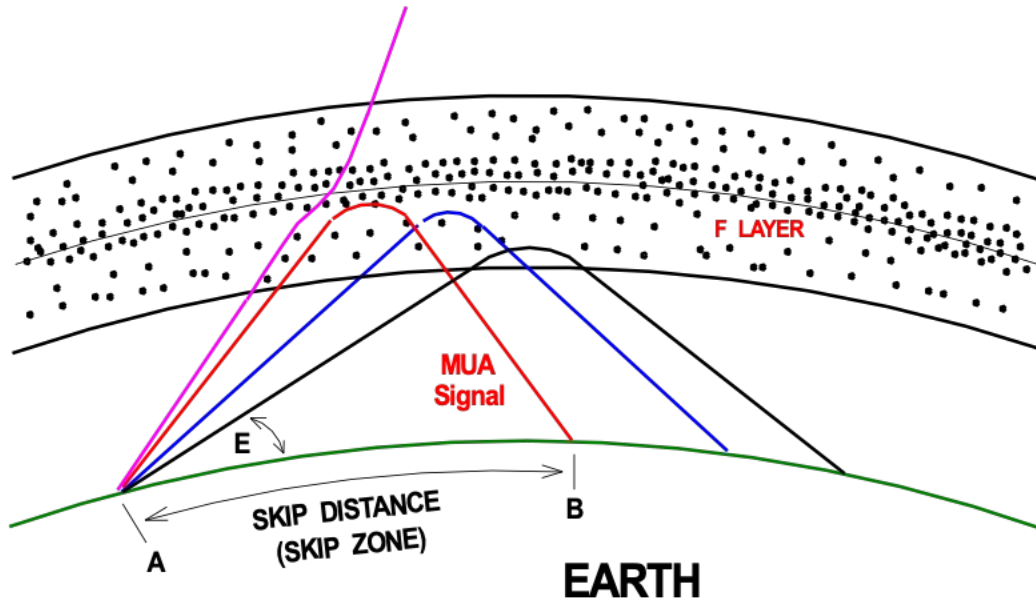
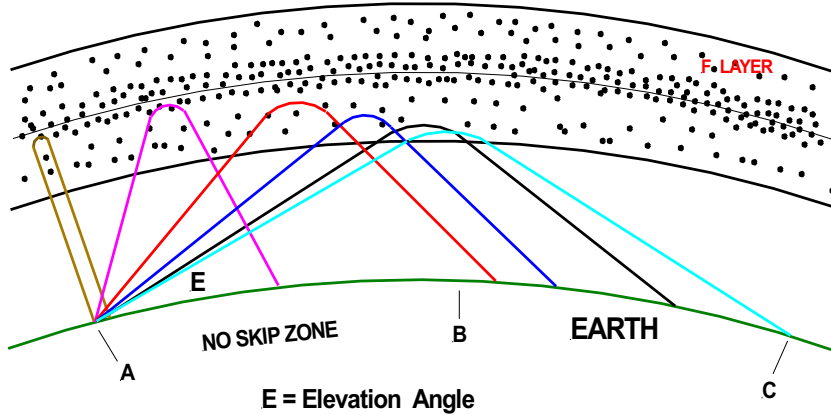


Skip Distance 40 Meter Test

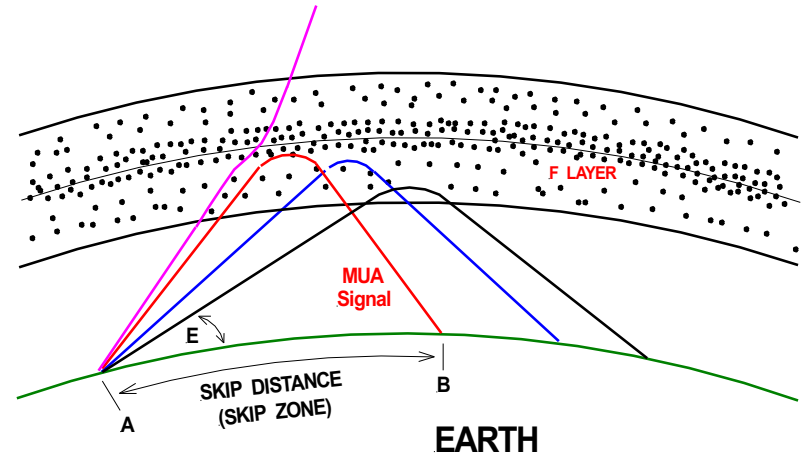


Ken Larson KJ6RZ
February 2024
www.skywave-radio.org

40 Meter Skip Distance Test



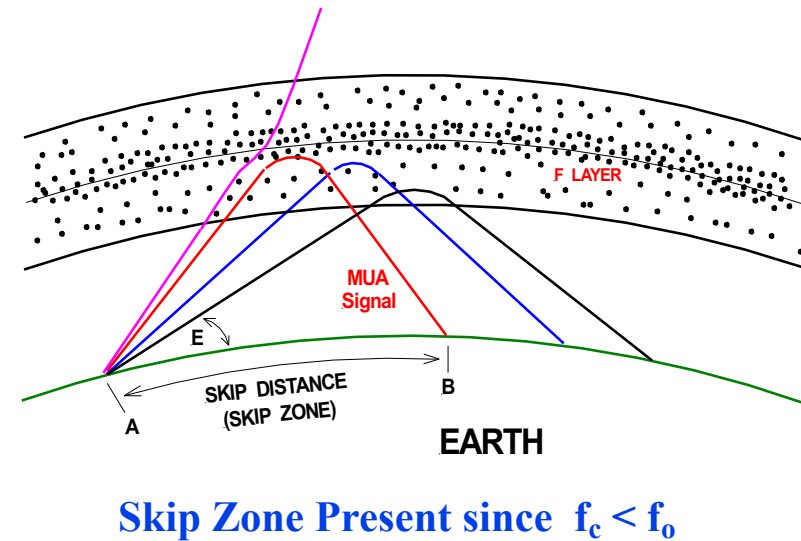
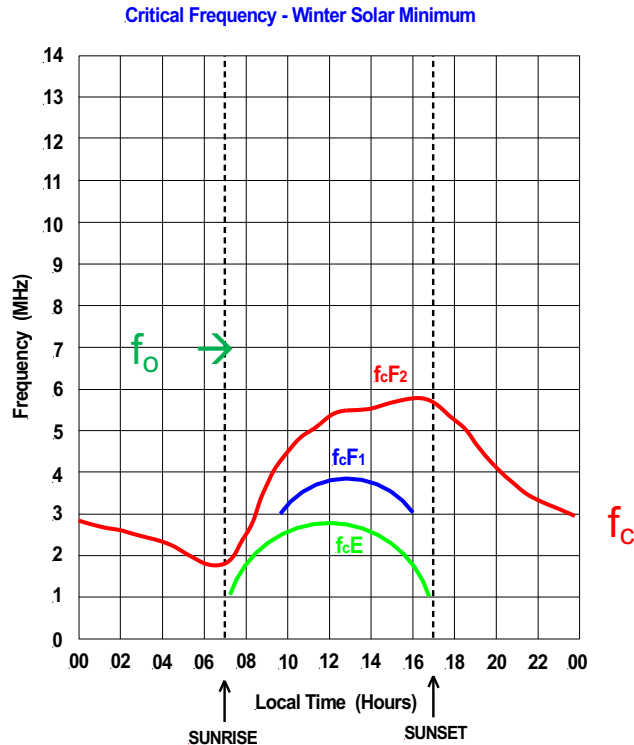
No Skip Zone if $f_c > f_o$



Skip Zone Present if $f_c < f_o$

- The presence of a 40 meter skip zone depends on:
 - The solar cycle, and
 - The time of day

40 Meter Skip Distance Test - Solar Minimum



- During **solar minimum** critical frequency f_c is nearly always less than the 40 meter operating frequency f_o of 7.0 – 7.3 MHz
- Consequently, during **solar minimum** a skip zone is present on 40 meters most of the time

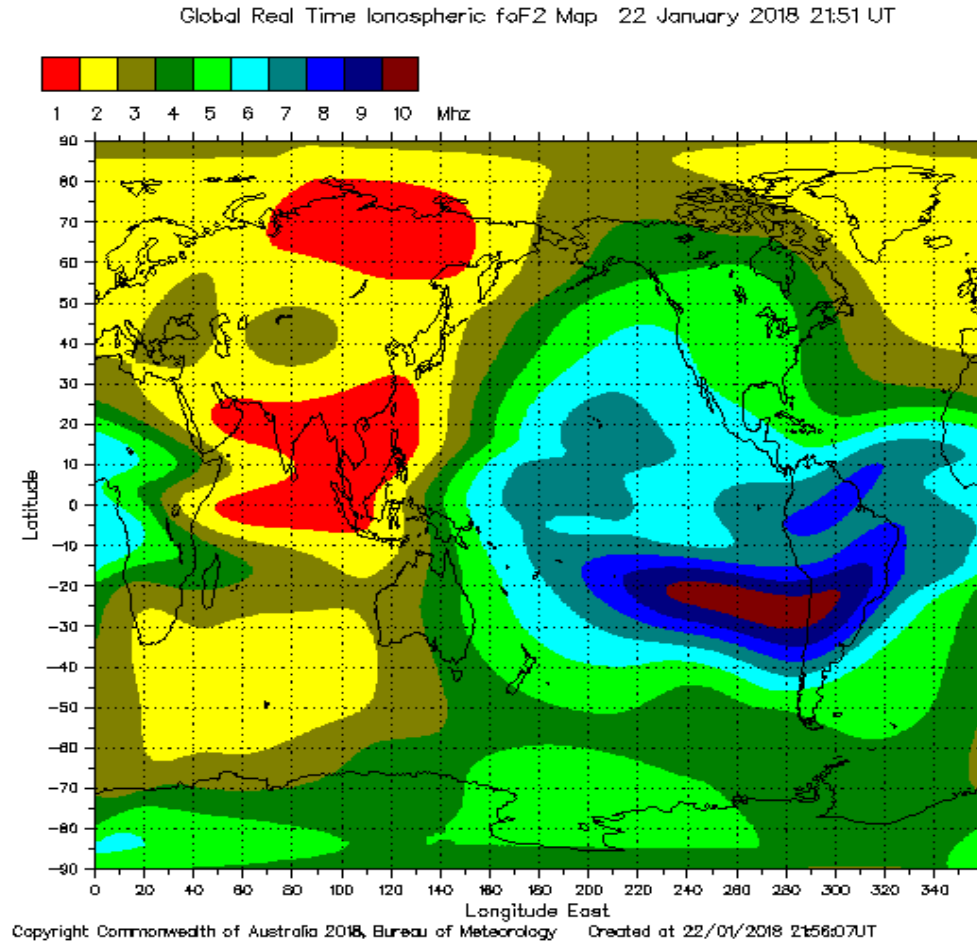
40 Meter Skip Distance Test Data – For 1/22/2018 @ 14:00 hours

Near Solar Minimum

Time	Frequency MHZ	Call	Contact Duration (min)	Power Watts	Antenna	Distance Miles	Comments
							Fc = 5.5 MHz
14:08	7100.500	AJ7C	nc	50	IV	31	Culver City, CA
14:10	7102.000	K6JGL	nc	50	IV	37	Torrance, CA
14:11	7066.500	XE2BNC	1.1	50	IV	160	Tijuana, Mexico
14:13	7100.000	KE7XO	nc	50	IV	251	North Las Vegas
14:14	7095.000	K2RDX	nc	50	IV	276	San Jose, CA
14:16	7105.500	KD7NHC	0.7	50	IV	320	Wellington, NV (SE of Tahoe)
14:17	7101.500	KJ6IX	0.7	50	IV	328	Gardnerville, NV
14:19	7103.000	K6SDR	0.8	50	IV	336	San Rafael
14:20	7095.500	KD6OAT	0.9	50	IV	585	Sandy, UT
14:23	7103.000	K7DAV	1.4	50	IV	605	Bountiful, UT
14:26	7100.000	KF7RSF	1.5	50	IV	685	Brandon, OR
14:35	7080.500	N7MO	0.7	50	IV	843	Pasco, WA

- 40 meter skip distance test for 14:00 PST January 22, 2018
- Sun Rise @ 6:55, Sun Set @ 17:14, SFI = 68, X-Ray Flux = A3.4, A Index = 10, K Index = 2, SSN = 0, antenna was an Inverted V (IV) with apex at 32 feet
- A station with no entry means that the station could not be reached because the frequency was in use by others, a commonly encountered problem

Global Critical Frequency Map for 14:00 PST 1/22/2018



- Critical frequency over Western United States was approximately 5.5 MHz at 14:00 PST

40 Meter Skip Distance Test Data – For 1/22/2018 @ 14:00 hours

Time	Frequency MHZ	Call	Contact Duration (min)	Power Watts	Antenna	Distance Miles	Comments
							Fc = 5.5 MHz
14:08	7100.500	AJ7C	nc	50	IV	31	Culver City, CA
14:10	7102.000	K6JGL	nc	50	IV	37	Torrance, CA
14:11	7066.500	XE2BNC	1.1	50	IV	160	Tijuana, Mexico
14:13	7100.000	KE7XO	nc	50	IV	251	North Las Vegas
14:14	7095.000	K2RDX	nc	50	IV	276	San Jose, CA
14:16	7105.500	KD7NHC	0.7	50	IV	320	Wellington, NV (SE of Tahoe)
14:17	7101.500	KJ6IX	0.7	50	IV	328	Gardnerville, NV
14:19	7103.000	K6SDR	0.8	50	IV	336	San Rafael
14:20	7095.500	KD6OAT	0.9	50	IV	585	Sandy, UT
14:23	7103.000	K7DAV	1.4	50	IV	605	Bountiful, UT
14:26	7100.000	KF7RSF	1.5	50	IV	685	Brandon, OR
14:35	7080.500	N7MO	0.7	50	IV	843	Pasco, WA

- During this test at 14:00 critical frequency was 5.5 MHz resulting in a significant skip zone
- Stations from 31 out to 276 miles were difficult if not impossible to reach
- These stations, marked nc for no connection, were in the roughly 300 mile skip zone
- Stations from 320 to 843 miles were easily reached since they were outside the skip zone
- This test used the Winmor digital protocol
- Contact durations of 0.7 to 0.9 were considered very good connections

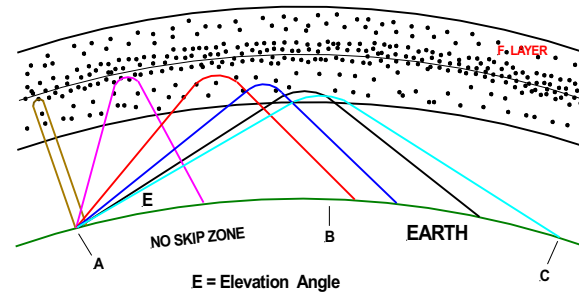
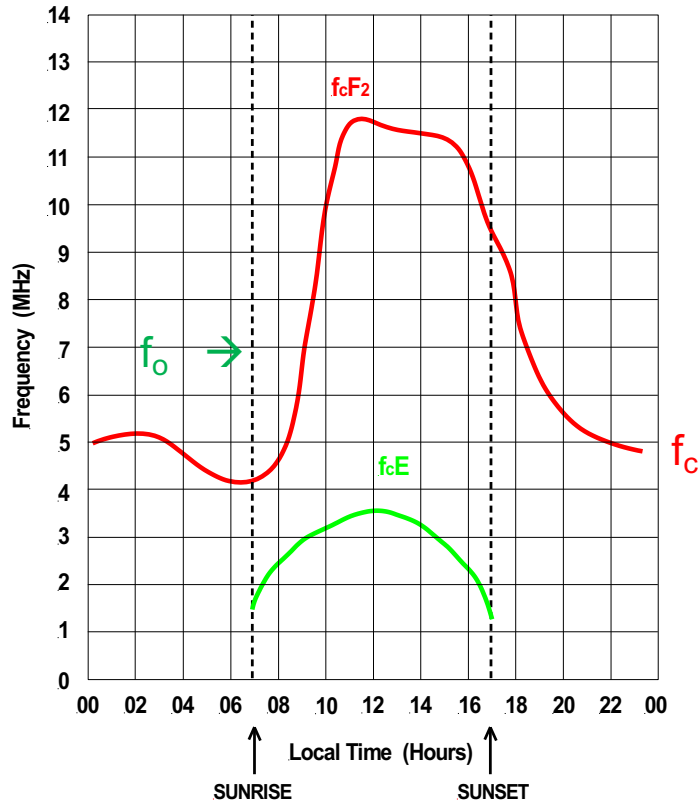
40 Meter Skip Distance Test Data – For 1/22/2018 @ 19:00 hours

Time	Frequency MHZ	Call	Contact Duration (min)	Power Watts	Antenna	Distance Miles	Comments
19:02	7100.500	AJ7C	nc	50	IV	31	Culver City, CA
19:04	7102.000	K6JGL	abort	50	IV	37	Torrance, CA
19:07	7066.500	XE2BNC	nc	50	IV	160	Tijuana, Mexico
19:08	7100.000	KE7XO	nc	50	IV	251	North Las Vegas
10:09	7095.000	K2RDX	nc	50	IV	276	San Jose, CA
19:11	7105.500	KD7NHC	nc	50	IV	320	Wellington, NV (SE of Tahoe)
19:14	7101.500	KJ6IX	nc	50	IV	328	Gardnerville, NV
19:15	7103.000	K6SDR	nc	50	IV	336	San Rafael
19:16	7095.500	KD6OAT	nc	50	IV	585	Sandy, UT
19:18	7103.000	K7DAV	nc	50	IV	605	Bountiful, UT
19:17	7100.000	KF7RSF	nc	50	IV	685	Brandon, OR
19:19	7105.000	KG7AV	nc	50	IV	696	Bend, OR
19:20	7088.500	W7YAM	nc	50	IV	796	McMinnville, OR
19:21	7083.500	W7BO	nc	50	IV	833	Woodland, WA (N Portland)
19:22	7080.500	N7MO	nc	50	IV	843	Pasco, WA

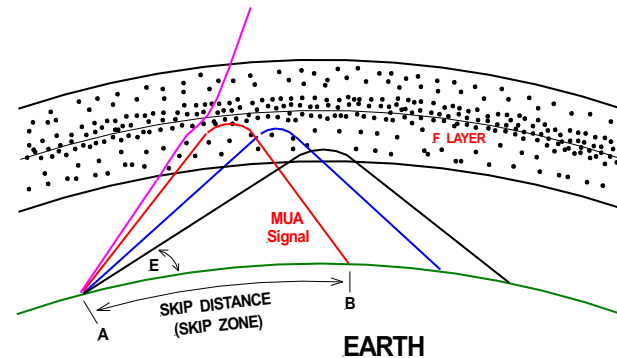
- At 19:00 on 1/22/2018, with a critical frequency of 2.5 MHz, the 40 meter band was dead

40 Meter Skip Distance Test - Solar Maximum

Critical Frequency - Winter Solar Maximum



During the day
NO skip zone since
 $f_c > f_o$



During the evening a
skip zone is present
since $f_c < f_o$

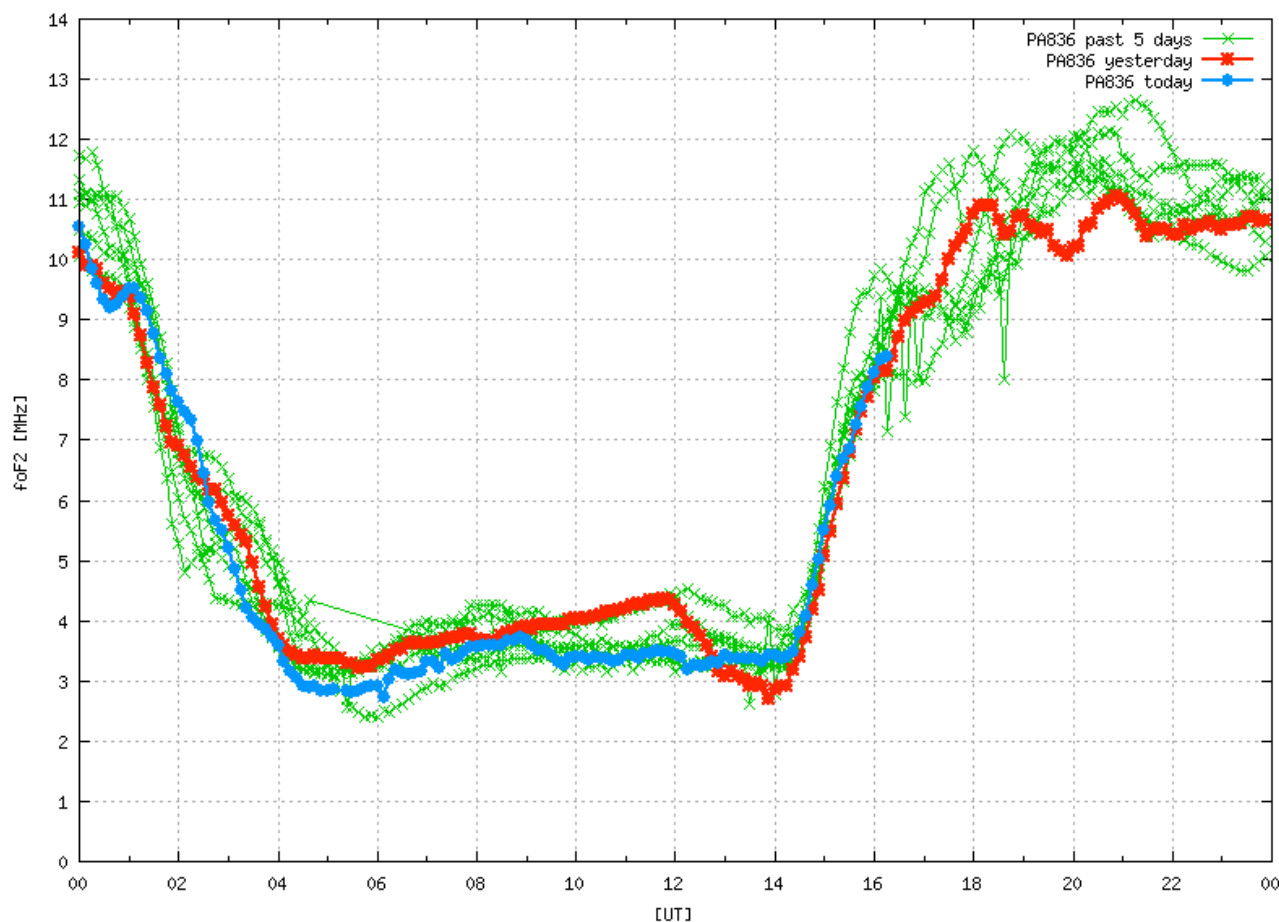
- During **solar maximum** critical frequency f_c is usually:
- Above the 40 meter operating frequency f_o of 7.0 to 7.3 MHz during the day, and
- Below the 40 meter operating frequency at night
- Resulting in a 40 meter skip zone occurring only during the evening and night

40 Meter Skip Distance Test Data – For 1/30/2024 @ 16:00 hours

Near Solar Maximum

Time	Frequency MHZ	Call	Distance Miles	Contact Duration (min)	Power Watts	Antenna	Tries	Comments
					10	Yellow		fc = 10.5 MHz
16:08	7102.100	W6BI	11	0:18				Simi Valley, CA
16:06	7106.500	KD6LLB	13	0:18				Oxnard, CA
16:10	7101.500	NR6V	20	0:21				Northridge, CA
16:11	7100.500	AJ7C	31	0:18				Culver City, CA
16:13	7100.000	KN6BKT	48	0:18				San Gabrile, CA
16:14	7106.000	N7OP	52	0:21				Lancaster, CA
16:15	7106.500	KT2KT	86	0:16				Bakersfield, CA
16:17	7066.500	XE2BC	160	0:21				Tijuana, Mexico
17:07	7094.500	W6CTT	187	0:19				Clovis, CA
16:22	7084.000	KB6HOH-12	338	0:25				Novato, CA [N of San Francisco]
16:23	7102.000	W7DEM	345	0:19				Minden, NV [S of Carson City]
16:26	7105.000	W6LHR	349	0:17				Lincoln, CA. [NE of Sacramento]
16:29	7108.500	KJ7GSK	386	0:16				Chandler, AZ. [SE of Phoenix]
16:30	7099.700	K7RRR	411	0:31				Gilbert, AZ. [SE of Phoenix]
	7103.000	KF7KLA	577					Klamath Falls, OR
16:32	7095.500	KD6OAT	585	0:31				Sandy, UT
16:39	7102.000	AG7MM	638	0:26				Burley, ID. [E of Twin Falls]
16:52	7102.000	KG7AV	693	1:11				Bend, OR
16:43	7099.700	W7INL	741	0:18				Rigby, ID. [N of Idaho Falls]
16:46	7095.000	K7UNI	769	0:21				La Grande, OR. [SE of Pendleton]
	7104.000	W7OWO	798					Dundee, OR. [SE of Portland]
16:48	7101.000	KD0SFY	845	0:23				Colorado Springs, CO

- 40 meter skip test at 16:00 PST 1/30/2024: Sun Rise @ 6:52, Sun Set @ 17:21, SFI = 135, X-Ray Flux = B7.4, A Index = 10, K Index = 2, SSN = 113, Inverted V antenna apex at 32 ft
- VARA digital protocol used; contact durations of 0.18 considered a very good connections
- A station with no entry means that the station could not be reached because the frequency was in use by others, a commonly encountered problem



Ionosphere Critical
Frequency at.
Point Arguello, CA

Test Time 16:00 PST

- This chart shows f_cF2 for the **past 5 days**, **yesterday**, and **today** in UT time for 1/31/24
- For test time of 16:00 PST 1/30/24 use **today blue trace** at 00:00 UT = 16:00 PST
- The result is $f_cF2 = 10.5$ MHz

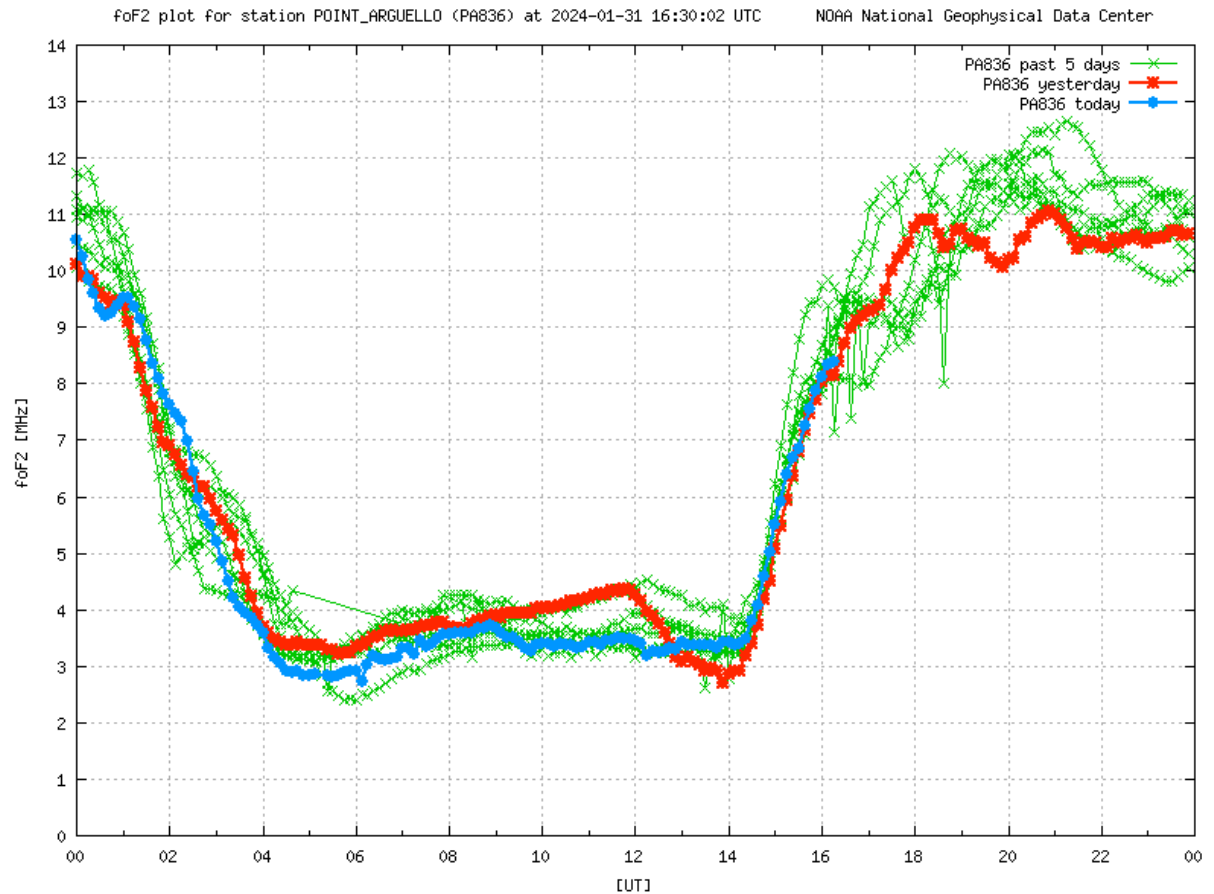
40 Meter Skip Distance Test Data – For 1/30/2024 @ 16:00 hours

Time	Frequency MHZ	Call	Distance Miles	Contact Duration (min)	Power Watts	Antenna	Tries	Comments
					10	Yellow		fc = 10.5 MHz
16:08	7102.100	W6BI	11	0:18				Simi Valley, CA
16:06	7106.500	KD6LLB	13	0:18				Oxnard, CA
16:10	7101.500	NR6V	20	0:21				Northridge, CA
16:11	7100.500	AJ7C	31	0:18				Culver City, CA
16:13	7100.000	KN6BKT	48	0:18				San Gabrile, CA
16:14	7106.000	N7OP	52	0:21				Lancaster, CA
16:15	7106.500	KT2KT	86	0:16				Bakersfield, CA
16:17	7066.500	XE2BC	160	0:21				Tijuana, Mexico
17:07	7094.500	W6CTT	187	0:19				Clovis, CA
16:22	7084.000	KB6HOH-12	338	0:25				Novato, CA [N of San Francisco]
16:23	7102.000	W7DEM	345	0:19				Minden, NV [S of Carson City]
16:26	7105.000	W6LHR	349	0:17				Lincoln, CA. [NE of Sacramento]
16:29	7108.500	KJ7GSK	386	0:16				Chandler, AZ. [SE of Phoenix]
16:30	7099.700	K7RRR	411	0:31				Gilbert, AZ. [SE of Phoenix]
	7103.000	KF7KLA	577					Klamath Falls, OR
16:32	7095.500	KD6OAT	585	0:31				Sandy, UT
16:39	7102.000	AG7MM	638	0:26				Burley, ID. [E of Twin Falls]
16:52	7102.000	KG7AV	693	1:11				Bend, OR
16:43	7099.700	W7INL	741	0:18				Rigby, ID. [N of Idaho Falls]
16:46	7095.000	K7UNI	769	0:21				La Grande, OR. [SE of Pendleton]
	7104.000	W7OWO	798					Dundee, OR. [SE of Portland]
16:48	7101.000	KD0SFY	845	0:23				Colorado Springs, CO

- During this test at 16:00 the critical frequency was 10.5 MHz resulting in **no skip zone**
- Consequently, all stations were reached from W6BI a distance of 11 miles from the author's station out to KD0SFY 845 miles away (all contact durations **green**)

Ionosphere Critical Frequency at Point Arguello, CA

Test Time = 19:00 PST



- For test time of 19:00 PST 1/30/24 again use [today blue trace](#) at 03:00 UT = 19:00 PST
- At 19:00 PST (03:00 UT) the critical frequency $f_cF2 = 5$ MHz

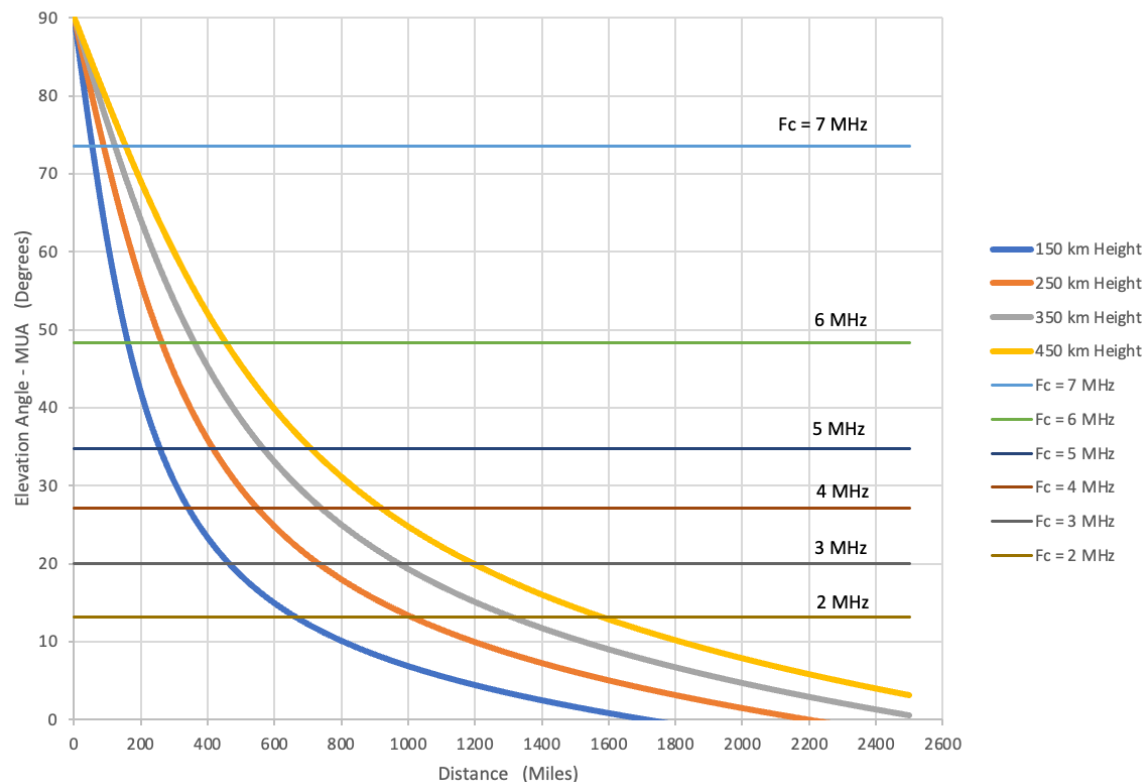
40 Meter Skip Distance Test Data – For 1/30/2024 @ 19:00 hours

Time	Frequency MHZ	Call	Distance Miles	Contact Duration (min)	Power Watts 10	Antenna Yellow	Tries	Comments
								fc = 5 MHz
	7102.100	W6BI	11					Simi Valley, CA
18:51	7106.500	KD6LLB	13	1:39		QRM		Oxnard, CA
	7101.500	NR6V	20					Northridge, CA
	7100.500	AJ7C	31					Culver City, CA
	7100.000	KN6BKT	48					San Gabrile, CA
19:04	7106.000	N7OP	52	nc		QRM	2	Lancaster, CA
	7106.500	KT2KT	86					Bakersfield, CA
18:55	7066.500	XE2BC	160	nc			2	Tijuana, Mexico
19:00	7094.500	W6CTT	187	nc			2	Clovis, CA
18:59	7084.000	KB6HOH-12	338	0:25				Novato, CA [N of San Francisco
	7102.000	W7DEM	345					Minden, NV [S of Carson City
19:29	7105.000	W6LHR	349	nc		QRM	2	Lincoln, CA. [NE of Sacramento
19:19	7108.500	KJ7GSK	386	nc			2	Chandler, AZ. [SE of Phoenix]
	7099.700	K7RRR	411	nc			2	Gilbert, AZ. [SE of Phoenix]
19:22	7103.000	KF7KLA	577	0:16				Klamath Falls, OR
19:06	7095.500	KD6OAT	585	0:18				Sandy, UT
19:38	7102.000	AG7MM	638	nc		QRM	2	Burley, ID. [E of Twin Falls]
19:40	7102.000	KG7AV	693	0:28				Bend, OR
19:07	7099.700	W7INL	741	0:18				Rigby, ID. [N of Idaho Falls]
19:09	7095.000	K7UNI	769	0:17				La Grande, OR. [SE of Pendleton]
19:33	7104.000	W7OWO	798	0:22				Dundee, OR. [SE of Portland]
19:35	7101.000	KD0SFY	845	0:19				Colorado Springs, CO

- During this test at 19:00 critical frequency was 5 MHz resulting in a **significant skip zone**
- Stations from **11 out to 400 miles** were difficult if not impossible to reach
- These stations, marked **nc** for no connection, were in the roughly 500 mile skip zone
- Stations **from 577 to 845 miles** were easily reached since they were outside the skip zone

40 Meter Skip Distance Chart

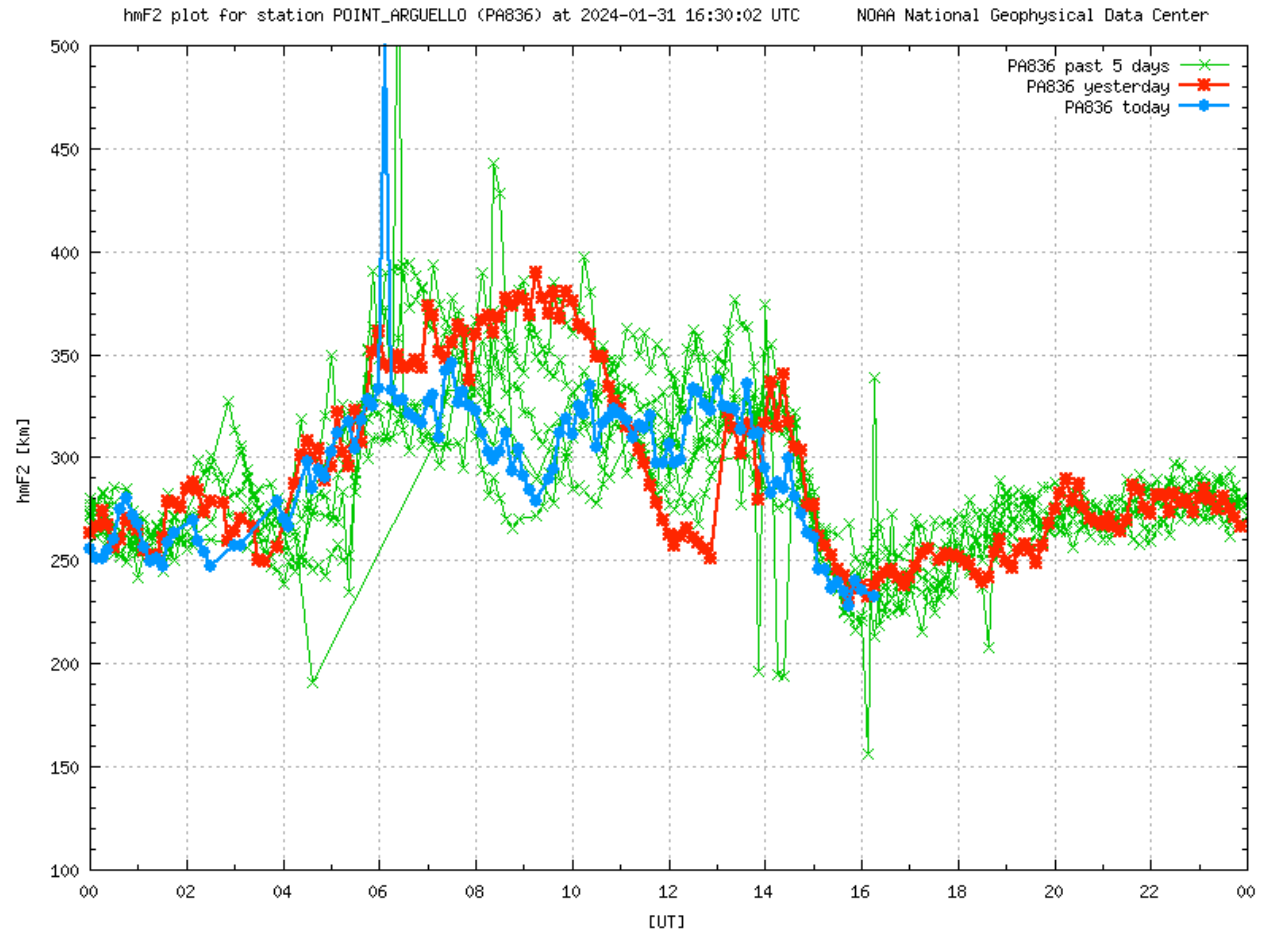
40 Meter Skip Distance Chart



- Skip distance can be estimated using the 40m Skip Distance Chart by selecting the F2 layer ionospheric height h_mF2 from the appropriate Ionosonde Site
- For California this is done by clicking on Ionogram under Current Conditions of website www.skywave-radio.org
- Then clicking on Point Arguello, CA h_mF2 .
- Next determine the critical frequency from the Point Arguello critical frequency chart provided below

Ionosphere Height
 h_mF2 at
Point Arguello, CA

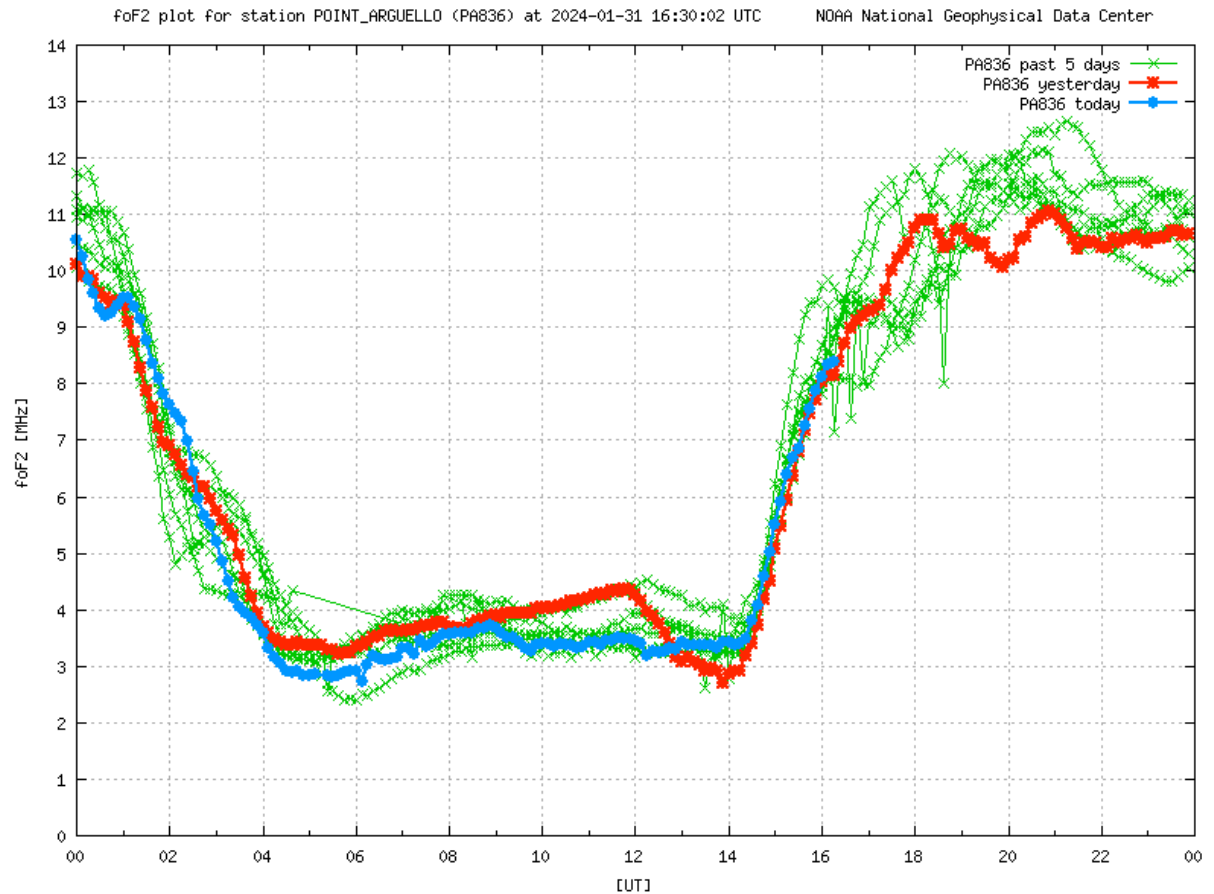
Test time = 19:00 PST



- This chart shows h_mF2 for the **past 5 days**, **yesterday**, and **today** in UT time for 1/31/24
- For 19:00 PST 1/30/24 use **today blue trace** at 03:00 UT = 19:00 PST
- The result is $h_mF2 = 270$ km

Ionosphere Critical Frequency at Point Arguello, CA

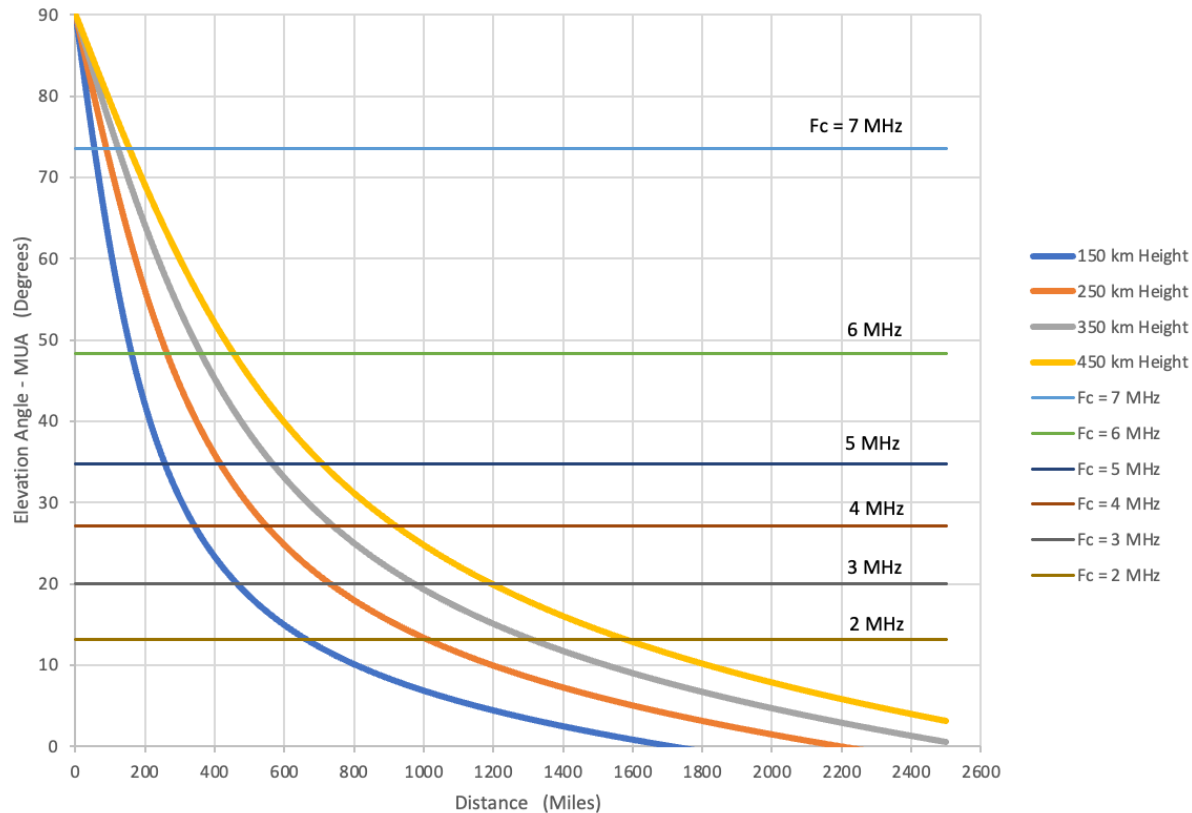
Test Time = 19:00 PST



- For test time of 19:00 PST 1/30/24 again use [today blue trace](#) at 03:00 UT = 19:00 PST
- At 19:00 PST (03:00 UT) the critical frequency $f_cF2 = 5$ MHz

Reading The 40 Meter Skip Distance Chart

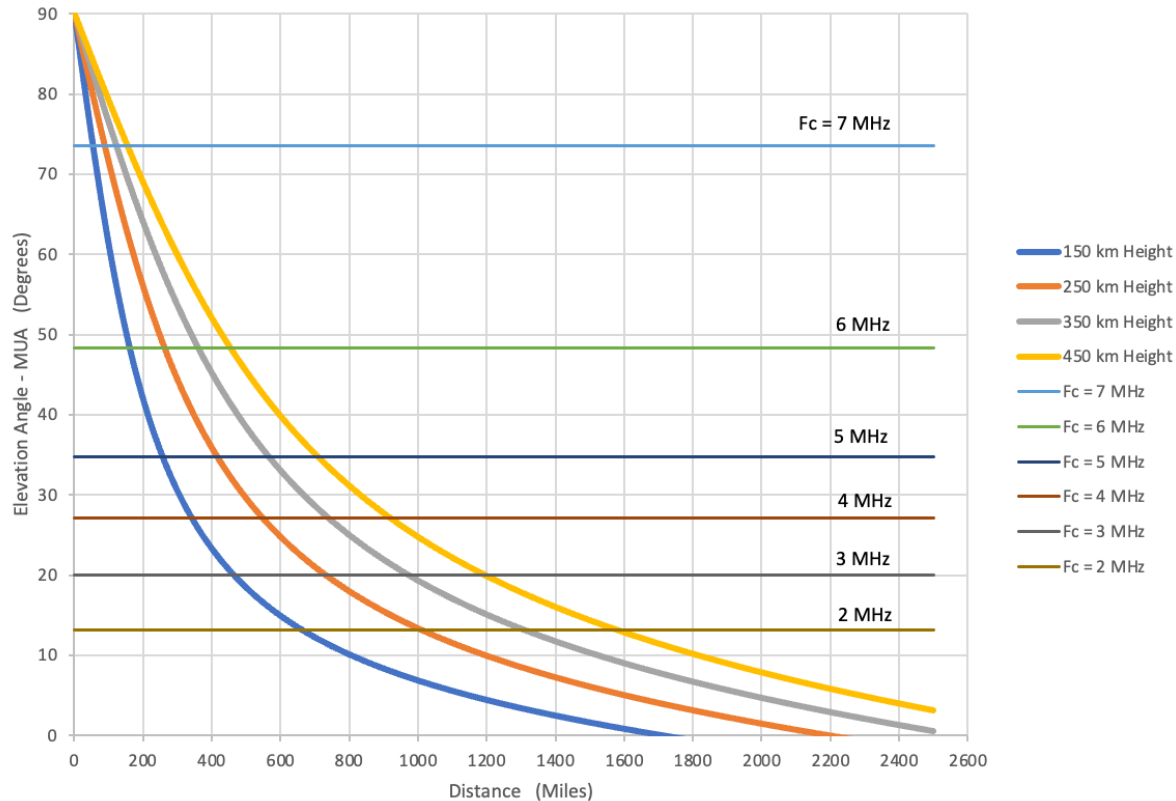
40 Meter Skip Distance Chart



- The estimated skip distance given by the Skip Distance Chart is found by reading down to the Distance axis from the intersection of $F_c = 5$ MHz and F2 layer height = 270 km
- The estimated skip distance is approximately 400 miles
- The 19:00 test data indicated that the skip distance was around 500 miles

Reading The 40 Meter Skip Distance Chart - continued

40 Meter Skip Distance Chart

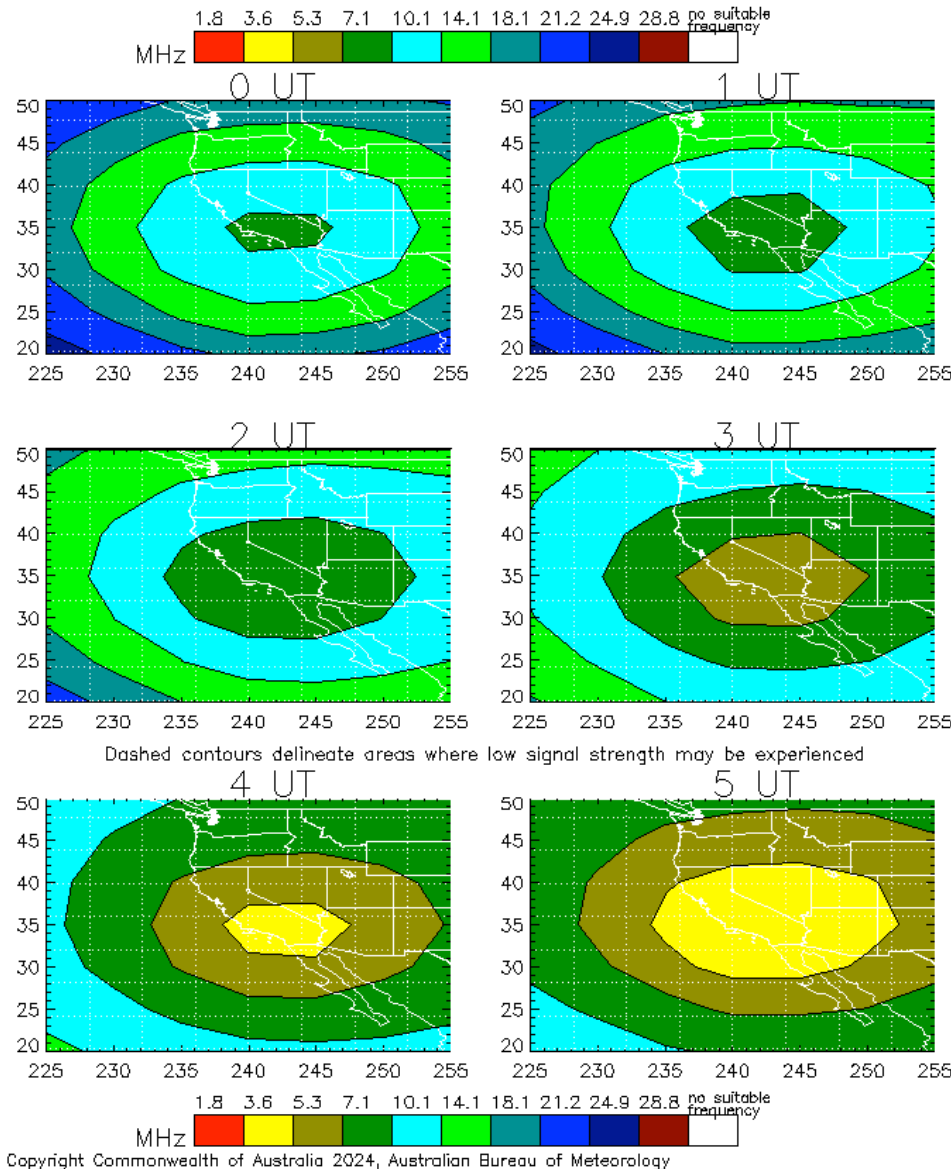


- The Skip Distance Chart is underestimating the actual skip distance
- For selecting reachable WinLink RMS stations it is better to underestimate skip distance
- Overestimating skip distance causes RMS stations to be rejected when they could be reached

40 Meter HAP Chart Data for 1/30/2024 @ 19:00 PST (03:00 UT)

Base: LOS ANGELES Date: 31 January, 2024 Tindex: 106

On-Line Hourly Area Predictions (HAP)



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- The HAP Chart for 19:00 hours (03:00 UT) indicates that the closest 40 meter stations that can be reached are about 350 miles for Los Angeles
- This distance is the boundary between optimum 40 meter coverage (dark green region) and 60 meter coverage (brown region)
- 40 meter stations closer than this boundary can not be reached
- The HAP skip distance estimate of 350 miles is close to the 400 mile estimate provided by the 40m Skip Distance Chart
- The 19:00 test data indicated that the skip distance was around 500 miles
- Both the HAP Chart and the Skip Distance Chart are slightly underestimating the actual skip distance

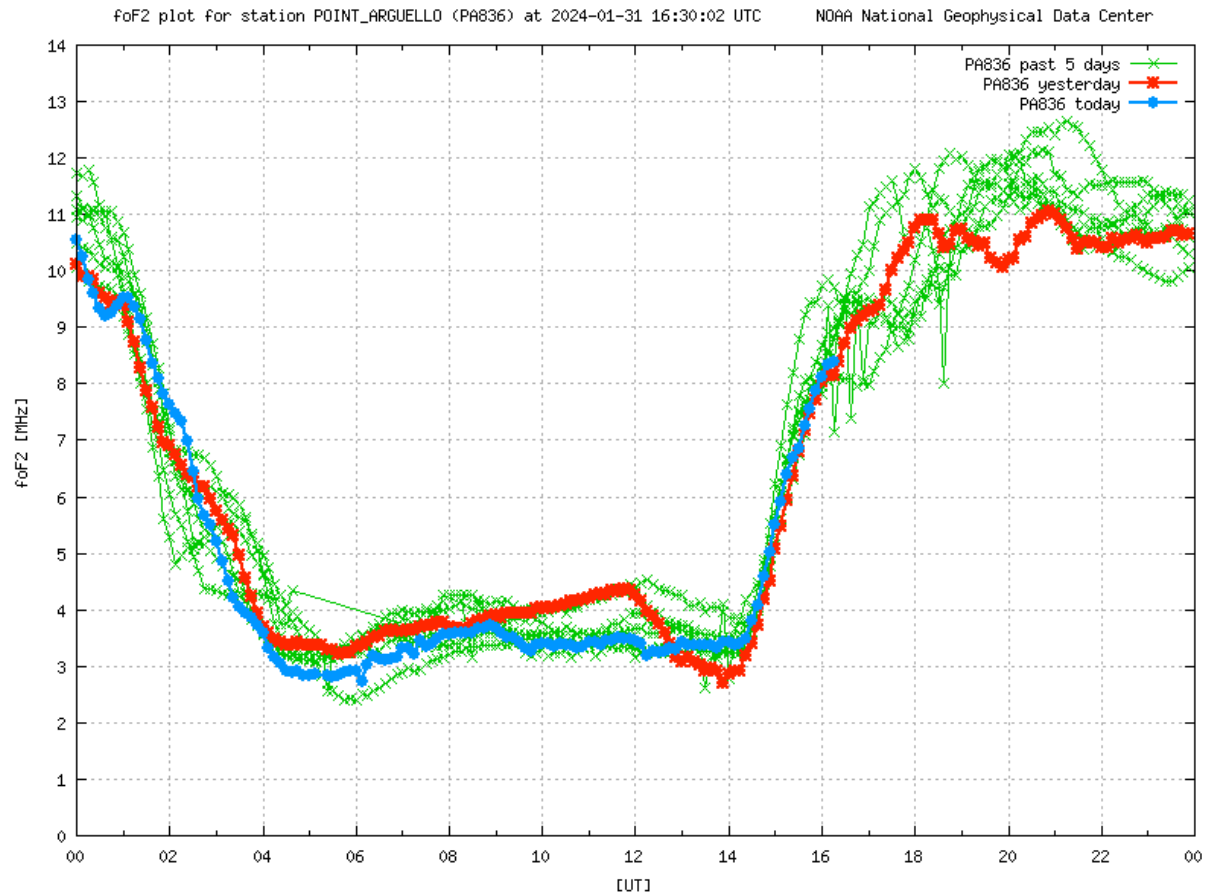
40 Meter Skip Distance Test Data – For 1/30/2024 @ 20:00 hours

Time	Frequency MHZ	Call	Distance Miles	Contact Duration (min)	Power Watts	Antenna	Tries	Comments
					10	Yellow		fc = 3.5 MHz
	7102.100	W6BI	11					Simi Valley, CA
19:49	7106.500	KD6LLB	13	nc			2	Oxnard, CA
	7101.500	NR6V	20					Northridge, CA
	7100.500	AJ7C	31					Culver City, CA
	7100.000	KN6BKT	48					San Gabrile, CA
20:13	7106.000	N7OP	52	nc			2	Lancaster, CA
	7106.500	KT2KT	86					Bakersfield, CA
19:52	7066.500	XE2BC	160	nc			2	Tijuana, Mexico
19:55	7094.500	W6CTT	187	nc			2	Clovis, CA
19:57	7084.000	KB6HOH-12	338	nc			2	Novato, CA [N of San Francisco
20:20	7102.000	W7DEM	345	nc				Minden, NV [S of Carson City
20:21	7105.000	W6LHR	349	nc			2	Lincoln, CA. [NE of Sacramento
20:23	7108.500	KJ7GSK	386	nc			2	Chandler, AZ. [SE of Phoenix]
	7099.700	K7RRR	411					Gilbert, AZ. [SE of Phoenix]
	7103.000	KF7KLA	577					Klamath Falls, OR
19:59	7095.500	KD6OAT	585	nc			2	Sandy, UT
20:15	7102.000	AG7MM	638	nc			2	Burley, ID. [E of Twin Falls]
20:18	7102.000	KG7AV	693	nc			2	Bend, OR
20:01	7099.700	W7INL	741	1:07				Rigby, ID. [N of Idaho Falls]
20:03	7095.000	K7UNI	769	nc			2	La Grande, OR. [SE of Pendleton]
	7104.000	W7OWO	798	nc			2	Dundee, OR. [SE of Portland]
20:05	7097.000	KD0SFY	845	nc			2	Colorado Springs, CO

- At 20:00 hours the 40 meter band was dead, no stations could be reached
- The critical frequency at 20:00 hours (4:00 UT) was about 3.5 MHz

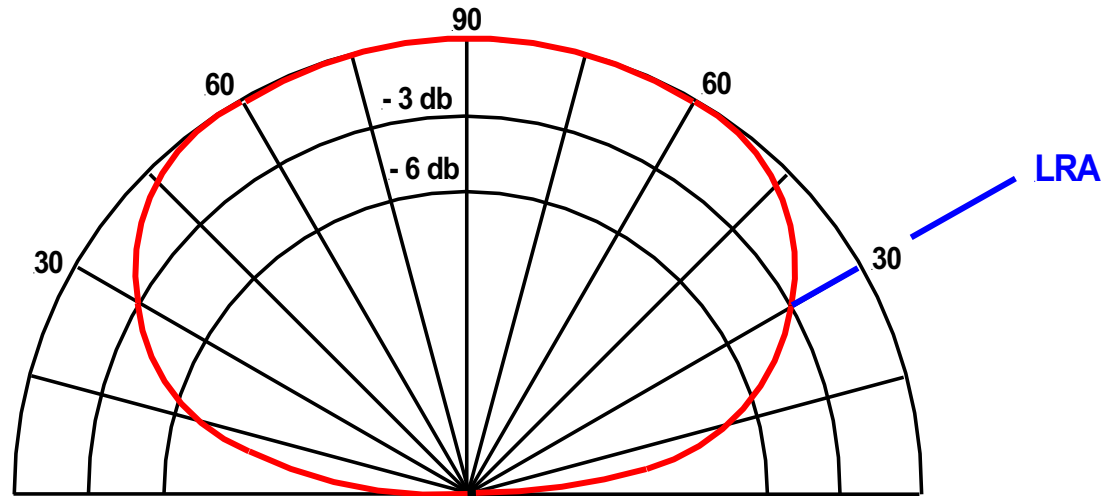
Ionosphere Critical Frequency at Point Arguello, CA

Test Time = 20:00 PST



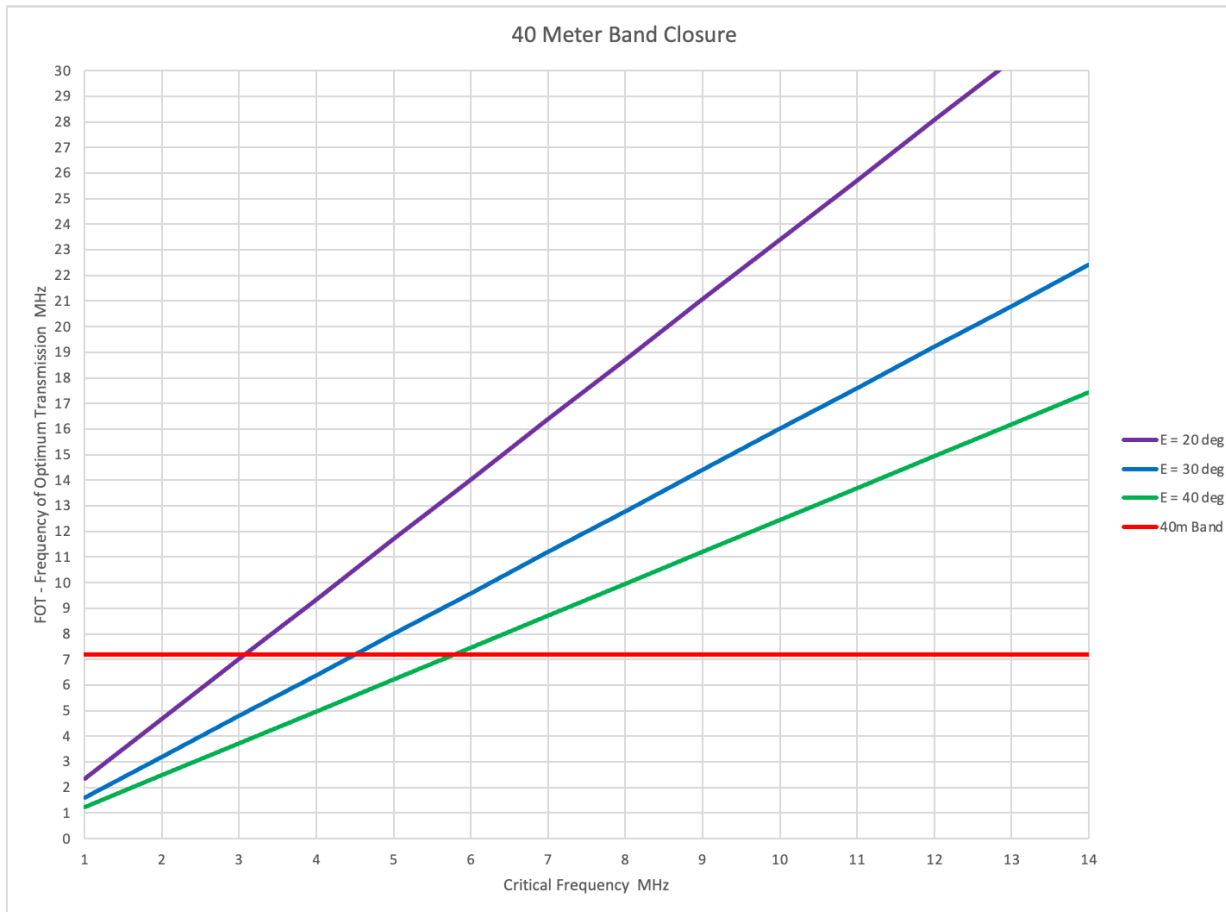
- For test time of 20:00 PST 1/30/24 again use [today blue trace](#) at 04:00 UT = 20:00 PST
- At 20:00 PST (04:00 UT) the critical frequency $f_cF2 = 3.5$ MHz

40 Meter Band Closure



- Lowest Radiated Angle (LRA) is the lowest elevation angle E_m at which an antenna can radiate a signal
- LRA is the angle at which the antenna's radiated power drops 3 db below its maximum radiated power
- Beyond this point the antenna's radiated power drops very quickly
- The LRA for a 40 meter NVIS antenna is approximately 30 degrees

40 Meter Band Closure continued

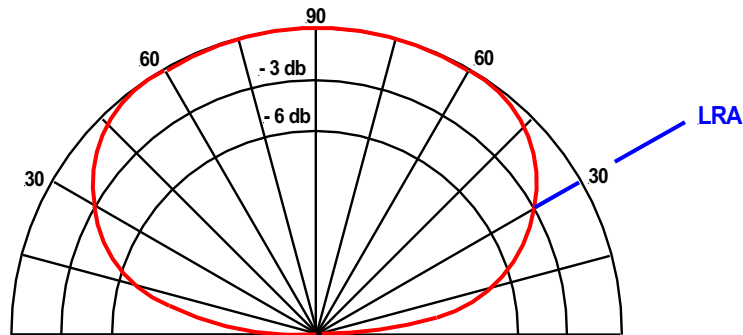


- At an elevation angle of $E_m = \text{LRA}$, the Frequency of Optimum Transmission (FOT) given by

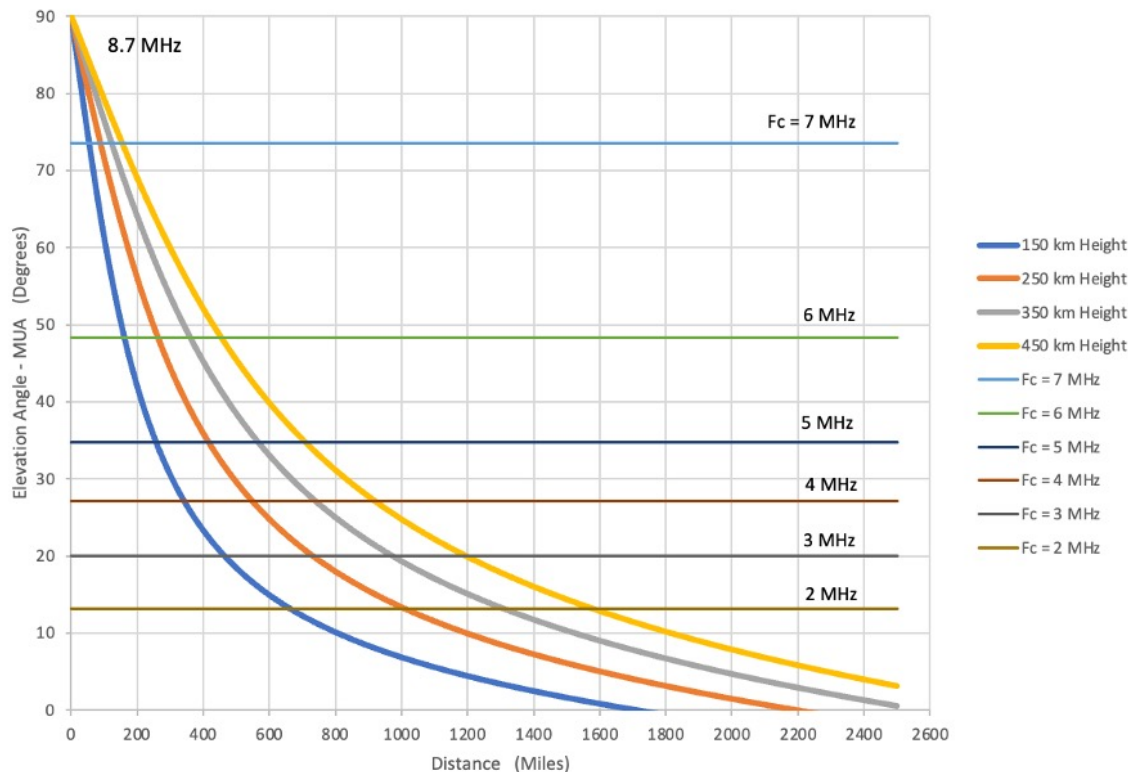
$$FOT = \frac{0.8 f_c}{\sin E_m}$$

- steadily decreases as the ionosphere's critical frequency f_c drops
- At $f_c = 4$ MHz, and $E_m = \text{LRA} = 30$ degrees, FOT goes below 7 MHz
- At that point the 40 meter frequency band becomes dead

40 Meter Band Closure continued



40 Meter Skip Distance Chart



- **Equivalently**, the band becomes dead when the ionosphere's Maximum Usable Angle (MUA) drops below the antenna's LRA
- At a critical frequency of $f_c = 4$ MHz, the MUA = 27 degrees is below the antenna's LRA of 30 degrees
- Consequently, at this critical frequency all of the antenna's radiated energy penetrates the ionosphere and is lost to outer space
- That is, the 40 meter band becomes dead

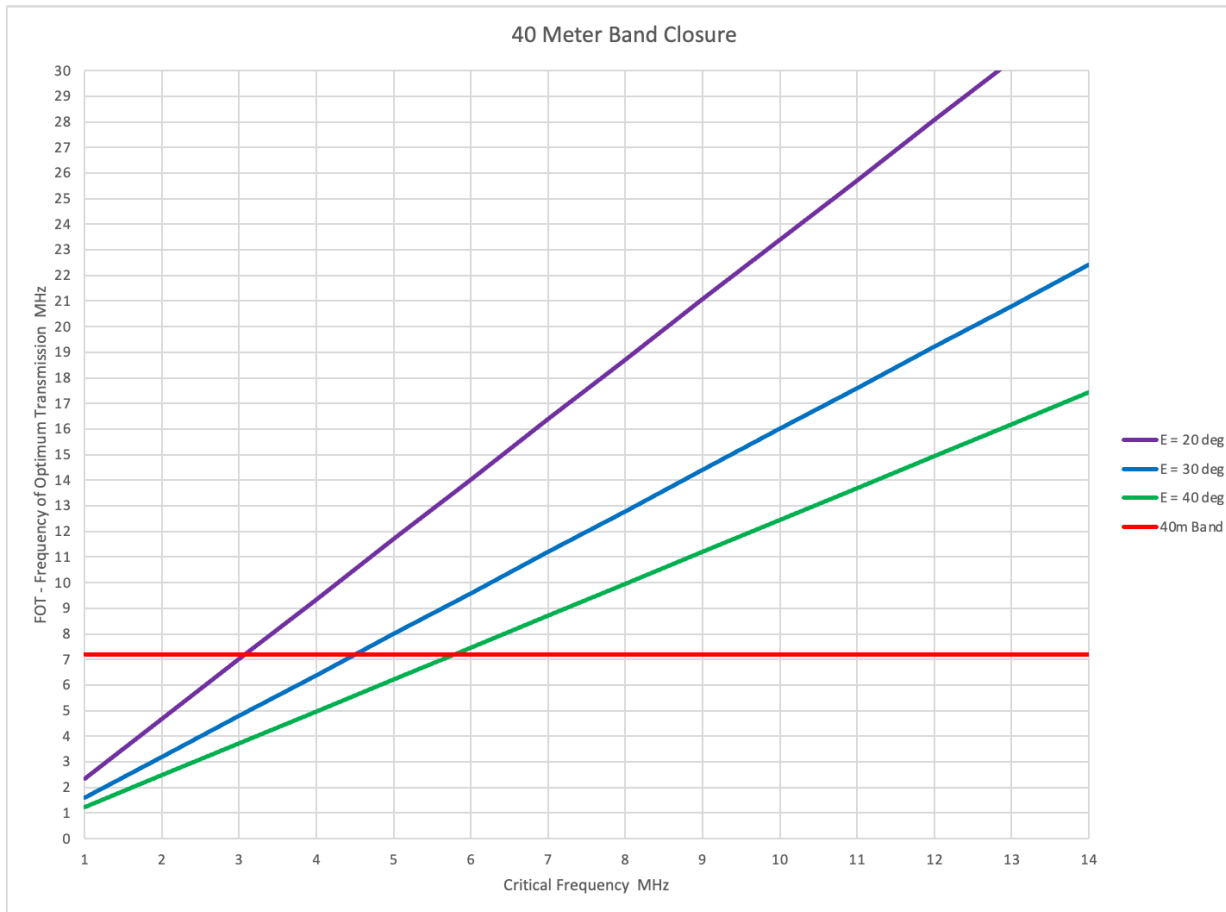
40 Meter Ground Wave Test Data – For 1/19/2024

Time	Frequency MHZ	Call	Distance Miles	Signal Qual	Contact Duration (min)	Power Watts	Antenna	Tries	Comments
						200	Yellow		8.2 MHz
17:09	7102.100	W6BI	11		0:22			QRM	Simi Valley, CA
17:10	7106.500	KD6LLB	13		0:18				Oxnard, CA
17:24	7101.500	NR6V	20		0:16				Northridge, CA
17:13	7100.500	AJ7C	31		0:16				Culver City, CA
17:15	7100.000	KN6BKT	48		0:18				San Gabrile, CA
17:16	7106.000	N7OP	52		0:18				Lancaster, CA
17:00	7106.500	KT2KT	86		0:18				Bakersfield, CA

Time	Frequency MHZ	Call	Distance Miles	Signal Qual	Contact Duration (min)	Power Watts	Antenna	Tries	Comments
						200	Yellow		2.5 MHz
21:00	7102.100	W6BI	11		0:17				Simi Valley, CA
21:01	7106.500	KD6LLB	13		1:17				Oxnard, CA
21:04	7101.500	NR6V	20		nc			2	Northridge, CA
21:05	7100.500	AJ7C	31		nc			2	Culver City, CA
21:20	7100.000	KN6BKT	48		nc				San Gabrile, CA
21:11	7106.000	N7OP	52		nc				Lancaster, CA
21:14	7102.000	K9NEY	68		nc			2	
21:16	7106.500	KT2KT	86		nc			2	Bakersfield, CA

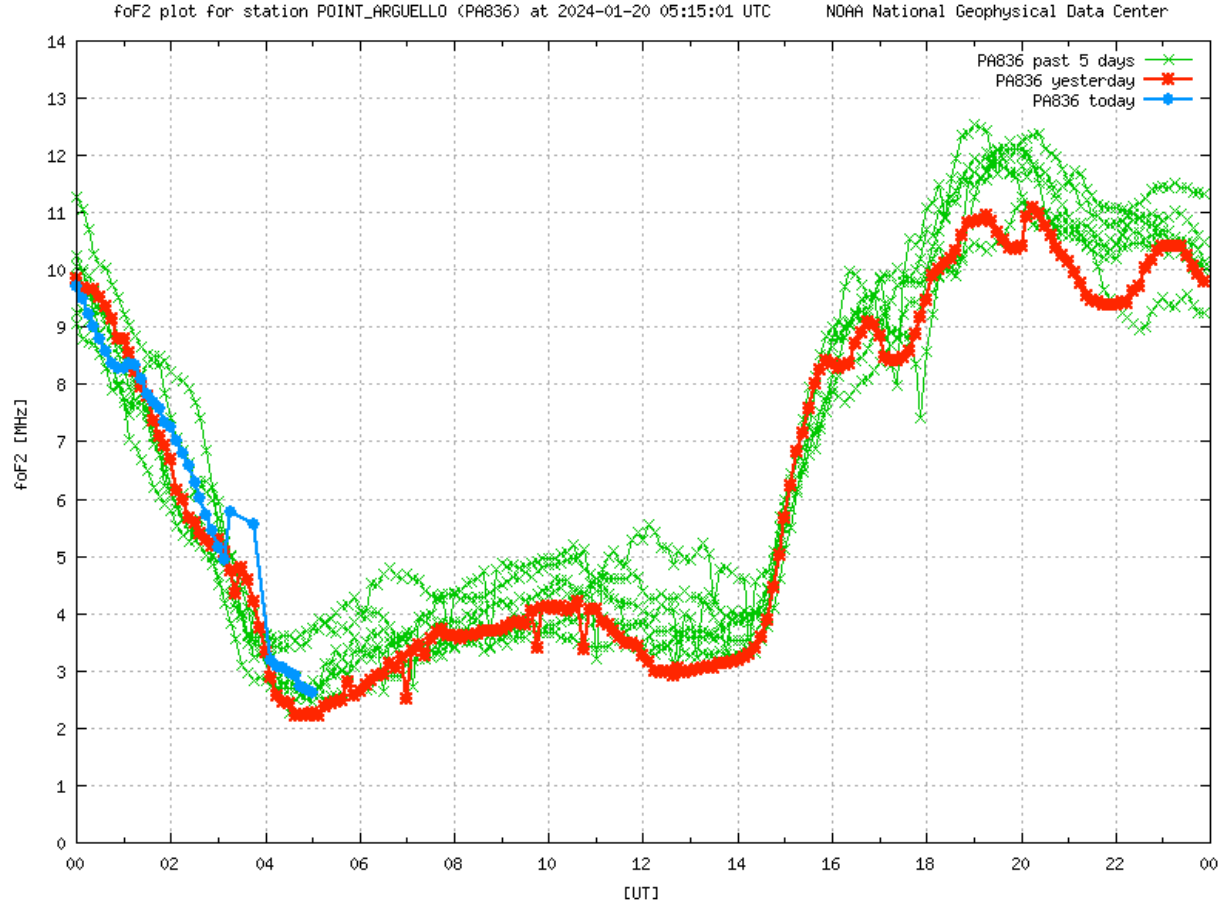
- At 17:00 hours with a critical frequency of 8.2 MHz there was no 40 meter skip zone ($f_c > f_o$)
- All close in 40 meter stations were reached from 11 out to 86 miles via NVIS propagation
- At 21:00 hours and critical frequency of 2.5 MHz (see next slides) the 40 meter FOT was approximately 4 MHz meaning that the 40 meter band was dead
- However, Simi Valley and Oxnard (at 11 and 13 miles respectively) could still be reached at a transmitting power of 200 watts, demonstrating the existence of ground wave propagation

40 Meter Band Closed at 21:00 Hours



- At 2100 hours
- $f_c = 2.5$ MHz, and
- $E_m = LRA = 30$ degrees,
- FOT = 4 MHz, well below the 7 MHz 40 meter band
- At 2100 hours the 40 meter band was dead

Critical Frequency For 1/19/2024



- This critical frequency chart is for 1/20/2024
- Critical frequency for 1/19/2024 at 21:00 hours PST is the **blue trace** at 21:00 PST = 5:00 UT
- The critical frequency at this time was approximately 2.5 MHz