



# **RGO/USAF Sunspot Areas**

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# Area vs. Number

Comparing the RGO areas to the International Sunspot Numbers gives:

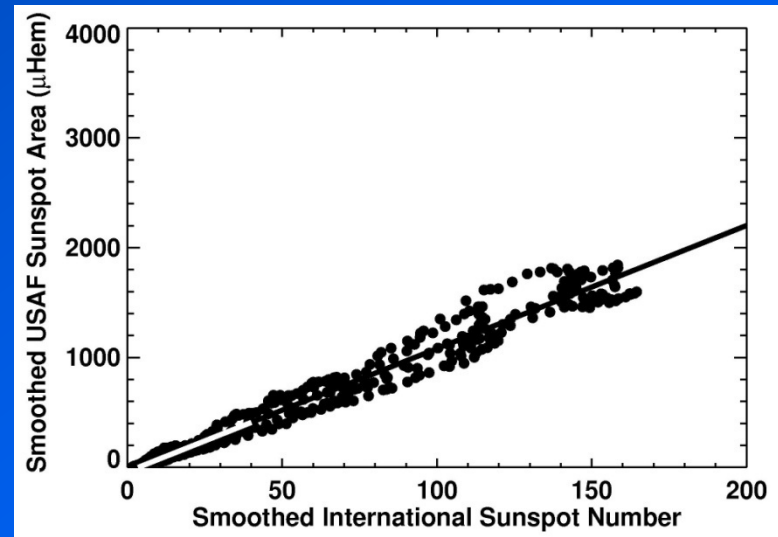
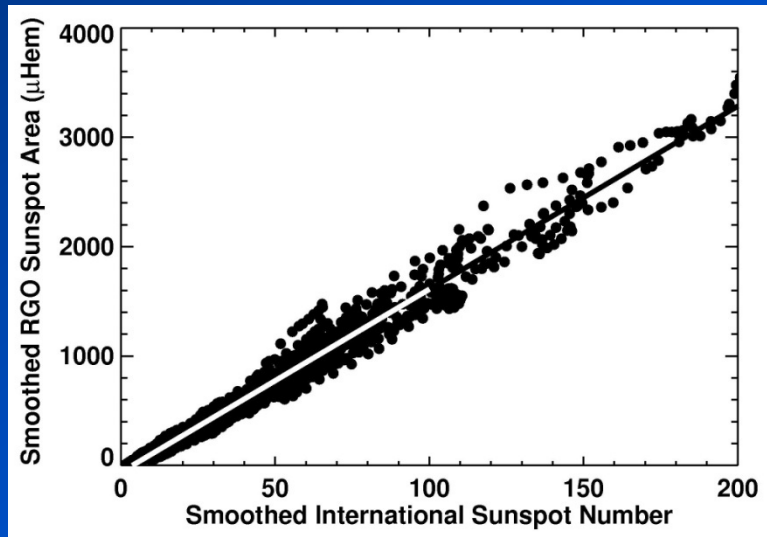
$$\text{Area}_{\text{RGO}} = 16.3 R_I$$

Comparing the USAF areas to the International Sunspot Numbers gives:

$$\text{Area}_{\text{USAF}} = 11.2 R_I.$$

This indicates a scaling factor to bring the USAF areas in line with the RGO areas:

$$\text{Area}_{\text{RGO}} = 1.45 \text{ Area}_{\text{USAF}}$$



# Area vs. 10.7 cm Flux

Comparing the RGO areas to the 10.7 cm Radio Flux gives:

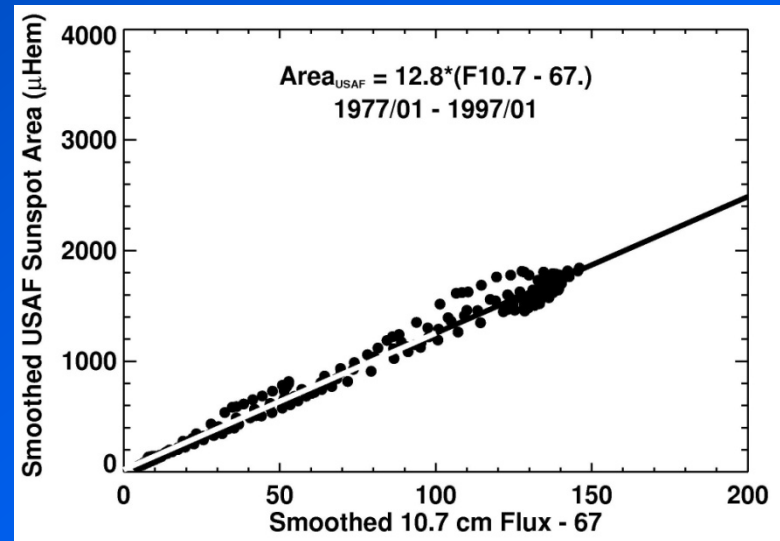
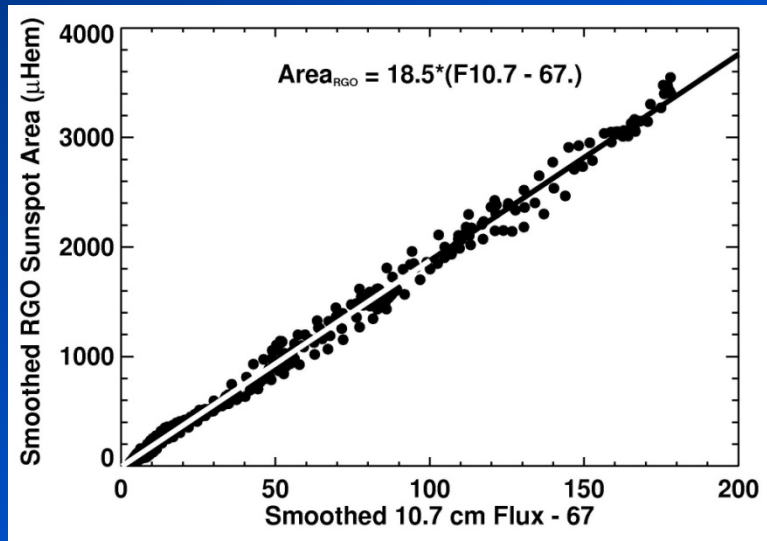
$$\text{Area}_{\text{RGO}} = 18.5 * (\text{F10.7} - 67.)$$

Comparing the USAF areas to the 10.7 cm Radio Flux gives:

$$\text{Area}_{\text{USAF}} = 12.8 * (\text{F10.7} - 67.)$$

This indicates a scaling factor to bring the USAF areas in line with the RGO areas:

$$\text{Area}_{\text{RGO}} = 1.44 \text{ Area}_{\text{USAF}}$$



# Which Areas are “Correct”?

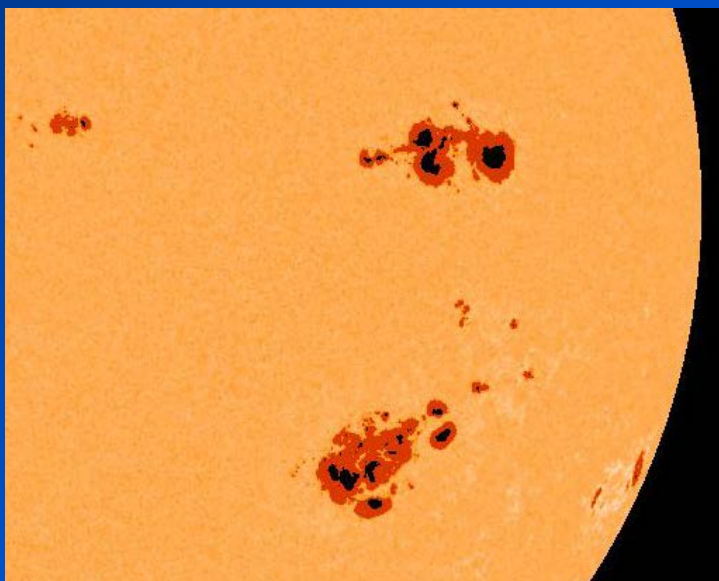
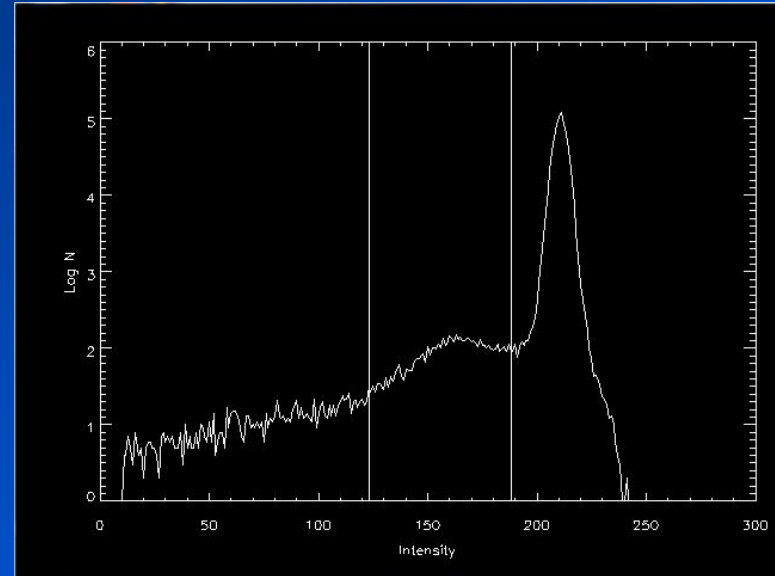
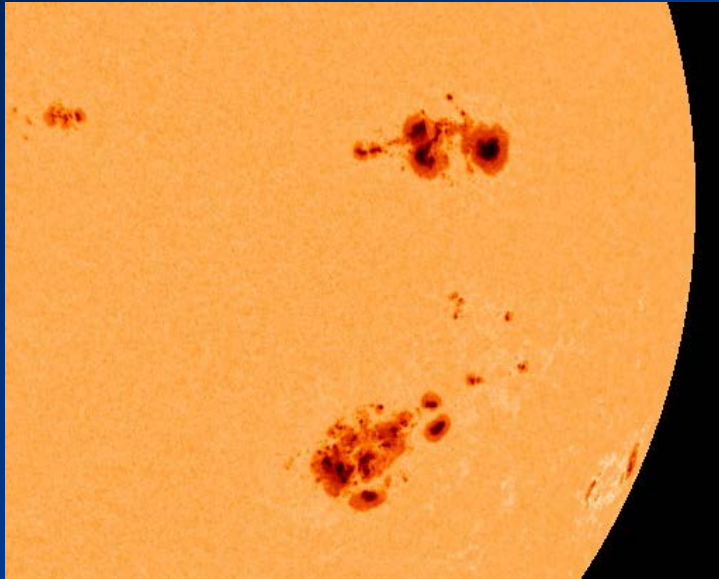
Should we use

$$\text{Area} = \text{Area}_{\text{RGO}} = 1.4 \text{ Area}_{\text{USAF}}$$

Or

$$\text{Area} = 0.7 \text{ Area}_{\text{RGO}} = \text{Area}_{\text{USAF}}$$

# Sunspot Areas from SOHO

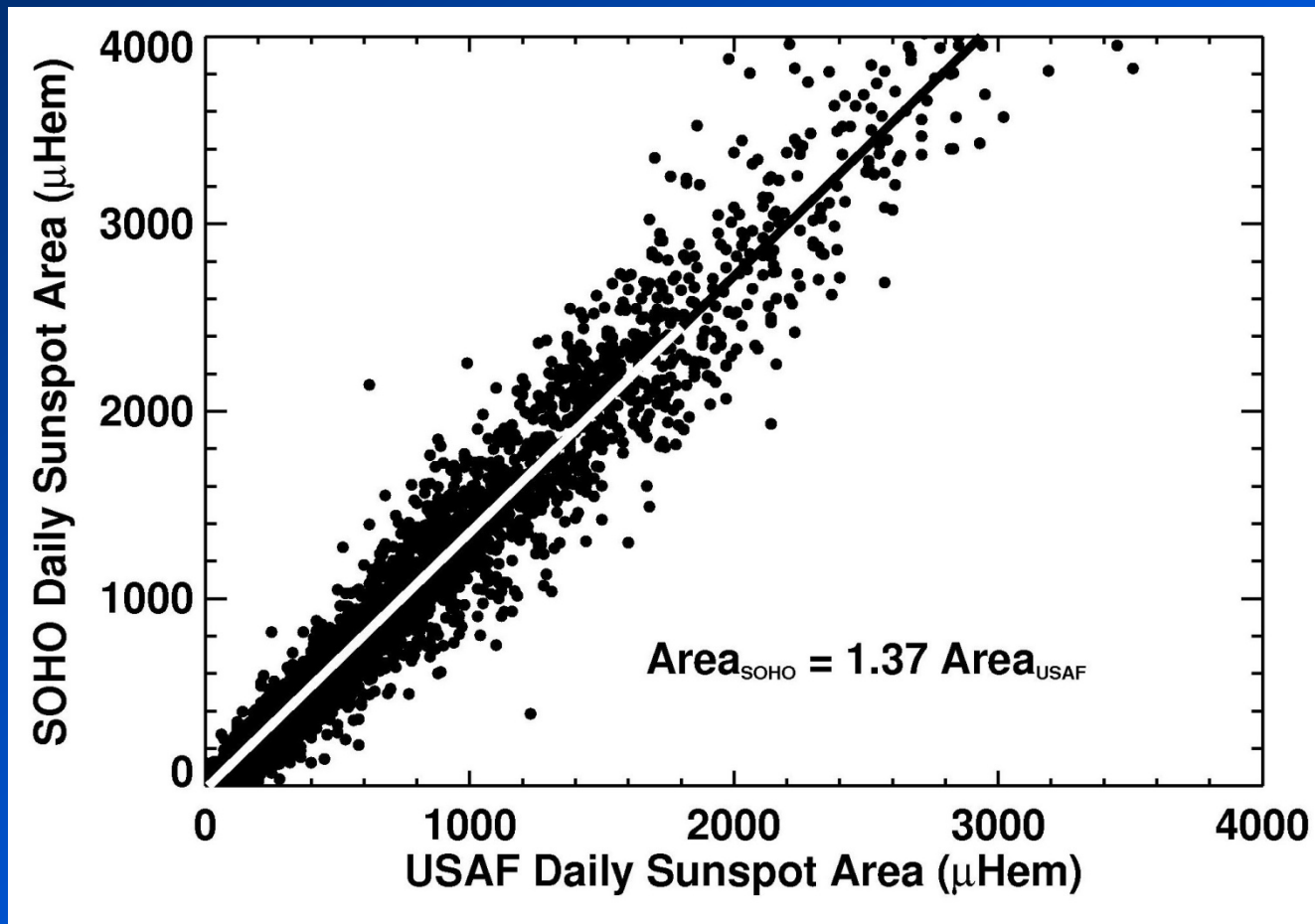


The “flattened” SOHO/MDI intensity images were processed with an IDL procedure that identifies penumbrae and umbrae using break points in the histogram of 8-bit intensities. The total corrected sunspot area for each of the 20,000 images was calculated using the center-to-limb distance of each sunspot pixel.



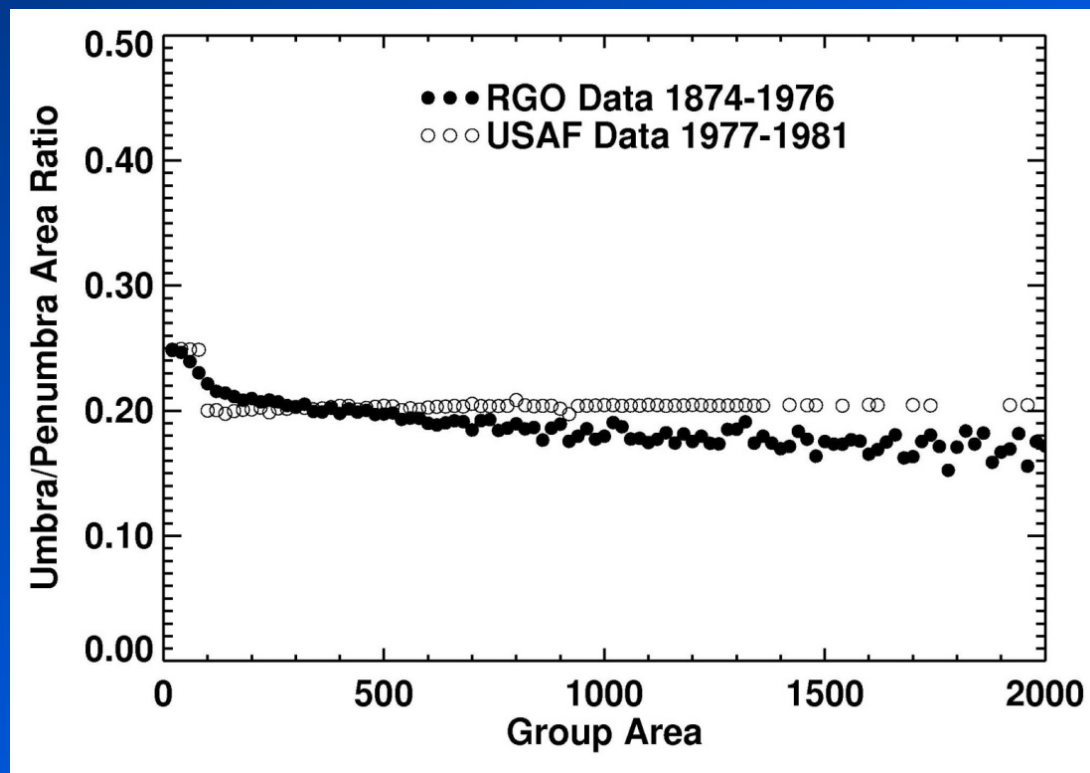
# SOHO Area vs. USAF Area

Comparing the daily sunspot areas from USAF and from SOHO for the time period of May 1996 through December 2010 indicates that it is the USAF data that needs correction.



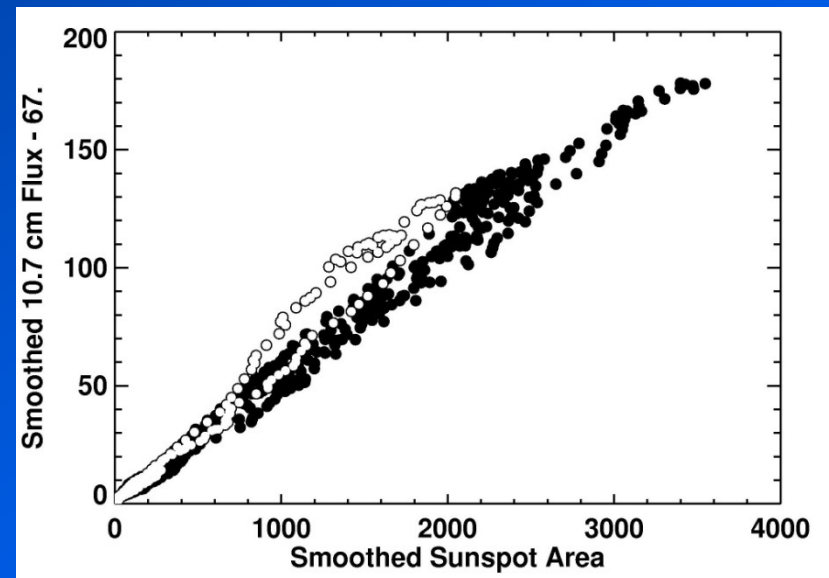
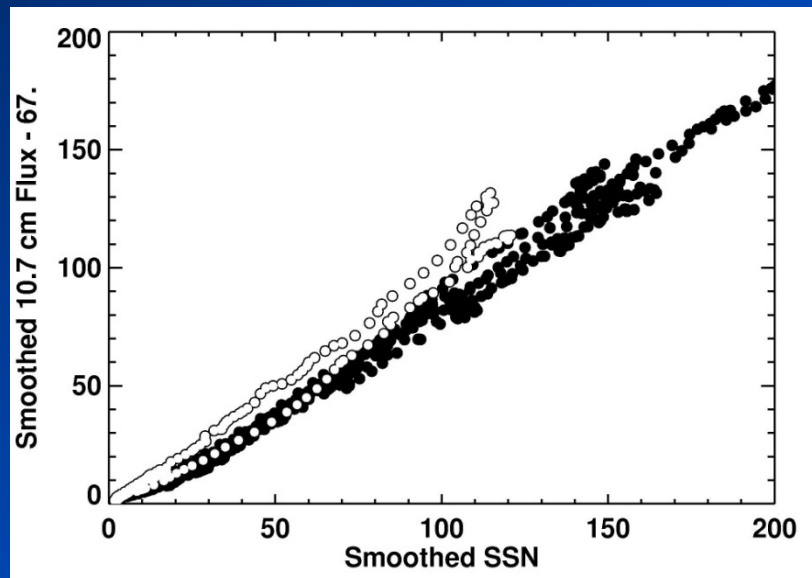
# USAF “Umbral” Areas?

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.



# 10.7 cm Flux Before/After 1997

A year or two after the start of Cycle 23 the 10.7 cm flux rose above its previous values relative to **both** sunspot numbers and sunspot areas.



Cycles 18-22 – filled circles, Cycles 23-24 – open circles



# Conclusions

- A uniform sunspot area dataset (starting in 1874 and continuing to the present) can be constructed from RGO and USAF data
- The sunspot areas reported by USAF should be multiplied by a factor of  $\sim 1.4$  (I would still like to understand why the area is underestimated)
- The umbral areas reported for 1977 to 1982 in the “Greenwich” data should be removed/ignored
- The 10.7 cm radio flux changed relative to both sunspot number and sunspot area sometime in 1997