Newcomers and Elmers Net: FM DXing
07/19/15 Robert AK3Q

Summertime is a mixed bag of opportunities for radio listening.
-- E-skip, tropospheric ducting, scatter, and refraction all make FM DXing fun and challenging.
-- As summertime static crashes interfere with AM listening, the action in the troposphere makes for great opportunities to hear FM stations as far away as 1,000 miles or more!
-- I'll begin by looking at some of the atmospheric issues which help our DX, then move on to equipment and techniques after that.

FM broadcast and amateur signals typically begin in the VHF portion of the band, while TV signals are in both the VHF and the UHF regions. I mention TV signals only because these signals often go hand-in-hand when looking for DX stations;
-- many folks who enjoy FM DX also enjoy catching distant TV signals as well. With the move to digital signals in the U.S. this has become harder in some ways, but TV DX is still alive and well, and much of the information provided here for FM will also work for TV.

FM signals are considered "line-of-sight" because they travel through the atmosphere without a lot of refraction (except as noted below), meaning they do not usually curve back down to earth.
-- FM signals break free from the atmosphere and travel on into space except when certain conditions exist which are favorable to refraction.
-- "Line-of-sight" is something of a misnomer in that FM signals will actually travel a bit further than the true line-of-sight, but not much more. About 10-15% under normal conditions. For my purposes here I will use the conventional line-of-sight language to refer to the signal path.

Weather Is Our Friend
By far the most influential factor for FM DXing is weather, and conditions in Spring through Fall are ideal.
-- If you are an avid DXer in any part of the spectrum you will already know chasing DX is not about hearing crystal-clear signals reliably found any time of day.
-- We call it *chasing* DX for a very good reason: sometimes signals may last only a moment or two, just long enough to hear a song or two and a station ID (hopefully).
-- on repeaters, we may only hear parts of a conversation or a repeater ID
-- Oftentimes one must listen repeatedly to catch a station's ID, or wait days or weeks to hear it again. Some stations never return at the right time, and we can only make guesses based on content, direction, etc.

There's nothing quite like finally being able to log that elusive signal fluttering in during a meteor shower or a Sporadic-E opening.
-- Our old friend *propagation* really comes into play with FM signals since some form of scatter or reflection/refraction is happening almost continually.
-- Temperature changes have a huge impact on the distance signals may travel, as well as seasonal highs and lows which affect the MUF (Maximum Useable Frequency).
-- The normal FM radio signals which may be relied upon day or night at any given location are usually unaffected by weather as the power levels and the close proximity of the signals allow for clear reception.
-- Weaker or more distant signals can be affected by a number of different atmospheric issues, and this is where things get exciting.

Tropospheric Scatter
Tropospheric scatter occurs regularly under a number of conditions, almost year-round, as signals are scattered about due to slight changes in temperature and humidity/barometric shifts.
-- As the term implies, signals are scattered in all directions including forward—these are the bits of the signal which allow for greater than line-of-sight reception.
-- Common reception distances can be 200-300 miles, sometimes out to 400-500 miles on a good day.
-- Reception is weaker, of course, since only a portion of the signal is being received, and the signals flutter a bit.
-- Unlike other forms of propagation such as skip and ducting, tropo-scatter tends to extend a signal's reach rather than allowing a signal to jump over a particular region.

It is worth noting for Amateur operators this tropospheric scatter works well for transmitting as well as receiving, and VHF/UHF communications are extended far beyond line-of-sight.
-- This can make for some exciting loggings. Adding height can significantly increase distance, so even if your base station is limited, get a portable station together and try finding some high ground like a hilltop or the roof of a tall building.
-- With scatter effects the increase in height multiplies the distance your signal can travel.

Tropo-scatter is affected by several things:

- free space loss from transmitter to the horizon
- scatter loss as signal interacts with troposphere
- free space loss from the horizon to receiving antenna:

While distances may be calculated mathematically from known points in free space, real-world conditions will always be changing and so these calculations are only a starting point.
-- The good news is that tropospheric scatter happens every day, and this means FM DXing (as well as Amateur FM work) is always possible to one degree or another.
-- No doubt you have experienced this effect even though you might not have known it at the time.
-- Even as seasons change tropo-scatter still happens, and while one region of the world may slow down for DX, another region is opening up.
-- This means there is a lot of fun to be had any time of year if you know where to look!

Two other aspects to tropo-scatter are worth mentioning. First, scatter is relatively frequency independent above 30MHz.
-- This means whatever VHF or above frequencies are used tropo-scatter is available to enhance DX.
-- Second, polarization remains relatively constant during scatter, so antennas which are both horizontally polarized will work best together if you are working another amateur station. For broadcast stations your receiving antenna will likely be horizontally polarized as well in order to have some directionality.

Scatter Sound Quality
The quality of the signal reaching your antenna is dependent on a number of factors, including the scatter angle and the amount of phasing which occurs at your location.
-- Signals arriving at different times or from different directions will be slightly out-of-phase, meaning there is a slight time delay or a slight conflict between signals of different polarizations.
-- The greater the scatter effect the more distortion one is likely to hear.
-- Often the signal is not so much distorted as it may sound a bit hollow.
-- Remember, this is DX work and signal fidelity is not our primary concern—logging that elusive station is! Some fading is inevitable especially with more distant signals.
-- Slow fading is likely caused by small shifts in the atmosphere, while rapid fading is more likely due to small but rapid movements of the scattering materials in the atmosphere.
-- Even a plane flying overhead between the signal and your radio can cause fading! Be sure to keep a log book handy and take good notes. You'll learn a fair amount about propagation as you do, and these lessons will serve you well in all parts of the radio hobby.

While tropo-scatter can be active all year long, warmer months tend to work best, probably because the tropopause (the highest layer of the troposphere) is higher in warmer months, and there is also likely more humidity as well.
-- The area of the tropopause is where most scattering occurs, so it follows if this is higher then the DX will be longer as a general rule.
-- Since the troposphere is highest along the equator, one can expect the strongest scatter to come from that direction.
-- However, much more important for personal use is knowing what is going on in the atmosphere around you regardless of your proximity to the equator.
-- Storm fronts can cause heightened tropospheric activity, as can changes in the Jetstream and turbulence caused by other weather factors.
-- If you live near an airport you may find this information is available through their weather services, or you can check online at: http://www.dxinfocentre.com/tropo.html

As a side note, for Amateur communications you might find 70 cm a better band than 2 meters for scatter partly because the noise floor is lower for UHF and therefore receivers "hear" better.
-- Also 70-cm antennas usually have better gain than 2-meter antennas, and since the signal itself is smaller it can be scattered more easily. Just my little plug to beef up our usage of the 440 band!

Tropospheric Ducting
Tropospheric ducting has some of the same characteristics of scatter, but with some significant differences as well.
-- Think of ducting as a hallway or corridor or tunnel by which radio signals can travel long distances like an express route.
-- The signal rides along the tunnel until conditions allow it to return to earth again. Temperature inversions are the primary cause of ducting, as the warmer air caught over cooler air allows signals to travel along the inversion for 500 or more miles.
-- Rare instances of 1,000+ mile ducting have been recorded, but these are very rare.
-- Another way to think of ducting is think of thermal layers in the ocean. Submarines rely on thermal layers to mask their movements.
-- By going through several thermal layers a submarine may avoid detection from a surface ship or another submarine sailing in a different thermal layer.
-- TV signal propagation by ducting is fairly common, with signals regularly traveling over 500 miles during the summer and autumn months.
-- Ducting is most likely to occur near large bodies of water due to regular temperature inversions, but even foggy days can allow for ducting, as well as approaching storm fronts.

-- Keep an eye on the weather predictions for ducting opportunities, as well as a number of DX websites which will indicate when conditions are right.
-- Even if you are not an Amateur Radio operator, when conditions are good for hams then they are good for broadcast FM station ducting as well!

Some well-known DX contacts to whet your appetite for ducting:

★ During October 1975, several United Kingdom DXers received band III and UHF television signals from Finland, Poland, Czechoslovakia, and the USSR at a distance of over 1,000 miles (1,600 km).

★ On October 18, 1975, Rijn Muntjewerff, the Netherlands, received UHF channel E34 Pajala, Sweden, at a distance of 1,150 miles (1,850 km).

★ On December 3, 1975, Robert Copeman, Sydney, Australia, received Auckland, New Zealand, TV-2 NZch4 band III TV at a great-circle distance of 1,340 miles (2,157 km).

★ On June 13, 1989, Shel Remington, Keaau, Hawaii, received several 88–108 MHz FM signals from Tijuana, Mexico, at a distance of 2,536 miles (4,081 km).

★ Throughout the 1990s, Fernando Garcia, located at what could be considered an ideal tropospheric DX location near Monterrey, Mexico, received numerous 1,000+ mile (1,600+ km) stations via tropo, both over the Gulf of Mexico and past land. Among his most impressive loggings are WGNT-27 from Portsmouth, Virginia, at a distance of 1,608 miles (2,588 km) and low-power (LPTV) station W38BB from Raleigh, North Carolina, at a distance of 1,460 miles (2,350 km).

★ On May 11, 2003, Jeff Kruszka, living in south Louisiana, received a few UHF DTV signals from 800+ miles. The longest of these was WNCN-DT, channel 55, Goldsboro, NC at 835 mi / 1,344 km (as of current writing, the record for UHF DTV).

★ On the late evening of June 19, 2007 and into the early morning hours of June 20, 2007, three DXers in Eastern Massachusetts, Jeff Lehmann, Keith McGinnis, and Roy Barstow, received FM signals from Southern Florida via tropo. All three logged WEAT 104.3 West Palm Beach, Florida, and WRMF 97.9 Palm Beach, Florida, at distances of around 1,200 miles, and Barstow logged WHDR 93.1 Miami, Florida, at a distance of 1,210 miles.

Sporadic-E Skip

Sporadic-E Skip is another propagation condition which can greatly enhance FM DX.

-- Hams familiar with this effect often see great 6 and 2 meter skip conditions during Spring and Summer months, and the FM broadcast band falls right in the optimal skip range.

-- Sporadic-E Skip occurs in the "E" layer of the atmosphere, and allows for single or multi-hop reception over great distances. Single-hop reception is common out to around 1500 miles, while multi-hop reception is common out to 2400 miles and more.

-- Unlike scatter, E Skip signals actually bounce over whole regions such that there will usually be a dead zone between where the signal falls off naturally from line-of-sight distances, only to bounce out to a thousand miles or more.

-- The part of the signal which enters the "E" region of the atmosphere is the part which is reflected back to earth; the rest of the signal behaves normally.

-- Often Tropospheric Scatter is mislabeled E-Skip or ducting, and it can be a bit confusing due to the distances involved.

-- To help clarify things, just keep in mind Scatter adds a moderate boost to a regular signal's reception capability, while both ducting and E-Skip add significantly to its distance reception.

-- Ducting occurs most commonly as a result of extreme temperature inversions, and reception of ducting signals requires both the transmitting antenna and the reception antenna be "in the duct." If the receiving antenna is below the duct (or above it) the signal is usually unreadable.

-- With E-Skip, the receiving antenna just needs to be in the path of the Skip—there is no layer effect on the signal.

Some Keys To Success With Skip, Scatter and Ducting

The biggest key to working Sporadic-E openings is just to be available.

-- Watch ham radio prediction sites or check out DX cluster sites for current conditions and then turn your radio on!

-- Also, don't assume Skip, Scatter, or Ducting isn't happening just because no one is talking about it—you may be the first one to start the ball rolling.

-- There is no substitute for simply listening at every opportunity. You can't work them if you can't hear them.

-- Since Scatter happens almost all year long, concentrate first on regions where you are most likely to be successful. If you have a big city with lots of buildings—try to point your radio wherever there is less congestion as you start to get a feel for FM DXing conditions.

-- After you have some good success with easier signals, try for harder, more challenging ones. These may be lower power stations, or more distant stations.

-- There are resources on the Internet which list stations by call sign and location, so find out what stations are in your general area and try to work them.
-- As you get more experienced you will be able to pull out weaker and more distant signals, and soon your log will be filling up with stations 100’s of miles away.

Whether it is FM Broadcast, Public Service, Amateur Radio or TV signals, chasing DX can be a lot of fun
-- if you have a spare radio (or room in memory) to plug in some distant police/fire bands or amateur repeaters, that can be a good way to know when some of these special propagation conditions are available
-- when you hear a distant repeater ID or you hear police and fire calls from Indianapolis, for example, some skip or scatter is happening. If you get even further away, you are probably getting some ducting.
- same thing is true with FM Broadcast stations, although this can be harder because frequencies are repeated regionally
-- however you can listen for fading or just listen for unfamiliar station IDs
-- also, directional antennas turned away from a local station can pull in DX stations from another area.
-- the main thing is to experiment and have fun, and make sure you log your catches!