

**F2 PROPAGATION  
ON THE 50 MHz AMATEURBAND  
IN THE NETHERLANDS**

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## **1. INTRODUCTION**

PA2HJS has been active on the 50 MHz band for many years. In 1978, during the development of the solar cycle 21 he became intrigued by the numerous phenomena that can be observed on the 50 MHz band.

Since March 1988, the 50 MHz band has gained much popularity in The Netherlands because of the special permissions granted by the authorities.

PAoERA also got interested in the interesting properties of the 50 MHz band. He has been active on this band since March 1988.

The increased activity has led to better and more detailed information about openings to other continents. This information, together with data from professional institutes has been researched by the authors. In this document, the first results are presented.

The authors hope that this work will lead to better understanding of the ionospheric phenomena and that we may get a little closer to revealing some secrets of the ionosphere.

## 2. F2 PROPAGATION STUDY

### §2.1. Introduction

The authors have done F2 propagation research work starting October 1988. This was the first month giving more or less regular F2 propagation on 50 MHz. The authors will continue the study during the remainder of the solar cycle 22.

Before presenting the results, general information will be given concerning the study and how it was set up.

#### **Research period**

The study will cover solar cycle 22. It is estimated that this cycle will be relevant for the F2 propagation on 50 MHz until around 1994.

#### **Solar data and ionospheric data**

The solar data and the ionospheric data originate from professional institutes in Boulder ( USA ) and Darmstadt ( Federal republic of Germany ). The magnetospheric data also originate from these institutes.

#### **Qualification bandopenings**

In order to obtain a reliable picture about the correlation between different phenomena and the 50 MHz band openings, objective criteria had to be developed. The chosen method divides the day in 24 equal time intervals. The day covers 00:00 to 24:00 UTC. The world is separated into six regions, roughly corresponding to the continents. Each hourly period having openings gets a value equal to the number of regions to which the openings took place. Here is an example: When the 50 MHz band was open to 3 regions during one hourly period, that period gets a value of 3. An hourly period without openings obtains the value zero. The total values are added for each day. The information about the openings originates from logs of 50 MHz stations.

The six regions mentioned are North America, Central America, South America, Africa, Asia and Oceania.

#### **Charts**

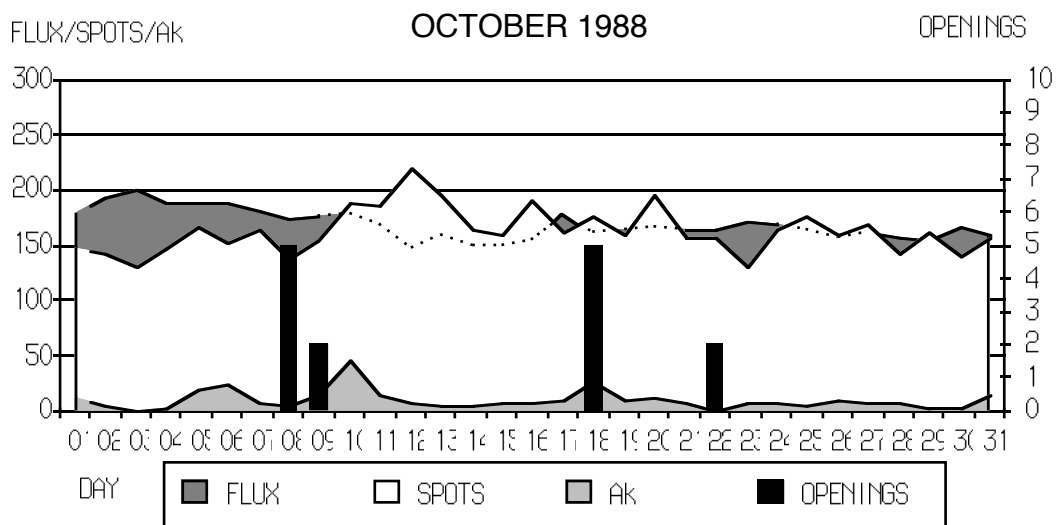
The charts show solar flux, sunspot number, Ak value and openings. They represent monthly periods and show day to day variations. The months April to September are left out because of the confusing influence of sporadic E propagation (Es). The charts have two scales: the left scale corresponds to the flux, spots and Ak values and the right scale corresponds to the openings.

## §2.2. Monthly charts

In this paragraph charts are presented with the results of the propagation study. Each chart is followed by brief comments.

In the next paragraph the results are further discussed.

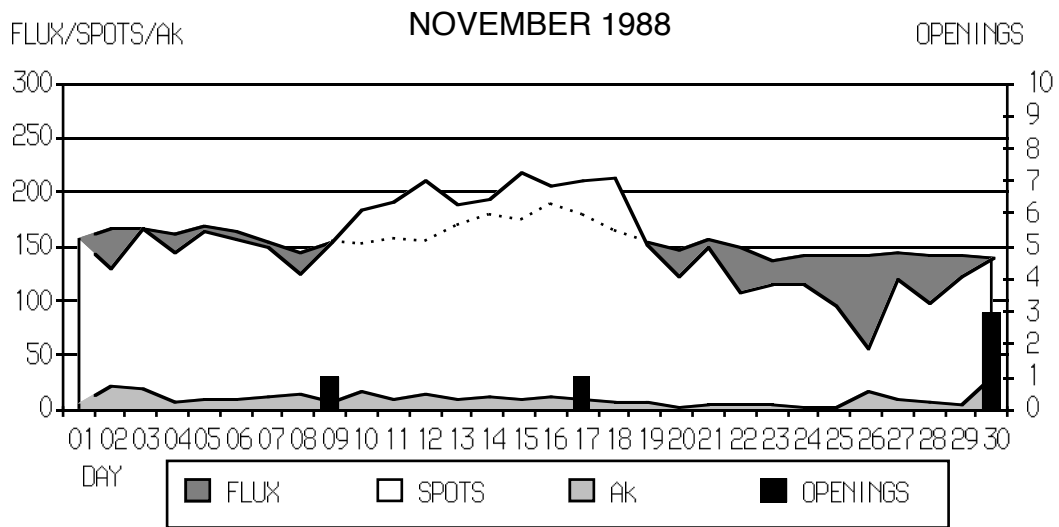
### §2.2.1. October 1988



October 1988 was the start of a period with more or less regular F2 type propagation during the solar cycle 22. On the 9th there was an opening to southern Africa. The ZS6PW beacon produced strong signals. ZS3E also produced strong signals. It was noticeable that N4EJW from the United States heard the stations from Africa the same time the Europeans were hearing the African stations.

On the 8th and 9th the openings apparently coincide with a magnetically disturbed period. The same seems to be true for the opening on the the 18th.

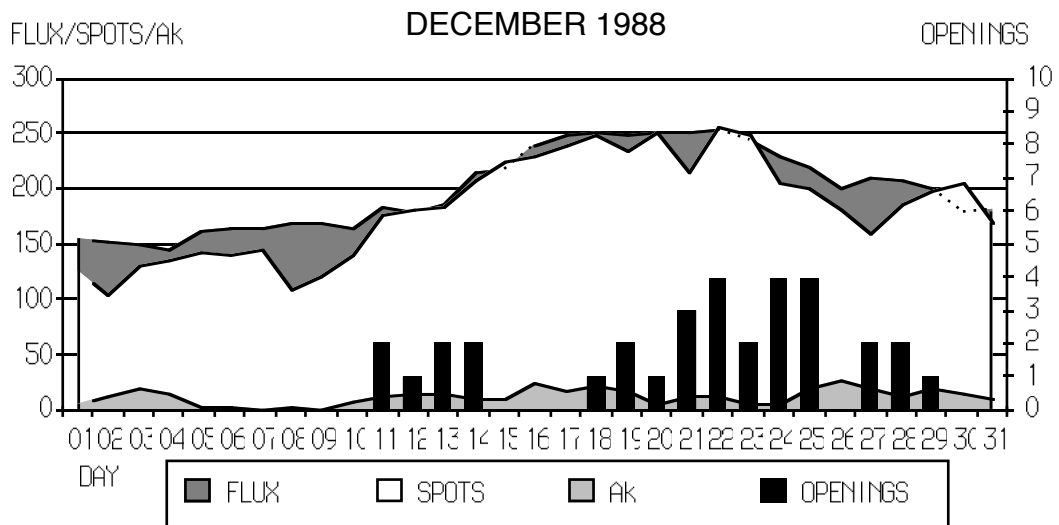
### §2.2.2. November 1988



November 1988 did not give many openings. The flux was fairly low and there were not many magnetic disturbances. On the 14th and 15th of November respectively 7 and 8 minor solar flares were reported. On the 28th a major flare was observed. The charts seem to show a correlation between the solar flares and the 50 MHz bandopenings with a two days difference in time.

During the opening on 30 November a magnetic storm occurred, which was caused by the eruption on 28 November. Stations from the Caribbean were worked and there were openings to Canada and the United States.

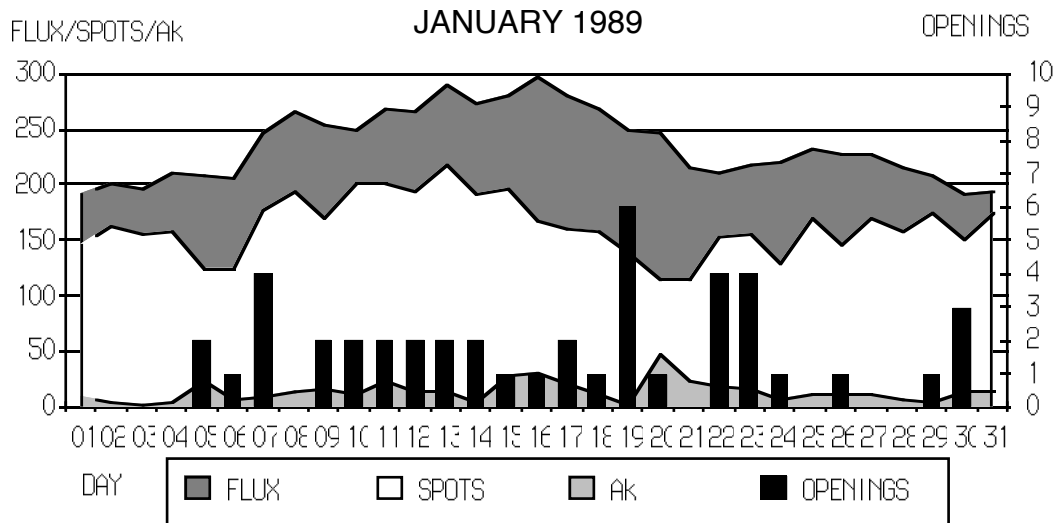
### §2.2.3. December 1988



The start of the December month did not go along with many spectacular openings. On the 9th, 3 minor flares were reported. That seemed to be the beginning of a period with many openings. The days around the 16th were not so good because of a magnetic storm. Major flares were observed on the following days of December: 18, 20, 22, 26 and 30. The solar flux became very high with the highest values thus far during solar cycle 22. In that period, several openings were reported mainly to North and Central America and to Africa.

Looking at the chart one gains the impression that a close correlation exists between the high solar activity and the openings.

§2.2.4. January 1989

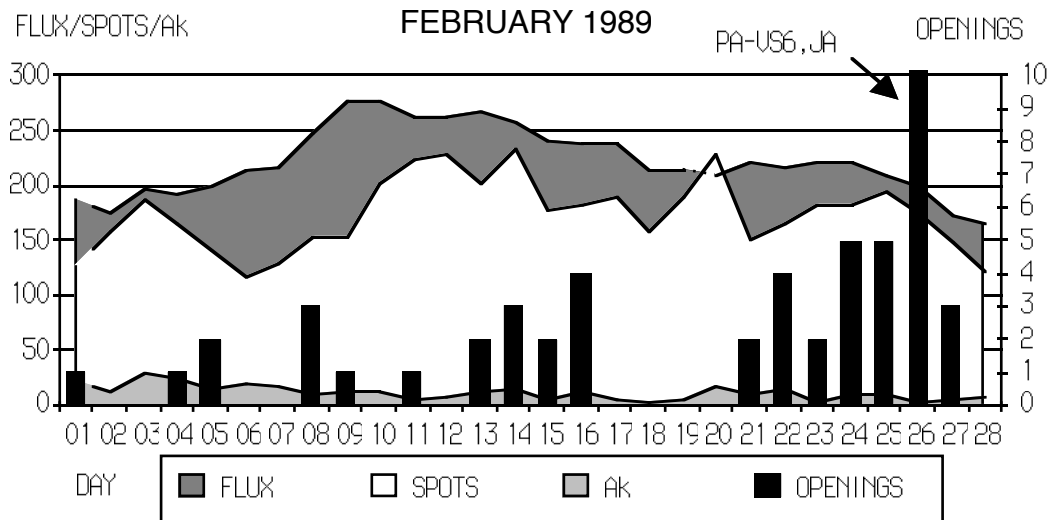


The first month of 1989 showed several F2 type openings. The solar activity was very high with quite a number of strong solar flares. The solar flux reached very high values. The openings on the 19th seem to correlate with three strong flares on 18 January. These eruptions almost certainly caused the magnetic disturbances on 20 January.

During January a number of openings were reported to North and Central America and also to the northern part of South America. Several openings to Africa took place as well.



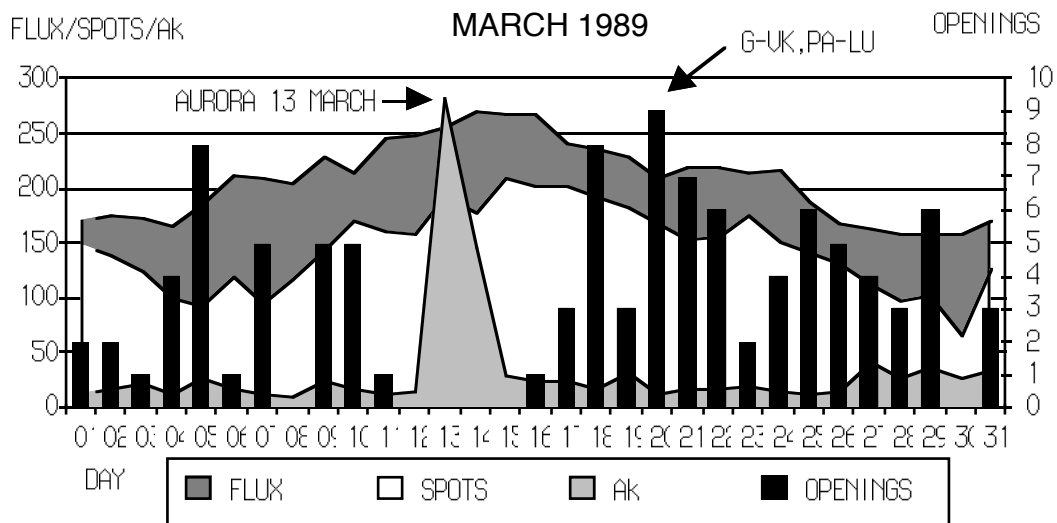
§2.2.5. February 1989



After the stormy developments in January the next month would tend to a lower solar activity. Major flares were reported on the 4th, 8th, 9th, 10th and 21st of February. If we observe the chart, the correlation between solar events and the openings does not appear to be as clear as in the months before.

Towards the end of February numerous openings were reported with highlights being Hong Kong and Japan. Those paths cross very high latitudes and are for that reason not frequently open.

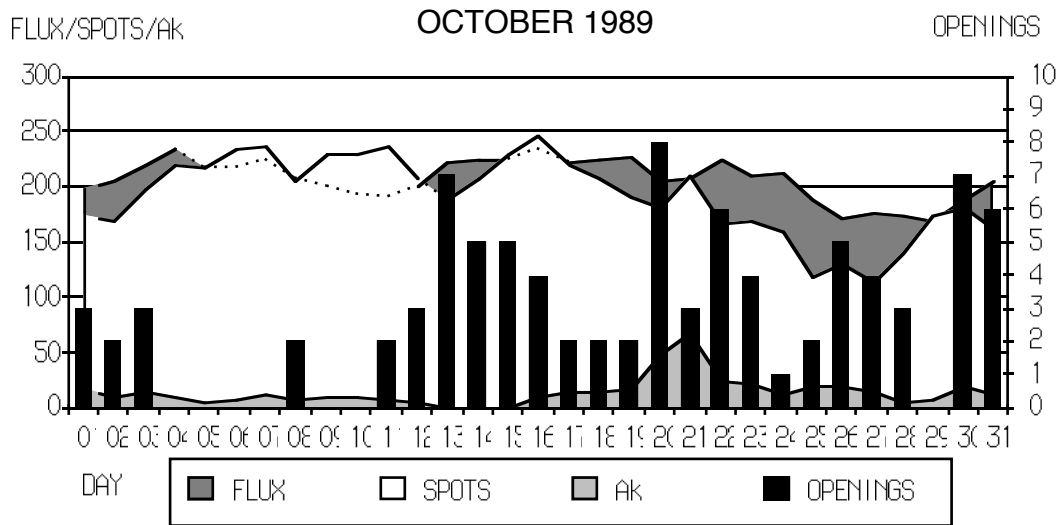
### §2.2.6. March 1989



March 1989 was a month with very spectacular phenomena. Several strong to very strong solar flares were reported. On 13 March, a very strong magnetic disturbance was observed, which went along with an aurora borealis which could be observed on low latitudes. This aurora produced strong radio effects with openings to very low latitudes. After this disturbance, the regular 50 MHz propagation recovered and interesting openings were noted.

On 20 March there was an opening formed by F2 propagation together with Es. From the Netherlands contacts were made with Argentina. From the United Kingdom an opening to Australia was reported. In the Netherlands nothing was heard. These local effects happen regularly. The Es part of the propagation can be held responsible for enhancement of the F2 range to South America and is also thought to be associated with the local effects.

### §2.2.7. October 1989



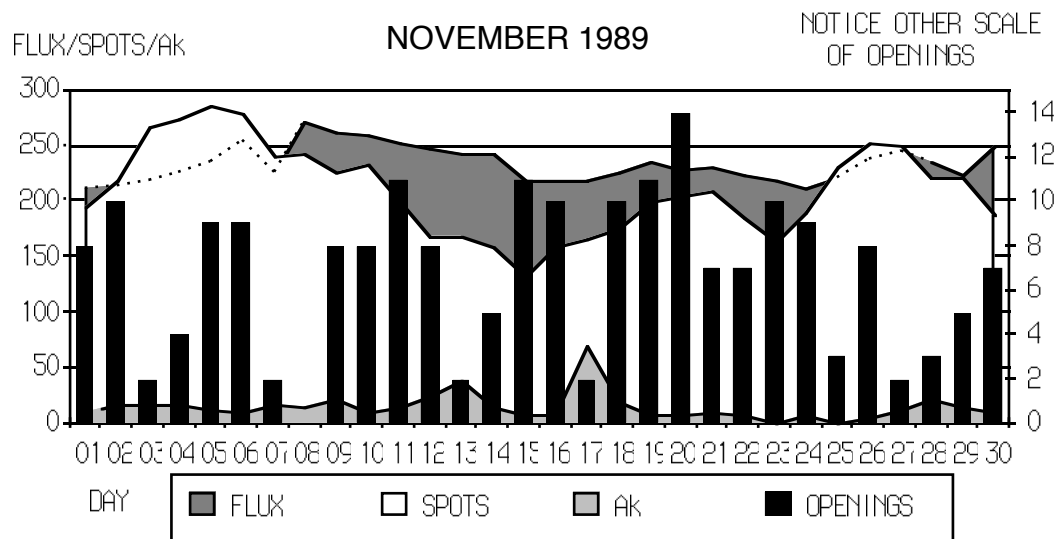
October 1989 was a month, which will be remembered by many amateurs as a special one. The start of the month had a few openings to Africa. The next days no F2 propagation of any importance was reported. On 8 October, a possible combination of F2 and Es produced an opening to southern Africa. On 11 October things started to become interesting: Contacts were reported between British stations and stations in Australia! In the Netherlands nothing was heard. We did not know yet what the next days would bring...

On 12 October an opening to Australia occurred between 08.15 and 09.30 UTC. Stations from several parts of Australia were contacted. On 13 October there were again openings: between 08.30 and 10.30 UTC contacts with Australia were possible. PA2HJS had contacts with VK8ZLX en VK8GF. The signal of VK8GF was very strong.

A remarkable aspect of this opening was, that VK8ZLX was worked at 09.00 UTC by PAoJOP whilst at that time nothing was heard by PA2HJS who lives only 15 km south of PAoJOP. At 09.08 UTC, VK8ZLX became audible by PA2HJS. An explanation for these effects is not easily given. Probably, small ionisation gradients caused the local differences. An other possible explanation is the existence of Es propagation (which leads to more local effects than F2 propagation) together with the F2 propagation.

In the period from the 19th to the 27th of October several strong solar flares took place. In that period a number of openings to Oceania and Asia were reported.

### §2.2.8. November 1989

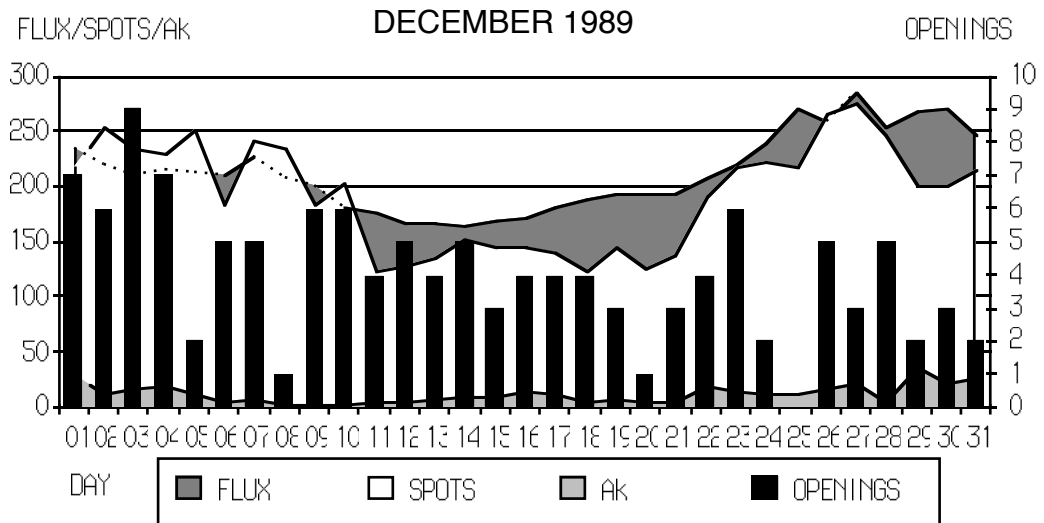


The month November 1989 can be described as the best one concerning F2 propagation so far in the current solar cycle. Both the number of openings and the strength of the signals are unequalled. In November contacts were possible to all continents. 10, 11, 19 and 20 November were very good days. The 50 MHz band looked more like one of the HF amateur bands than like the otherwise more quiet band. The openings were very widespread with little local effects, which leads to the assumption that the maximum usable frequency (MUF) must have had values in excess of 50 MHz.

In November, solar flares were reported on 6, 7, 8, 10, 11, 15, 16, 18, 19, 20, 21, 25 and 29 November.

The chart shows that nearly no correlation can be found between the solar flares and the openings. The chart shows no short term correlation between solar flux, R number and openings as well.

**§2.2.9. December 1989**



In December 1989 the propagation fell to a lower level than in November. In the first week of December openings to Asia en Oceania were reported, whilst later in the month openings to mainly North, Central en South America were reported.

Compared to the openings in November, the openings in December were generally shorter and the signals were weaker.

Solar flares were reported on 5, 26 and 29 December. The eruptions of the 26th and 29th caused auroral propagation.

Equally to November, the December chart shows that a short term correlation between solar events and the 50 MHz openings does not clearly exist.

### §2.3. Discussion: correlation between openings and solar activity

The charts in the foregoing charts are meant to show possible correlation between solar activity and 50 MHz openings. Other related quantities such as solar spot numbers and magnetic indices are also covered in the charts.

Before drawing any conclusions, some aspects are discussed below.

The data concerning the 50 MHz openings originate from bandreports from a small number of active amateur stations. Because of the small number the accuracy of the data is limited. It is very well possible that openings occurred whilst none of the stations was active. A further drawback is the absence of 50 MHz signals or the very low 50 MHz activity in several regions. It is thus a reasonable assumption that more openings occurred than were noticed.

#### §2.3.1. Solar flux related to 50 MHz openings

It appears from the charts that a clear short term relationship between solar flux and openings does not exist. If a longer period of time is considered, a certain relationship becomes evident. During a period of high solar flux (over 250 ) openings frequently occur. During a period of the solar flux being about 200, fairly regular openings are reported. When the flux falls below 150, openings are rare. Another noticeable factor is that more openings occur after a solar flux peak than before one.

As will be explained in the next paragraph, more than just the solar flux is responsible for the 50 MHz F2 propagation.

#### §2.3.2. Solar spot numbers related to 50 MHz openings

As well as with the flux, there seems to be no direct relationship. The charts show some evidence that openings tend to take place during minima of sunspot numbers. Examples of this are:

- 6 January 1989
- 19 January 1989
- 5 March 1989
- 2 October 1989
- 13 October 1989
- 26 October 1989
- 1 November 1989
- 15/16 November 1989
- 23/24 November 1989
- 12 December until 23 December 1989

Because openings also occur while this condition is not satisfied, this conclusion is of minor importance.

### §2.3.3. Ak index related to 50 MHz openings

In contrast with solar flux and solar spots a more clear correlation can be found between Ak index and 50 MHz openings. In several cases openings occur during periods of magnetically active conditions. Especially in the period between two days before a magnetic disturbance and the disturbance itself many openings take place. The magnetically disturbed periods can be recognised by the high Ak values.

Examples of this effect are:

- 8/9 October 1988
- 18 October 1988
- 30 November 1988
- 19 January 1989
- 20 October 1989
- 15/16 November 1989

During a period of marginal 50 MHz conditions the above mentioned correlation is clear. If we consider the literature concerning the effects of solar flares and the effects that are caused by the flares, the conclusions about the correlation between Ak values and 50 MHz openings are consistent with the literature [1].

Another noticeable effect is the relatively bad propagation during magnetic disturbances. This effect can be related with the disturbances in the F2 region during these periods of high magnetic activity.

Examples of this effect are:

- 13 March 1989 ( very strong disturbance )
- 20 January 1989
- 21 October 1989
- 17 November 1989

To explain some of these effects, we will describe some phenomena as taken from the literature [1].

A solar flare produces a broad spectrum of energy. The first effects that can be noted on earth is ultraviolet radiation and the radiation of X-rays. This energy has ionising capabilities. The flare also produces particles, which reach the earth at a later time. The particles are electrically charged and interact with the plasma around the earth. Hydromagnetic waves are believed to develop in the

magnetosphere, leading, for example, to a heating of the ionosphere and prolonged disruptions - the disturbances observed in the F2 region. Disturbances are also encountered in the E region. These disturbances are observed all over the earth and represent the strongest effect by a solar flare that is observed in radio investigations of the ionosphere[1].

The disturbances of the F2 region can be both negative and positive. A positive disturbance leads to higher critical frequencies and a negative disturbance results in less than normal F2 region conditions.

When the MUF of the F2 region is just below 50 MHz, it is not difficult to understand that a positive disturbance can lead to a 50 MHz opening. As the disturbances are associated with solar flares and the resulting magnetic activity, they give a reasonable explanation for the correlation found between Ak values and 50 MHz openings.

Negative disturbances in the high- and midlatitude regions are accompanied by positive disturbances in low latitudes and near the equator. The sign of the disturbance changes near geomagnetic latitudes of  $40^{\circ}$ . In §2.4. this effect will be further discussed.

For the use of forecasting possible 50 MHz openings, reports about solar flares can be of a certain value, as explained.

#### §2.4. Further aspects and correlations

Using the data for this study, some charts were made, which can give additional information about the F2 propagation on 50 MHz.

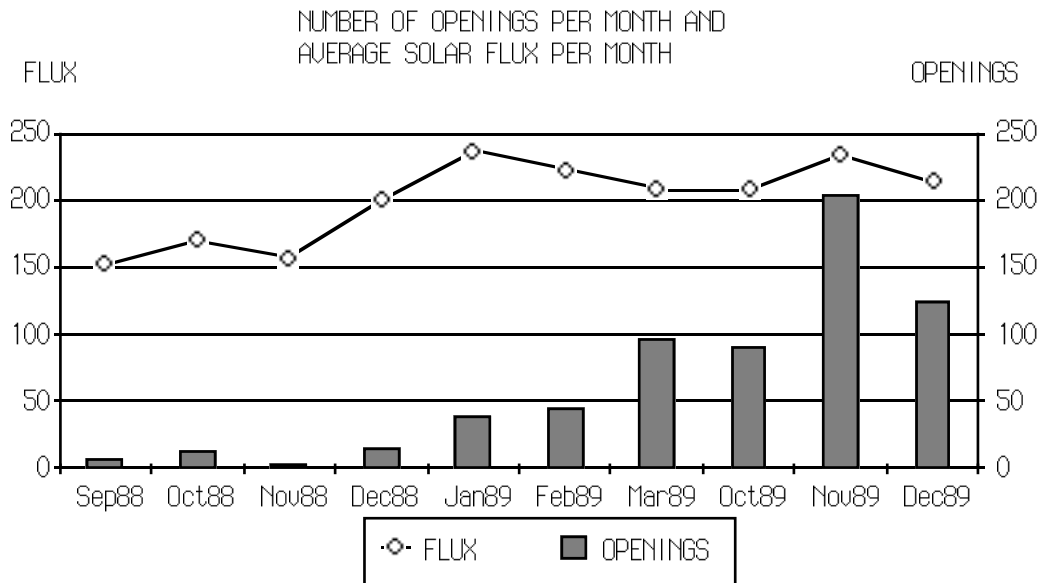
The chart on the next page shows the average solar flux per month together with the total number of openings per months.

From this chart, some interesting details can be learned.

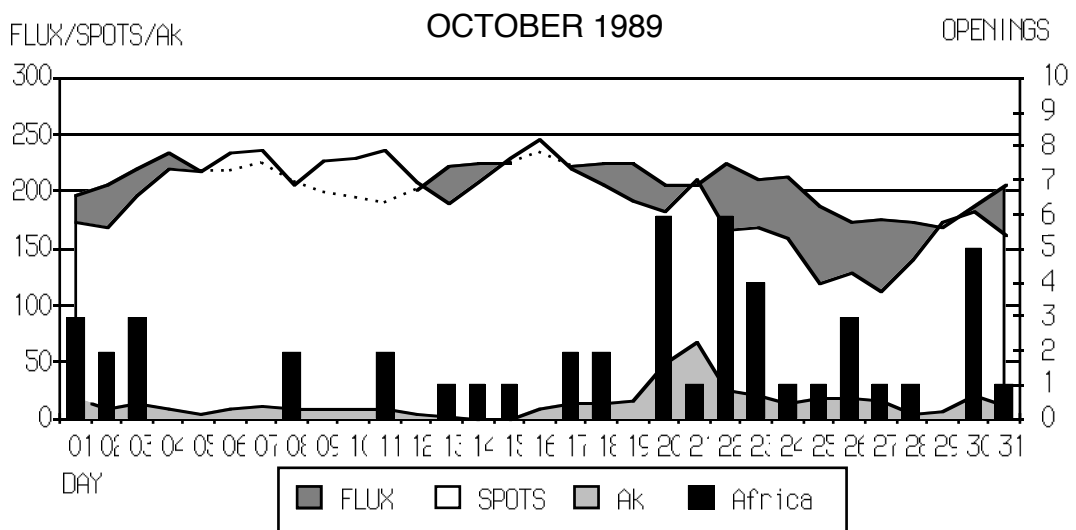
For example, the average flux in December 1989 is just a little over the December 1988 value. However, the number of openings in December 1989 is far greater than in December 1988. Apparently, the solar flux is not the only factor responsible for the 50 MHz F2 openings.

If the chart is considered as a whole, one gains the impression, that the openings show a cycle which lags the solar flux cycle. In the literature [3] it is stated, that the magnetic activity shows a cycle that lags the solar cycle by about two years. The chart indicates that this statement is true. A possible explanation could be that openings correlate with magnetic disturbances. In § 2.3.3. this correlation was discussed. When there is a close relationship between openings and the magnetic activity cycle, we can expect the openings to lag the solar cycle by about two years. It will be interesting to see the future developments in this respect.





The next chart shows the openings to Africa related to flux, spots and Ak values during the month October 1989. This chart indicates that openings across the equator have a fairly close relationship with magnetic disturbances. As stated earlier, negative disturbances on middle and high latitudes go along with positive disturbances in the equatorial zone. During magnetically active periods these conditions occur most.



The chart shows the mentioned relationship, especially in the period around 21 October.



Another example is the occurrence of openings to Australia and Oceania during successive days in October 1989. This is a remarkable effect which could be investigated more in detail.

### §2.5 Comparison with solar cycle 21

If we compare the current solar cycle with the previous one, there seems to be a close correlation between comparable directions, times and quality of the propagation. PA2HJS had 50 MHz listening equipment and kept a detailed record of the stations and signals heard, whilst Ken Ellis, G5KW published a series of interesting articles concerning 50 MHz propagation [2].

During cycle 21, the autumn of 1979 was the start of regular F2 propagation. In November and December 1979 many openings were reported, especially to North and Central America.

The last months of 1989 show comparable openings and it should be noted, that this is only 10 years after comparable circumstances in 1979. This fact is a source for some speculation about the further development of cycle 22.

During cycle 21, the months November and December showed most openings. The F2 propagation was much less in January. This study does not cover the year 1990, but it can already be said, that in the start of 1990, the F2 propagation fell to a much lower level than in the last months of 1989. Thus, the F2 propagation in this cycle seems to develop the same way as in cycle 21.

### References:

- [1] Yakov L Al'pert, Radio wave propagation and the ionosphere, second edition.
- [2] Ken Ellis, G5KW, "Propagation study on 50 MHz during Sunspot Maximum, Cycle 21", The Short Wave Magazine, May 1986 p. 100-102, June 1986 p. 129-133, July 1986 p. 181-183.
- [3] RSGB Handbook, fifth edition, volume 2, 1977 p.11.13 - 11.20.