Ideas for More Effective HF Antennas

Geography, Terrain, Siting and Operation

Dave Leeson, W6NL

Why a Better Signal?

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- Emergency communications
  - Other end may be marginal
- DX: Pileups from either end
  - Pileup: Break early
  - DXpedition: Better geographic coverage, rate
- Contesting
  - Competitive score, operator improvement
  - My particular interest, will use as examples
- Personal technology achievement

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- "2 dB is a Ton," 20-40 dB is a galaxy!

What Makes a Difference?

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Ionospheric Propagation Basics

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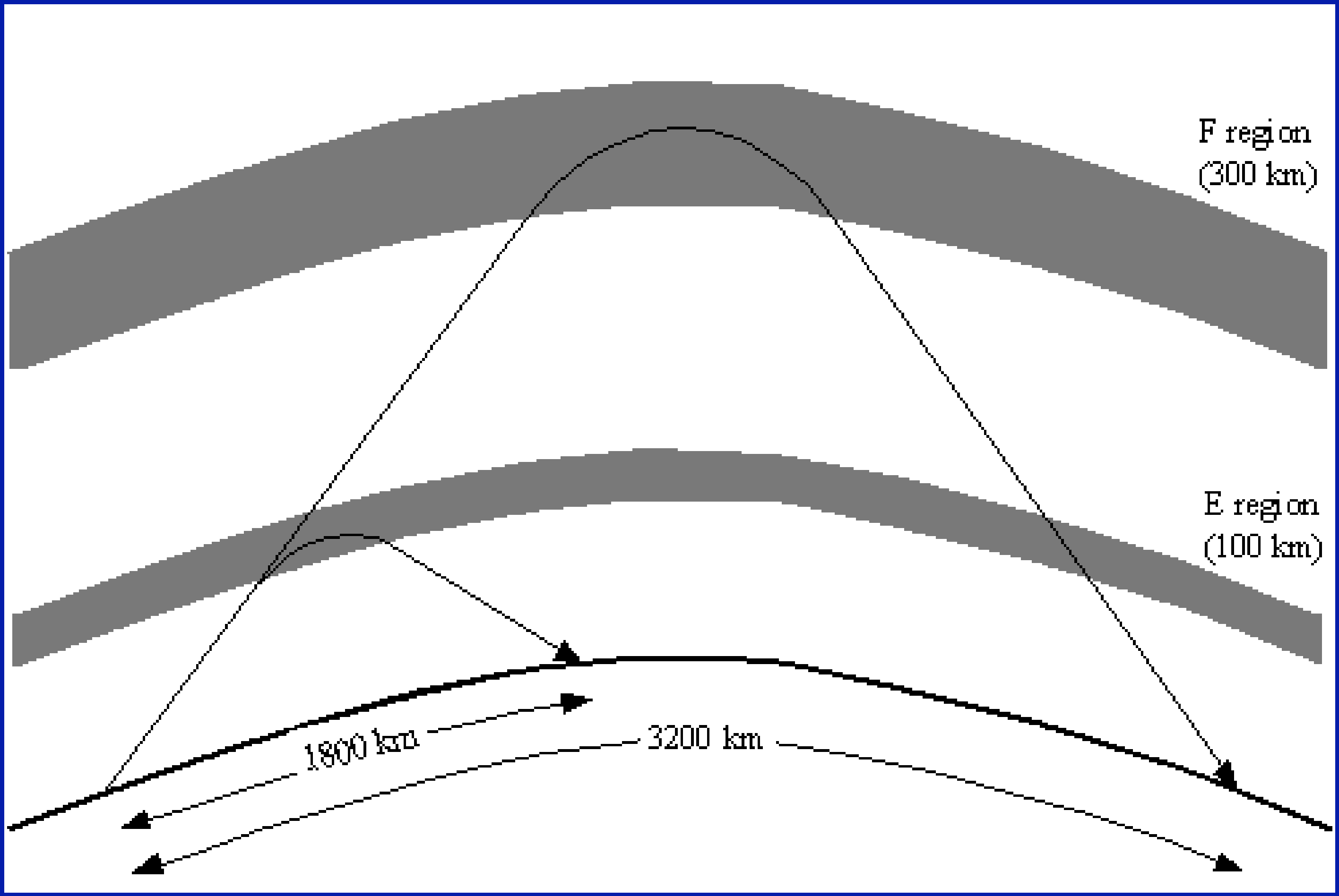
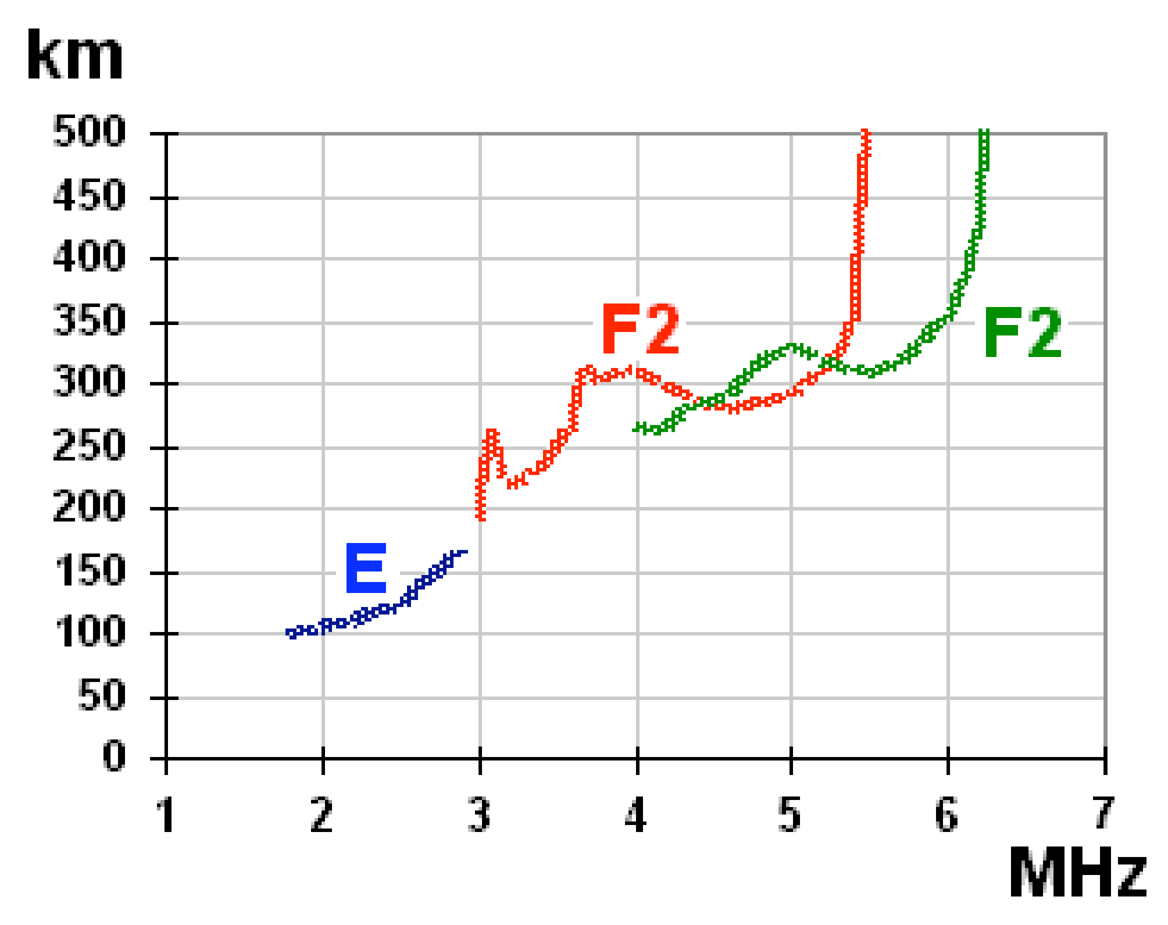
- Max oblique return frequency (MUF) higher than f_o, depends on elevation angle
- Lower elevation angle yields higher MUF

Ionospheric Refraction

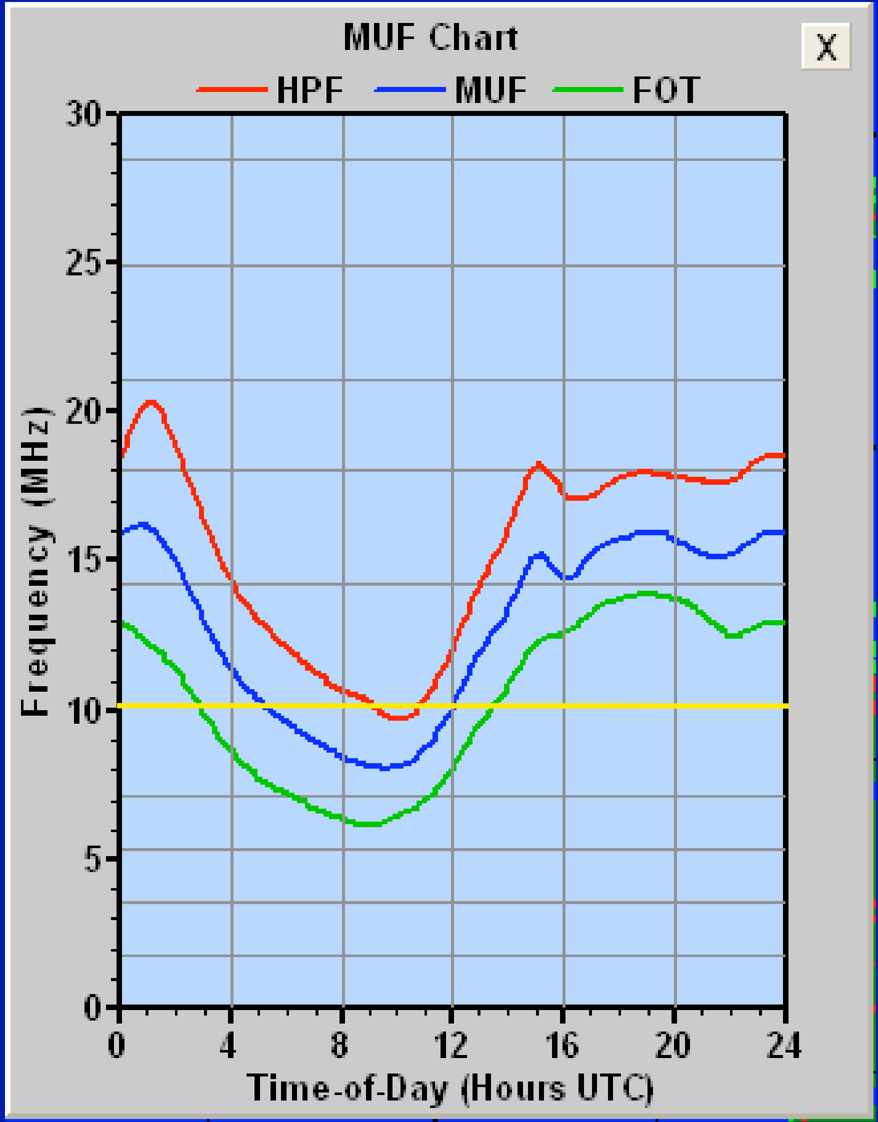


Vertical Incidence Return

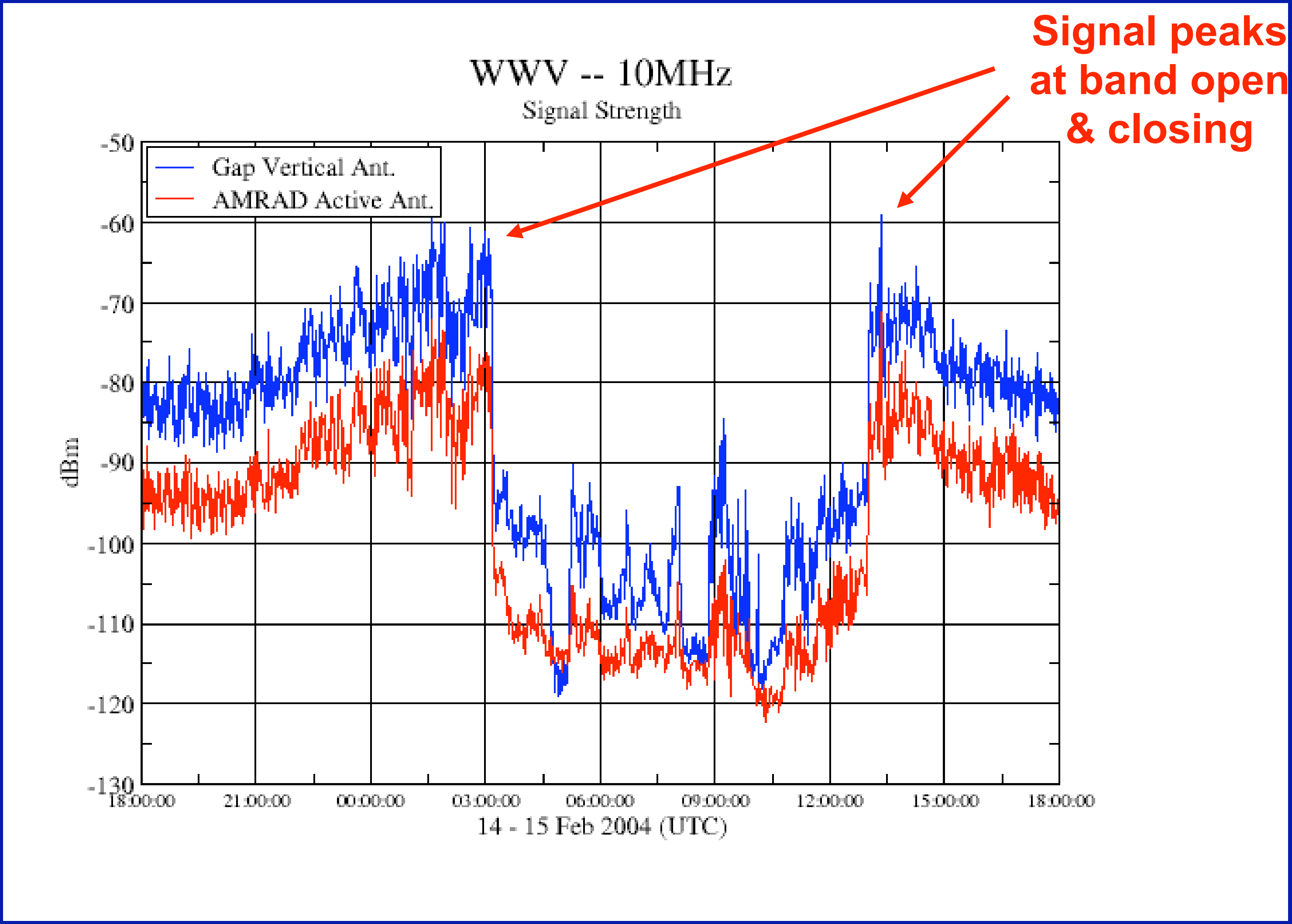


Max. Usable Freq. vs. Time

- MUF at mid-hop
- f>MUF: Band open
- f<MUF: Band closed
- f>>MUF: Absorption
- Not really so simple
  - Fading: Multiple paths
  - f<EMUF: D, E layers
  - Other complications



Signal Strength vs. Time



Geography Lessons

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- f_o & MUF decrease toward higher latitude
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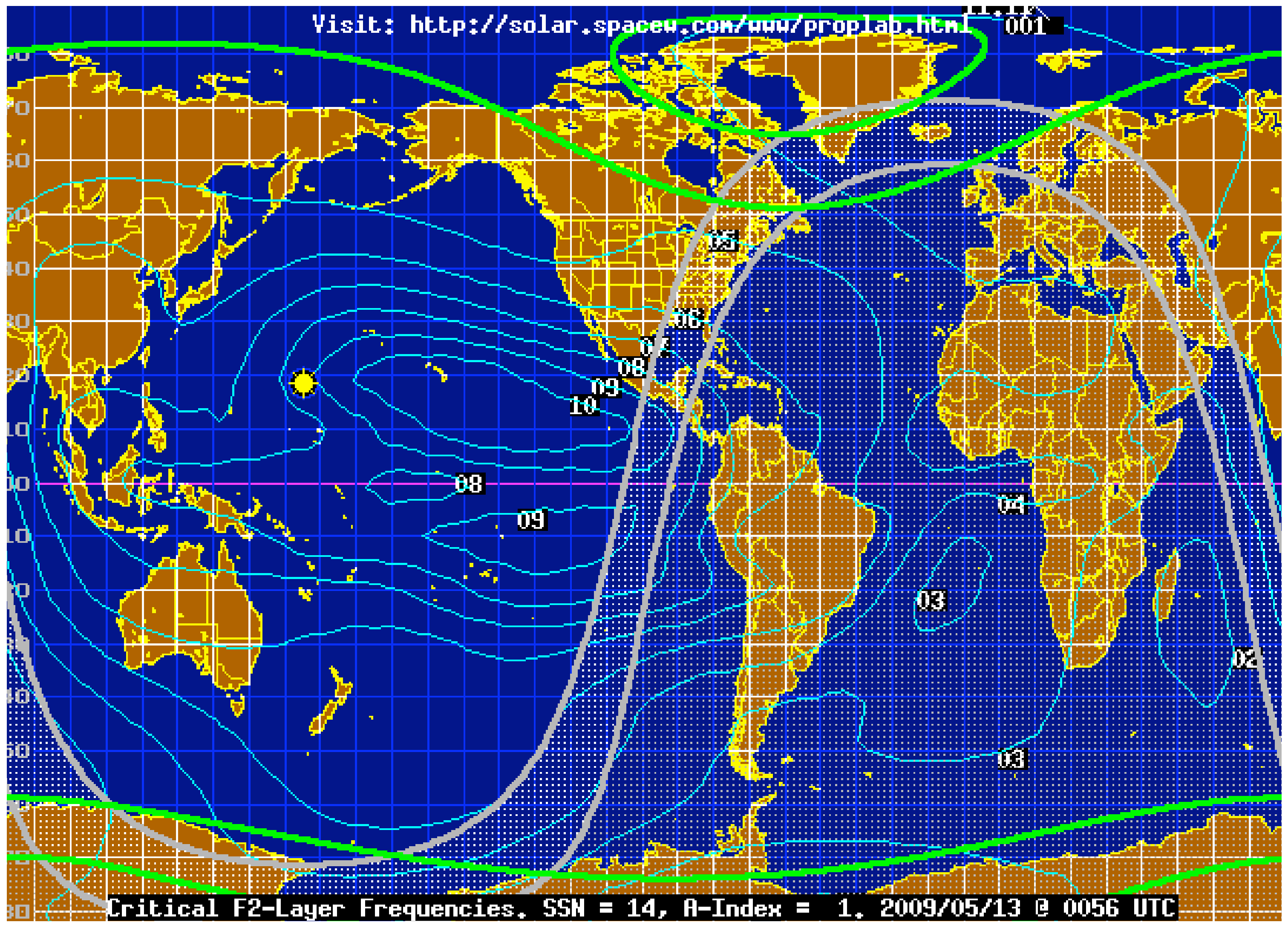
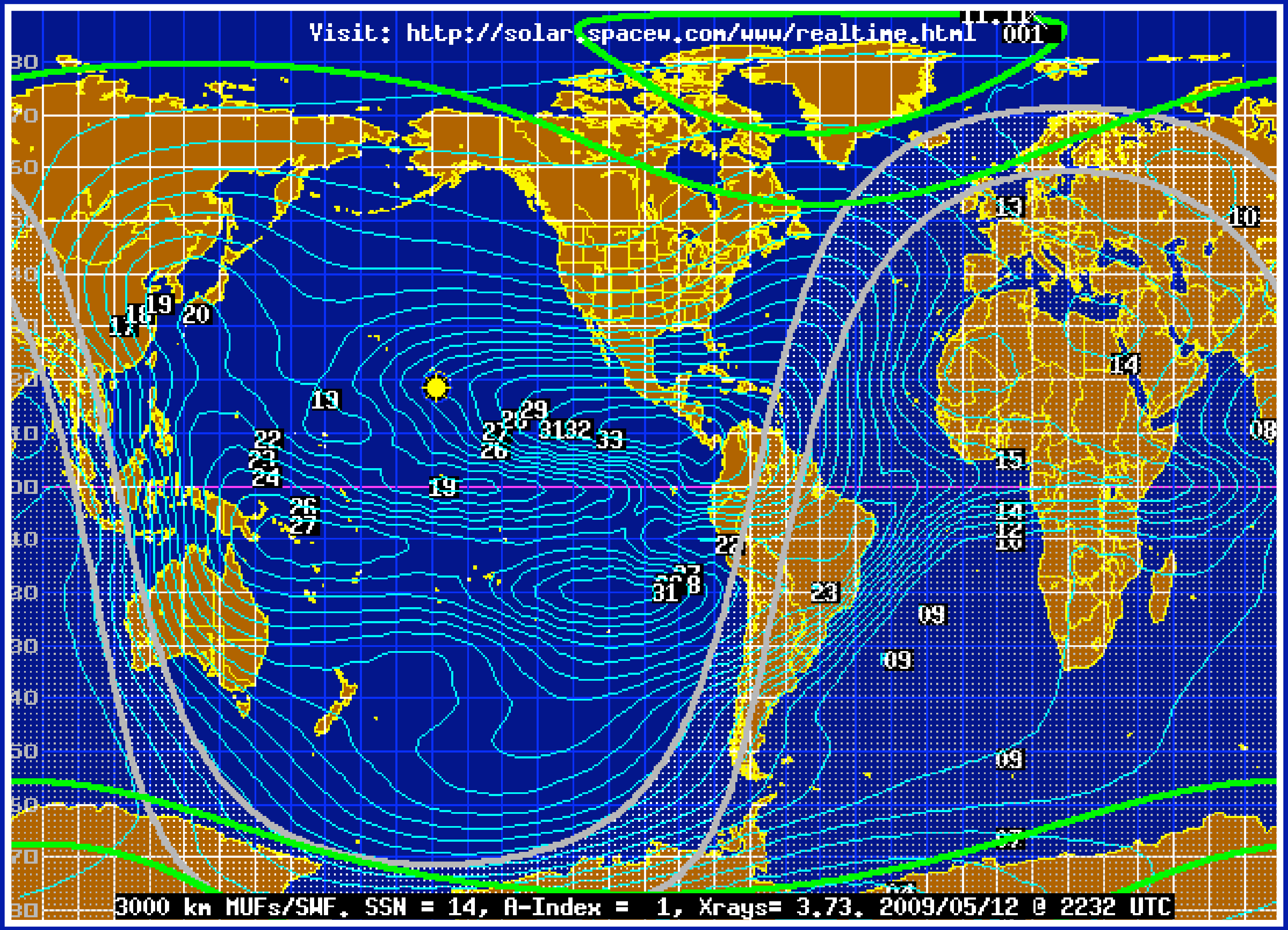
  - Day-to-night paths more difficult
- Population density: High contests, low DX

f_o vs. Location and Time

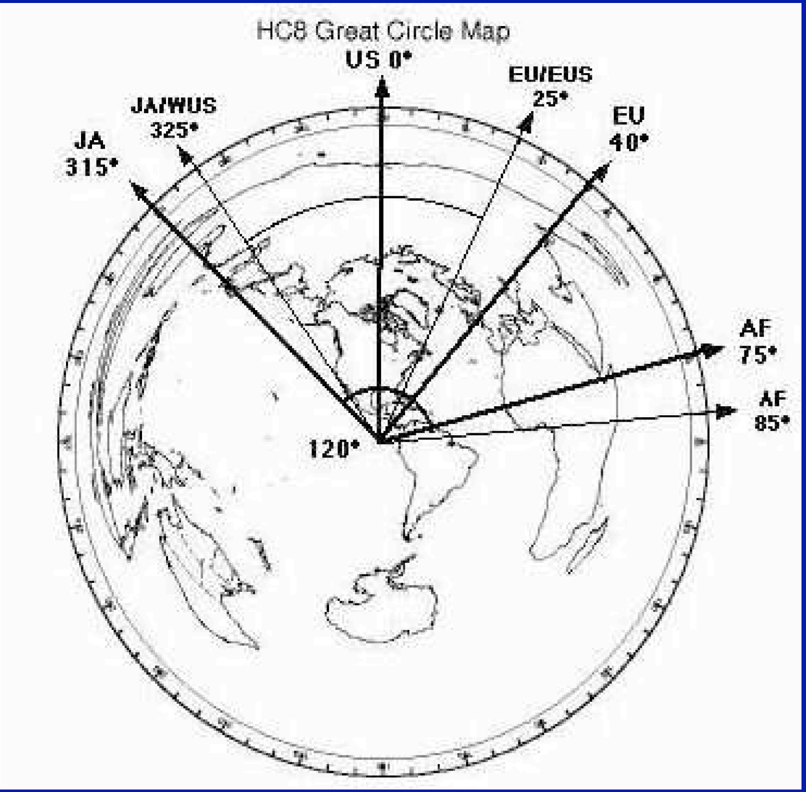


MUF vs. Location and Time



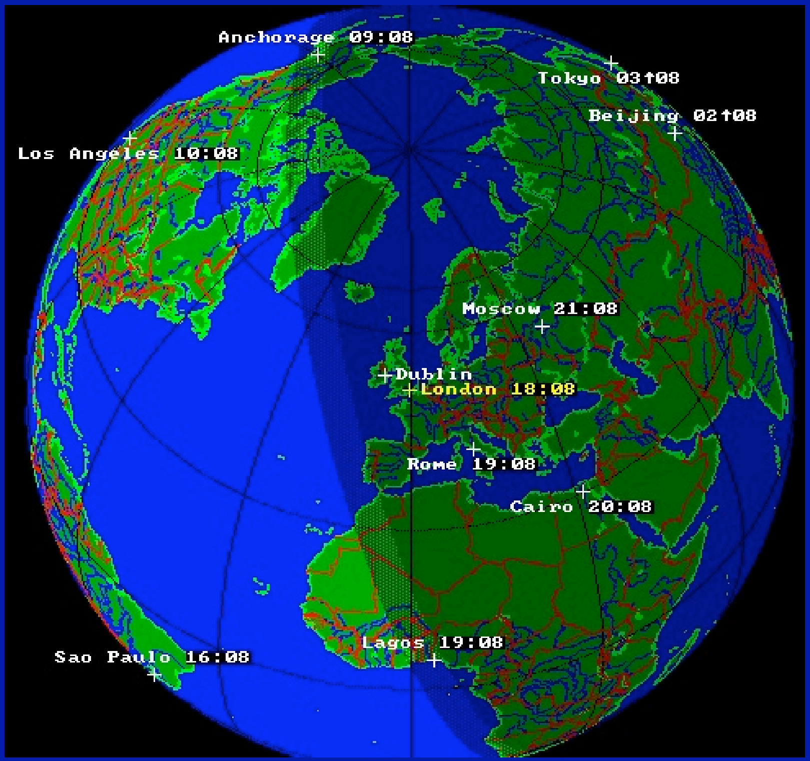
Path Considerations

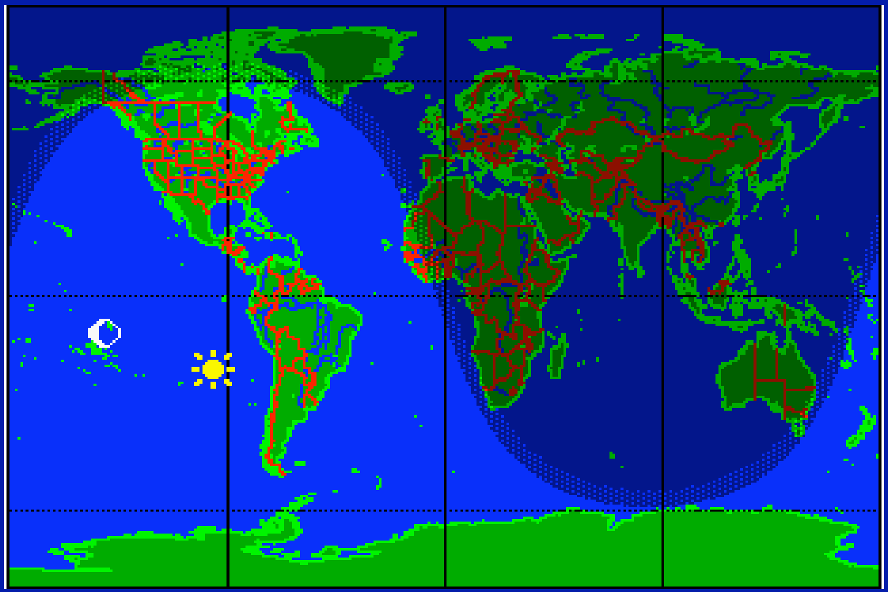
- Where is the ham population?
- Day/night overlap (longitude: time zone)
- Propagation from your location (latitude)
- Path from your location (auroral oval?)



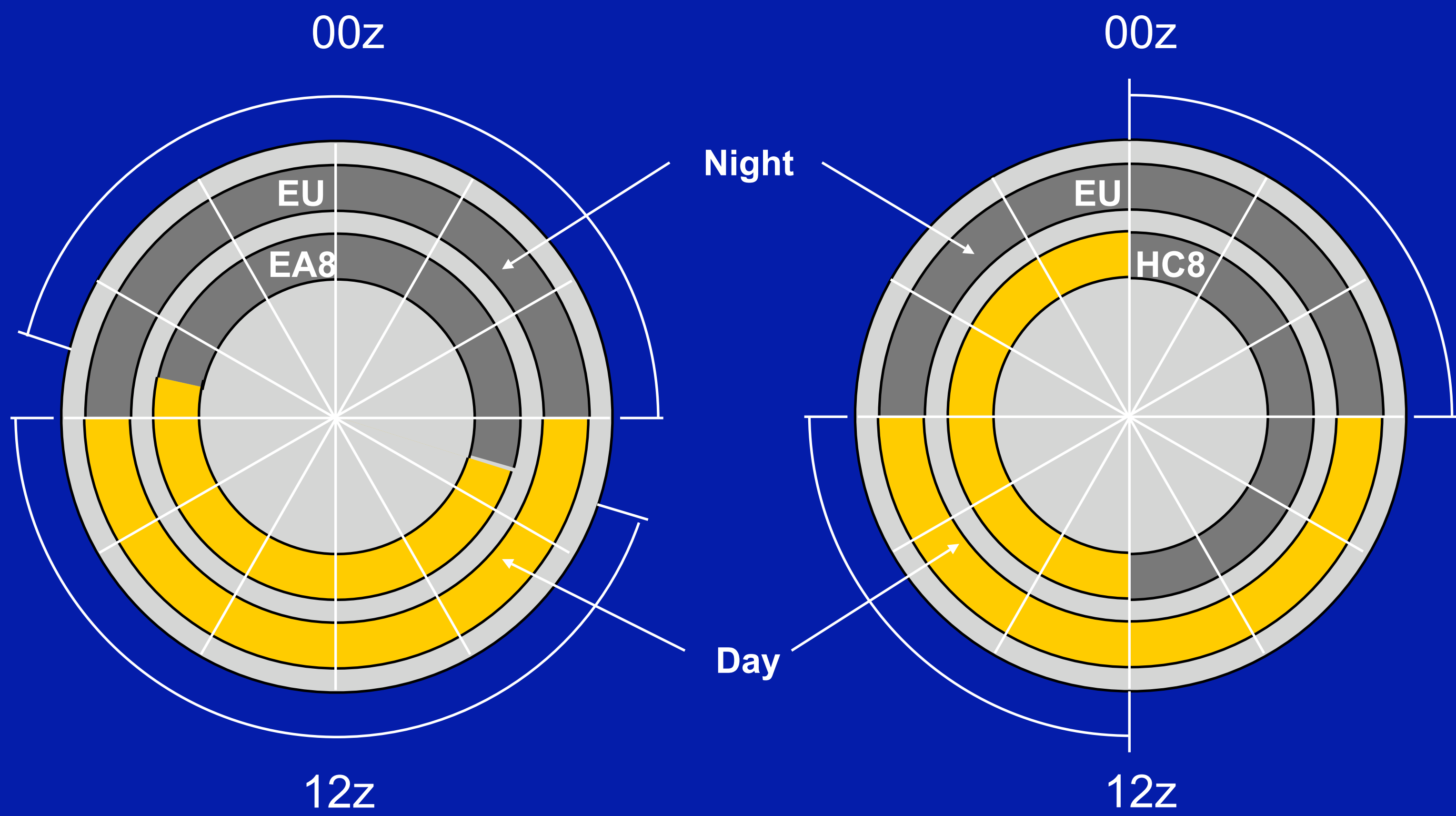
Population Density

Day or Night Overlap





EA8/HC8 Day/Night Overlap to EU



Frequency and Angle are Related

- Critical frequency f_o depends on solar ionization
- Dependent on elevation angle:
  - MUF
  - Max hop length
  - Ground reflection efficiency

MUF is Higher at Low Angles

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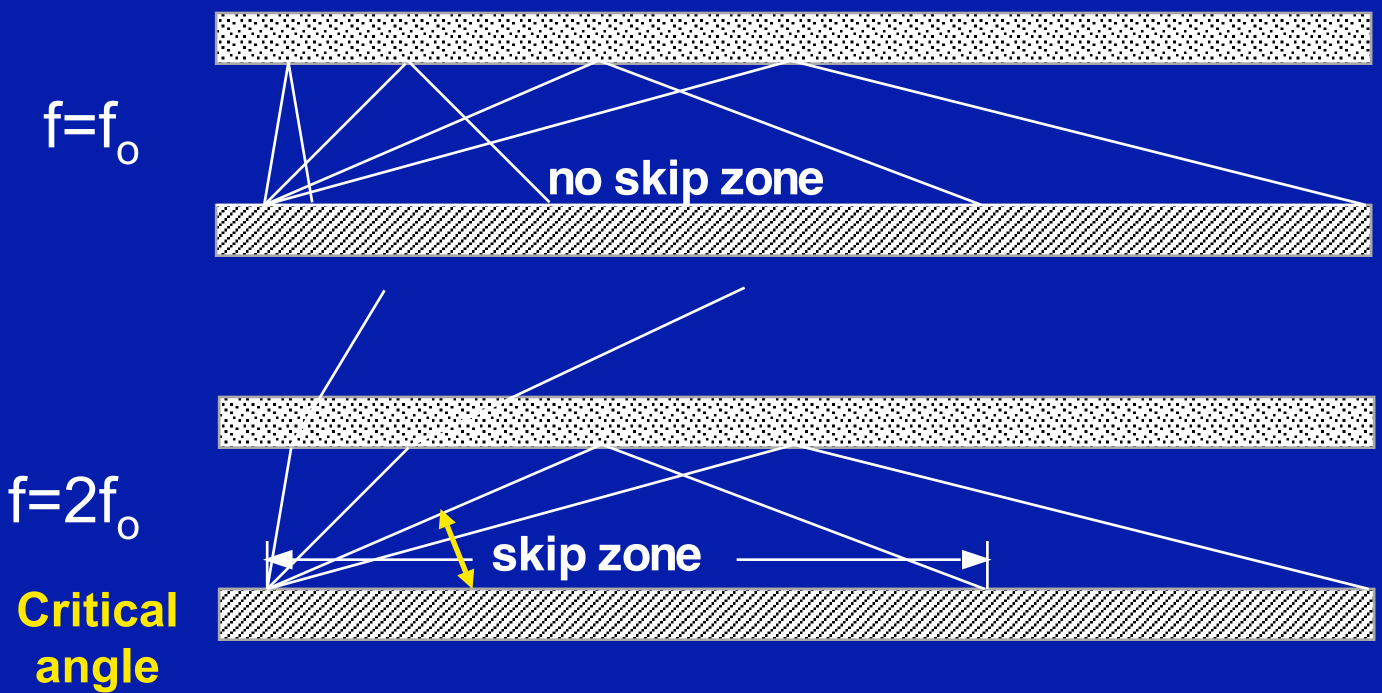
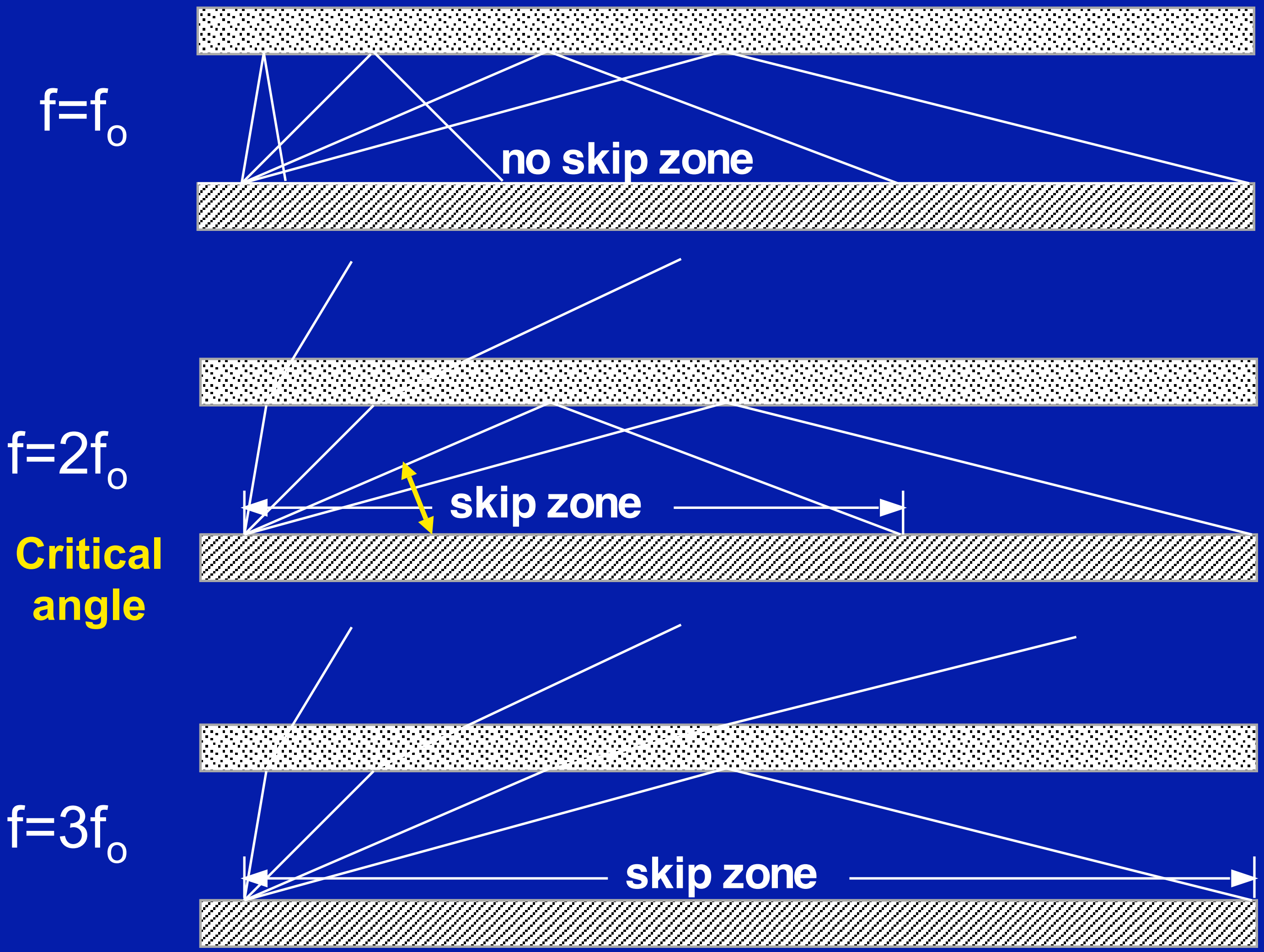
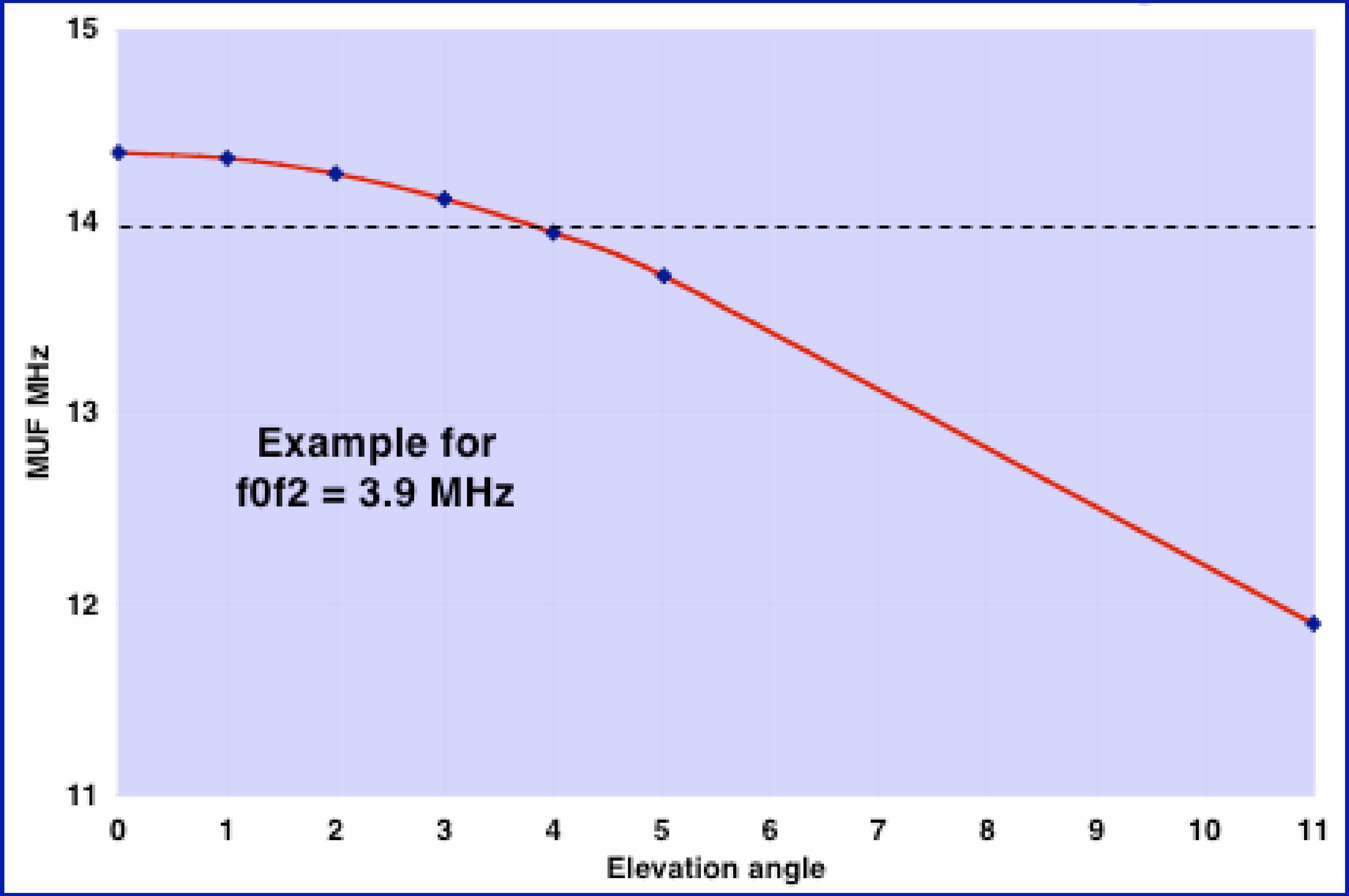


MUF is Higher at Low Angles



MUF Varies with Elevation Angle



What Makes a Difference?

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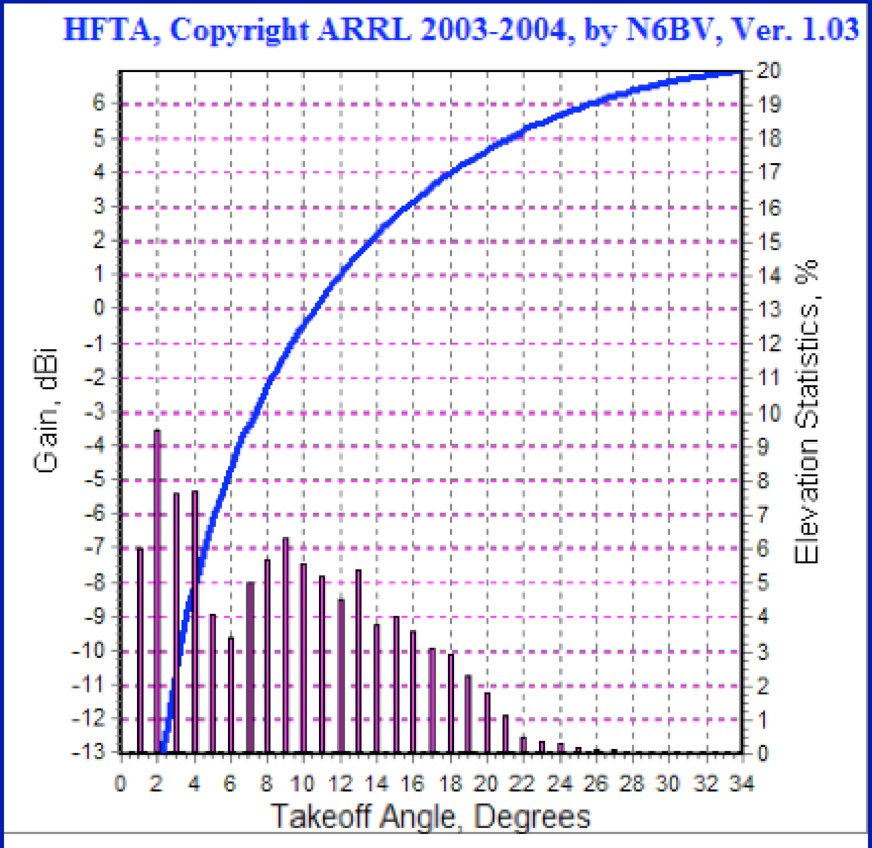
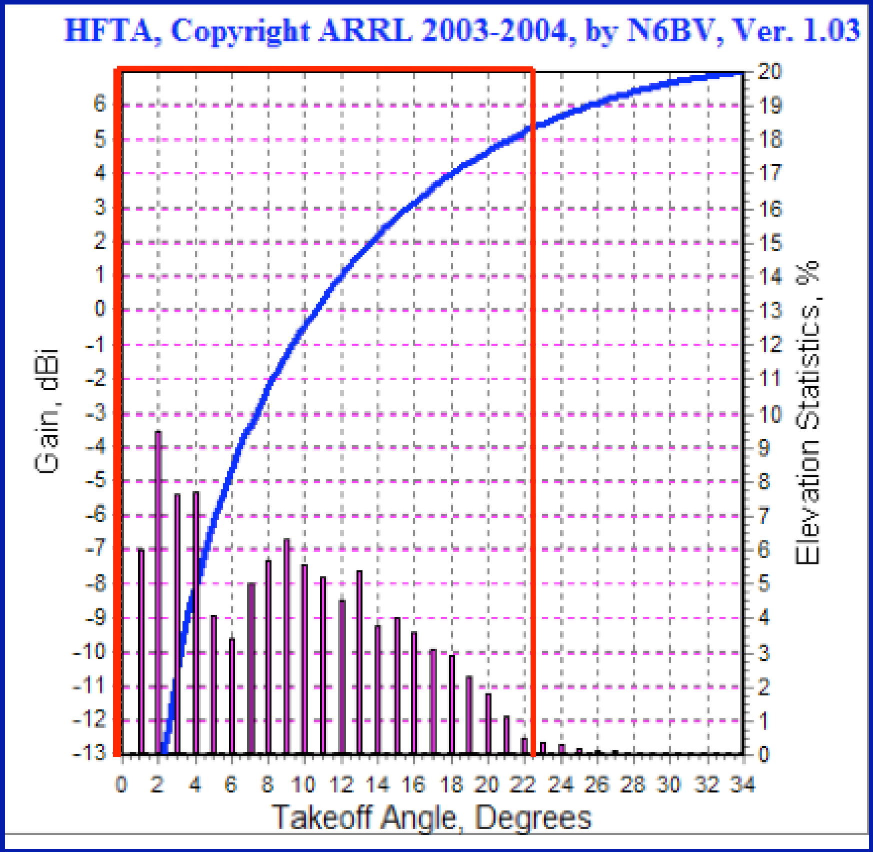
Elevation Angles: Statistical Avgs.

- Range from zero-30°
- IONCAP data from N6BV presentations
- Low angles: Band opens first, closes last
- Time: lower angles sooner and longer



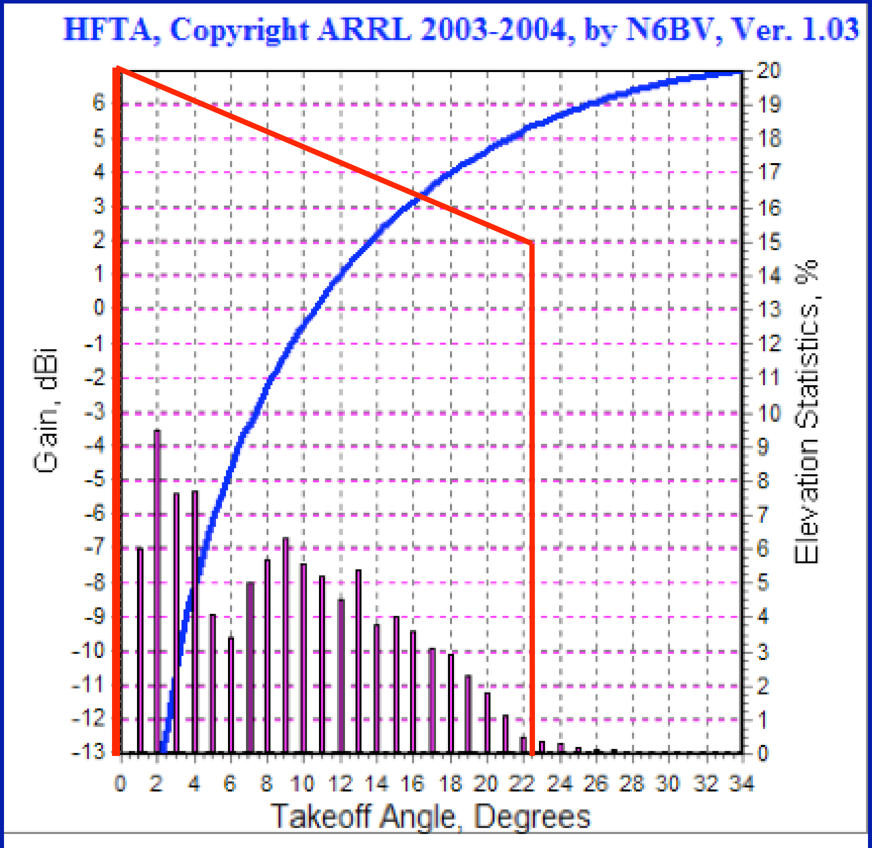
Windowed Gain: FOM

- Gain only useful at angles with signals
- Flat: Is this the right weighting?
- Weight by probability?
- Weight by time?
- Also need NVIS (near vertical for close-in at $f<f_0$ critical frequency)

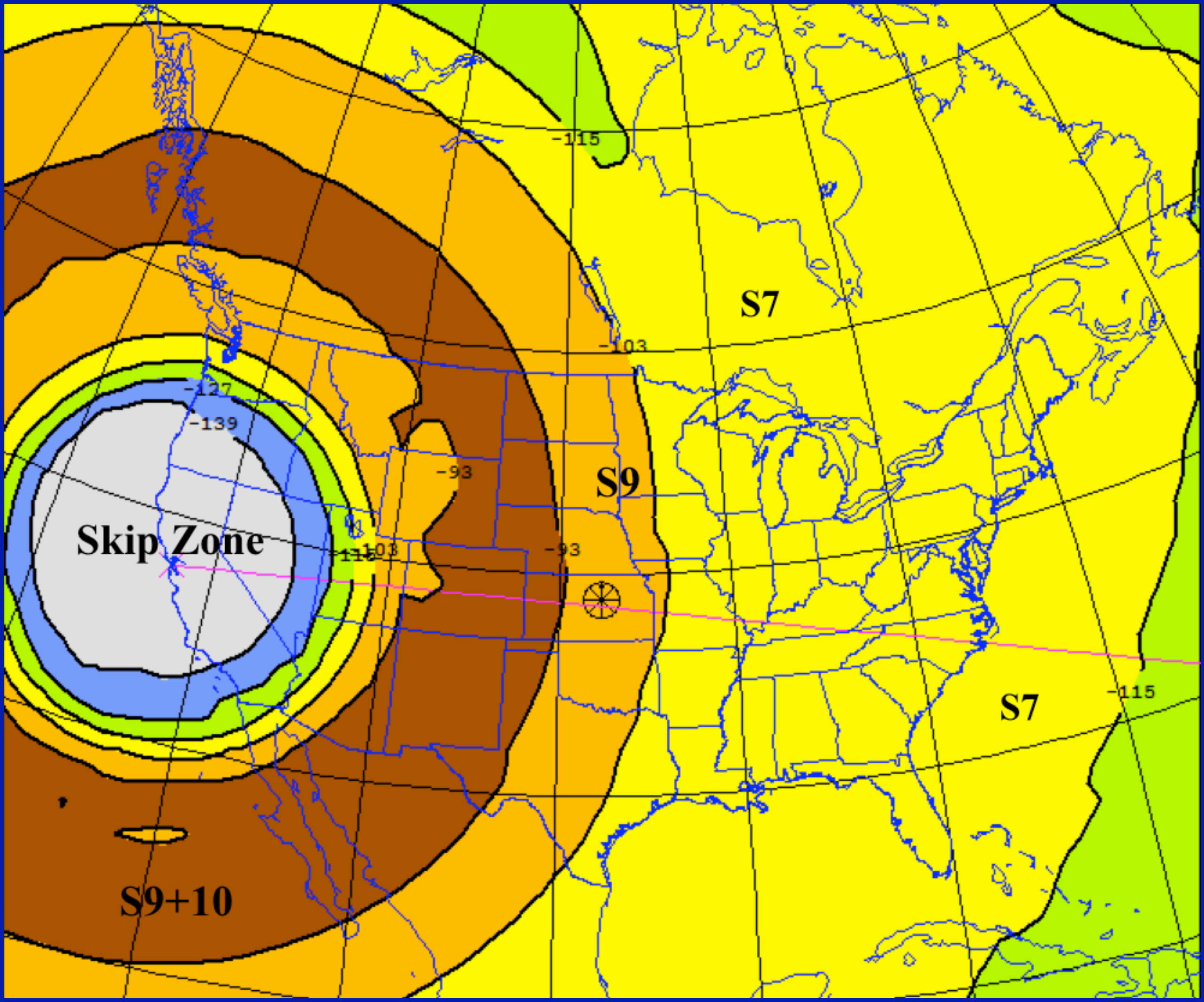


Weighted Window

- Might be more realistic
- 2%-98% within 1°-22°
- Try with signal-strength simulation to see if it's better
- NVIS not in statistics, used for close-in at night

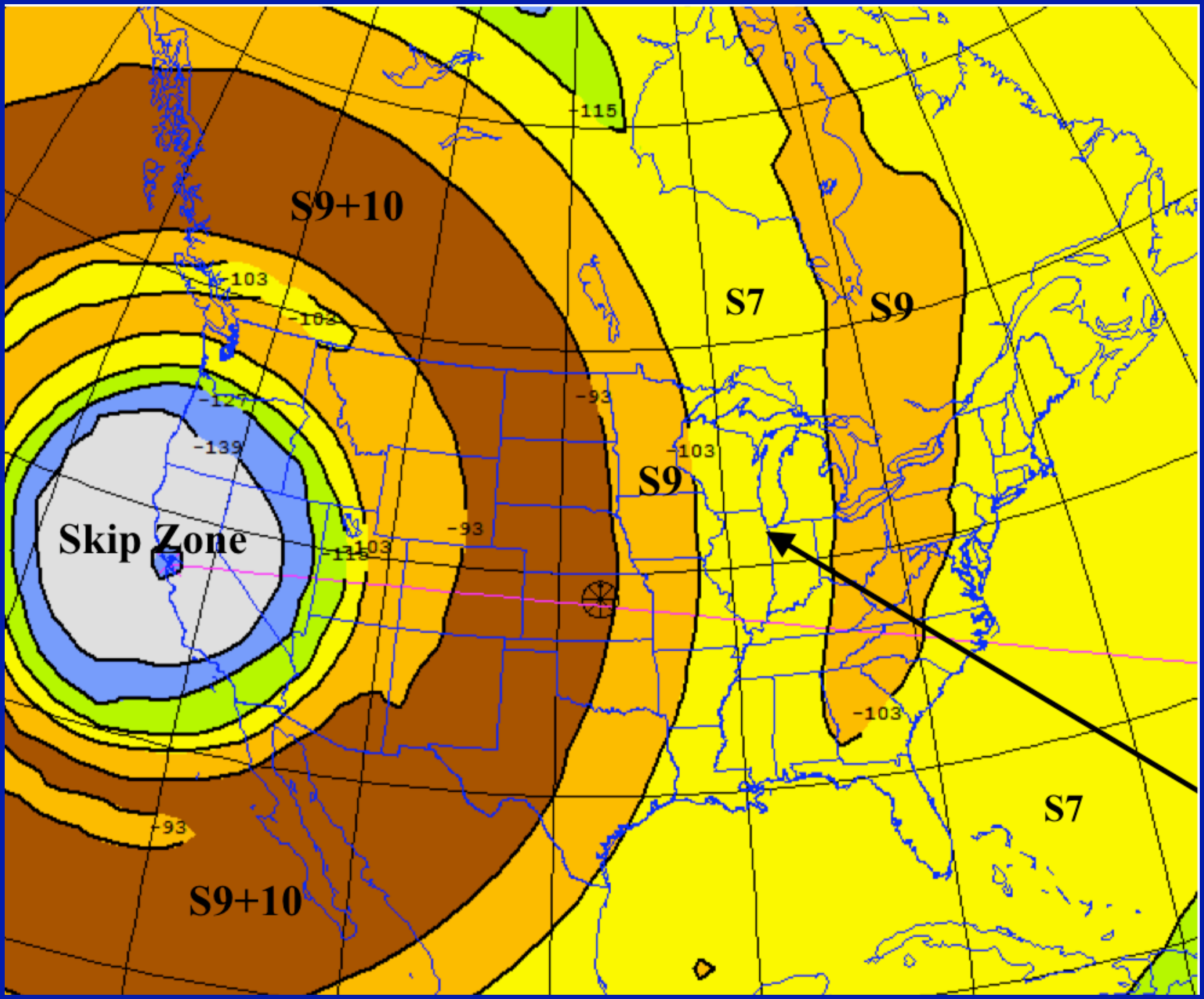


Signal Strength 21 MHz 3el 35'



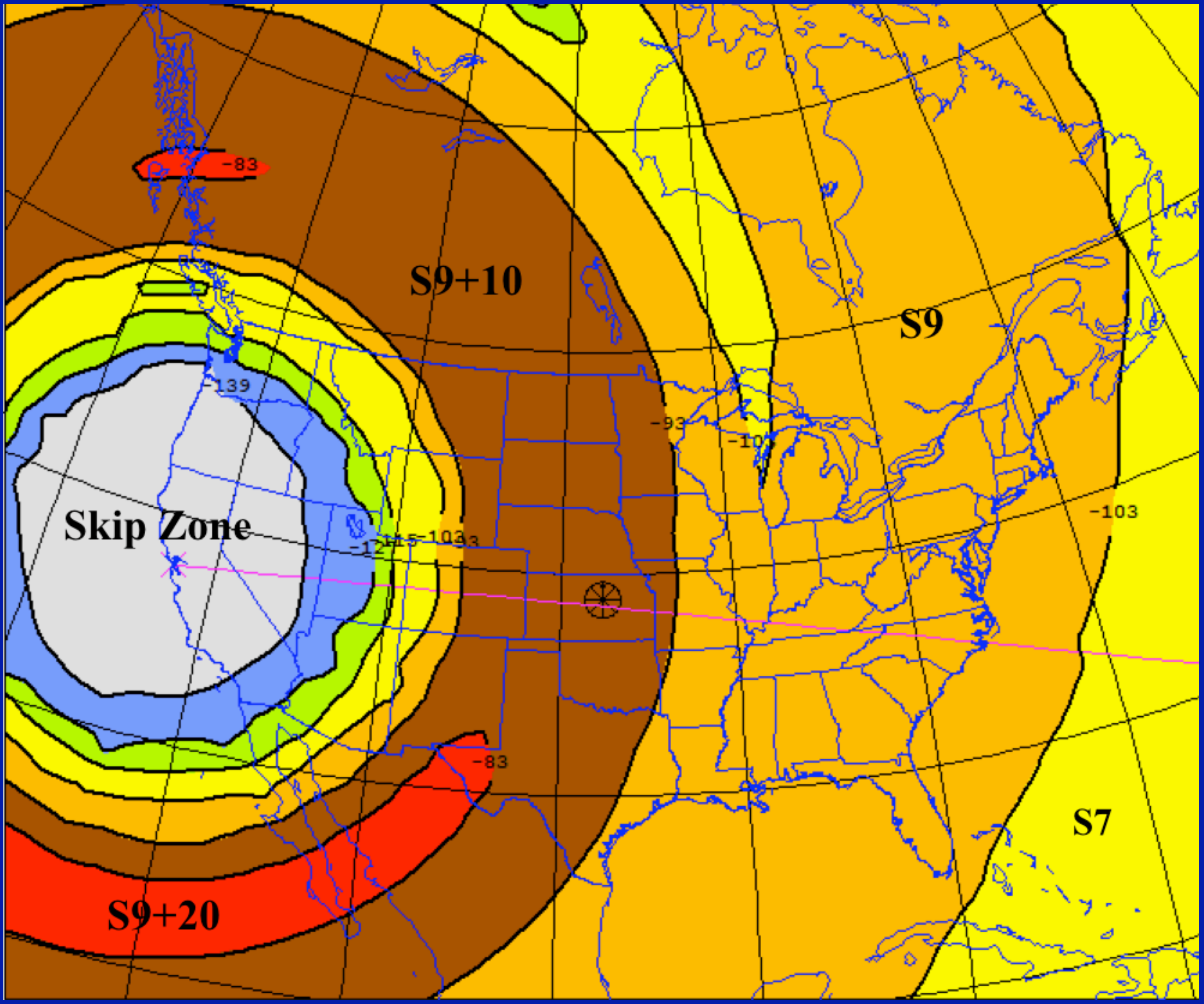
N6BV 18z

Signal Strength 21 MHz 3el 70'



N6BV 18z

Signal Strength 21 MHz 5el Stack



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Terrain Issues for Low Angles

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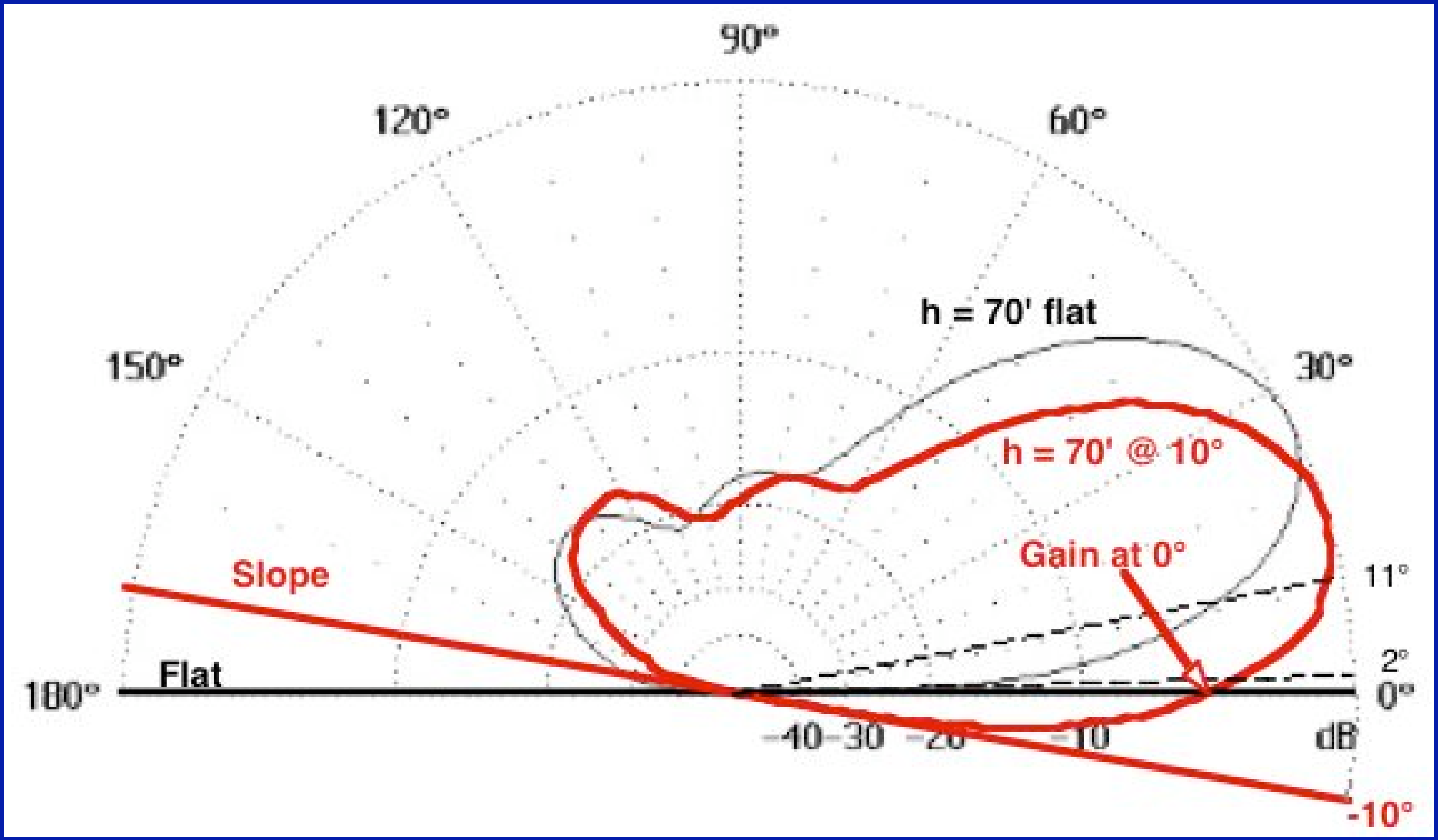
- Most terrain is alluvial (flat)
  - Complete cancellation of grazing (low angle) signal
- Foreground slope or salt water: low angle
- Clearance of obstacles for lowest angles
- Ground reflection coefficient vs. angle
  - Grazing angle: lowest loss (like a mirage)

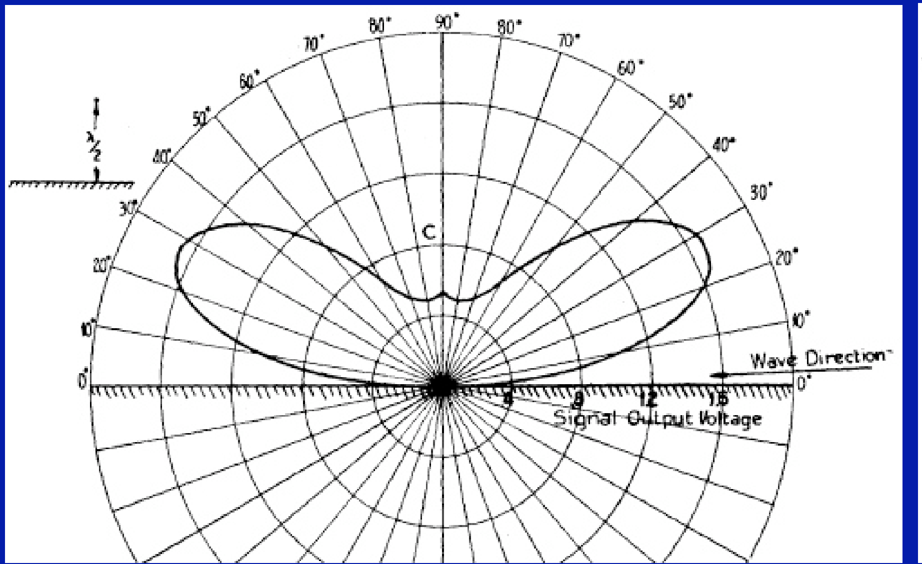
"Tip the Picture" Slope Model

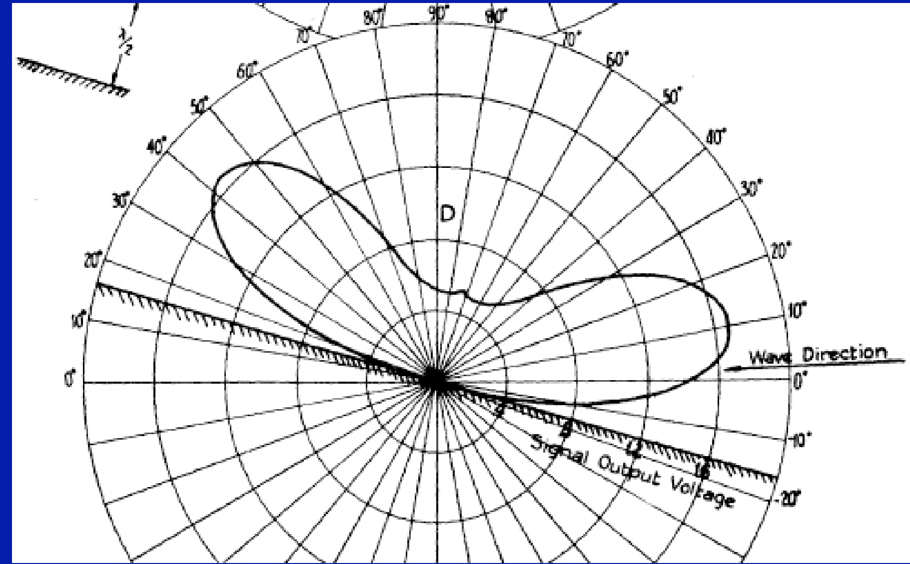


Proceedings of the Institute of Radio Engineers
Volume 20, Number 4 *April, 1932*

SOME EFFECTS OF TOPOGRAPHY AND GROUND ON SHORT-WAVE RECEPTION*

By
R. K. Potter[1] and H. T. Friis[2]
([1]American Telephone and Telegraph Company, New York, N. Y.; [2]Bell Telephone Laboratories, New York, N. Y.)





Chain Home HF Radar 1937

360’ Towers,
26 MHz

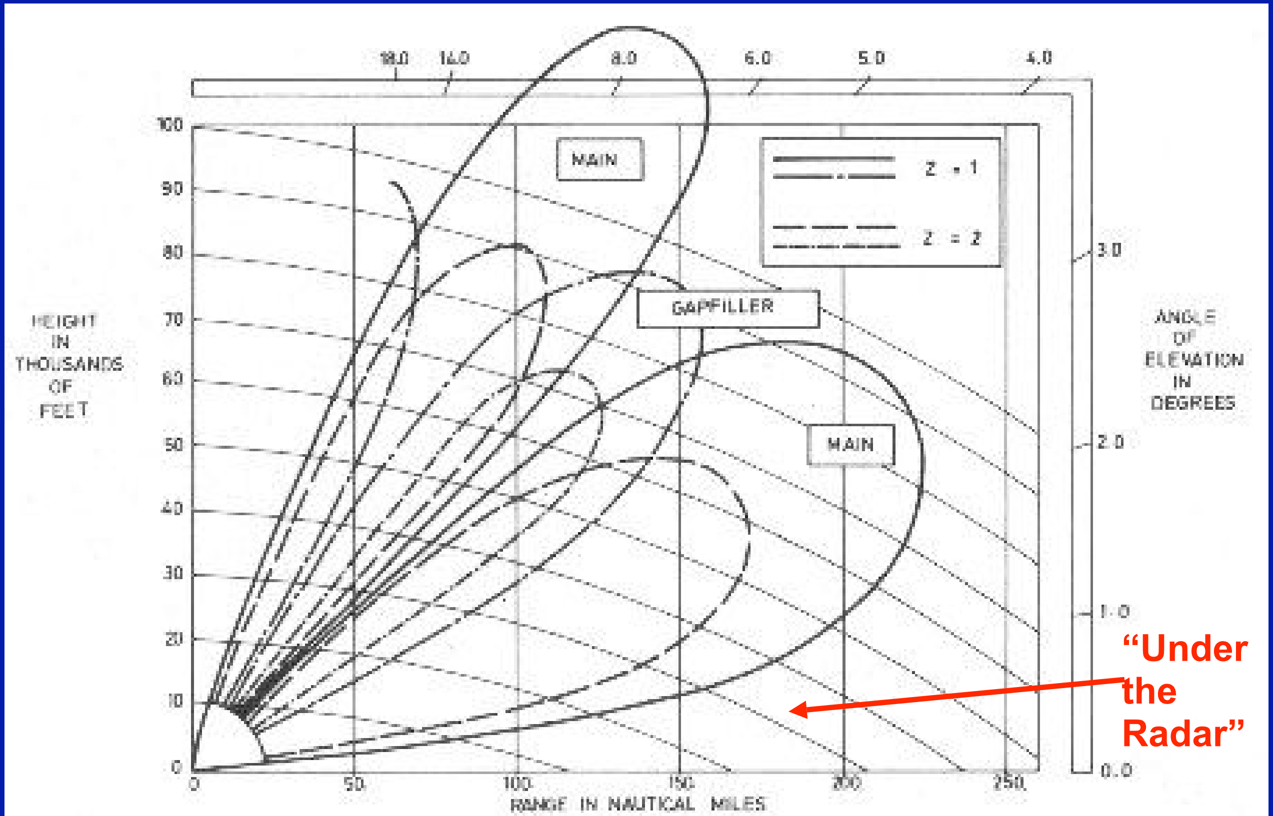
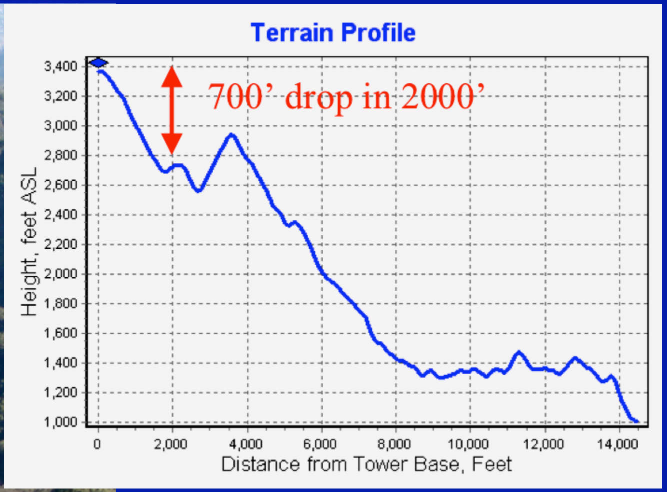


Fig. 6. Typical CH performance diagram

W6NL Slope

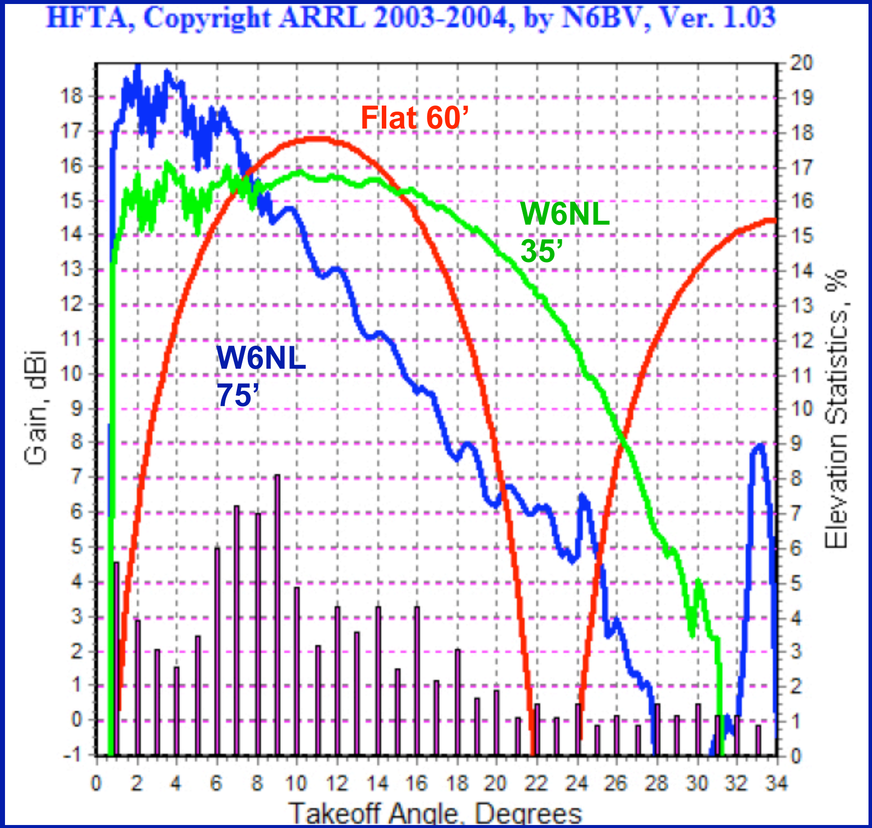


Aerial photo

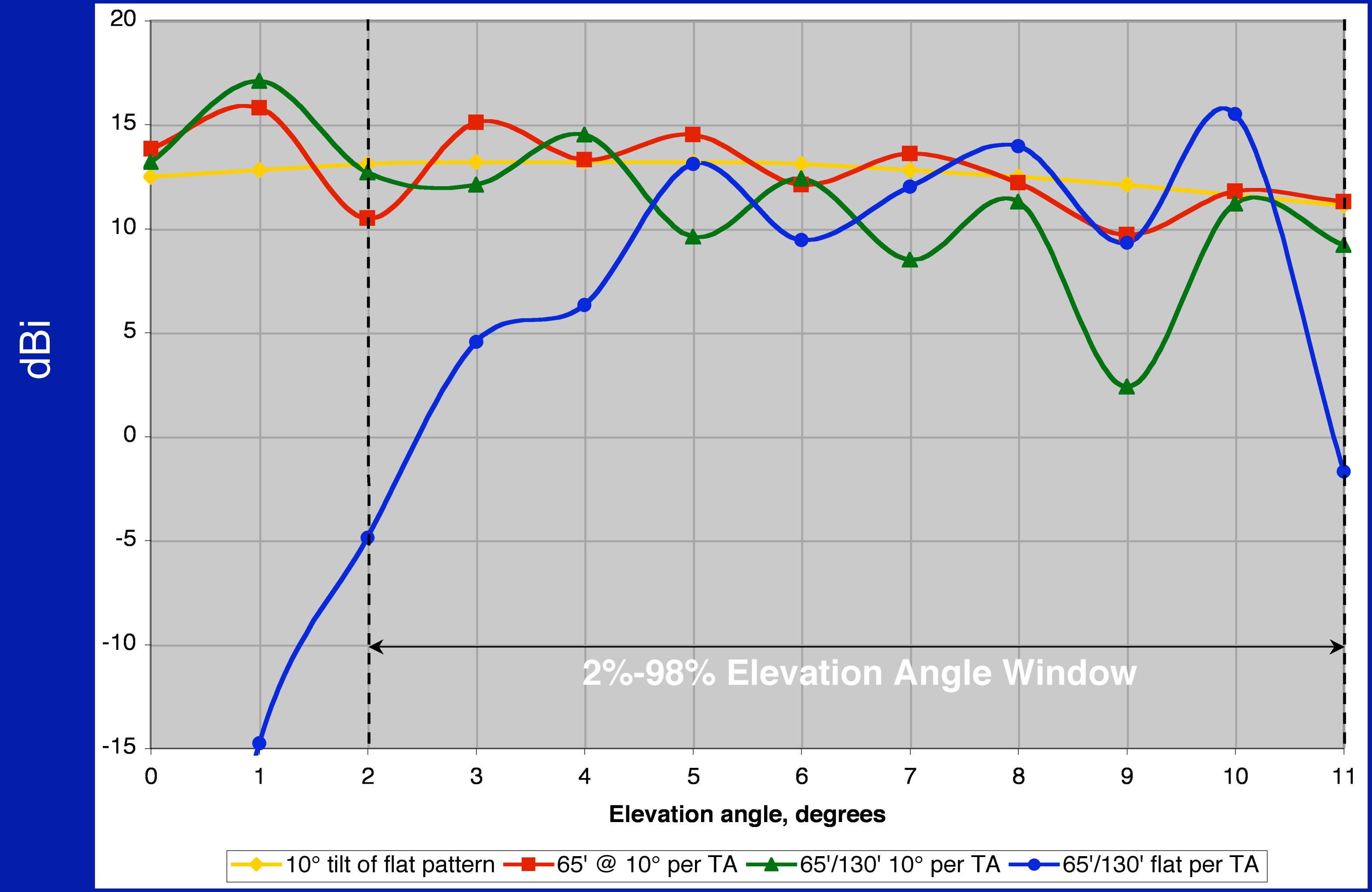
Slope
from below

Sloping Foreground Result

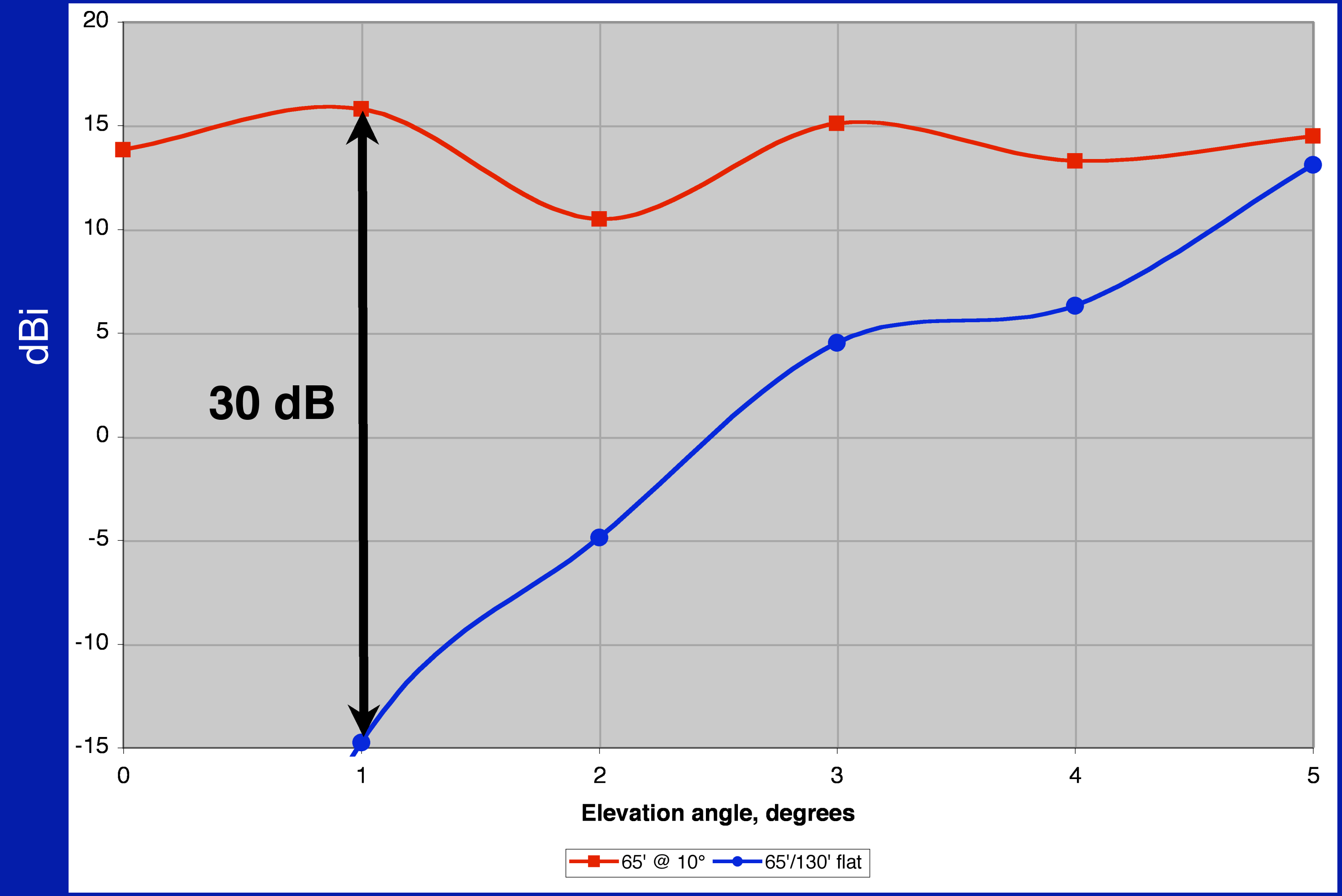
- Note these are heights above slope
- Good results with 70' tower, 50' above slope
- Use a separate antenna for NVIS
- Station has won Sprint and NAQP
- Model for HC8 station



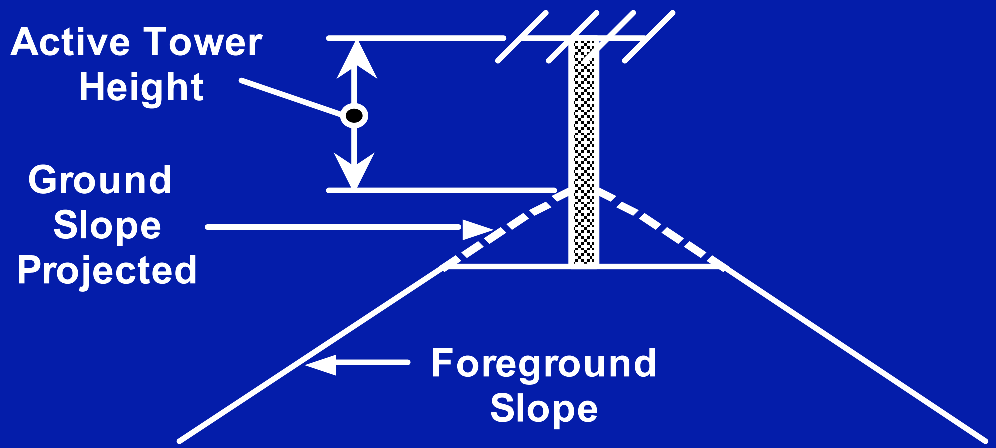
Gain vs. Elevation Angle



Gain at Very Low Angle



Effective Tower Height



What if No Slope?

- Salt water foreground
- Height, stacks to get narrow el. beamwidth
- Narrower az. beamwidth + auto rotators
- Guest op
- Vacation or remote station

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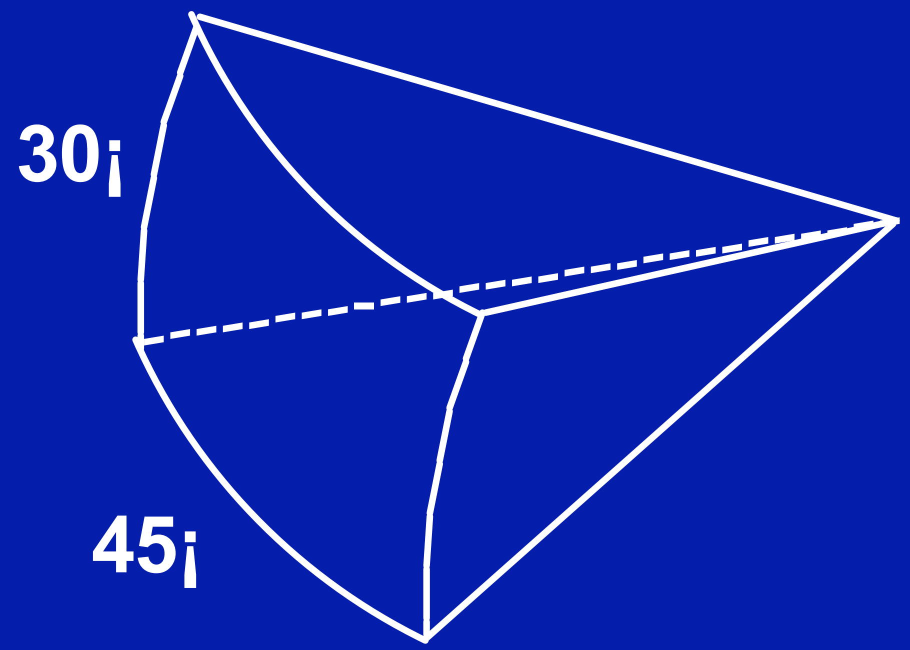
What About Antennas?

- Antenna modeling is now accurate
- Best designs have bandwidth, good pattern
- Gain increases with boom length, but by log(L)
  - Diminishing returns and mechanical problems
- Make sure you get what you model
  - Adjacent antennas, structures kill pattern
  - Compare to reference
- Stacks: Good, not fully equivalent to slope

Max Gain for Full Coverage



$$G \approx \frac{33{,}000}{\theta_a \theta_e} = \frac{33{,}000}{30 \times 45} = 14\,\text{dB}$$

Gain in dBi

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Station Maximized?

- Output power
- Coax loss
- Receiver capability in crowded band
- Antenna condition
- Signal quality: Don’t cheat yourself
  - No clicks, hum, distortion
- This will make your antennas better

Operator Maximized?

- Practiced, fluent in your mode(s), conditioning
- Learn “secrets” of project management
  - Show stoppers first
  - Control lead time, op and station ready
  - Integration takes most of the time
  - Don’t make last-minute changes without recovery time
- How to get a seat at a big station?
  - Win something small (QRP, LP?), become known
  - Then learn from the best examples, see what they do
- This will make your antennas better

Queuing theory of Pileups

- Service rate limited
- Minimize service time
  - No extras, get a call
  - Receiving, logging key
  - Use split, std. phonetics
- Discipline pileup by actions, not words
  - Different pile every minute
  - Answer after one call
- Sign call "enough"

- Arrival rate limited
- Higher duty cycle
  - Beacon for "fish swimming by"
  - Different CQ message
- This can be max rate
  - Easier receiving
- Keep CQing if rate
  - But also S&P, SO2R
- Time is key here, too

Antenna Experiences to Try

- Put up temporary antennas
- Mobile or portable operation
- Try antenna ideas on Field Day
- Try operating in another part of the world
- Remote station operation?

Experiment Trumps Theory

- Compare antennas
  - Keep your reference antenna!
  - Or compare to known good station nearby
- Antennas are cheaper than rotators
  - Spacing too close ruins higher band antennas
- Experiment confirm theory?

Antennas in HC8

on an equatorial mountain-top with slope

Antennas: Cheaper the Rotators

…and generally more reliable (K7NV prop pitch excepted)

Ten Years at HC8