SIGNATURE OF A POSSIBLE RELATIONSHIP BETWEEN THE MAXIMUM CME SPEED INDEX AND THE CRITICAL FREQUENCIES OF THE F1 AND F2 IONOSPHERIC LAYERS: DATA ANALYSIS FOR A MID-LATITUDE IONOSPHERIC STATION DURING THE SOLAR CYCLES 23 AND 24

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OUTLINE

- Descriptions of the used solar and ionospheric indices
- Methods
- Analysis and Results
- Conclusions

Descriptions of the used solar and ionospheric indices

1. **Solar indices:** (i) The Maximum CME Speed Index (MCMESI) derived from the SOHO LASCO CME catalog (http://cdaw.gsfc.nasa.gov/CME_list/). The determination of the MCMESI is based on the measurements of the highest daily linear CME speed averaged over one month (for more details, see Kilcik etal.,2011a).
(ii) The International Sunspot Number (ISSN) from the National Geophysical Data Center (http:/www.ngdc.noaa.gov/) for the production, preservation and dissemination of the ISSN is presented as the reference to the sunspot cycle phases.

2. Ionospheric indices: The ionospheric data were obtained from the Space Physics Interactive Data Resource, SPIDR (www.spidr.ngdc.noaa.gov/spidr/). While the SPIDR web page includes ionospheric data from more than 200 stations. Only12 stations have data that fully cover the investigated time interval. We chose to use data from the Chilton station, which has one of the best coverages of the ionospheric critical frequency data. We use hourly critical frequencies foF2 and foF1 recorded at Chilton Station, United Kingdom (51° 36´ N, 1° 18´ W) from 1996 to 2013. Monthly median values calculated from data taken at 14:00 LT (local time) for each day of that month. In Fig. 1 we present the variation of monthly total number of observing days with time.

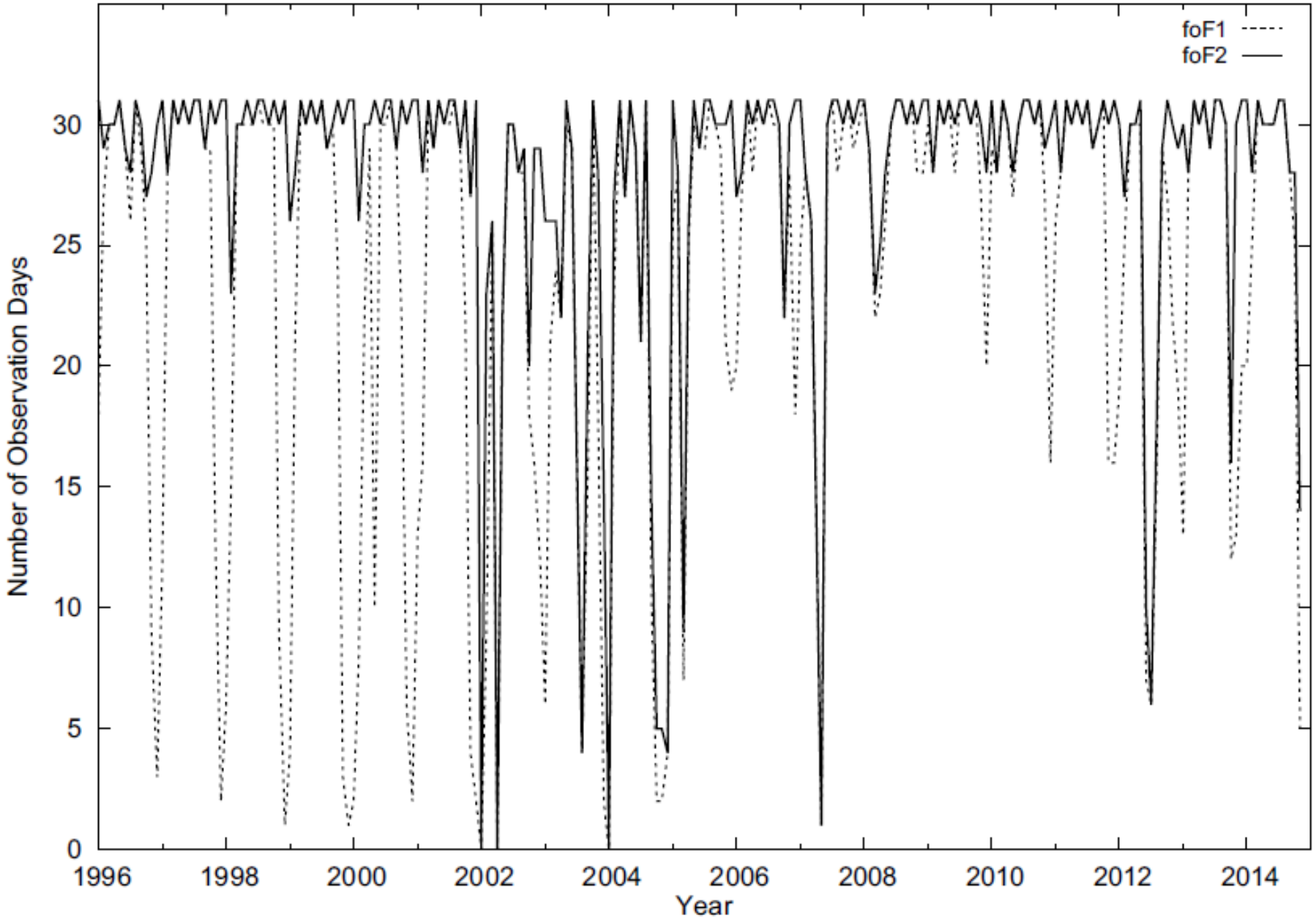

Fig. 1. Temporal variation of monthly total number of observing days for foF1 and foF2.

Methods

To investigate the relationship between the solar indices (ISSN and MCMESI) and the ionospheric critical frequencies (foF1 and foF2) two methods were applied.

The first medhod is the cross-correlation analysis, which produces the degree of coupling with possible time delay between two compared data sets. To calculate the significance level of obtained correlation coefficients, Fisher's test, which evaluates the upper and lower significance limits of the correlation coefficients, was applied by 95% confidence.

The second tool is hysteresis analysis method which was used to estimate the hysteresis behavior between the ionospheric F region critical frequencies (foF1 and foF2) and the solar ISSN and MCMESI indices separately for each solar cycle.

Analysis and Results

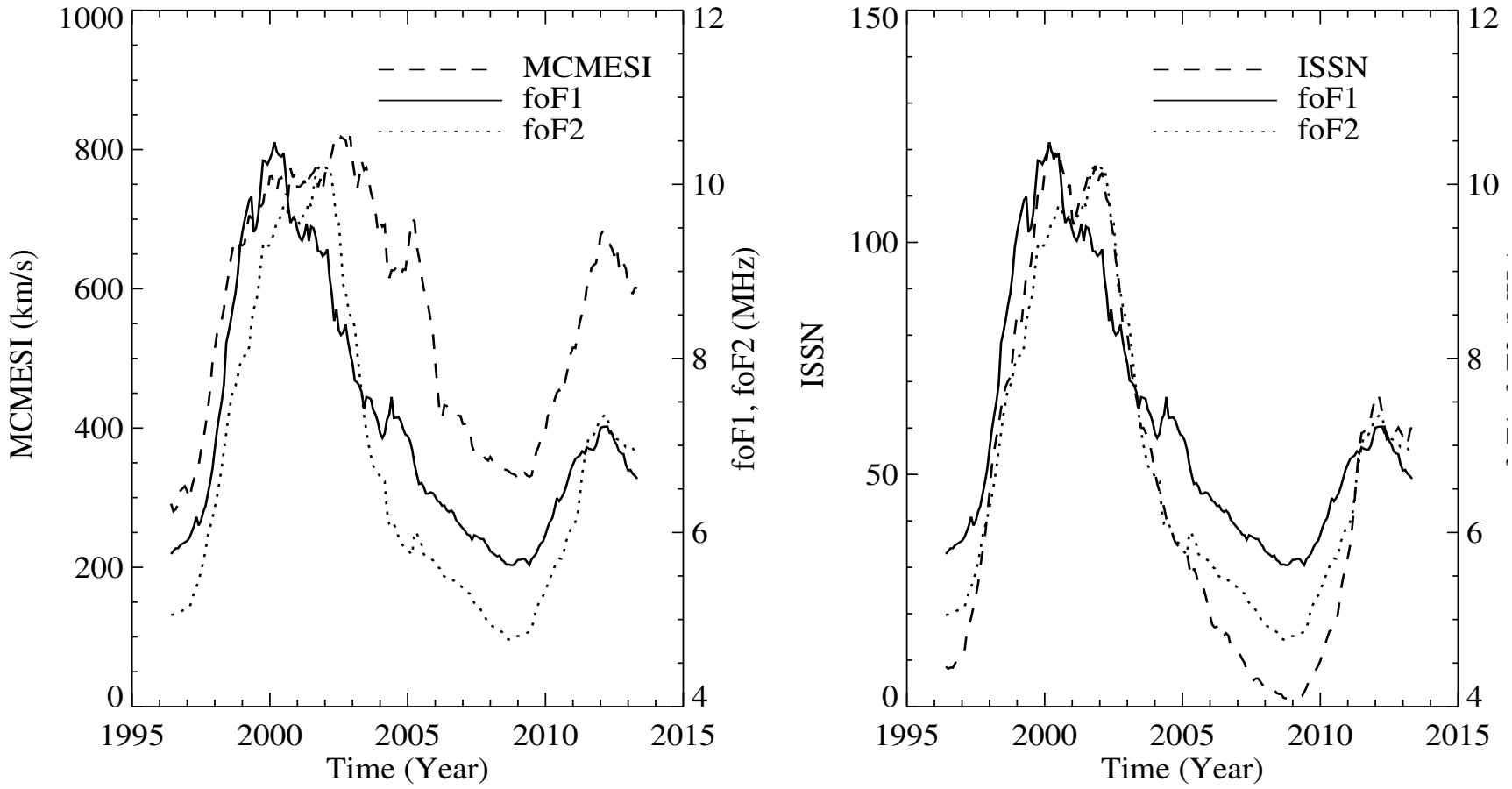

Fig. 2. Temporal variations of the MCMESI (ISSN) plotted along with foF2, and foF1 in the left (right) panels. For display purposes, foF1 values were rescaled.

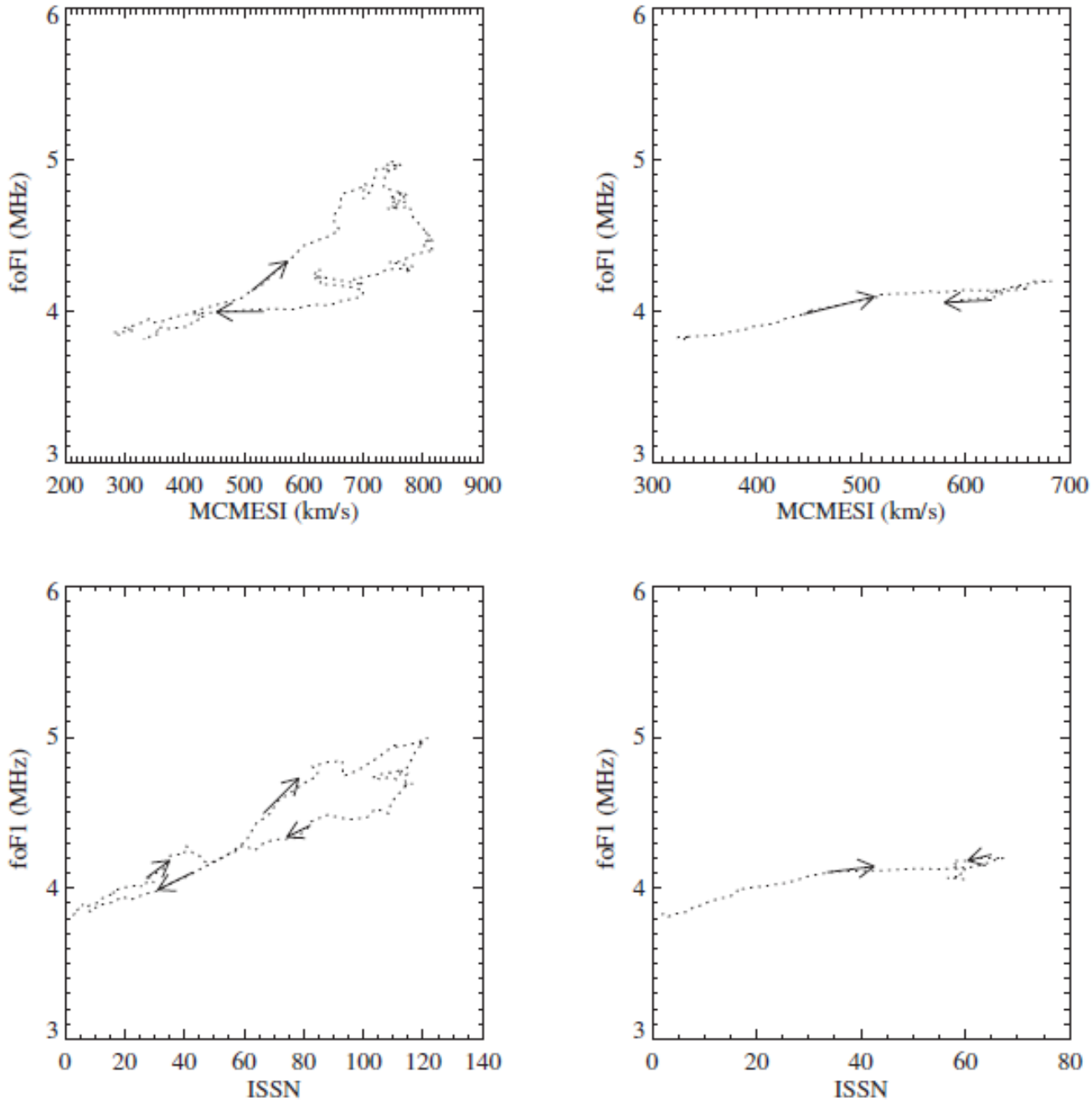

Fig. 3. Hysteresis analysis of the foF1 relative to the MCMESI (upper panel) and ISSN (lower panel) for solar cycle 23 (left panel) and the ascending phase of solar cycle 24 (right panel).

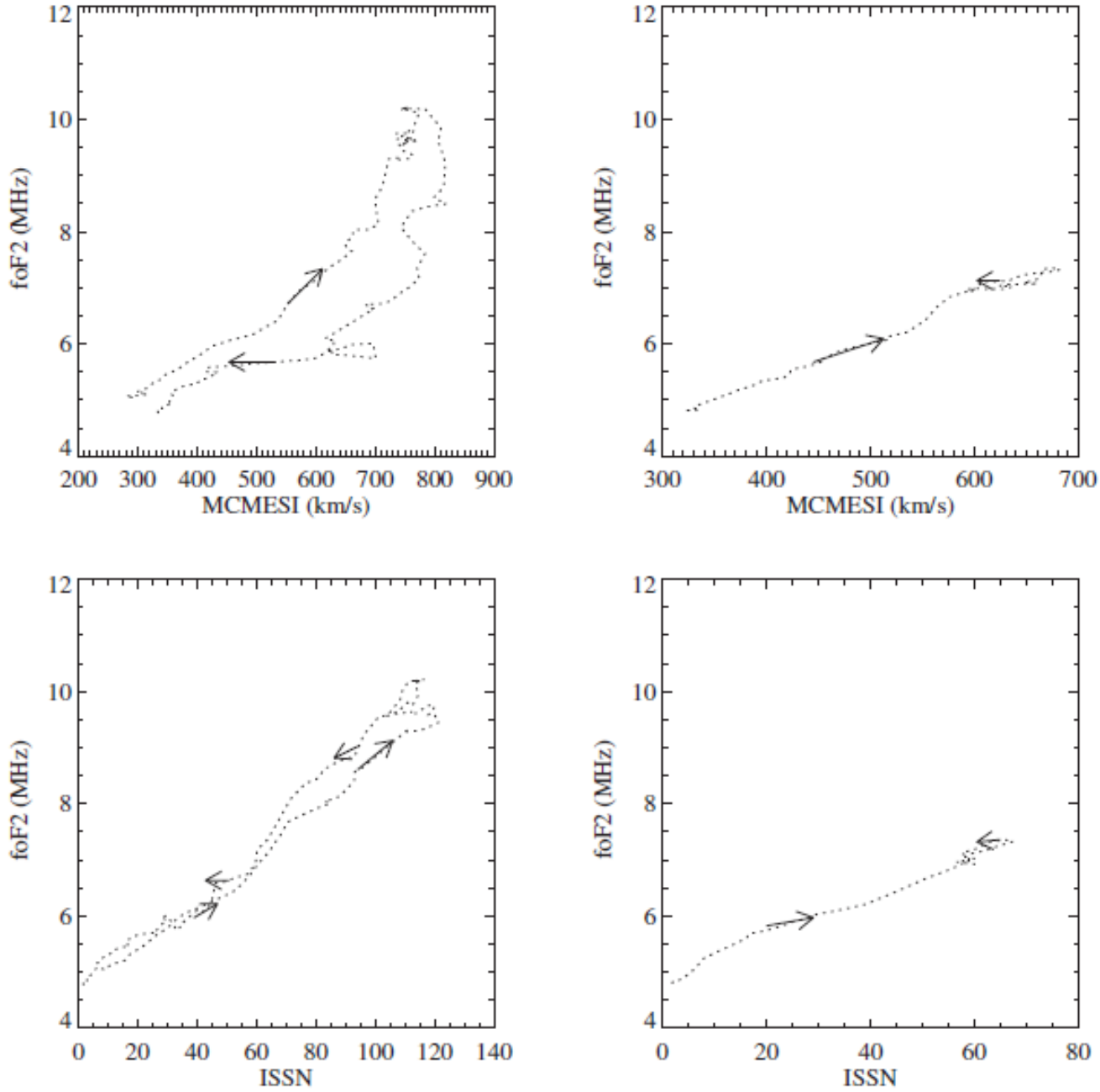

Fig. 4. Hysteresis analysis of the foF2 relative to the MCMESI (upper panel) and ISSN (lower panel) for solar cycle 23 (left panel) and the ascending phase of solar cycle 24 (right panel).

Table 1
Cross-correlation analysis results between the solar indices (ISSN and MCMESI) and ionospheric critical frequencies (foF1 and foF2) for the last two solar cycles.

	foF1/foF2	foF1/foF2
	Solar Cycle 23	Solar Cycle 24
ISSN	$0.72 \pm 0.09/0.83 \pm 0.06$	$0.32 \pm 0.25/0.85 \pm 0.09$
MCMESI	$0.56 \pm 0.12/0.66 \pm 0.10$	$0.39 \pm 0.24/0.68 \pm 0.17$

Conclusions

- The statistically significant correlations between foF1 and foF2 and the MCMESI suggest that the MCMESI index can be regarded as a possible proxy for the F1 and F2 layer critical frequencies.

- The ascending and descending phases of the solar cycle 23 show different hysteresis pattern for the foF1 and foF2 frequencies.

- Similar to the MCMESI and ISSN, the foF1 and foF2 strongly diminished during the weak current solar cycle 24.

- Ionospheric frequencies (foF1 and foF2) peak at different times during the solar cycle 23: foF1 data reaches maximum during the first peak of the ISSN (around 2000), while foF2 data peaked during the second peak of ISSN data (around 2002).

- Similar to the solar indices the ionospheric frequencies (foF1 and foF2) have a double/multiple peak during their maxima.

THANKS FOR YOUR ATTENTION