Ground, Elevation Angles, Terrain and Polarization

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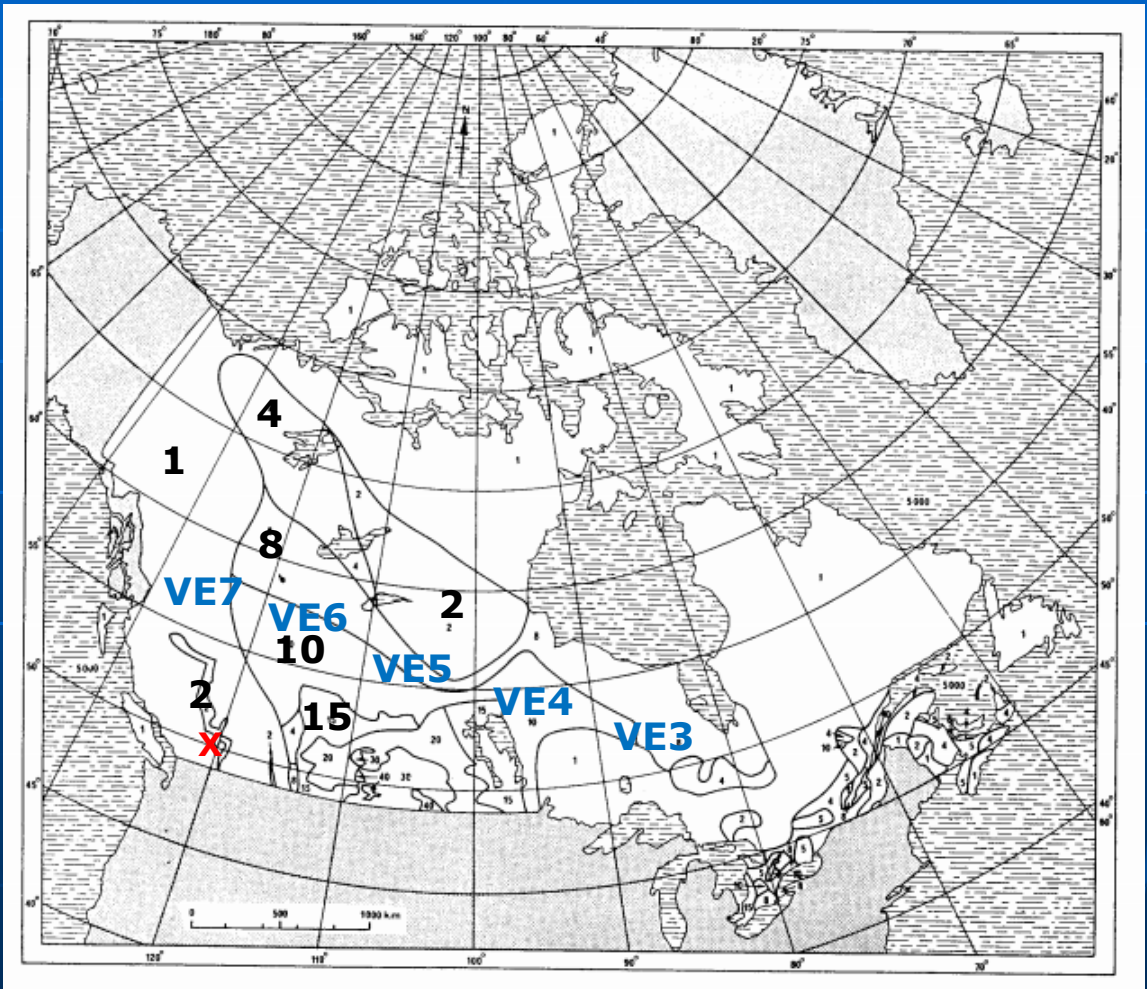
Ground

- Lots of different types of "ground"
- We generally consider "ground" to fall into three categories

Soil type	dielectric constant	conductivity mS/m
Very good (salt water)	81	5000
Average	13	5
Poor	13	2

Conductivity is the most important

Canadian Ground Conductivities

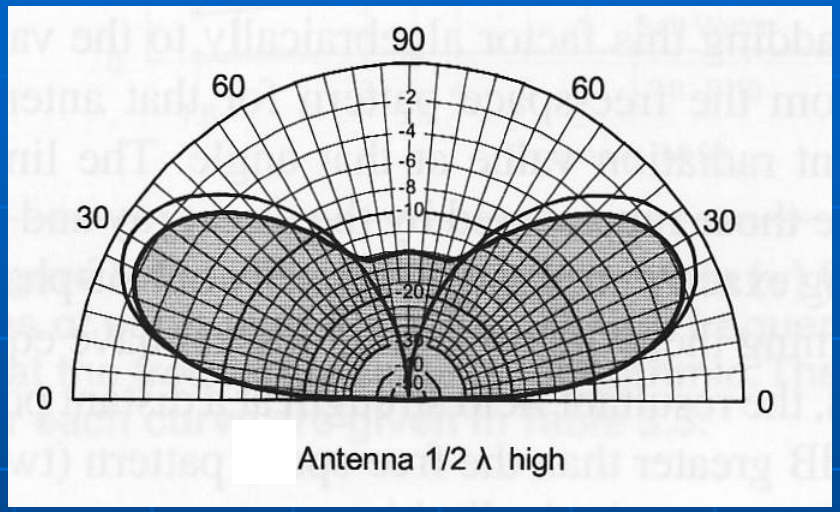


- Red X is Kamloops
- Black numbers are conductivity in mS/m
- My QTH in NE Indiana is about 15 mS/m (a bit above average)

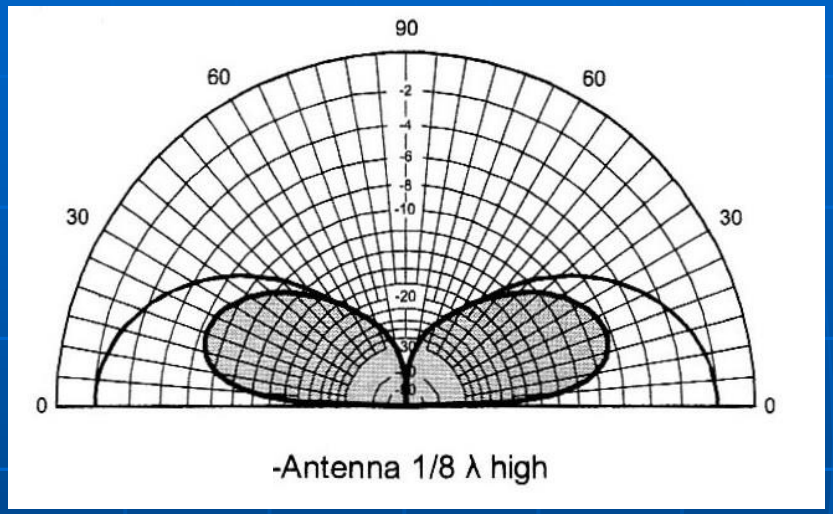
Effect on Antennas

- In general we want the highest conductivity under our antenna
  - To increase efficiency
- In general we want the highest conductivity far away from our antenna
  - To improve low angle radiation
- Verticals are most affected by ground
  - See plots on next slide
- Vertical antennas pick up more man-made noise than horizontal antennas

Elevation Patterns



Horizontal dipole at 14 MHz



Vertical ground plane at 14 MHz

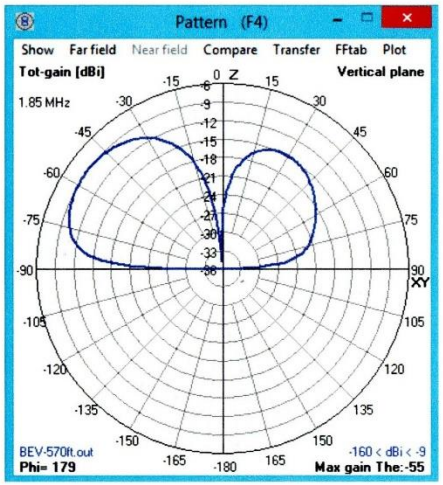
Solid line is for perfect ground
Shaded pattern is for average ground

I personally believe it is best to use horizontal antennas on the higher HF bands

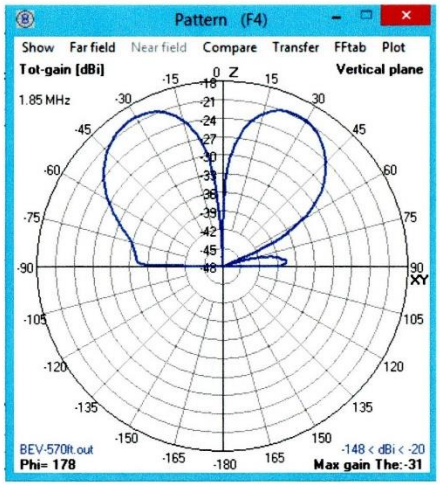
Beverage for RX on Low Bands

- Good pattern
- 12 dB F/B at low elevation angles
- Gain -9 dBi

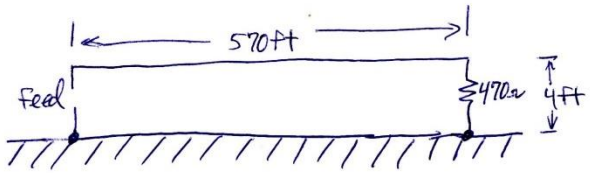
570ft long Beverage 4ft above ground



average ground



salt water



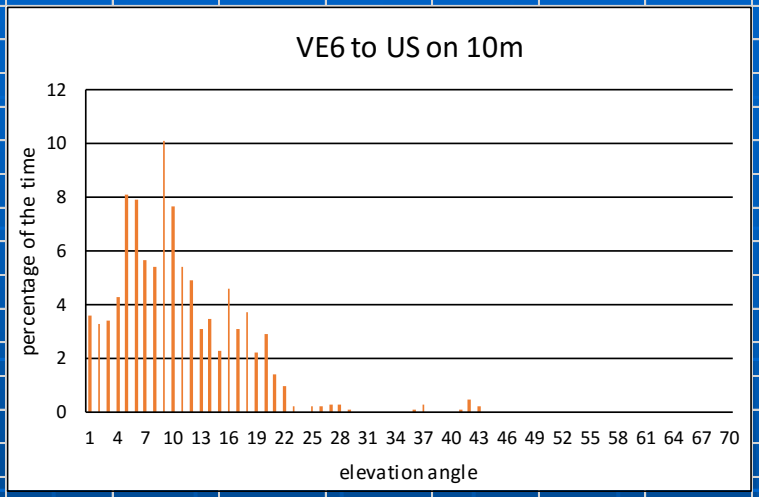
- Screwed up pattern
- F/B not good
- Gain -21 dBi

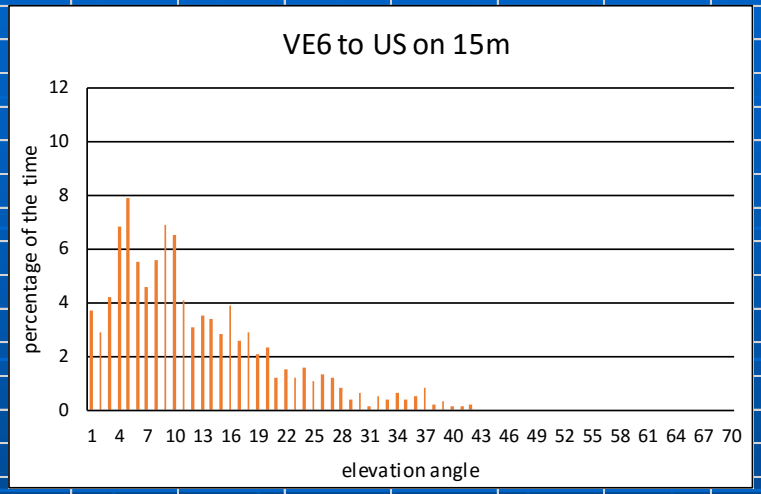
Don't put a Beverage over very good ground!

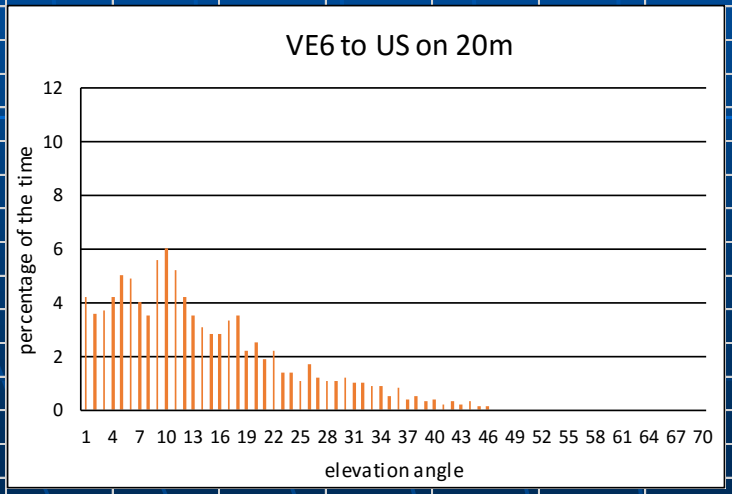
Required Elevation Angles

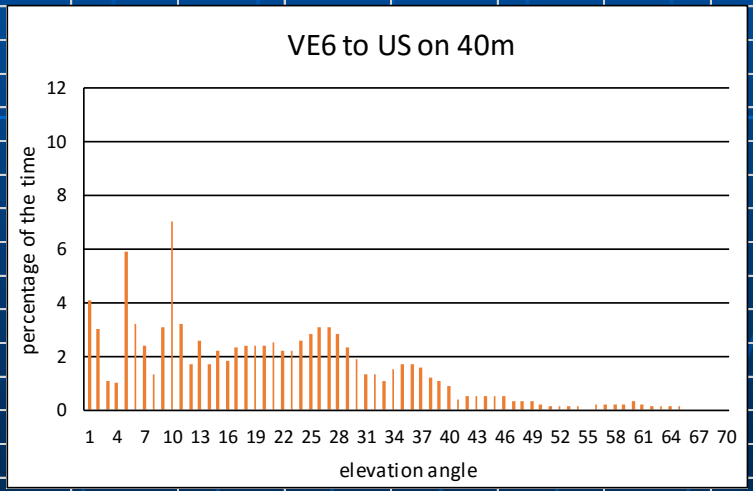
- N6BV used IONCAP to generate elevation angle data on a large number of paths
  - By band, throughout a solar cycle, all seasons
- Data is on the CD with the ARRL Antenna Book
  - VE7 Vancouver data is suspicious (N6BV is looking at it), so I will use VE6 Calgary data
  - Kamloops is about halfway between Vancouver and Calgary, so this is not unreasonable

Elevation Angles to the US





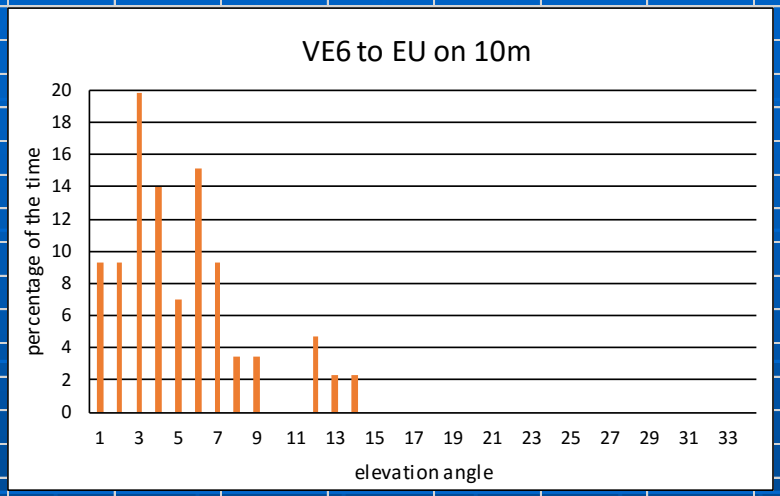


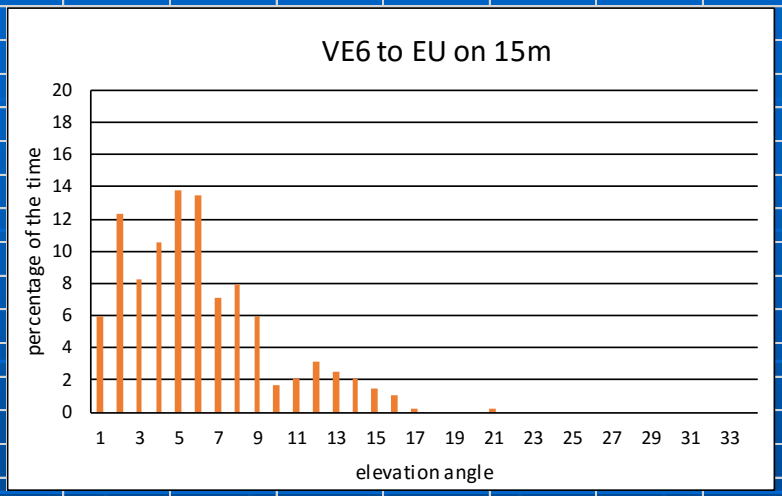


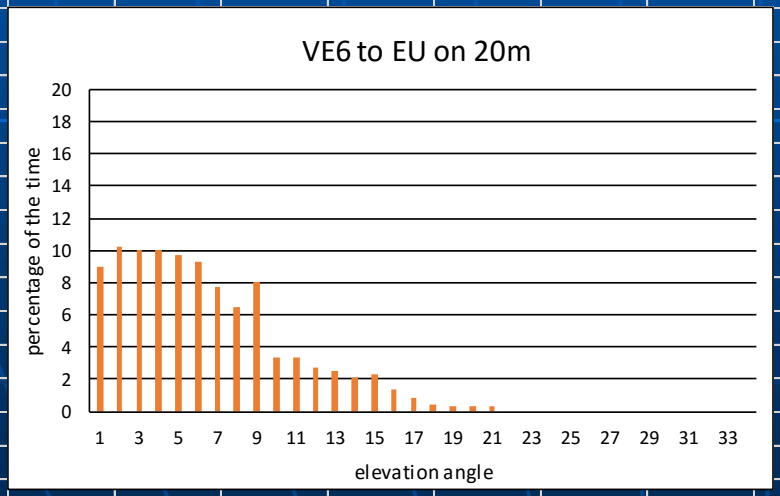
Summary – Angles to the US

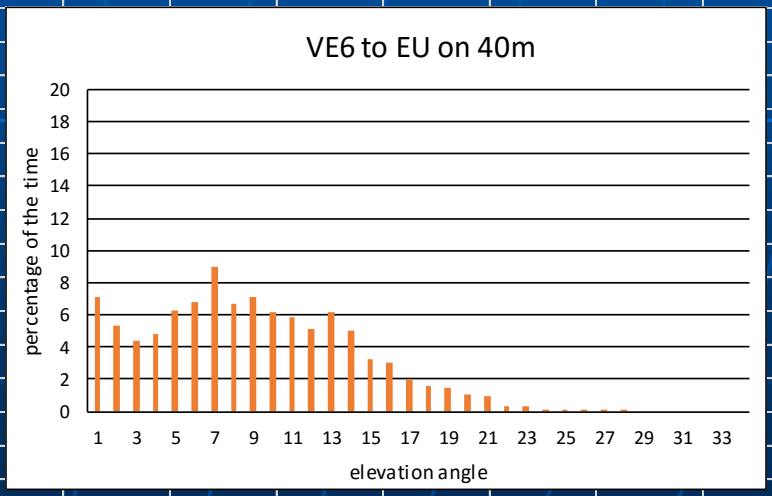
- Distances to the US from Kamloops are from nearby (State of Washington at 300 km) to far away (W1 and W4 at 3600 km)
- Low angles are important on all the bands
- As you go lower in frequency, there are more opportunities at the higher angles
- Need an antenna (or antennas) to cover a wide range of angles

Elevation Angles to EU





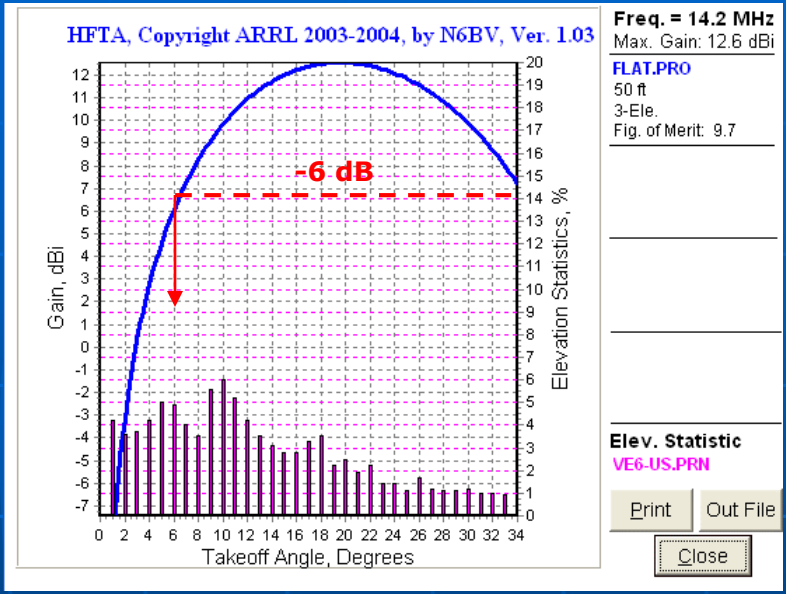




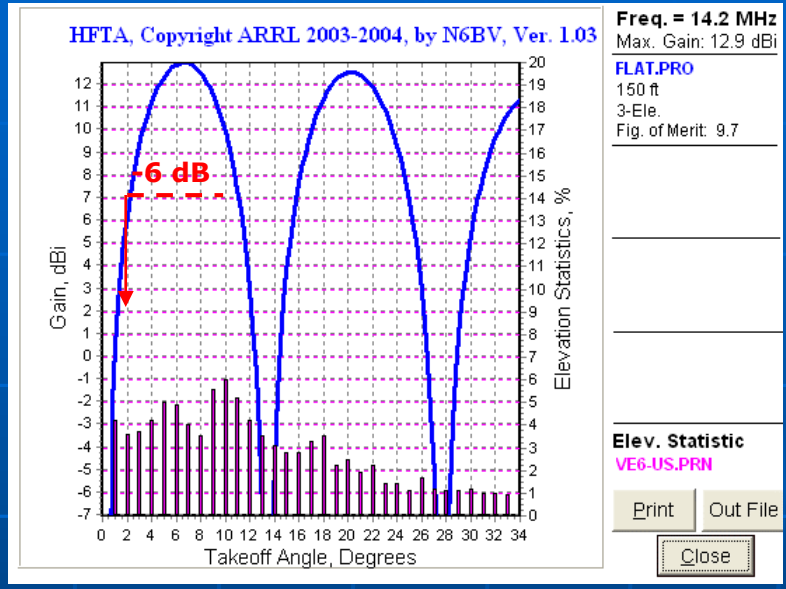
Summary – Angles to EU

- EU is far from Kamloops
- Expect mostly low elevation angles
- That's what the data says
  - 20m thru 10m – up to 21°
  - 40m – up to 28°
- Still need to cover a wide range of angles
- How do you do that?

Ant Pattern + Elev Angles



Yagi at 50 ft covers the higher angles very well, but gives up gain at the lower angles ($\leq 6^{o}$)



Yagi at 150 ft covers the lower angles very well, but gives up gain at the higher angles

To cover a wide range of elevation angles, we use stacked antennas

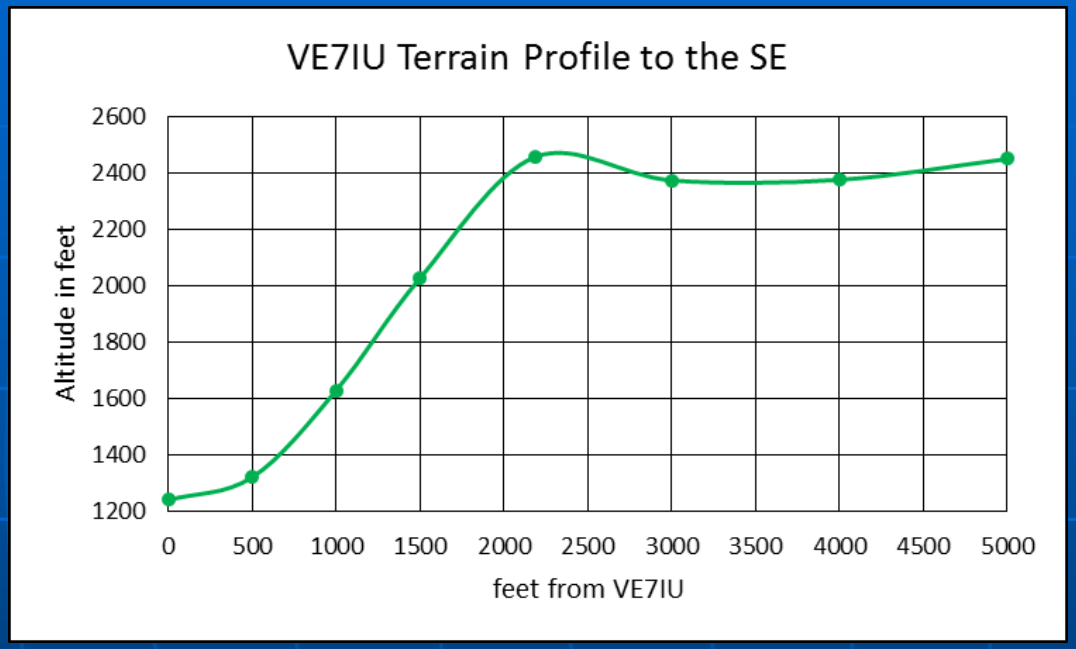
HFTA is N6BV's High Frequency Terrain Analysis software that is on the CD in the Antenna Book

Now for Mountainous Terrain

- All previous slides have been for flat terrain
- In my area, a mountain is any "hill" higher than 100 feet ! ☺
- All of my antenna pattern analysis can be done assuming flat terrain
  - Makes it easy
- But all terrain isn't flat
  - What does that do to propagation?

VE7IU in Chase - To The SE

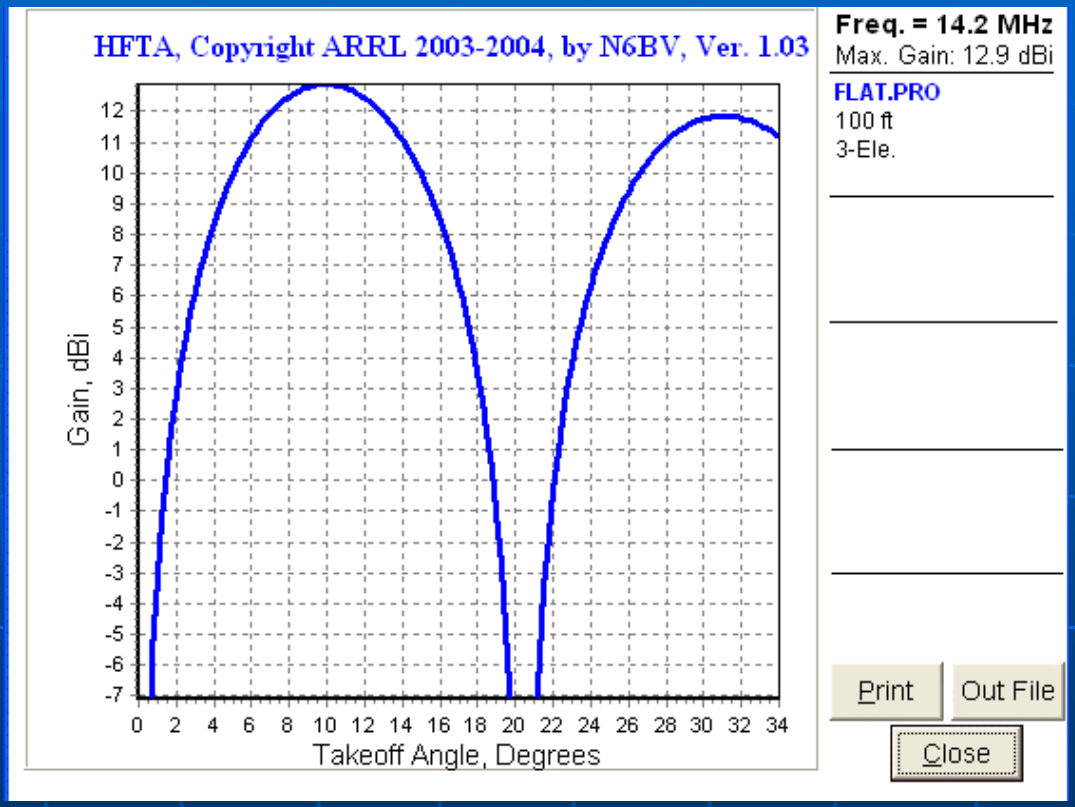
VE7IU Profile To The Southeast



Remember that this is a coarse estimate from Google Earth

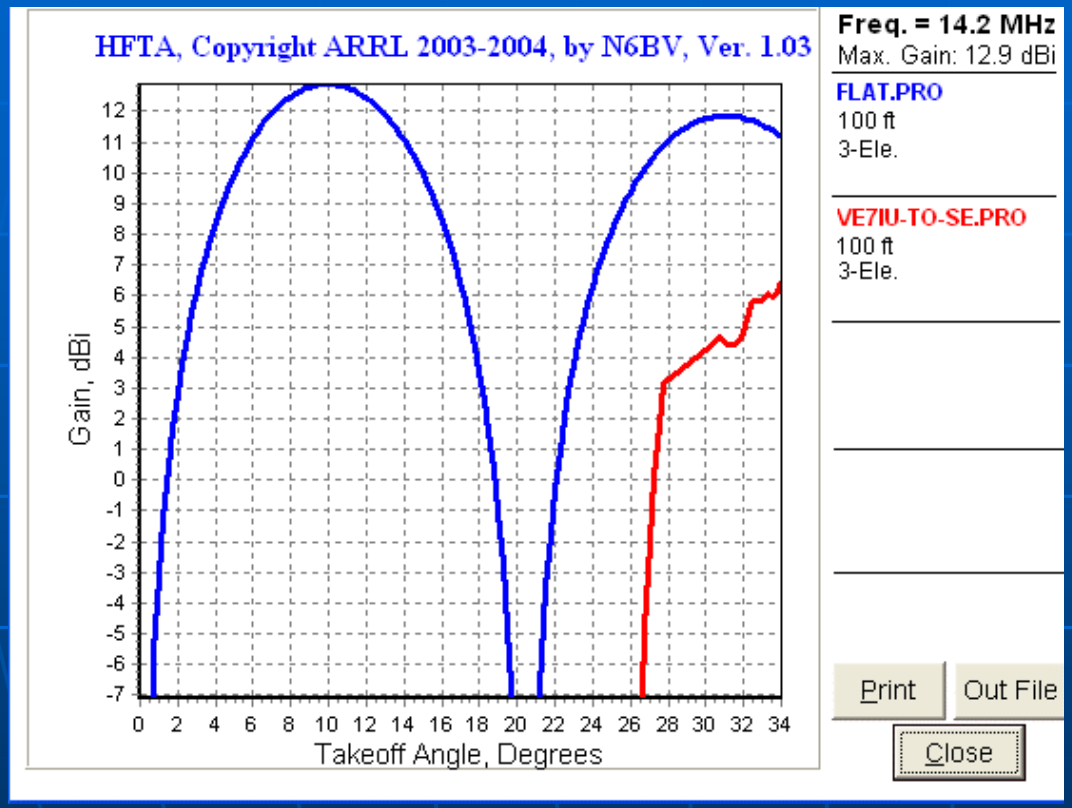
- Darrell has about a 28° upward slope to the SE
- Makes it very tough for QSOs to the southeast
- Does diffraction help?

20m Yagi at 100ft – Flat Ground



Covers the low angles very nicely

20m Yagi at 100ft With Terrain



Blue is with flat terrain

Red is with VE7IU terrain to SE

Diffraction does not help the situation

6m Observations

- Darrell reports hearing a Colorado station on 6m
  - Colorado is about 1700 km to the SE
  - Terrain blocks angles below about 28°
- Normal F_2 and normal E_s not likely
  - 1700 km distance needs low angles
- Possible modes
  - F_2 region scatter
  - F_2 region high angle ray (Pedersen ray)
  - High angle multi-path via E_s

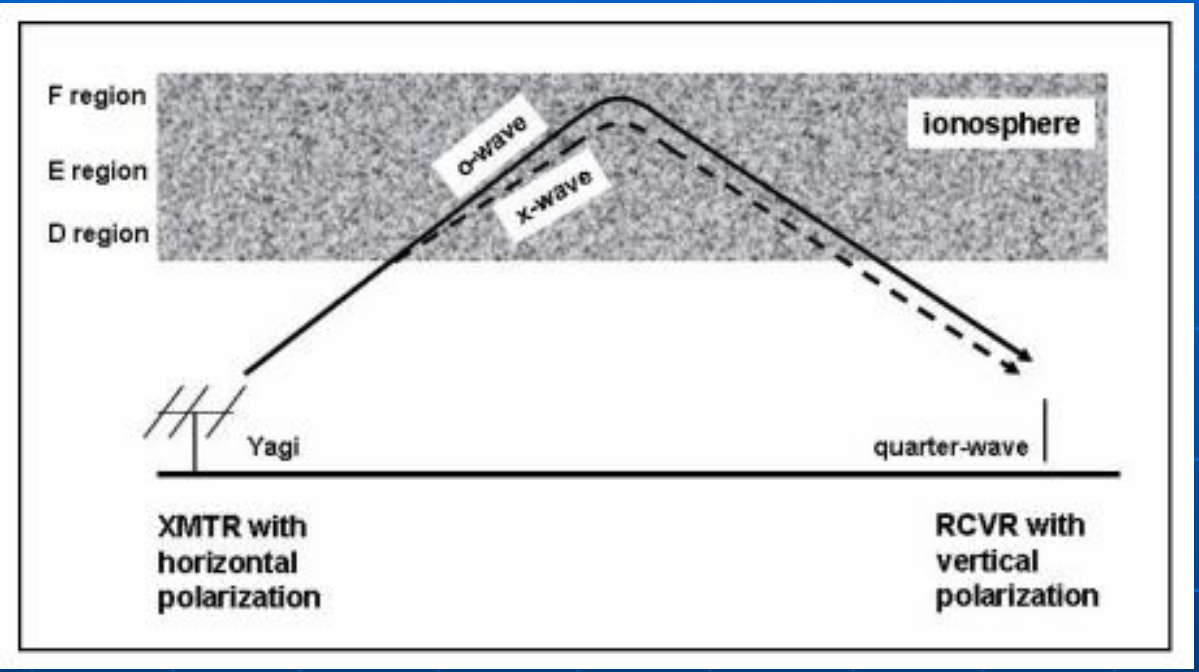
California Stations

- California is about 1500 km to the South
- Terrain to the south is about a 10º upward slope per Google Earth
- Darrell can copy loud signals from W6 on 40m
  - Many opportunities for angles > 10º
- Can also hear loud signals from W6 on 20m and 15m
  - Many opportunities for angles > 10º

Polarization

- I've seen many comments saying that "polarization is random"
- Not true – there's more order to polarization than we acknowledge
- This is due to the fact that the ionosphere is immersed in a magnetic field (the Earth's magnetic field)

When We Transmit . . .



Our RF couples into the two characteristic waves that propagate through the ionosphere

Polarization on HF

- On our HF bands (80m-10m) the two waves are circularly polarized
  - They are orthogonal and rotate in opposite directions
  - Both propagate similarly through the ionosphere
  - They both come out of the ionosphere on the other end
- Thus a horizontal or vertical antenna will be acceptable with respect to polarization
  - But a horizontal antenna depends less on ground and does not pick up as much man-made noise

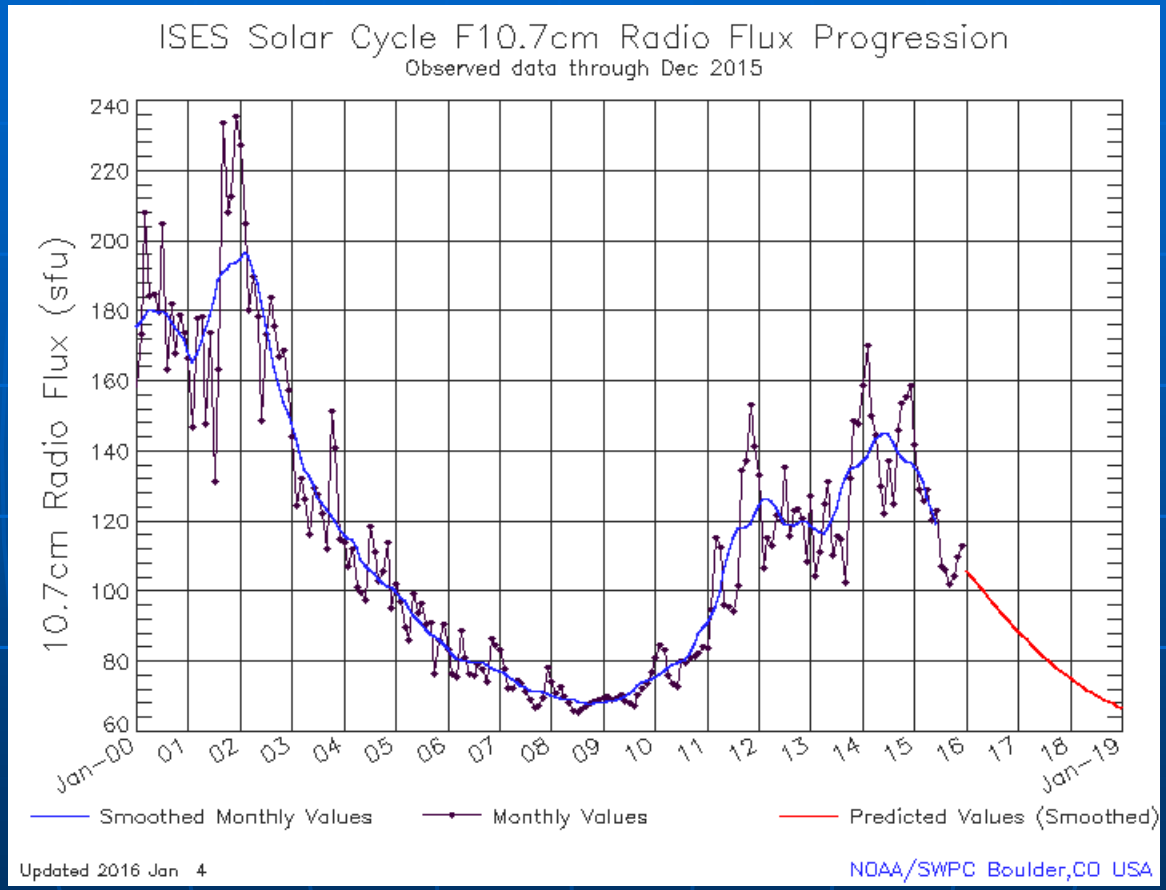
Polarization on 160m

- Two important issue on 1.8 MHz due to 160m being close to the electron gyro-frequency
  - Polarization becomes highly elliptical – tending towards vertical or horizontal
  - One of the characteristic waves (the extraordinary wave) is more highly attenuated
- Thus only one wave exits the ionosphere on the other end
  - Pay attention to polarization
  - For those of us at mid to high latitudes, vertical polarization is dominant – use a vertical
  - This doesn't mean horizontal polarization doesn't happen at times

Speaking of 160m . . .

- We don't fully understand all that makes 160m work
- Understand the concept of common darkness and learn how to determine it
- If you have a good transmit antenna, you'll likely need low noise receive antennas
- Watch for signal enhancements around sunrise (especially on the eastern end of the path) and around sunset
- Keep your butt in the chair to catch short-term openings like spotlight propagation
- In general vertical polarization will work best
  - But you can't have too many antennas on 160m
- Don't shy away from elevated K-indices
  - Can provide skewed paths around the auroral zone
  - Can provide enhanced paths across the high latitudes
- Remember "southwest at sunrise" and "southeast at sunset" along the long path
- Don't shy away from solar maximum
  - Even though S9+ signals on 10m are easier to deal with, be persistent and stay on 160m

Cycle 24



Next minimum around the end of 2019

Cycle 25

- If we have a long minimum between Cycle 24 and 25, then expect a low Cycle 25
- If Cycle 25 is low, how low?
- Talk of another Maunder Minimum always attracts attention
- But right now it looks like it will just be a small Cycle, not the beginning of another Maunder Minimum
- How will the bands be?

Predictions at Cycle 24 Max

Nov., British Columbia (Vancouver), for SSN = High, Sigs in S-Units. (c) 2010 Dean Straw, N6BV

	80 Meters							40 Meters							20 Meters							15 Meters							10 Meters							
UTC	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	UTC
0	1	-	2	2	-	-	9+	5	-	8	6	2	1	9+	8	9	9+	9	8	9	9+	2*	9	9+	8	7	9+	9+	1*	9	9	5*	1*	9	9	0
1	2	-	6	4	-	-	9+	7	1	9	7	5	5	9+	8	8	9+	9	8	9+	9+	2*	9	9	7	8	9+	9+	-	9	6	4*	5	9	4	1
2	4	-	8	6	-	1	9+	7	2	9	7	4	8	9+	8	8	9+	9	8	9+	9+	1	9	9	5	8	9+	9	-	8	5*	5*	1	8	2*	2
3	5	-	6	6	-	6	9+	6	2	9	7	4	9	9+	7	8	9+	8	8	9+	9+	1	9	5	7*	5*	9	7	-	4	1*	1*	-	4	-	3
4	6	-	7	7	-	8	9+	6	3	9	6	1	9	9+	7	8	9	6	7	9+	9	1*	6	1*	5*	2*	7	-	-	-	-	-	-	-	-	4
5	7	-	8	7	-	9	9+	8	5	9	7	1	9+	9+	5	8	9	6*	3	9+	8	1*	-	-	1*	-	2	1	-	-	-	-	-	-	-	5
6	7	1	8	8	-	9+	9+	8	6	9	8	1	9+	9+	3	2	9	5	2	9	9+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
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9	1	8	7	-	1	9+	9+	5	8	9	3	5	9+	9+	8	1*	9	5	5	5	9	-	-	-	-	-	-	1	-	-	-	-	-	-	-	9
10	-	8	7	-	1	9+	9+	5	9	9	1	7	9+	9+	7	4	9	1	7	5	9+	-	-	-	-	-	-	1	-	-	-	-	-	-	-	10
11	-	8	7	-	3	9+	9+	4	9	9	1	7	9+	9+	5	1	5	1*	4	8	9+	-	-	-	-	-	-	2	-	-	-	-	-	-	-	11
12	-	9	5	-	7	9+	9+	3	9	9	-	7	9+	9+	1	5	1	1*	4	8	9+	-	-	-	-	-	-	2	-	-	-	-	-	-	-	12
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14	-	9	-	-	6	9+	9+	5	9	4	-	7	9	9+	8	-	9	6	5	1*	9+	-	2*	8	3	2*	2*	9	-	-	-	-	-	-	-	14
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18	-	2	-	-	-	-	9	2	7	-	-	4	5	9+	7	9	6	8	6	9+	9+	8	7	9	8	2	9+	9+	5*	2*	9	9	2*	9	9+	18
19	-	-	-	-	-	-	8	1	5	-	-	3	4	9	8	8	6	8	6	9	9+	3	8	9+	9	1	9+	9+	3*	2*	9	9	2*	9	9+	19
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23	-	-	-	-	-	-	9	5	-	6	5	2	-	9+	8	9	9+	9	8	9	9+	3	9	9+	9	4	9+	9+	2*	9	9	5*	-	9	9+	23
	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	

Predictions for Zero Sunspots

Nov., British Columbia (Vancouver), for SSN = Very Low, Sigs in S-Units. (c) 2010 Dean Straw, N6BV

	80 Meters							40 Meters							20 Meters							15 Meters							10 Meters							
UTC	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	UTC
0	4	-	5	5	1	-	9+	7	2	8	7	5	4	9+	3	9	9+	8	8	9+	9+	-	9	8	4*	2*	8	7	-	-	-	-	-	1	-	0
1	5	-	7	7	1	-	9+	8	2	9	8	6	7	9+	3	8	9	8	8	9+	9+	-	8	5*	4*	2	8	2*	-	-	-	-	-	-	-	1
2	6	-	7	8	1	4	9+	7	2	9	8	4	9	9+	3	8	8	6	7	9+	9	-	2	-	1*	-	4	-	-	-	-	-	-	-	-	2
3	7	-	8	8	-	8	9+	8	3	9	8	3	9	9+	1*	7	6	4*	3	8	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
4	7	-	8	9	-	9	9+	8	4	9	8	4	9+	9+	1*	1	5	2*	1*	7	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
5	7	1	8	9	-	9	9+	8	6	9	9	5	9+	9+	-	-	6	1*	-	5	9+	-	-	-	-	-	-	1	-	-	-	-	-	-	-	5
6	8	3	8	9	-	9+	9+	8	8	9	9	5	9+	9+	-	-	6	1*	-	2	9+	-	-	-	-	-	-	2	-	-	-	-	-	-	-	6
7	8	7	8	8	1	9+	9+	8	8	9	8	5	9+	9+	-	-	8	-	-	-	9+	-	-	-	-	-	-	3	-	-	-	-	-	-	-	7
8	4	9	8	5	3	9+	9+	8	9	9	8	6	9+	9+	1	-	8	-	-	-	9+	-	-	-	-	-	-	3	-	-	-	-	-	-	-	8
9	2	9	8	1	5	9+	9+	6	9	9	6	8	9+	9+	1	1*	8	-	-	-	9+	-	-	-	-	-	-	4	-	-	-	-	-	-	-	9
10	1	9	7	-	6	9+	9+	6	9	9	2	8	9+	9+	-	-	8	-	1	1	9+	-	-	-	-	-	-	5	-	-	-	-	-	-	-	10
11	1	9	7	-	8	9+	9+	4	9	9	1	8	9+	9+	-	-	3	-	-	2	9+	-	-	-	-	-	-	5	-	-	-	-	-	-	-	11
12	1	9	5	-	8	9+	9+	3	9	9	-	8	9+	9+	-	-	-	1*	-	3	9+	-	-	-	-	-	-	6	-	-	-	-	-	-	-	12
13	2	9	3	-	7	9+	9+	7	9	8	1	8	9+	9+	-	1*	5	-	-	1	9+	-	-	-	-	-	-	7	-	-	-	-	-	-	-	13
14	1	9	-	-	8	9+	9+	6	9	6	2	9	9	9+	4	1*	9	5	1	2*	9+	-	-	2	-	-	-	7	-	-	-	-	-	-	-	14
15	1	9	-	-	8	9	9+	6	9	1	4	8	9	9+	7	-	9	8	2	4	9+	1*	4*	8	2	3*	3*	7	-	-	-	-	-	-	-	15
16	1	8	-	-	6	8	9+	6	9	-	4	8	9	9+	7	1*	9	8	5	8	9+	2*	3*	9	6	5*	2*	9	-	1*	1	-	1*	-	-	16
17	-	6	-	-	3	2	9+	6	8	-	1	5	8	9+	7	4	8	8	5	9+	9+	6*	2*	9	8	5*	2	9+	1*	-	2	1*	2*	-	-	17
18	-	3	-	-	1	1	9	5	8	-	1	6	7	9+	5	8	7	8	4	9+	9+	2*	1*	9	8	2*	9	9+	-	-	4	2*	1*	1	1	18
19	-	-	-	-	-	-	9	5	6	-	1	5	5	9+	2	5	8	7	4	9+	9+	-	-	9	8	1*	9	9+	-	-	5	2*	-	3	4	19
20	-	-	-	-	-	-	8	2	4	-	2	5	4	9	5	5	8	8	5	9	9+	-	-	9	8	1*	9	9+	-	-	8	3*	-	5	5	20
21	-	-	-	-	-	-	8	5	2	1	2	5	1	9	1	9	9	8	5	8	9+	-	1	9	8	-	9	9+	-	-	3	2*	-	3	1	21
22	1	-	-	-	-	-	9	5	1	4	5	5	-	9+	-	9	9	8	6	8	9+	-	6	9	8	-	9	9+	-	-	5	1*	-	2	-	22
23	2	-	1	2	1	-	9+	6	1	7	6	6	1	9+	1	9	9+	8	6	9	9+	-	8	9	5*	-	9	9	-	-	1	1*	-	2	-	23
	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	EU	FE	SA	AF	AS	OC	NA	

summary on next slide

Cycle 24 vs Zero Sunspots

- As expected, 10m, 12m and 15m should suffer the most with no sunspots
- 17m, 20m and 30m will hang in there
- 40m and 80m should be better with no sunspots
- 160m should be better with no sunspots
  - But the general consensus among topbanders is that solar minimum between Cycle 22 and 23 was better than solar minimum between Cycle 23 and 24 in spite of the solar minimum between Cycle 23 and 24 being deeper and longer – we still don't understand 160m

Summary

- Ground quality matters
- Verticals are affected more by ground that horizontal antennas
- Verticals pick up more man-made noise
- Elevation angle data is in the Antenna Book CD
- It's better to be on top of a hill than behind it
- Terrain can be analyzed with HFTA software (in the Antenna Book CD)
- Polarization not much of an issue – except on 160m
- Tips for chasing DX on 160m - see slide 24
- Cycle 25 likely to be a small cycle – low bands should be good and 20m/17m should be decent
- Unusual propagation happens – enjoy it!