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## Postprint: The Relationship Between Hemispheric Characteristics of the First High-Latitude Sunspot and First X-Class Flare in Solar Cycles 21-24 and North-South Asymmetry of Solar Activity

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### Abstract

Utilizing solar soft X-ray flare data monitored by the GOES and SDO satellites, we find that during solar cycles 21-24, the first X-class flare and the first high-latitude sunspot both appeared in the same hemisphere. Similar to the north-south hemispheric asymmetry of solar activity characterized by high-latitude sunspots, the occurrence of the first X-class flare in a solar cycle likely indicates that the hemisphere where the X-class flare first appears will experience more intense solar activity than the other hemisphere.

### Full Text

## The Relationship Between the First High-Latitude Sunspot and First X-Class Flare of Solar Cycles 21-24 and the North-South Asymmetry of Solar Activity

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**Abstract:** Based on solar X-ray flare data observed by GOES, we have identified and analyzed the first X-class flare that occurred during solar cycles 21-24. The results show that the first high-latitude sunspot and the first X-class flare

occur in the same solar hemisphere during cycles 21-24. This appears to support the hypothesis that if the first X-class flare occurs in one solar hemisphere, solar activity is very likely to be more intense in that hemisphere throughout the entire cycle. The first X-class flare of solar cycle 24 occurred in the southern hemisphere of the Sun, suggesting that solar activities will be more intense in the southern hemisphere during the whole solar cycle 24.

**Keywords:** Solar activity; Sunspot; Flare

## Introduction

At the beginning of a solar cycle, sunspots emerge in high-latitude regions. Previous studies have demonstrated that when sunspots first appear in the high-latitude region of a particular hemisphere, that hemisphere exhibits stronger solar activity (as measured by sunspot number or total area of sunspot groups) than the opposite hemisphere during the entire solar cycle. This phenomenon was observed during solar cycles 21-23, with actual observational data confirming these predictions.

Sunspots represent gradual, evolving solar activity, whereas solar flares are eruptive events. According to data published by the U.S. National Oceanic and Atmospheric Administration (NOAA) on solar active region positions, areas, and flares, during solar cycle 23, not only did the total area of active regions in the southern hemisphere exceed that of the northern hemisphere, but flare activity in the southern hemisphere was also more intense than in the north.

This observation leads to an important question: If a hemisphere first exhibits high-latitude sunspots, will it also produce the first flares of a given intensity? More specifically, can the hemisphere that first produces flares of a certain intensity predict that solar activity in that hemisphere—including total active region area—will be stronger than in the other hemisphere throughout the solar cycle? To address this, we investigated which flare intensity classes appear in the same hemisphere as the first high-latitude sunspot across solar cycles 21-24.

## Data and Methods

We analyzed solar flare events during cycles 21-24. The United States' geostationary meteorological satellites carry X-ray detectors, and all data are publicly available online. Through NOAA's website (<http://legacy-www.swpc.noaa.gov/ftpmenu/warehouse.html>), we accessed soft X-ray flare data in the 0.1-0.8 nm band observed by GOES.

Data for the first high-latitude sunspots in cycles 21-23 were obtained from reference [1], while data for cycle 24 were determined from NOAA active region data. The positions of high-latitude sunspots in cycles 21-22 were described using Carrington longitude and solar latitude—for example, the first high-latitude

sunspot of cycle 21 was located at Carrington longitude 119° and southern latitude 44° (L119S44). For cycles 23–24, positions were described using solar longitude and latitude (e.g., S37E57).

The position of the first X-class flare was determined based on flare data from the Hinode satellite ([http://st4a.stelab.nagoya-u.ac.jp/Hinode\\_flare/](http://st4a.stelab.nagoya-u.ac.jp/Hinode_flare/)).

The first high-latitude sunspot and the first C, M, and X-class flares for cycles 21–24

[The table with data for cycles 21–24 would appear here]

## Results

Our analysis reveals that during solar cycles 21–24, the first X-class flare consistently appears in the same hemisphere as the first high-latitude sunspot. For cycles 21–22, the first X-class flare occurred in the southern hemisphere, coinciding with the hemisphere of the first high-latitude sunspot. For cycle 23, the first X-class flare occurred in the northern hemisphere, again matching the hemisphere of the first high-latitude sunspot. For cycle 24, both the first high-latitude sunspot and the first X-class flare appeared in the southern hemisphere.

Observational studies have proven that during cycles 21–23, the hemisphere where high-latitude sunspots first emerged exhibited more intense solar activity, whether measured by sunspot number, total active region area, or solar flare activity.

## Conclusion and Discussion

During solar cycles 21–23, the hemisphere containing the first high-latitude sunspot showed more intense activity than the opposite hemisphere. Actual observational data and research have confirmed this pattern. Based on NOAA data on solar active region positions and total areas, we find that during a solar cycle, if the first X-class flare appears in a particular hemisphere, that hemisphere's solar activity—including sunspot number, total active region area, and flare frequency—is likely to be more intense than in the other hemisphere.

X-class flares represent extremely powerful solar eruptive events, far exceeding the intensity of C and M-class flares. Therefore, if an X-class flare first appears in a given hemisphere, it likely indicates that solar activity in that hemisphere will be stronger throughout the cycle. The first X-class flare of cycle 24 appeared in the southern hemisphere, suggesting that southern hemisphere activity may be more intense than northern hemisphere activity during this cycle. However, this prediction can only be verified when cycle 24 concludes.

## Acknowledgments

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