



# **The Curious Case of the Sunspot Penumbrae**

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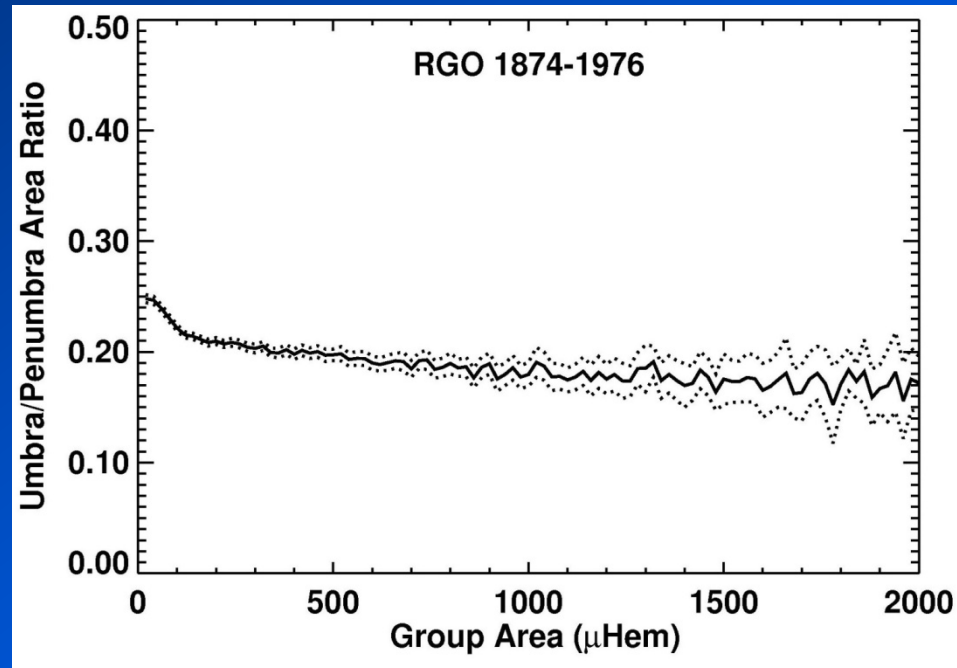
**NASA Marshall Space Flight Center  
Heliophysics and Planetary Science Office**

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**Sunspot Sunspot Workshop**

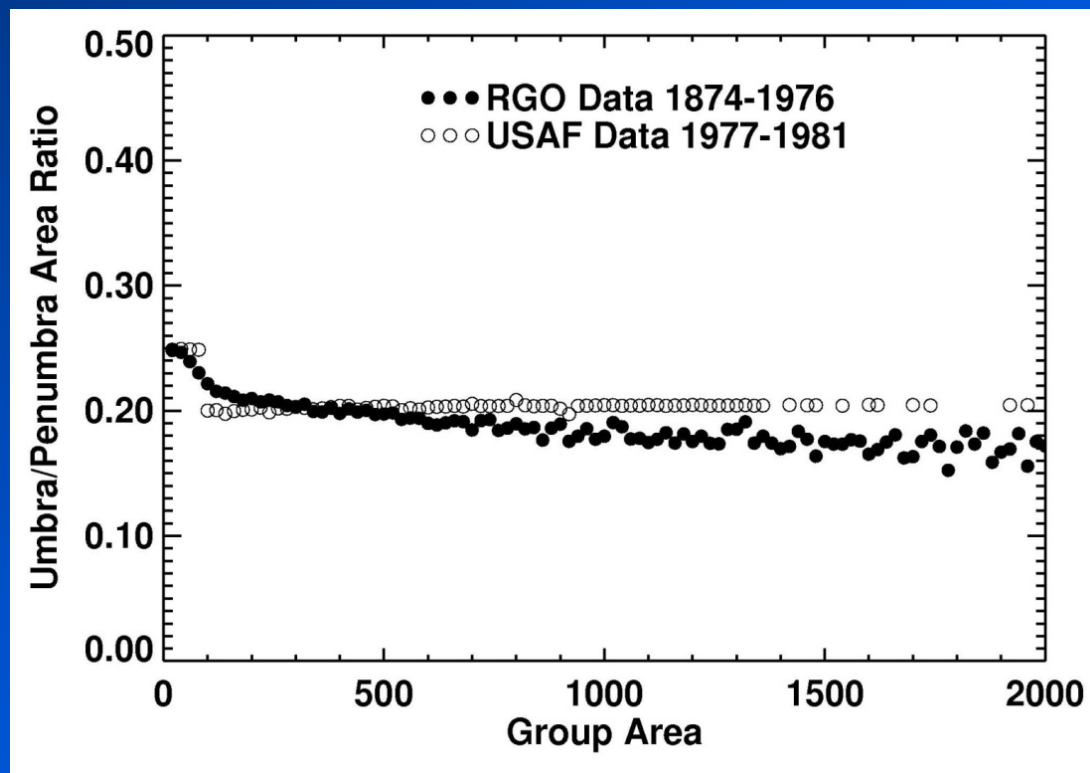
# Umbra/Penumbra Area Ratio

The ratio of umbral area to penumbral area in sunspot groups is about 0.2 and varies only slightly with sunspot group size. Small sunspot groups (areas  $< 100 \mu\text{Hem}$ ) have slightly more umbral area and there is a downward trend in umbral area for larger sunspot groups.



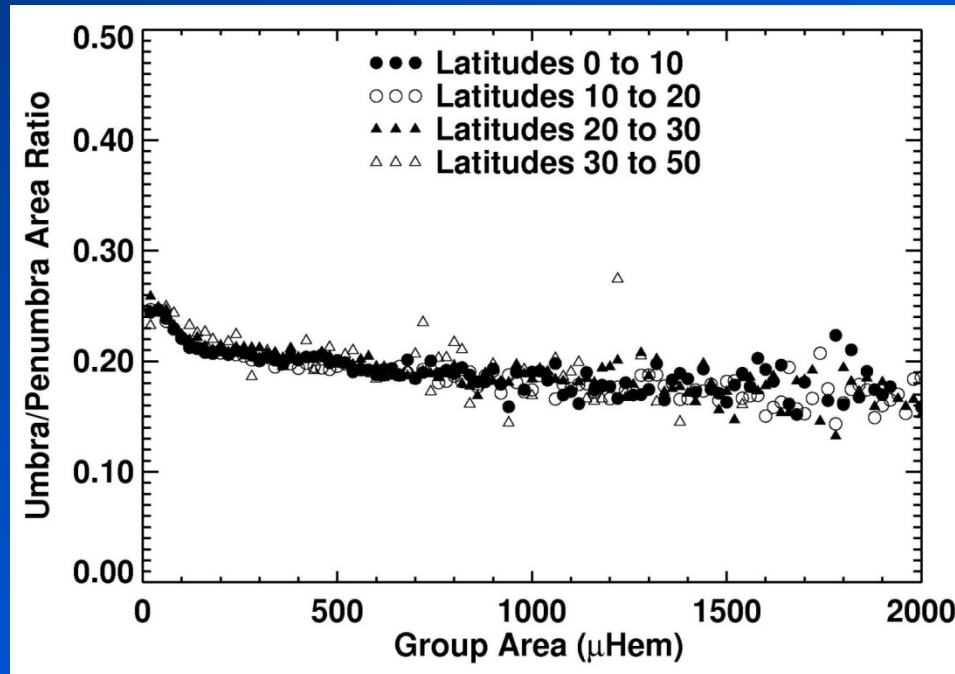
# USAF “Umbral” Areas?

After RGO discontinued its measurements of sunspot areas and positions at the end of 1976 the USAF continued the tradition using their Solar Optical Observing Network (SOON). The data suggest that the USAF only provided corrected whole spot areas and someone used a simple relationship to **simulate** umbral area information which is reported as Greenwich data from 1977 to August 1982.



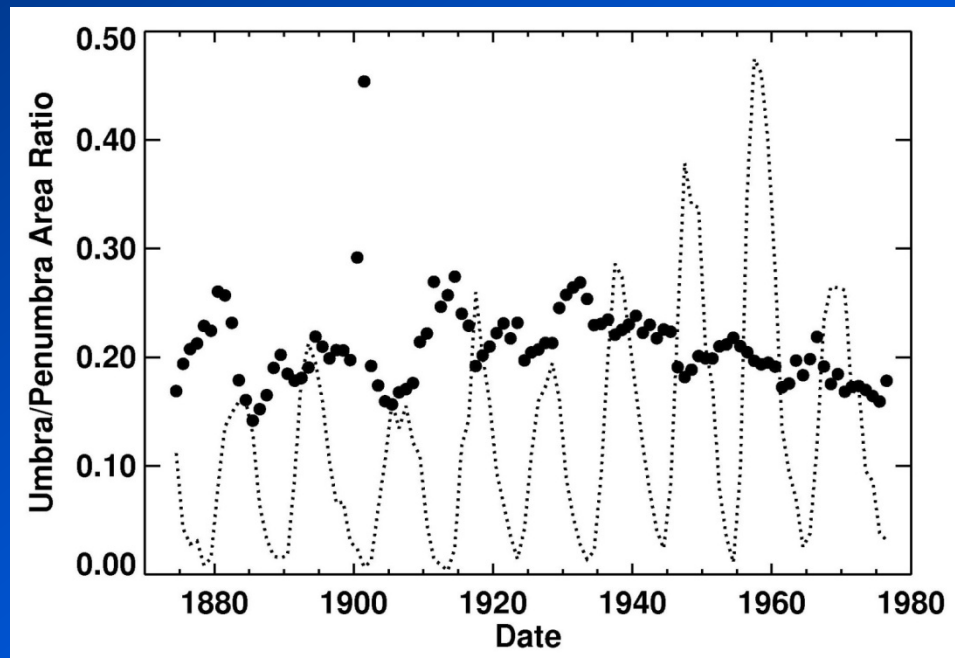
# Latitudinal Variations?

Sorting the sunspot groups into  $10^\circ$  latitude bins indicates little or no variation in the umbra/penumbra area ratio with latitude.



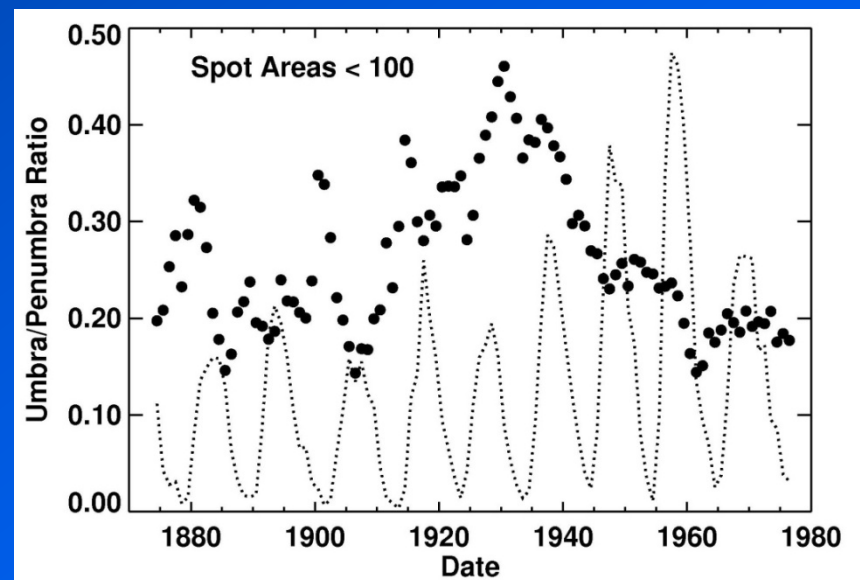
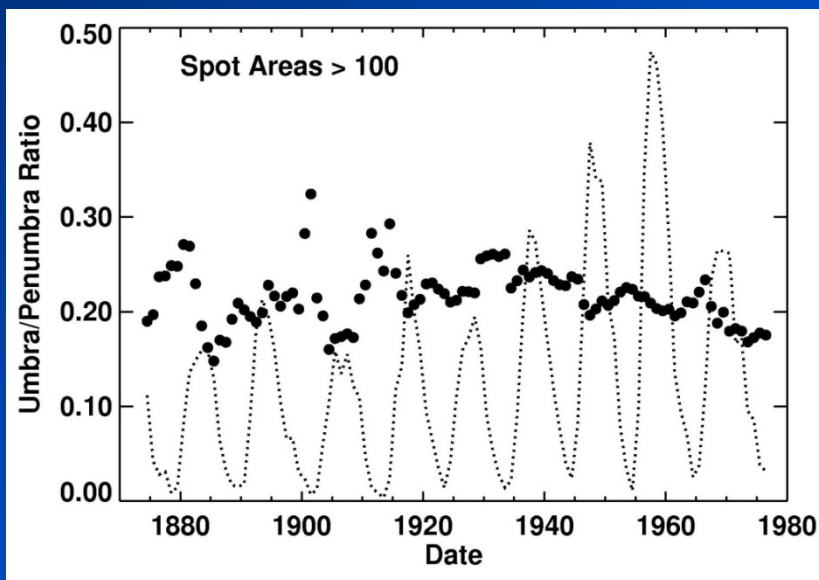
# Temporal Variations?

The yearly ratio of the total umbral area to the total penumbral area shows a slight increase at sunspot cycle minima (which are dominated by smaller sunspot groups) but little evidence of any other trends.



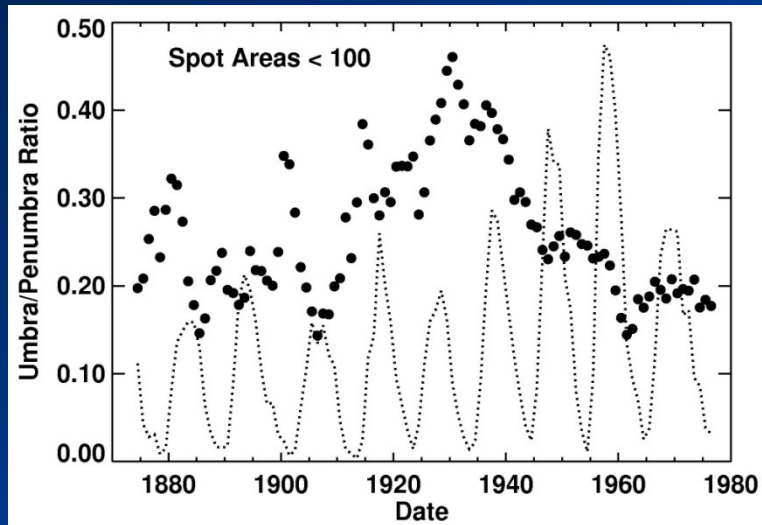
# Temporal Variations with Size?

Separating the sunspot groups by size into small (area < 100  $\mu\text{Hem}$ ) and large (area > 100  $\mu\text{Hem}$ ) **does** indicate a substantial variation in this ratio for the small sunspot groups with the ratio doubling from 1910 to 1930 and then dropping back to its previous value from 1930 to 1950 – **Curious Behavior**.

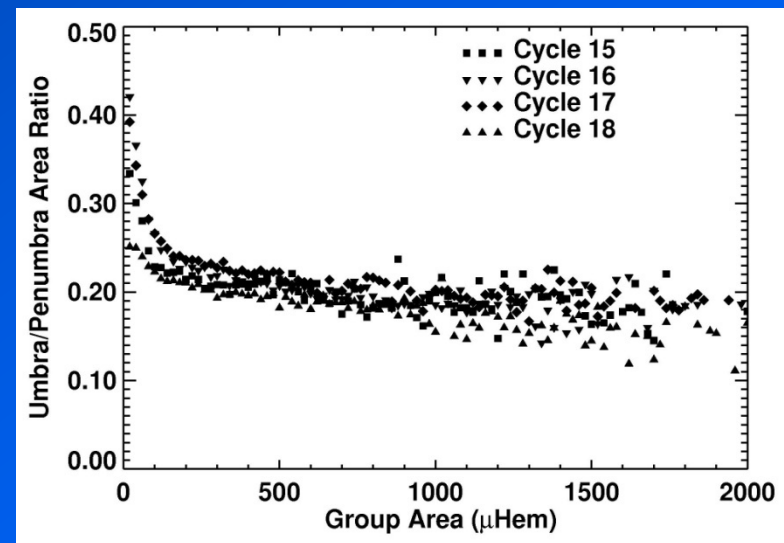
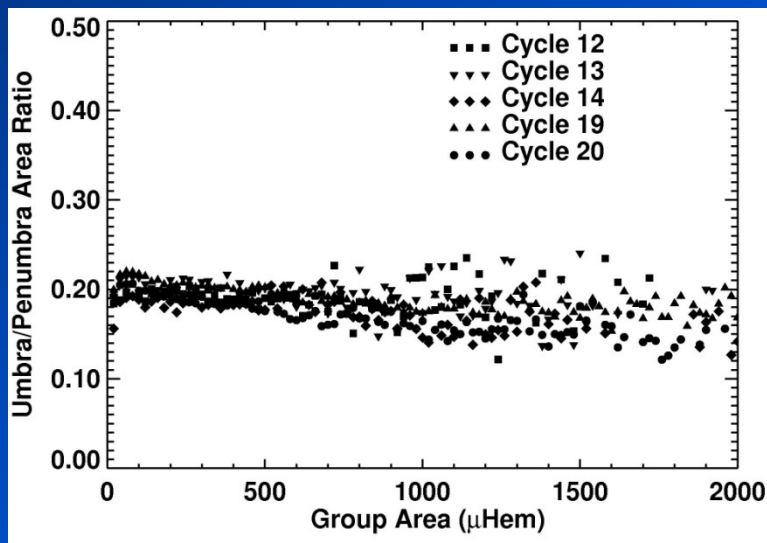




# Curious Small Spot Behavior

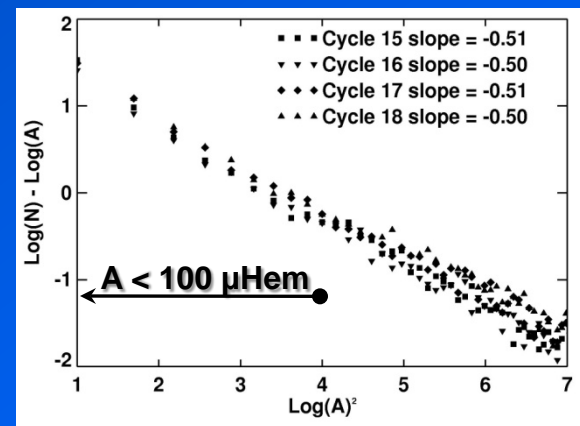
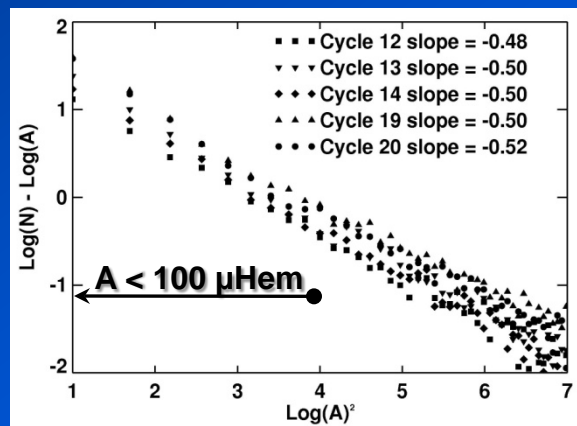
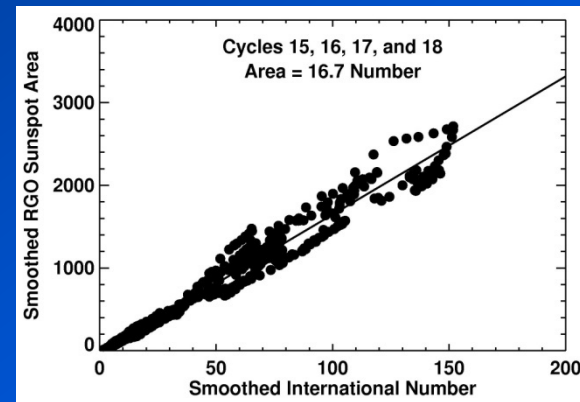
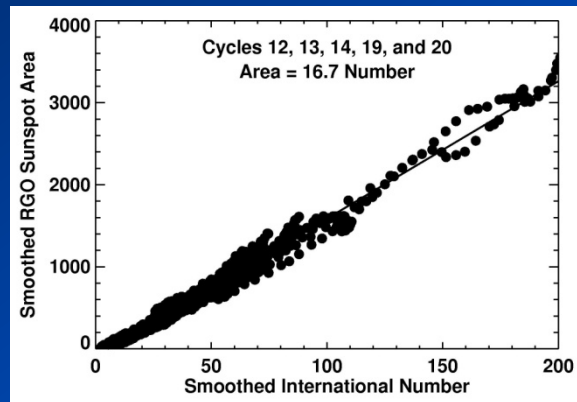


This behavior is even more evident in the variation with total area. Prior to 1910 and after 1945 the small sunspot groups have the same ratio as the larger groups  $\sim 0.2$ . From 1910 to 1945 the small sunspot groups have larger umbrae (or smaller penumbrae).



# Observational Artifact?

E. Walter Maunder retired in 1913. Was the larger umbra/penumbra ratio due to a change in observers at RGO? Both the relationship between sunspot area and sunspot number and the Log-Normal sunspot group size distribution appear unchanged.





# Conclusions

1. The ratio of umbral area to penumbral area in sunspot groups is about  $1/5$  with little variation with total sunspot group area.
2. This relationship changed for small sunspot groups (areas  $< 100 \mu\text{Hem}$ ) in the mid-20<sup>th</sup> century. The ratio doubled to  $2/5$  for the smallest spots from 1915 to about 1930 and then slowly returned to its previous value from 1930 to 1945.
3. Is this an observation artifact? The relationship between sunspot area and sunspot number was unchanged but this relationship is dominated by the larger groups. The distribution of group sizes was unchanged – even for the small groups in question.
4. **We need an independent measurement of this ratio for these sunspot groups during the period in question.**