VHF/UHF Propagation – Why Your Signal Sometimes Acts Like It Has a Mind of Its Own

By Greg N5XO

Introduction – The Great Mystery Above Your Antenna

You key the mic…
Some days you're working stations 300 miles away like they're next door…

Other days you can't hit the guy across town who owes you coffee.

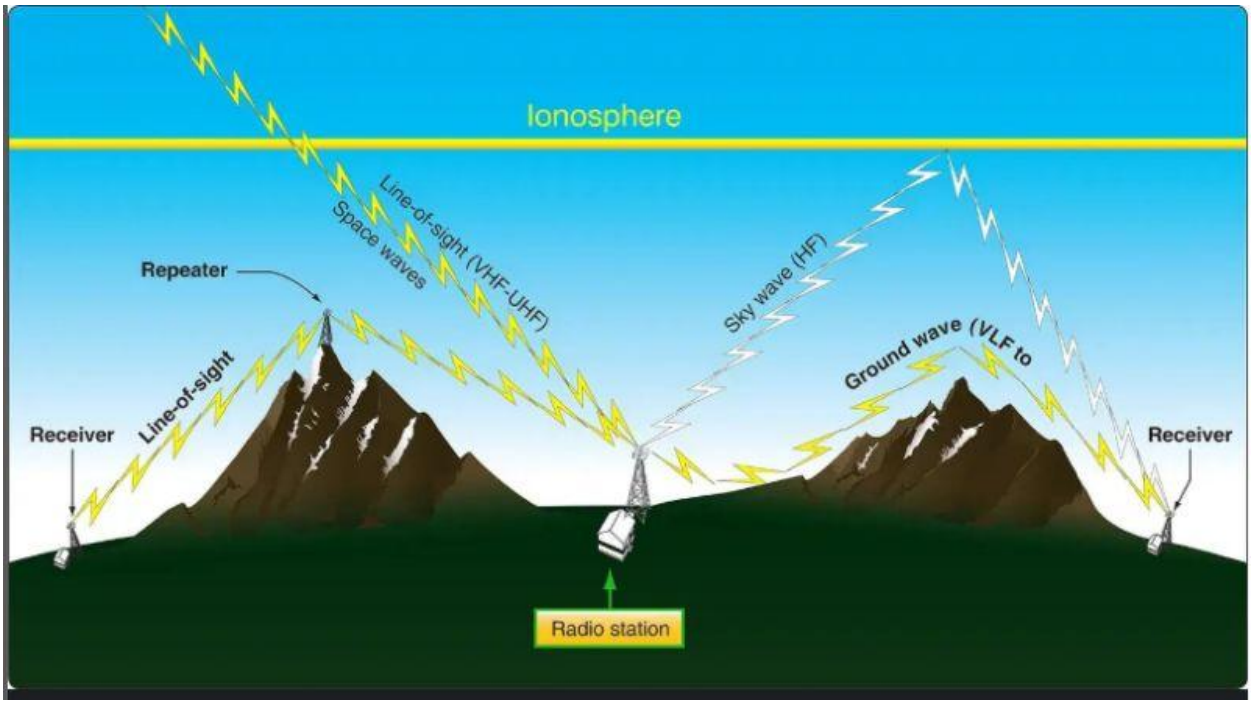
Welcome to **VHF/UHF propagation**—where the real "antenna farm" is the atmosphere above your head.

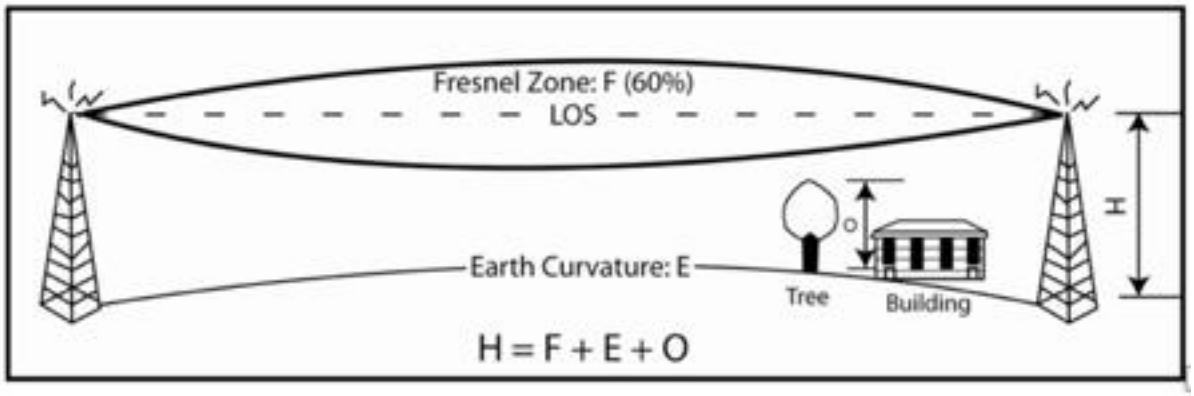
The good news? It's not magic.
The better news? Once you understand it, you can **predict it—and use it to your advantage**.

PART 1 – The Different Types of VHF/UHF Propagation

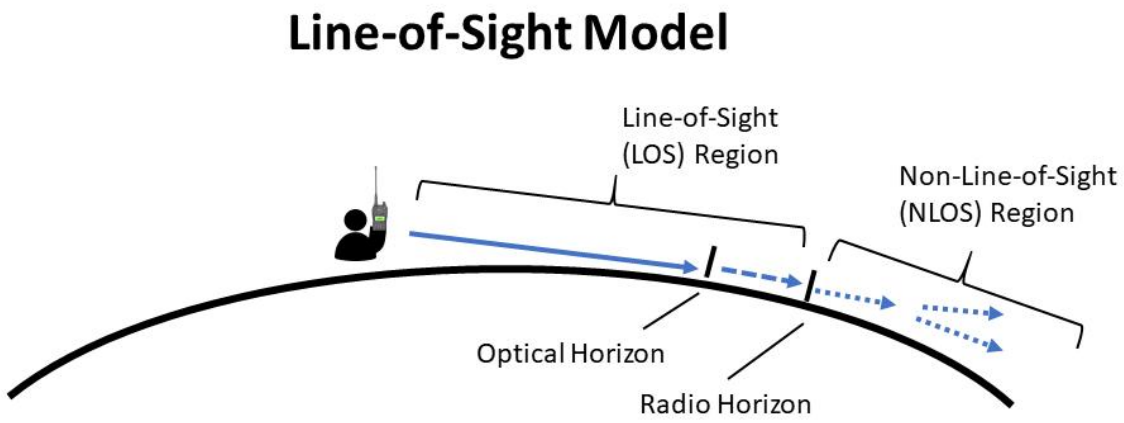
Let's break this down in plain English, starting with the most common and working our way up to the "wait…how is that even possible?" stuff.

1. Line-of-Sight (LOS) – Your Everyday Workhorse





Wireless Link Distance (Miles)	Value Fresnel Zone F (60% at 2.4 GHz.) Approx. Value	Value E (Earth Curvature) Approx. Value	Antenna Height H Antenna Height No Obstruction
1	2	3	4
3	23	4	27
5	30	5	35
8	40	8	48
10	44	13	57
15	55	28	83
20	65	50	115
25	72	78	150



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What it is:

- Straight-line communication from one antenna to another
- Limited by **Earth's curvature and terrain**

What helps:

- Height (get that antenna UP!)
- Clear path (no hills, buildings, or your neighbor's metal barn)

What hurts:

- Terrain (welcome to the Hill Country…)
- Low antenna height

Reality check:

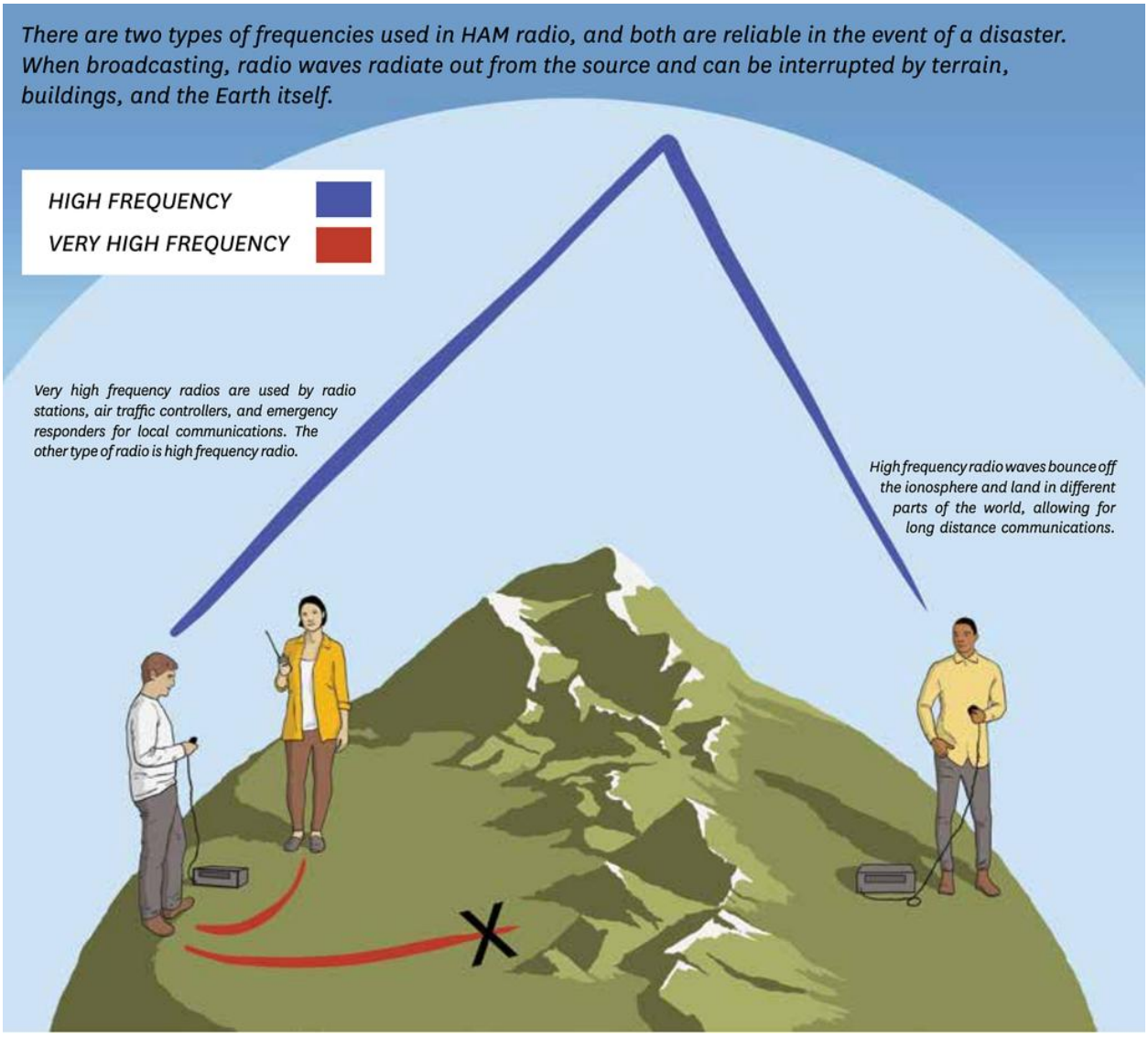
👉 Most 2m/70cm FM operation is LOS

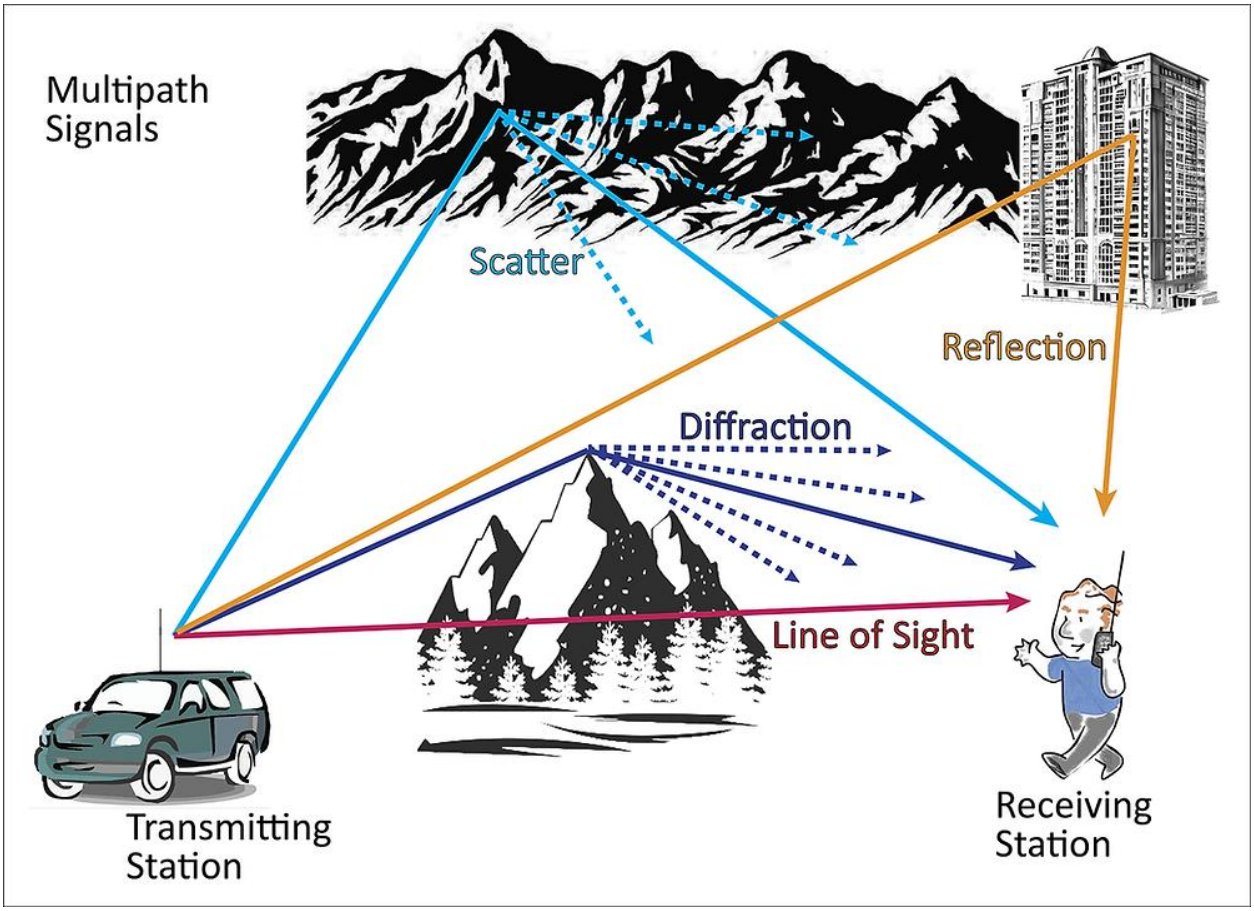
Rule of thumb:

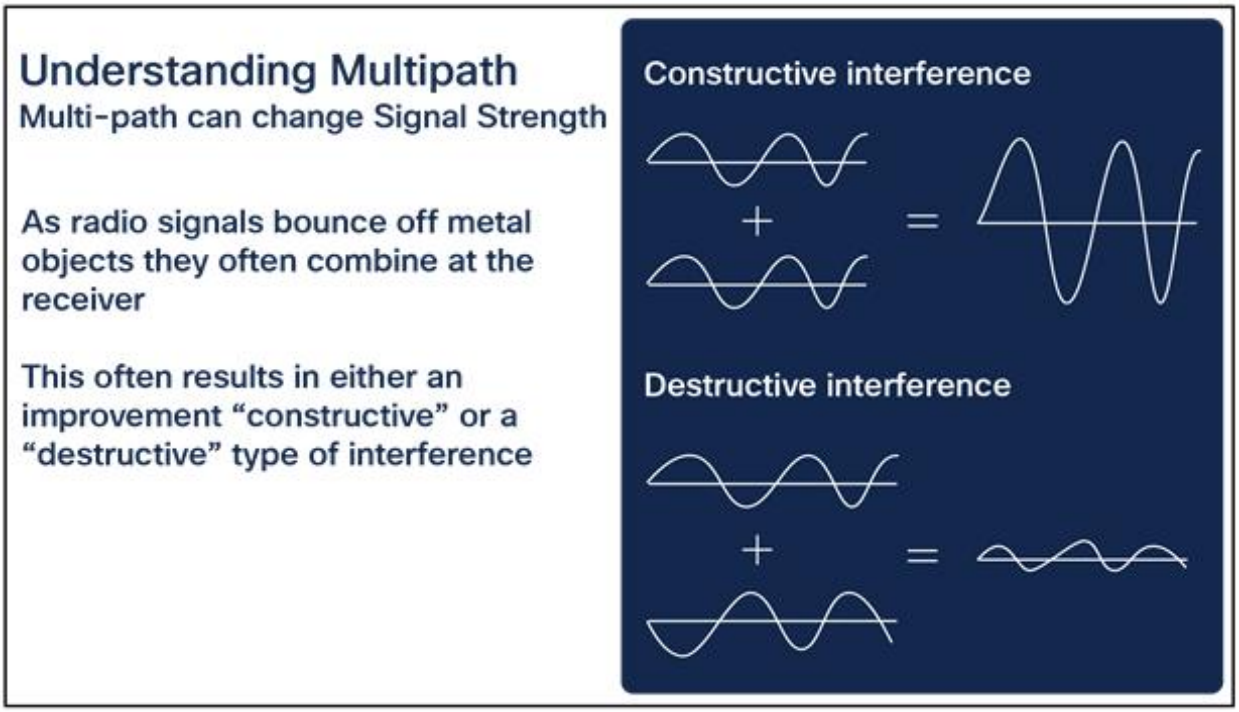
If you can "see" them (radio-wise), you can work them.

2. Ground Reflection & Diffraction – Bending the Rules (Literally)

There are two types of frequencies used in HAM radio, and both are reliable in the event of a disaster. When broadcasting, radio waves radiate out from the source and can be interrupted by terrain, buildings, and the Earth itself.




Multipath
Signals
Scatter
Reflection
Diffraction
Line of Sight
Transmitting
Station
Receiving
Station


Understanding Multipath
Multi-path can change Signal Strength
As radio signals bounce off metal objects they often combine at the receiver
This often results in either an improvement “constructive” or a “destructive” type of interference
Constructive interference
Destructive interference

What it is:

- Signals **bend over hills** or reflect off the ground and objects

What helps:

- Irregular terrain (yes, sometimes hills help!)
- Multiple signal paths

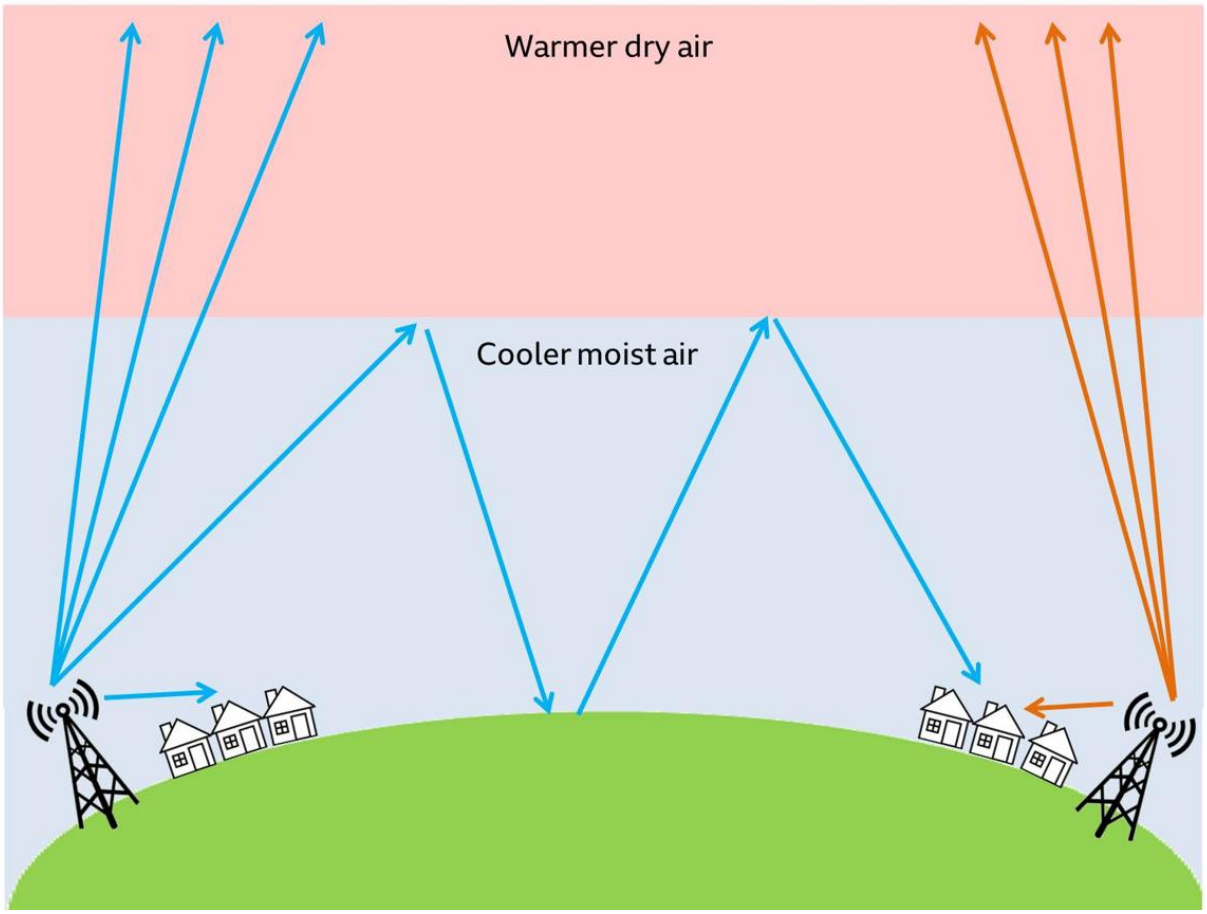
What hurts:

- Multipath distortion (that "picket fencing" sound on FM)

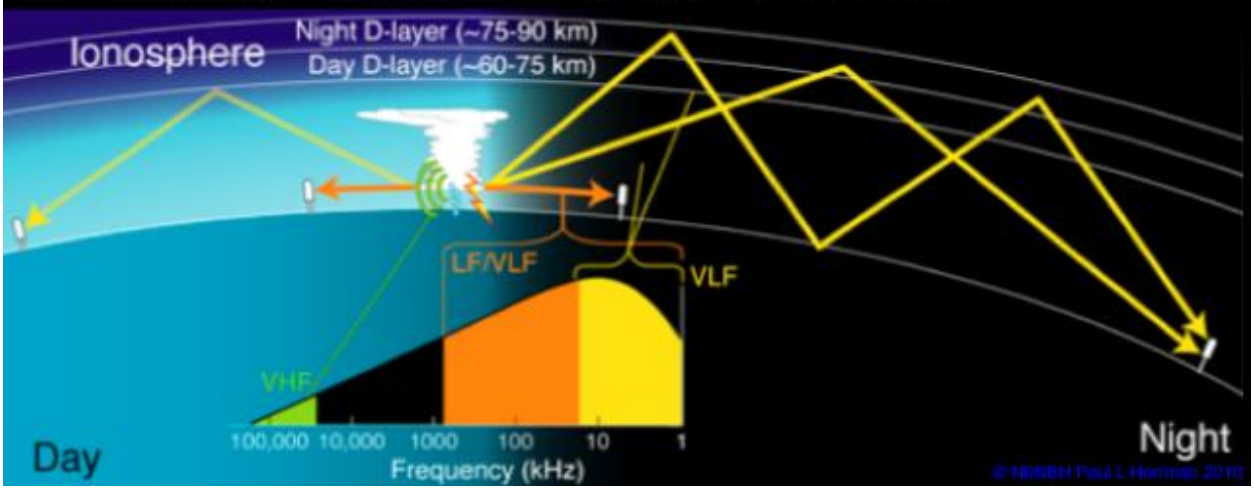
Reality check:

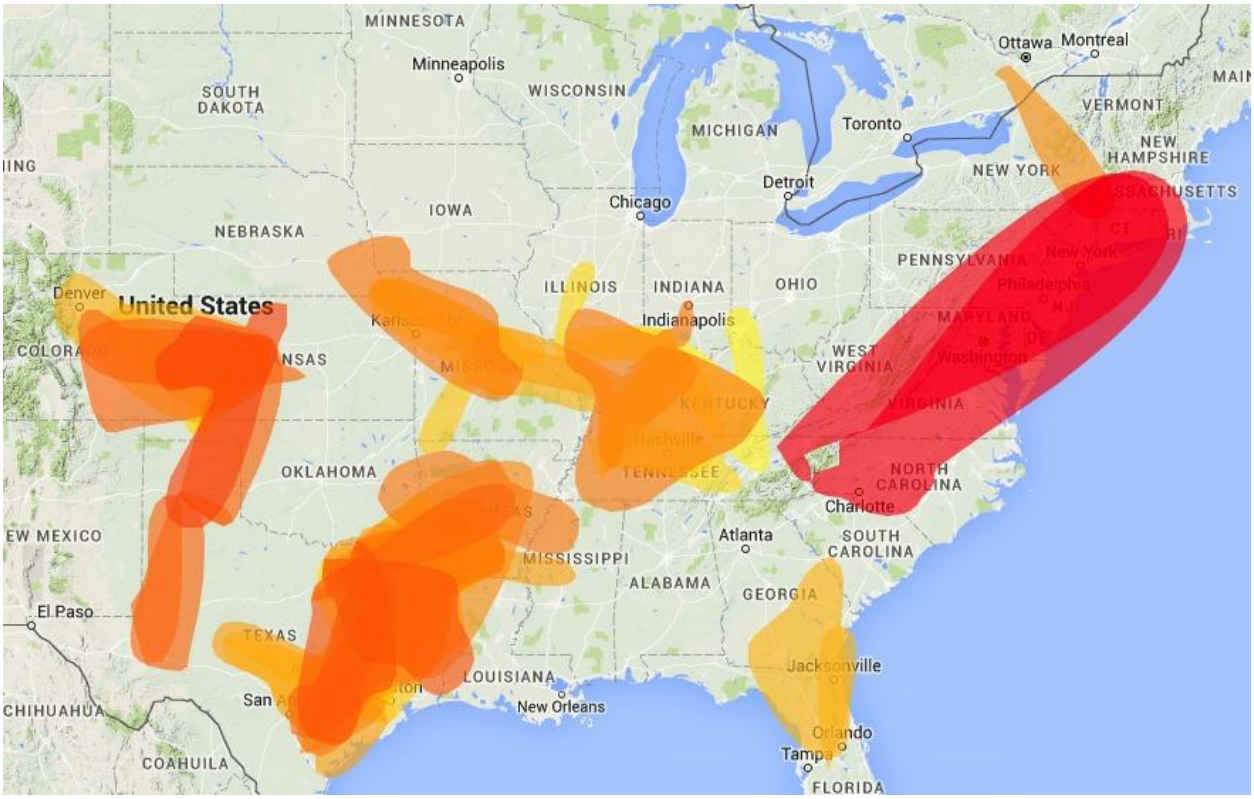
👉 This is why you can sometimes hit a repeater you "shouldn't" be able to.

3. Tropospheric Enhancement & Ducting – The DX Machine



Band	Frequency	Primary Mode of Propagation
VLF	3-30kHz	Guided between the earth & ionosphere
LF	30-300kHz	Guided between the earth & D layer of ionosphere. Also surface waves
MF	300-3000kHz	Surface waves. E, F layer ionospheric refraction at night, when D layer absorption weakens
HF	3-30MHz	E layer ionospheric refraction. F1, F2 layer ionospheric refraction. Auroral reflection. Meteor scatter
VHF	30-300MHz	Infrequent E ionospheric refraction (Es). Extremely rare F1,F2 layer ionospheric refraction during high sunspot activity up to 80MHz. Direct wave. Auroral reflection. EME reflection. Meteor scatter. Sometimes tropospheric ducting
UHF	300–3000MHz	Direct wave. EME reflection. Tropospheric ducting. Meteor scatter
SHF	3–30GHz	Direct wave. EME reflection. Tropospheric ducting
EHF	30–300GHz	Direct wave limited by absorption. EME reflection





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What it is:

- Signals get **trapped between layers of air** and travel long distances

What helps:

- **High pressure systems**
- **Temperature inversions**
- Calm, stable air

What hurts:

- Storms, turbulence, falling pressure

What you'll see:

- 2m contacts 200–800+ miles
- 432 MHz coming alive
- Signals that sound like locals…from another state

Reality check:

👉 This is where weak-signal SSB shines

👉 FM guys? You might get lucky—but SSB guys are cleaning up

4. Sporadic E (Mostly 6 Meters, Occasionally Higher)

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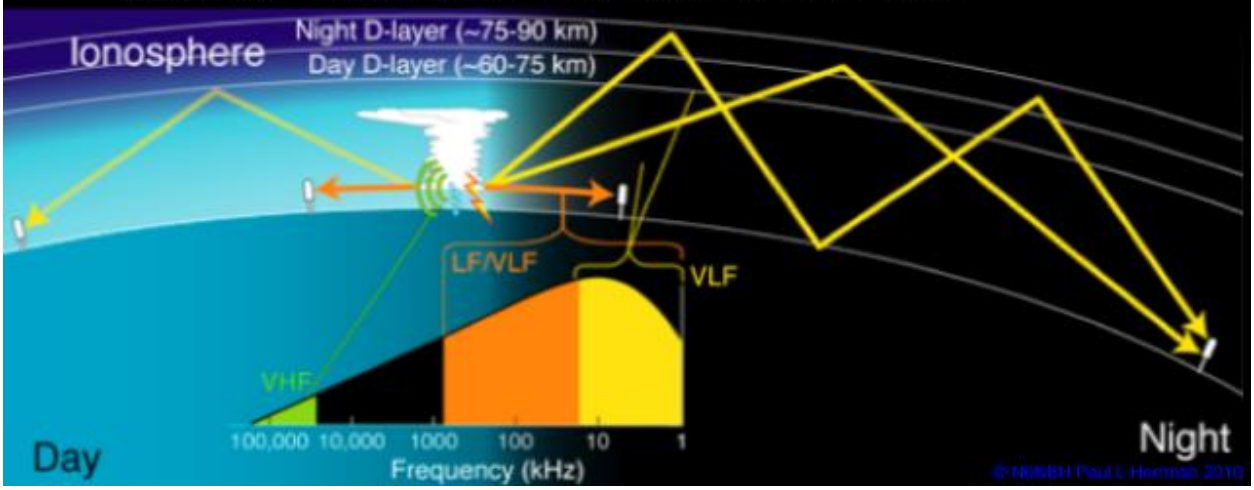

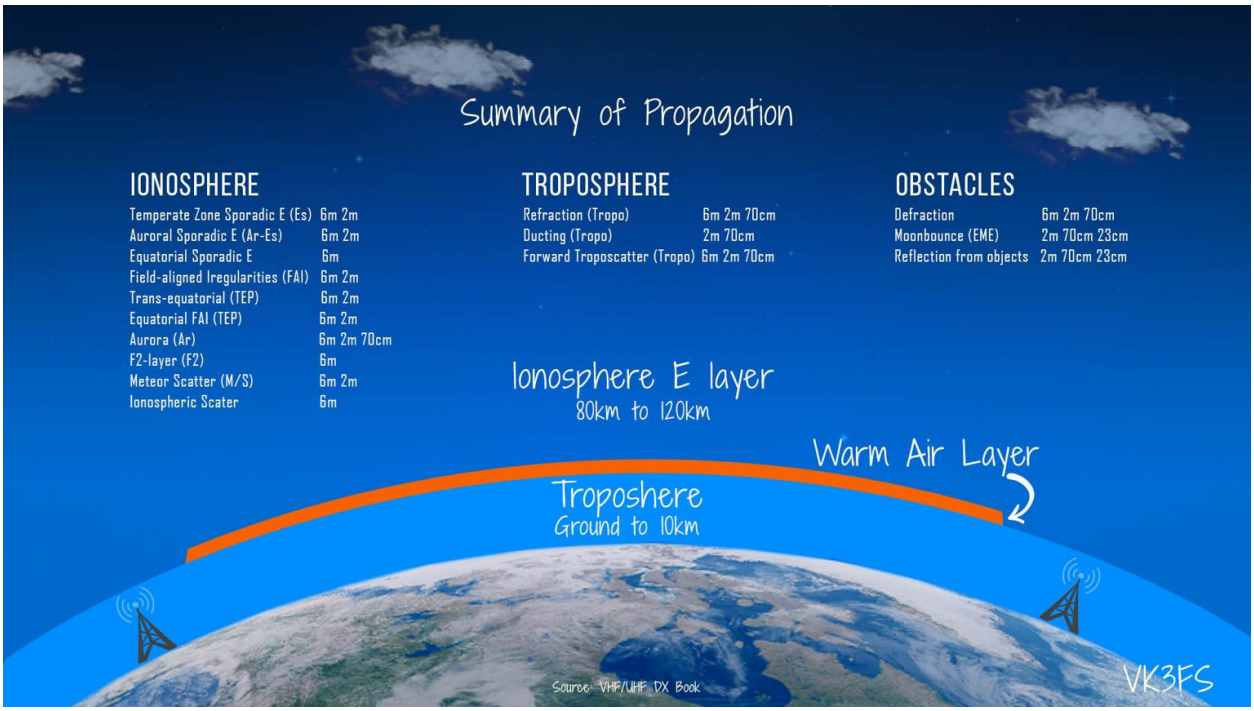

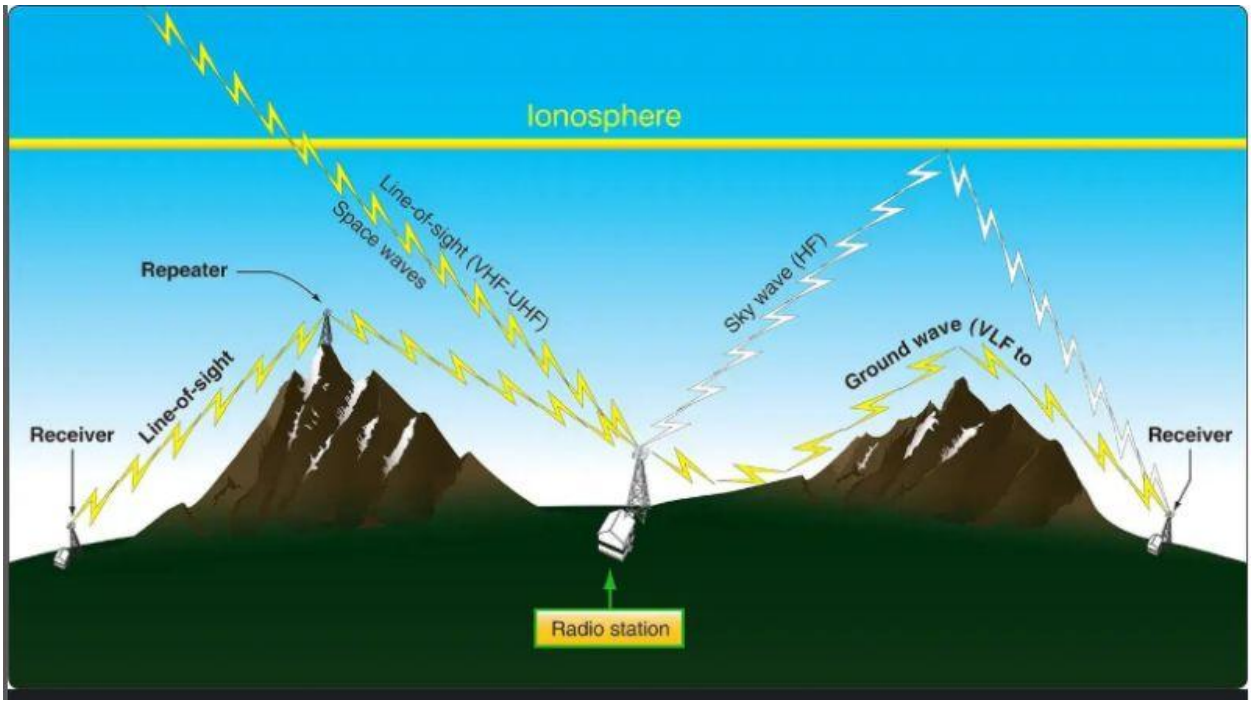

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What it is:

- Signals bounce off **ionized patches in the upper atmosphere**

What helps:

- Seasonal patterns (late spring/summer)

- Solar activity (sometimes)

What hurts:

- It’s unpredictable (welcome to the fun)

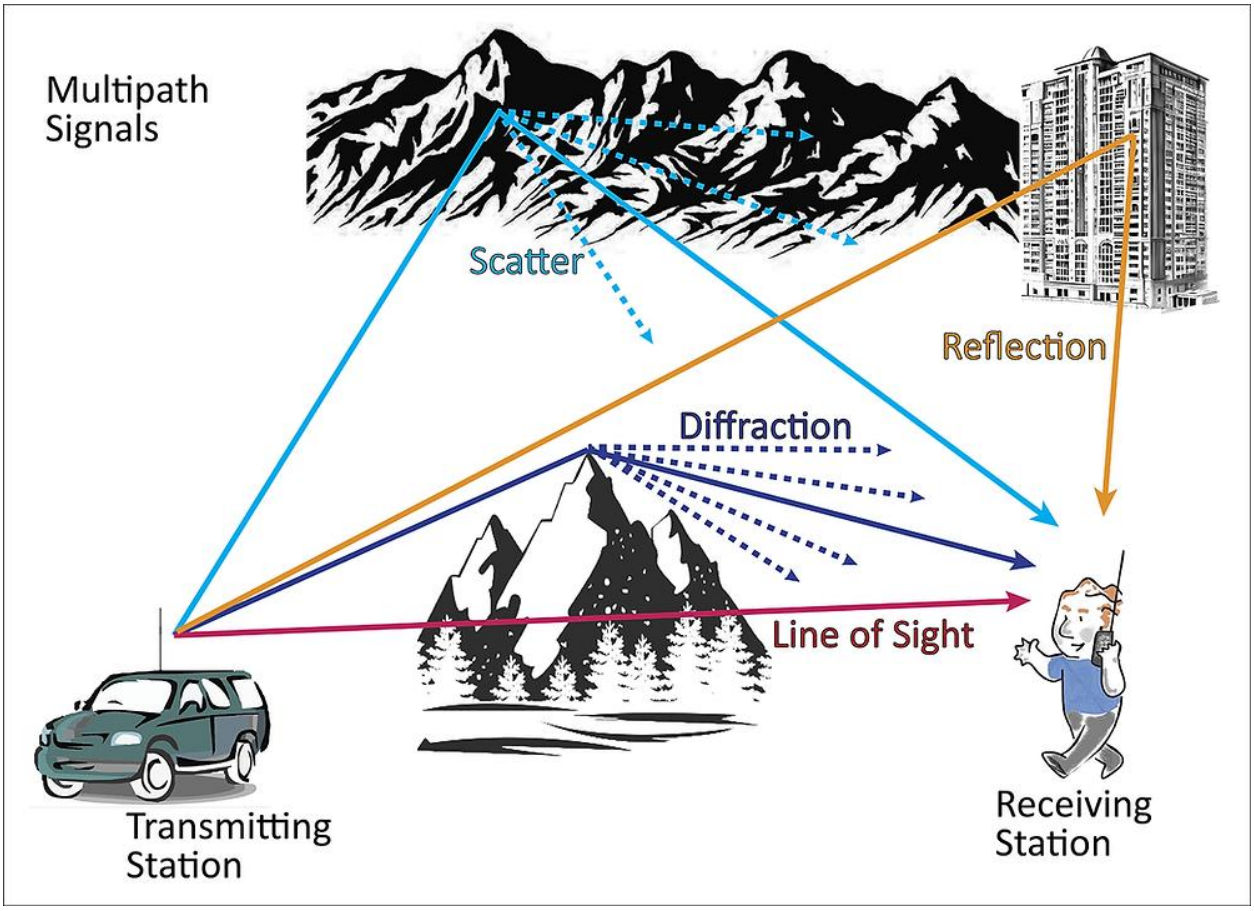
What you’ll see:

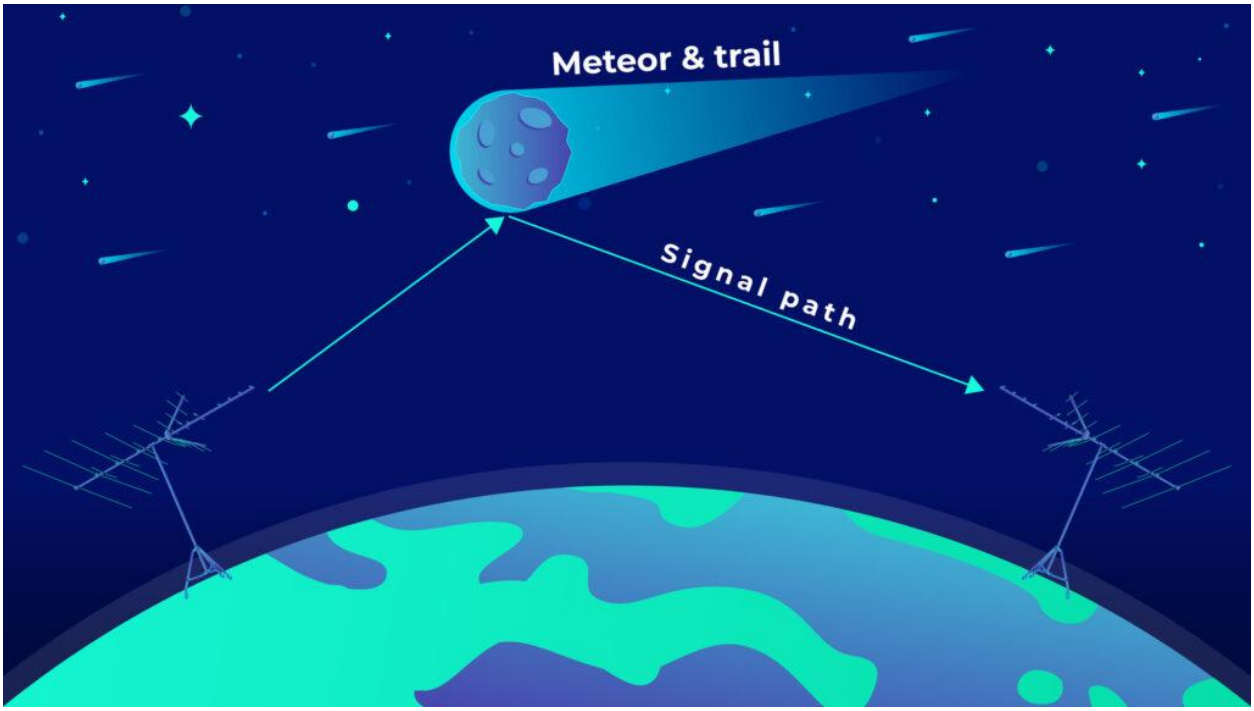
- 6m exploding with signals
- 1000–1500 mile contacts like it’s HF

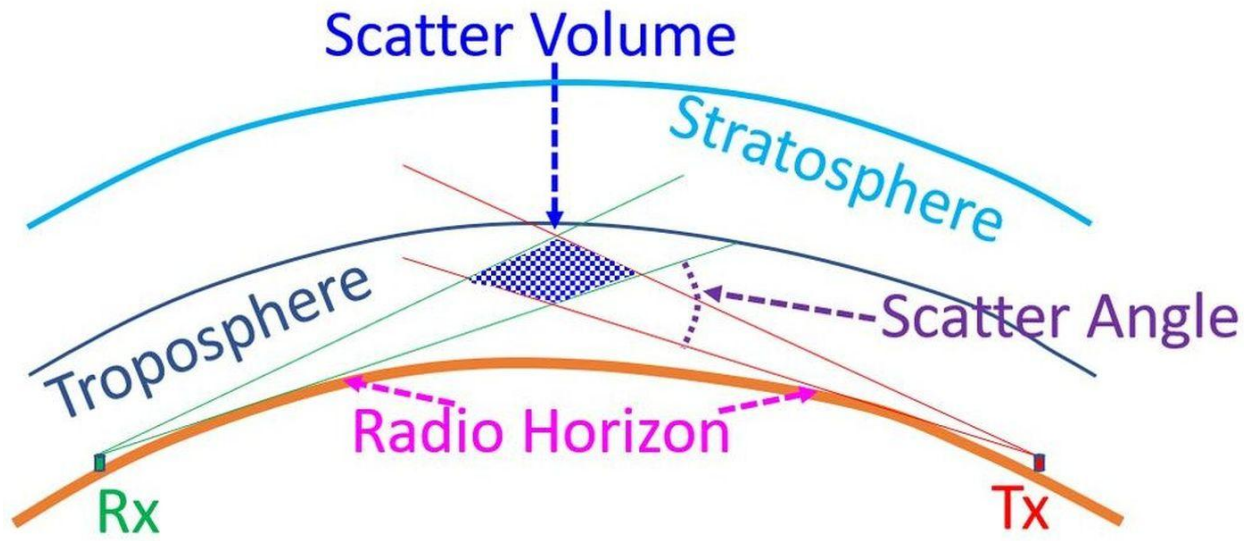
Reality check:

👉 Less common on 2m—but when it happens, it’s wild

5. Scatter Modes – When Everything Else Fails







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Types:

- **Meteor Scatter**
- **Aircraft Scatter**
- **Troposcatter**

What it is:

- Signals bounce off **tiny objects or irregularities**

What helps:

- Sensitive equipment
- Digital modes (FT8, MSK144)

What hurts:

- Weak signals (this is advanced territory)

Reality check:

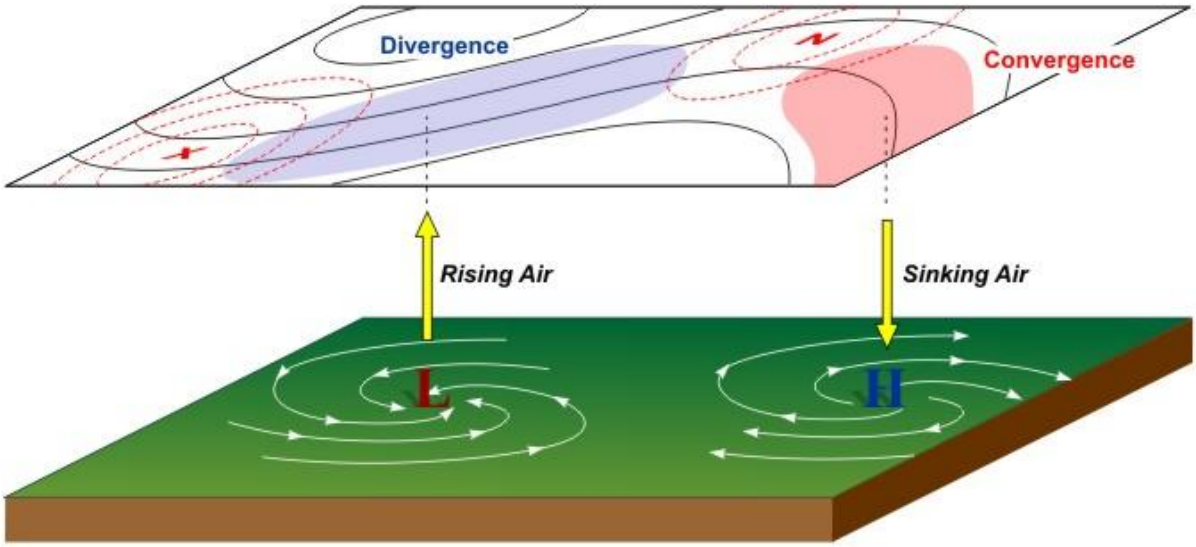
👉 This is where weak-signal operators live

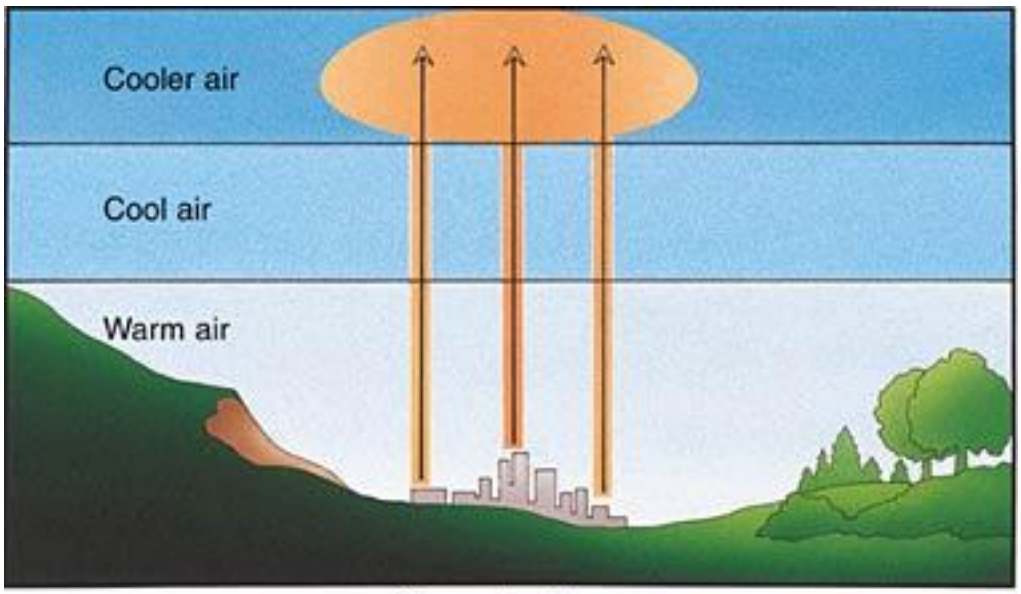
👉 FM? Not invited to this party

PART 2 – How Weather Impacts Propagation

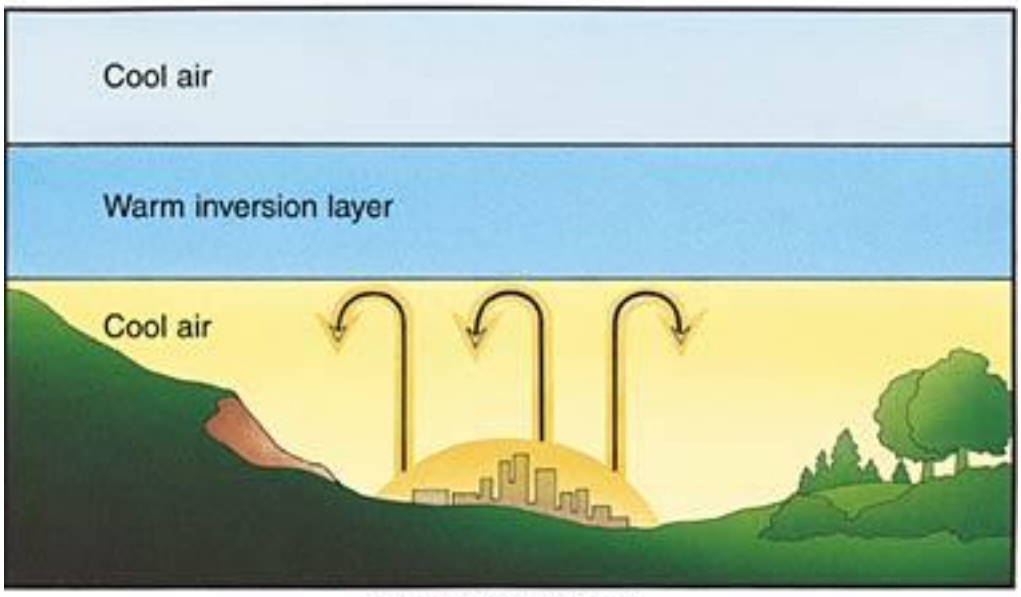
Now here's where things get interesting—and where most people get it wrong.

High Pressure = Your Best Friend

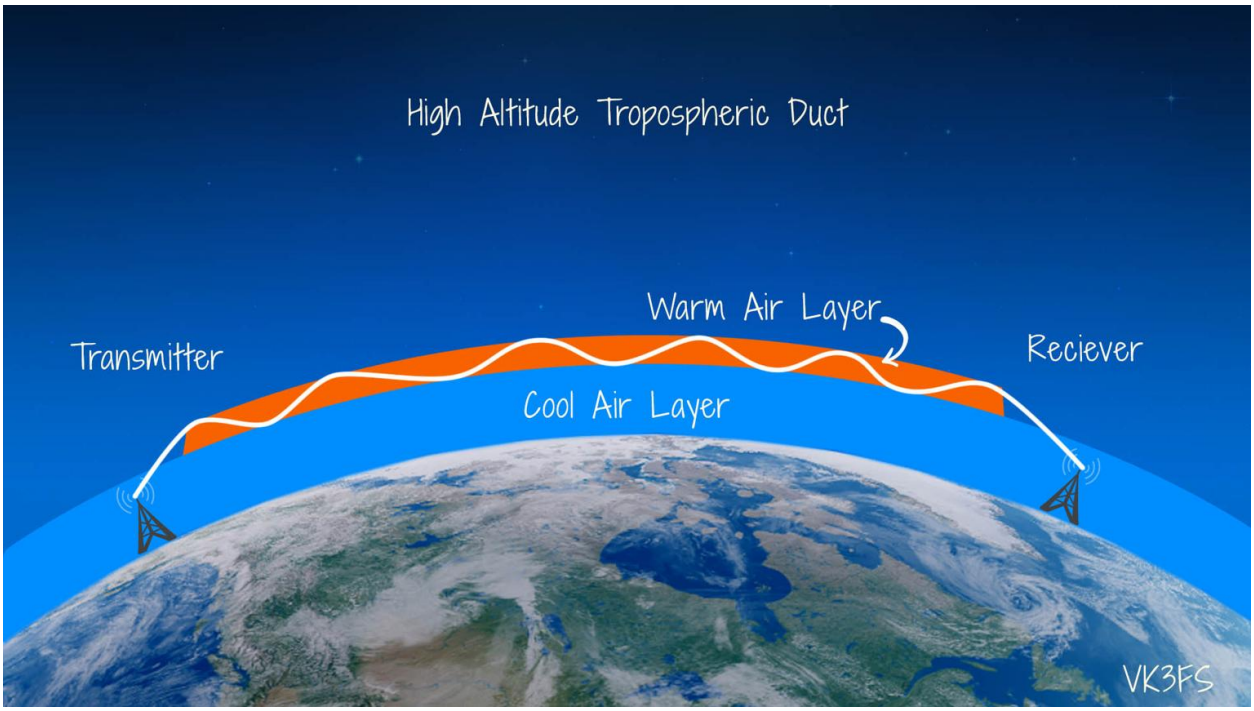




Normal pattern



Thermal inversion



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What's happening:

- Air is **sinking and stable**
- Layers form (inversions)

What it does:

- **Bends signals back toward Earth**
- Creates **ducting paths**

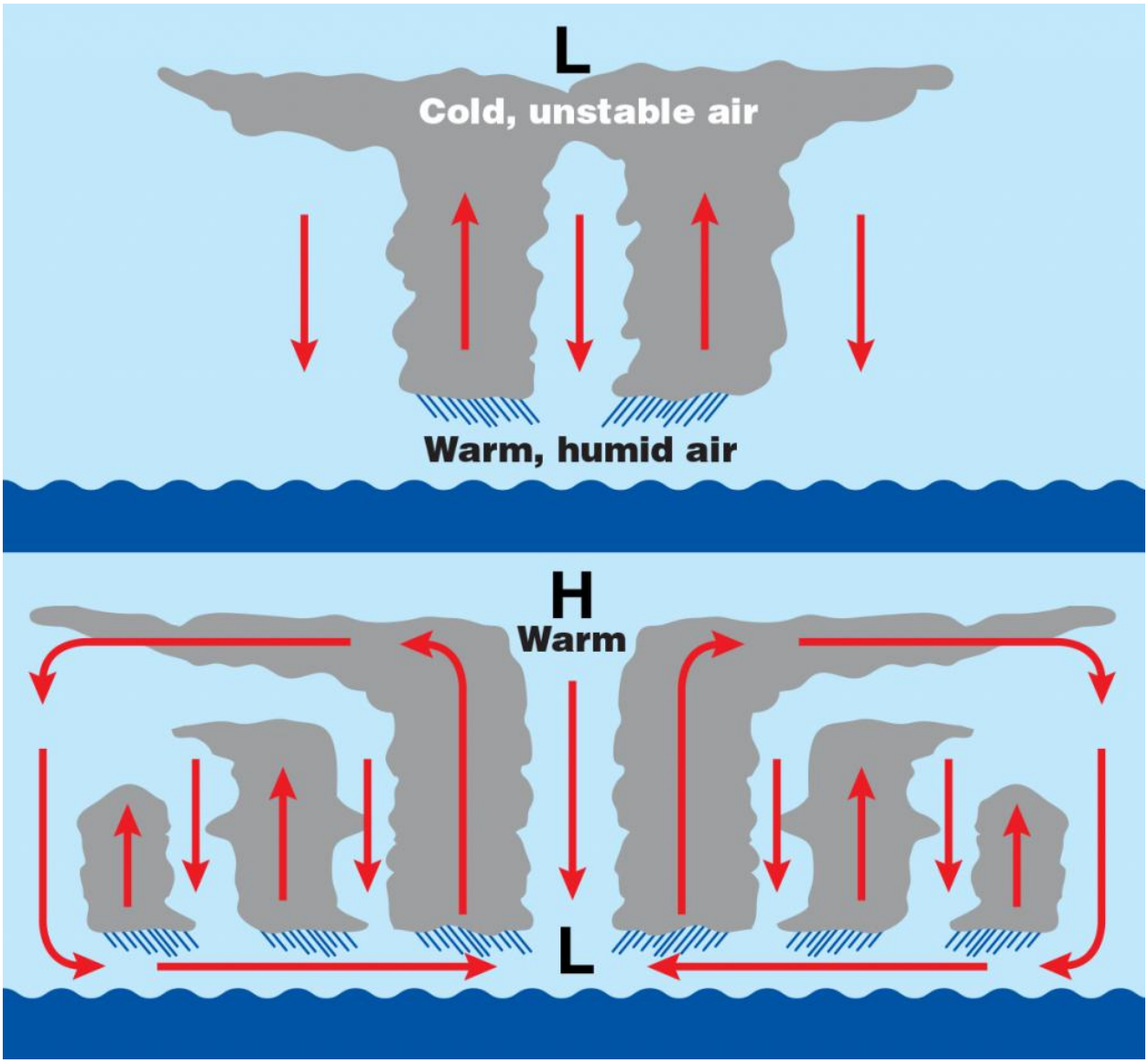
Result:

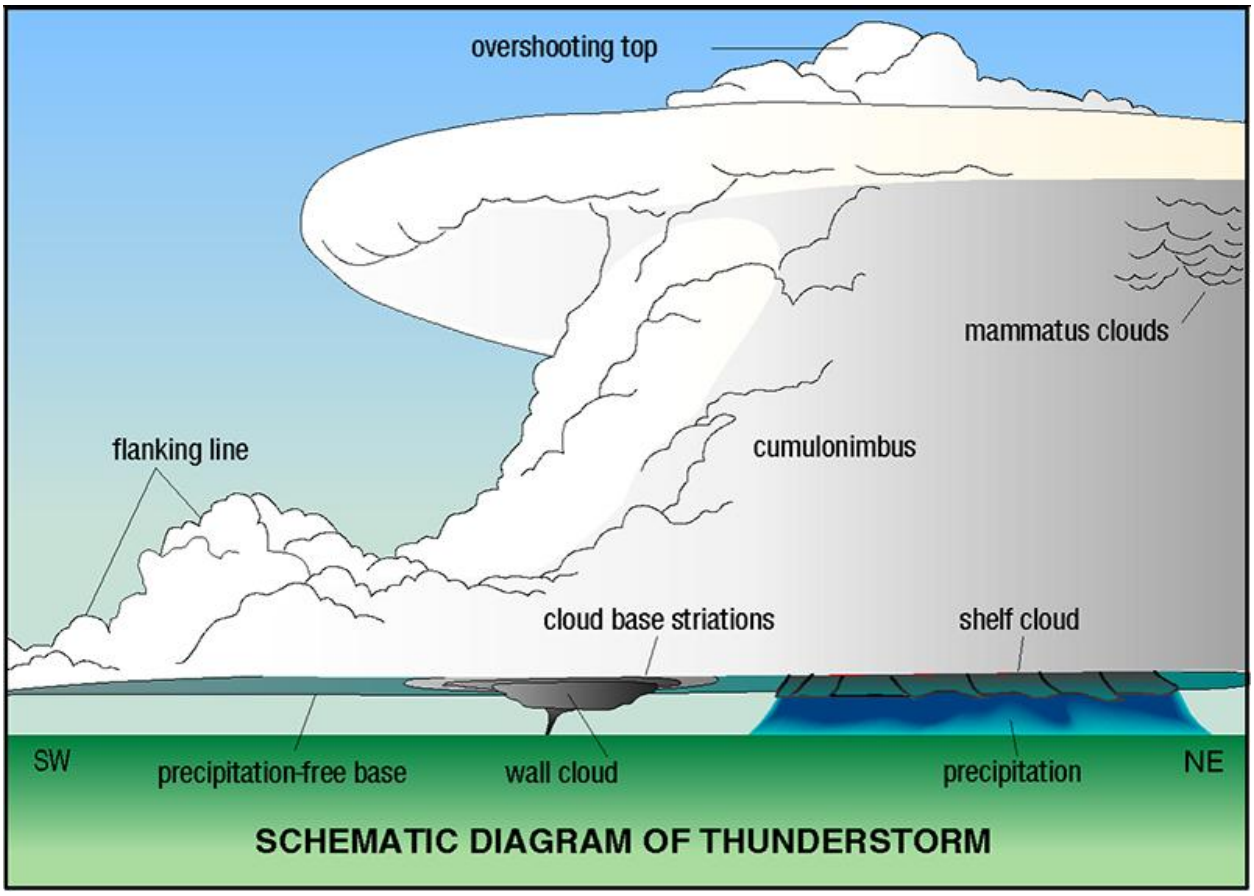
✅ Long-distance VHF/UHF

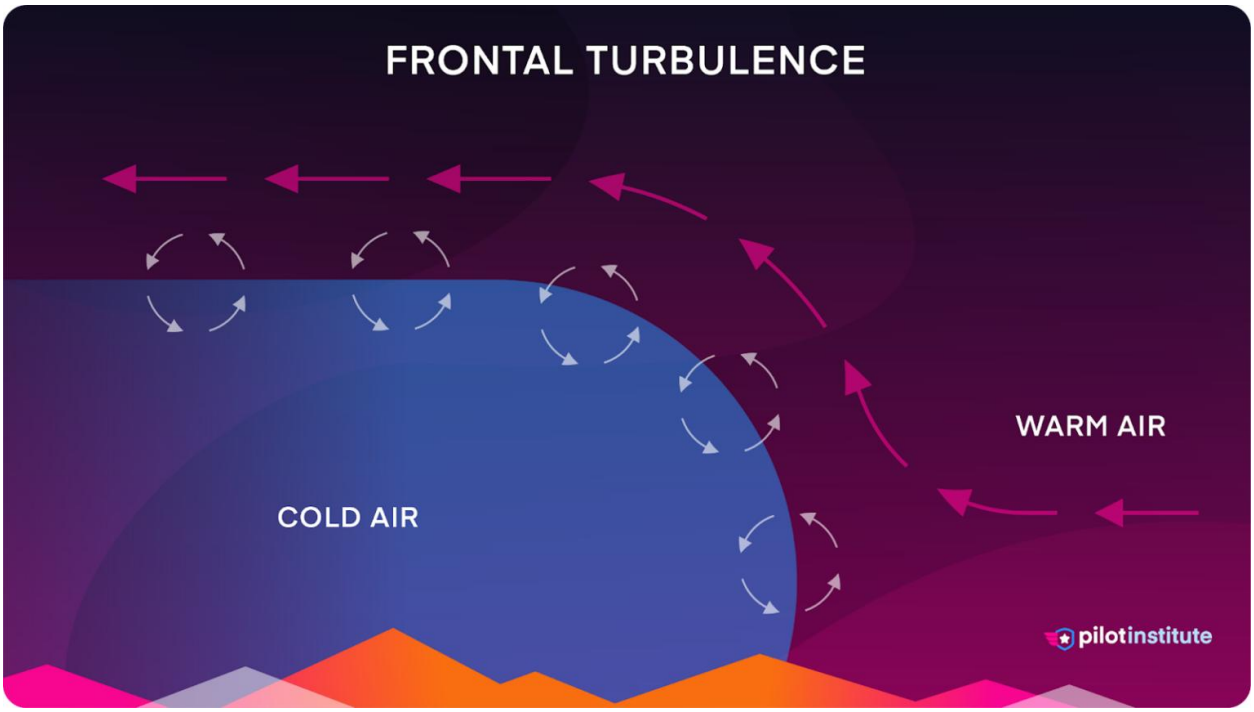
✅ Smooth, strong signals

✅ "Why is Oklahoma booming in tonight?"

Low Pressure = Chaos


L
Cold, unstable air
Warm, humid air
H
Warm
L





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What's happening:

- Air is **rising and mixing**
- Atmosphere becomes **unstable**

What it does:

- Breaks up signal paths
- Destroys inversions

Result:

❌ Weak-signal paths disappear

❌ Signals become noisy and inconsistent

❌ FM range shrinks

The Sweet Spot – Just Before the Weather Turns

This is the part most hams miss.

👉 The **BEST propagation often happens right before a front moves in**

Why?

- Air is still stable
- Moisture and layering increase
- Inversions strengthen

Then the front hits…

💥 Propagation collapses

PART 3 – Practical Takeaways (The Stuff That Actually Matters)

If you're running FM:

- Height is king
- Terrain matters more than anything
- Weather helps—but not dramatically

If you're running SSB/CW (your people 👍):

- Watch **weather maps**, not just your S-meter
- Look for:

- High pressure systems
- Calm winds
- Clear nights

If conditions suddenly get "weirdly good":

- Stop talking…start calling CQ
- Move to **144.200 / 432.100**
- You're missing opportunities if you stay on the repeater

If a storm is rolling in:

- Expect things to go downhill fast
- Don't blame your radio (this time…)

Final Thoughts – The Atmosphere is Your Real Amplifier

You can have:

- The best radio
- The biggest amplifier
- The most expensive antenna

…and still get beat by a guy with 10 watts and a Yagi

👉 **if he understands propagation better than you**

Bottom Line

- **LOS = your baseline**
- **Tropo = your opportunity**
- **Weather = your predictor**
- **Experience = your advantage**

If you really want to level up next, the natural step is:

👉 learning how to read **surface maps, upper-air charts, and tropo forecasts**

That's when VHF/UHF stops being "random"…
…and starts being **predictable—and profitable**.

73,
Greg N5XO