Propagation
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Where Do the K and A Indices Come From?

The K and A indices are readily available parameters (for example, they're given at 18 minutes past the hour on WWV) that can give us an indication of how the high latitude ionosphere might be affecting propagation. Let's take a look at where the K and A indices come from to hopefully gain a better understanding of these important propagation parameters.

It all starts with the K index. The K index is a 3-hour measurement of the variation of the Earth's magnetic field relative to quiet day conditions. The K index is determined from the data taken by a magnetometer, which measures the variation of the magnetic field in nanoTeslas (nT). Table 1 shows the nT range versus the K index for the mid latitude Boulder magnetometer.

K	**nT**
0	0-5
1	5-10
2	10-20
3	20-40
4	40-70
5	70-120
6	120-200
7	200-330
8	330-500
9	> 500

Table 1 nT vs K for Boulder

If we plot nT (using mid range values of nT) versus K, we get the plot of Figure 1.

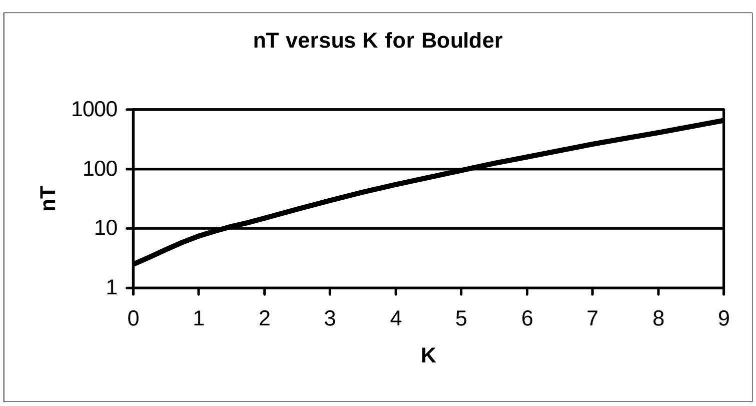

Figure 1

Note that nT is plotted on a logarithmic scale and that the curve is almost a straight line. Since it isn't *exactly* a straight line, the K index is said to be quasi-logarithmic.

Before moving on, an important comment is in order. Each station has its own scale of nT versus K. This is done to try to make the K index from each station represent the same level of disturbance. For a given disturbance, the variation of the Earth's magnetic field will be greatest at the high latitudes. Thus at the high latitude College (Alaska) station, a K index of 9 is a variation greater than 2500nT. At the low latitude Kuyper (Sumatra) station, a K index of 9 is a variation greater than 300nT. Compare these nT values with the mid latitude Boulder nT value at K=9 in Table 1.

Now let's look at a magnetometer record (which is called a magnetogram) to see how the K index is determined. Figure 2 is a snapshot of the magnetogram from Boulder on April 16, 2003 (thanks to Dr. Christopher Balch at NOAA/SEC).

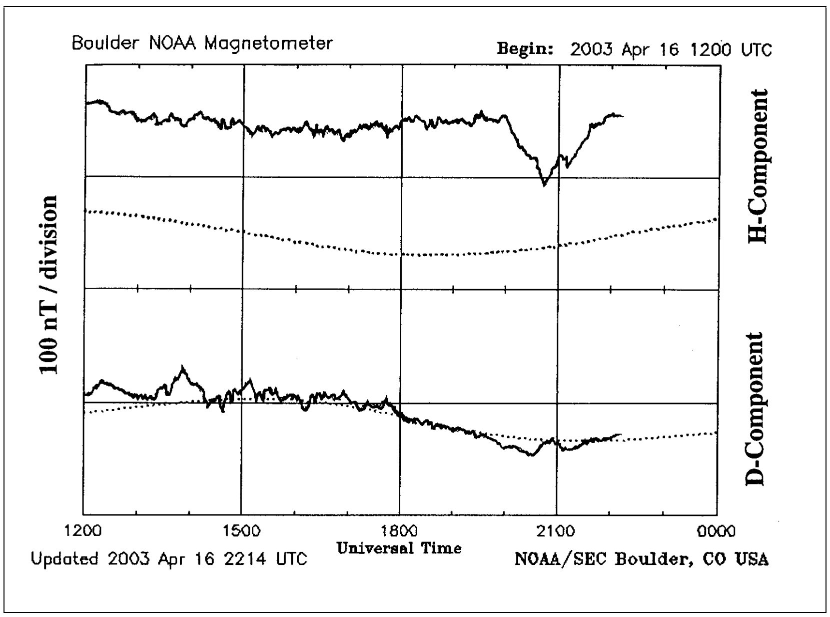

Figure 2 Boulder magnetogram

The solid line at the top of the plot is the variation of the H-Component (vector horizontal component) of the magnetic field. The dotted line about one vertical division below this solid line is the quiet day curve for the H-Component.

The solid line at the bottom of the plot is the variation of the D-Component (magnetic declination) of the magnetic field. The dotted line running almost concurrent with this solid line is the quiet day curve for the D-Component.

The K index for any 3-hour period is determined by first finding the maximum positive and negative deviations of both components relative to their respective quiet day curves. Next these are added together for each component to determine the maximum fluctuation of each component. The component with the largest fluctuation is used to determine the K index. In the 1200-1500 UTC period of Figure 2, for example, the D-component exhibits the maximum deviation from the quiet day curve. This is easiest seen by mentally overlaying the H-component quiet day curve on the H-component data, and noting that the H-component varies less about its quiet day curve than the D-component.

The maximum positive deviation for the D-component is +35nT around 1350 UTC. The maximum negative deviation is –10nT around 1440 UTC. The maximum fluctuation is therefore (+35nT) – (-10nT) = 45nT. Going to Table 1 says the K index for this period is 4, which is what Boulder reported. In a similar manner, the K indices for the other seven 3-hour time periods can be determined. Note that the magnetometer only measures the deviation from a quite day curve, not an absolute value.

Now we have eight K indices for the entire day, and we'd like to come up with an average for the entire day. Since the K index is logarithmic, mathematically we shouldn't simply add all eight K values and divide by eight to get an average. To do averaging, we need indices that are linear. This is where the A index comes in.

Table 2 shows the conversion between the K index and the a index (the little 'a' indicates it's an equivalent 3-hour value – a big 'A' indicates it's a daily average value).

K	**a**	**nT**
0	0	0-5
1	3	5-10
2	7	10-20
3	15	20-40
4	27	40-70
5	48	70-120
6	80	120-200
7	140	200-330
8	240	330-500
9	400	> 500

Table 2 a vs K

If we now plot nT versus the a index we get Figure 3.

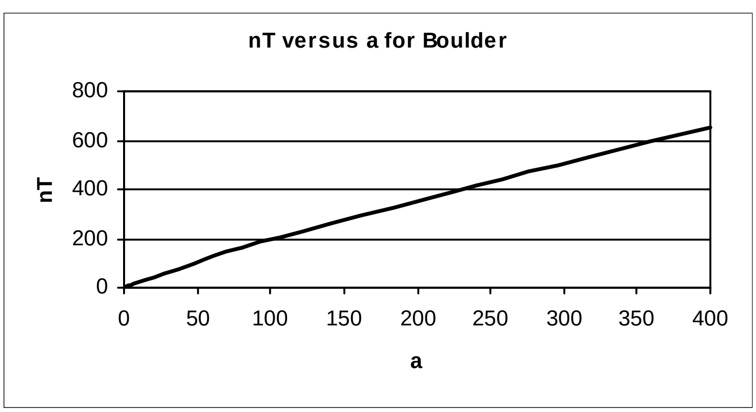

Figure 3

Note that nT is now plotted on a linear scale and that the resulting curve is for all intents and purposes a straight line. Thus the 3-hour a index (and the subsequent A index) is said to be linear.

Now we can simply add the eight 3-hour a indices, divide by eight, and come up with a daily average – which is the A index. We can also do this for many worldwide stations and come up with the daily average planetary A index, Ap. In a like manner, we can use many worldwide stations to come up with the 3-hour planetary K index, Kp.

Ok, now we know where K and A come from. But how do they tie to HF and VHF propagation conditions? In general, as the K and A indices become elevated:

1. The high latitude E region ionization can increase significantly (VHFers like this)
2. Increased D region absorption can occur in and near the auroral oval (not good)
3. Usually the F region ionization at mid and high latitudes decreases (not good)
4. Sometimes, depending on how the geomagnetic storm evolves, the F region ionization at low and mid latitudes increases (this can be good)

The extent to which the above events occur on a specific path is hard to pin down. It depends on the geomagnetic storm itself, the geomagnetic latitude along the path, the level of solar activity, the season, and the local time along the path. Both W6ELProp and ICEPAC (the derivative of IONCAP that incorporates a high latitude ionosphere model) allow input of the K index to make a broad assessment of the impact of an active geomagnetic field.

One last 'problem' should be mentioned. The K index and thus the a and A indices are measurements of currents flowing at E region altitudes. Thus they don't really give us any indication of what's going on at F region altitudes. Additionally, since the A index is the average of eight K indices, a spike in one or two of the eight 3-hour K indices may not show up very much in the daily average A index, even though the spike affected the ionosphere. So the A index could be encouraging, but it may not indicate the effects of a short-term event. A good example of this 'problem' is what happened to 10m in the CQ WPX CW contest in 2002. See the March 2003 issue of CQ for details of this.

There you have it. You should now have a good understanding of how the K and A indices are determined.