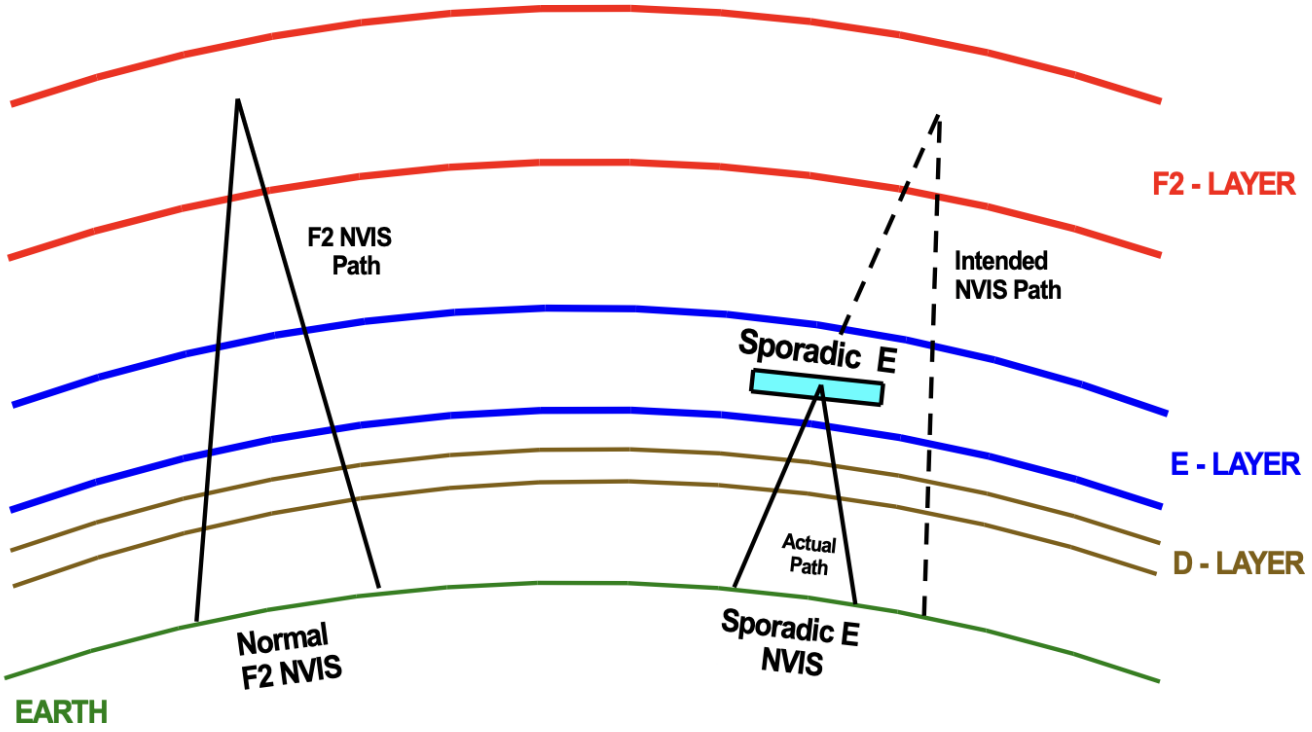
NVIS - Sporadic E Test



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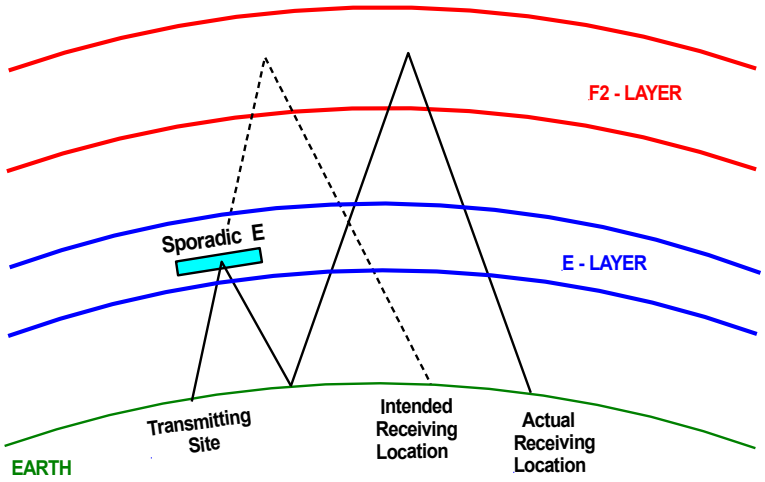
April 25, 2025

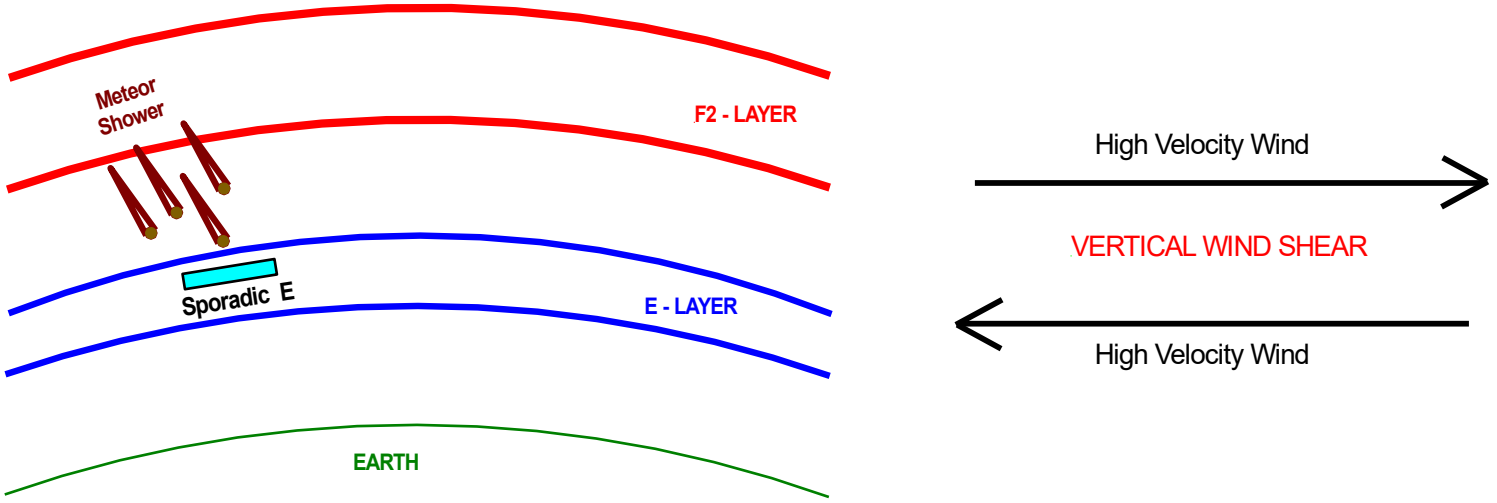
www.skywave-radio.org

Sporadic E Characteristics



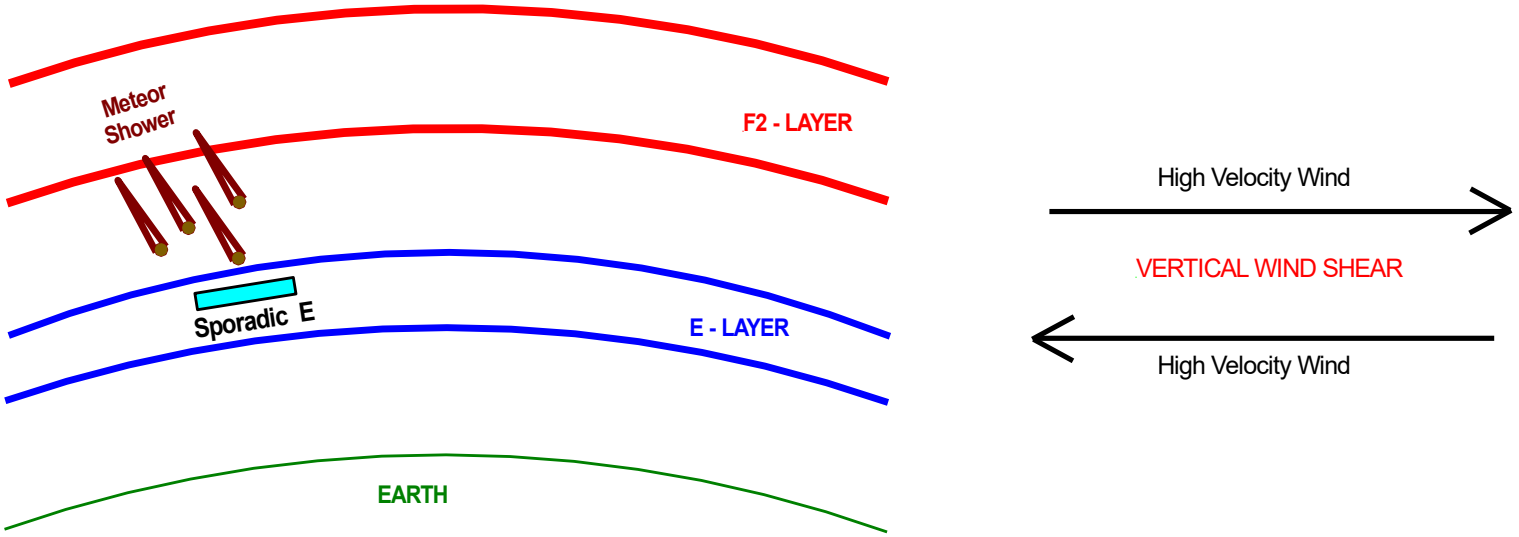
- Sporadic E (E_s) formations are regions of abnormally high ionization within the E region
- Sporadic E zones appear randomly in various sizes and shapes, persist for minutes to hours, and occur from one day to the next with little predictability
- Sporadic E zones are relatively large structures about 2 kilometers thick with horizontal dimensions stretching hundreds of kilometers
- In general, sporadic E appearances seem to have little direct relationship to the ionization processes responsible for the E region itself

Formation of Sporadic E Regions



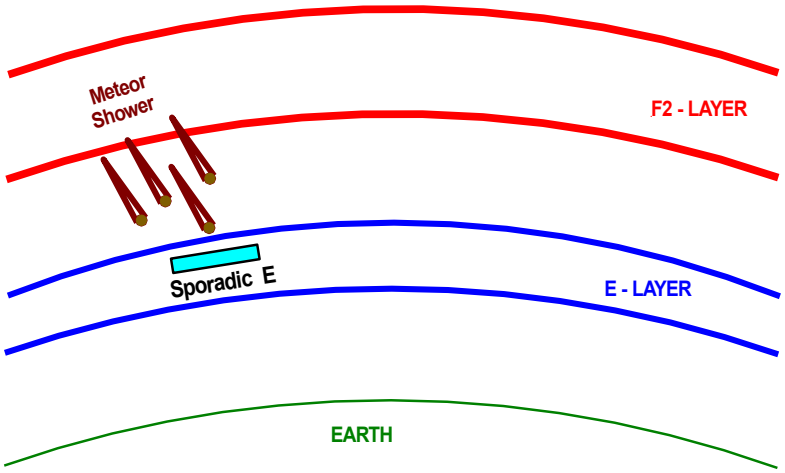
- It is believed that sporadic E patches at mid latitudes form as the result of wind shear in the upper atmosphere in combination with meteoric debris
- Enormous numbers of meteors burn up in the E region of the atmosphere
- The meteoric debris is largely monatomic metallic ions consisting of iron, sodium, and magnesium, much smaller in size than normal E region molecular ions
- Because of their small size these metallic ions recombine with free electrons at a rate much slower than that for normal E region molecular ions

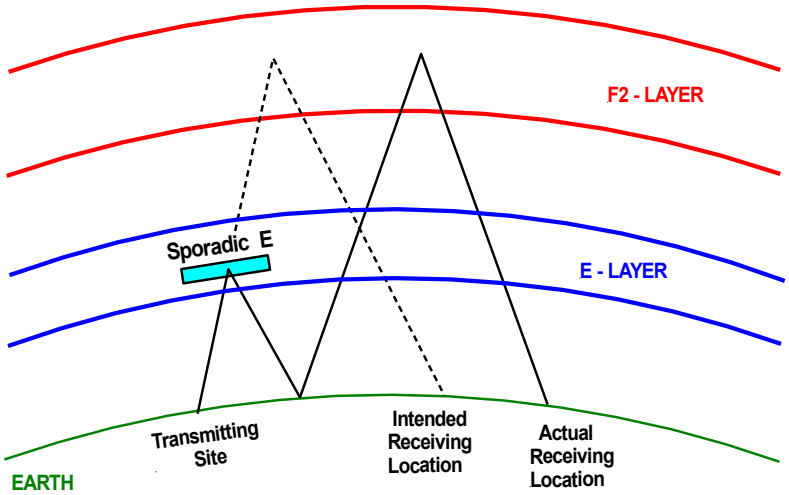
Formation of Sporadic E Regions



- High velocity winds that travel in opposite directions at slightly different altitudes can develop in the upper atmosphere producing wind shear
- Meteoric debris becomes trapped between the wind reversals at locations where the wind velocity tends to be low

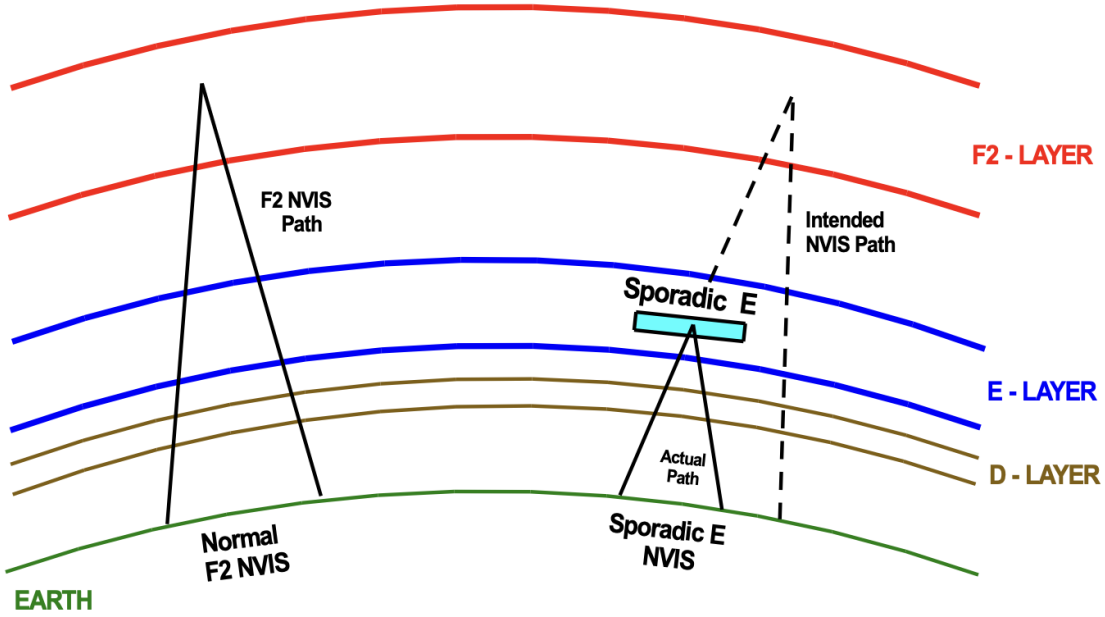
Formation of Sporadic E Regions





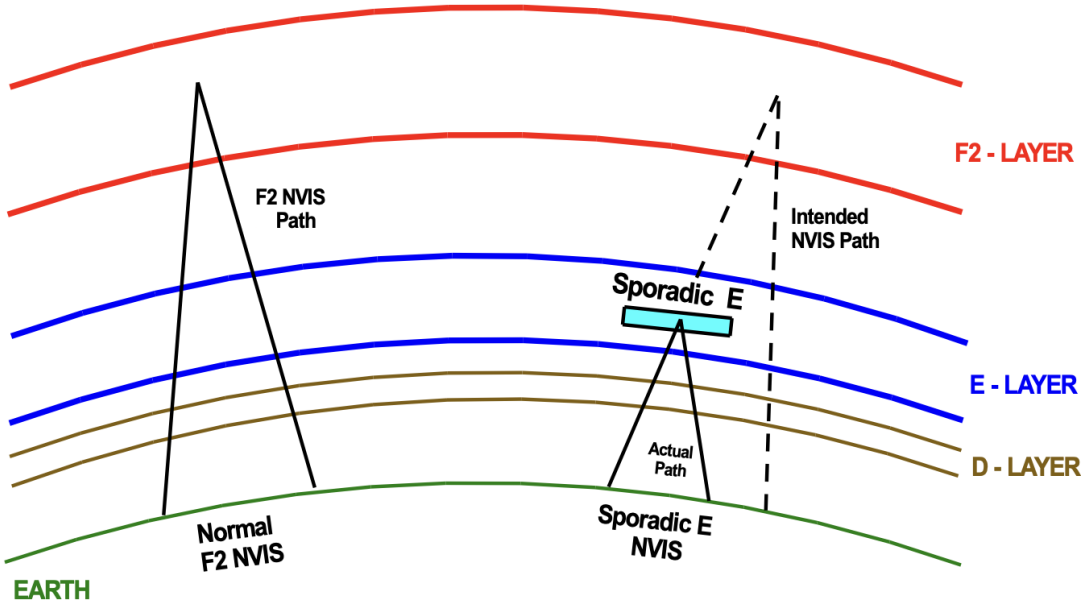
- Relatively high electron concentrations develop within the pockets of trapped debris because of the slow rate at which metallic ions recombine with free electrons
- The pockets of trapped debris form sporadic E patches
- Sporadic E zones often have electron densities far greater than normal E region levels and at times even greater than in the F region
- Sporadic E patches are opaque to radio waves, reflecting waves that normally would have been refracted high in the F2 layer

Sporadic E Affect on NVIS Propagation



- Sporadic E patches have a profound affect on NVIS propagation
- NVIS signals refract for the ionosphere's F2 layer whenever the F2 critical frequency is greater than the NVIS frequency
- That is f_c F2 > f_{NVIS} is a strict requirement for NVIS propagation
- However, a NVIS signal reflected from a E_S patch never reaches the F2 layer
- Instead the NVIS signal is reflected from the metallic ions trapped in the E_S zone

NVIS Independent of f_cF2 If Sporadic E Present



- Consequently, NVIS propagation is independent of the F2 critical frequency when a Sporadic E patch is present
- That is during a Sporadic E event the strict NVIS requirement for $f_cF2 > f_{NVIS}$ does not apply
- Instead NVIS propagation occurs as long as the Sporadic E patch is present, even if the F2 layer critical frequency is far below the NVIS frequency
- The following experiment illustrates this unexpected NVIS behavior

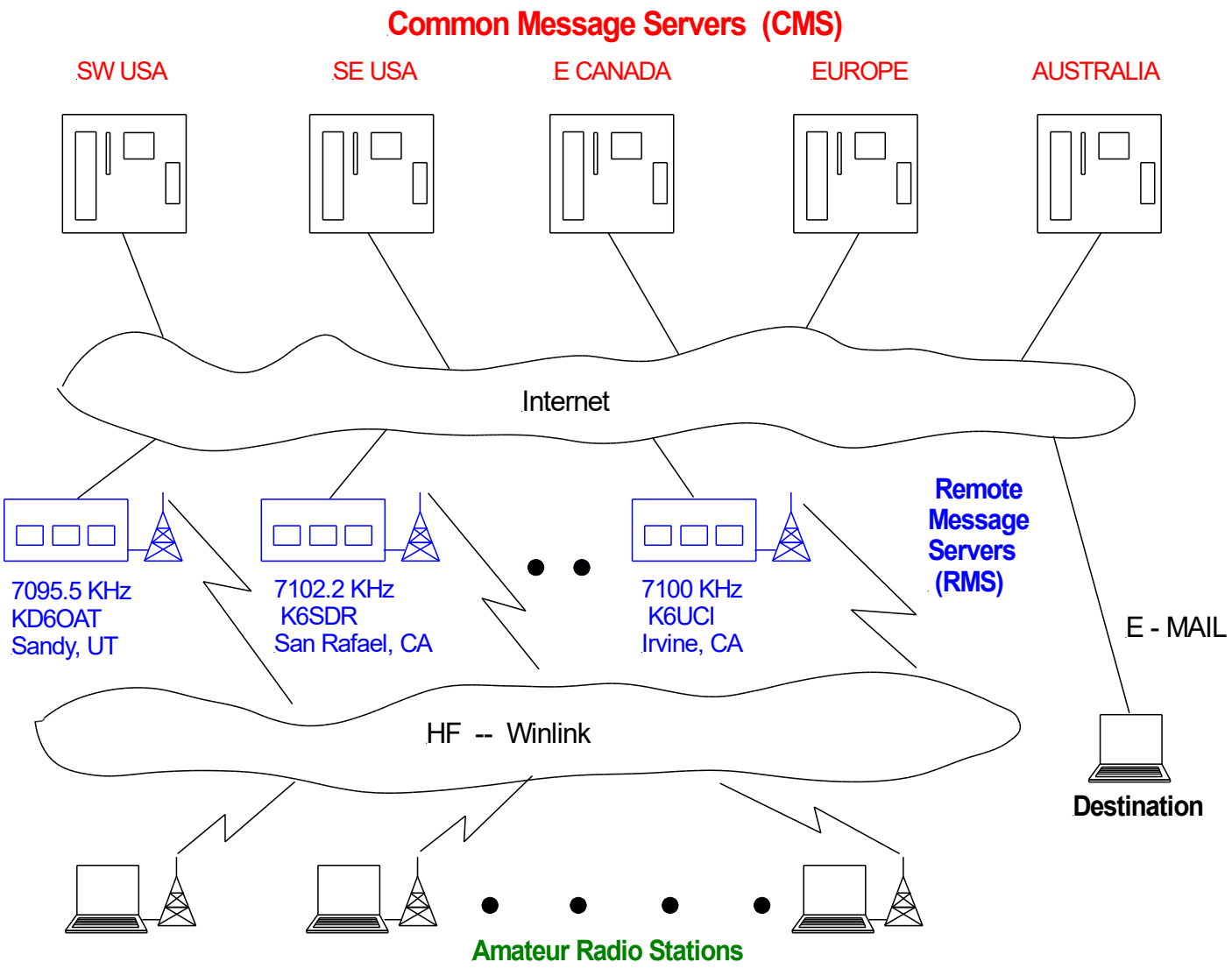
NVIS - Sporadic E Propagation Test

Date:	4/1/25						
					SFI	182	Sporadic E Test
	Sun Rise	5:40	Sun Set	18:14	fcF2	10 MHz	
					X-Ray	C1.6	
					Kp	2	
					Proton	18	
					SSN	151	

Time PDT	Frequency MHZ	Call	Distance Miles	Contact Duration (sec)	Power Watts	Antenna	Comments
1658	7.1021	W6BI	11	31	200	Yellow	Simi Valley, CA
1702	7.1065	KD6LLB	13	18			Oxnard, CA
1703	7.1015	NR6V	20	16			Northridge, CA
1705	7.1005	AJ7C	31	23			Culver City, CA
1707	7.1010	KK6DA	34	17			Los Angeles, CA
1708	7.1000	KN6BKT	48	22			San Gabriel, CA
1709	7.1060	N7OP	52	23			Lancaster, CA
1710	7.0835	KF6NYM	55	21			Santa Barbara, CA
1714	7.1000	K6UCI	73	16			Irvine, CA
1715	7.0997	N0CSM	213	22			Pahrump, NV
1722	7.1020	KO0OOO	252	18			North Las Vegas, NV
1717	7.1000	K9ONR	311	16			Walnut Creek, CA
1718	7.1015	KD7NHC	320	28			Wellington, NV (SE Carson City)
1720	7.1022	K6SDR	332	18			San Rafael, CA

- NVIS Sporadic E test 16:58 thru 23:47 April 1, 2025, Antenna: 40 meter inverted V with apex at 32 ft, VARA digital protocol used to connect to Winlink RMS stations (next slide)
- Contact duration is the time to connect to a RMS station, send a message, and disconnect
- For this test a contact consisted of a Connect followed by a Disconnect since the message field was empty, i.e. it did not contain any text
- A contact test duration greater than 40 seconds is considered a very poor connection unsuitable for sending text messages
- NC = No Connection, the station could not be contacted

Winlink Network



f_cF2 = 10 MHz NVIS Sporadic E Data

Date:	4/1/25						
					SFI	182	Sporadic E Test
	Sun Rise	5:40	Sun Set	18:14	fcF2	10 MHz	
					X-Ray	C1.6	
					Kp	2	
					Proton	18	
					SSN	151	
Time PDT	Frequency MHZ	Call	Distance Miles	Contact Duration (sec)	Power Watts	Antenna	Comments
1658	7.1021	W6BI	11	31	200	Yellow	Simi Valley, CA
1702	7.1065	KD6LLB	13	18			Oxnard, CA
1703	7.1015	NR6V	20	16			Northridge, CA
1705	7.1005	AJ7C	31	23			Culver City, CA
1707	7.1010	KK6DA	34	17			Los Angeles, CA
1708	7.1000	KN6BKT	48	22			San Gabriel, CA
1709	7.1060	N7OP	52	23			Lancaster, CA
1710	7.0835	KF6NYM	55	21			Santa Barbara, CA
1714	7.1000	K6UCI	73	16			Irvine, CA
1715	7.0997	N0CSM	213	22			Pahrump, NV
1722	7.1020	KO0OOO	252	18			North Las Vegas, NV
1717	7.1000	K9ONR	311	16			Walnut Creek, CA
1718	7.1015	KD7NHC	320	28			Wellington, NV (SE Carson City)
1720	7.1022	K6SDR	332	18			San Rafael, CA

- At a critical frequency of 10 MHz
- 40 meter (7.1 MHz) NVIS contacts were very good throughout a 332 mile range, with most durations < 25 sec
- This was expected since $f_cF2 >> f_{NVIS}$

f_cF2 = 8 MHz NVIS Sporadic E Data

Date:	4/1/25				SFI	182	
					fcF2	8 MHz	
					X-Ray	C1.4	
					Kp	1	
					Proton	16.5	
					SSN	151	
Time PDT	Frequency MHZ	Call	Distance Miles	Contact Duration (sec)	Power Watts	Antenna	Comments
2022	7.1021	W6BI	11	17	200	Yellow	Simi Valley, CA
2003	7.1065	KD6LLB	13	19			Oxnard, CA
2004	7.1015	NR6V	20	18			Northridge, CA
2005	7.1005	AJ7C	31	16			Culver City, CA
2006	7.1010	KK6DA	34	17			Los Angeles, CA
2008	7.1000	KN6BKT	48	18			San Gabriel, CA
2019	7.1060	N7OP	52	18			Lancaster, CA
2010	7.0835	KF6NYM	55	16			Santa Barbara, CA
2011	7.1000	K6UCI	73	21			Irvine, CA
2012	7.0997	N0CSM	213	18			Pahrump, NV
2014	7.1020	KO0OOO	252	18			North Las Vegas, NV
2015	7.1000	K9ONR	311	16			Walnut Creek, CA
2016	7.1015	KD7NHC	320	28			Wellington, NV (SE Carson City)
2017	7.1022	K6SDR	332	18			San Rafael, CA

- At a critical frequency of 8 MHz
- 40 meter (7.1 MHz) NVIS contacts also very good throughout a 332 mile range, with most durations < 25 sec
- This also was expected since $f_cF2 > f_{NVIS}$

f_cF2 = 7 MHz NVIS Sporadic E Data

Date:	**4/1/25**				**SFI**	182	
					fcF2	7 MHz	
					X-Ray	C1.2	
					Kp	4.33	
					Proton	15.6	
					SSN	151	
Time PDT	**Frequency MHZ**	**Call**	**Distance Miles**	**Contact Duration (sec)**	**Power Watts**	**Antenna**	**Comments**
2103	7.1021	W6BI	11	16	200	Yellow	Simi Valley, CA
2104	7.1065	KD6LLB	13	18			Oxnard, CA
2107	7.1015	NR6V	20	16			Northridge, CA
2108	7.1005	AJ7C	31	16			Culver City, CA
2109	7.1010	KK6DA	34	23			Los Angeles, CA
2111	7.1000	KN6BKT	48	28			San Gabriel, CA
2112	7.1060	N7OP	52	28			Lancaster, CA
2114	7.0835	KF6NYM	55	16			Santa Barbara, CA
2115	7.1000	K6UCI	73	16			Irvine, CA
2116	7.0997	N0CSM	213	22			Pahrump, NV
2118	7.1020	KO0OOO	252	27			North Las Vegas, NV
2119	7.1000	K9ONR	311	18			Walnut Creek, CA
2124	7.1015	KD7NHC	320	29			Wellington, NV (SE Carson City)
2125	7.1022	K6SDR	332	18			San Rafael, CA

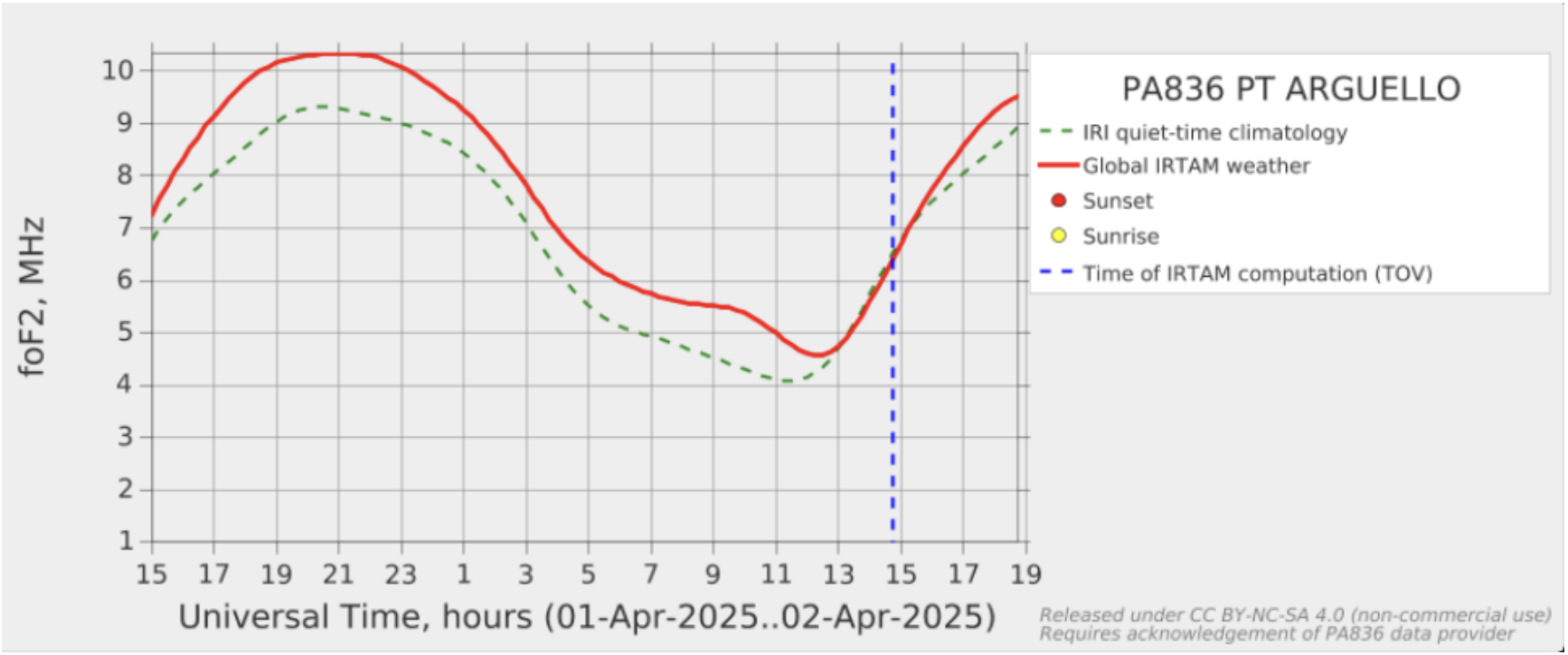
- At a critical frequency of 7 MHz $f_cF2 = f_{NVIS}$
- At this critical frequency the quality of NVIS contacts, as measured by contact duration, should be some what erratic but still good, and they were
- When the critical frequency drops more ($f_cF2 < f_{NVIS}$) NVIS contacts should no longer be possible

f_cF2 = 5.8 MHz NVIS Sporadic E Data

Date:	4/1/25				SFI	182	
					fcF2	5.8 MHz	
					X-Ray	C1.3	
					Kp	3.67	
					Proton	12.3	
					SSN	151	
Time PDT	Frequency MHZ	Call	Distance Miles	Contact Duration (sec)	Power Watts	Antenna	Comments
2328	7.1021	W6BI	11	16	200	Yellow	Simi Valley, CA
2330	7.1065	KD6LLB	13	17			Oxnard, CA
2331	7.1015	NR6V	20	16			Northridge, CA
2333	7.1005	AJ7C	31	23			Culver City, CA
2334	7.1010	KK6DA	34	28			Los Angeles, CA
2336	7.1000	KN6BKT	48	16			San Gabriel, CA
2338	7.1060	N7OP	52	37			Lancaster, CA
2339	7.0835	KF6NYM	55	16			Santa Barbara, CA
2341	7.1000	K6UCI	73	16			Irvine, CA
2342	7.0997	N0CSM	213	18			Pahrump, NV
2343	7.1020	KO0OOO	252	18			North Las Vegas, NV
2345	7.1000	K9ONR	311	18			Walnut Creek, CA
2346	7.1015	KD7NHC	320	28			Wellington, NV (SE Carson City)
2347	7.1022	K6SDR	332	18			San Rafael, CA

- At a critical frequency of 5.8 MHz NVIS should no longer be possible since $f_cF2 << f_{NVIS}$
- However, that was not the case at all
- At nearly mid-night contact durations were nearly as good as when the critical frequency was 8 MHz, four hours earlier
- Something else had to be reflecting NVIS signals other than the F2 region
- That something was probably a Sporadic E patch
- On most nights this phenomena did not occur

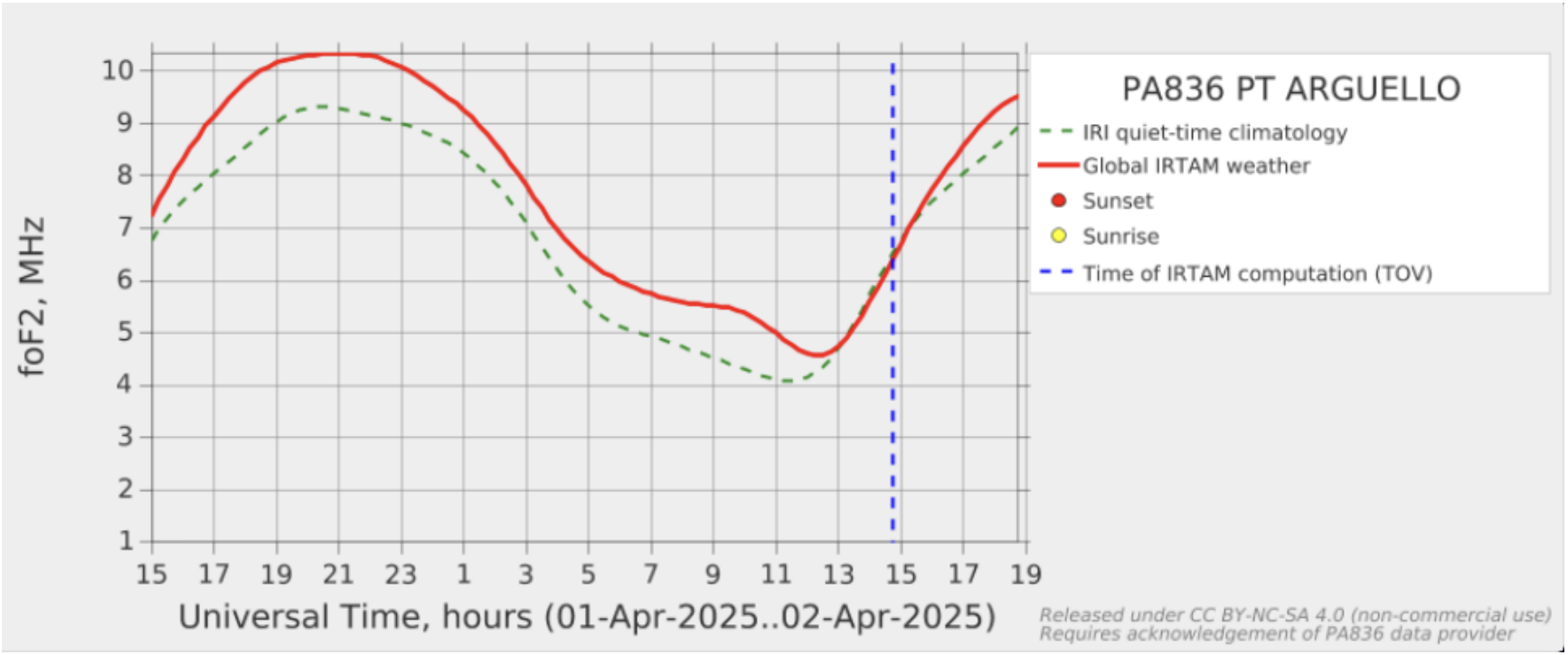
Critical Frequency Data



16 18 20 22 00 PDT

- The red trace is the critical frequency measured at Pt Arguello, CA on the California coast west of Lompoc
- The vertical blue line was the critical frequency the following morning at 15 UT when this chart was generated
- Left of the blue is the critical frequency history, to the right is the projected critical frequency
- The green trace is the Ionosphere Reference model prediction

Critical Frequency Data Near Midnight PDT



16 18 20 22 00 PDT

- Notice that the Pt Arguello critical frequency (red trace) was 5.8 MHz near midnight (00 PDT), considerably less than the NVIS operating frequency of 7.1
- Yet NVIS propagation was very good with most contact durations < 25 seconds