Terrain Analysis: Some YCCC Case Studies

A Presentation at

The New England Division YCCC Meeting

Saturday, August 14, 2004

Boxboro, MA

by Dean Straw, N6BV
Senior Assistant Technical Editor, ARRL

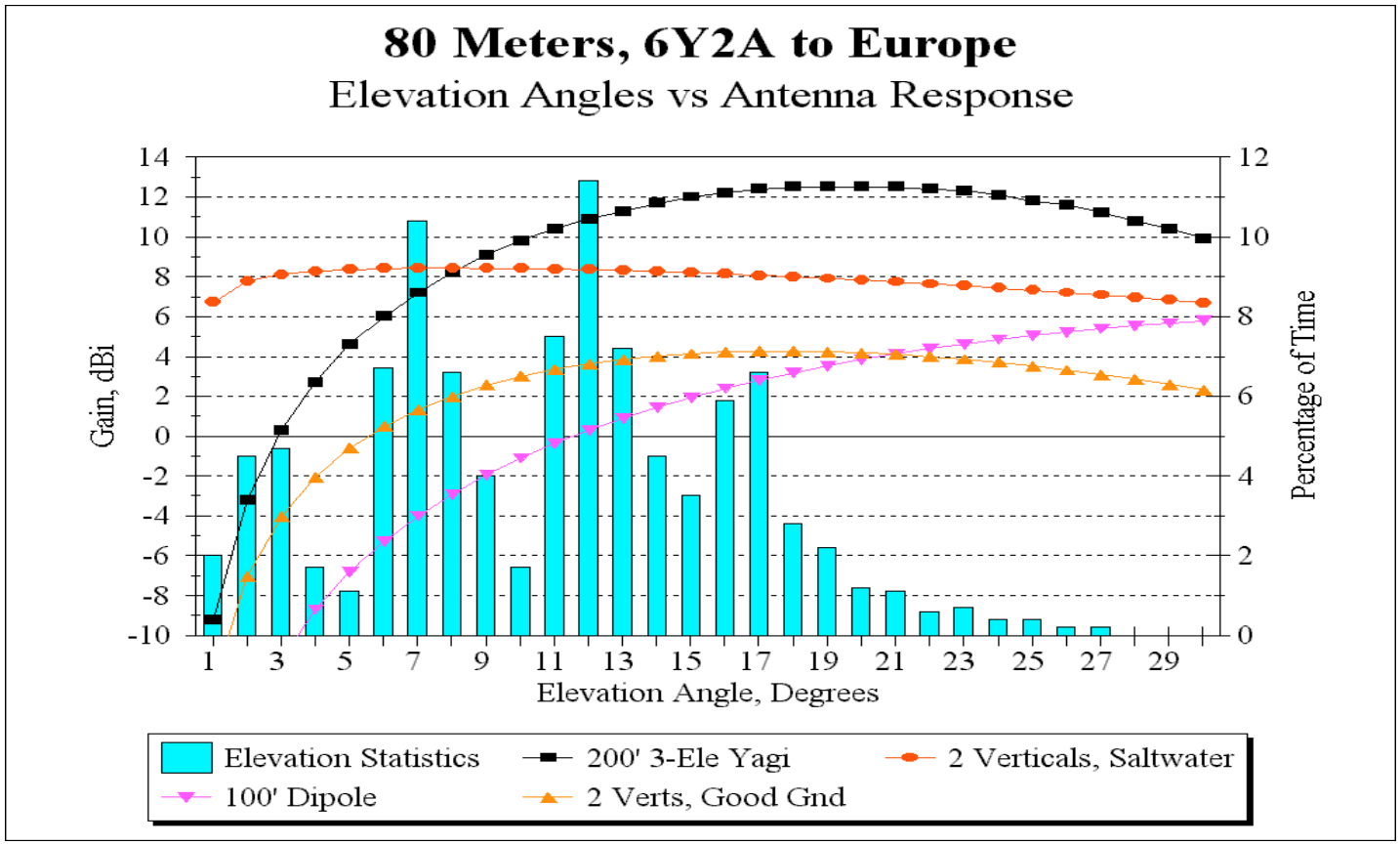
Is This the Best Place to Put Up My Antenna?

- The first question a true DXer or Contester asks when looking for a new QTH!
- Is this *the* mountain top where I will reign supreme?
- Or might I be stronger at the beach, where I can practically *see* the flag flying over Parliament?

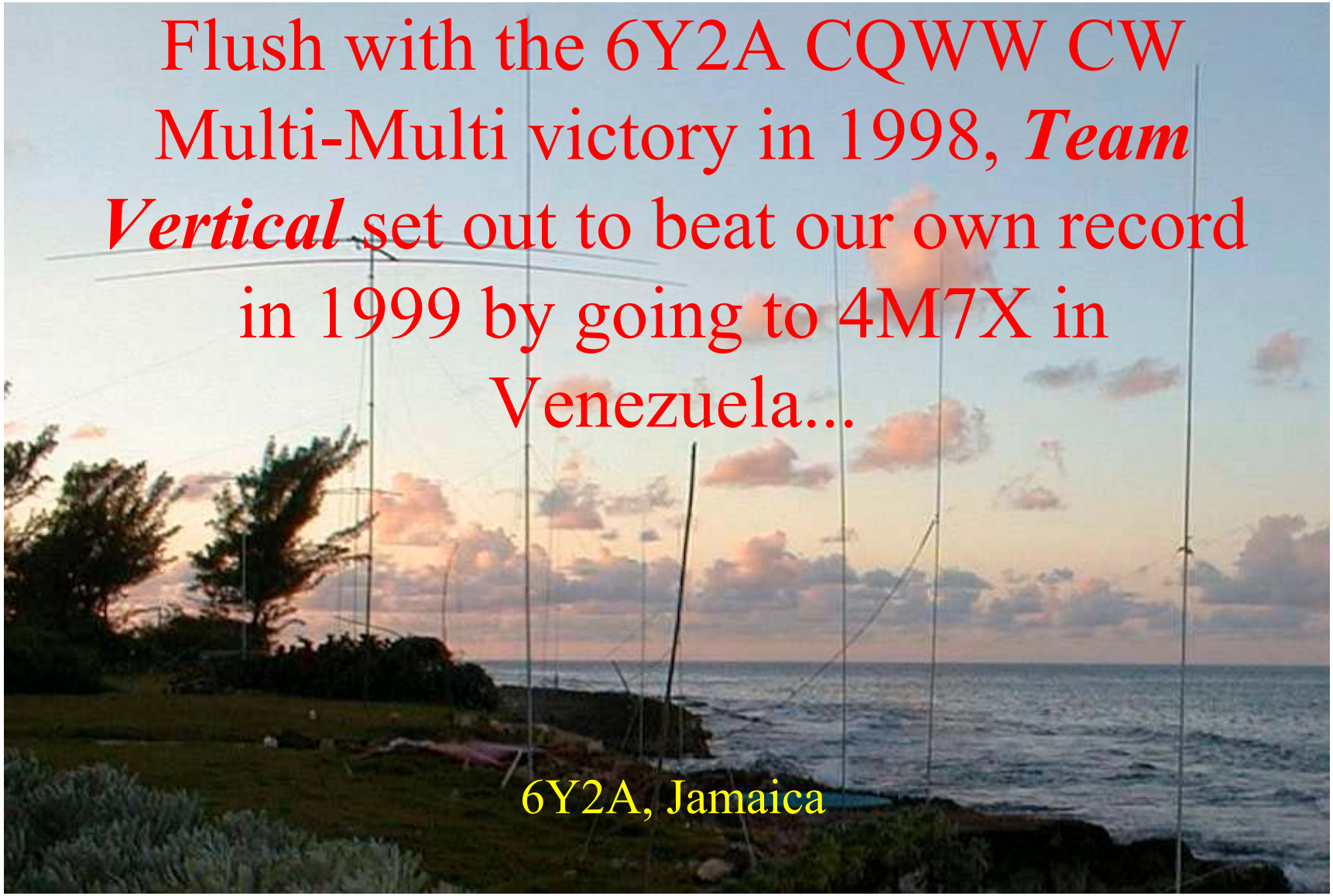
What Terrain is Best?

- *Team Vertical* for a number of years has been stressing the virtues of verticals over saltwater.
- There's no question about it, especially on the low bands: Verticals over saltwater do indeed rock and roll!

Low Elevation Angles Are Critical, Especially on the Lower Bands.



A pair of verticals on the beach holds its own against a 3-element 80-meter beam at 200 ft!


Flush with the 6Y2A CQWW CW Multi-Multi victory in 1998, *Team Vertical* set out to beat our own record in 1999 by going to 4M7X in Venezuela...
6Y2A, Jamaica

Yes, that really is salt water and there really were 43 verticals in total!

There are, However, Some Problems with Verticals on the Beach...

Like high winds, tides, corrosion… hurricanes.

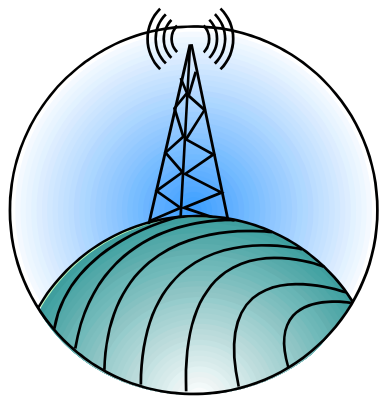
Back to Dry Land

- OK, so not everyone can do the beach thing with verticals.
- Horizontal antennas: Flat land is *easy*! Things are nice and predictable. (Saltwater is flat too.)
- What tools are available for assessing the effect of real-world terrain on the launch of HF signals?

Scientifically Planning a Station

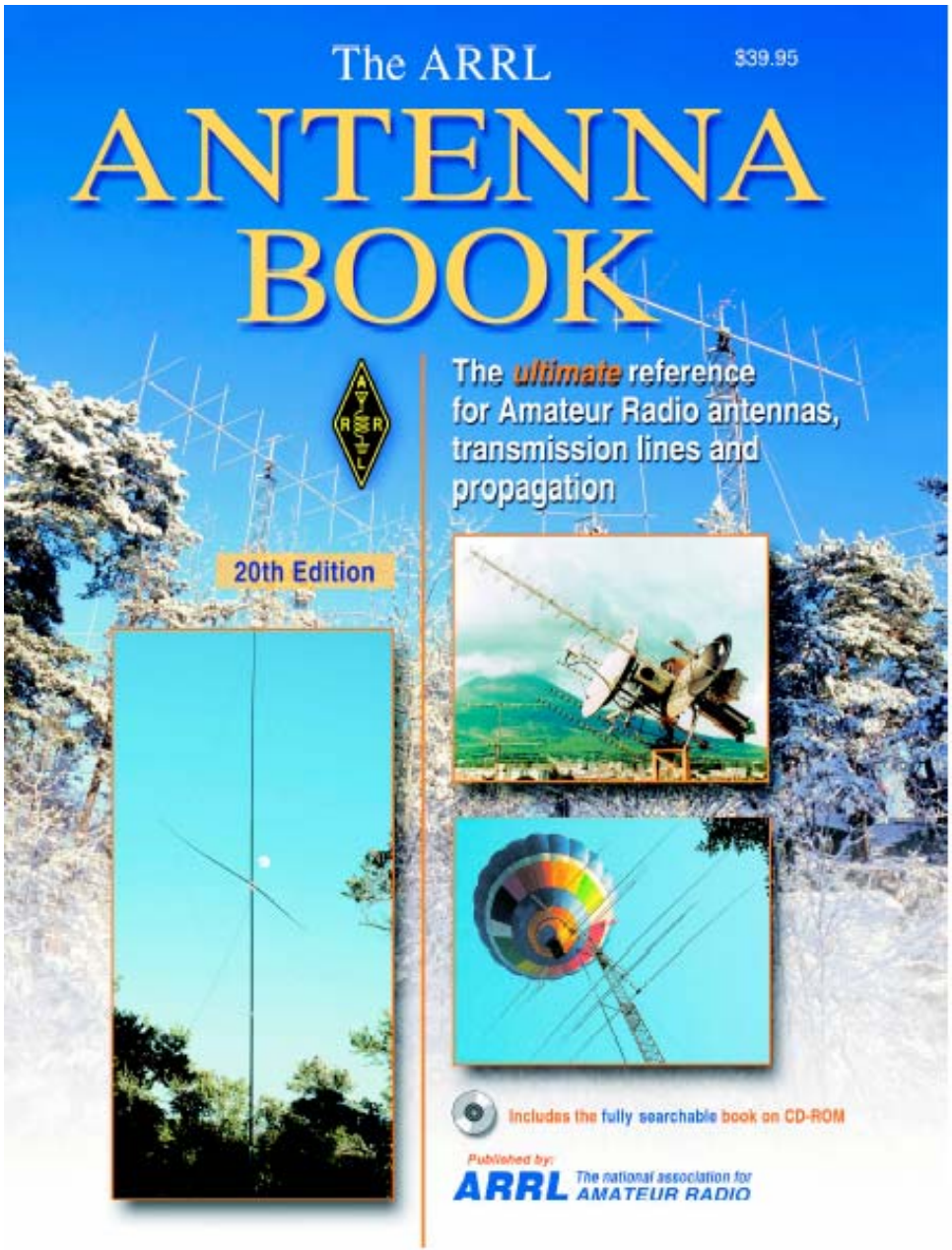
You've heard me say this before. There are three elements needed to plan an HF station *scientifically*:

- The range of elevation angles needed.
- Individual antenna performance parameters.
- The effects of local terrain.



The *HFTA* Program

- *HFTA* stands for "High Frequency Terrain Assessment." It is a full Windows program.
- *HFTA* traces the path of rays over 2D terrain, taking into account reflections and diffractions.
- The display of elevation angles needed are integrated into *HFTA*.
- *HFTA* is bundled with the 20th Edition of *The ARRL Antenna Book*.



For $39.95 you get some very useful software -- and a 900-page printed book thrown in for free!

But I'm biased...

Getting Terrain Data for *HFTA*

- From paper topo maps -- excruciatingly painful!

- "Seamless" USGS NED (National Elevation Dataset) database -- easy to use.

- DEM (Digital Elevation Model) data -- may require "merging" of several 7.5-minute maps to cover required area. Merging can be a pain.

(The *HFTA* manual details how to access either electronic form of terrain data.)

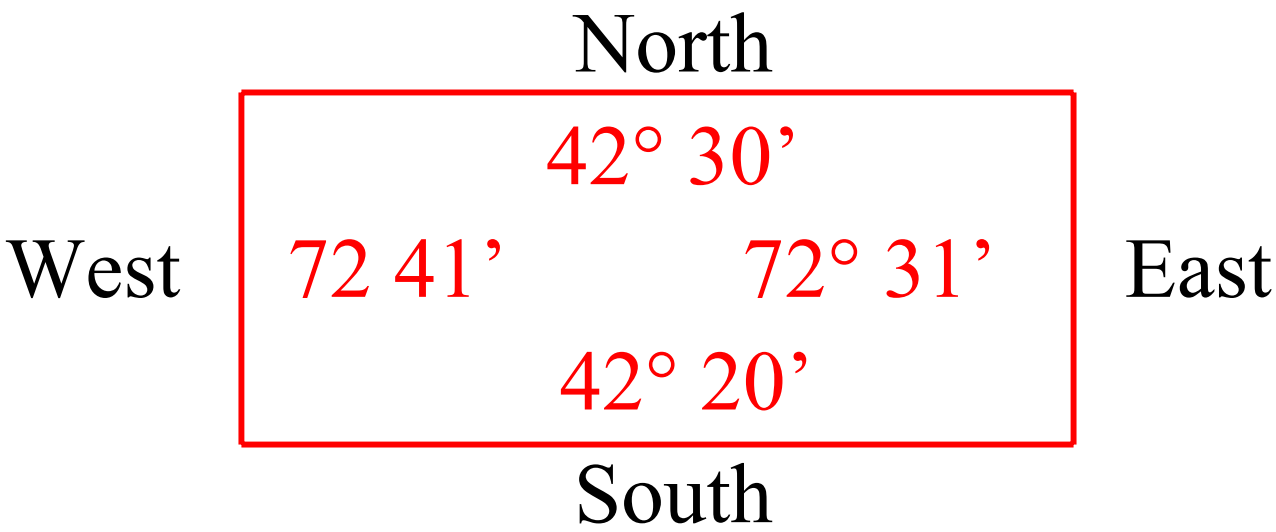
Seamless USGS NED Database

The seamless USGS NED database is easiest to use.

You just specify the area to be covered -- ±5 minutes North/South and ±5 minutes East/West, centered on the latitude and longitude at the tower base. Use a hand-held GPS to get the lat/long position information.

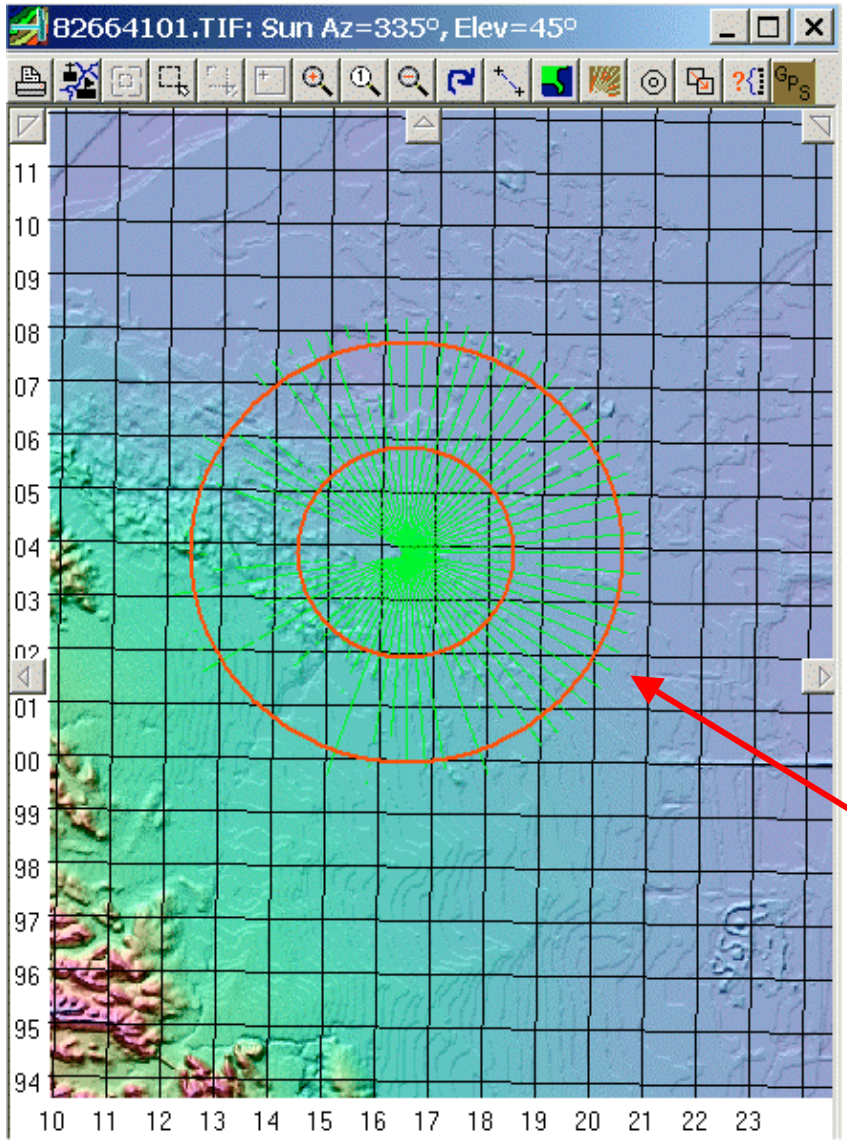
Seamless USGS NED Database

For ex., 42° 25’ 28” N and 72° 36’ 14” W:



Note: You can neglect the seconds. This will give you a coverage circle of at least 4400 meters around tower base.

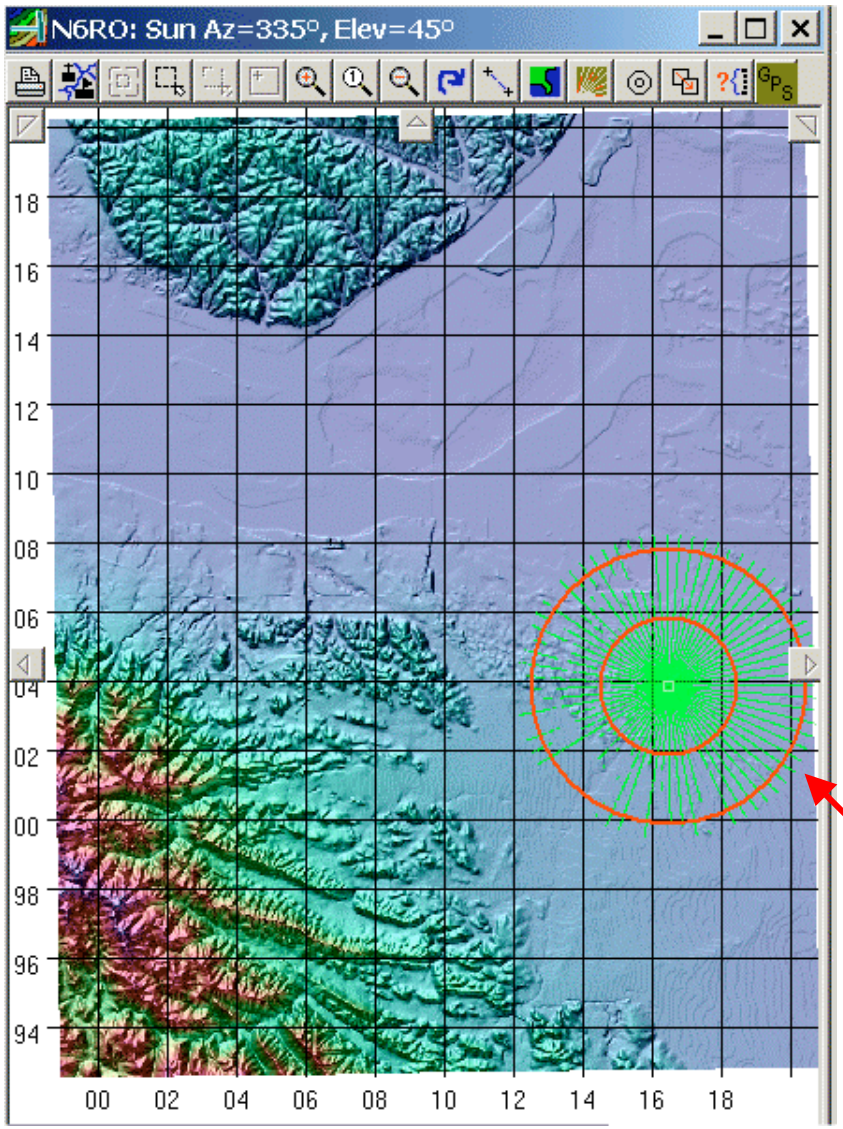
MicroDEM & Seamless NED Data



Note how circle is in central portion of the seamless NED map

The 4400-meter circle in 5° steps shows the terrain data for *HFTA*

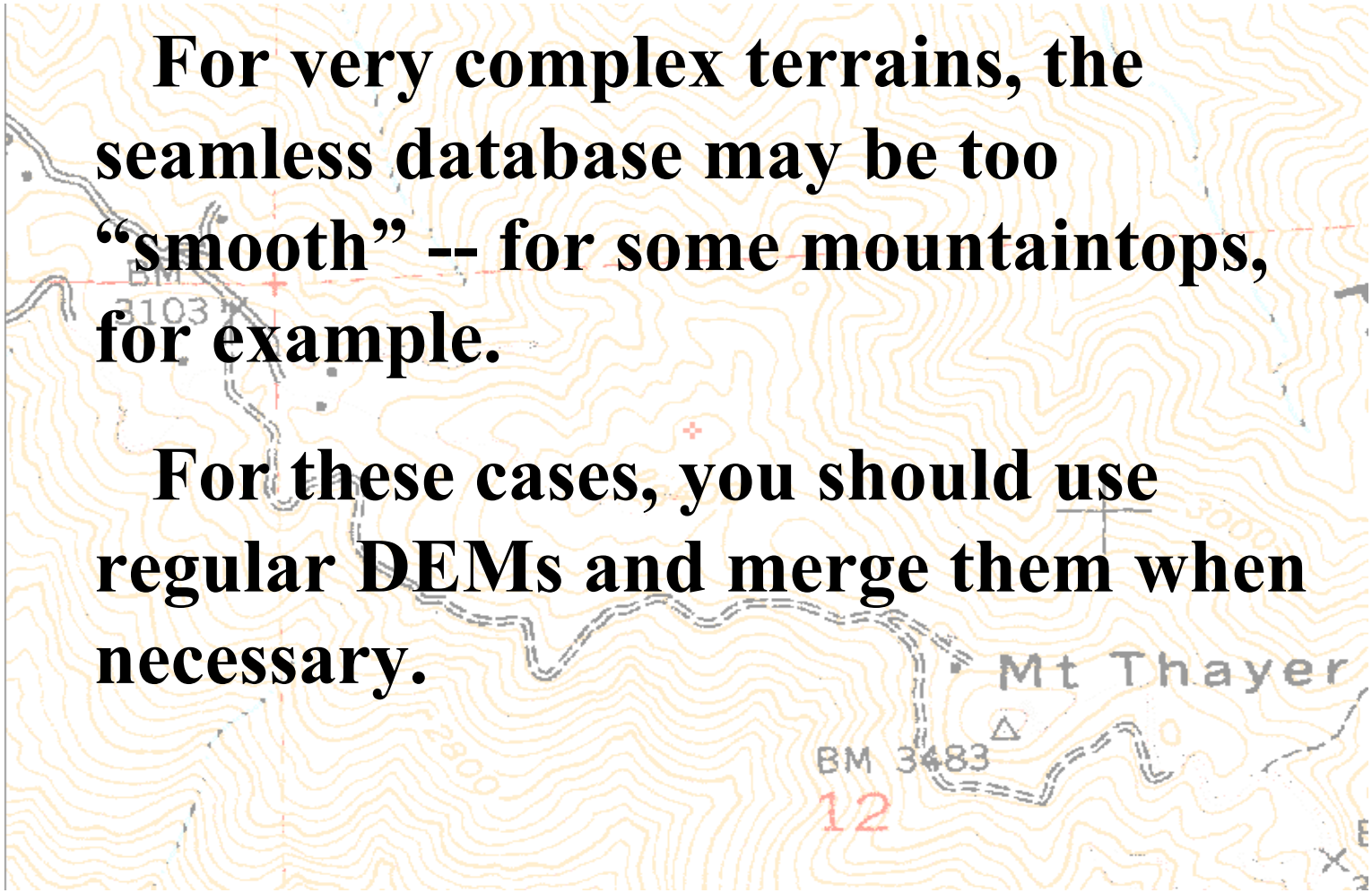
MicroDEM & USGS DEM Data



This map didn't require merging of DEMs, but just barely because it's right on the edge.

Terrain data for *HFTA*

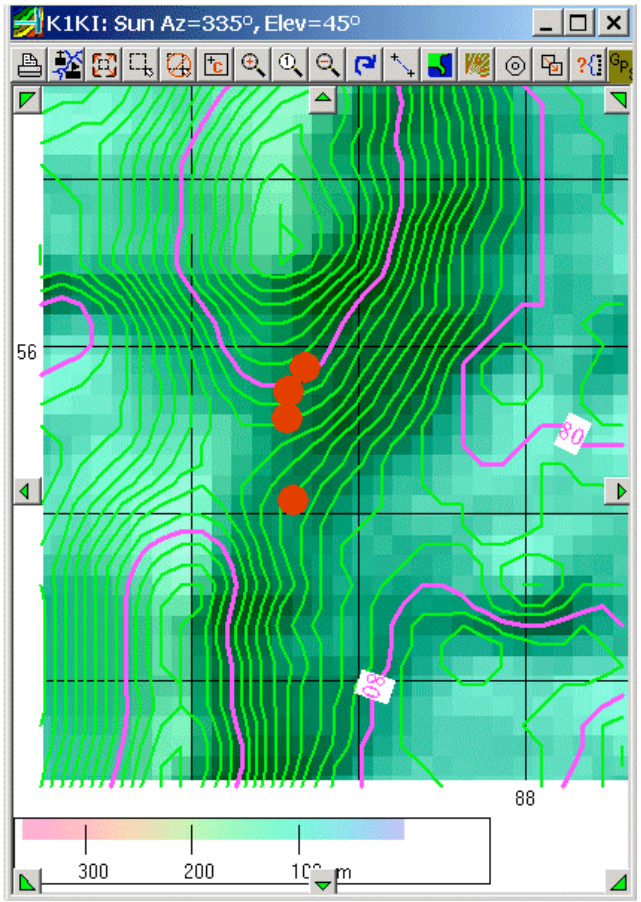
Seamless USGS Database



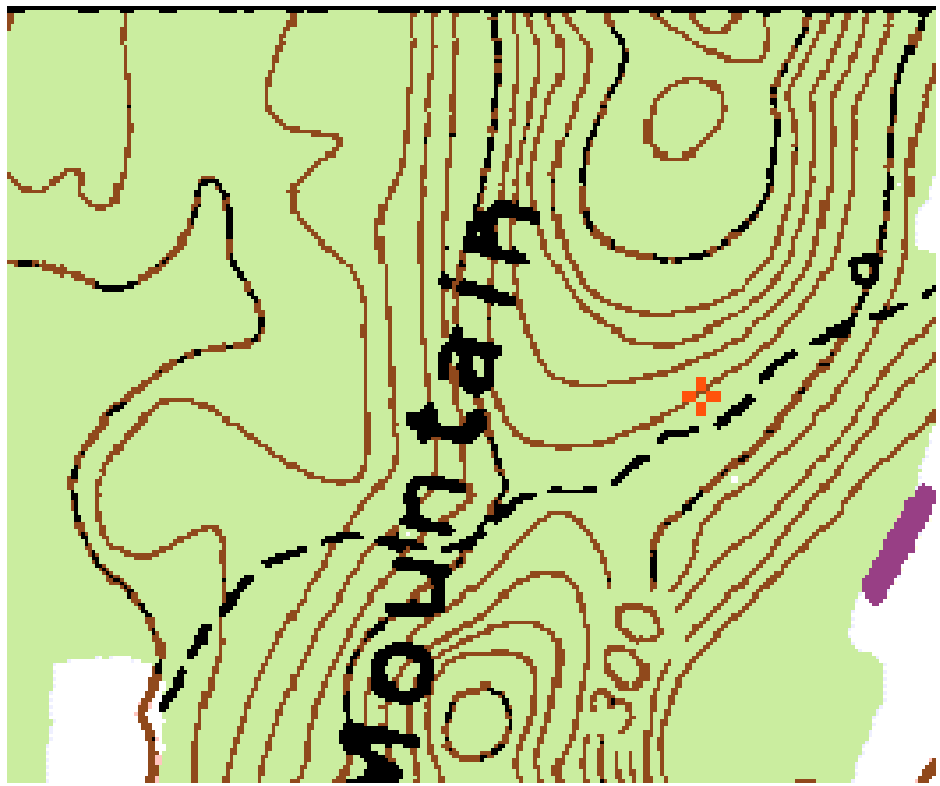
For very complex terrains, the seamless database may be too "smooth" -- for some mountaintops, for example.

For these cases, you should use regular DEMs and merge them when necessary.

MicroDEM & Paper-Map Data: Using "Contours" to Compare



MicroDEM Contours, K1KI



"Paper" Topo

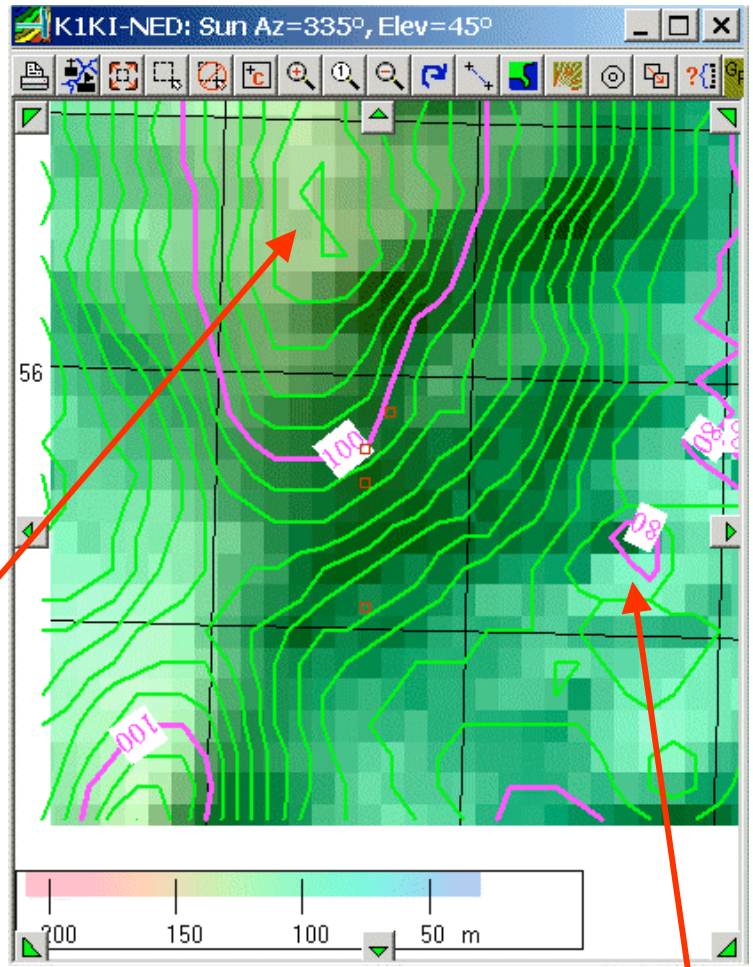
MicroDEM & DEM / NED Data Contours

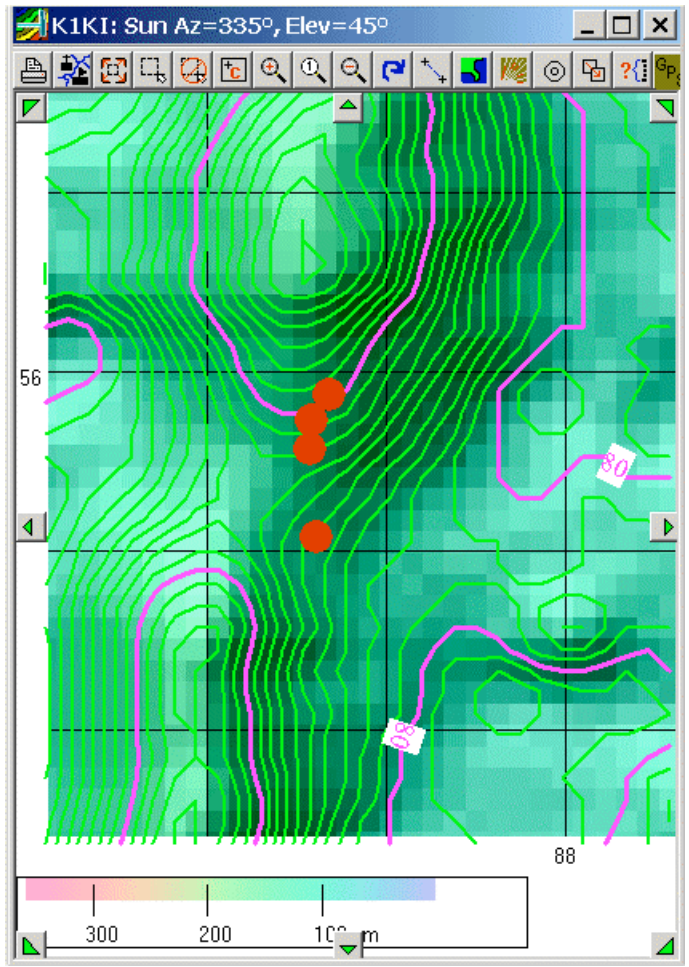
- **Contours are activated using: Overlay, Contour menus.**
- **Watch out: Contours are in meters, while USGS topos are usually in feet.**
- **"Contour interval" doesn't always work -- it seems that *MicroDEM* has a mind of its own. I usually use intervals of 3 meters (about 10 feet).**

MicroDEM, DEM & NED Data Contours

- **Contours, particularly using small intervals, can take a *very long* time to compute for large map areas! In fact, it may lock up *MicroDEM*.**
- **I highly recommend that you *Zoom In* to a much smaller area centered around your tower(s) and then invoke the contours.**

Seamless vs DEM Databases



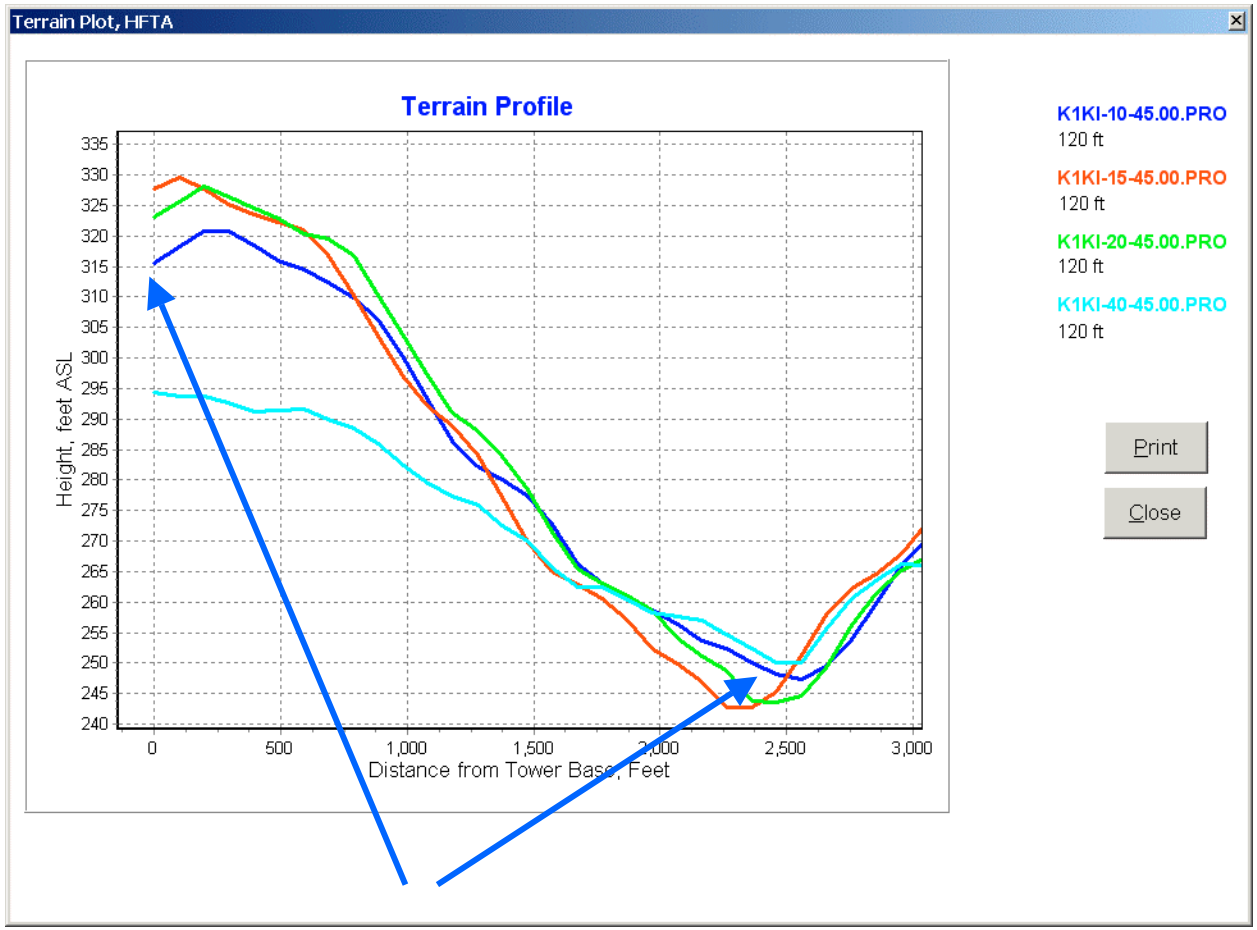


Seamless NED

DEM

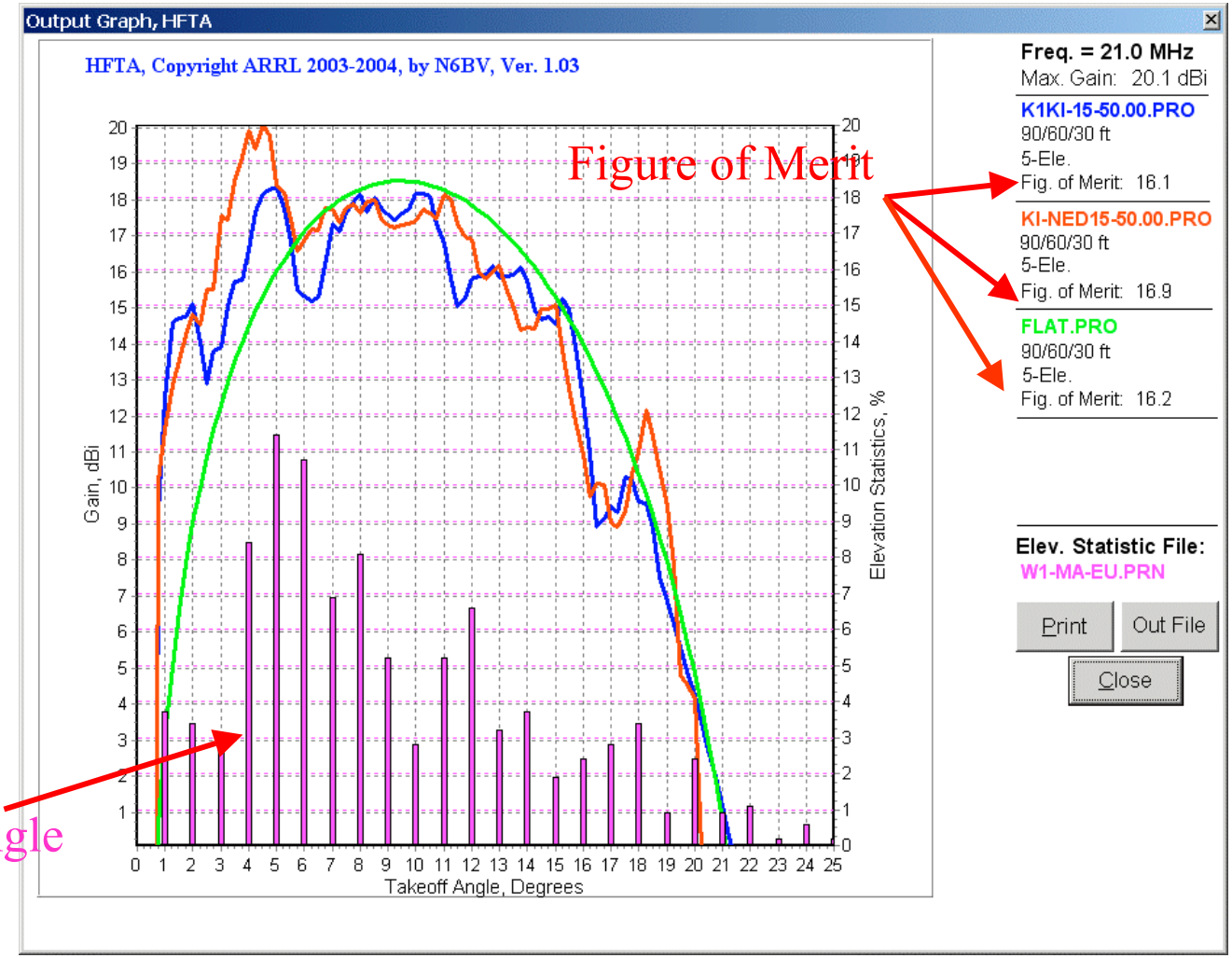
DEM is actually "smoother" looking for K1KI's QTH

K1KI's Terrain Towards Europe From His Four Towers



A 67-foot drop in 2500 feet isn't really very steep

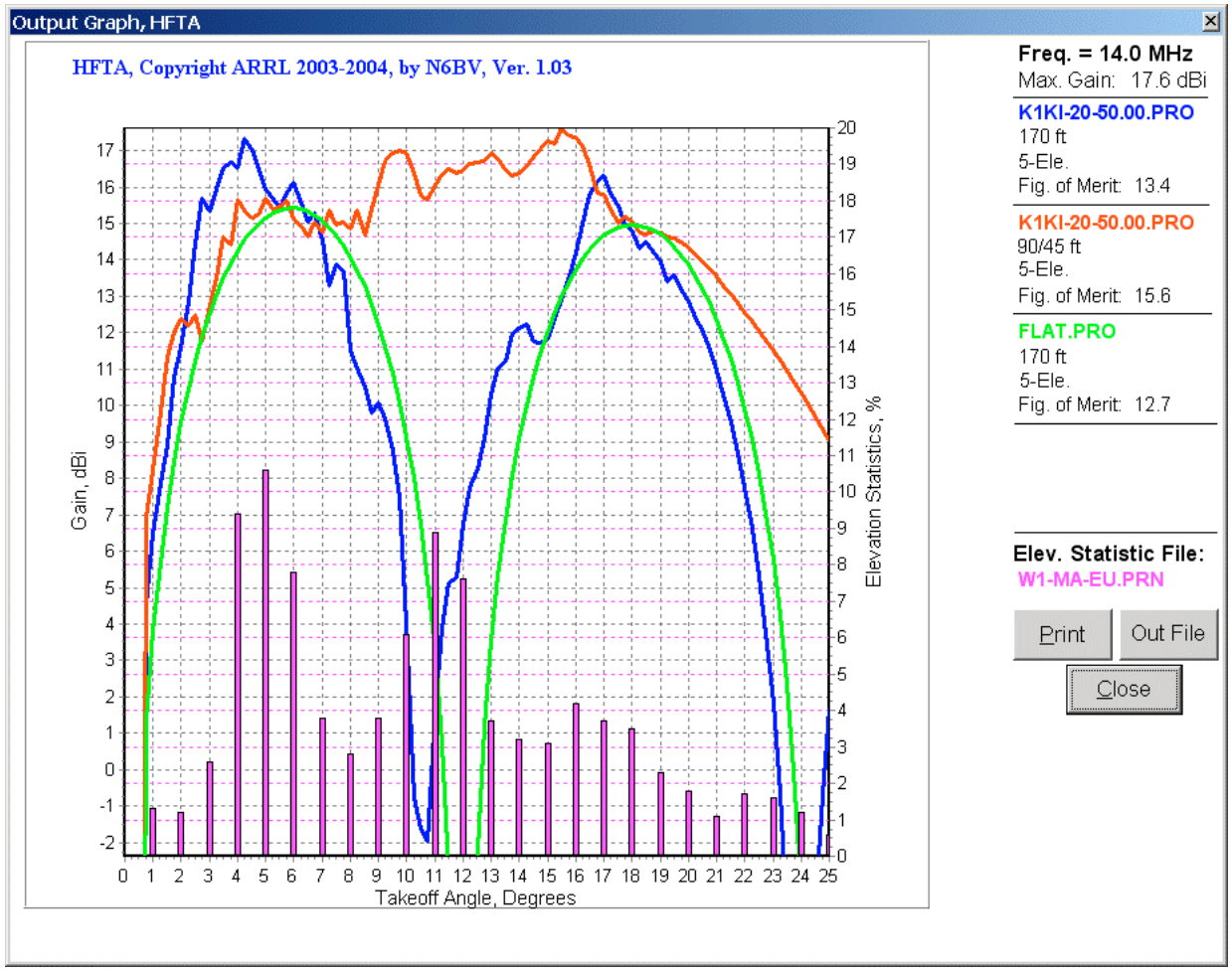
15 Meters to Europe at K1KI



Elevation-Angle Statistics

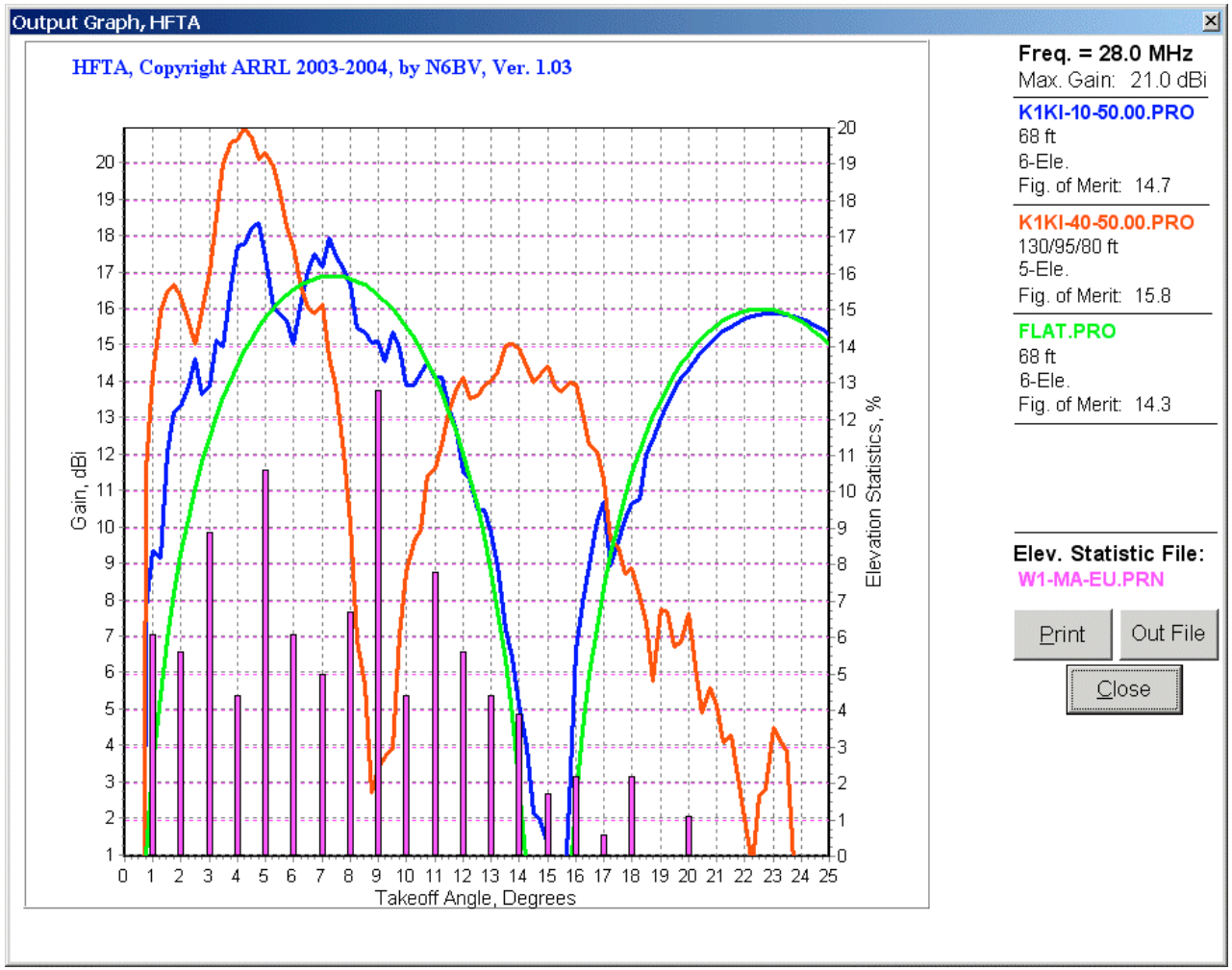
Both NED and DEM responses are close to flat-land response but stronger at very low angles.

Can an Antenna be Too High?



Note the nasty null at 11° for a proposed 170' antenna. An 11° elevation angle is very common in the afternoon on 20 meters from W1 to Europe.

K1KI, 10-M to Europe

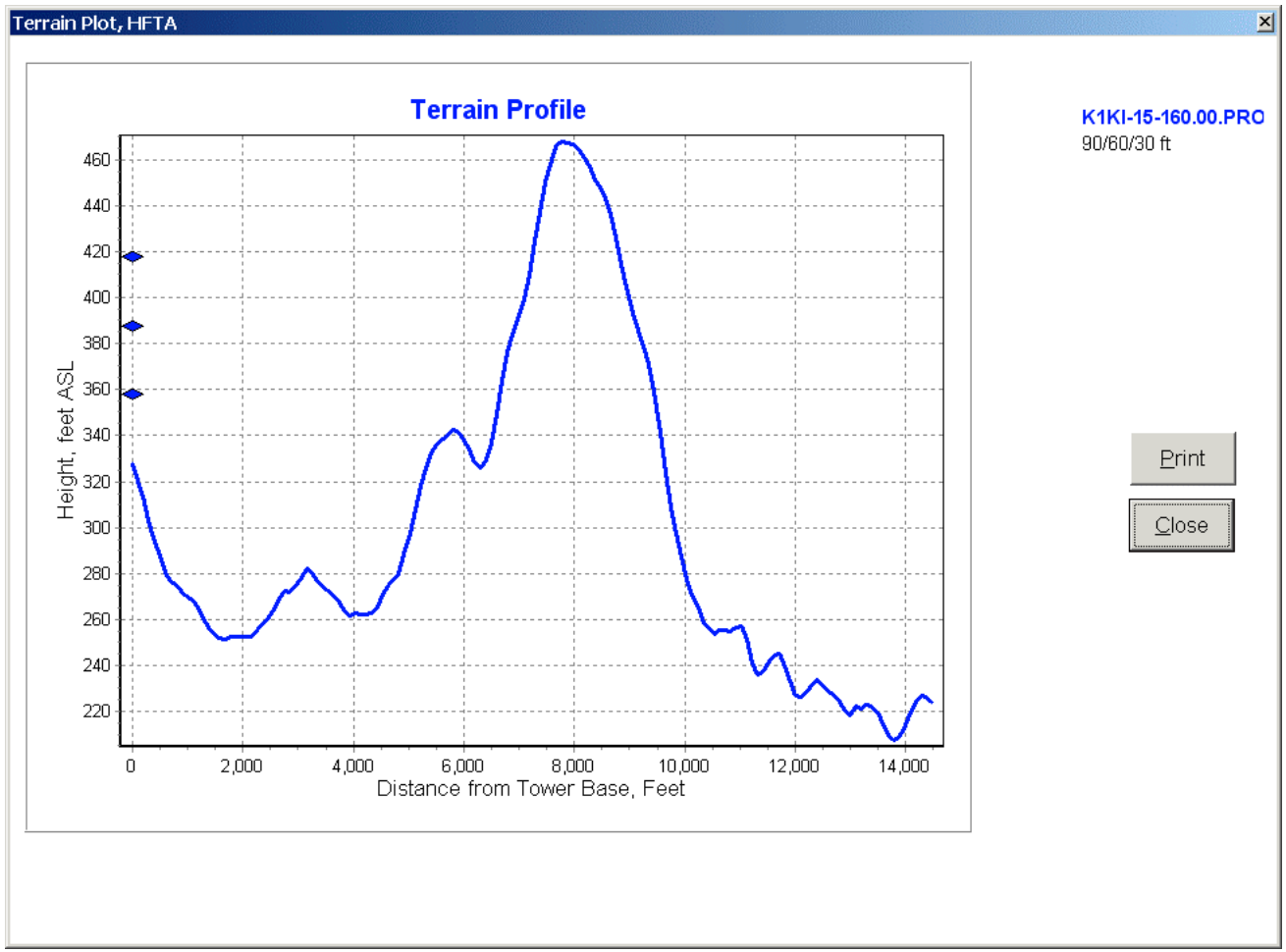


The long-boom Yagi at 68’ has more consistent coverage to Europe than the high 10-meter stack on 40-m tower.

K1KI, 10-M and 40-M Stacks

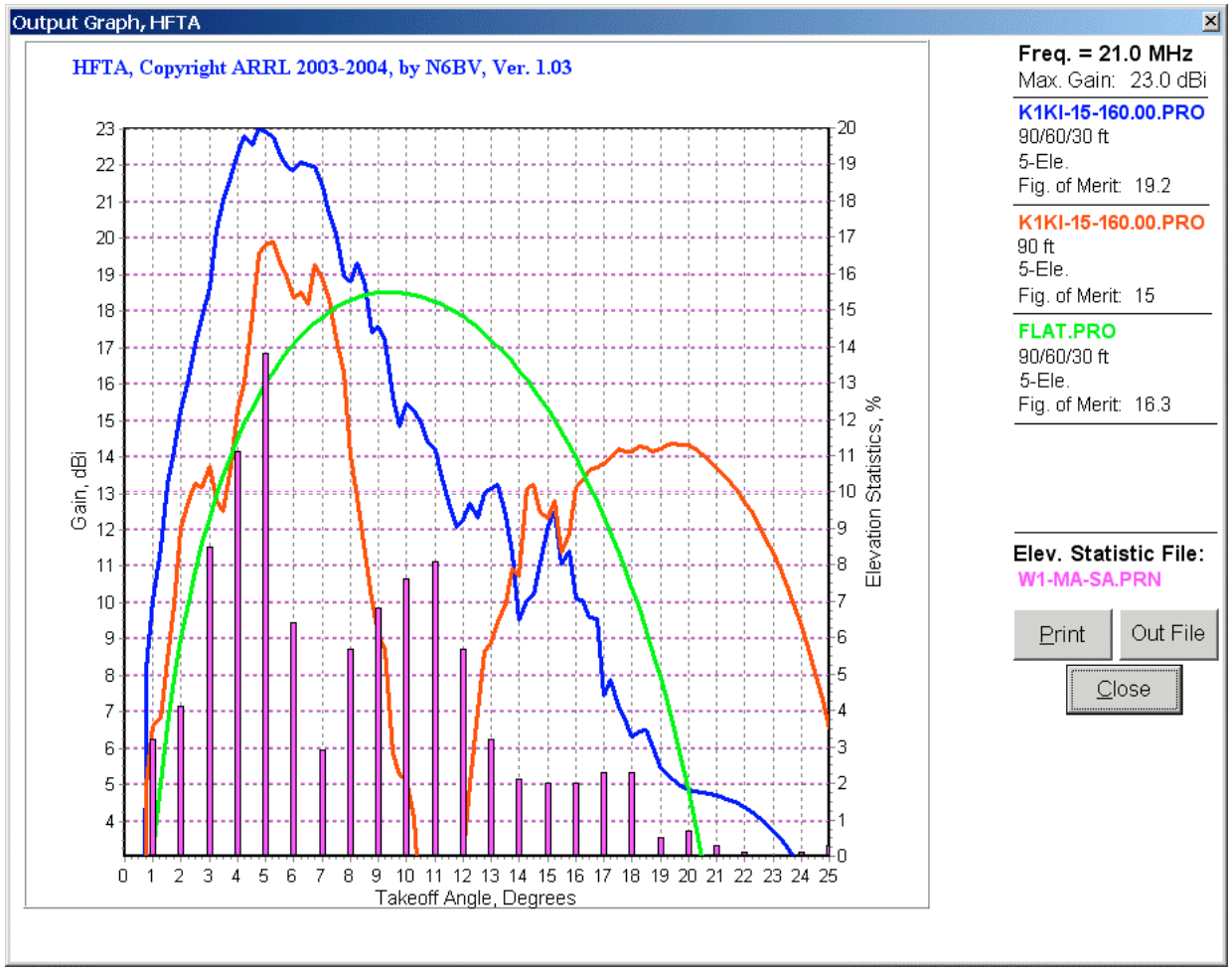
4L40 @120', 2 x 2L40, 3 x 5L10

K1KI, 15-M to South America



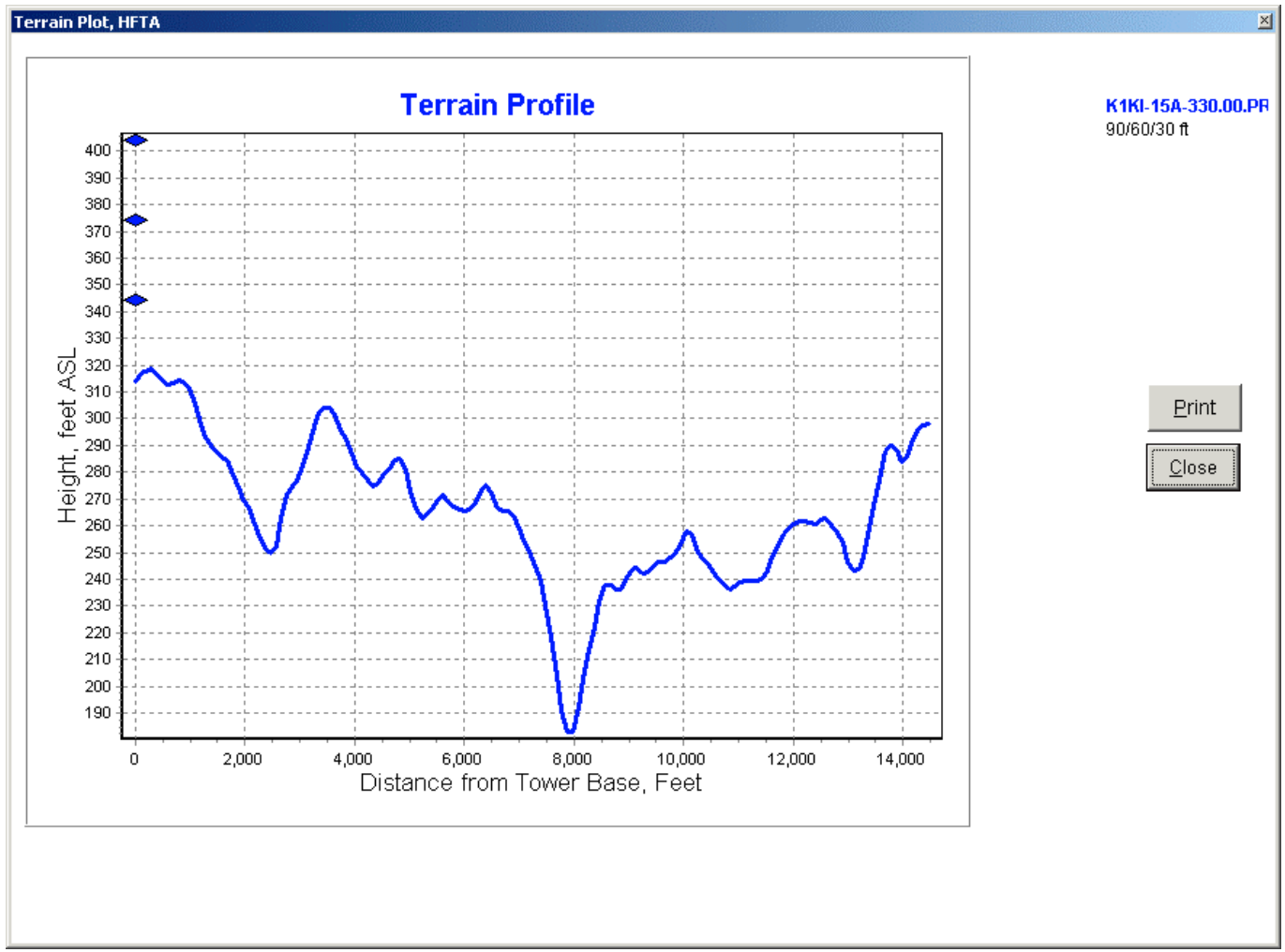
Hill in the way -- but it's 8000' away. Does it have any effect?

K1KI, 15-M to South America



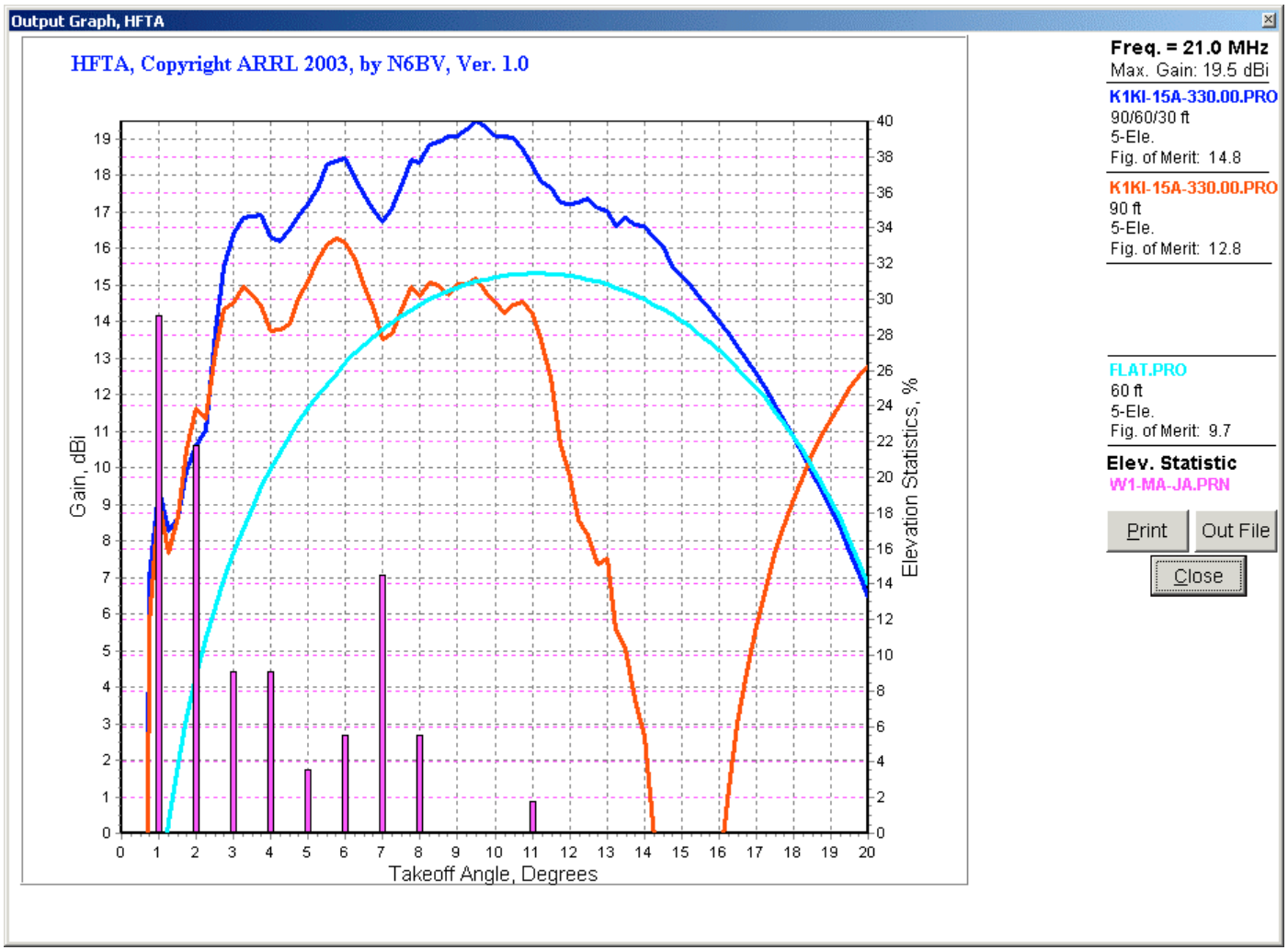
Very strong to SA with stack. Not bad with just top 90’.

K1KI, 15-M to Japan



Fairly flat near tower to JA, and nice initial dropoff.

K1KI, 15-M to Japan



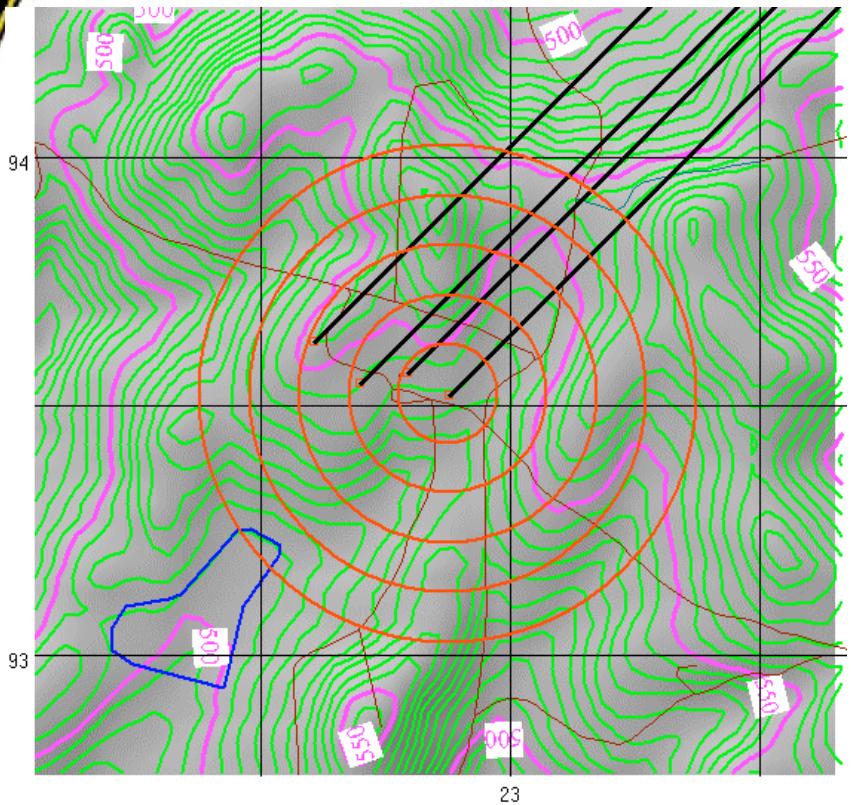
Very strong! Compare to 3-ele. At 60’

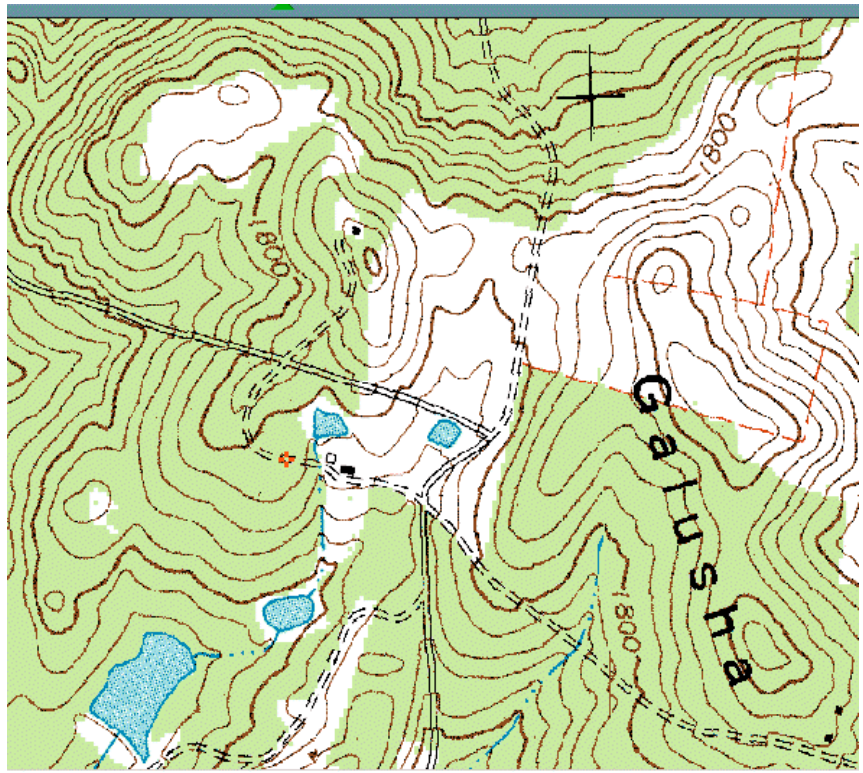
NT1Y

- Bill Hein, NT1Y, lives on a mountaintop overlooking steep terrain in Montpelier, VT.
- The ground slopes away nicely to Europe, but there is a “saddleback” ridge nearby in that direction from his present towers.

175’ high 80-m Yagi at NT1Y -- *before* it broke in an ice storm

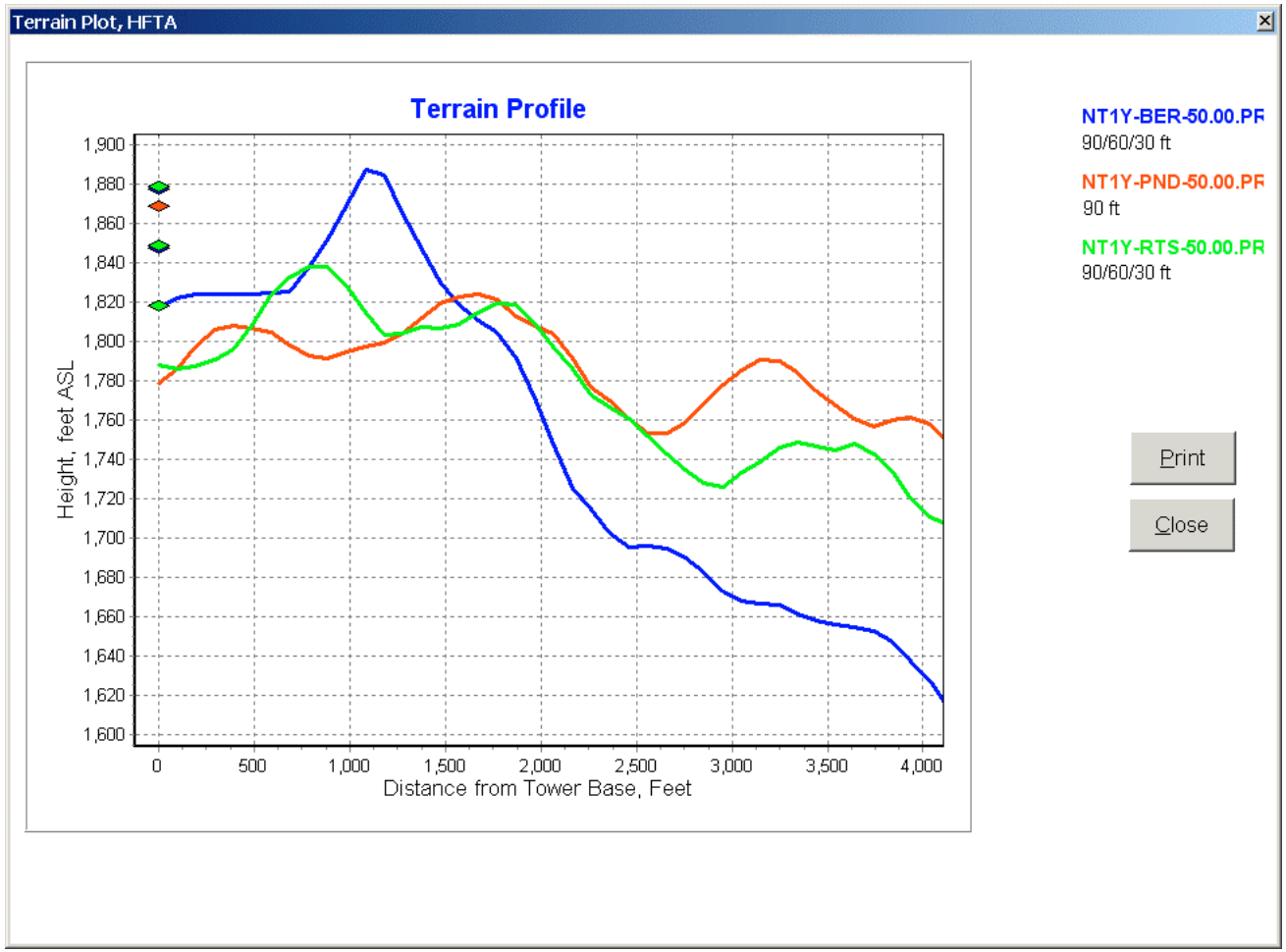
DEM & Topo Map for NT1Y





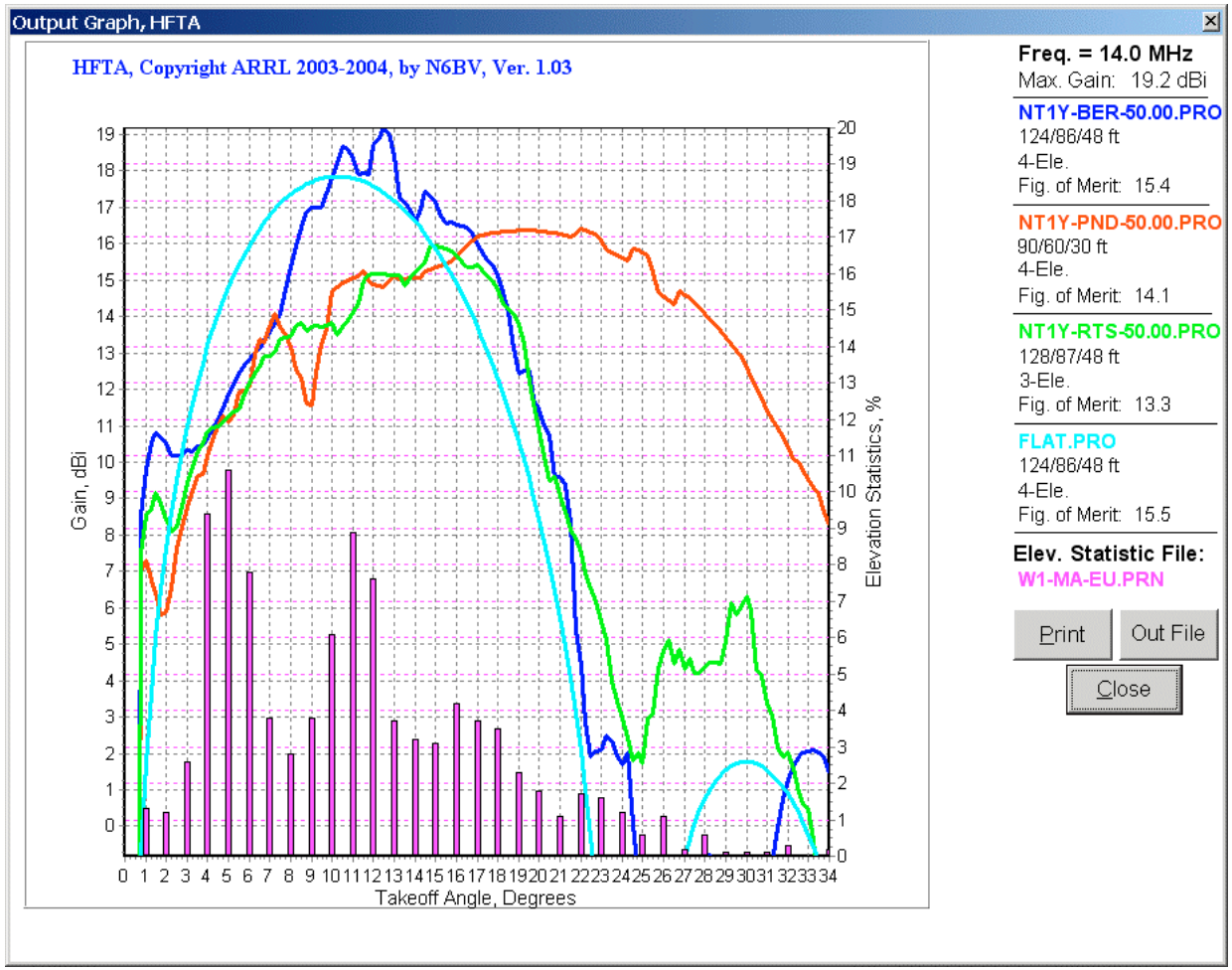
Pretty close match

NT1Y Terrains to Europe



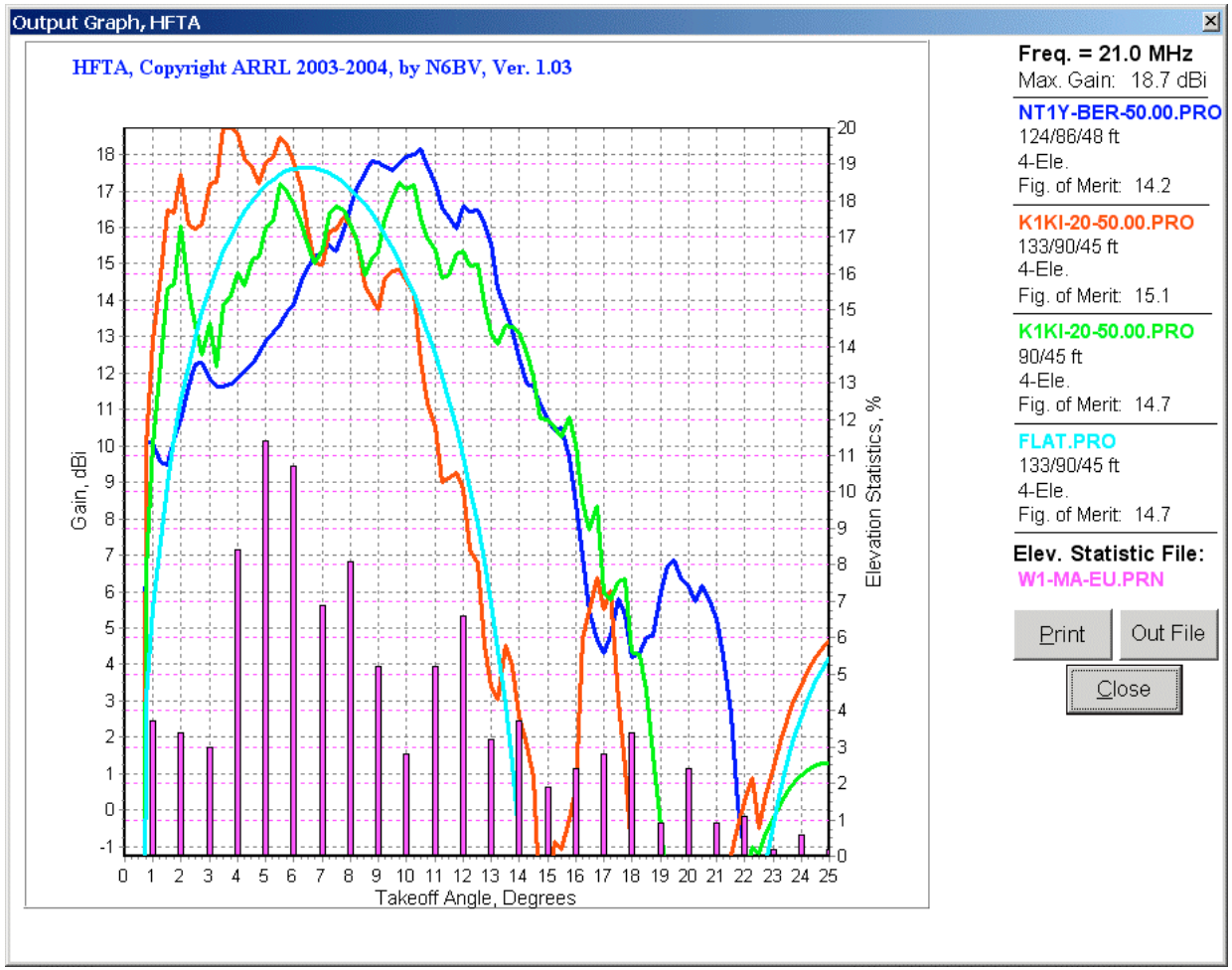
BER = Big Bertha tower; PND = Pond tower; RTS = Rotating Tower System. Note "saddleback" shapes.

NT1Y to Europe, 20 m



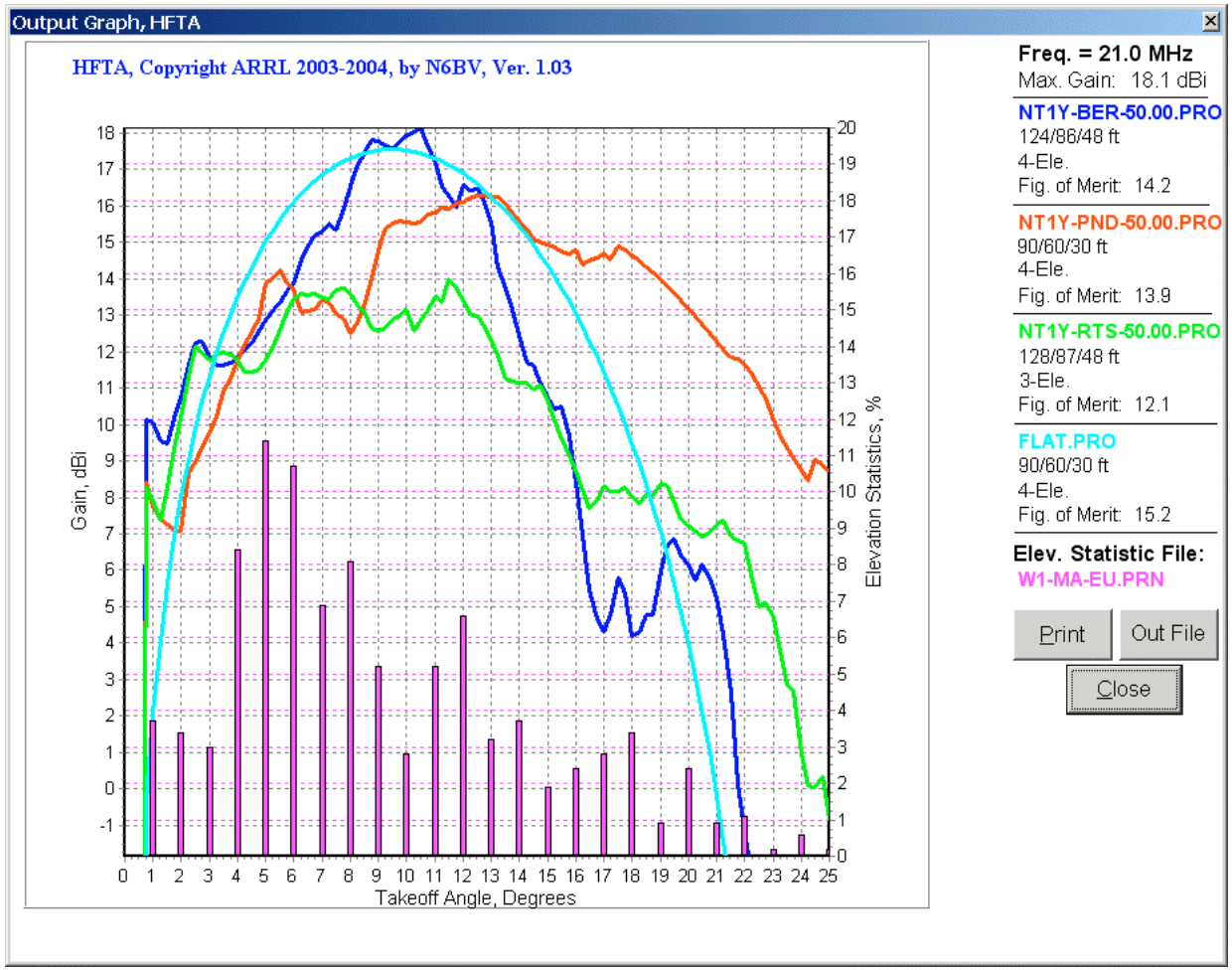
BER = Big Bertha tower; PND = Pond tower; RTS = Rotating Tower. Saddleback has definite effect.

NT1Y & K1KI to Europe, 20 m



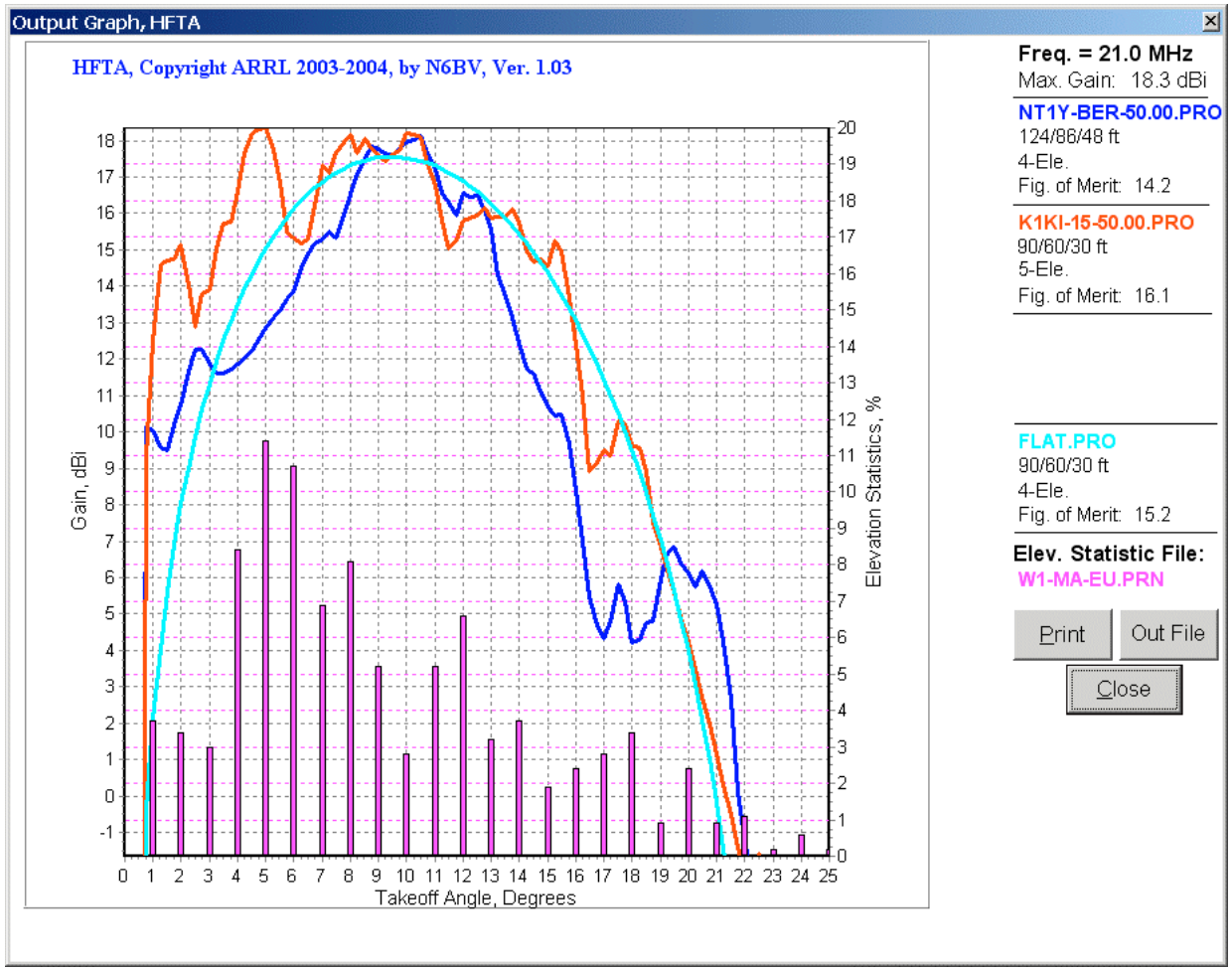
FOM difference ≈ 0.9 dB, but 4 dB down at 5°, an important angle. K1KI needs 90/45' for high angles.

NT1Y to Europe, 15 m



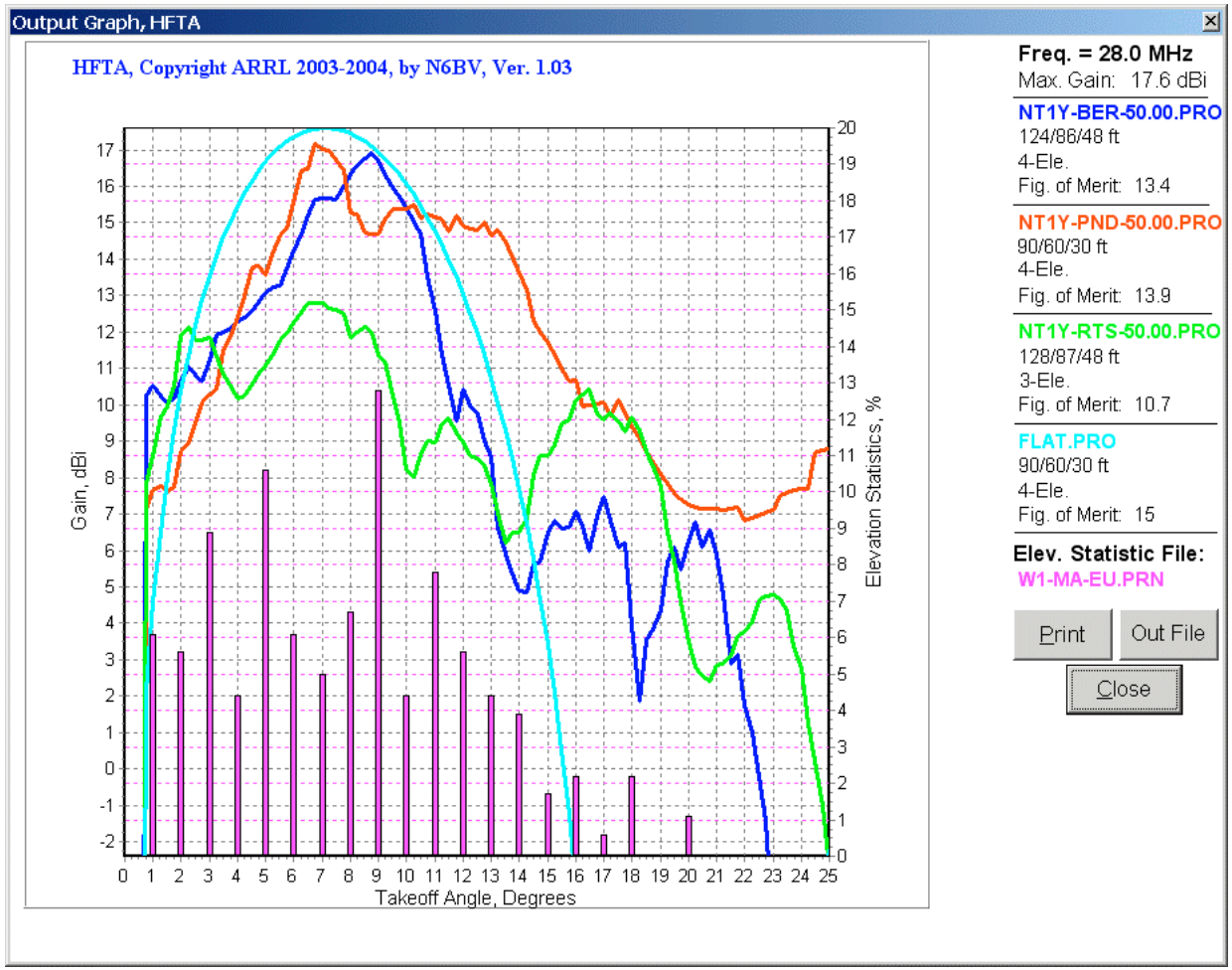
BER = Big Bertha tower; PND = Pond tower; RTS = Rotating Tower. Saddleback makes it difficult.

NT1Y and K1KI Europe, 15 m



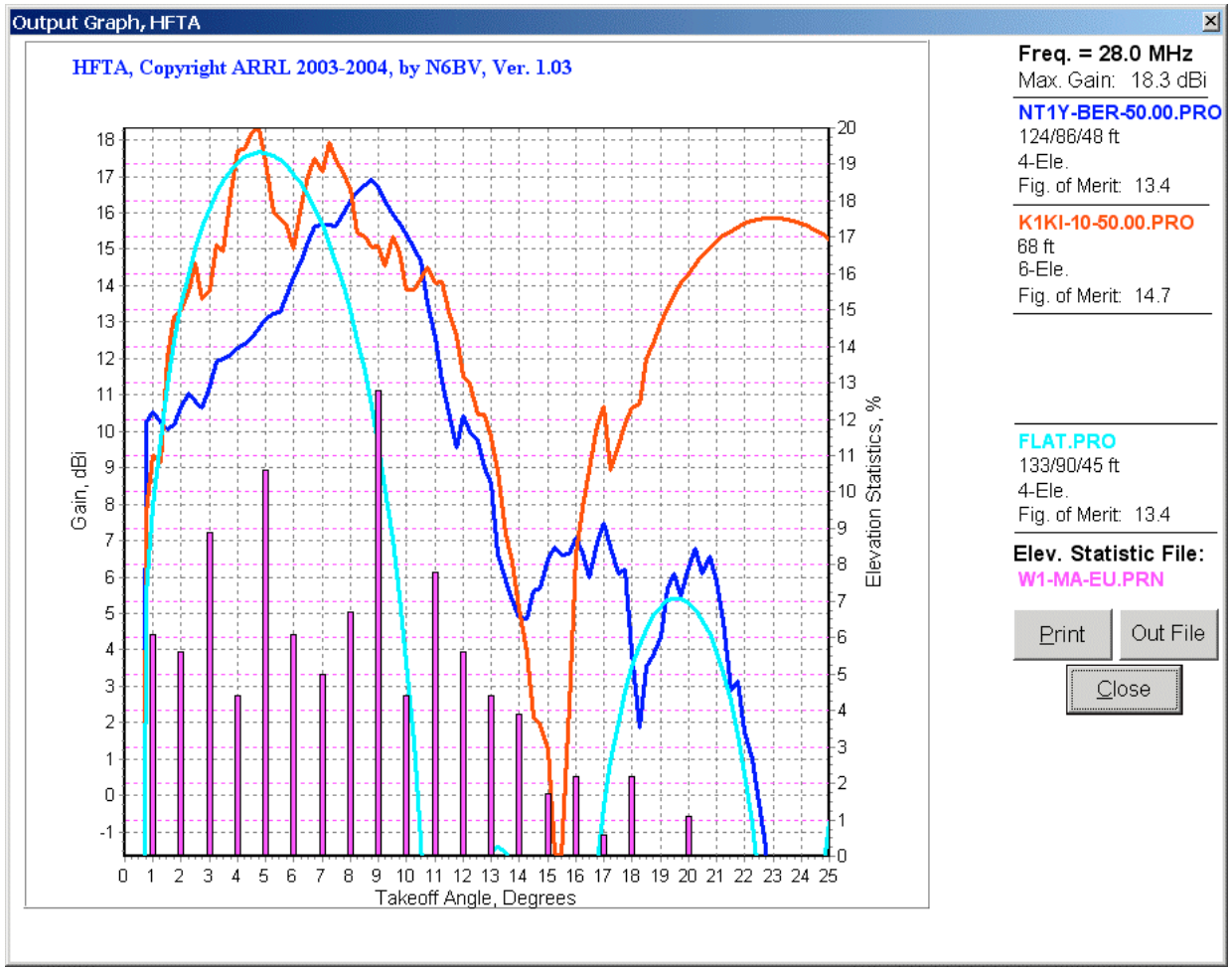
Big Bertha at NT1Y. FOM difference ≈ 2 dB, but almost 6 dB down at 5°, again an important angle.

NT1Y to Europe, 10 m



BER = Big Bertha tower; PND = Pond tower; RTS = Rotating Tower. Saddleback makes it hard.

NT1Y & K1KI to Europe, 10 m



BER = Big Bertha tower. FOM difference ≈ 1.3 dB, but again 6 dB down at 5°.

Steep Dropoffs, Summary

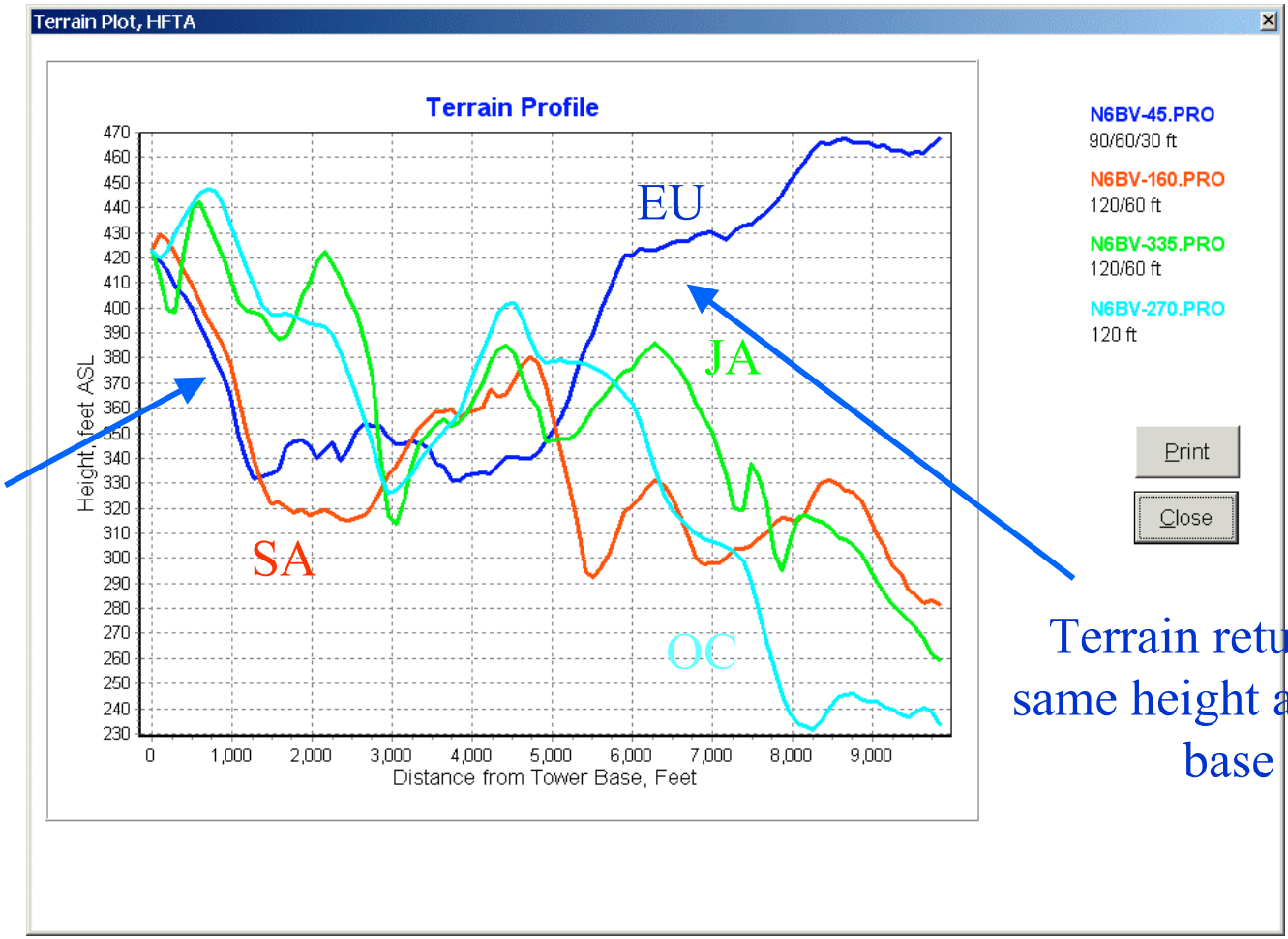
- Tower heights over flat terrain are easy to optimize -- while mountaintops can be non-intuitive.
- Watch those nulls -- they can be killers!
- Nearby “saddleback” terrain shapes can be killers too.

Figure of Merit?

- Figure of Merit (FOM) is a convenient, but one-dimensional, look at system performance at a particular azimuth. Since it's an "average" it can mask problem elevation angles.

- FOMs vary with different target QTHs for rotatable antennas, even at the same antenna height.

My Old New Hampshire QTH



Gentle 3-deg. slope to Europe

Terrain returns to same height as tower base

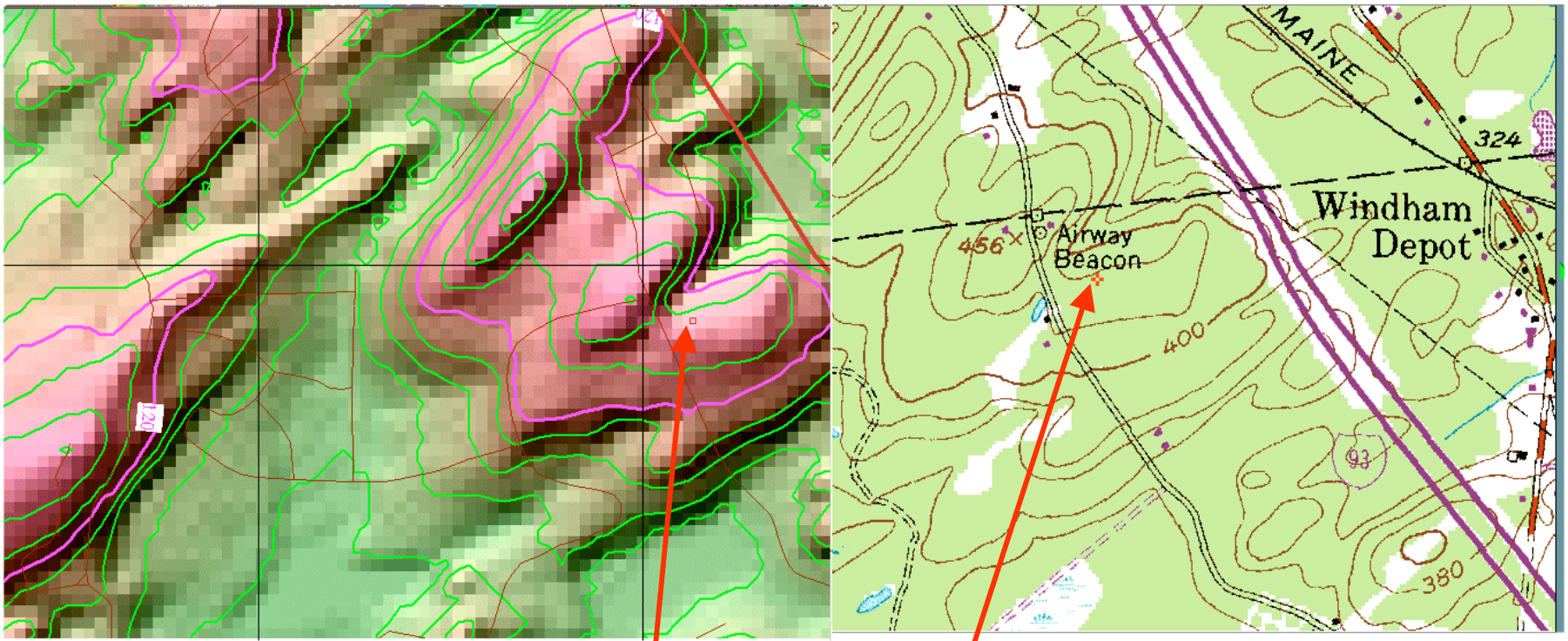
Terrain to Europe and South America was best; the shot to Japan was worst (saddleback); shot to Oceania was marginal too.

N6BV/1 in Windham, NH

N6BV/1 Stacks in New Hampshire:

TH7DX @ 30/60/90’
Create 714X3 @120’
2-ele. 80-m quad @115’
Inv.-L 160 m @ 90’

Comparing DEM vs Paper Topo, N6BV/1 Windham, NH

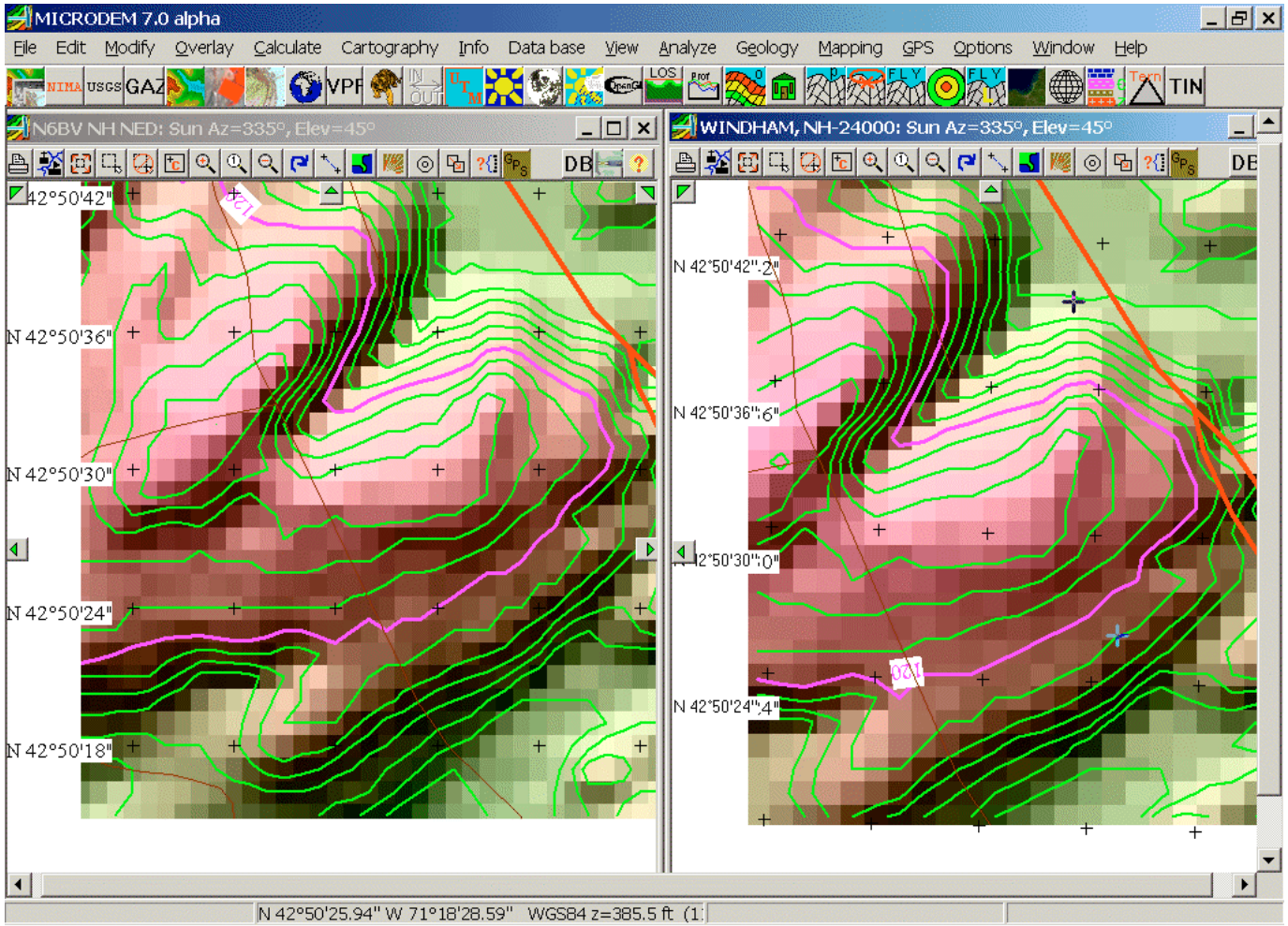


6-meter steps

20-foot steps

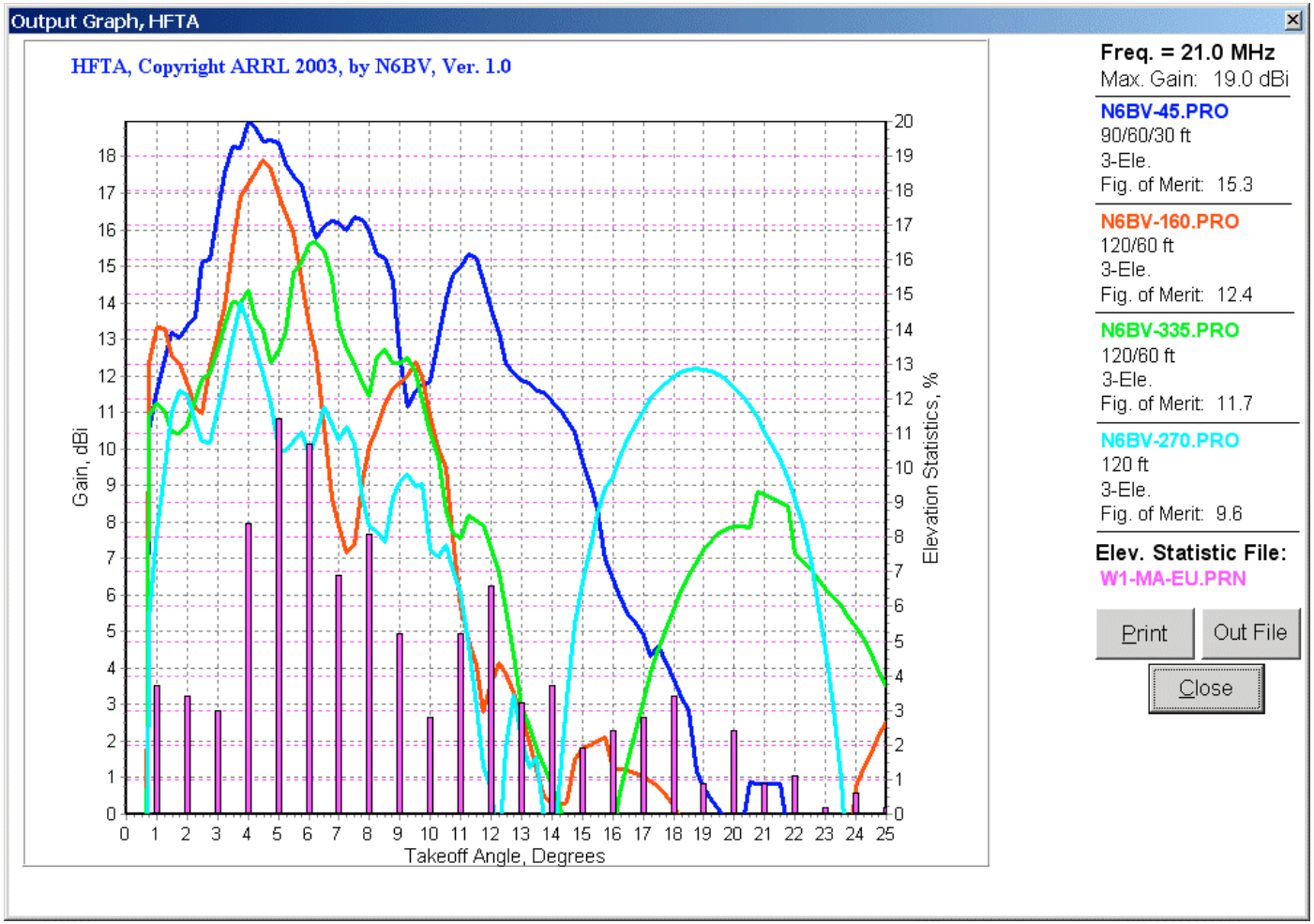
N6BV/1 Tower

N6BV/1 in Windham, NH



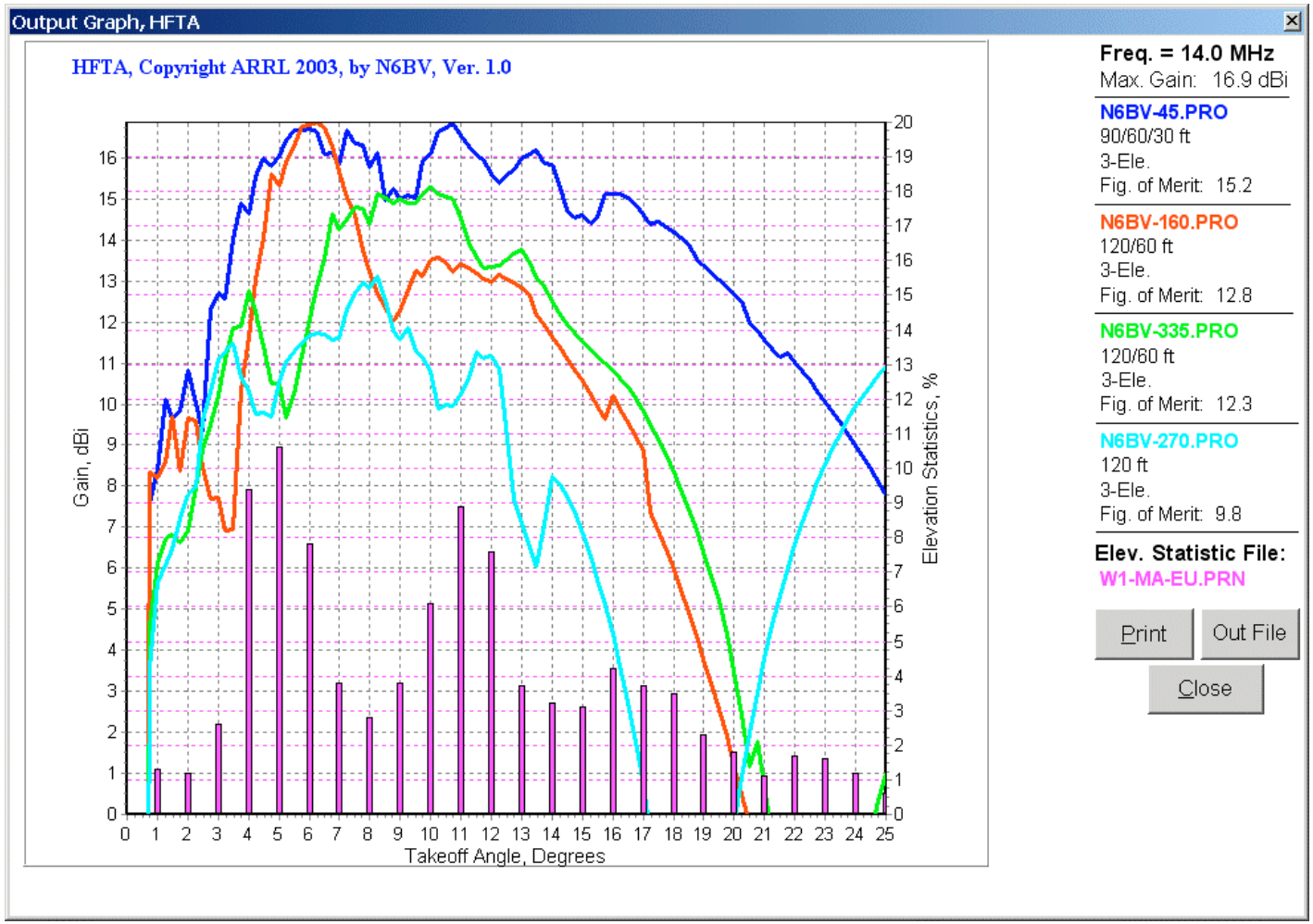
NED and DEM are very close

N6BV/1 on 15 Meters



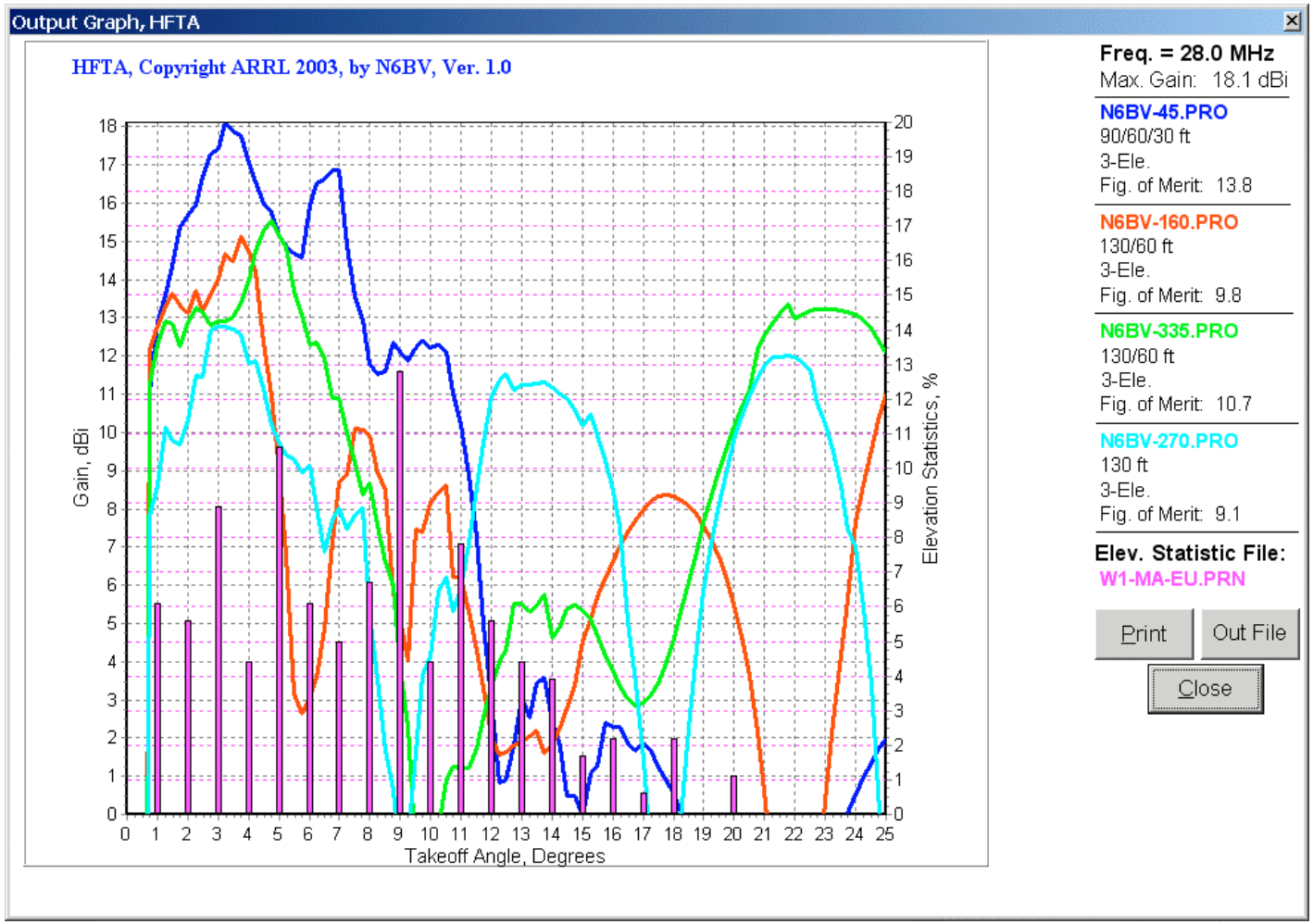
Different antenna combinations for different directions.
15 meters really played into Europe. (FOMs for Europe.)

N6BV/1 on 20 Meters



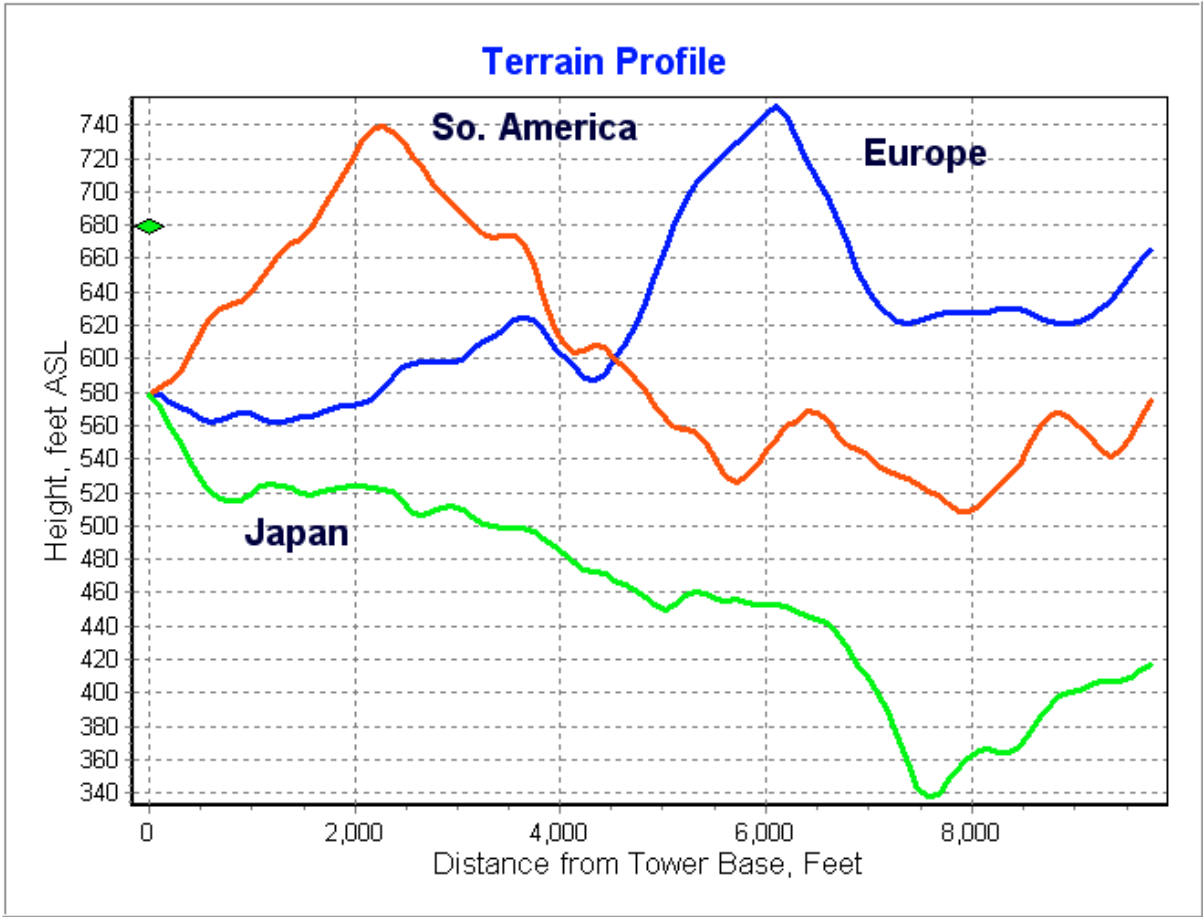
20 meters was fantastic into Europe! 20 meters into Japan was marginal at low angles.

N6BV/1 on 10 Meters



10 meters was great into Europe. 10 meters into Japan was OK at low angles. S. America best on 60’ Yagi.

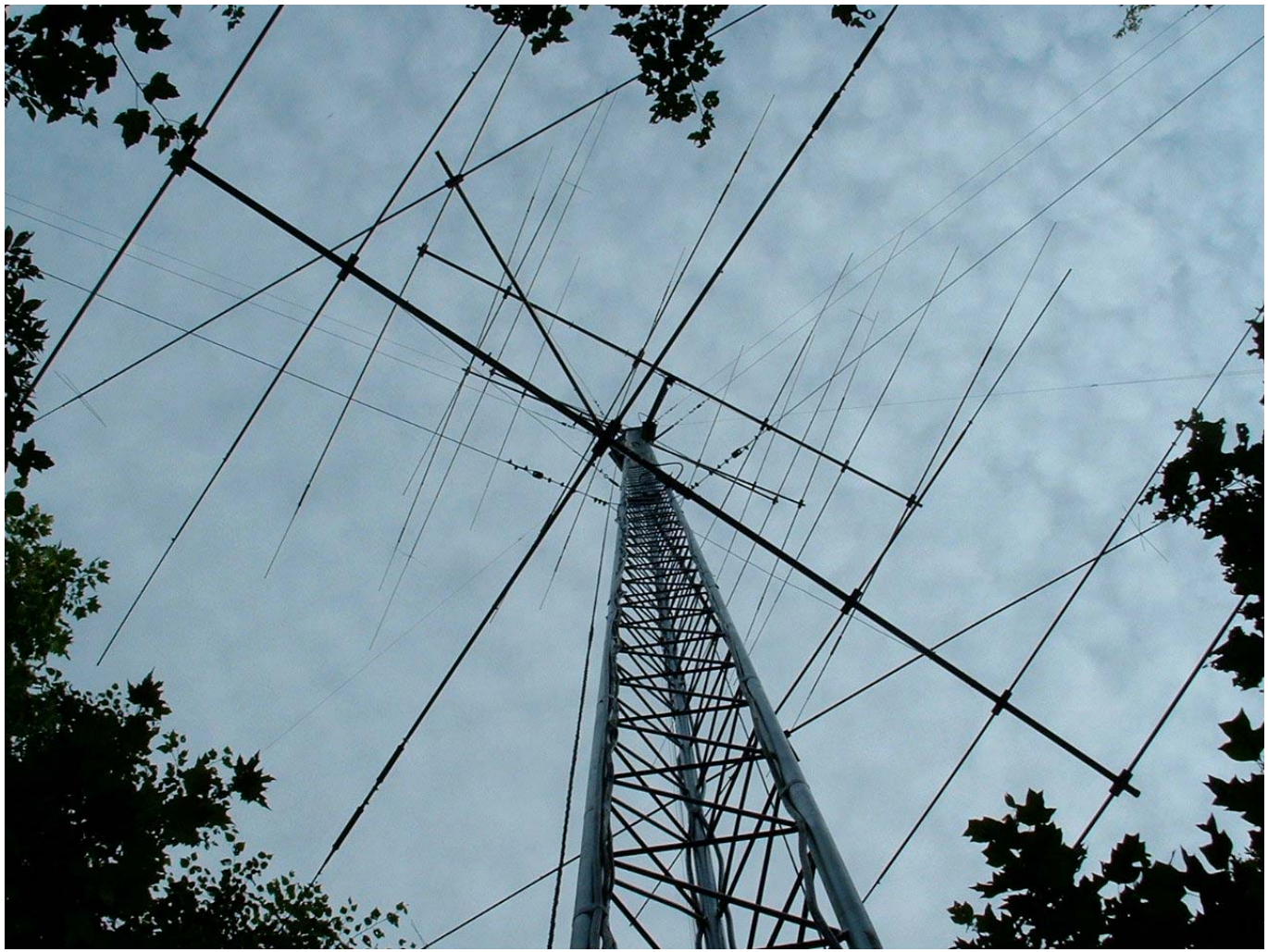
W1WEF's Terrain



- Good to Europe
- Not-so-good to South America
- Great to Japan

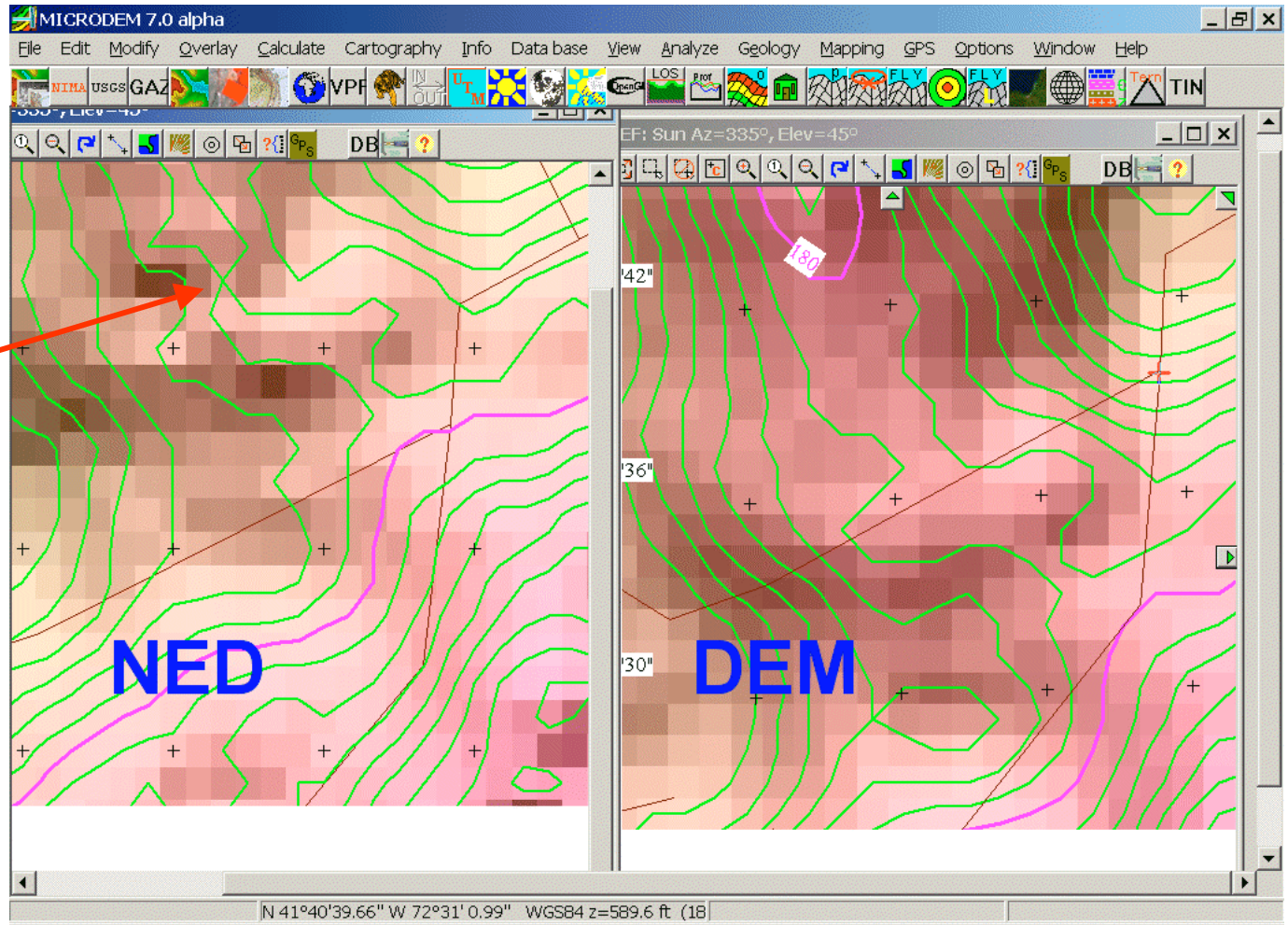
Terrain at W1WEF in Glastonbury, Connecticut. Jack's 105' high tower is populated with *lots* of antennas!

W1WEF's Single Rohn 25 Tower



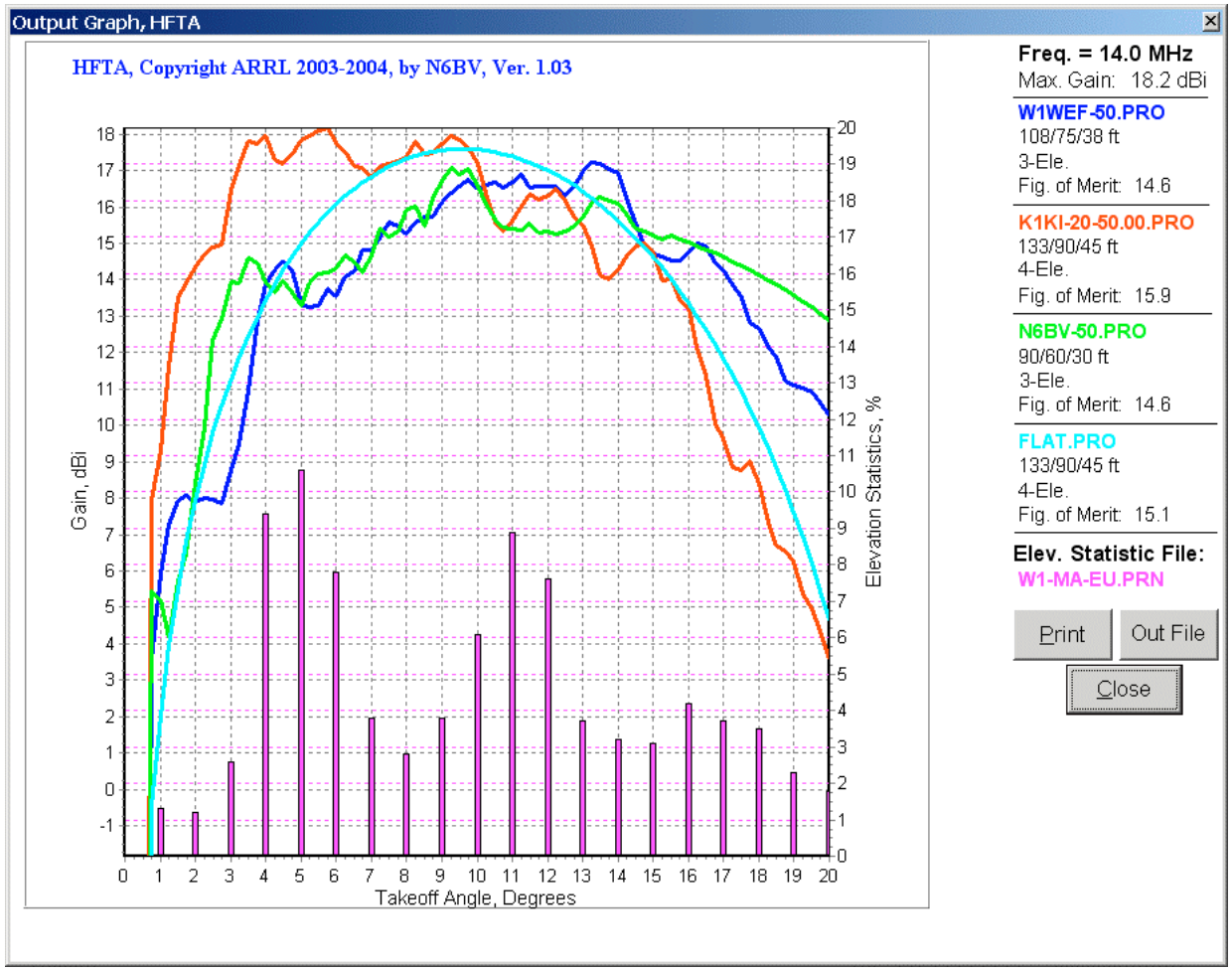
Comparing DEM & NED, W1WEF

Interesting point… how can contours cross over?



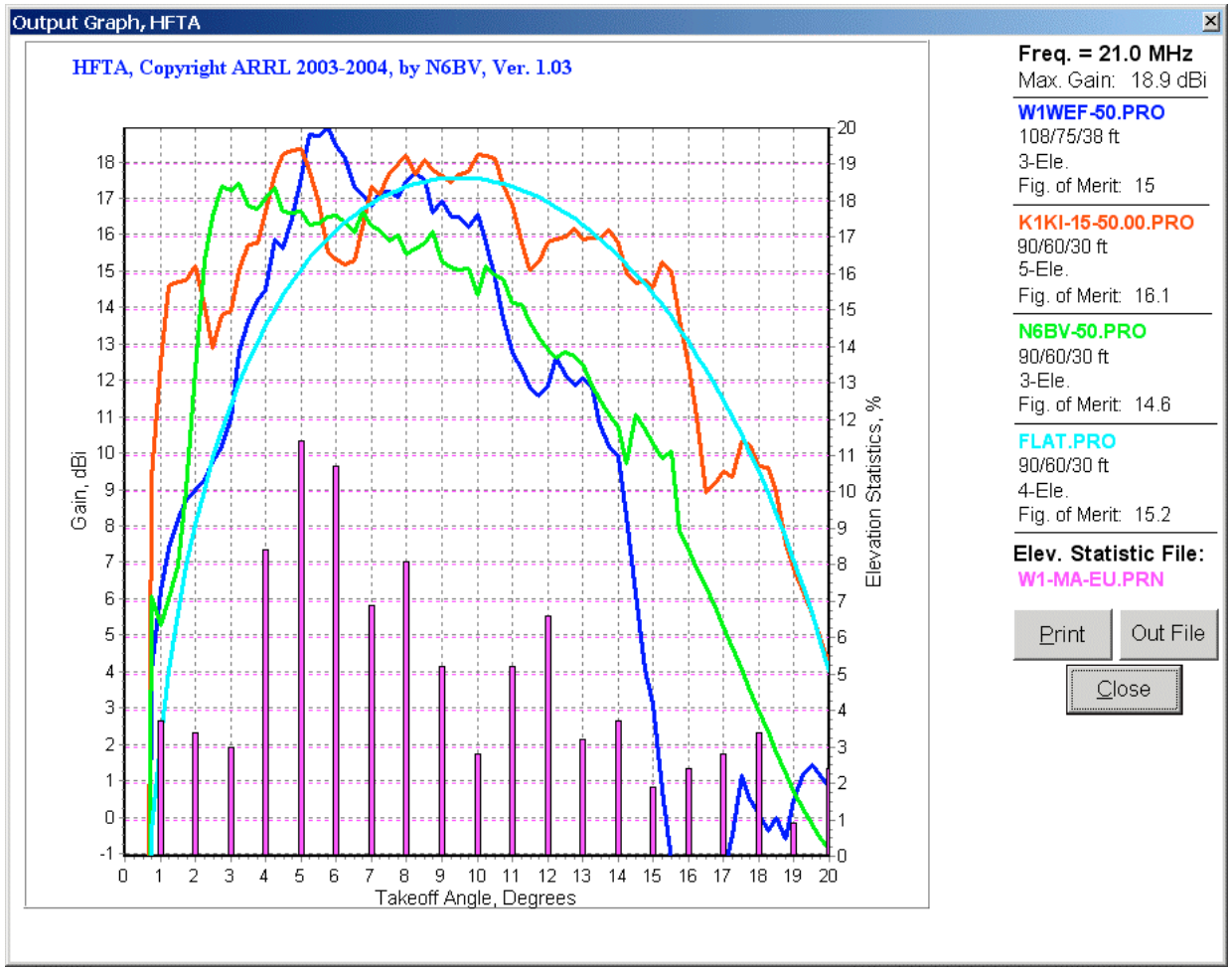
Significant differences in contours -- use DEM

20 Meters, Horserace to Europe



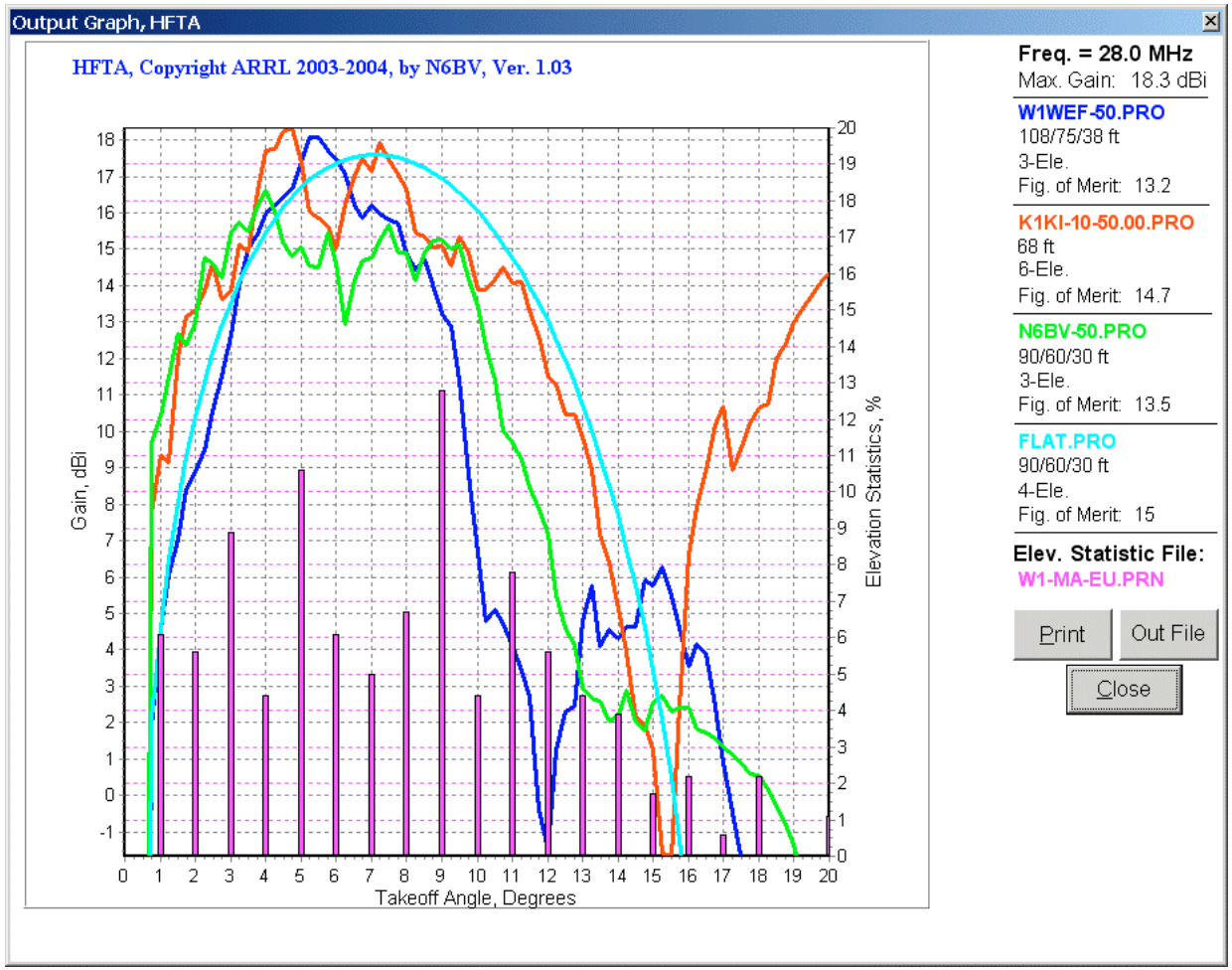
TH6DXs at 108'/75'/38'. W1WEF is competitive, especially in the afternoon when angles are higher.

15 Meters, Horserace to Europe



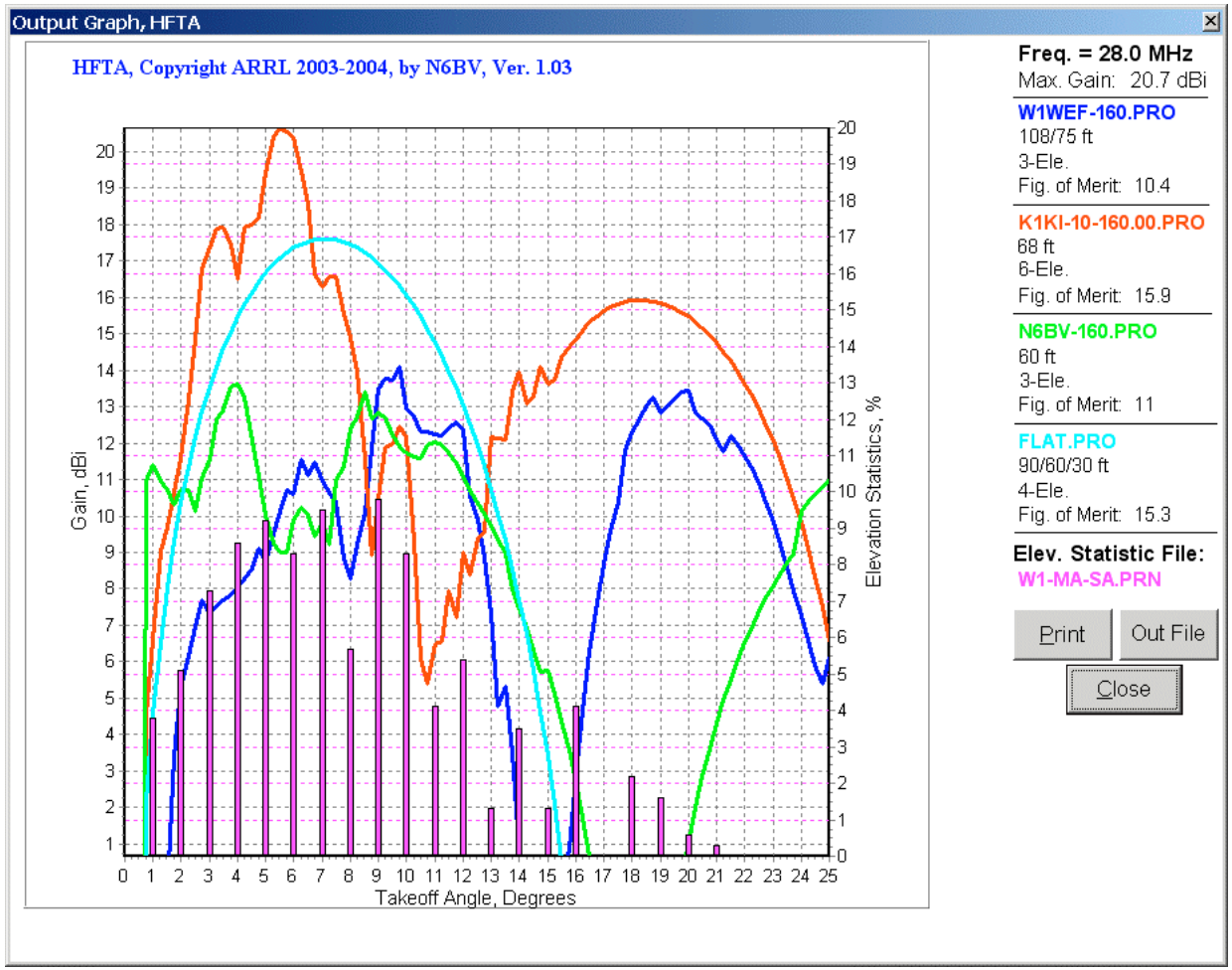
TH6DXs at 108'/75'/38'. W1WEF is still very competitive, especially for tribanders!

10 Meters, Horserace to Europe



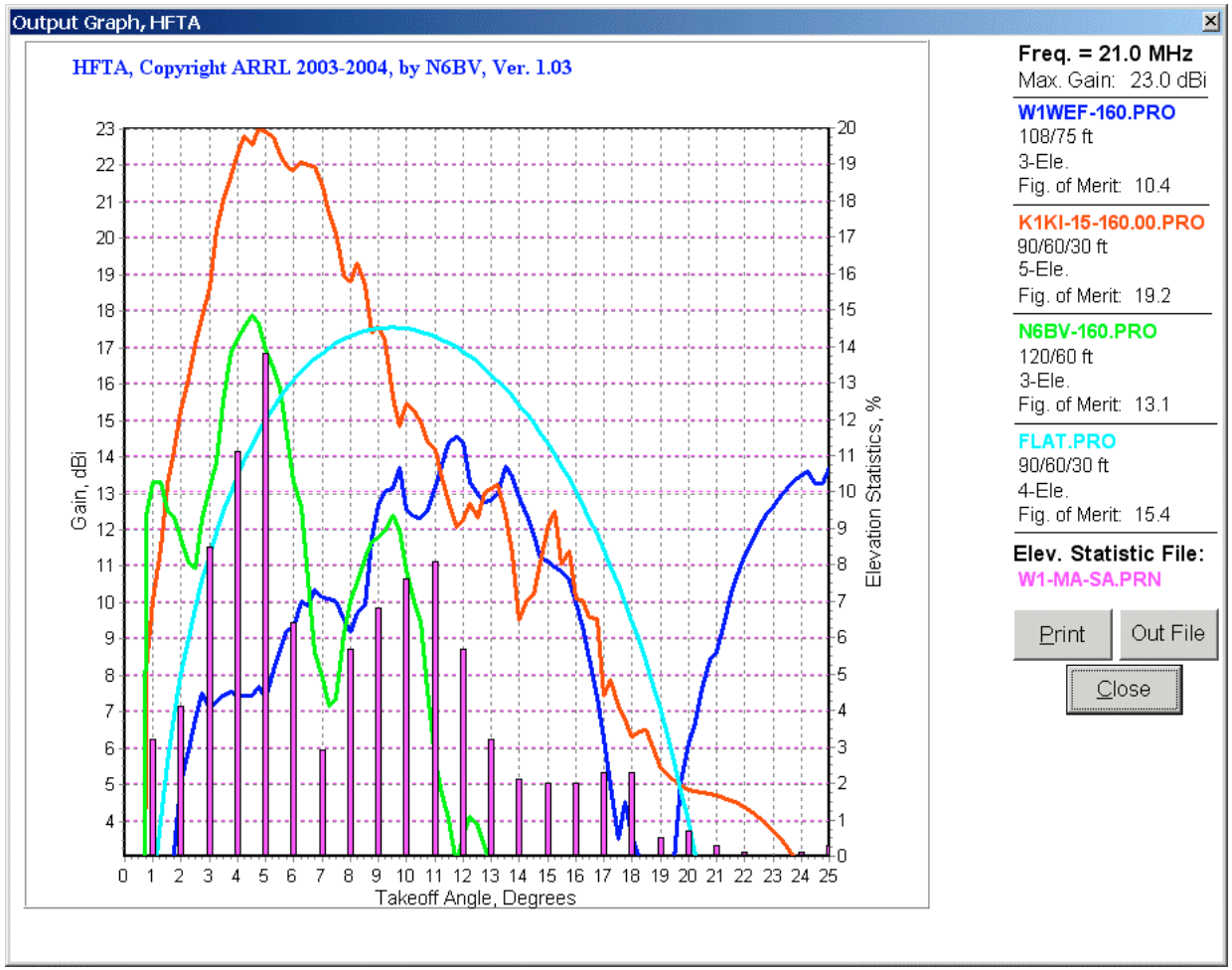
W1WEF hangs in there with that K1KI guy! Jack might have to switch out top antenna in stack at times.

10-M Horserace to S. America



W1WEF & N6BV are a little behind the power curve here. K1KI is wicked strong...

15-M Horserace to S. America



Wow! K1KI is *really* strong to South America with that rotatable 15-m stack...

Some Hints About Using *HFTA*

- Make sure you check heights for "aliasing" glitches -- check in 1-foot increments.
- Be careful of relying solely on FOMs.
- Validate the terrain profiles (particularly with "seamless" datasets) to the real-world.
- Mountain tops can be complicated!
- Watch out for common "saddleback" shapes in terrains.

“Best” Terrains -- Generalizations

- Flat terrain is easy.
- Gently sloping terrain (eg, N6BV/1 to Europe) is good for stacking smaller Yagis (such as tribanders).
- Steep terrain doesn’t allow simple stacking on 15 and 10 meters -- it’s very easy to be too high. Watch out at different azimuths at same antenna heights for rotatable Yagis.
- Do model your tower height/antenna types, just to be sure!

The Wonder of HF Propagation

The very fact that I can launch a small signal into the ionosphere and communicate with someone halfway around the world is still truly wonderous to me -- after 45 years of being a ham.

Despite the challenges -- or probably because of them -- I love operating HF radio! I hope that BPL doesn't happen for real...

Speaking of BPL, Here's an Analogy

The Federal government is going to allow a toxic-waste dump to be established in your backyard, but we assure you that toxic emissions will be low.

However, if somehow the emissions from the toxic-waste dump in your backyard do affect you in the future, we are setting up rules so that you can petition the company running the toxic-waste dump to move it to someone else's backyard. And we're confident that all the toxic-waste companies will be excellent corporate public citizens and that they will take care of any problems in a prompt and courteous fashion.

And just to be sure that Federal operations vital to your safety and welfare aren't affected by any emissions, we're not going to allow the establishment of any toxic-waste dumps on Federal property.

Submitted as Reply Comments to FCC by N6BV

If you substitute ***BPL*** for ***toxic waste dump***, doesn't this sound rather familiar?