# Examination of the solar cycle variation of *f*oF2 for cycles 22 and 23

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# Goals

- To demonstrate which solar activity index is more convenient for ionospheric predictions.

- To determine the strength of Hysteresis and its detailed course during the studied period.

Ionospheric variations can be considered in time scales

(a) Day-to-day, including 27-day solar rotation,

(b) Semiannual,

(c) Annual,

(d) Solar cycle.

examination is made only of the long-term (solar cycle) variations of solar activity indices and ionospheric parameter *f*oF2.

We investigate the response of the ionosphere to the solar activity by using

- Flare index,
- Mg II index,
- Solar radio flux at 10.7 cm.
- Relative sunspot numbers

during the solar cycles 22 and 23.

The F2 layer critical frequency (*f*oF2) is one of the ionospheric parameters observed regularly by several observatories and it provides us to examine the relation of F2 layer with the solar activity indices.

The monthly median noon values of *f*oF2 of the

Rome (41.9 N)

Slough (51.5 N)

ionosonde stations are used.

# What is Flare Index?

- The quantitative flare index first introduced by Kleczek [1952], FI = i t. In this relation, i represents the intensity scale of importance of a flare in Ha and t the duration in Ha (in minutes) of the flare. The daily sums of the index for the total surface are divided by the total time of observation of that day. Because the time coverage of flare observations is not always complete during a day (sometimes 75% or 90%), it is corrected by dividing by the total time of observations of that day to place the daily sum of the flare index on a common 24-hour period. The daily total time of observation is calculated from Solar Geophysical Data Comprehensive Reports. Calculated values are available for general use in anonymous ftp servers of our observatory and NGDC

# Table I

- . Values of i Used for the Determination of FI

| **Importance** | **i** |
|---|---|
| SF, SN, SB | 0.5 |
| 1F, 1N | 1.0 |
| 1B | 1.5 |
| 2F, 2N | 2.0 |
| 2B | 2.5 |
| 3F, 3N, 4F | 3.0 |
| 3B, 4N | 3.5 |
| 4B | 4.0 |

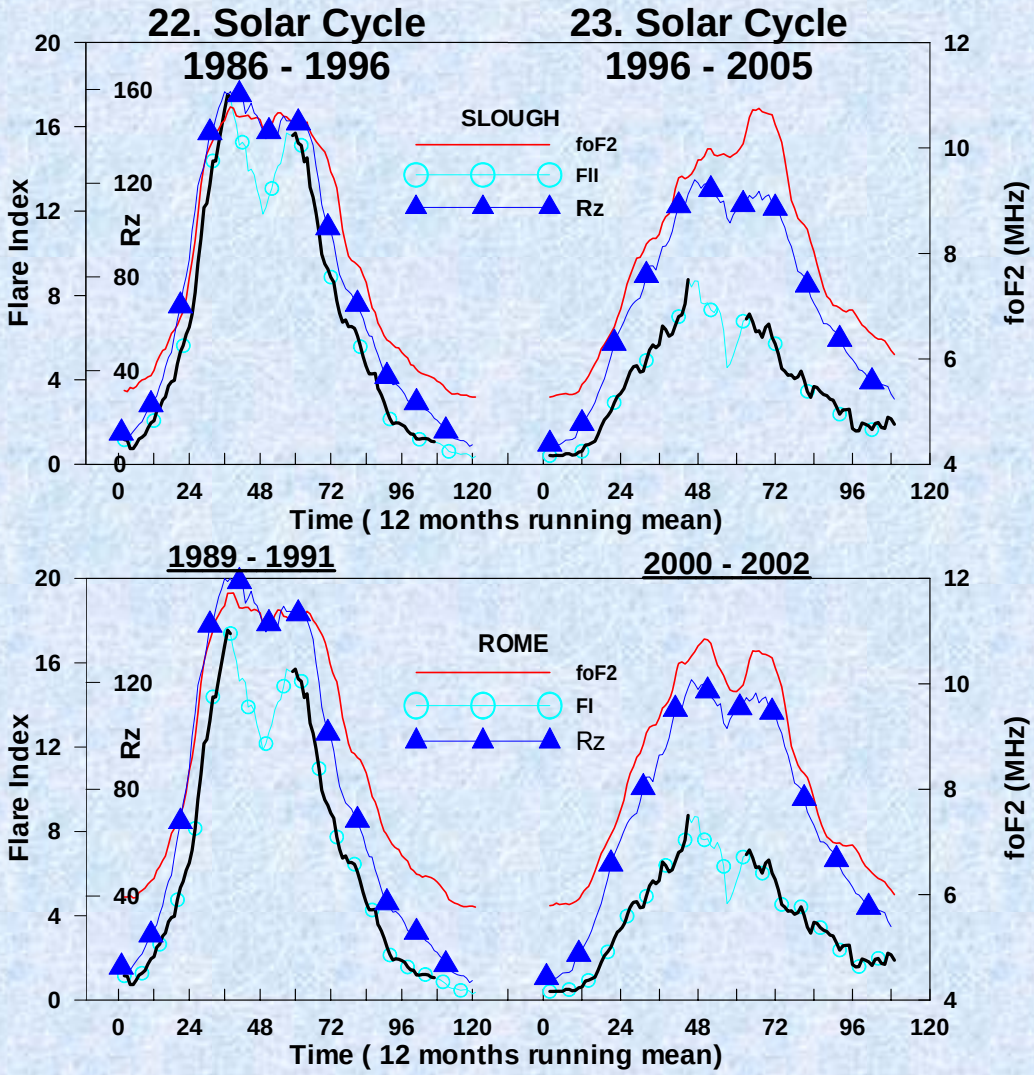
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/INDEX/
http://www.koeri.boun.edu.tr/astronomy/23cyc.html

# Results

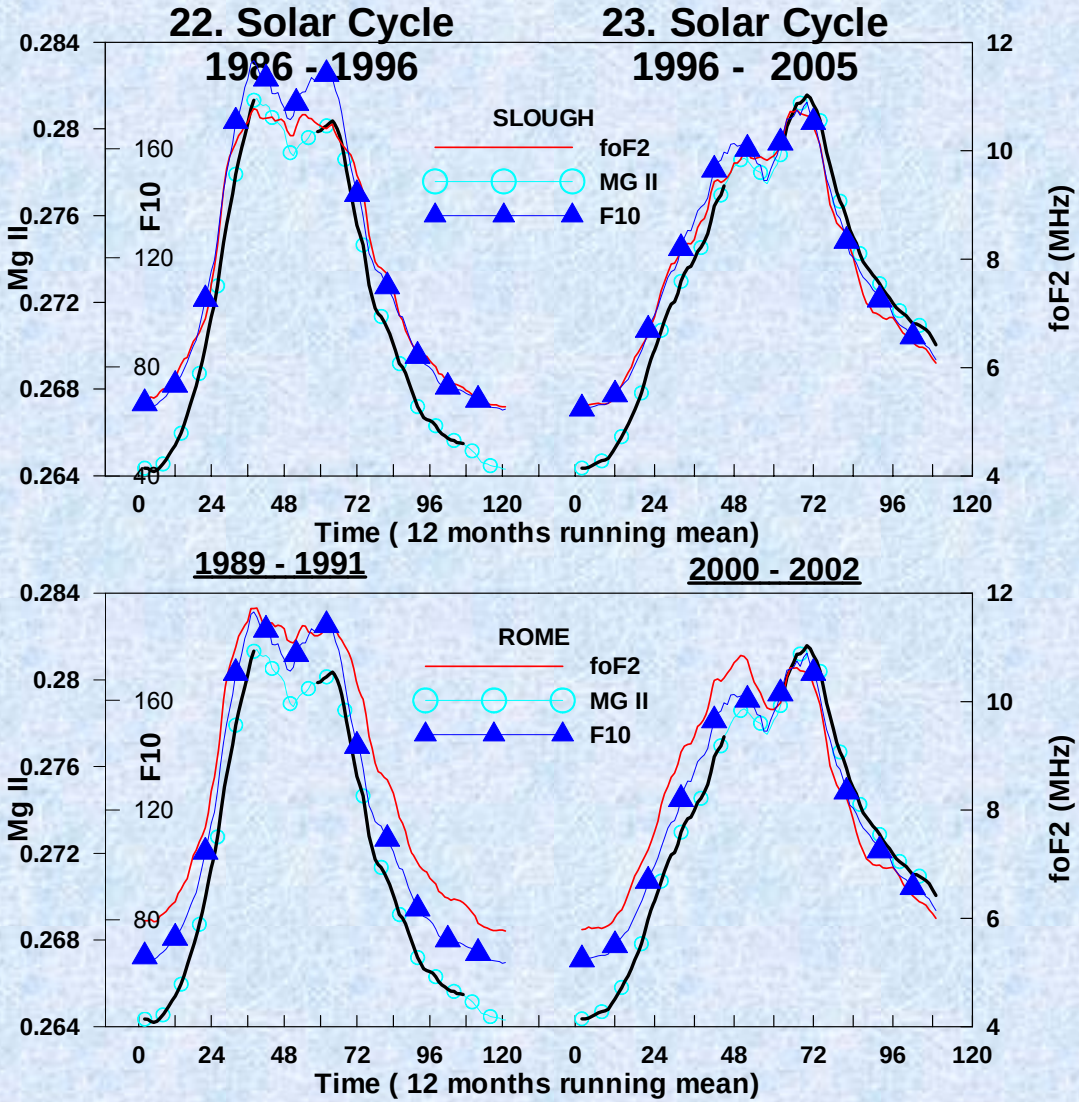
-Four studied solar activity indices show two maxima with the first maximum higher than the second one at the cycle 22

-Only two solar parameters (Rz and FI) show two maxima during the cycle 23 with the same behavior of the cycle 22.

-F10 and MGII also show two maxima during the cycle 23, but not like the other examined indices, namely with the second maximum higher than the first one.




12-month moving averages of flare index, sunspot number and *f*oF2



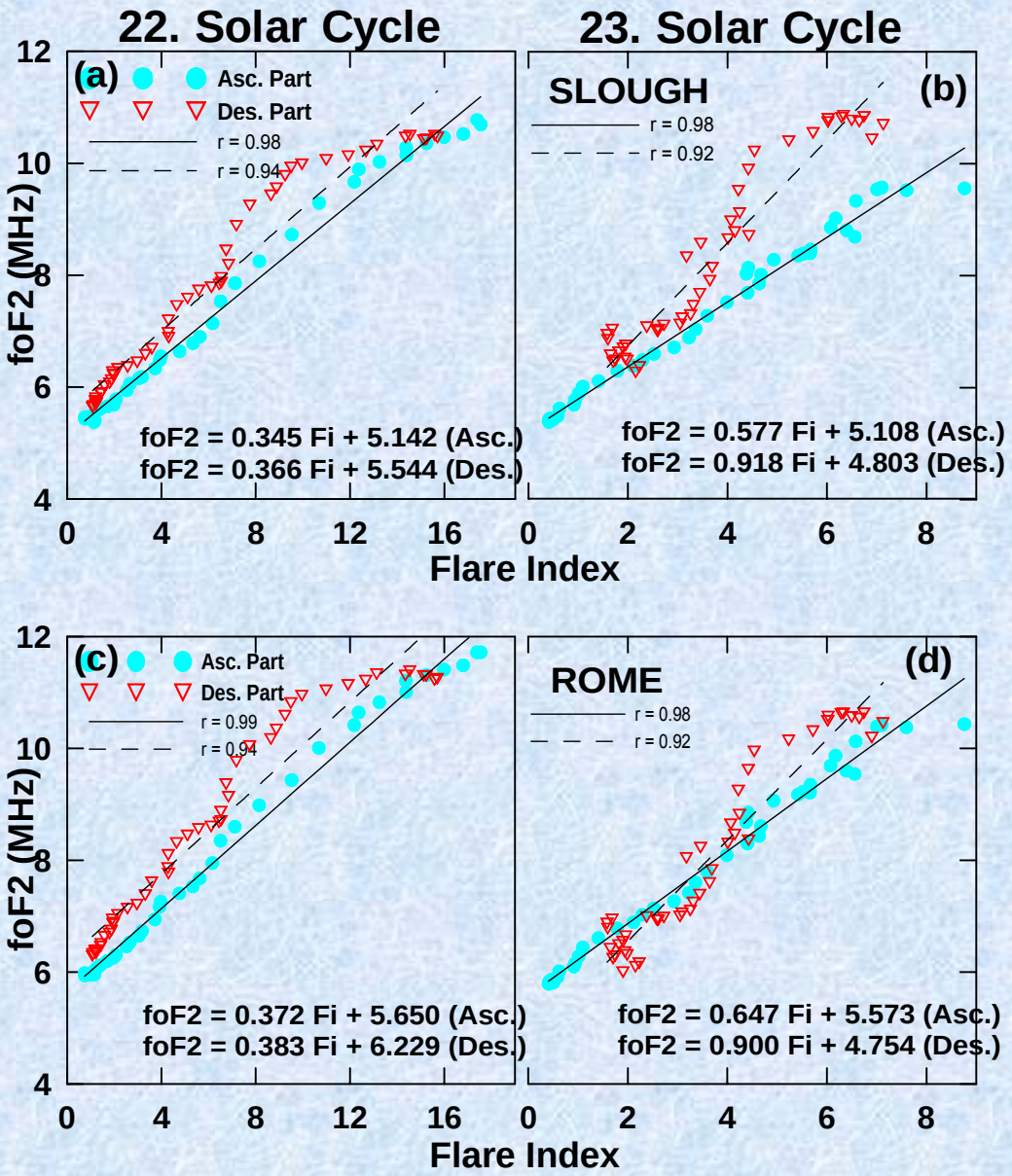

12-month moving averages of solar flux, Mg II and *f*oF2

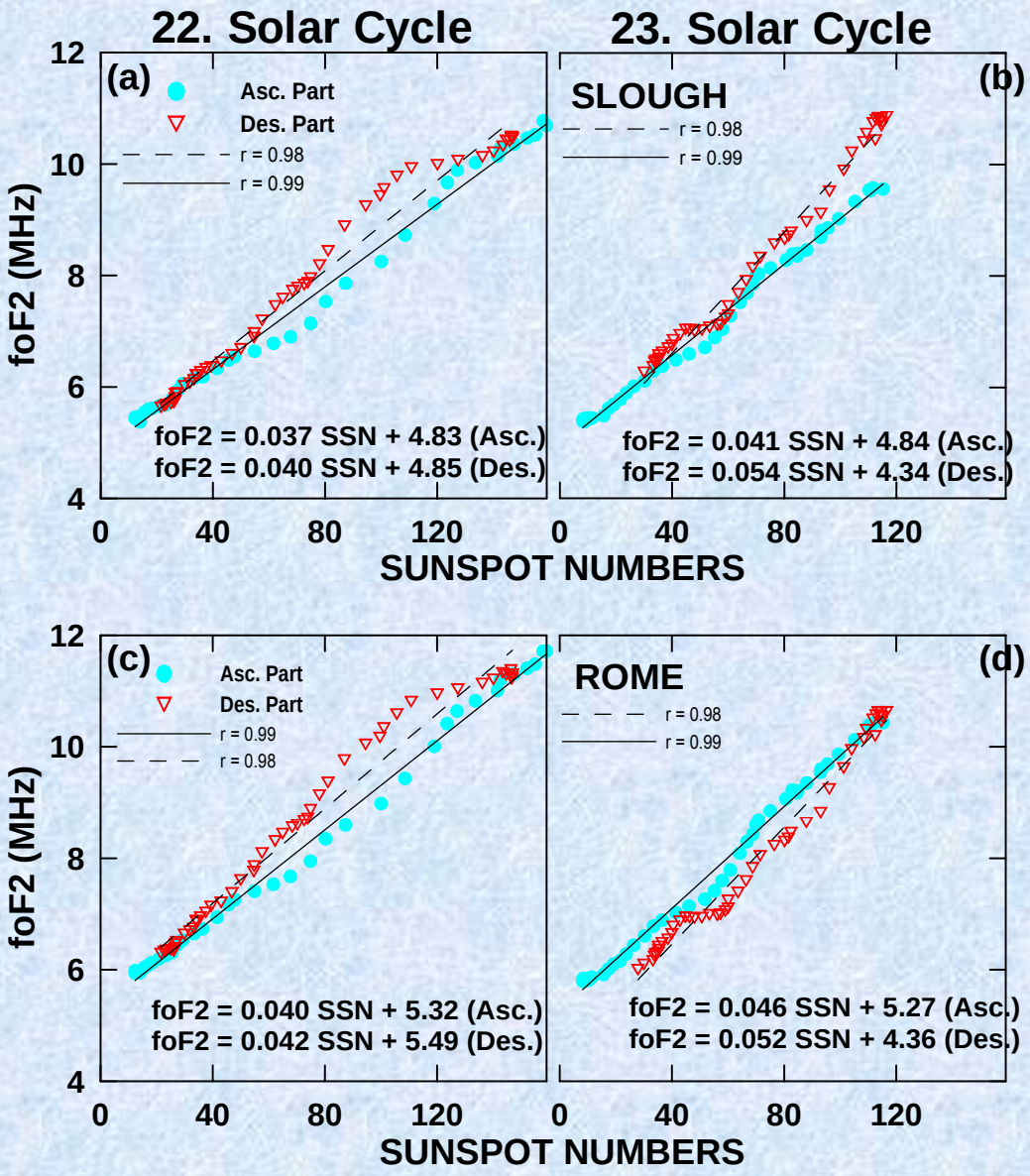
-*f*oF2 values of Slough show multi peaks in cycle 22 and two peaks in cycle 23. However the values of the second maximum relative to the first one are not alike.

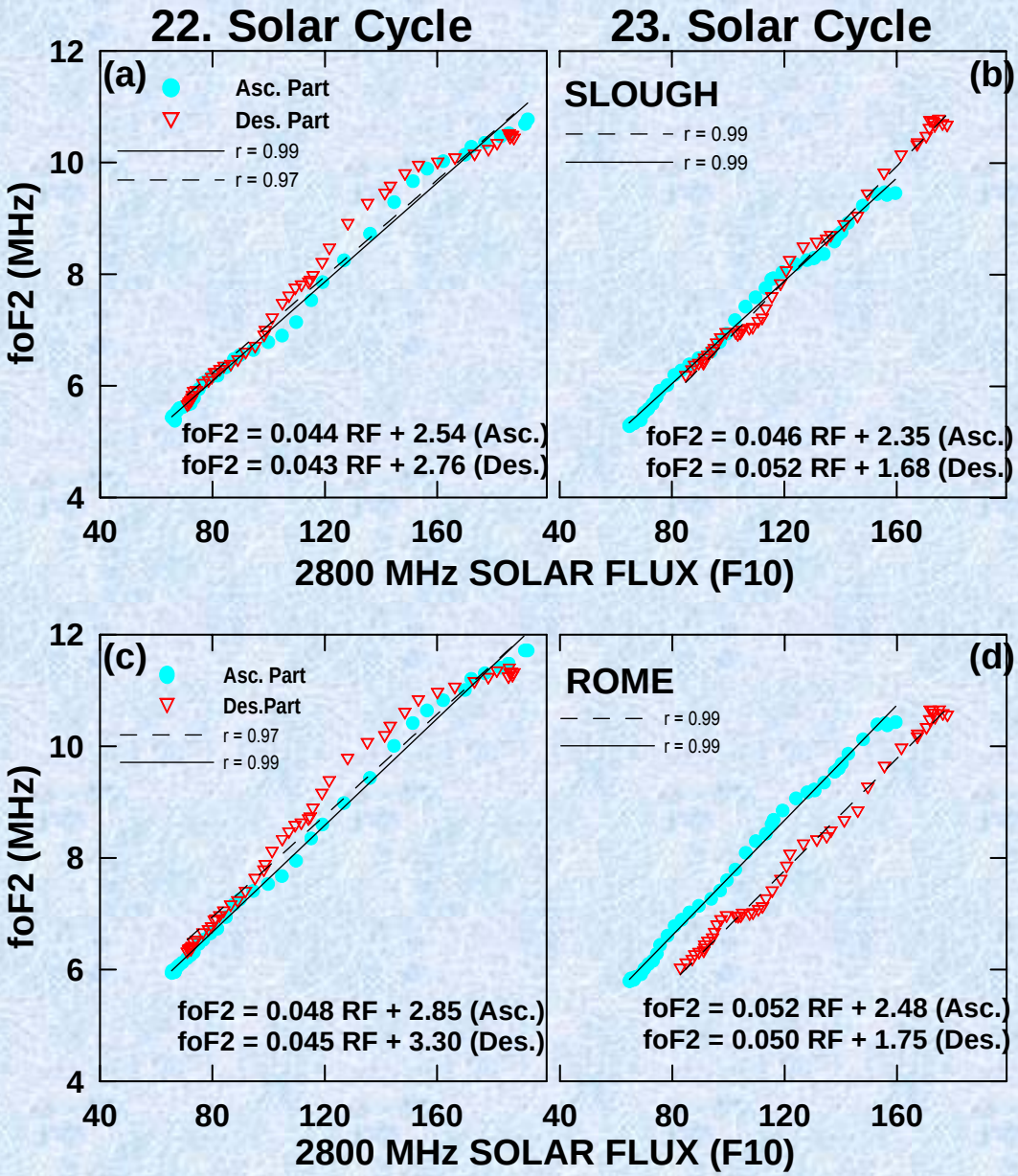
- Rome *f*oF2 values also show the same behavior as Slough values.

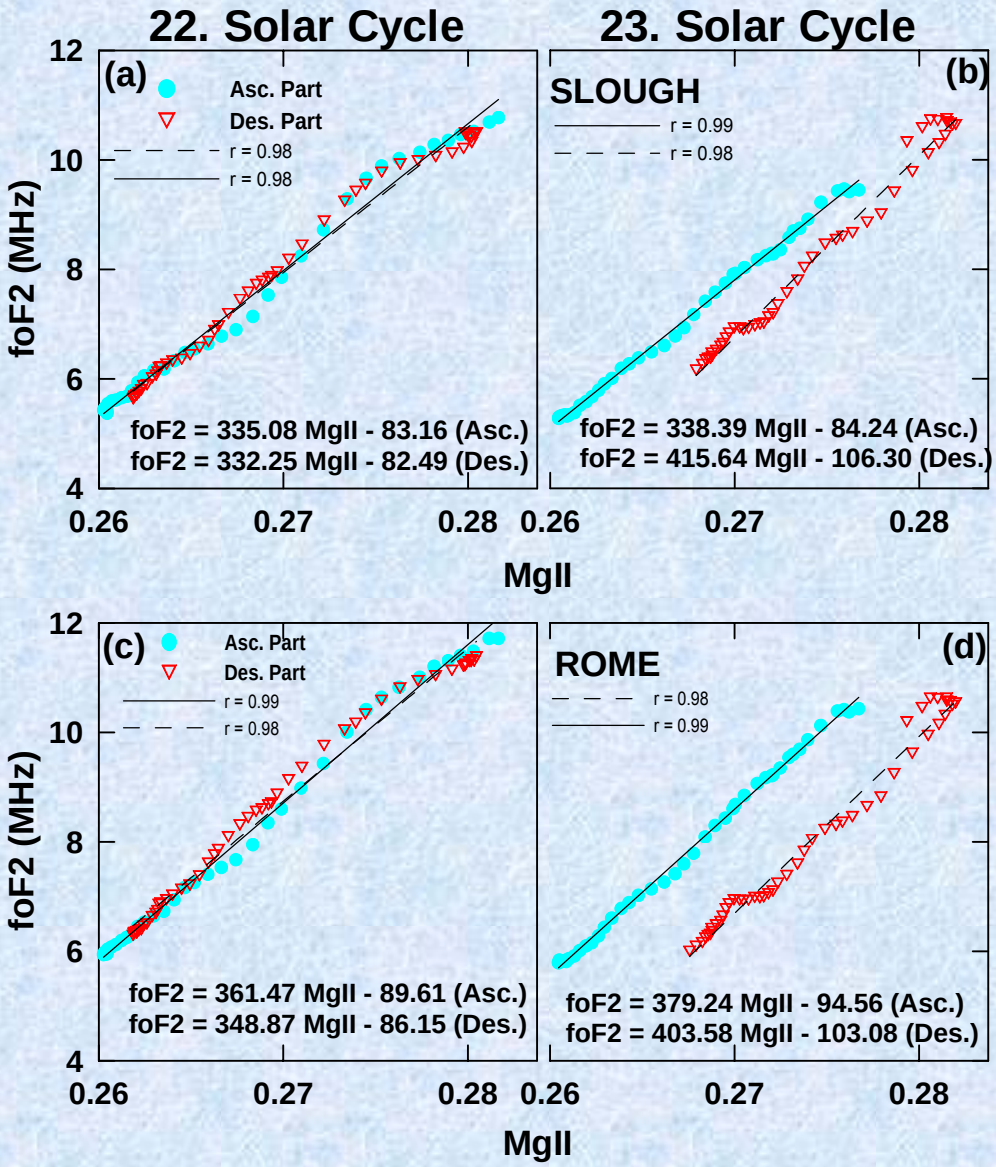
Thus, it is indicated that qualitative similarity with the solar indices depends on the solar cycle.

In order to determine the relationships between foF2 and the solar activity parameters, a single regression analysis was carried out for each station, and it was observed that the relationship is linear.


22. Solar Cycle
23. Solar Cycle
(a)
Asc. Part
Des. Part
r = 0.98
r = 0.94
foF2 = 0.345 Fi + 5.142 (Asc.)
foF2 = 0.366 Fi + 5.544 (Des.)
SLOUGH
(b)
r = 0.98
r = 0.92
foF2 = 0.577 Fi + 5.108 (Asc.)
foF2 = 0.918 Fi + 4.803 (Des.)
(c)
Asc. Part
Des. Part
r = 0.99
r = 0.94
foF2 = 0.372 Fi + 5.650 (Asc.)
foF2 = 0.383 Fi + 6.229 (Des.)
ROME
(d)
r = 0.98
r = 0.92
foF2 = 0.647 Fi + 5.573 (Asc.)
foF2 = 0.900 Fi + 4.754 (Des.)
foF2 (MHz)
Flare Index


22. Solar Cycle
23. Solar Cycle
(a)
Asc. Part
Des. Part
r = 0.98
r = 0.99
foF2 = 0.037 SSN + 4.83 (Asc.)
foF2 = 0.040 SSN + 4.85 (Des.)
SLOUGH
(b)
r = 0.98
r = 0.99
foF2 = 0.041 SSN + 4.84 (Asc.)
foF2 = 0.054 SSN + 4.34 (Des.)
foF2 (MHz)
SUNSPOT NUMBERS
(c)
Asc. Part
Des. Part
r = 0.99
r = 0.98
foF2 = 0.040 SSN + 5.32 (Asc.)
foF2 = 0.042 SSN + 5.49 (Des.)
ROME
(d)
r = 0.98
r = 0.99
foF2 = 0.046 SSN + 5.27 (Asc.)
foF2 = 0.052 SSN + 4.36 (Des.)


22. Solar Cycle
23. Solar Cycle
(a)
Asc. Part
Des. Part
r = 0.99
r = 0.97
foF2 = 0.044 RF + 2.54 (Asc.)
foF2 = 0.043 RF + 2.76 (Des.)
SLOUGH
(b)
r = 0.99
r = 0.99
foF2 = 0.046 RF + 2.35 (Asc.)
foF2 = 0.052 RF + 1.68 (Des.)
foF2 (MHz)
2800 MHz SOLAR FLUX (F10)
(c)
Asc. Part
Des.Part
r = 0.97
r = 0.99
foF2 = 0.048 RF + 2.85 (Asc.)
foF2 = 0.045 RF + 3.30 (Des.)
ROME
(d)
r = 0.99
r = 0.99
foF2 = 0.052 RF + 2.48 (Asc.)
foF2 = 0.050 RF + 1.75 (Des.)


22. Solar Cycle
23. Solar Cycle
(a)
Asc. Part
Des. Part
r = 0.98
r = 0.98
foF2 = 335.08 MgII - 83.16 (Asc.)
foF2 = 332.25 MgII - 82.49 (Des.)
SLOUGH
(b)
r = 0.99
r = 0.98
foF2 = 338.39 MgII - 84.24 (Asc.)
foF2 = 415.64 MgII - 106.30 (Des.)
(c)
Asc. Part
Des. Part
r = 0.99
r = 0.98
foF2 = 361.47 MgII - 89.61 (Asc.)
foF2 = 348.87 MgII - 86.15 (Des.)
ROME
(d)
r = 0.98
r = 0.99
foF2 = 379.24 MgII - 94.56 (Asc.)
foF2 = 403.58 MgII - 103.08 (Des.)
foF2 (MHz)
MgII
12
10
8
6
4
0.26
0.27
0.28

We may note that the hysteresis shows generally lower *f*oF2 for the rising branches compared with the falling branches of the two solar cycles. However, this is not the case in some individual indices for cycle 23.

# Conclusions

- The linear correlation between the solar activity indices and *f*oF2 is very strong during the ascending and descending branches of the two cycles.

-The slope of their linear fits show variations from cycle to cycle, as well as index to index.

- Hysteresis is due to the latitude and meteorological influences as well as solar wind conditions.

- The hysteresis magnitude varies non-systematically with the solar cycles;

-The inclusion of the hysteresis into the long-term ionospheric predictions seems not suitable.

**Thank you for your attention**