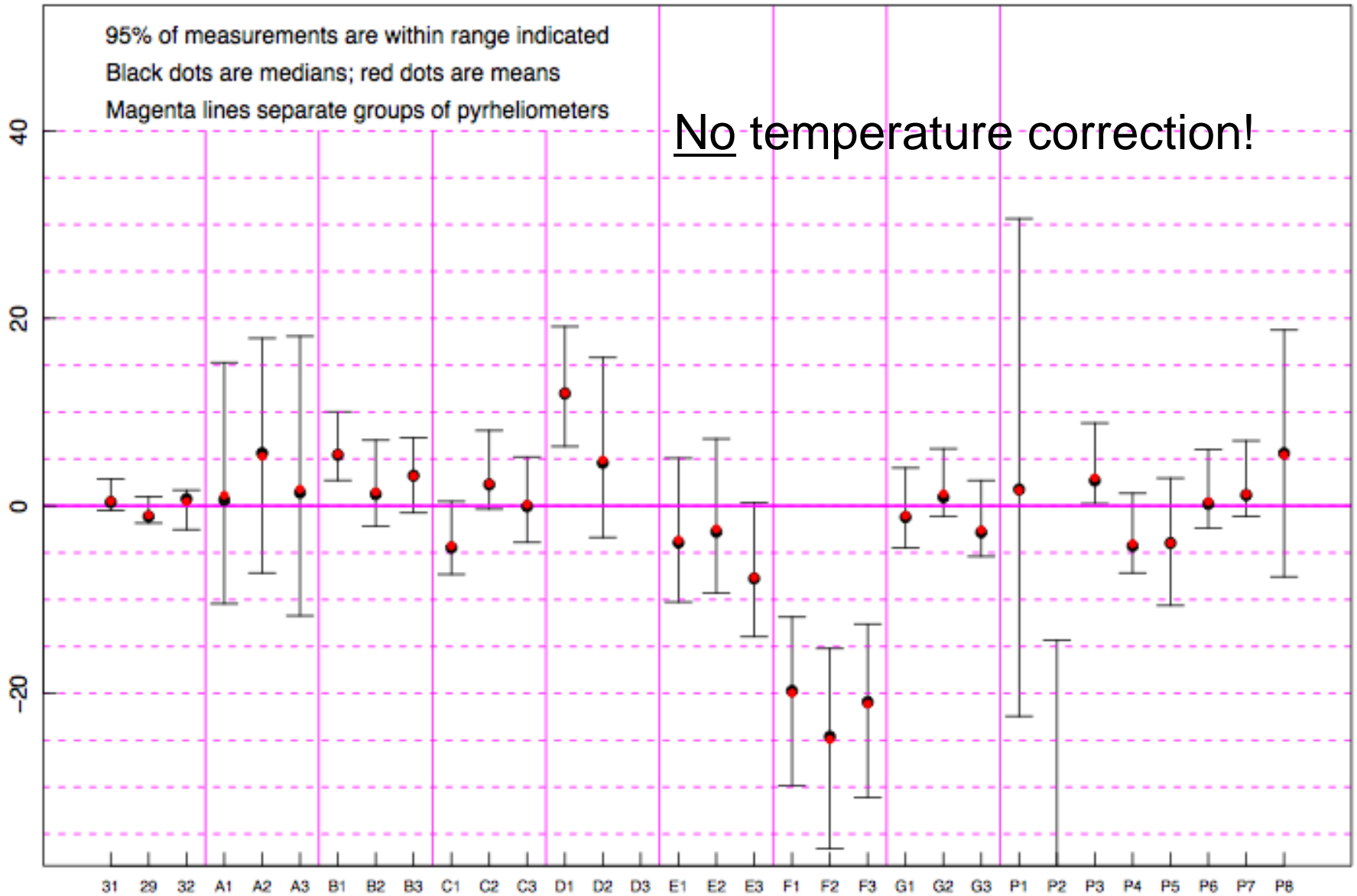


# Uncertainty Estimates for VCPC – Cold



Temperature corrected!

## Uncertainty Estimates for VCPC – Cold



### Uncertainty Estimates for VCPC – Clear

