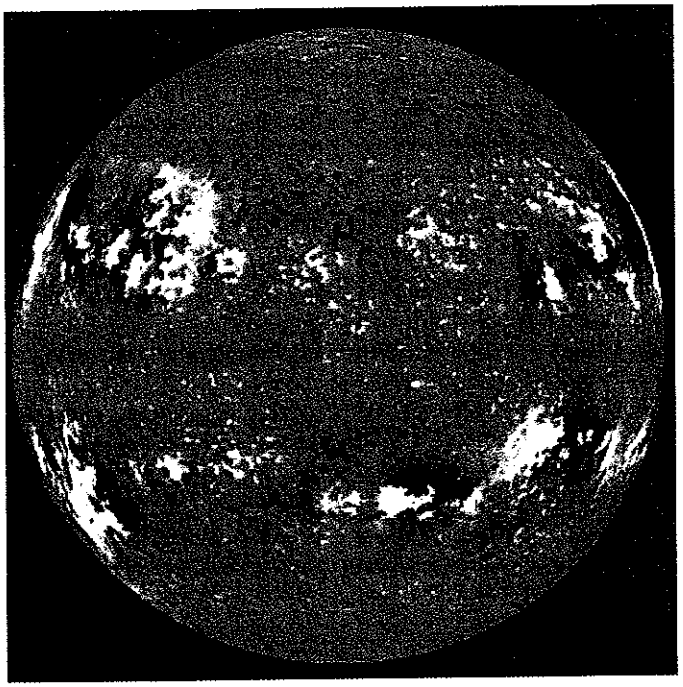
Down To Earth

An Introduction to Solar Indices

By Gwyn Williams, G4FKH*

TO GAIN A better understanding of the figures quoted each week on the RSGB GB2RS bulletins, some of the more important indices are explained below. This is not a comprehensive coverage of indices, rather a simple introduction. To retain simplicity, emphasis will be given to HF conditions. The indices that will be discussed are Solar Flux, the Ap and Kp indices, and how these interact and affect our ability to propagate signals around the earth.



Picture of a very active sun, taken during a solar maximum.

SOLAR FLUX

THE 10.7cm (2800MHz) radio flux is the amount of solar noise that is emitted by the sun at these wavelengths. The solar flux is measured and reported at approximately 1700 UTC daily by the Penticton Radio Observatory in British Columbia, Canada. The solar flux is used as a basic indicator of solar activity. It can vary from values around 60 to values in excess of 300 (representing very low solar activity and high to very high solar activity respectively). It is worth noting that it takes several days of high values for the ionosphere to improve, one high day will not improve communications. Values in excess of 200 occur typically during the peak of solar cycles.

The solar flux is closely related to the amount of ionization (electron concentration) taking place at F2 region heights (heights sensitive to long-distance radio communication), **Fig 1**. High solar flux values generally provide good ionization for long distance communications at higher than normal frequencies. Low solar flux values can restrict the band of frequencies which are usable for long distance communications. The solar flux is measured in 'Solar Flux Units' (SFU).

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A-INDEX

THE GEOMAGNETIC A-index represents the severity of magnetic fluctuations occurring at local magnetic observatories. During magnetic storms, the A-index may reach levels as high as 100. During severe storms, the A-index may exceed 200. Great 'rogue' storms may succeed in producing index values in excess of 300, although storms associated with indices this high are very rare indeed.

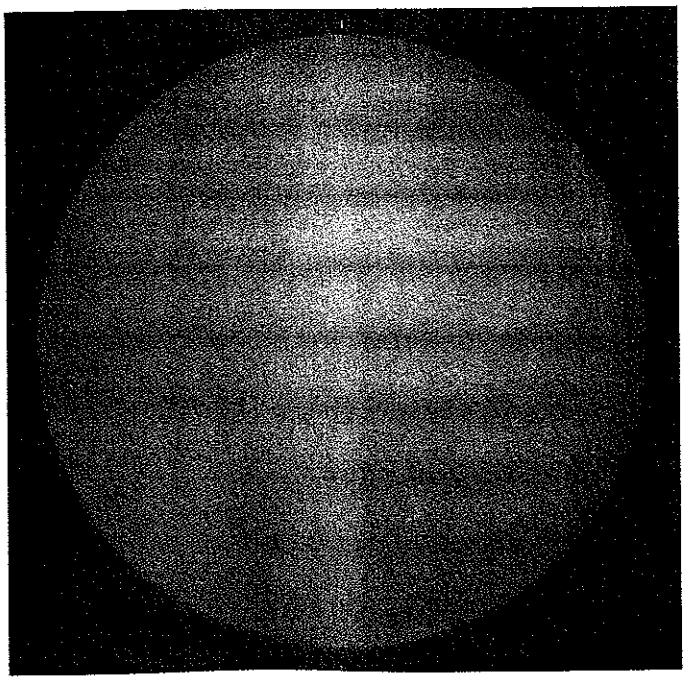
The A-index varies from observatory to observatory, since magnetic fluctuations can be very local in nature. A quoted A-index will indicate a local reading, whilst an Ap-index represents a *planetary* A-index.

K-INDEX

THE K-INDEX is related to the A-index. Comparison figures are given in **Table 1**.

Each UTC day is divided into eight 3-hour intervals, starting at 0000 UTC. In each 3-hour period, the maximum deviation from the quiet day curve is measured and the largest deviation is selected. It is then put into a standard mathematical equation to yield the K-index for the period.

The K-index is useful in determining the state of the geomagnetic field, the quality of radio signal propagation and the condition of the ionosphere. Generally, K-index values of 0 and 1 represent *quiet* magnetic conditions and imply good radio signal propagation conditions. Values between 2 and 4 represent *unsettled* to *active* magnetic conditions and gen-



Picture of a spotless sun, taken during a solar minimum.

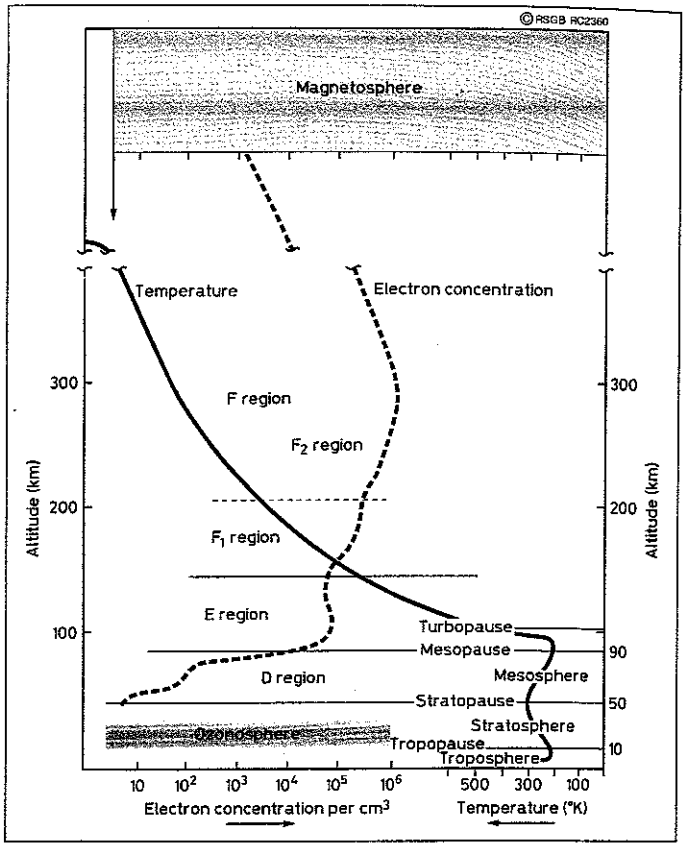


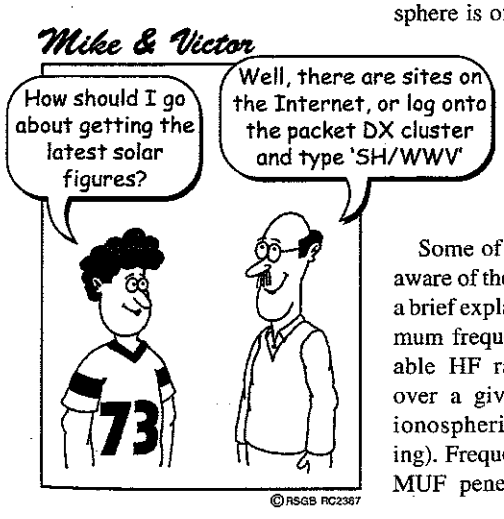
Fig 1: General shape and electron concentration at the various region heights.

erally correspond to less-impressive HF radio propagation conditions. K-index values of 5 represent *minor storm* conditions and are usually associated with fair to poor propagation on many HF paths. K-index values of 6 generally represent *major storm* conditions and are almost always associated with poor radio propagation conditions. K-index values of 7 represent *severe storm* conditions and are often accompanied by 'radio blackout' conditions (particularly over higher latitudes). K-indices of 8 or 9 represent *very severe storm* conditions and are rarely encountered (except during exceptional periods of solar activity). K-indices this high most often produce radio blackouts for periods lasting in excess of 6 to 10 hours (depending upon the intensity of the event).

COMPLETE PICTURE

KEEPING THE ABOVE explanations in mind, it is now time to put it together and get a more complete picture of the various interactions. Referring once again to Fig 1, the various regions of the ionosphere receive their ionization from the sun. Basically, the greater the received ionization the more capable the ionosphere is of bending radio transmissions back to earth. Also, the greater the received ionization the higher will be the Maximum Usable Frequency (MUF).

Some of you may not be fully aware of the term MUF, so here's a brief explanation: It is the maximum frequency that allows reliable HF radio communication over a given ground range by ionospheric refraction (bending). Frequencies higher than the MUF penetrate the ionosphere and become useful for extraterrestrial communications.



Ionization comes as mentioned from the sun. By far the most important type is extreme ultraviolet (EUV) radiation. Bright areas called 'plage' can be seen surrounding sunspot groups, as shown in the photo on the extreme left. Plage is the primary source of the sun's EUV radiation. As plage levels vary throughout the solar cycle, so too does the level of EUV radiation. This leads to changes in the electron concentration of the ionosphere during the course of a solar cycle. The ionosphere's ability to refract signals is dependent upon the electron concentration - the higher the electron concentration and SFU, the better able the ionosphere is to refract radio signals. The MUF also rises with a greater electron concentration; which explains why radio communication conditions are enhanced during the peak of solar cycles. The photo (bottom left) shows the sun at the bottom of a solar cycle. Notice the distinct lack of plage regions and therefore the shortage of EUV. Also, the low solar activity will result in very low SFU levels.

Kp	Ap	State
0o	0	
0+	2	
1-	3	Quiet
1o	4	
1+	5	
2-	6	
2o	7	Unsettled
2+	9	
3-	12	
3o	15	
3+	18	
4-	22	
4o	27	Active
4+	32	
5-	39	
5o	48	Minor storm
5+	56	
6-	67	
6o	80	Major storm
6+	94	
7-	111	
7o	132	Severe storm
7+	154	
8-	179	
8o	207	Very severe storm
8+	236	
9-	300	
9o	400	

Table 1: The relationship between Ap and Kp. Note that normally only the figures of Kp with an 'o' after them are quoted. This means that each 'K' index covers a range of 'A' indices.

The key points to remember are that a high SFU will result in superior communications capabilities, whilst a low SFU will result in inferior communications capabilities. Another important point is that it takes some time for the ionosphere to react to increasing SFU, so it requires quite some building up before it is capable of supporting higher MUFs.

THE DOWN SIDE

WITH INCREASING solar activity on the sun, as a cycle gathers momentum towards a peak and following that peak, geomagnetic activity also tends to build. This is the result of activity on the sun producing interactions with the earth and causing disturbances to the earth's magnetic field. As previously mentioned, this activity is measured, the 'A' and 'K' indices being the result.

The higher the A/K index, the more likely that there will be an interaction with the ionosphere, ie a high A/K level will depress the MUF. The amount by which the MUF is depressed will depend upon the severity of the storm, whilst the period of depression will depend upon the duration of the geomagnetic/ionospheric storm. Geomagnetic and ionospheric storms are intrinsically associated, however, a geomagnetic storm is a disturbance affecting the earth's geomagnetic field and ionospheric storms are disturbances in the earth's ionosphere.

CONCLUSIONS

FOR THE BEST chance of HF DX, look for high levels of SFU, say 150+, and low levels of K, say 0-2. It is when these indices have been around these levels for some days that the best communicating conditions will be observed. ♦