

# Report for the SPD Thomas Metcalf Travel Award

HINODE-17 / IRIS-15 / SPHERE-3 Joint Science Conference  
Bozeman, MT, 23-26 July 2024



## Dr. Hisashi Hayakawa

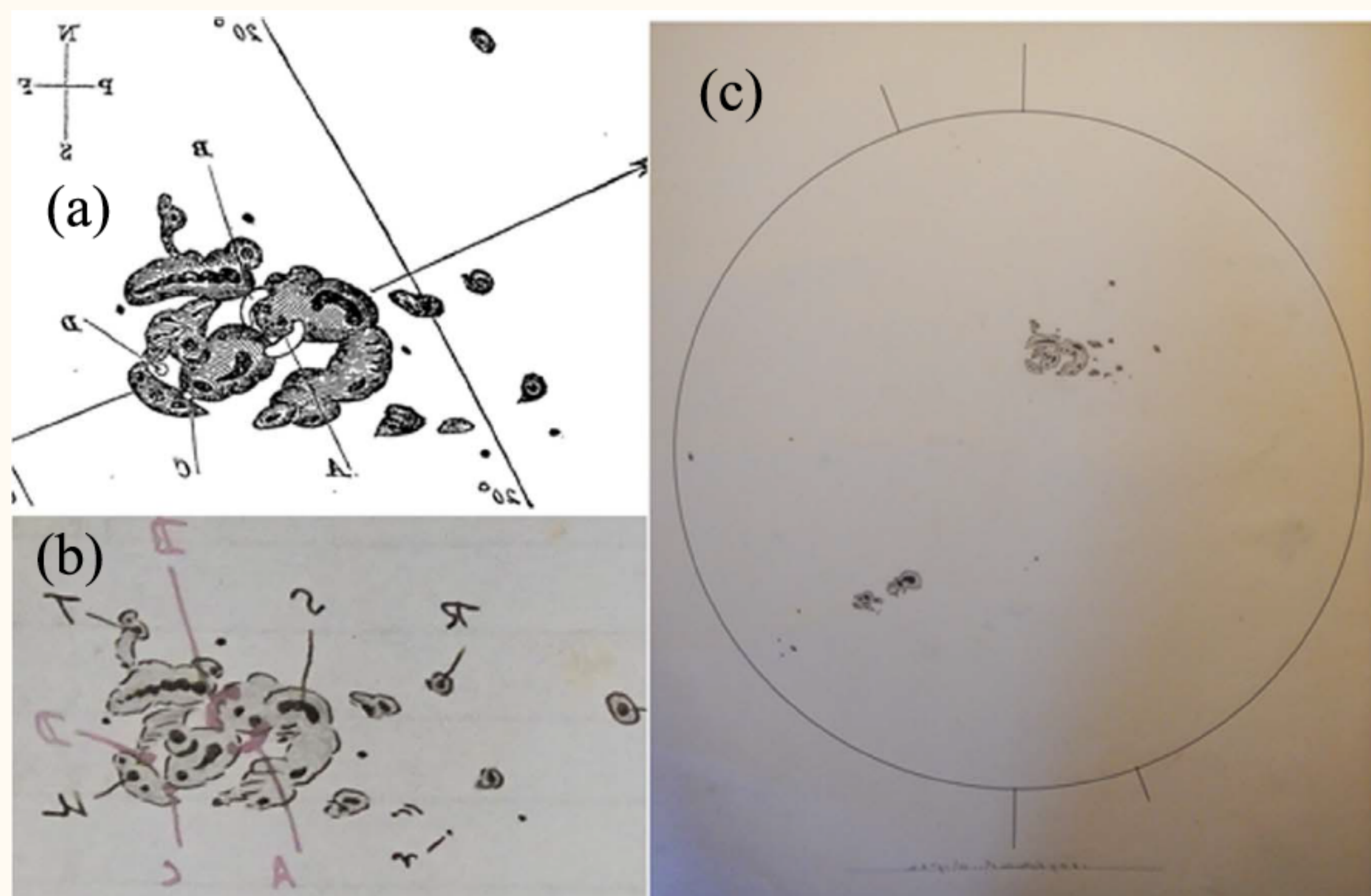
Hisashi Hayakawa is a designated assistant professor of Institute for Space-Earth Environmental Research and Institute for Advanced Research of Nagoya University. He got his PhD (Science) as a thesis doctor from Kyoto University, under supervision of Prof. Kazunari Shibata and his PhD (Letters) as a course doctor from Osaka University, under supervision of Prof. Masaharu Arakawa. He has been working on reconstructions of extreme solar and geomagnetic storms and long-term solar activity using archival records and historical documents.

## Invited Talk: Archival Investigations for the Extremity of the Solar Eruptions in the Past

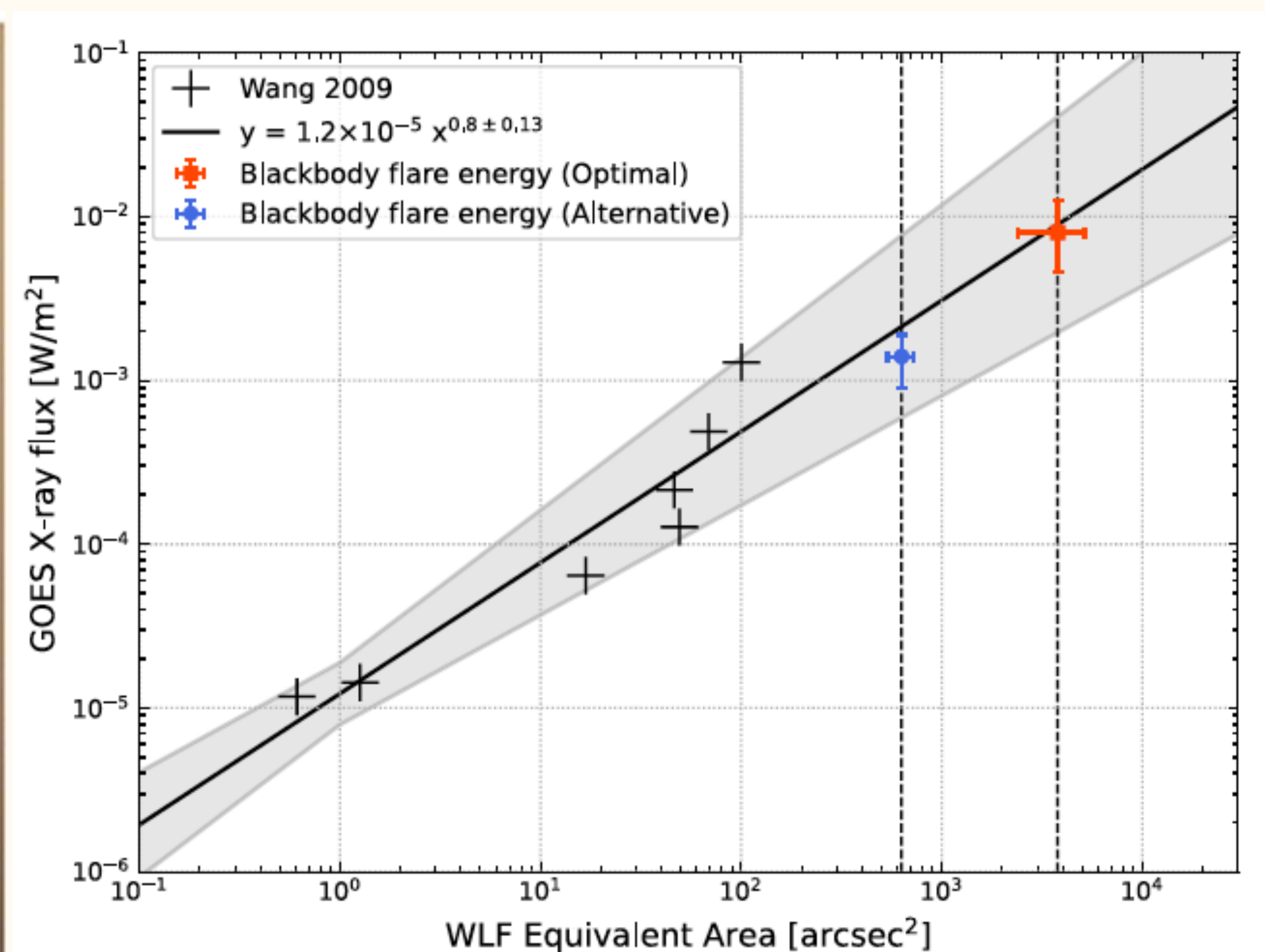
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Solar eruptions occasionally release considerable energy, launch geo-effective interplanetary coronal mass ejections, and trigger intense geomagnetic storms. It is important to study their extremity, as the modern civilization has accelerated dependency on technological infrastructure and vulnerability to such intense solar eruptions. However, it is challenging to quantify their extremity such as once-a-century events or once-a-millennium events, as many of our modern database extends coverage only for decades since the International Geophysical Year in 1957-1958. This presentation aimed at mitigating this difficulty on the basis of archival investigations for historical records upon extreme solar storms in the past. This presentation first consulted archival records (Figure 1) and quantified the Carrington flare (Figure 2) and the Carrington geomagnetic storm in 1859 to contextualize them with the modern studies in multiple aspects (Hayakawa *et al.*, 2022, *The Astrophysical Journal*, **928**, 32; Hayakawa *et al.*, 2023a, *The Astrophysical Journal Letters*, **954**, L3). This presentation also shows another extreme storm in 1872 and compares this with the Carrington storm (Hayakawa *et al.*, 2023b, *The Astrophysical Journal*, **959**, 23). This presentation showed a potential for archival investigations to extend our scientific discussions to the extremity of the solar eruptions.



**Figure 1:** Carrington's sunspot drawings on 1859 September 1, in corrected orientations: (a) Carrington's published close-up drawing (Carrington 1859); (b) Carrington's original close-up drawing (RAS MS Carrington 1, v. 2, f. 64a); and (c) Carrington's original whole-disk drawing (RAS MS Carrington 3, v. 2, f. 313a). These images are reproduced by courtesy of the Royal Astronomical Society and Hayakawa *et al.* (2023a, *The Astrophysical Journal Letters*, **954**, L3).



**Figure 2:** Comparisons of the WLF equivalent area in  $\text{arcsec}^2$  ( $EA_{\text{flare}} \times (\text{contrast} - 1)$ ), following Wang (2009), and GOES SXR flux in  $\text{W m}^{-2}$ , following Table 1 of Wang (2009) in a revised scale, on the basis of **Hinode/SOT WLF observations**. The red and blue error bars include those for flare areas and resultant magnitude estimates from our photometric discussions. The gray shades indicate error margins for those for flare areas and resultant magnitude estimates from this figure's fitting parameters.

I wish to thank the AAS/SPD committee and the organizers of HINODE-17 / IRIS-15 / SPHERE-3 Joint Science Conference for kindly granting me this award. I have been honoured to attend this excellent symposium and have expanded my knowledge especially on the state of the art of the flare studies using these satellites. This opportunity is essentially important for me to link my studies on the historical extremes with the modern state-of-the-art scientific results from these satellite missions and improve the understanding on their possible background mechanisms.