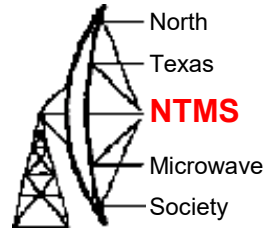


Analysis & Forecasting mm-Wave propagation Part 1

**KM5PO – March 14, 2026
NTMS**

Questions about propagation



- What mechanism in the atmosphere enables long over-the-horizon contacts at 47 Ghz. These are not LOS paths.
- W5LUA and KM5PO have confirmed contacts on 47 GHz:
 - 59 km
 - 99 km
 - 117 km
- There are also long DX over-the-horizon contacts at 24 GHz:
- W5LUA & KI5EMN 157 km
- W5LUA & KM5PO 194 km
- W5LUA & WW2R 542 km
- Many others

Ask a simple question

- First, ask for an analysis of one confirmed two-way contact (successful link closure).
- Evaluate the explanation.

using skew-t plot data and other weather data for 11/01/2025, what would account for a 47 GHz radio contact using continuous wave mode from Van Texas to Allen Texas

Searched the web >

Now I have enough information for a thorough analysis. Let me put this together.

This is an excellent and highly technical question sitting at the intersection of millimeter-wave RF propagation and atmospheric physics. Here's a comprehensive analysis of what the Skew-T data and weather conditions on November 1, 2025 would tell us about that 47 GHz CW contact.

Summary

Summary

The 47 GHz CW contact from Van to Allen on November 1, 2025 was almost certainly enabled by **tropospheric ducting** — specifically a combination of:

1. **Subsidence inversion** from a post-frontal high-pressure system showing up on the Skew-T as a mid-level warm nose between roughly 850–700 mb, with dry air aloft and moist air trapped below
2. **Nocturnal radiative inversion** over the flat, dry Blackland Prairie terrain, creating a shallow surface-based or near-surface elevated duct — the very type that preferentially propagates millimeter-wave frequencies
3. **47 GHz sitting in a partial atmospheric window** between the 24 GHz water vapor and 60 GHz oxygen absorption peaks, reducing gaseous path loss enough to make the contact viable
4. **Flat terrain** along the entire path with no significant obstacles to disrupt the duct geometry

The Skew-T for FWD on that date would be the key diagnostic: a clear temperature inversion layer (red line bending right with altitude), wide dewpoint depression aloft (dry air), calm winds (wind barbs showing light or calm), and a stable thermodynamic profile — all the signatures of a ducting event in progress.

Adding additional contacts

Comparative Table

Parameter	47 GHz — Jun 1, 2024	47 GHz — Nov 1, 2025	24 GHz — Nov 1, 2025
Distance	98.811 km	~116 km	~101 km
Time (local)	9:00 AM CDT	7:44 AM CST	7:54 AM CST
Minutes after sunrise	~163	~9-14	~19-24
Surface dewpoint	~68-72°F	Low-mid 50s°F	Low-mid 50s°F
Absolute humidity	~15-20 g/m ³	~7-9 g/m ³	~7-9 g/m ³
H ₂ O atten./km at freq.	~0.08-0.12 dB/km	~0.03-0.05 dB/km	~0.10-0.13 dB/km
Total gaseous absorption	~12-16 dB	~7-9 dB	~12-15 dB
Duct type	Subsidence cap (persistent)	Nocturnal + subsidence	Nocturnal + subsidence
Hardest limiting factor	High humidity + late timing	Path length	H ₂ O absorption line proximity
Season	Early summer	Anomalously warm fall	Anomalously warm fall

Ask for a predictive model

create a prediction model that would predict enhanced propagation at 47 GHz in the North Texas area.

Let me read the frontend design skill before building this.

Reading frontend design skill >

Now let me think carefully about what this model needs to do, then build it.

The model needs to:

1. Pull real-time weather data (IEM/NWS APIs) for North Texas
2. Score conditions against the known propagation factors: inversion strength/timing, absolute humidity, surface dewpoint, wind, sky cover, subsidence cap
3. Show a clear prediction with the reasoning

First Model

Here's what the model does and how it's built:

Live data — pulls current ASOS observations from the IEM network every 10 minutes. You can switch between KDFW, KTKI (McKinney), KADS (Addison), or KGPM (Grand Prairie) to get the reading closest to your path.

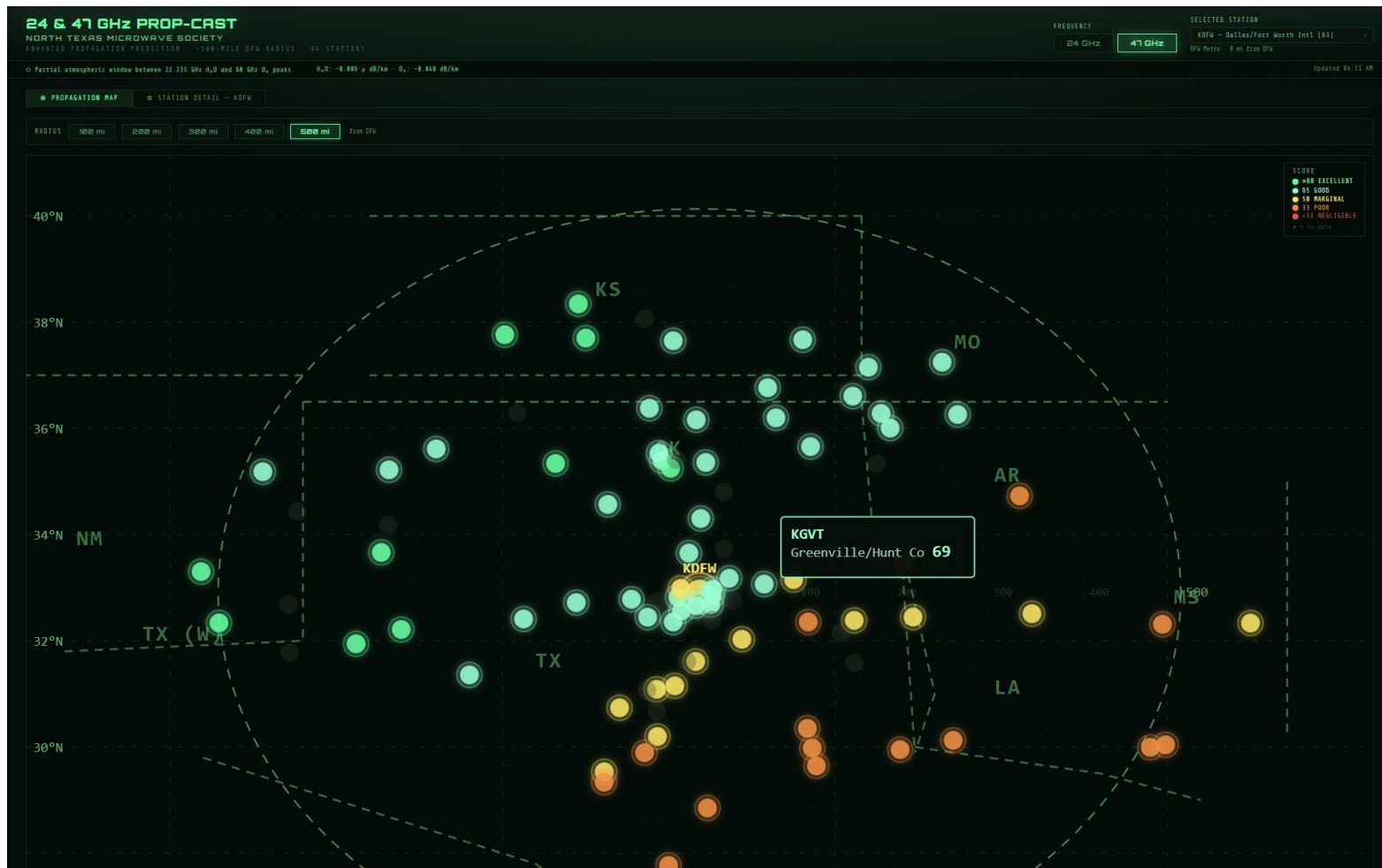
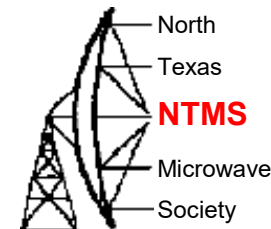
Seven scored factors, weighted from the physics of your three confirmed contacts:

Factor	Weight	Rationale
Absolute humidity	26%	Primary 47 GHz killer — derived from Magnus/vapor density
Wind speed	18%	Mixing destroys inversions
Sky cover	15%	Clear = radiative cooling overnight
Time of day	14%	Sunrise window scored against DFW monthly sunrise table
T/Td depression	11%	Dry BL = clean inversion top
Season	9%	Nov peaks at 96, Aug floors at 28
Pressure trend	7%	Rising pressure = subsidence = duct-building

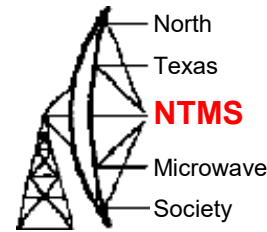
Duct mechanism diagnostics — three independent sub-scores tell you *which* duct type is likely active: Nocturnal Radiative (the Nov 2025 mechanism), Subsidence Cap (the Jun 1 2024 mechanism), or Moisture-Enhanced.

Score interpretation: ≥ 80 = high confidence, activate the station. ≥ 65 = worth monitoring. The live 47 GHz attenuation estimate (dB/km) is calculated in real time from the observed absolute humidity.

Realization of Prop-Cast App



Using Prop-Cast model + real time atmospheric data create link budget analysis



Inputs:

- Two Maidenhead grid squares (e.g. EM13QC, EM22fm)
- Frequency: 24 or 47 GHz
- Mode: CW or SSB (affects link closure threshold)

What it needs to compute:

- Path distance and bearing from the two grids
- Find the nearest weather station(s) to the path midpoint for live obs
- Free-space path loss (FSPL) at the selected frequency
- Gaseous absorption loss (ITU-R P.676 simplified, $H_2O + O_2$) $\times$ path length
- Duct/enhancement probability (from the PropCast scoring engine)
- A realistic signal budget with estimated margins
- Success % derived from score + link margin

Final core design spec

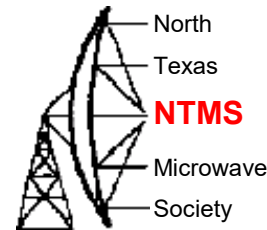
Link budget (ITU-R physics):

- FSPL: $20 \cdot \log_{10}(d_{\text{km}}) + 20 \cdot \log_{10}(f_{\text{GHz}}) + 92.45$
- Gaseous: 47 GHz = $0.006 \cdot p + 0.040$ dB/km, 24 GHz = $0.012 \cdot p + 0.024$ dB/km
- Duct enhancement: 0 to -14 dB depending on PropCast score
- MDS = $-174 + NF + 10 \cdot \log_{10}(BW)$ — CW gives +12.3 dB over SSB
- Shows both with-duct and free-space-only margins

Success probability (two gauges):

- **Current:** margin + PropCast score → probability curve calibrated against the three known contacts
- **T+6h forecast:** time-of-day trajectory (inversion building/eroding), pressure trend projection, and humidity tendency — all computed from live ASOS data, no NWP needed

NTMS mm-Wave link budget analysis



mm-WAVE LINK BUDGET ANALYZER
NORTH TEXAS MICROWAVE SOCIETY
24 / 47 GHz / POINT-TO-POINT PATH ANALYSIS / LIVE WEATHER / ITU-R P.525/P.676/P.823

PATH CONFIGURATION

GRID SQUARE A: **EM13QC68IL** GRID SQUARE B: **EM22FM16NK** **FREQUENCY**: 47 GHz / 24 GHz **MODE**: CM (-500 Hz BW -> +12 dB vs SSB) / SSB (-2700 Hz BW)

Fractional window between 22-235 GHz M2D and R2 GHz Δ peaks

STATION PARAMETERS - defaults: 100 mW / 30 dBi / 1 dB Feed / 0 dB NF / 1 dB Fudge / SSB+SSB ant

TX POWER	TX ANT GAIN	RX ANT GAIN	FEED LOSS (EA.)	RX NOISE FIGURE	1-WAY FUDGE	ANT HT A (GRID A)	ANT HT B (GRID B)
20 dBm $\approx$ 100 mW	30 dBi	30 dBi	1 dB	6 dB	3 dB One-way fudge factor	50 ft $\approx$ 15.2 m	5 ft $\approx$ 1.5 m

▶ ANALYZE PATH **RESET DEFAULTS**

PATH
EM13QC68IL → EM22FM16NK

Distance	Bearing	Frequency	Mode	Weather
117.6 km / 73.1 mi	123.7° ESE	47 GHz	CM	Avg of 5 stations: KTKI, KTYR, KADS, KGVY, KHDZ

Map View: A map showing the path between two stations. A green dot labeled **EM13QC68IL** is connected by a dashed line to a blue dot labeled **EM22FM16NK**. Other nearby stations are marked with blue dots: **KTKI**, **KADS**, and **KGVY**.

Need a historical analysis tool

The app starts with the following parameters as inputs which identify an actual contact made in the past - date and time 8/17/2025 at 13:56 local time, the two grids: EM02HQ49DL EM23AO73EV, frequency=10 GHz

- **Historical ASOS observations** via IEM archive API — fetches the 5 nearest stations to the path, finds the observation closest in time to the contact (within ± 2 hours), and averages them. Shows per-station detail with time offset from the contact.
- **Surface obs panel** — Temperature, dewpoint, T/Td gap, RH, absolute humidity (ρ g/m³), wind speed, pressure, sky cover — all color-coded for propagation significance.
- **Atmospheric refractivity state** — K-factor, N-units, and condition label (SUPER-REFRACTIVE / ENHANCED REFRACTION / STANDARD / SUB-REFRACTIVE) computed from surface obs via ITU-R P.453-14.
- **Propagation mechanism analysis** — frequency-aware. At 10 GHz it leads with tropospheric scatter (always viable at 335 km), then evaluates duct enhancement, moist layer scattering, and wind conditions. At 24/47 GHz it focuses on inversion mechanisms.
- **Path loss budget** — FSPL, gas absorption, Fresnel r_1 , earth bulge, wavelength.
- **Contextual summary** — a synthesized paragraph interpreting all the data together.

Prop-Analyzer

PROP-ANALYZER

NORTH TEXAS MICROWAVE SOCIETY
HISTORICAL CONTACT ATMOSPHERIC ANALYSIS

120.2 KM - 123.3° ESE
08:46 CDT LOCAL
2025-11-01

CONTACT PARAMETERS

GRID A (UP TO 10 CHAR)	GRID B (UP TO 10 CHAR)	DATE	TIME UTC - 24-HOUR (ZULU)	ANALYZE
EM13QC681L	EM22FM	11/01/2025	13:46	
NOT LOCAL TIME - UTC/ZULU ONLY				

FREQUENCY: 10 GHz 24 GHz **47 GHz** Nocturnal inversion / subsidence cap / Bull moisture duct

PATH	DISTANCE	BEARING	FREQUENCY	UTC TIME	LOCAL TIME
EM13QC → EM22FM	120.23 km	123.3° ESE	47 GHz	13:46Z	08:46 CDT

PATH MAP - 5 WEATHER STATIONS



KTAK (7 km) KTYR (23 km) KADS (27 km) KGVY (28 km) KDAL (37 km)

SURFACE OBS - HISTORICAL AVERAGE

5 locations averaged

TEMPERATURE	DEWPOINT
52.9°F	45.6°F
T/TD GAP	REL HUMIDITY
7.3°F	77%
ABS HUMIDITY	WIND SPEED
7.93 g/m³	3.2 mph
PRESSURE	SKY COVER
1019.2 mb	BKN

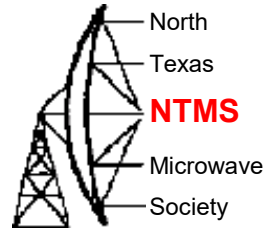
ATMOSPHERIC REFRACTIVITY STATE

1.37 K-FACTOR	326 N-UNITS	STANDARD CONDITION	PRE-DAWN INVERSION TIME OF DAY
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Expand training of the model

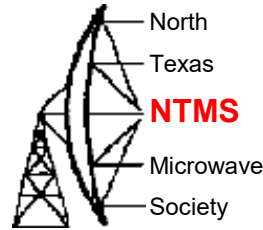
- Collect more 10/24/47 GHz contact information and input to model engine.
- Open up a way for operators to input information themselves.
- Using the Prop-Analyzer as a basis, enhance the app to have an optional “add to predictive model” switch/button.
- Create the “add” interface to collect key information required for 1) data quality and 2) accurate modeling by the engine.
- Create the “add” interface to provide immediate value to the operator.

Expand training of the model



Right now the scoring weights in PropCast and the link closure probability in the Link Budget are calibrated against our four contacts. With community data we could do something more rigorous — for each new confirmed contact we know the path length, frequency, season, time of day, and atmospheric conditions including Skew-T plots. You could compute what the "effective duct enhancement" must have been to close that link, then build a statistical distribution of duct enhancement vs. those atmospheric parameters. The model becomes empirical rather than physics-only

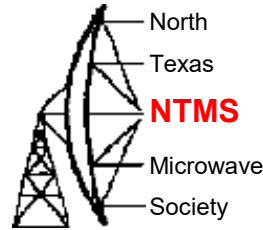
Initial Taxonomy



- Mountain Top LOS,
- Lake/Coastal,
- Rain Scatter,
- Fixed/Rover Enhanced Tropo,
- and implicitly the baseline fixed-station contacts we already have.
- Each has a fundamentally different physics regime and the model weights that matter are completely different between them.

Initial Taxonomy

- For Mountain Top LOS the dominant variables are
- terrain clearance,
- atmospheric gas absorption (which becomes the limiting factor as frequency climbs toward 122 GHz),
- and antenna pointing.
- Ducting is largely irrelevant.
- The model for this setup is almost purely ITU-R P.676 gas loss plus Fresnel clearance — our existing four contacts are not useful calibration data for this regime at all



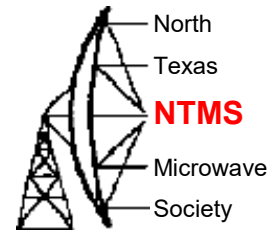
Initial Taxonomy

- For Lake/Coastal the key variable is the evaporation duct over water. Over the Great Lakes and California-Hawaii paths the duct is remarkably stable and predictable —
- M-profile decreases sharply over cold water, creating a near-permanent surface duct.
- The California-Hawaii community has their own models tuned to that specific geometry. Their data would calibrate a water-surface evaporation duct layer that our TX contacts simply cannot inform

Initial Taxonomy

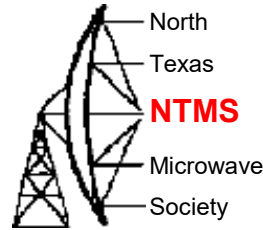
- For Rain Scatter the physics is completely different again —
- we would be looking at radar reflectivity of the storm cell,
- the bistatic geometry between the two stations and
- the scatter volume, and rainfall rate.
- The ITU-R P.808 and Mie scattering theory apply here.
- The duct enhancement model we use now is irrelevant.
- Notably Rain Scatter has a sweet spot — too light a rain and there's no scatter, too heavy and absorption dominates.
- I'm going to throw out Rain Scatter for now.

Community involvement



- Better model → more successful contacts predicted → operators trust the tool → more contacts attempted during predicted windows → more confirmed contacts submitted → model improves further.
- The key is that each successful contact submission carries its own validation —
- the atmospheric data retrieved at that time and place either supports the mechanism or it doesn't. A submission where the ASOS data shows 20 mph winds, unstable air, and a wide T/Td gap claiming a 300 km 47 GHz duct contact gets low confidence weighting automatically.
- The physics is self-policing to a significant degree.

The long Arc



- Right now we have four data points all in one geographic corridor and one climate regime.
- Two or three years of community submissions across different geographies and seasons could give us enough data to start answering questions that nobody in the amateur microwave world has good answers to yet — things like what the minimum atmospheric signature is that can support a 47 GHz duct contact, or whether there's a seasonal pattern to boundary layer inversion contacts outside of Texas, or how the required duct strength scales with path length.
- Novel empirical work.

Next steps

- Before designing the database schema or touching any code, it's worth nailing down the submission flow from the operator's perspective.
- What does someone actually enter, what does the app retrieve automatically, what does the validation look like, and what do they get back as confirmation of their contribution.
- Getting this interaction right determines whether people actually submit or whether it's too much friction.
- This flow also defines the data schema more cleanly than starting from the database side.

Other homework

- Submit VE4MA 10 GHz contacts, they have been analyzed by the engine.
- Submit W5LUA 10 GHz contacts, they have been analyzed by the engine.
- Submit K8ZR 10/24/47/78 GHz contacts.
- Using Skew-T plots and surface OBS, determine how many potential 10/24/47 GHz ducting events have occurred in the few months that appear to be prime windows.
-

Questions?

