

# The Troposcatter Propagation Mode and How to Predict Coverage on the VHF/UHF Bands

Prepared in 2017 for the CSVHF Society  
Conference, and New Mexico TechFest

by

KK6MC

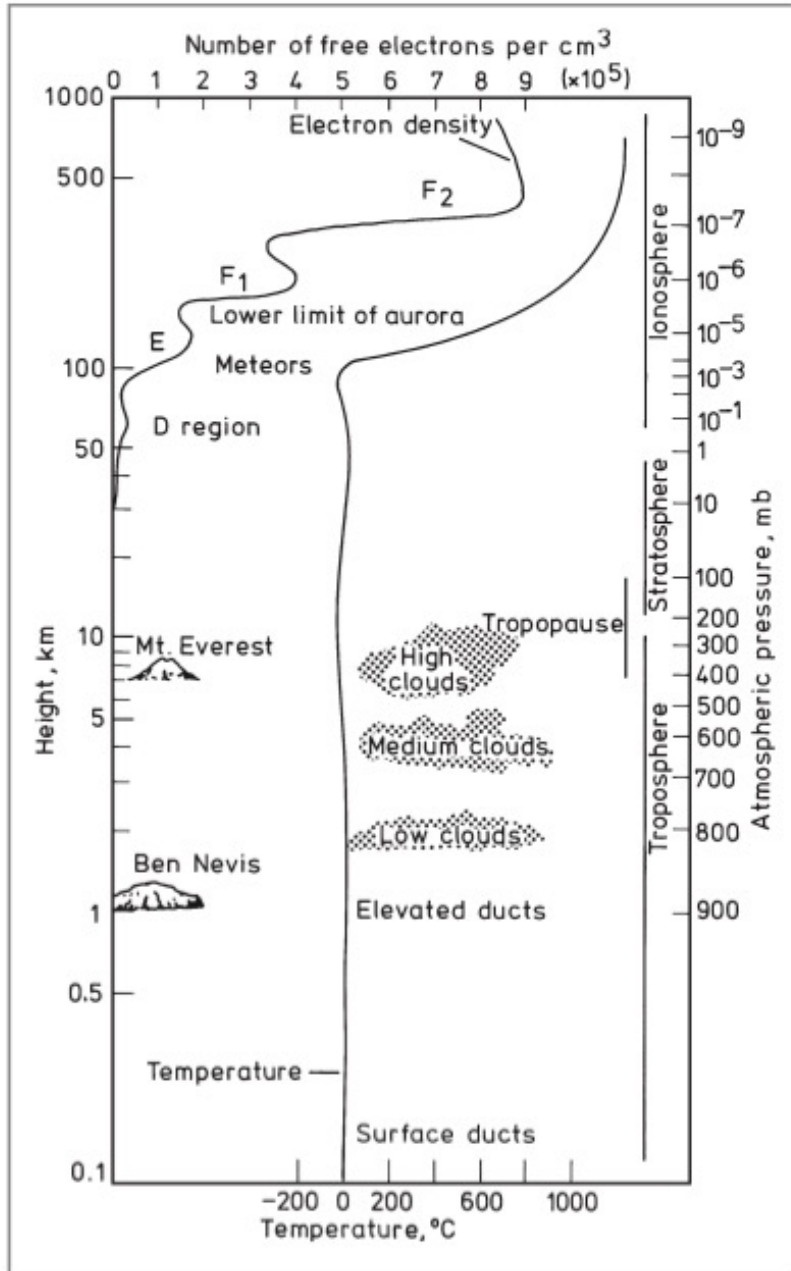
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# What is Troposcatter

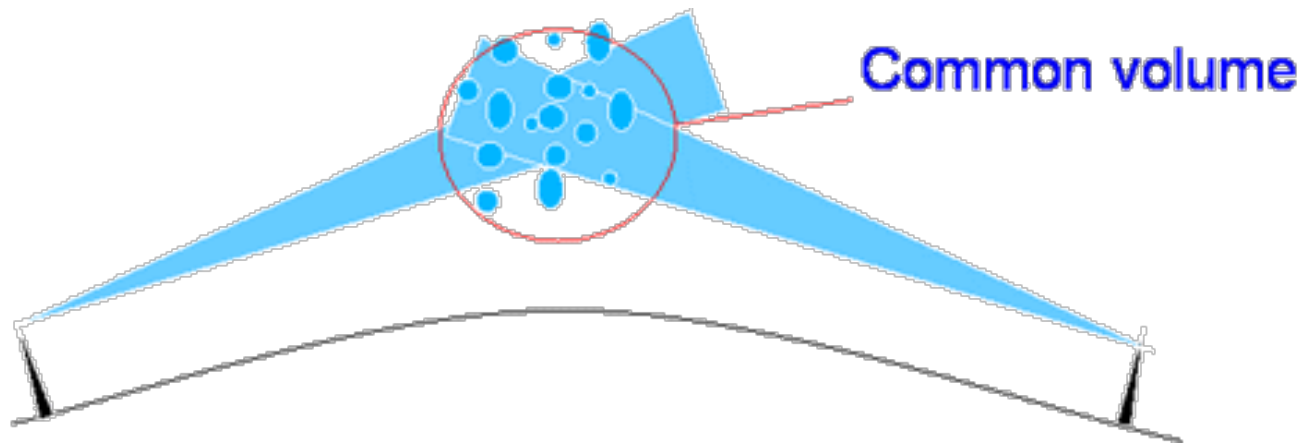
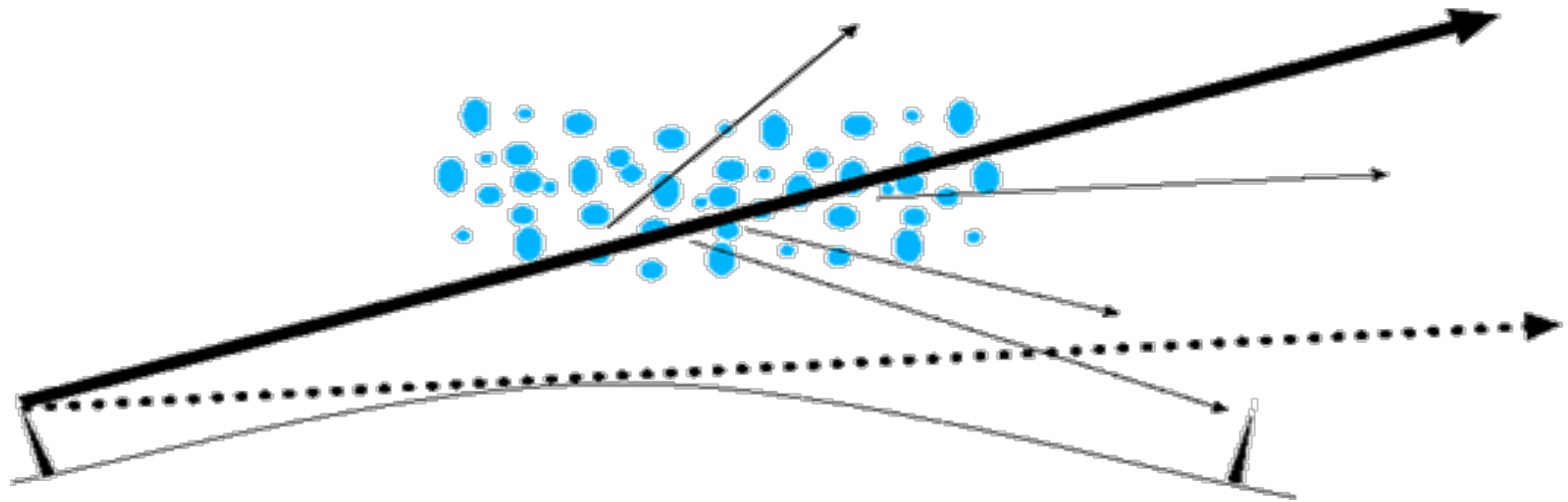
- Scattering (not reflection) from inhomogeneities (blobs of uneven density) in the troposphere
- Allows propagation beyond normal line-of-sight and diffraction distances
- Always present, although strength varies considerably
  - 13 to 15 dB
  - Varies with time of day, season of year, weather
- Very dependent on effective radiated power, angle of radiation
- Viable propagation mode from 50MHz (6M) to over 10GHz (3cm)

# Troposphere



Troposphere is atmosphere from ground level to about 35,000 feet. It is the region where clouds are formed.

# Troposcatter from Inhomogeneities



# Density Inhomogeneities (Blobs) in Upper Atmosphere





# Troposcatter Path Loss from Bray, QST, November 1961

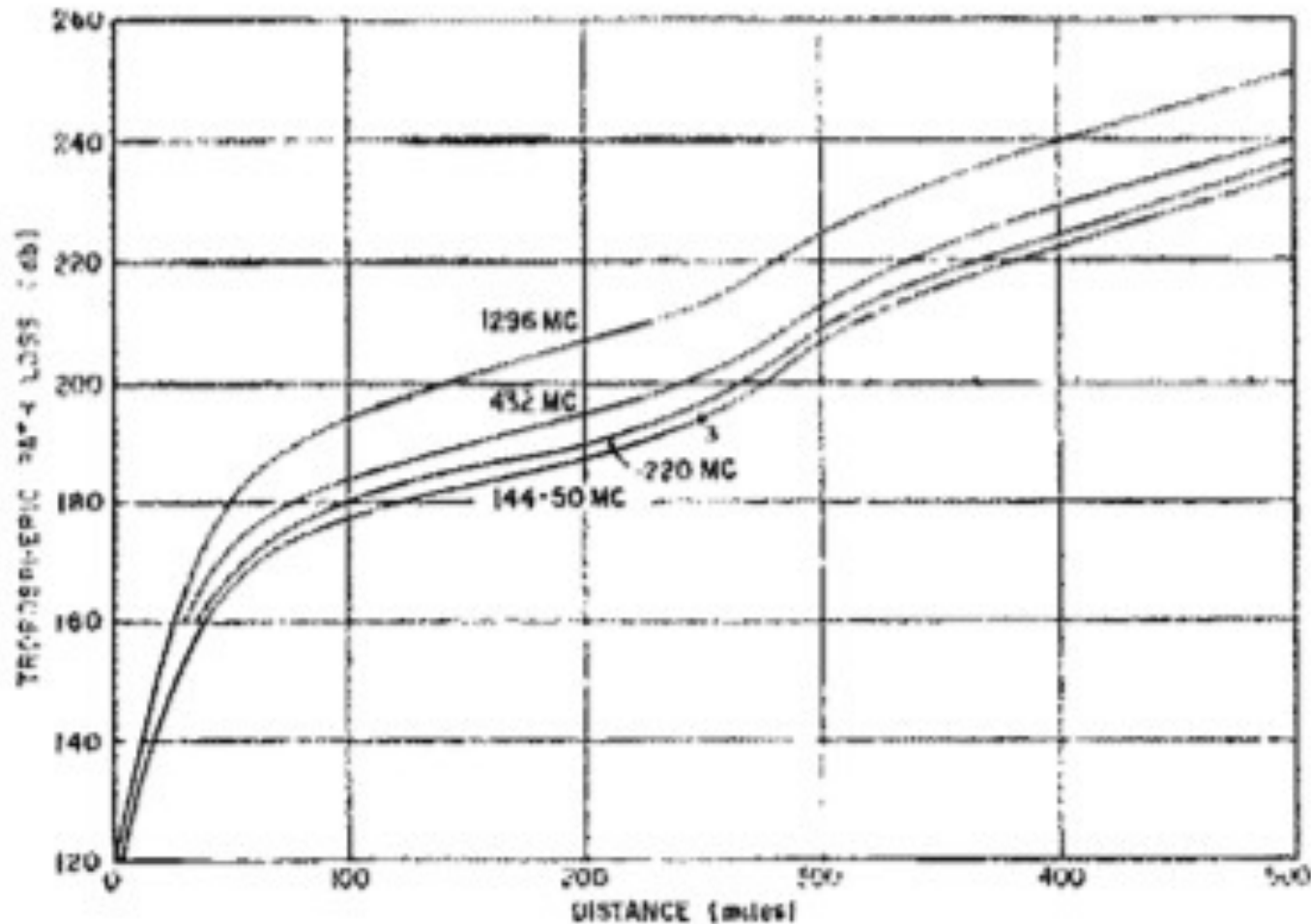
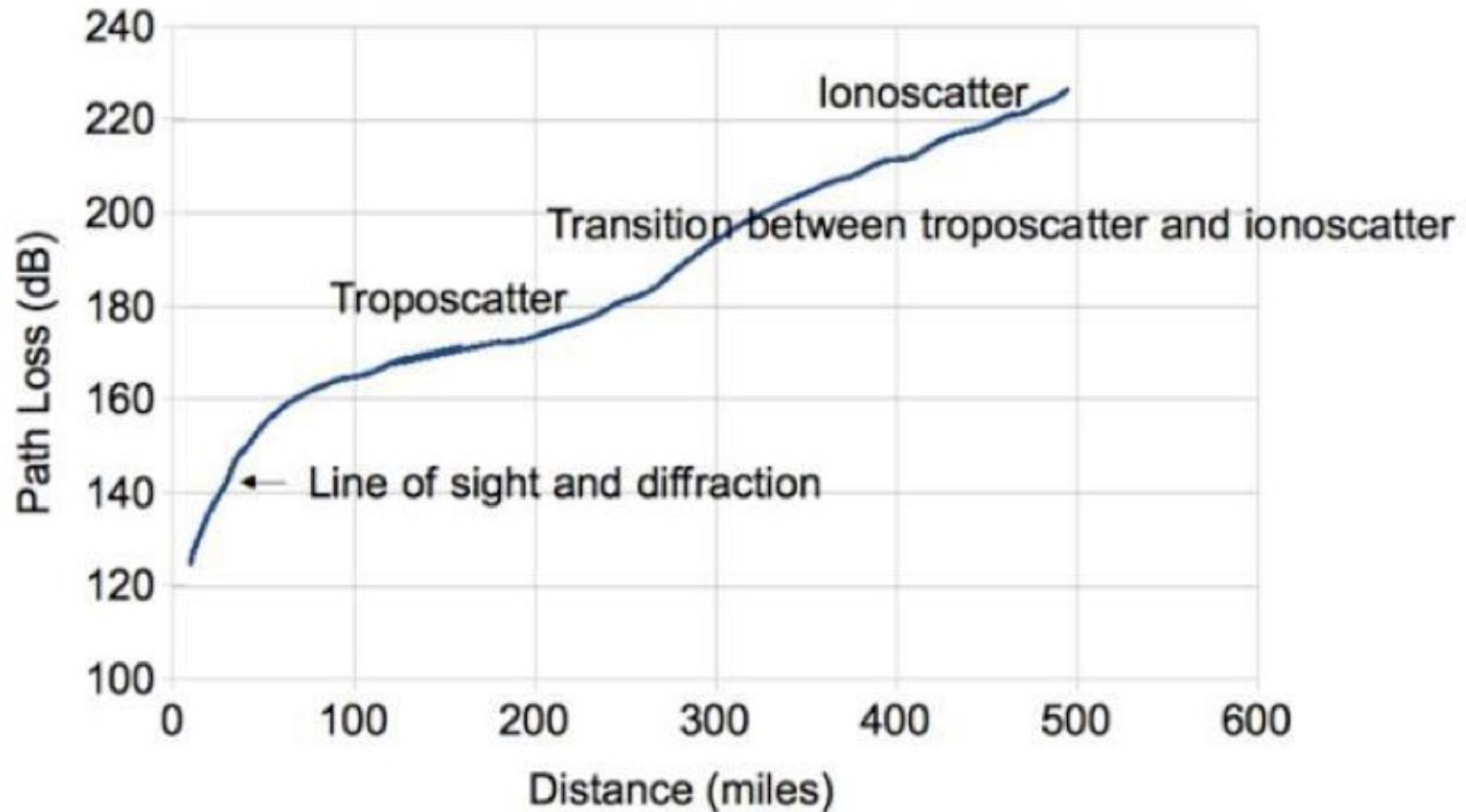


Fig. 2—Path loss vs. distance for 50 per cent of the hours of the year.

# Two Meter Path Loss as a Function of Distance

Two Meter Path Loss as Function of Distance for 50% Reliability

from Dishman QST November 1961



# Planning - Path loss capability

path loss capability (plc) = effective isotropic radiated power (eirp) + effective receiver sensitivity (ers)

$$\text{eirp} = (10 \cdot \log(P)) + G_{\text{trans}} - \text{transTL}$$

where P = transmitter power, Gtrans is gain of antenna, transTL is transmission line loss

$$\text{ers} = -10 \cdot \log(k \cdot T \cdot B) + G_{\text{recv}} - \text{recvTL} - \text{threshold}$$

where kTB = receiver noise power in bandwidth B, Grece receiver antenna gain, recvTL receiver transmission line loss

$$\text{predicted snr} = \text{plc} - \text{pl}$$

For my 25 watts to the WA5VJB Yagi:

P=25W, Gtrans=10, transTL=1

eirp:23 dBW

For a modest 2M weak signal station: T= 438 K (equivalent to nf=4dB), B=2500 (SSB), Grece=15dBi, recvTL=1, threshold=0 (SSB),

ers:-182

-- and the effective path loss capability

plc: 205 dB



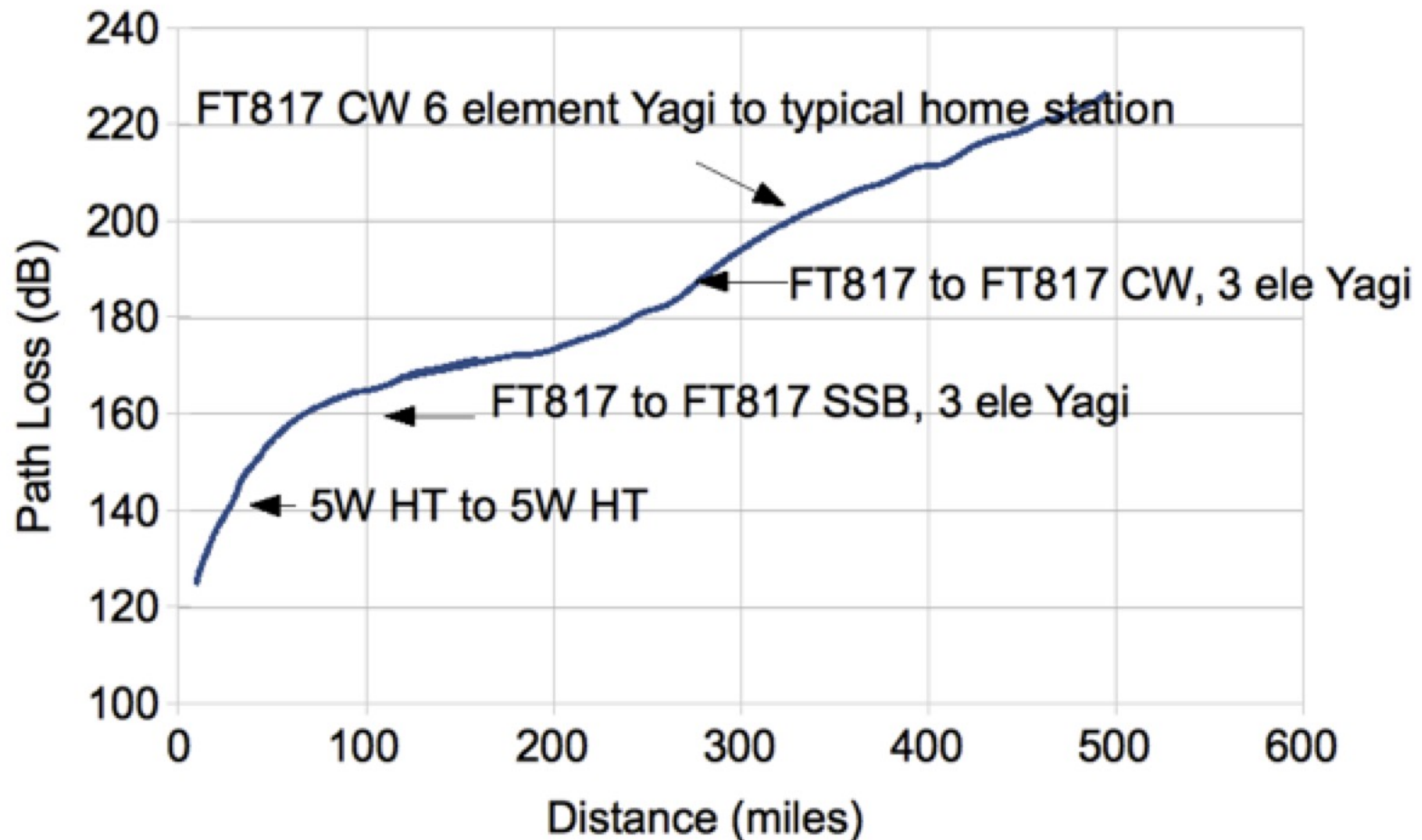
# Typical VHF Station Capability

	Receive Station	Mode	Path Loss Capability (dB)	Distance (miles) for SNR=10
5W HT 1/4 wave	HT 1/4 wave	FM	156	15
5W HT 1/4 wave	Long Yagi, low noise receive	FM	170	30
FT817 3el Yagi	FT817 3 el Yagi	SSB	184	80
FT817 3el Yagi	FT817 3 el Yagi	CW	195	130
IC706 6 el Yagi	TS2000 Long Yagi	SSB	207	250
IC706 6 el Yagi	TS2000 Long Yagi	CW	214	310
TS2000 Long Yagi	TS2000 Long Yagi	SSB	215	270
TS2000 Long Yagi	2dB NF, stacked Yagis	SSB	223	300
KW, Stacked Yagis	2dB NF, stacked Yagis	SSB	236	400

# Going from FM to SSB to CW to better antennas increases distance a lot

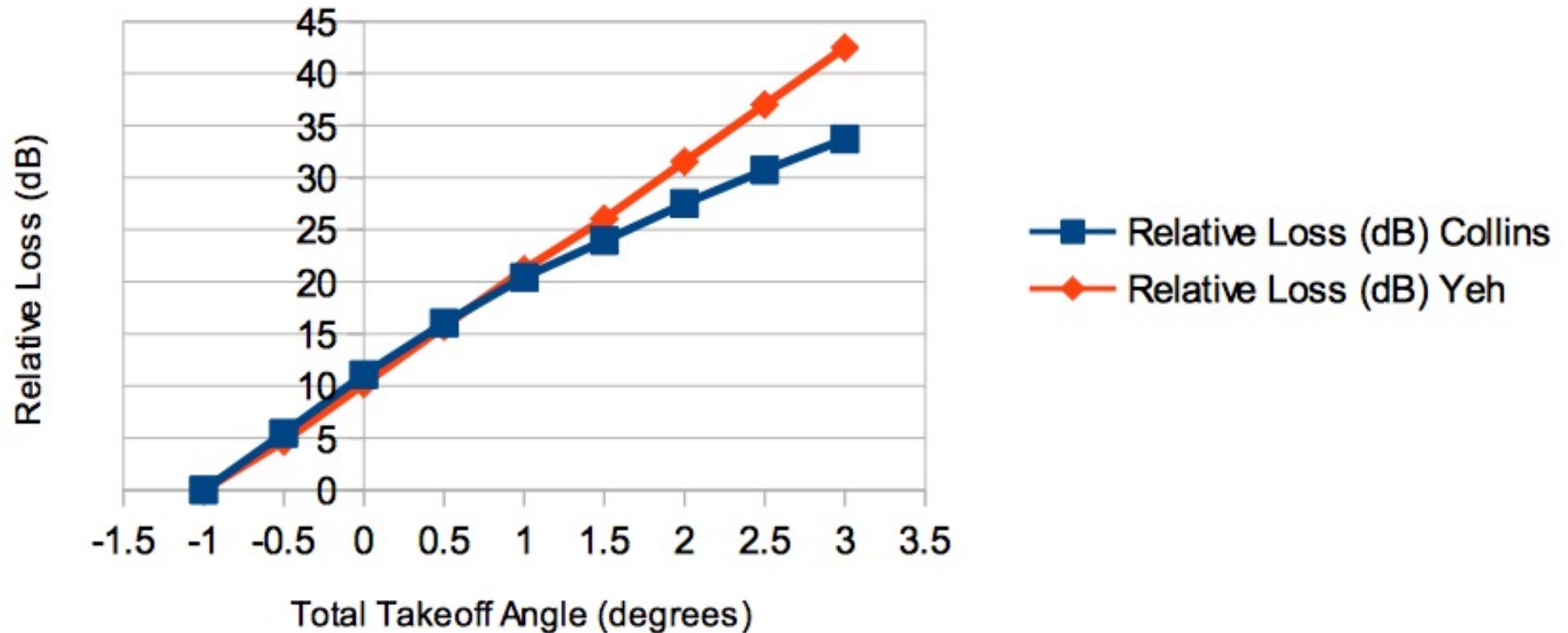
Two Meter Path Loss as Function of Distance for 50% Reliability

from Dishman QST November 1961

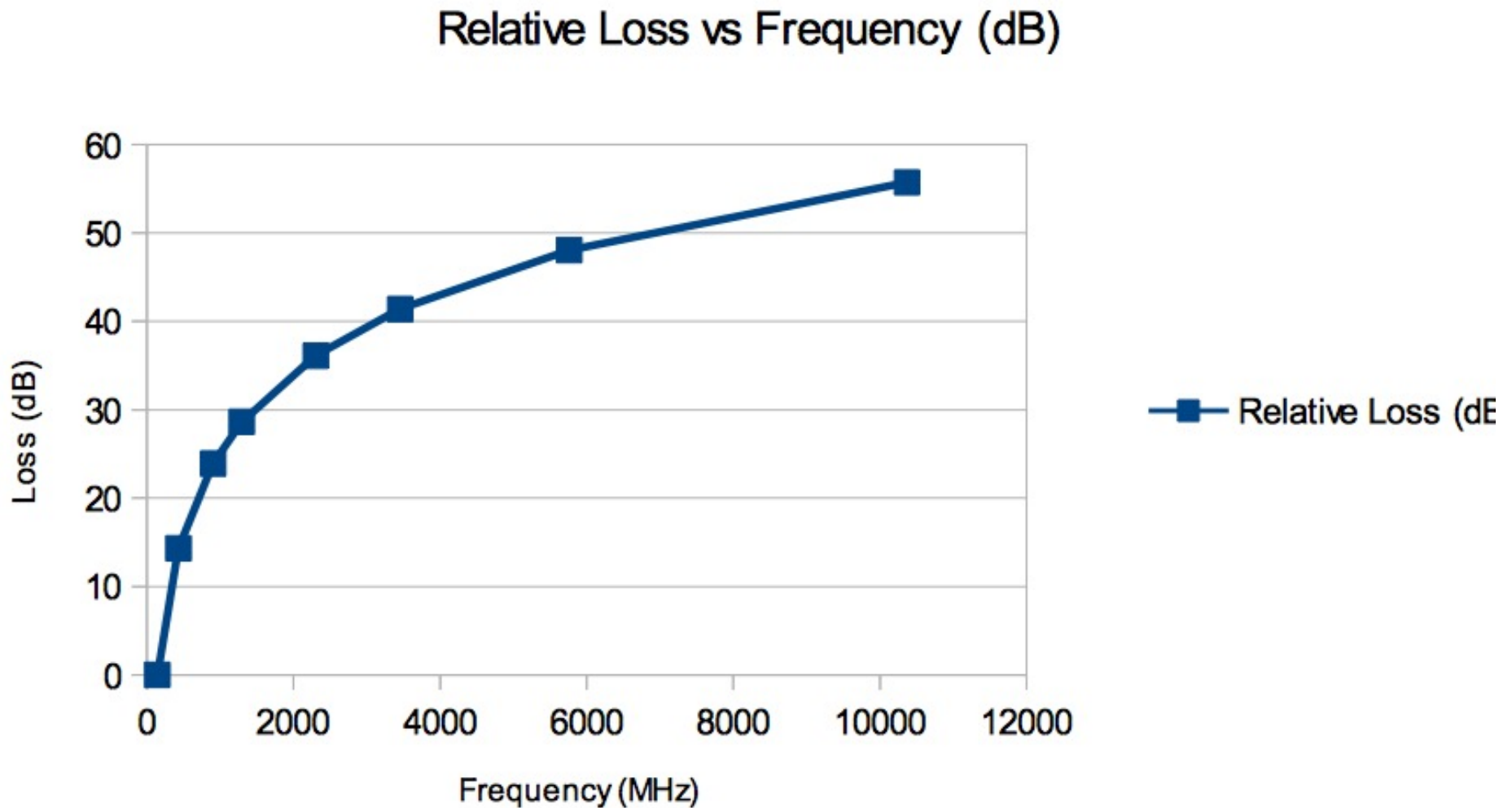


# Loss very dependent on takeoff angle – Hills are nice

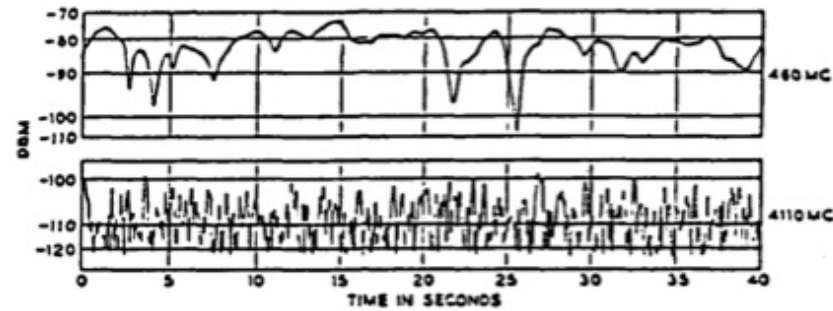
Troposcatter Loss vs Total Takeoff Angle



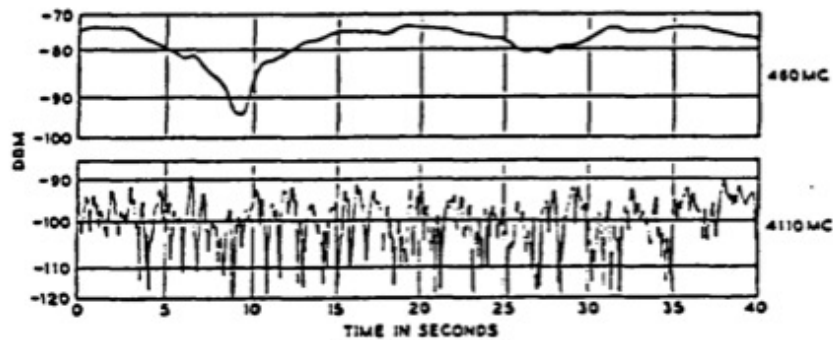
Relative path loss increases as frequency increases – offset by increase in antenna capture area



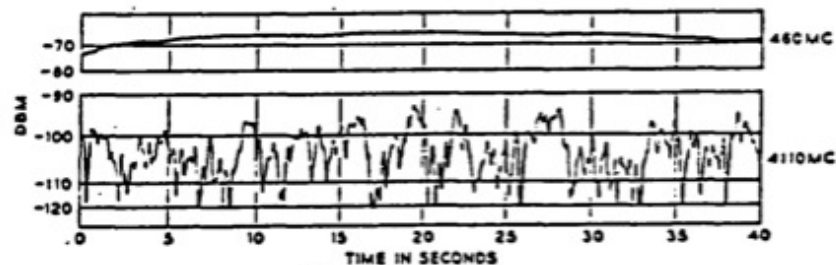
# QSB is significant on Troposcatter



(a) RAPID FADING



(b) SLOW FADING



(c) VERY SLOW FADING

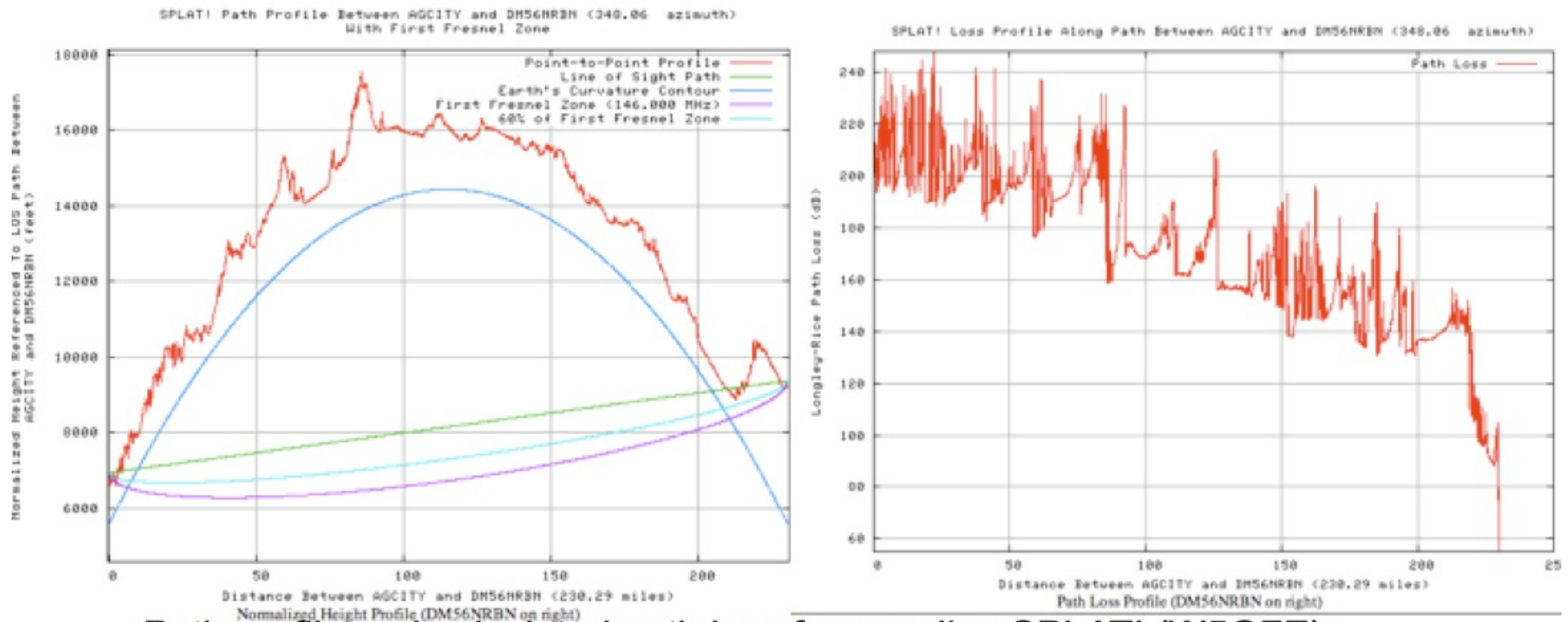
Source: Crawford, A.B., Hogg, D.C., and Kummer W.H. "Studies in Tropospheric Propagation Beyond the Horizon." *The Bell System Technical Journal*, vol. 38, no. 5 (September 1959), p. 1119.



# Tools to Calculate Path Loss

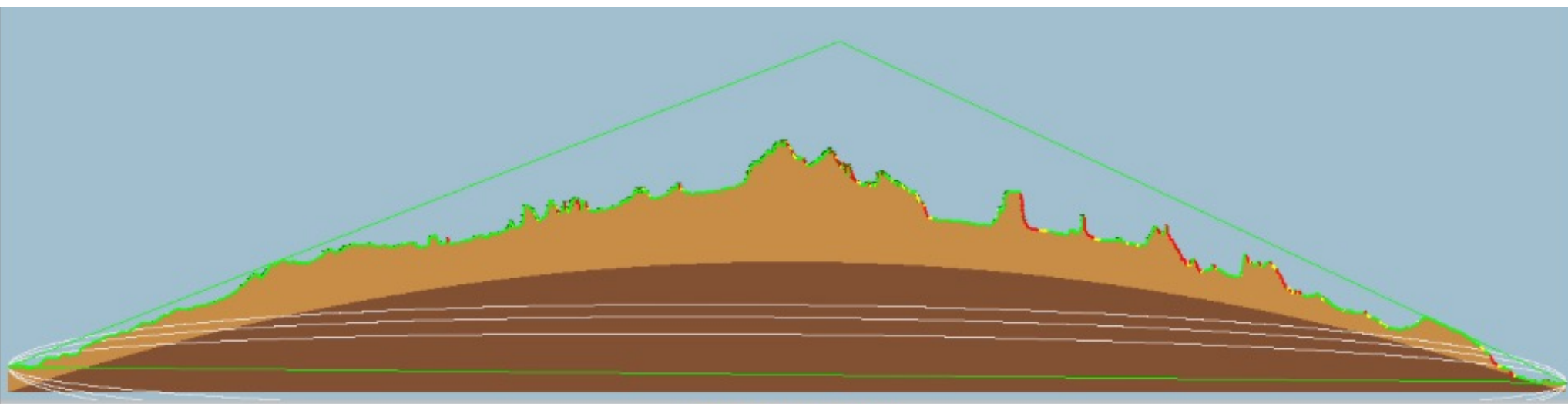
- There is no first principles theory, all calculations are made with numerical constructs built to match observed data
  - can be big variation in results depending on whose technique you use
- Calculations can be made by hand using troposcatter loss formulas – requires knowing distance to nearest obstruction on each end.
  - Visual Basic <  
<http://www.bobatkings.com/radio/scatter2.html> >
- Computer tools using Longley Rice NBS model have terrain data built in and are much easier to

# Calculating Path Loss Capability with SPLAT!



- Path profile and calculated path loss from on line SPLAT! (W5GFE)
- Path loss is for 50% reliability; 50% of the time it will be worse, and 50% of the time it will be better
- Prediction is for ~200 dB path loss
- Made QSO on second (or more?) attempt an hour apart

# Radio Mobile On-line Calculations



Painted Desert to WB2FKO

Painted Desert DM54 (1)		(2) WB2FKO DM65	
Latitude	35.065411°	Latitude	35.119010°
Longitude	-109.781570°	Longitude	-106.578817°
Ground elevation	1757.5m	Ground elevation	1601.0m
Antenna height	4.0m	Antenna height	10.0m
Azimuth	87.91 TN   77.94 MG°	Azimuth	269.75 TN   261.07 MG°
Tilt	-1.34°	Tilt	-1.28°
<b>Radio system</b>		<b>Propagation</b>	
TX power	54.77dBm	Free space loss	124.98dB
TX line loss	1.00dB	Obstruction loss	64.60dB
TX antenna gain	11.00dBi	Forest loss	1.00dB
RX antenna gain	15.00dBi	Urban loss	1.00dB
RX line loss	1.00dB	Statistical loss	-3.92dB
RX sensitivity	-120.98dBm	Total path loss	187.65dB
<b>Performance</b>			
Distance			291.444km
Precision			145.8m
Frequency			146.000MHz
Equivalent Isotropically Radiated Power			3000.000W
System gain			199.75dB
Required reliability			50.000%
Received Signal			-108.88dBm
Received Signal			0.81µV
Fade Margin			12.10dB

Using Radio Mobile On line

# Create account or log in



This tool is sponsored by

commandite cet outil

[TowerCoverage.com](http://TowerCoverage.com)



## Radio Mobile Online / En ligne

[Try the new Windows Desktop version - RmWeb 1.9.2.0 - Essayez la nouvelle version pour bureau Windows](#)

Utilisateur

User

Mot de passe

Password

[Create a New account](#)

English

[Lost your user name or password](#)

[Créer un Nouveau compte](#)

Français

[Perdu votre nom d'utilisateur ou le mot de passe](#)

[Crea una cuenta nueva](#)

Español

[Perdiste tu nombre de usuario o contraseña](#)

[Crea un nuovo Account](#)

Italiano

[Dimenticato username o password](#)


A free tool for amateur radio

[ve2dbe@yahoo.ca](mailto:ve2dbe@yahoo.ca)

Un outil gratuit pour la radio amate
















# Initial Menu




Radio Mobile


Welcome kk6mc

-  My Settings
-  New Site
-  My Sites
-  Multiple Sites
-  New Link
-  My Links
-  Multiple Links
-  New Coverage
-  My Coverages
-  Multiple Coverages
-  New Antenna type
-  My Antenna types
-  Log Out

# Settings

 [Radio Mobile](#)

---

 **My settings**

---

User Name	kk6mc
Password	<input type="password"/>
Confirm Password	<input type="password"/>
Email address	<input type="text" value="jamesduffey@comcast.net"/>
Confirm Email	<input type="text" value="jamesduffey@comcast.net"/>
Language	<input type="text" value="English"/>
Map background source	<input type="text" value="GoogleMap"/>
Status	Amateur
Home Name	Base
Home Latitude	0.00000000
Home Longitude	0.00000000
Home zoom	2

---

# New Site


Radio Mobile Par/By Roger Coudé VE2DBE [Information](#)

Map  Satellite

Latitude    
Longitude

Map data ©2017 Google 5 km [Terms of Use](#) [Report a map error](#)

# Submit



[Radio Mobile](#)

**+ New Site**

-

Latitude

Longitude

Zoom

Name


Elevation (m)

Description

Group

---

# New Link

 [Radio Mobile](#)

**New Link**

From: Veterans Memorial to Olathe CO

From

Antenna height (m above ground)

---

To

Antenna height (m above ground)

---

Description

Frequency (MHz)

Tx power (Watts)

Tx line loss (dB)

Tx antenna gain (dBi)

Rx antenna gain (dBi)

Rx line loss (dB)

Rx threshold ( $\mu$ V)

Required reliability (%)

Use land cover

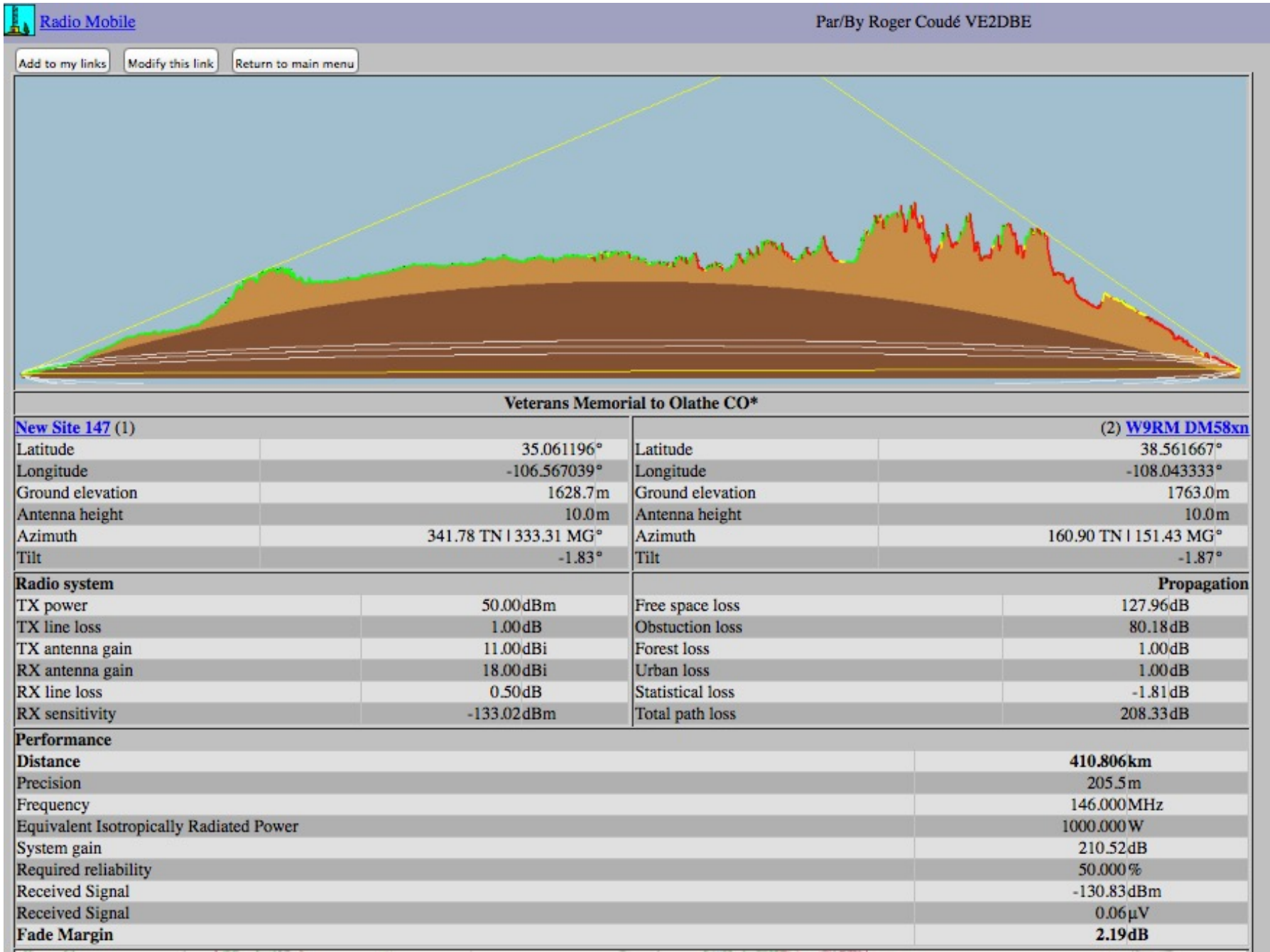
Use two rays

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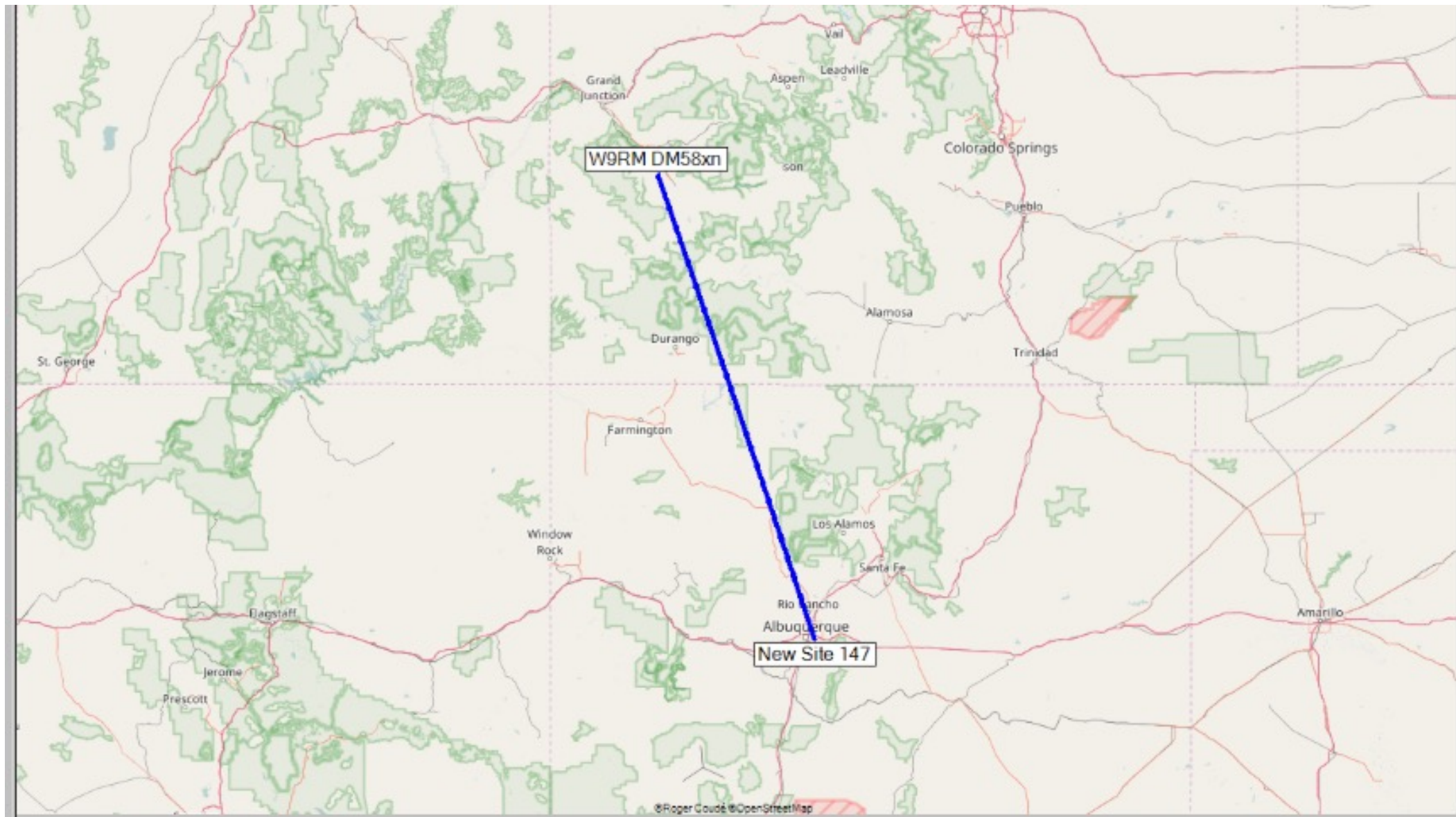
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# Submit



# You also get a map



# Useful References

- Bray, QST, November 1961
- SPLAT!  
< <http://www.qsl.net/kd2bd/splat.html> >  
On line at: < <http://splat.adis.ca> >
- RadioMobile  
< <http://www.cplus.org/rmw/english1.html> >
- Atkins  
< <http://www.bobatkins.com/radio/troposcatter.html>>
- Rehr  
< <http://flarc.net/eme-info/PDF/W3SZ-2.pdf> >
- < NMVHF.org > and the NM VHF Society