5. Weighting According to Size

Many years after Waldmeier took over the production of the sunspot series we learn that he weighted sunspots according to size (Waldmeier, 1961):

> *Since Rudolf Wolf began the sunspot measurement, he set the standard. And although he counted each spot regardless of its size, he failed to include those smallest spots visible only under a stable atmosphere. Around 1882 Wolf's successors permanently changed the counting method in two ways to compensate for the large variation in size:*
>
> *i) by including the smallest spots visible under an atmosphere of constant transparency and*
>
> *ii) by weighting spots with penumbrae according to their size and umbral structure.*

and (Waldmeier, 1968):

> *Später wurden den Flecken entsprechend ihrer Größe Gewichte erteilt: Ein punktförmiger Fleck wird einfach gezählt, ein größerer, jedoch nict mit Penumbra versehener Fleck erhält das statistische Gewicht 2, ein*

> *kleiner Hoffleck 3, ein größerer 5. (Later the spots were weighted according to size: A pore was counted as one, a larger spot but still without penumbra get a statistical weight of 2, a small spot with penumbra one of 3, and a larger of 5).*

Kopecký and colleagues note (Kopecký *et al.*, 1980), essentially quoting Waldmeier with a twist, that:

> *beginning with Wolfer, a "modified" method of calculating the number of sunspots, but* ***without mentioning it****, is being used in Zürich. (emphasis added).*

This counting method is still in use at the reference station used by SIDC. As a typical example we take the drawing made at Locarno on 21st October, 2010 (Figure 2). Three sunspot groups are visible, numbered 102, 104, and 107, corresponding to NOAA active region numbers 11113, 11115, and 11117. From http://solarscience.msfc.nasa.gov/greenwch.shtml we list in Table 1 pertinent data, in particular the observed areas in μHemispheres of the disk.

Table 1. Areas (in μHem.) of sunspot groups observed at Locarno (top) and at MWO.

Year Month Day. fraction UT	Region number	Locarno number	Obs. Area	Corr. Area	Center dist. ($R_\odot$)	Lat	CM dist.
2010 10 21.500	11113	102	134	80	0.533	16.0	31.0
2010 10 21.500	11115	104	223	140	0.595	-29.0	13.0
2010 10 21.500	11117	107	104	80	0.760	23.0	-48.0
1920 11 21.550	9263	MWO	223	118	0.328	18.3	9.8

The raw sunspot number reported by Locarno (upper right-hand table in Figure 2: $g = 3$, $f = 11$) was $3 \times 10 + 11 = 41$, which with Locarno's standard k-factor of 0.60 translates to a reduced relative sunspot number on the Wolf scale of $0.6 \times 41 = 25$ which is indeed what SIDC reported for that day.

If we take Waldmeier at face value then Wolfer would have introduced and used the weighting scheme. Can we check this? As Wolfer reported (see format in Figure 1) the number of groups and spots for the whole disk we need to find an observation by Wolfer of a single group with only one spot with an observed area similar to that of Locarno group 104. Such was the case on 21st November, 1920, listed as the last group in Table 1 with, as luck will have it, precisely the same observed area (223 μHem). Figure 3 shows the drawing from Mount Wilson Observatory (MWO) for 21 November, 1920 of a solitary spot with the same area as Locarno Region 104. An insert shows a similar group observed at MWO on 5th November, 1922. For both groups, Wolfer should have recorded the observation as 1.3 if he had used the weighting scheme, but they were recorded as 1.1, clearly counting the large spots only once (thus with no weighting). The Zürich sunspot number was 7 ($= 0.6 \times (1 \times 10 + 1)$) on both those days, consistent with no weighting. There are many other such examples, *e.g.* 16th September, 1922 and 3rd March, 1924 for which MWO drawings are readily available. We thus consider it established that Wolfer (and by extension the other observers before Waldmeier) did not apply the weighting scheme contrary to Waldmeier's assertion. This is consistent with the fact that nowhere in Wolfer's otherwise meticulous yearly reports in the *Mittheilungen über Sonnenflecken* series is there any mention of a weighting scheme. We shall not here speculate about the motive or reason for Waldmeier ascribing the weighting scheme to Wolfer. Waldmeier himself was an assistant to Brunner since 1938 and performed routine daily observations with the rest of the team so should have known what the rules were.

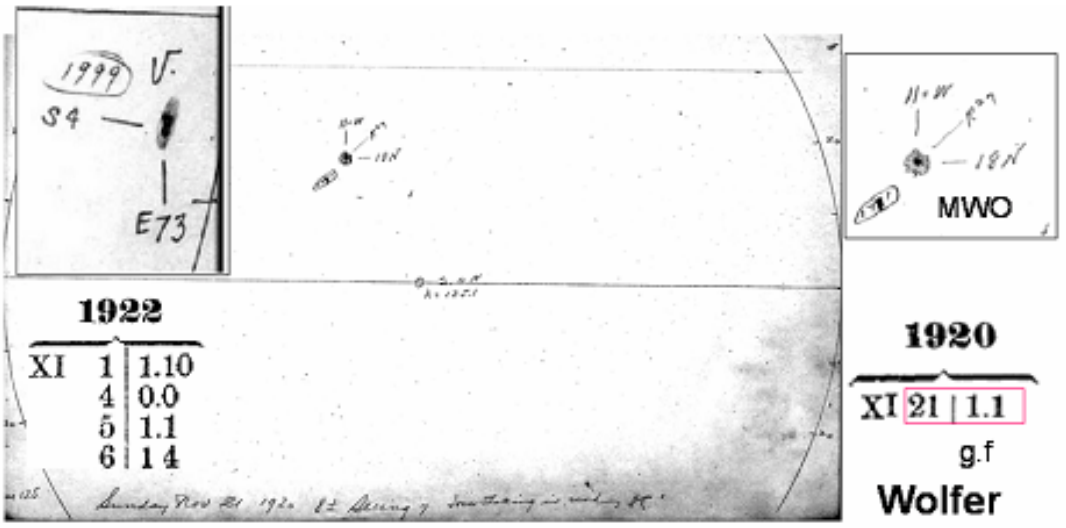

Figure 3. Drawing from Mount Wilson Observatory (MWO) 21 November, 1920 showing a solitary spot with the same area as Locarno Region 104. An insert shows a similar group observed at MWO on 5th November, 1922. For both groups, Wolfer recorded the observations as 1.1, clearly counting the large spot only once (thus with no weighting). (ftp://howard.astro.ucla.edu/pub/obs/drawings/1920/dr201121.jpg)

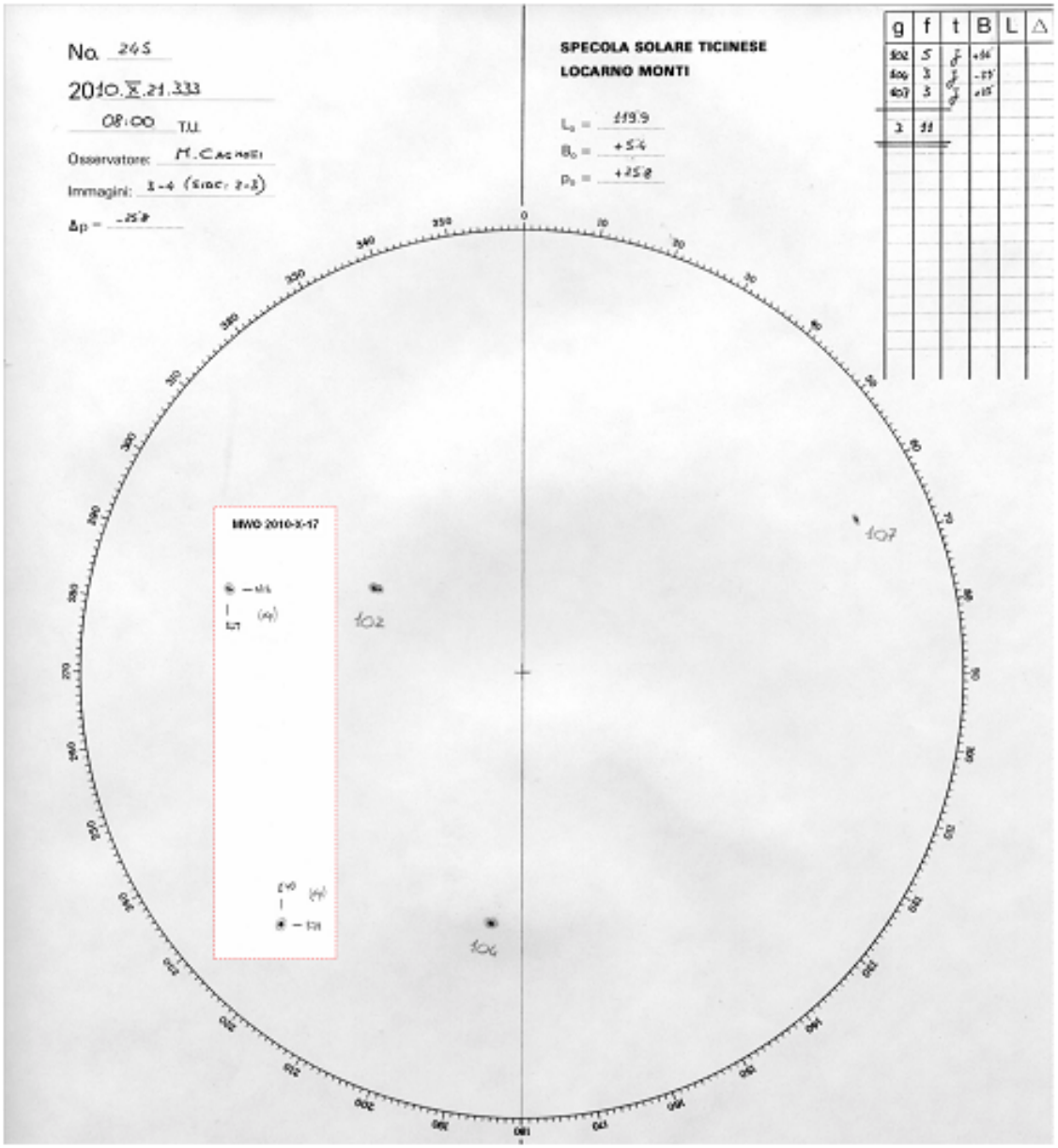

Figure 2. Drawing from Locarno 21 October, 2010 showing the three Locarno Regions 102, 104, and 107. The table at the upper right gives the weight assigned to each group. An insert (red border) shows the regions as observed at MWO on the 17th October (no observation the 21st). (http://www.specola.ch/drawings/2010/loc-d20101021.JPG)