# Skip—what's it all about?

**Although shooting skip may seem pretty hit or miss to some, you can improve your chances of snagging a rare one if you follow these simple suggestions.**

by George McCarthy

One listen on the CB channels or the ham bands in the last few months should be enough to convince anyone that the long-awaited Cycle number 21 has arrived and those sun spots are doing their thing. The effect of the increased sun spot activity has been most evident on the higher frequencies, where long distance skip is an everyday occurence.

For thousands of new hams and CB skip shooters this will be the first of the familiar 11 year cycles. And the fun is only beginning. This current cycle is expected to peak in 1980. Then it will decline for some four years before it begins to bottom out. Yes, we are expecting at least six years of a level of sun spot activity that should support fairly consistent long distance communication.

This new cycle is being greeted with enthusiasm in the ham ranks. But, there are already millions of CBers who are no longer intrigued by the sound of someone calling *CQ-DX* from the other side of the country—right on a channel that had previously been used for local communication.

This article is not primarily about sun spot activity, however. Rather, it is about one of the ways to use this cycle if you do like to chase DX. At this point let me clear up one possible ambiguity. DX is an abbreviation of long standing that means *distance*.

In the amateur radio business it always stands for a contact with another station that is in a different country—outside of the country of the station calling. It is considered bad form to reply to a station calling CQ-DX if you are in the same country. In the CB business, on the other hand, the expression just means that one is calling for a contact with a distant station, preferably in another state and as far away as possible.

## Ground and sky waves

In both cases the calling station is making use of the well established fact that his radio signals are putting out a *sky wave* as well as a *ground wave*. Radio signals from the sky wave come off of the antenna at various angles, depending on the antenna and the frequency, and travel on up to the ionosphere, where they *may* be reflected back to Earth some distance away from the transmitting location.

This phenomena was first observed and proved by two physicists, Kennelly of the U.S. and Heaviside of Great Britain. They realized that Marconi's successful transmission of radio signals across the Atlantic could not have taken place on a direct path, but must have been reflected back to Earth. Even today not everything is yet known about how many factors might affect the transmission and reception of radio signals.

The term *skip* came into being when it was first recognized that some radio signals were literally skipping over the space between the point of origin and the point of reception. This phenomena was the result, of course, of the fact that the signal was not following the curvature of the Earth, but was traveling in a relatively straight line up to one of the *layers* above the Earth and then bouncing back down.

A receiving station over the horizon and out of range of the transmitting station's ground wave would not even hear the signal. But another station hundreds of thousands of miles away—where the signal came back down to Earth—would receive it loud and clear. The area in between, in which signals were not heard, became known as the *skip zone* to designate that signals were skipping over it.

There are a couple of things that should be mentioned because they have a direct bearing on the effective use of the right radio path. Looking at *figure 1* you'll see that the lower the angle of radiation, the greater the distance from the point of origin the signal will be when it returns to Earth.

The geometric law that the angle of reflection equals the angle of incidence is not absolutely true. Apparently some bending of the radio wave occurs, rather than a point-to-point reflection. But for most purposes we can assume that the radio wave will be reflected or refracted back to Earth as near the same angle as it arrived.

## More Than One

At first it was thought that there was only one layer up there that was doing the bouncing back to Earth. For many years it was known as the *Kennelly-Heaviside layer*, in recognition of its discoverers. After a time it became apparent from various radio soundings that there were several layers up there and they varied in their effective height above the Earth.

*Figure 2* shows the layers concerned with long distance propagation. The *E* layer is about 70 miles above the Earth. The *F* layer is actually two layers, the *F-1* layer at about 140 miles and the *F-2* layer at around 200 miles. At night the two F layers recombine into a single layer about 175 miles high. Not shown is a *D* layer, which exists only around the noon

## Radio skip

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I'd set the pointer to Germany, and find that the bearing was 30 degrees. That means that my signal would bounce down somewhere in Hudson Bay, in Canada, and take off again over Greenland and come down in the snow, and go up again. The distance is about 5600 miles, great circle, so the third bounce would land me in Germany.

There are two likely times during each 24-hour period, that give me the best chance of hearing signals from Europe on 20 meters. One is early morning when it is late afternoon there. The other is when it is late evening here and morning there. Frequencies as high as 15 or 10 meters are likely to be open between California and Europe at those times.

As you might have suspected the East Coast has an advantage when working skip into Europe compared to the West Coast. They don't have to pay the 10 dB penalty of an extra bounce. Of course those of us on the West Coast have the same type of advantage when working Australia or Japan.

Most of the country has complained of the West Coast's aluminum curtain when they want to reach out into the Pacific. It's often hard to get through all of those high powered California stations.

There are times when the best route between two locations is the so-called *long path*. It's called that because radio signals are bouncing the long way around the Earth. Again, it depends on the state of ionization existing between the stations. Frequently the longer path is actually the stronger path.

When I hear a peculiar echo effect on a DX signal I know that it is likely that I am hearing their signal from both directions at almost the same time. That's when I spin my antenna to a heading opposite the one normally used.

A few months of practicing and you will know most of the bearings automatically, and the approximate local time at the DX location. Knowing that the path depends on those ionized layers allows you to calculate your chances of making contact at a particular hour to some specific place in the world.

Unfortunately, for those hard working types who have a daily job, much of the good DX takes place in the morning hours, so retirees, swing shift people and housewives have a big advantage. I suppose that I ought to include writers, since I keep hearing the statement, "Oh, you're a writer. That sure must beat working!"

Radio propagation is one of the most complex subjects known to man, so you should know that we have barely scratched the surface in this article. However, you ought to have a handle on which way to point your beam antenna if you want to chase DX or shoot skip. Good luck and good DX.

hour and affects only frequencies below 5 mHz.

It is important to realize that these layers are not some solid permanent wall up there that bounces signals back like ping-pong balls. Rather they vary in thickness and height and in their ability to reflect radio waves. That is, they are constantly changing in composition.

Perhaps the most important factor for us to consider is the degree of ionization that is present at any one time. It is the ionization that determines if the layer will absorb most of the radio energy, reflect most of it back, or allow it to pass right on through to outer space.

There are many factors that affect long distance radio propagation. Not all of them are yet understood. We have evidence that the Earth's magnetic flux has a decided effect. We are also aware of effects from solar storms, from the aurora borealis, and so forth. However, in this article we are going to concern ourselves only with reflections from the ionospheric layers.

### The effects of cosmic rays

What causes these layers to bounce radio signals back to Earth? Apparently it is the ionization level. Ionization takes place when the atoms that comprise the thin atmosphere up there are bombarded by ultra violet rays from the sun. Other particle bombardment from cosmic rays may also be present. The impact of the rays temporarily separates the ions and electrons that are normally in a state of electrical balance.

Where the atmosphere is relatively dense and the atoms close together, the recombination of electrons and ions into a balanced state takes place fairly rapidly. There must be a constant bombardment to keep enough ions split off to maintain a state of ionization in the layer.

Since the source of the bombardment that ionizes a particular layer is the sun, it becomes obvious that if the rays from the sun are not hitting a layer it will no longer have ions splitting off. All will recombine and the ionization will disappear. No ionization—no radio reflection and no skip.

At the higher altitudes, where the atmosphere is less dense, the recombination takes place more slowly. The layer may retain enough ionization to reflect radio signals long after it has ceased to be hit by radiations from the sun. This is true of the nighttime F layer, if it was thoroughly ionized while in sunlight.

The degree of ionization obviously is the controlling factor of how well those layers will provide long distance skip propagation. In turn, that depends on the sun's level of activity in generating solar energy in the form of ultra violet radiations. This appears to be directly related to the so-called sun spot activity.

The spots are actually parts on the sun's surface that are cooler than the surrounding areas. They are the source of tremendous amounts of energy that pour in a stream of hydrogen and calcium gases in a vortex like a cyclone between the two poles of an apparent magnetic loop.

### Sun spots

In one 11 year cycle they will be below the sun's equator, while in the next cycle they will be above the equator. In either cycle the effect is stronger as the spots move closer to the sun's equatorial line. We won't go further into this subject except to state that the level of ionization seems to be directly dependent on the number of sun spots.

The cycles actually overlap each other. The current cycle was first noticed several years ago, but will not reach a peak until 1980.

We have, in very general terms, established that layers do exist above the Earth and that they will reflect radio signals, depending on the degree of ionization. We can now direct our attention to the more specific aspects of getting our radio signals from here to there.

We mentioned that both absorption and reflection take place when a radio wave enters an ionized layer. Some of the energy used to excite the ions will be expended in this job, but some will be bounced back.

The phenomena of reflection is very dependent not only on the degree of ionization, but also on the frequency of the radio wave. And that later is a variable because the frequency that will be bounced back is constantly changing in direct relation to ionization. Less ionization is required to reflect the lower frequencies than the higher frequencies.

At any one time, for a particular zone of the layer, there will be a *maximum useable frequency or muf*. This represents the highest frequency that will be reflected back to Earth from a specific area of the layer.

The layer is not a homogeneous mass surrounding our Earth with uniform thickness and density. Rather it is constantly expanding and contracting, moving up and down, and variable in the amount of ionization.

For any particular path between two points on our Earth the layer will be in a given state. It will reflect signals up to some maximum frequency. Beyond that the signals will not be reflected, but will penetrate the layer completely.

### Changing muf

From the foregoing you can see that the muf is not constant each hour, but must be calculated over a specific radio path, taking into account the degree of ionization that will exist over that path. In general you can get a pretty good idea of possible radio paths if you can visualize the illumination of the Earth as if you


One side of my great circle pointer. The bearing of 197° would put me in Israel on "long path".

were looking at it from outer space. The tv pictures that our astronauts sent back of the terminator line—the edge of darkness and light—from the moon were spectacular proof that half the Earth is in relative darkness half of the time. There is a wide variation depending on time of year and latitude, but while the rays of the sun are hitting, the layers will be ionized to some degree.

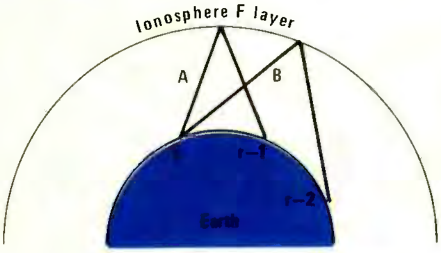


*Figure 1* **Showing that high angle signal at A will travel less the distance than the low angle signal at B.**

Your radio signals will travel over the path that offers the best reflecting surface back to Earth. If you are not using a beam antenna, you pretty much have to take what comes. You will notice that the radio path seems to generally move with the sun. As signals fade from the east they pick up strength from the west. This is directly attributable to the decreasing ionization as the F layer thins out and splits into two separate layers.

Generally the first frequencies to lose the reflection necessary for communication are the higher ones, since they require more ionization. First you'll lose contacts on 10 meters. Then, later, 15 will drop out. In winter time, 20 will then drop out and you'll be left with skip propagation only on 40 meters or lower bands.

In summer, during the peak period of the sun spot cycle, 20 meters will be open to some spot on the Earth on a 24-hour basis. 15 meters will frequently be open until almost midnight to the west and even 10 may last well into the evening.

Now, before all of you CBers land on my head with your skip contacts late at night, let me hasten to add that I am talking about radio paths using the F layers. The E layer, which provides one bounce contacts over a 1250 mile maximum path, is also subject to occasional retentions of a high degree of ionization, particularly in the spring and fall months.

This is known as sporadic E skip and it accounts for those very loud signals heard on the higher frequencies over relatively short ranges. Usually the sporadic E skip is fairly local in nature, since the ionization takes place in only particular areas of the layer. You may hear loud signals out of the northwest, but nothing from other areas of the country.

For this discussion we are relating only to the skip from the F layer(s) and preferably obtained with the use of a directive antenna—a rotary beam. In order to make use of the optimum radio path between our location and that of the station we are trying to contact we must know something of both the probable area of best ionization and the correct heading in which to point our beam.

## Unlearn old ideas

Heck, you say, point the beam right at the station you want. Right. But, what is *right at?* If you are used to looking at the typical mercator projection map you are going to have to unlearn your idea of directions when it comes to pointing your beam antenna.

From grammar school onwards we are shown maps which seem to indicate that certain areas of the world lie in well-defined directions from our country. You want to talk to Rome from Chicago? Heck, you're almost on the same latitude. You can just about draw a straight line going east and connect the two cities. So you point your beam due east at 90 degrees, Right? Wrong!

Radio signals generally prefer to take the shortest path between two points. Sure, that's a straight line. But it's using the "great circle" path—the same path international airplane flights take if they want to go non-stop the fastest way. You can get a good idea of this path if you pin a string on a globe of the world at your location and then move it around to find the shortest length that will get you to another location.

If you don't have a globe use an orange and visualize where the countries are. Now you will find that your heading for Rome from Chicago should be northeast, not east as you expected.

With a little practice you will quickly start to think in these new dimensions. You will realize that aiming over the polar regions is frequently the shortest path. A great circle chart of the world will aid in finding the right direction. But, you should be aware that it must be centered near your location to be correct, as far as antenna headings are concerned.

Even a shot from Los Angeles to New York City would be east northeast—about 60 degrees—in spite of the fact that we tend to think of "Fun City" as being east—90 degrees. You should learn to visualize the path your signal will take, where it will hit the layer, where it will come down and bounce up again. Yes, I said bounce up again.

Even with a low angle of radiation and a bounce off of the F layer the longest single hop distance is around 2500 miles. The distance from San Francisco to Rome is 6228 miles on the great circle path—the shortest route. Obviously it can't be made on one hop. Most likely it will take three or four hops, depending on the best path and the angle of radiation.

This isn't done for free however. It is estimated that each hop takes about 10 dB off of the signals. That means that only one tenth of the power gets back on up for the next hop.

You can figure what a multi-hop path will cost in the way of lost signal strength. Even with that, I've heard signals from half way around the world pounding in at 30 dB over S-9. Don't lose hope of being heard just because you have to bounce your signal many times.

## Practical approach

Let's practice with a few radio paths to demonstrate how we can get from here to there and be heard with a strong signal. Our station is near Los Angeles. On a mercator projection map we can immediately see that it puts us at about 34 degrees latitude and 118 degrees longitude.

I have a quad beam antenna to squirt my signal in a particular direction. The first thing I did was to calibrate the antenna so that my indicator would show, in degrees, exactly what direction it was pointing. To do this accurately I had to know the deviation between *magnetic* north and *true* north, since all bearings are based on true north. For this location the variance is 17 degrees, so I allowed for that correction before bolting the boom-to-mast coupler into position.

Another thing that helps me to work DX is a good 24 hour clock set for GMT, now known as *Coordinated Universal Time* or UTC. Not only do I always keep my log book in UTC to avoid time and date problems when QSLing DX stations, but also I know the local time for most parts of the world.

That's important in calculating how much of the "path" between my station and other parts of the world is or has recently been, in sunshine.

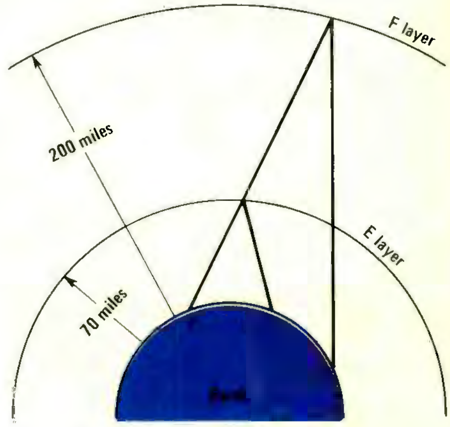


*Figure 2* **Showing radio wave reflection off of both E and F layers. Distance at r—2 will be twice that at r—1.**

What about a bearing to swing the quad antenna to? I have a handy little device that is a cardboard great circle map centered on California. It has a plastic pointer that rotates from the middle. I move it to point to the location I want to reach. If, for example, I wanted to communicate with a German station,

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