The Relationship between the Sunspot Counts and Ionospheric Critical Frequencies during Solar Cycles 23

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Solar Influences on the Magnetosphere, Ionosphere and Atmosphere

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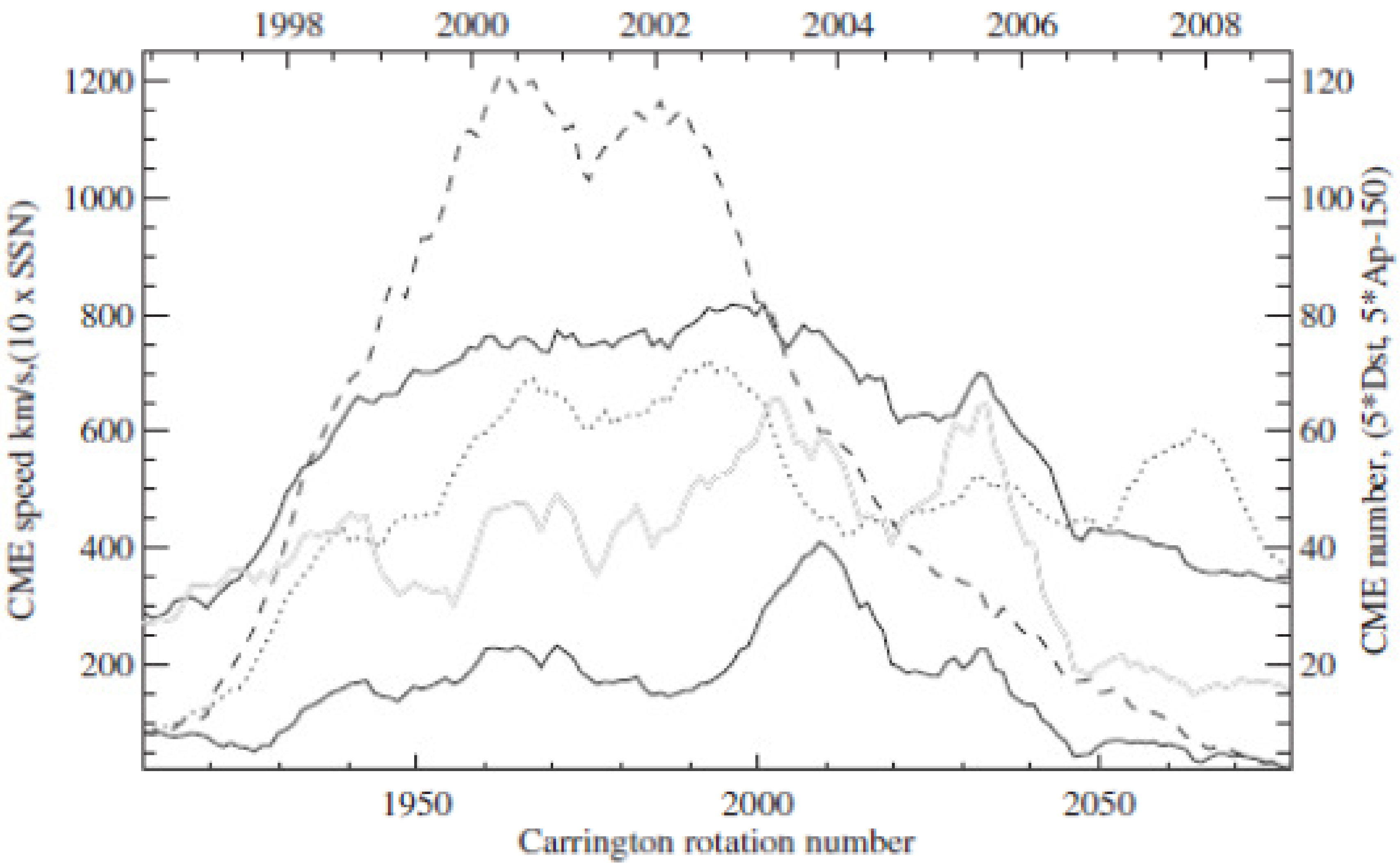

Figure 1. *Time profiles of 12 point running averaged monthly data sets. In this plot, the dashed line shows the sunspot numbers, the bold solid line the CME index, the dotted line the CME number, the double line the Dst index, and the thin solid line represents the Ap index. (Kilcik et al., 2011, ApJ, 727:44)*

1. There is a good relationship between monthly averaged maximum CME speeds and sunspot numbers, *Ap* and *Dst* indices (correlation coefficients are 0.76, 0.68, and –0.53, respectively). We note that the CME speed index displays better correlation with the geomagnetic indices than the sunspot numbers, which suggests that the CME speed index may be a powerful indicator of both solar and geomagnetic activities.

2. Unlike the sunspot numbers, the CME speed index does not exhibit a double peak maximum.

3. The CME number shows a double peak similar to that seen in the sunspot numbers. The CME occurrence rate remained very high even near the minimum of the solar cycle 23, when both the sunspot number and the average maximum CME speed were reaching their minimum values.

4. A well-defined peak of the *Ap* index between 2002 May and 2004 August was co-temporal with the excess of the mid-latitude CHs during solar cycle 23.

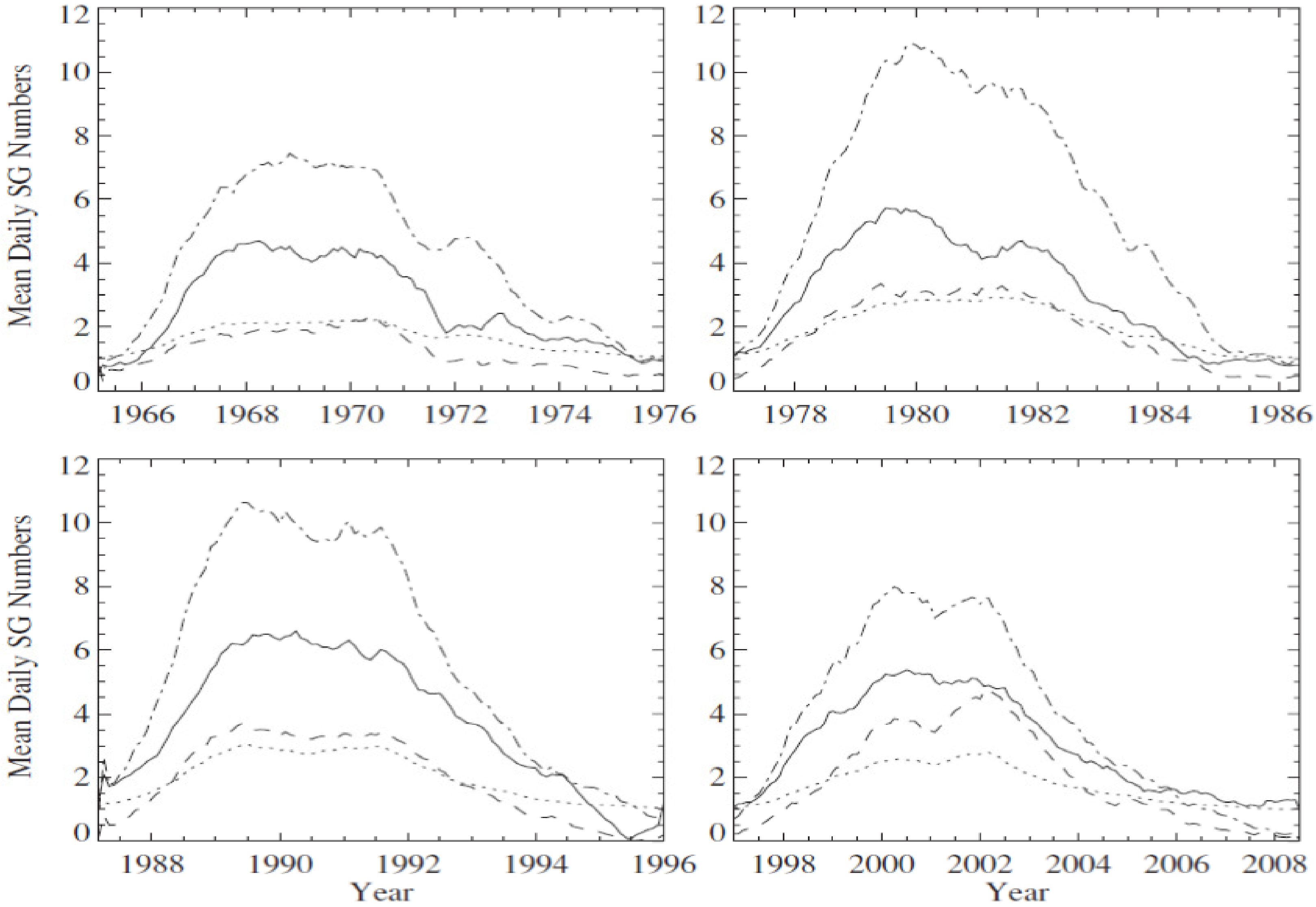

Figure 2 *Solar cycle variations of selected parameters smoothed with a 12 step running average filter. For display purposes, the ISSN and 10.7 cm solar radio data were re-scaled: the ISSN was divided by 15, while the F10.7 cm radio flux is divided by 700. The solid (dashed) line represents small (large) SG numbers, the dashed-dotted line the ISSN, and the dotted line represents the F10.7 radio flux. (Kilcik et al., 2011, ApJ, 731:30)*

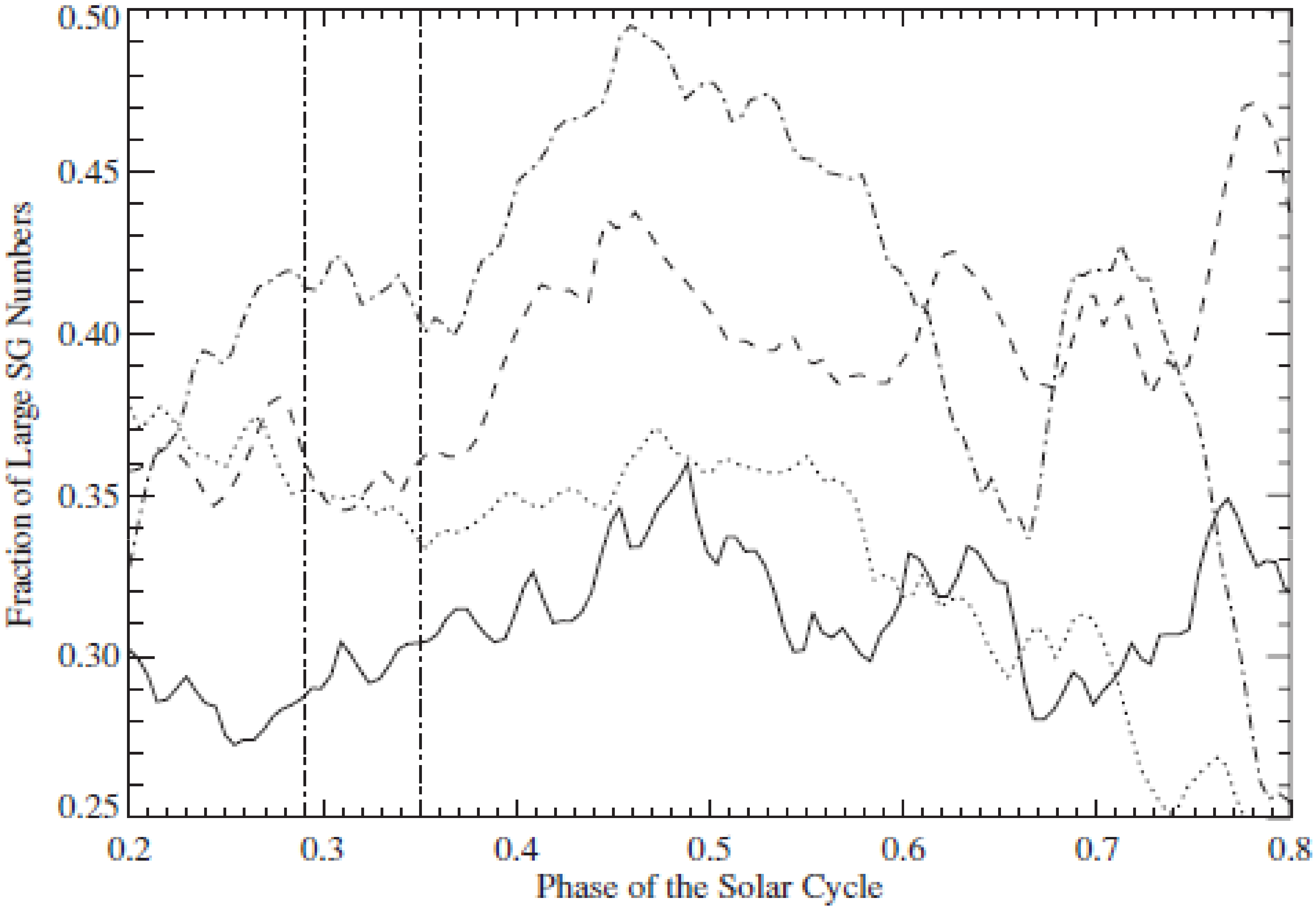

Figure 3. *Ratio of the large SG number to the total number of all active regions (i.e., sum of small and large SG numbers) plotted vs. the solar cycle phase. The solid line is cycle 20, the dashed line is cycle 21, the dotted line is cycle 22, and the dashed dotted line is cycle 23. Vertical lines indicate the range of the maximum phase of the ISSN determined for the four studied solar cycles (Kilcik et al., 2011, ApJ, 731:30).*

1. The time distributions of the large and small Sunspot group numbers show asymmetries except for cycle 22. While the number of small sunspot groups peaks at the time of the first ISSN maximum, the peak of the large groups is delayed by about of two years and is co-temporal with the second ISSN maximum.

2. Large sunspot groups tend to reach their maxima nearly half-way through the solar cycle (phases 0.45–0.5), while the ISSN generally peaks at solar cycle phase of 0.29–0.35.

3. During the most recent cycle, 23, the large sunspot group numbers were higher (and the total number of sunspots belonging to large sunspot groups was nearly the same) when compared to those for solar cycle 22. At the same time the total SSA in cycle 23 was smaller.

4. The F10.7 radio flux, facular areas, and the maximum CME speed show better agreement with the large sunspot group numbers than they do with the small sunspot group numbers.

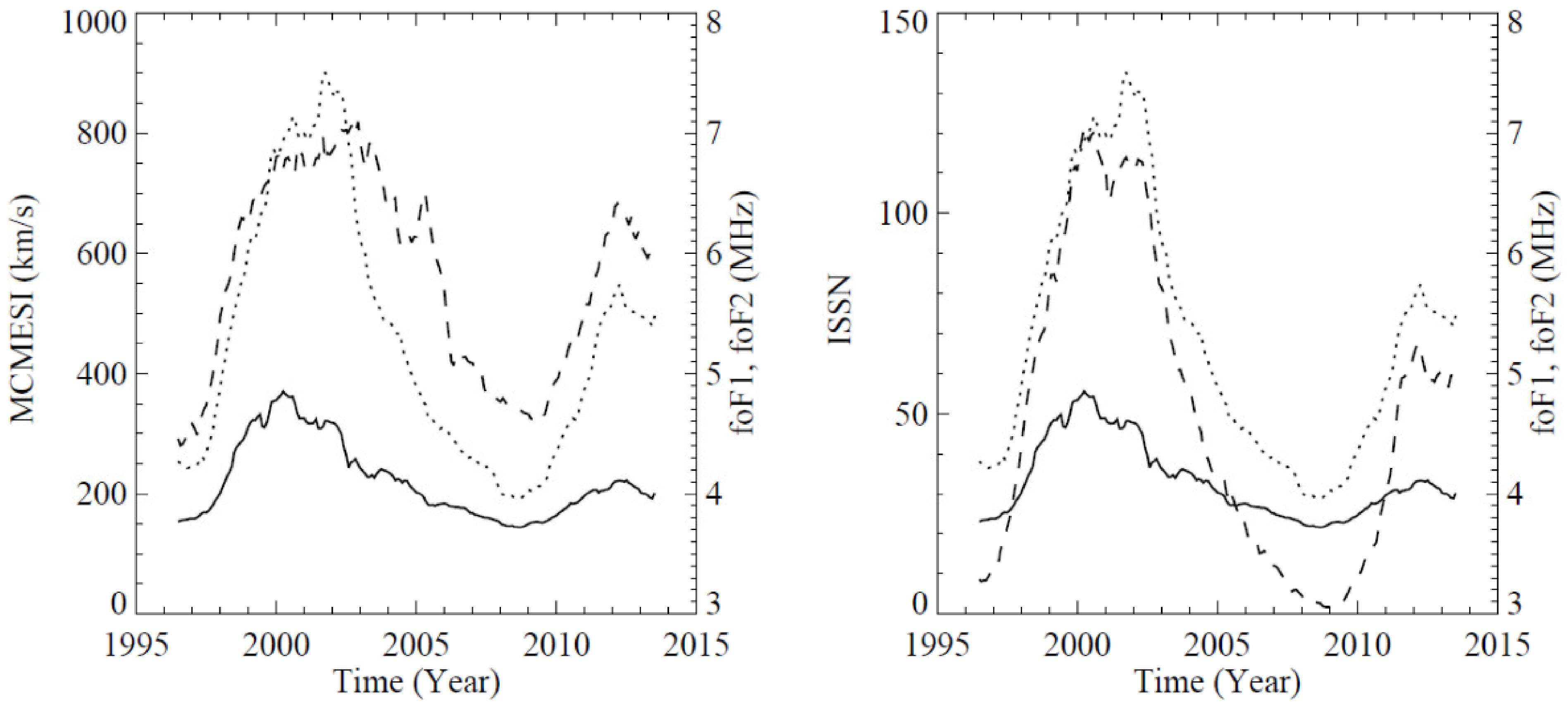

Figure 4. Temporal variations of the MCMESI (ISSN) (dashed line) plotted along with foF2 (dotted line), and foF1 (solid line) in the left (right) panels. (Kilcik et al., 2015 submitted to JASTP)

1. The MCMESI is found to be a good proxy for the F1 and F2 layer critical frequencies of Chilton station.

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

3. Ionospheric critical frequencies (foF1 and foF2) peak at different times during solar cycle 23: foF1 reaches maximum during the first peak of the ISSN (around 2000), while foF2 reached to their maxima during the second peak of ISSN data (around 2002).

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

Is this relation general?
or
Is it station dependent?

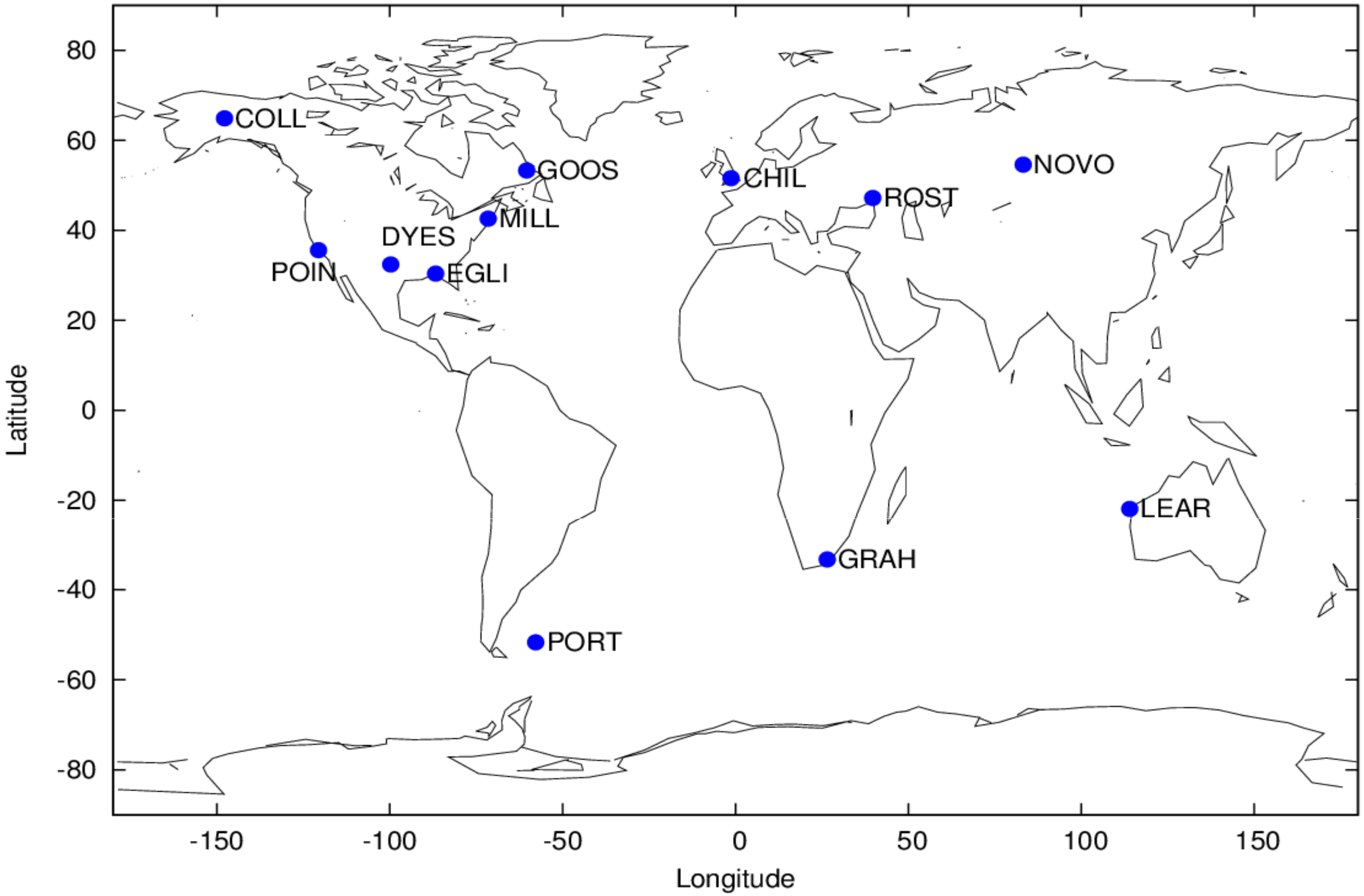

Figure 5. Distribution of the ionospheric critical frequency stations (foF1, and foF2), which data were taken, over the globe.

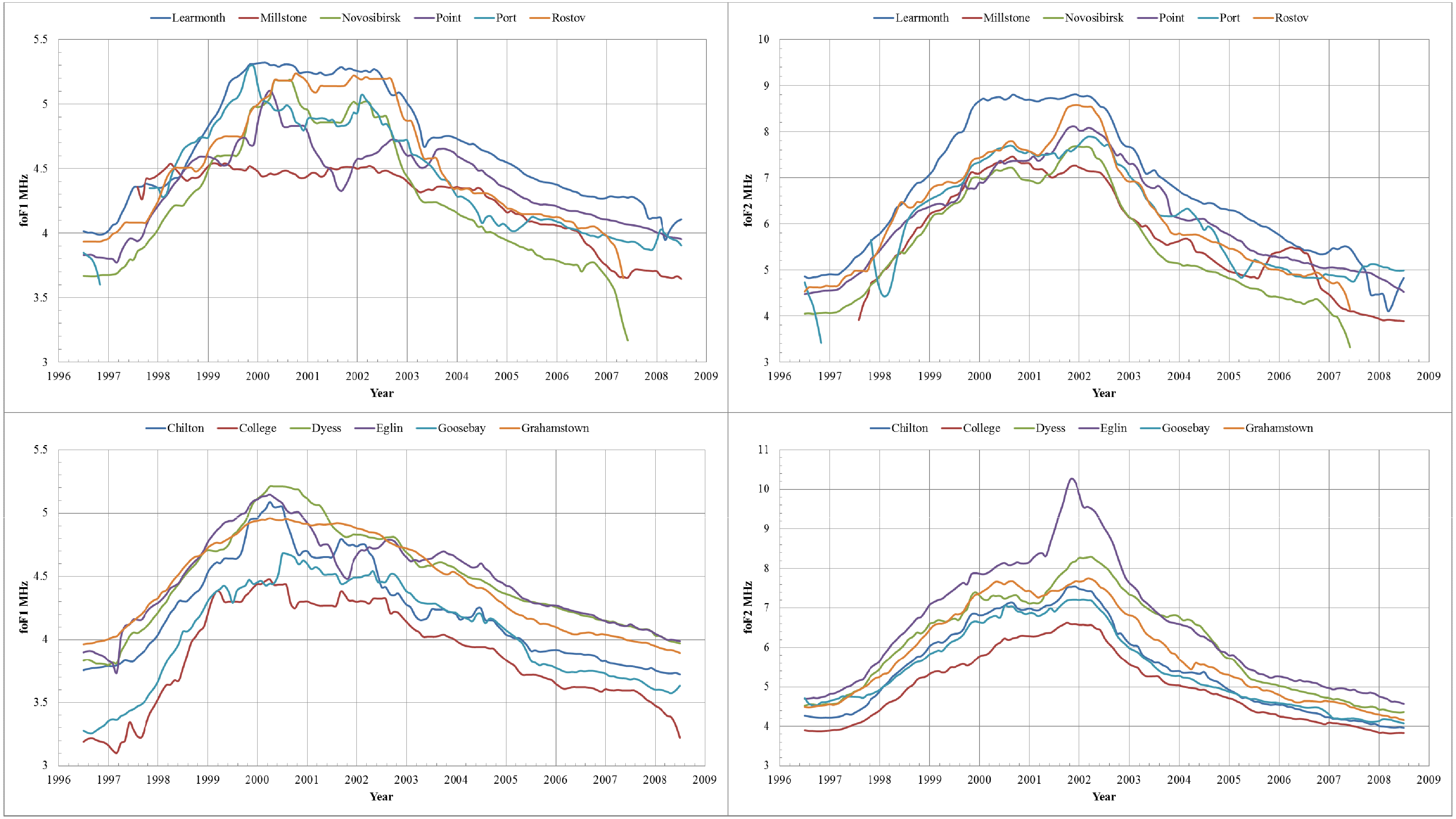

Figure 6. Temporal variations of foF1 (left panels) and foF2 (right panels) for the investigated stations during solar cycle 23.

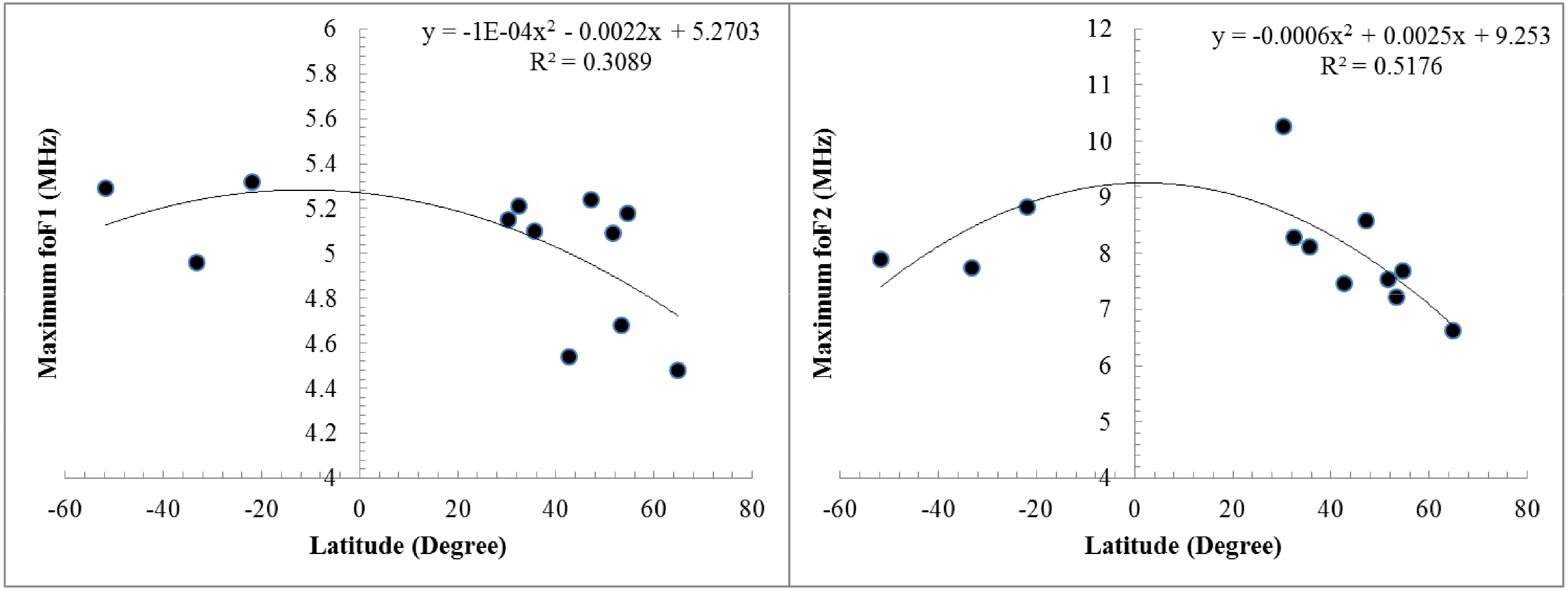

Figure 7. Variation of the peak values of foF1 (left) and foF2 (right) with latitude during the investigated time period.

Acknowledgement

The CME speed data used in this study are taken from the http://cdaw.gsfc.nasa.gov/CME_list/index.html, and fof1 and foF2 data sets from spidr.ngdc.noaa.gov/spidr/. The ISSN and sunspot group data sets are taken from NGDC

THANK YOU FOR YOUR ATTENTION