Selected Terrain Studies for Optimum HF Station Performance

A Presentation at

The Dayton Hamvention Antenna Forum

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Dayton, OH

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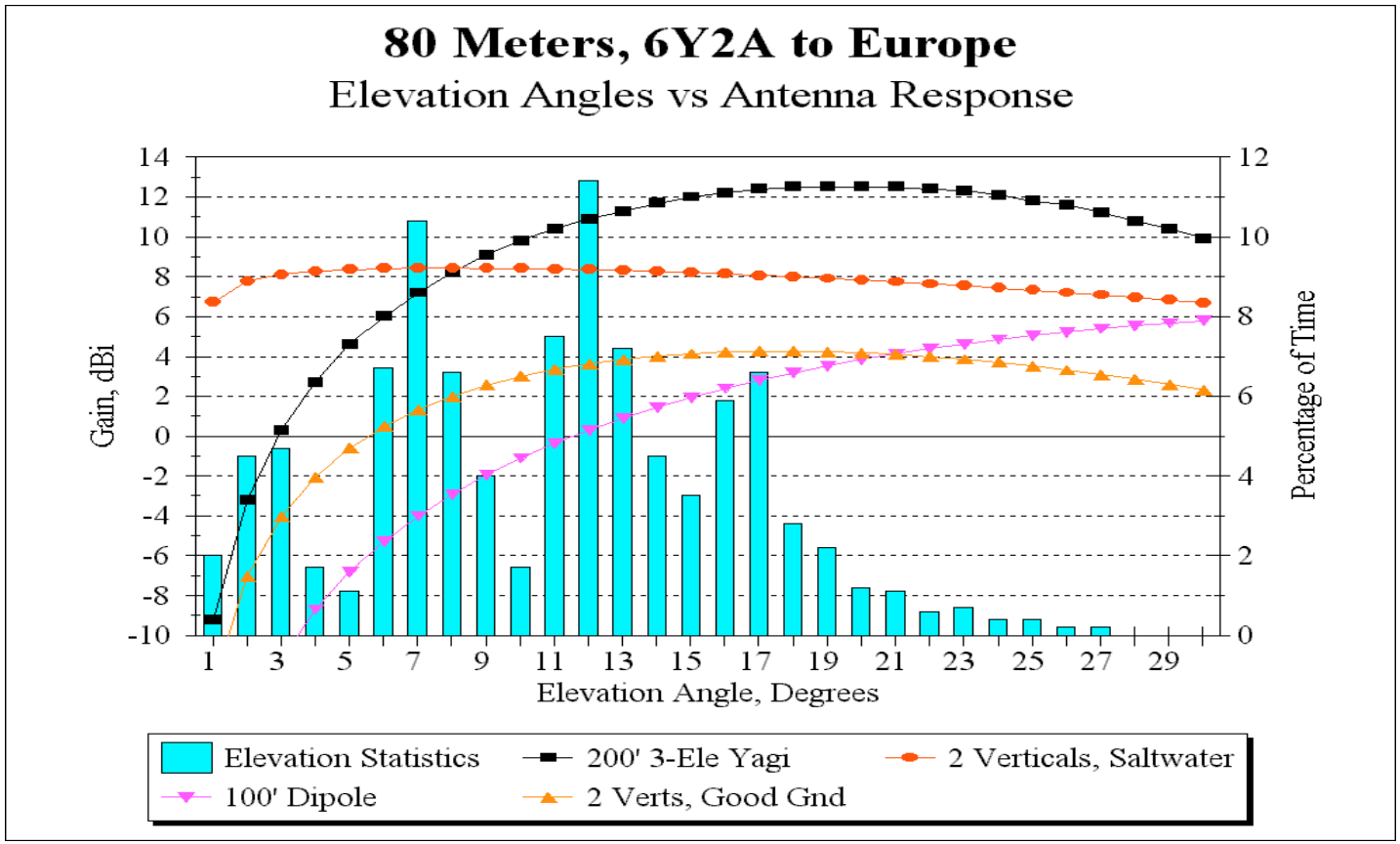
Is This the Best Place to Put Up My Antennas?

- 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 will I be stronger at the beach, where I can practically *see* the flag flying over Parliament?

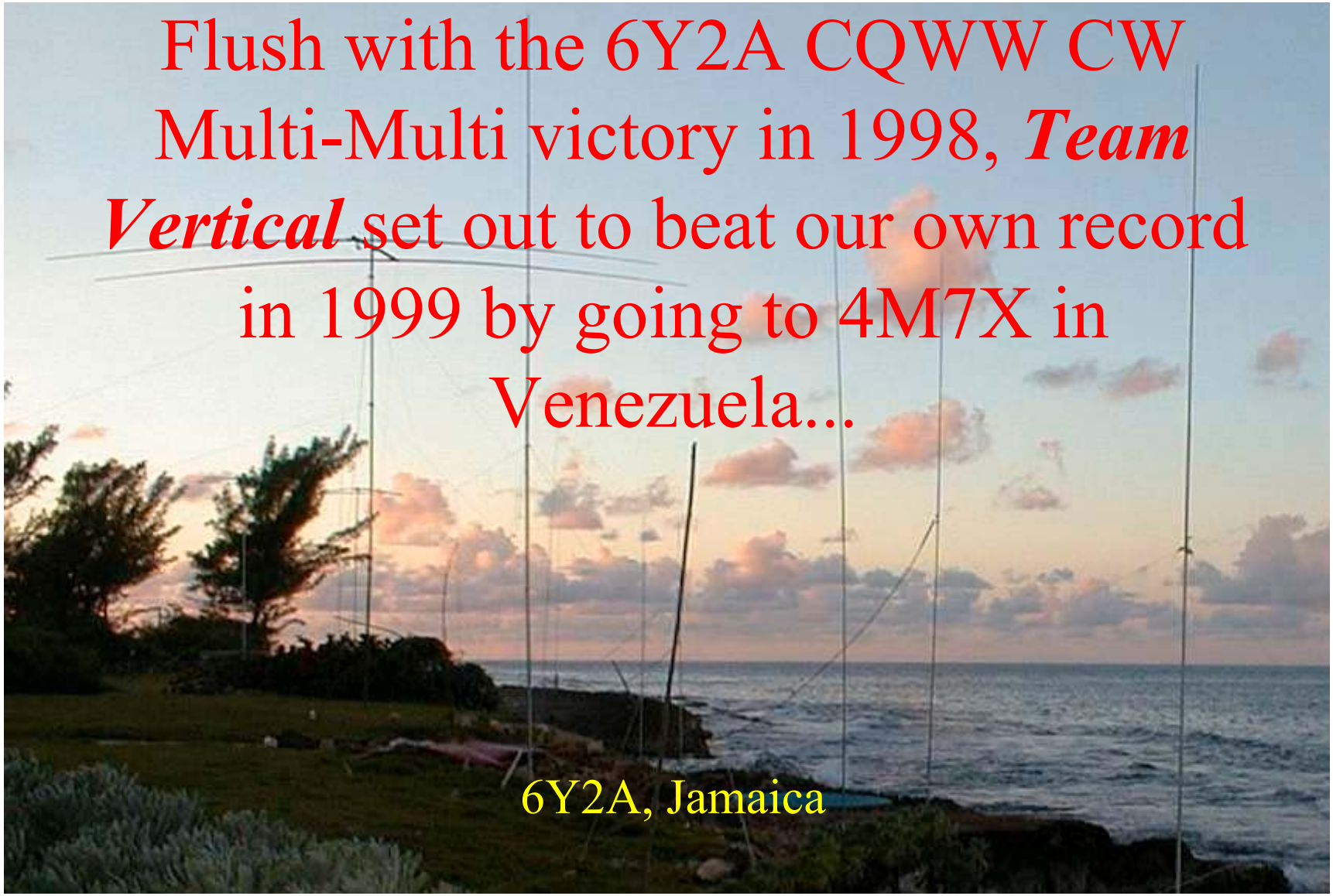
What Terrain is Best?

- *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 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

Bigger and Better for 4M7X!

20/15/10-m Arrays Each Had 11 Verticals

Yes, that is really salt water.

There are Some Disadvantages to Verticals on the Beach...

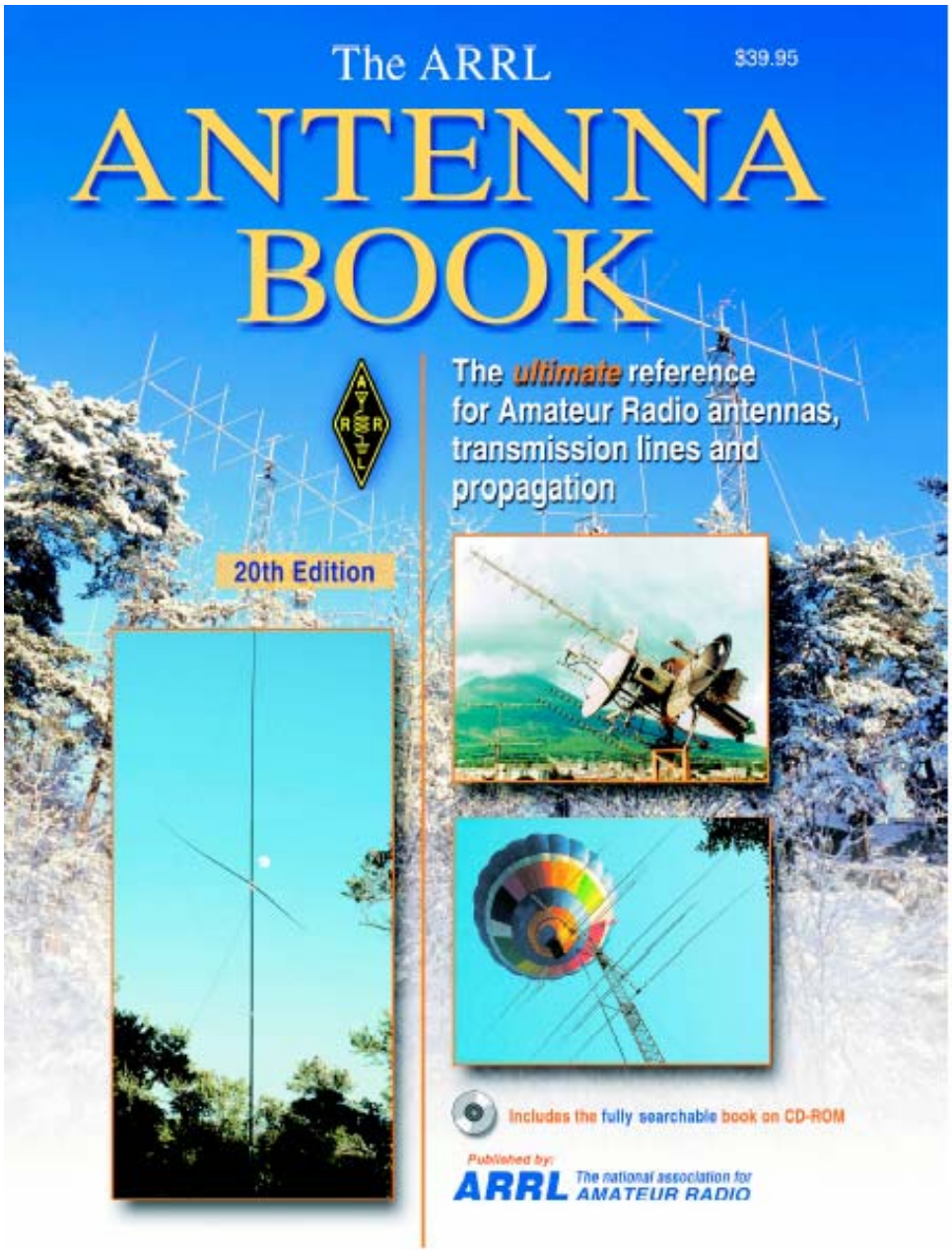
Like high winds, tides, corrosion… hurricanes.

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?

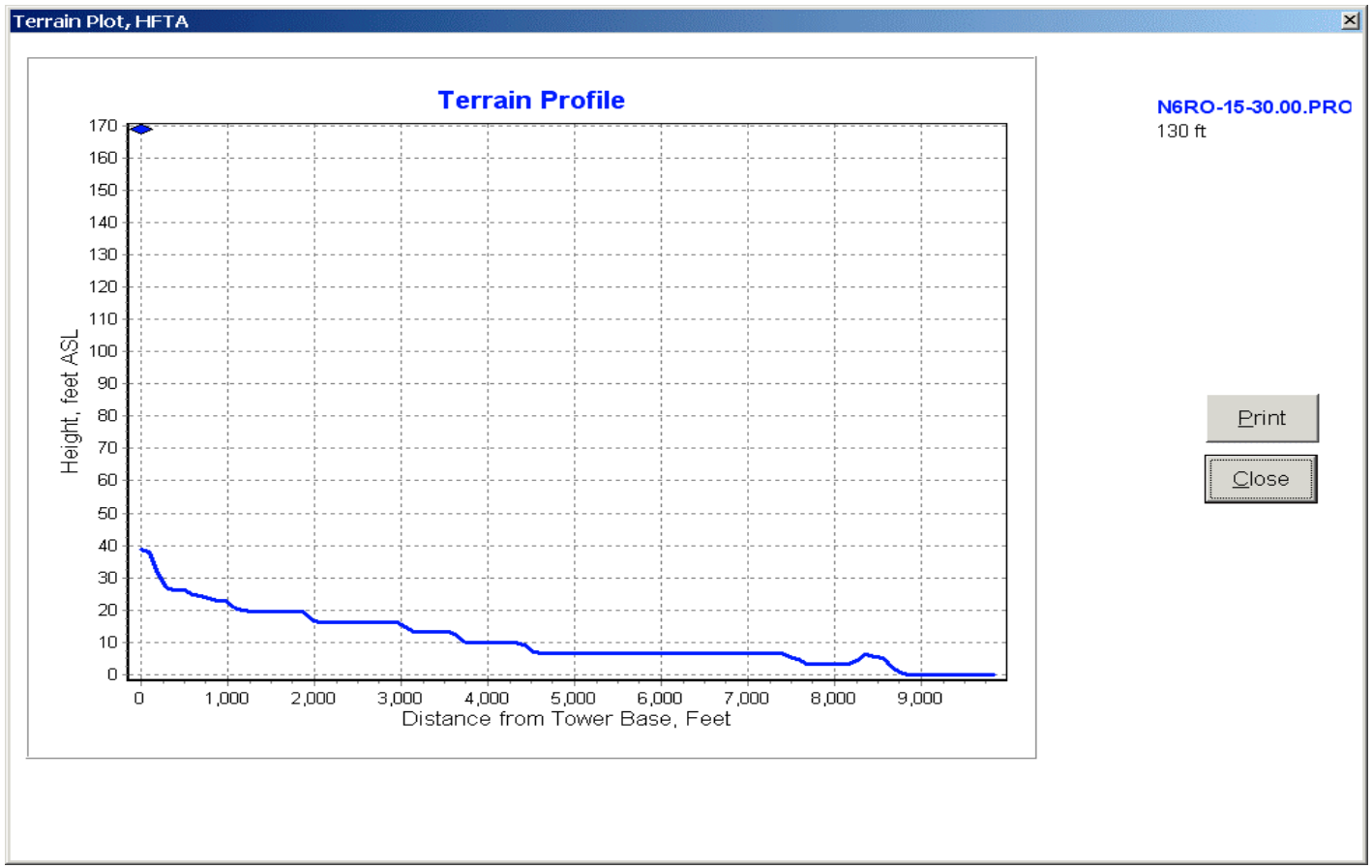
The *HFTA* Program

- *HFTA* stands for "High Frequency Terrain Assessment."
- *HFTA* traces the path of rays over 2D terrain, taking into account reflections and diffractions.
- *HFTA* is bundled with the 20th Edition of *The ARRL Antenna Book*.



At $39.95: Some very useful software -- with a 900-page printed book thrown in for free! But I'm biased...

N6RO's Terrain Towards Europe From His 15-Meter Tower



A 40 foot drop in 2 miles, with 15 feet in first 200 feet -- that's pretty flat!

15 Meters to Europe at N6RO

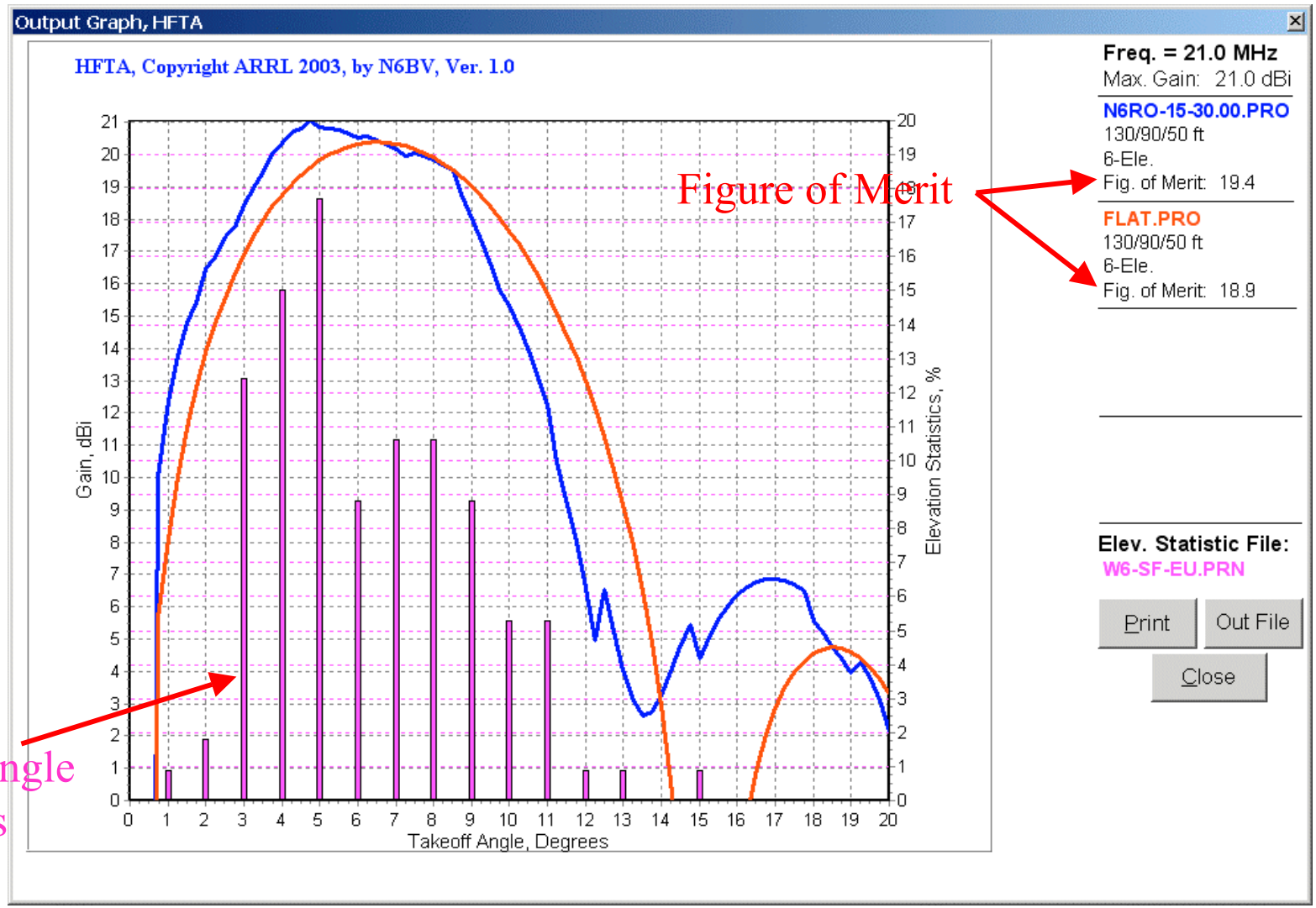
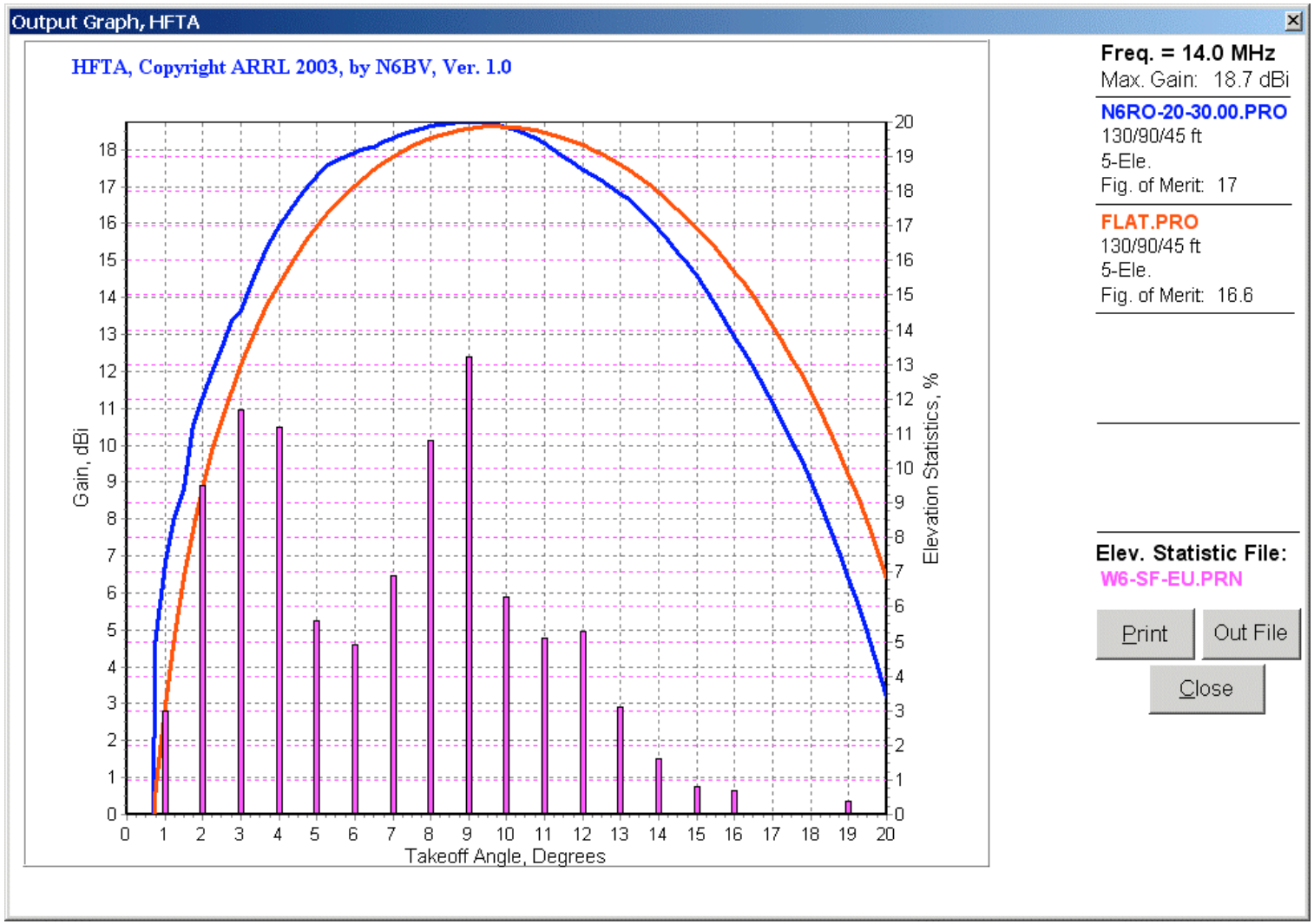


Figure of Merit

Elevation-Angle Statistics

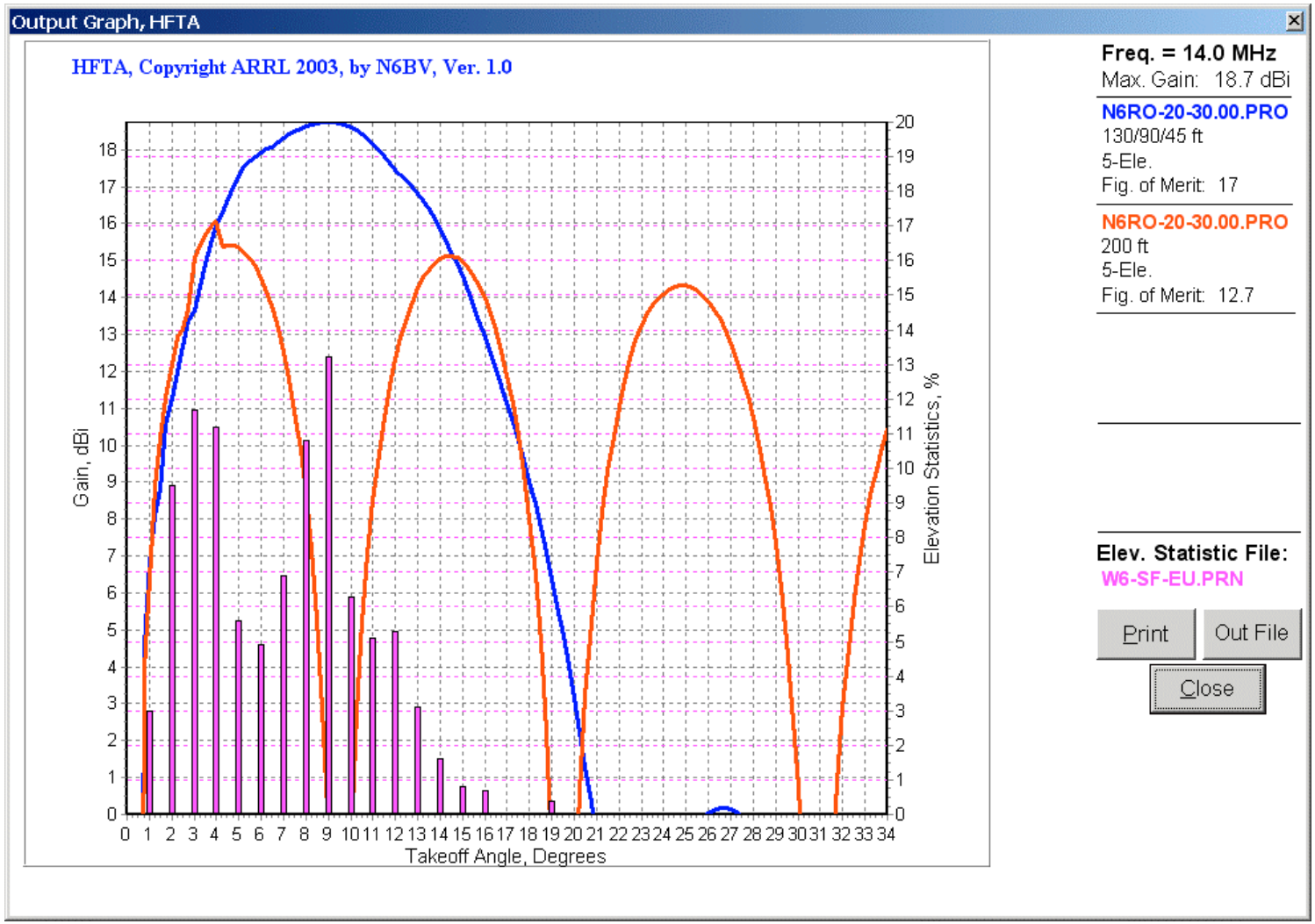
Response is close to flat-land response.

20 Meters to Europe at N6RO



Again, response is close to flat-land response.

Can an Antenna be Too High?



Note: The nasty null at 9° for the 200’ antenna.

Getting Terrain Data for *HFTA*

- From paper topo maps -- excruciatingly painful!
- "Seamless" USGS 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.)

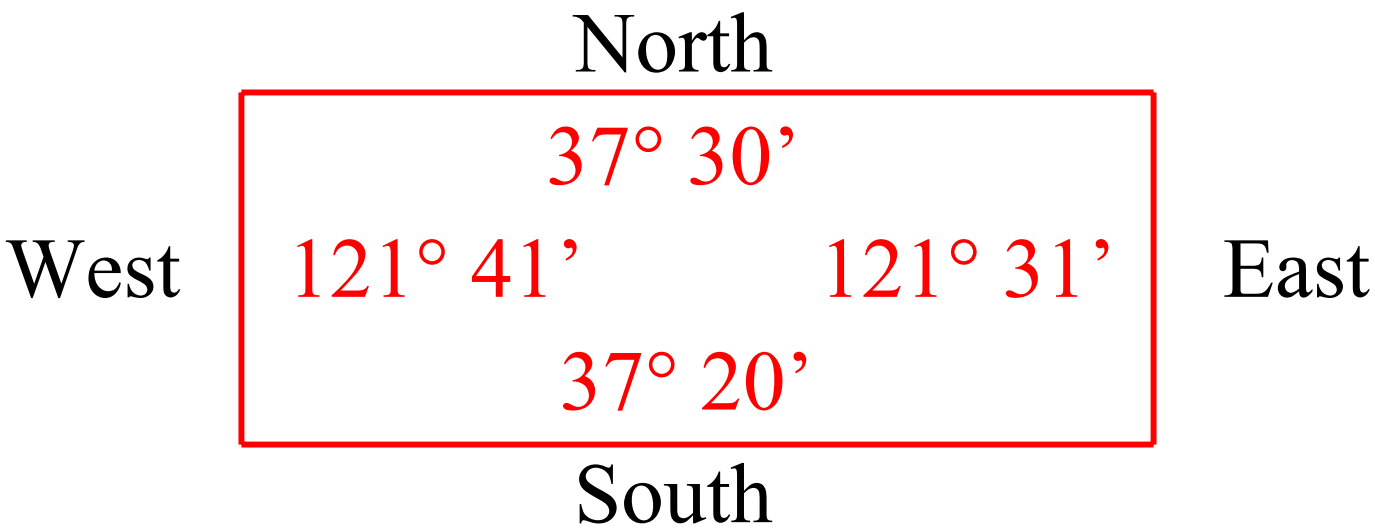
Seamless USGS Database

The seamless USGS database is easiest to use.

Just specify area to be covered -- ±5 minutes North/South and ±5 minutes East/West, centered on latitude and longitude at tower base.

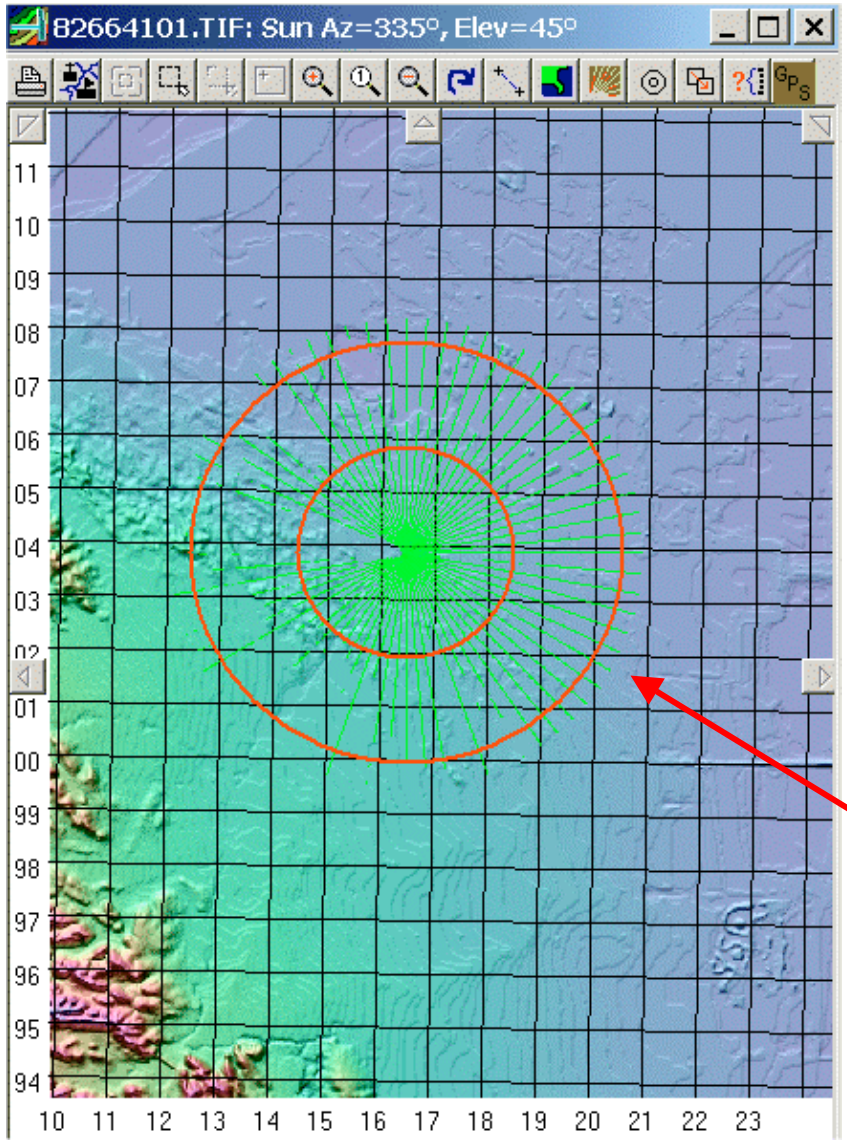
Seamless USGS Database

For ex., 37° 25’ 28” N and 121° 36’ 14” W



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

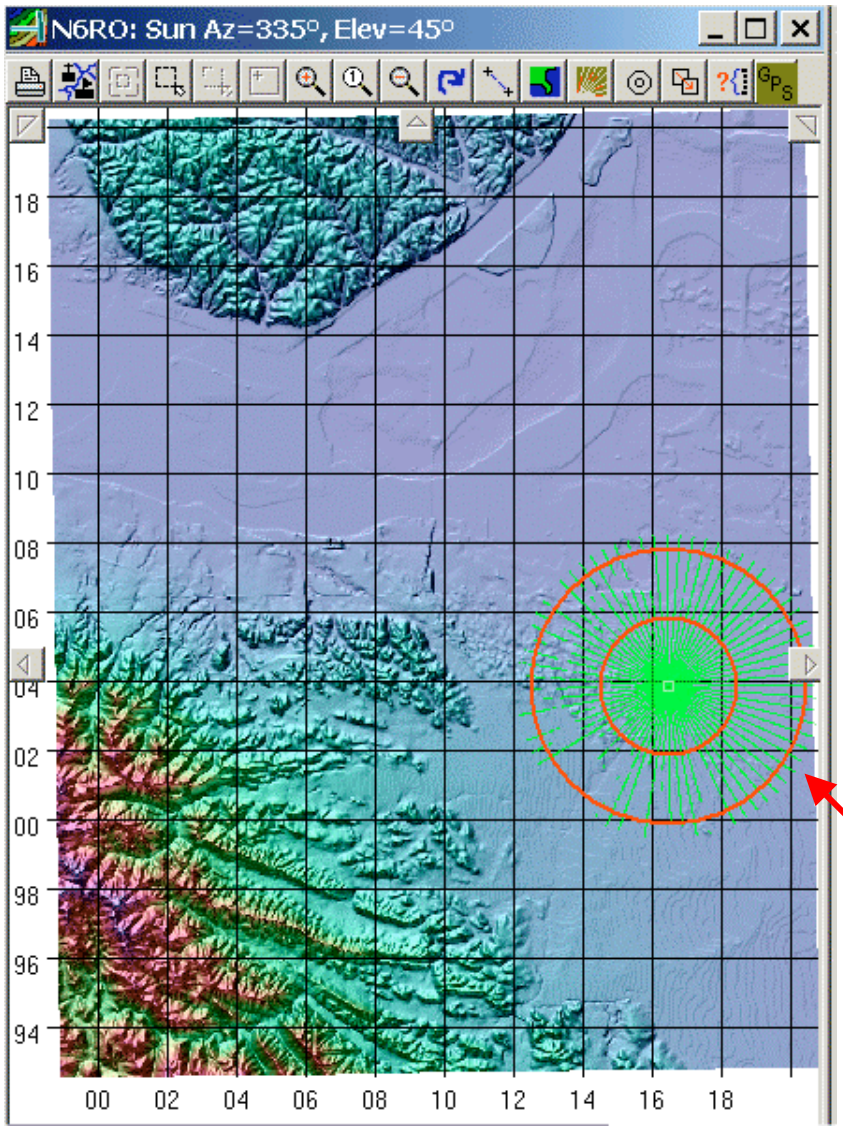
MicroDEM & Seamless Data



Note how circle is in central portion of the seamless map

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

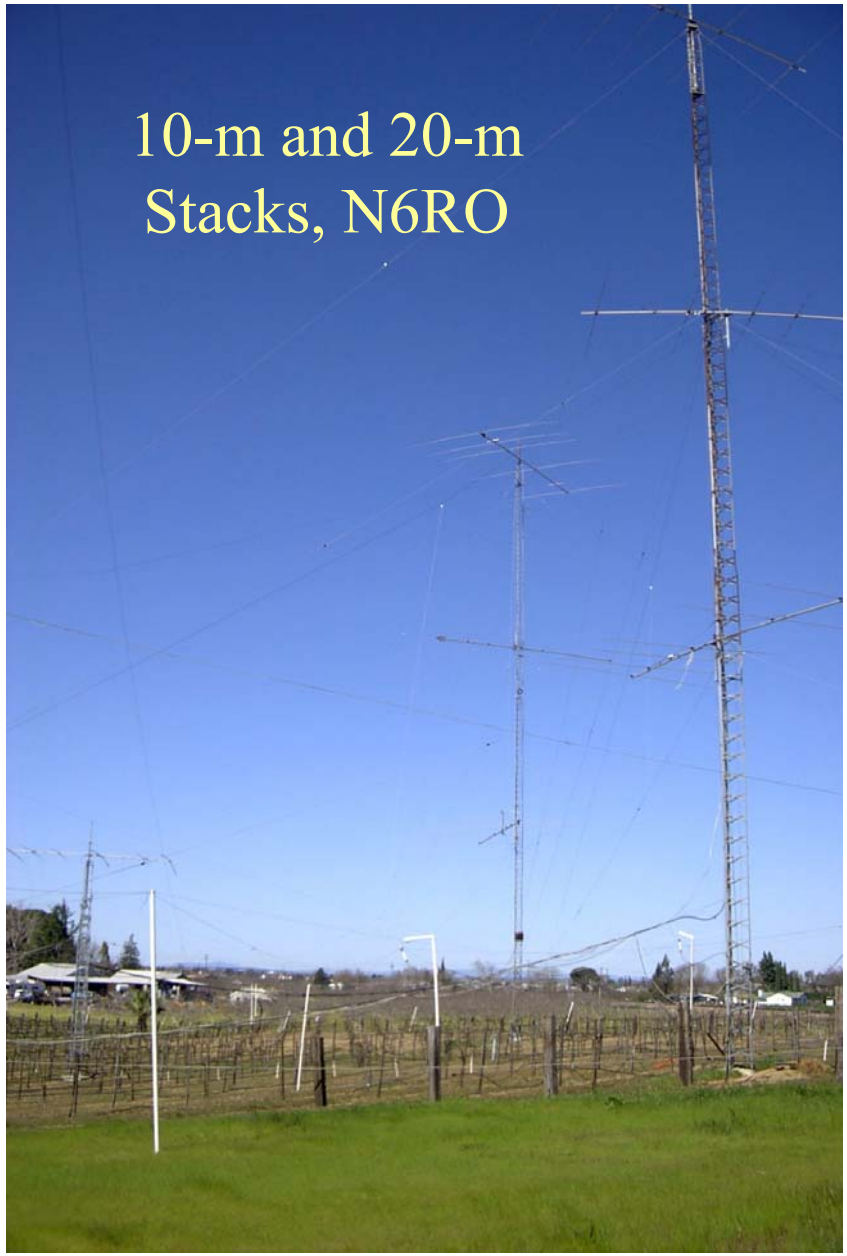
MicroDEM & USGS DEM Data



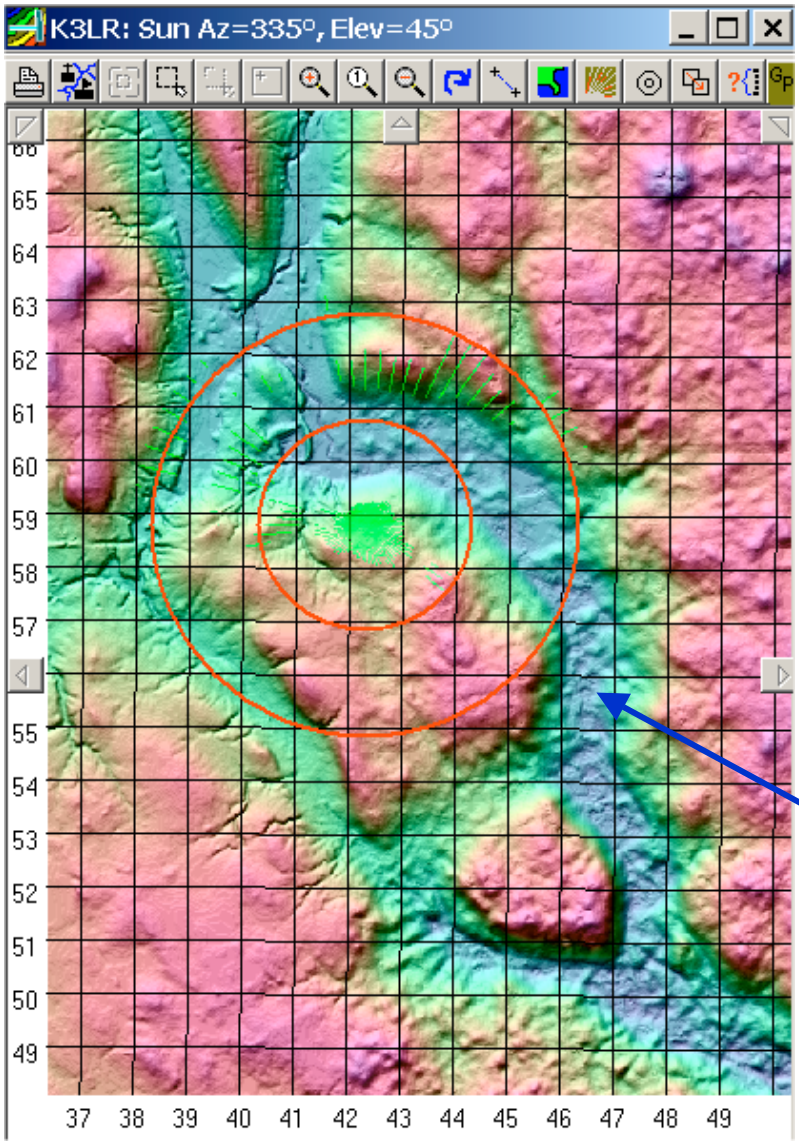
Did I mention that it's flat at N6RO? This map didn't require merging of DEMs, but just barely.

Terrain data for *HFTA*

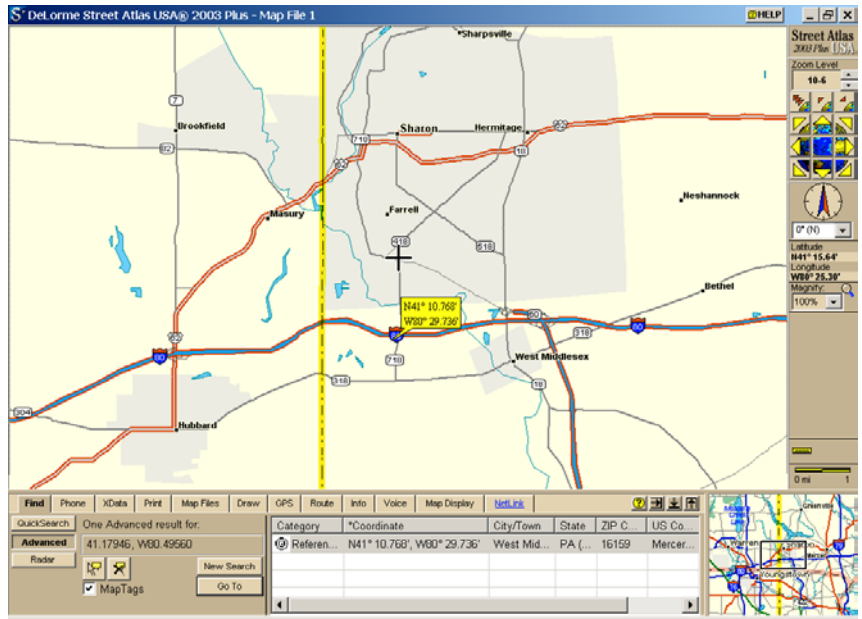

40-m Stack, N6RO


10-m and 20-m
Stacks, N6RO

K3LR's Superstation



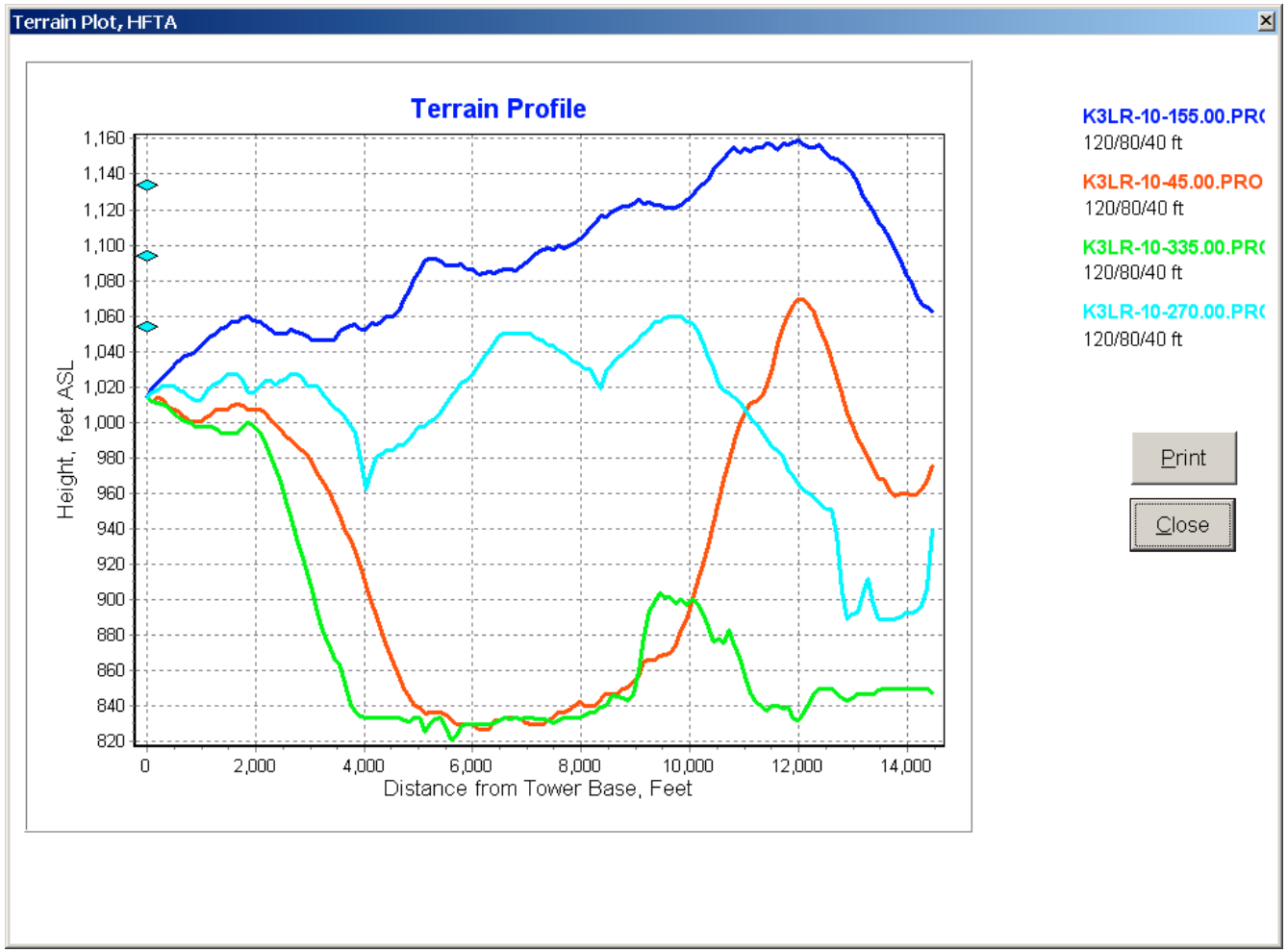
West Middlesex, PA



Shenango River

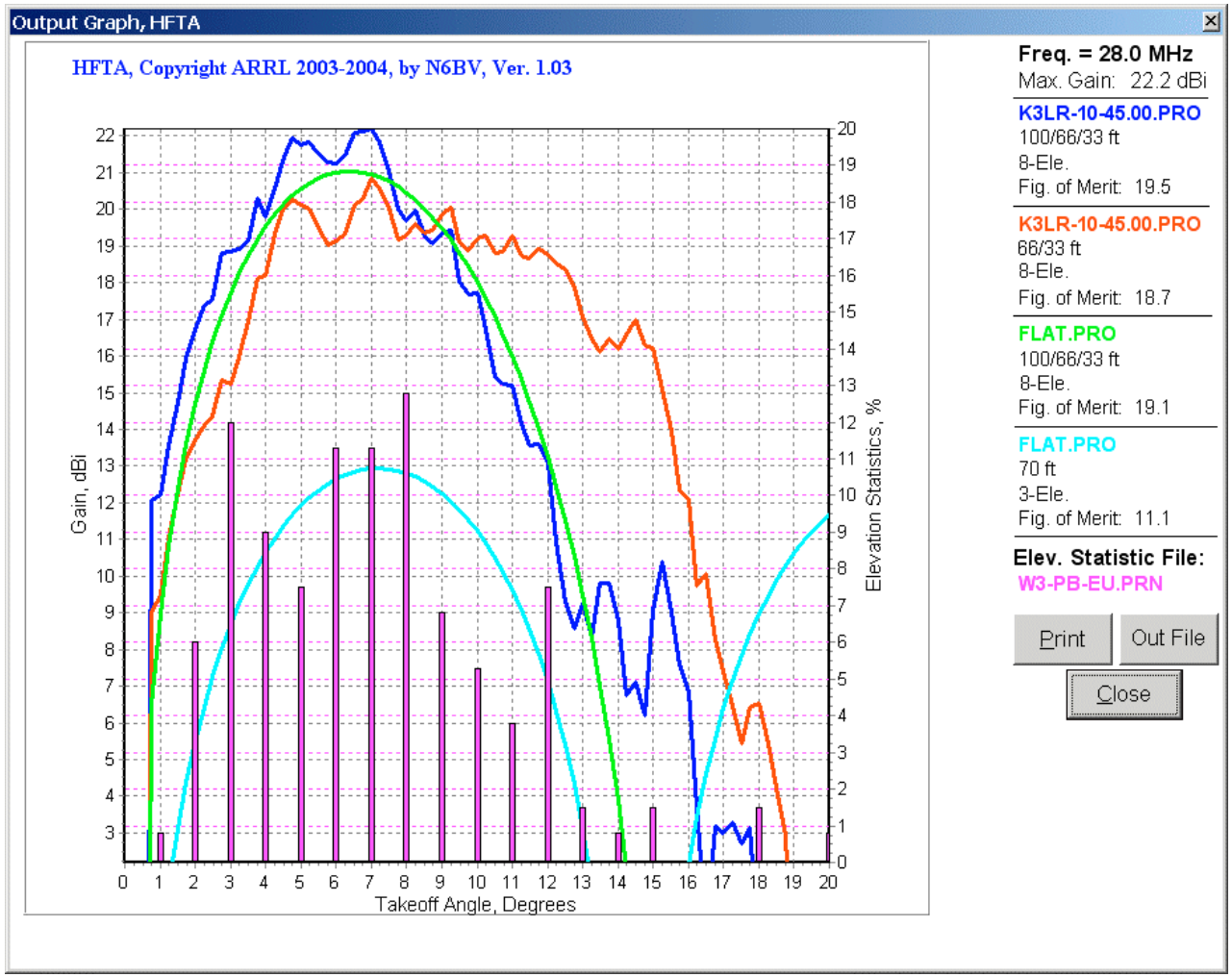
MicroDEM Map

K3LR's Superstation



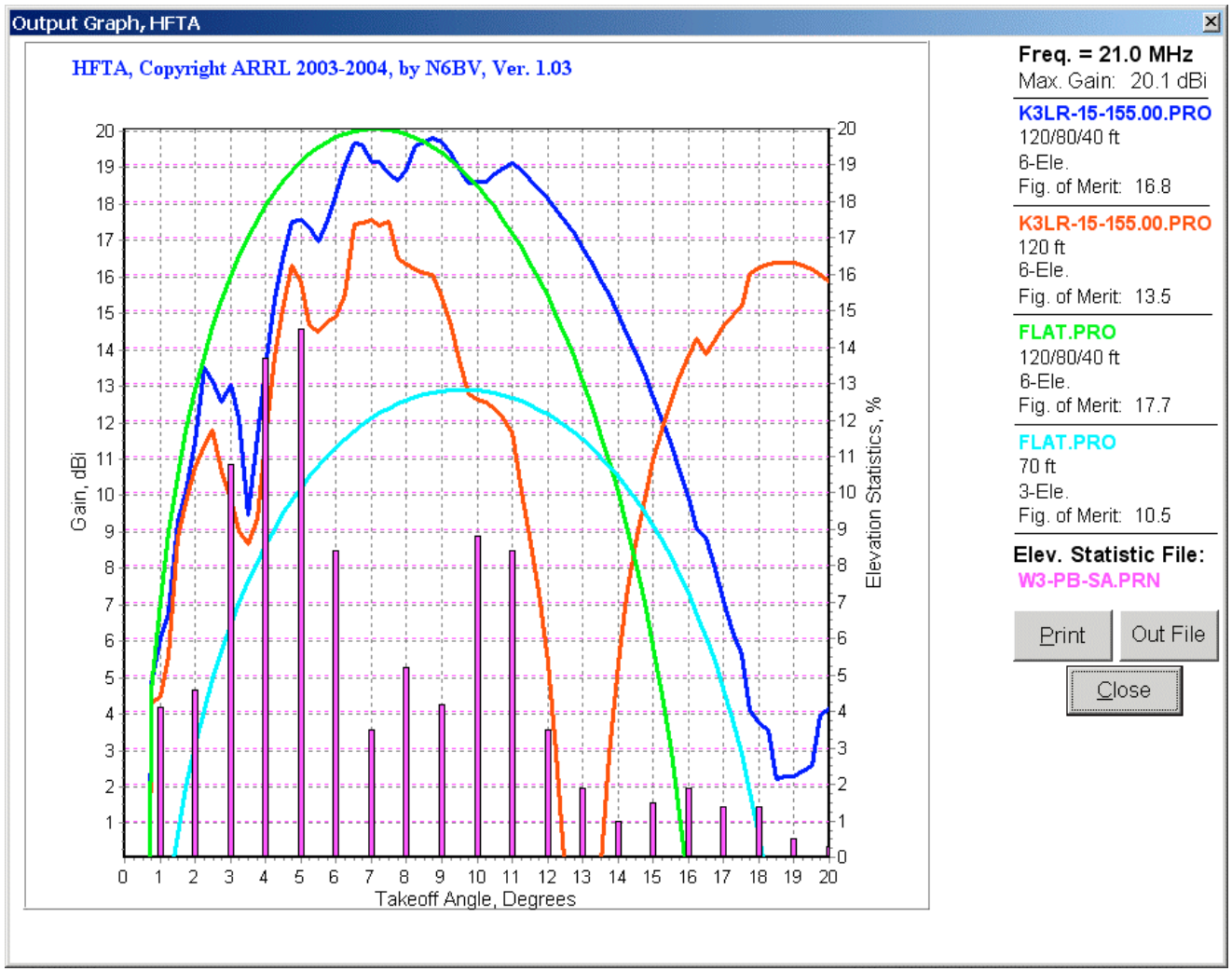
Terrain profiles from 10-m tower -- essentially the same from the other towers

K3LR, 10-M to Europe



The huge peak gain is close to the flatland case.
Only the lower two Yagis are needed at times.

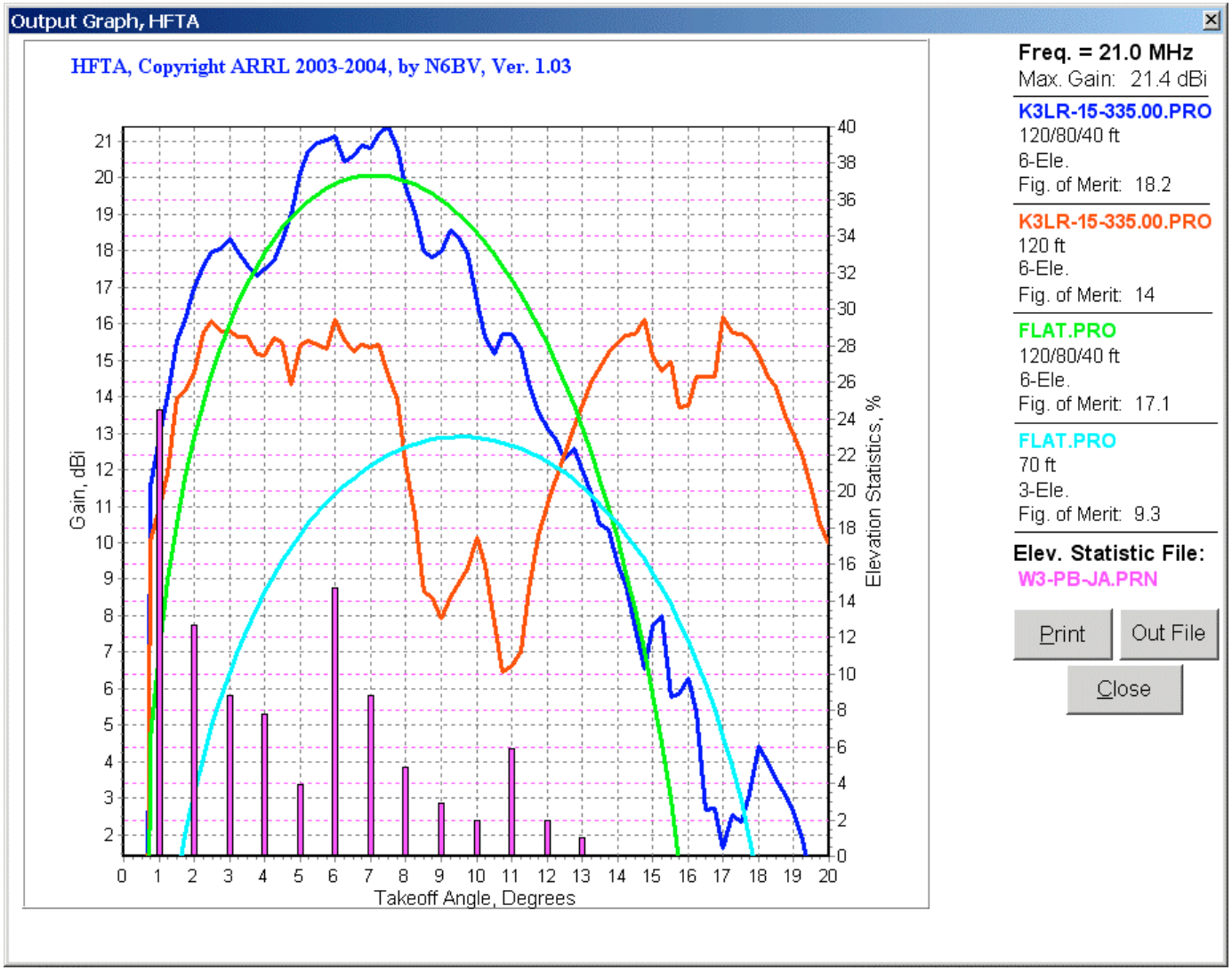
K3LR, 15-M to South America



Dominant, but not *super* dominant. (Don't feel bad for Tim -- look at 70' 3-element Yagi's response.)

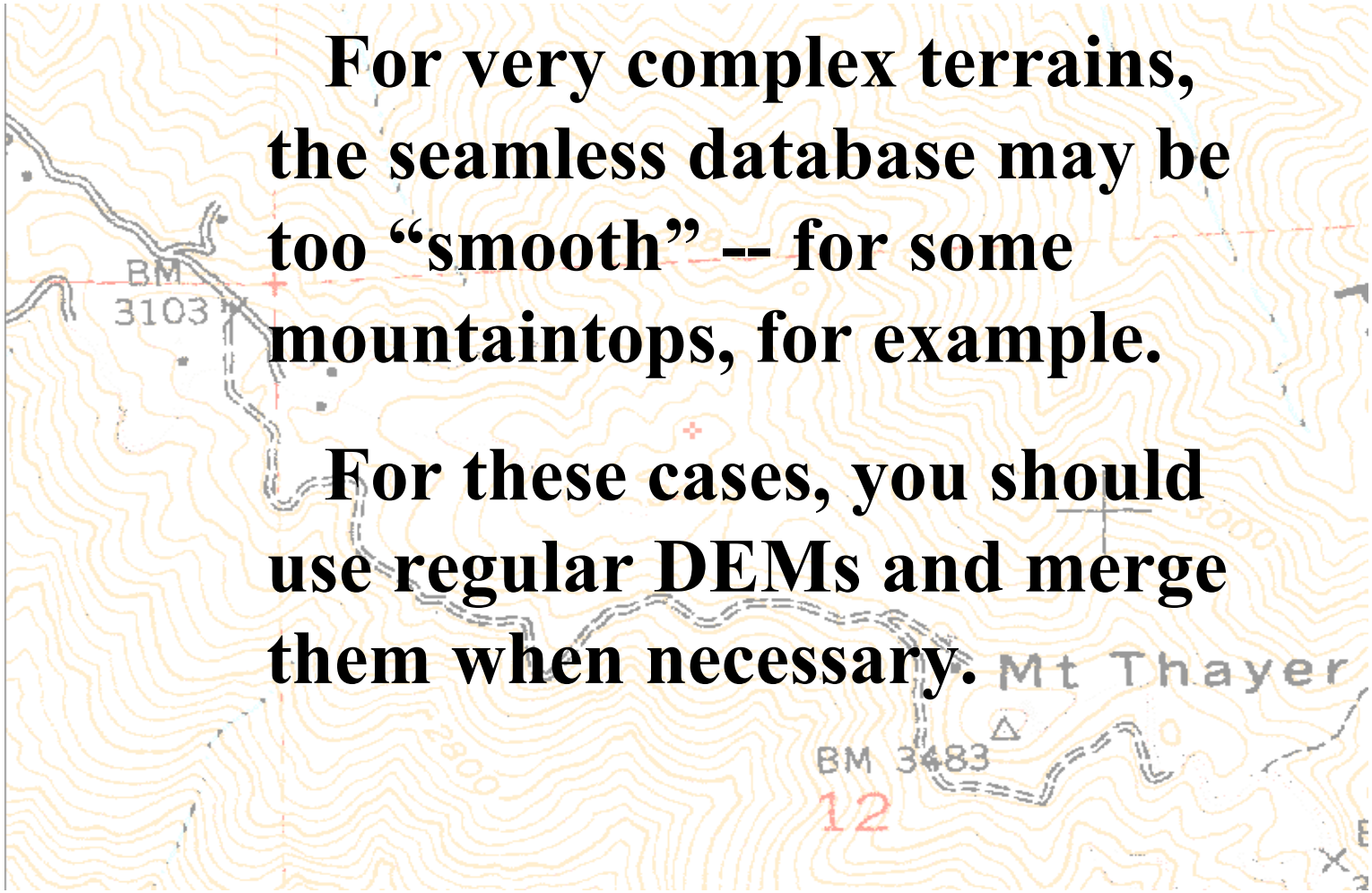
K3LR, 15-M Stack

K3LR, 15-M to Japan



Really, really strong.

Seamless USGS Database



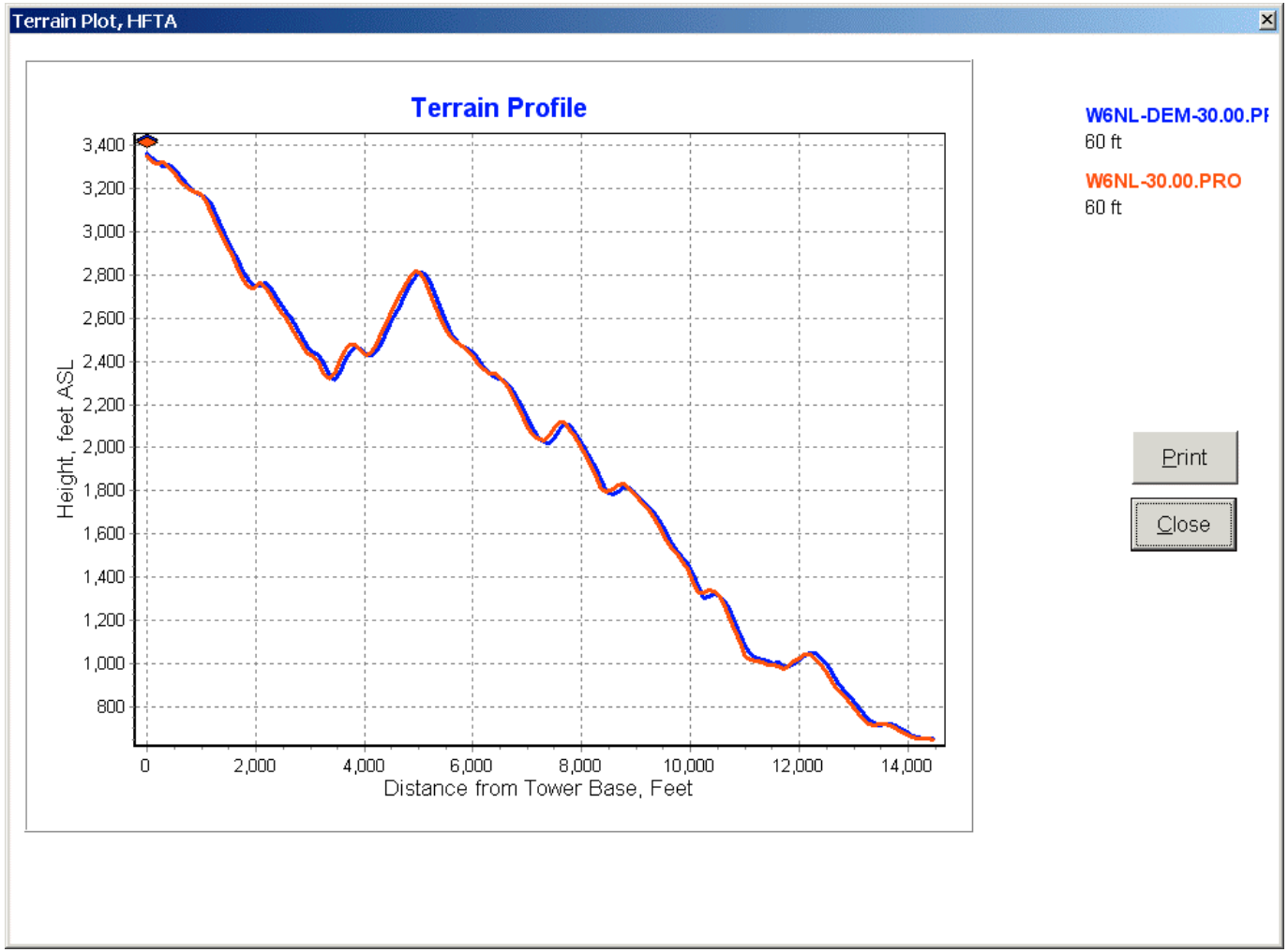
For very complex terrains, the seamless database may be too "smooth" -- for some mountaintops, for example.

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

Seamless vs DEM at W6NL

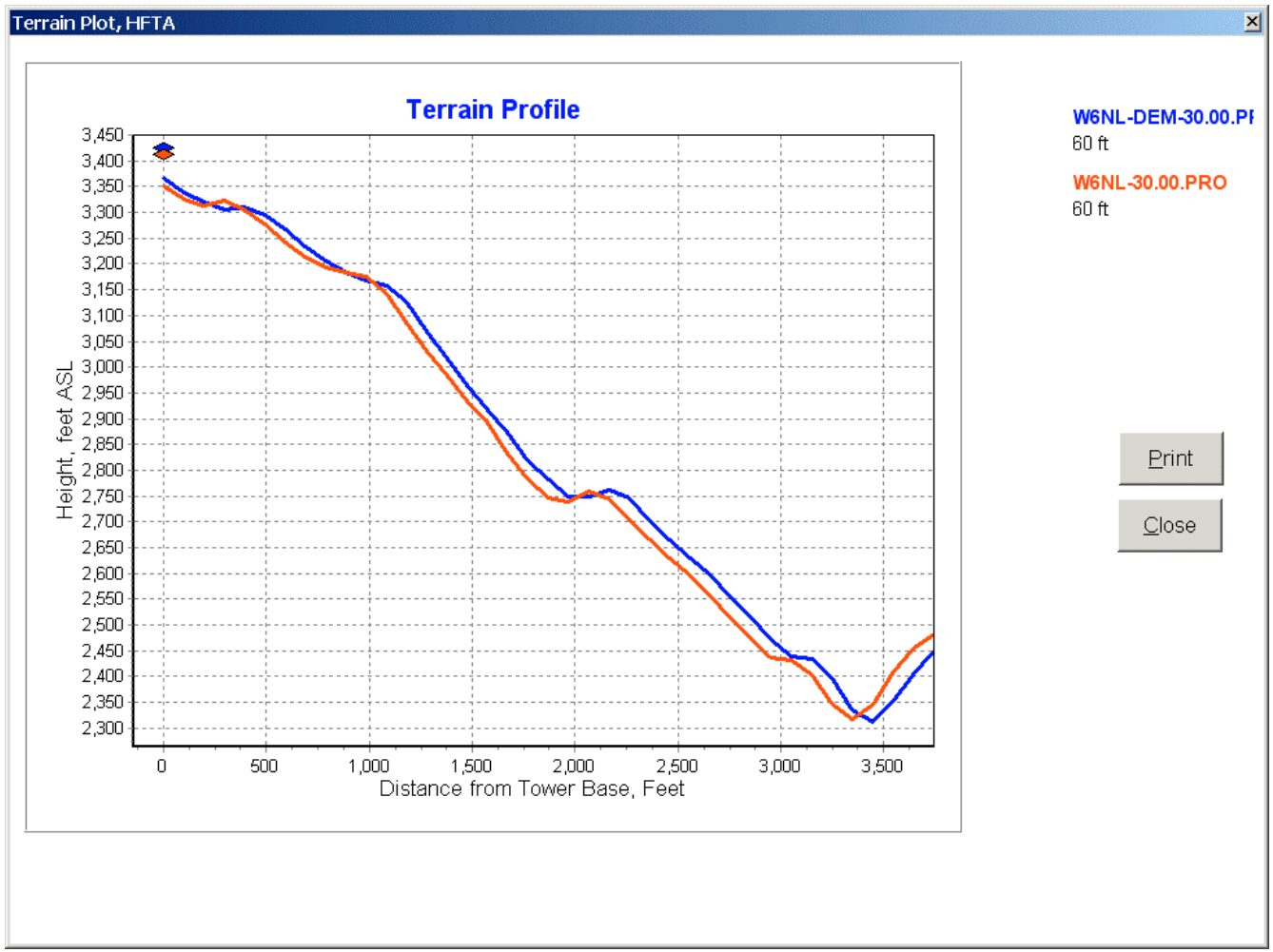
- Dave Leeson, W6NL, lives on a mountaintop overlooking Los Gatos, CA.
- The ground slopes away about –12°, very steep indeed.

Seamless vs DEM at W6NL



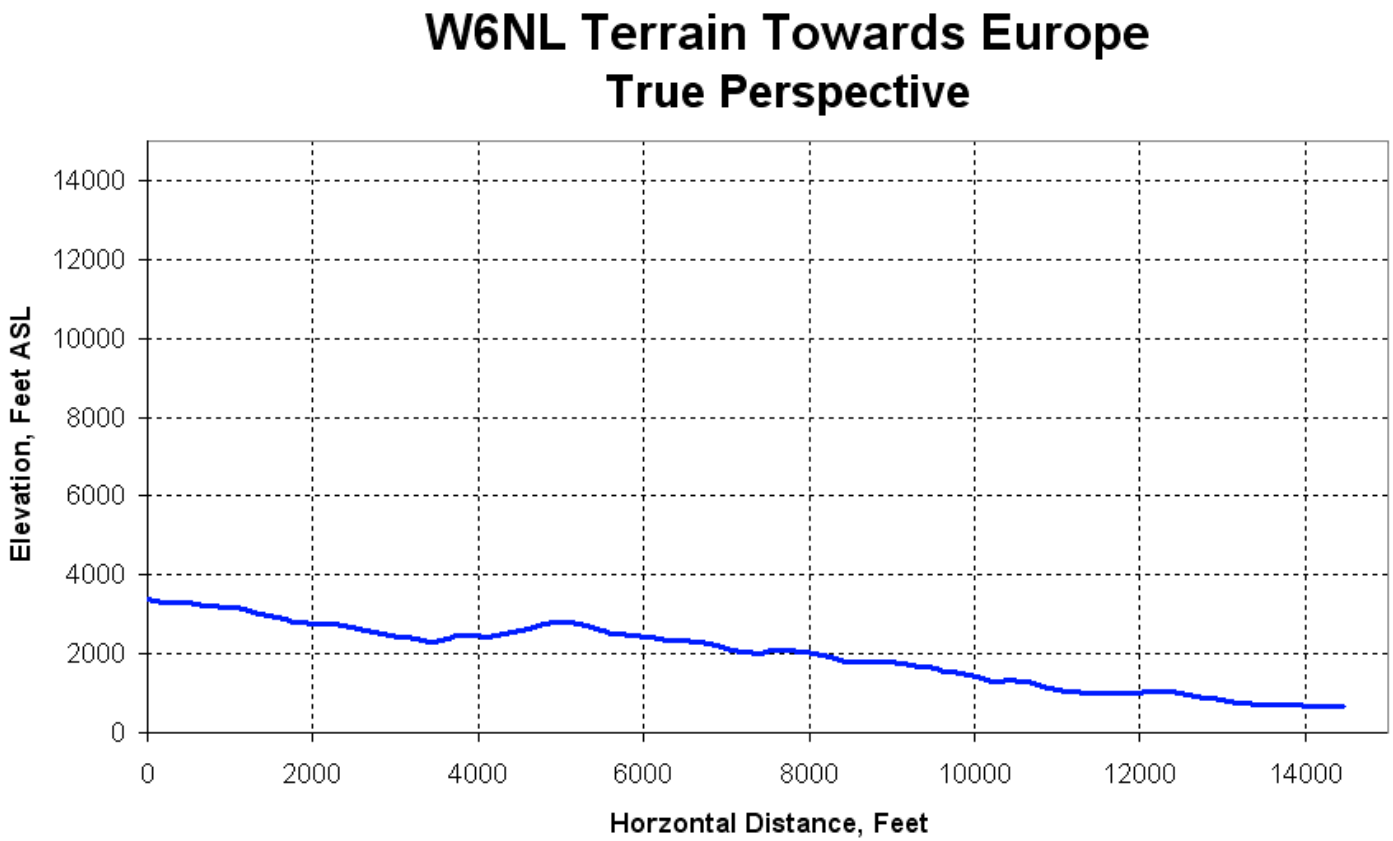
Can't see much difference, can you?

Seamless vs DEM at W6NL



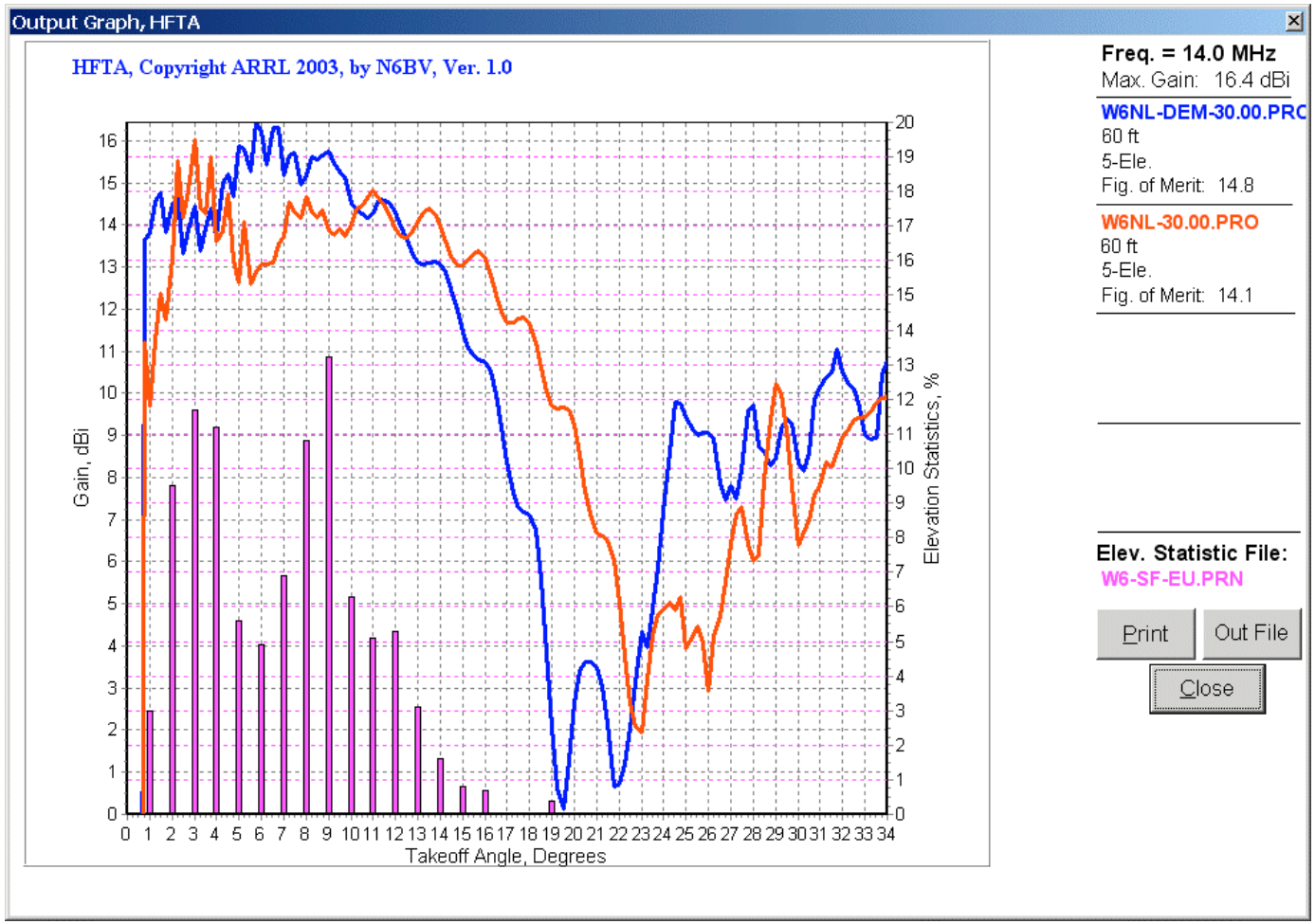
When expanded, you can see small differences.

A Matter of Perspective



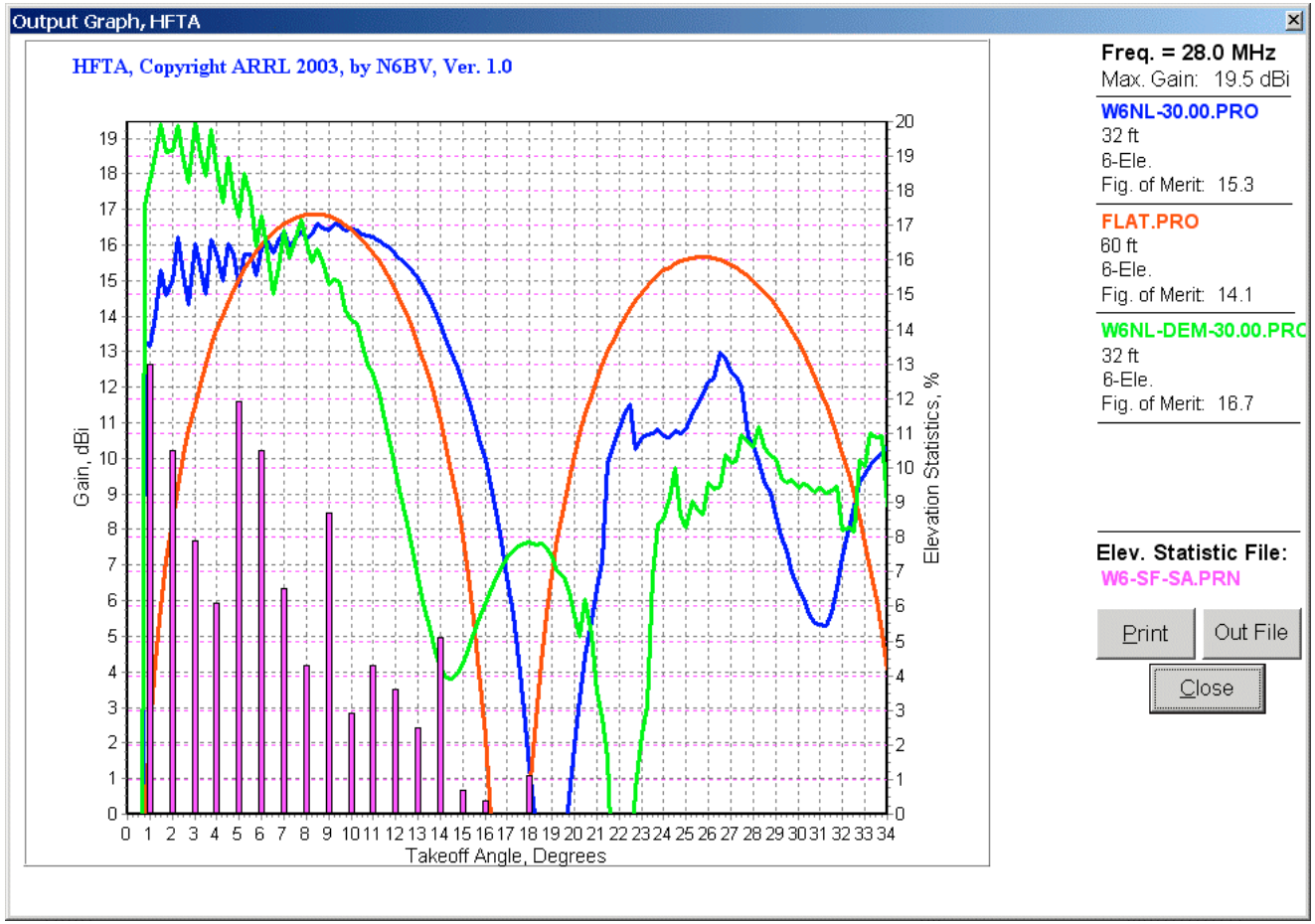
Now, even a –12° slope doesn't look so steep.

Seamless vs DEM at W6NL



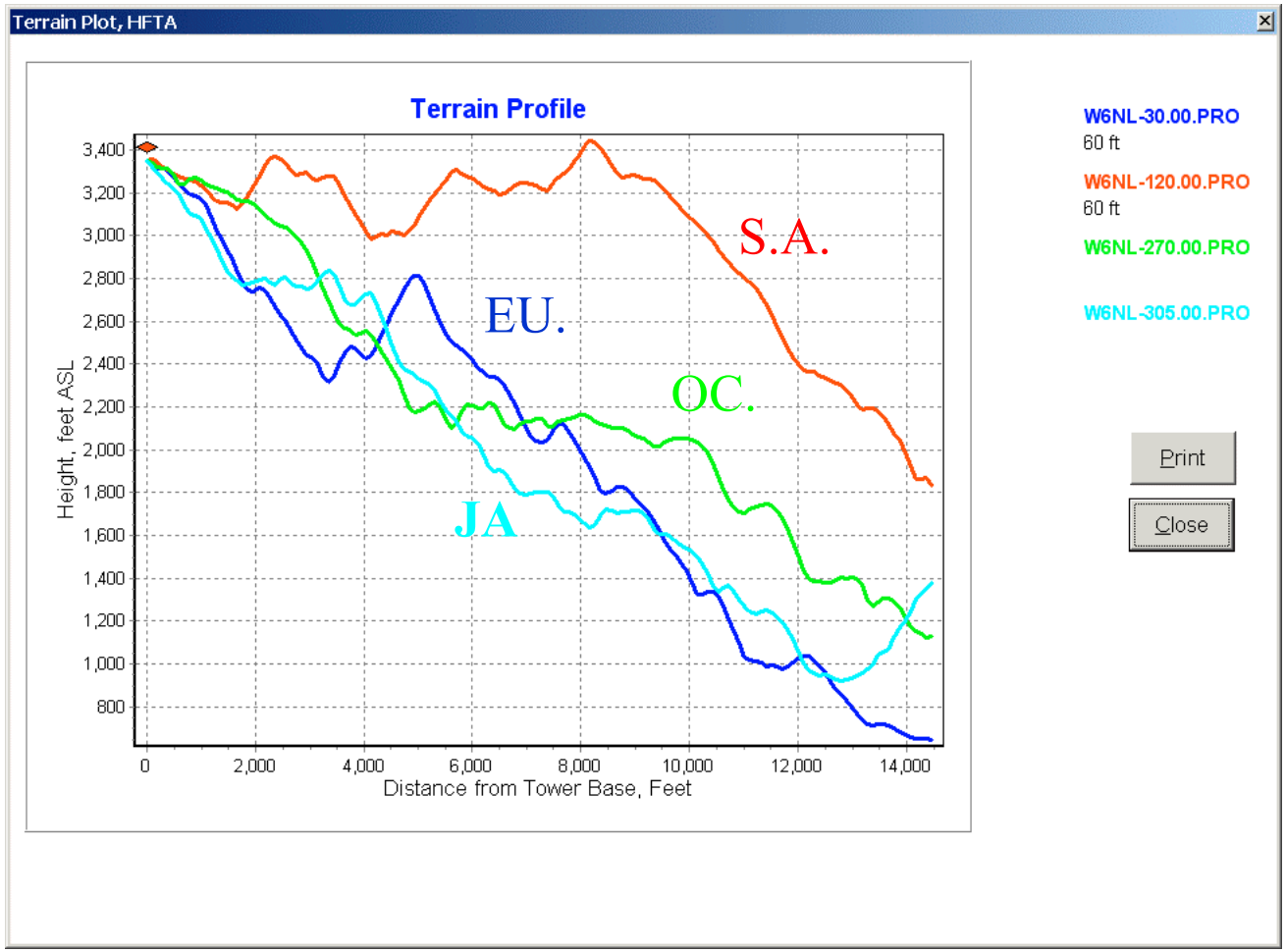
The responses, however, are slightly different for the two terrain databases on 20 meters.

Seamless vs DEM at W6NL



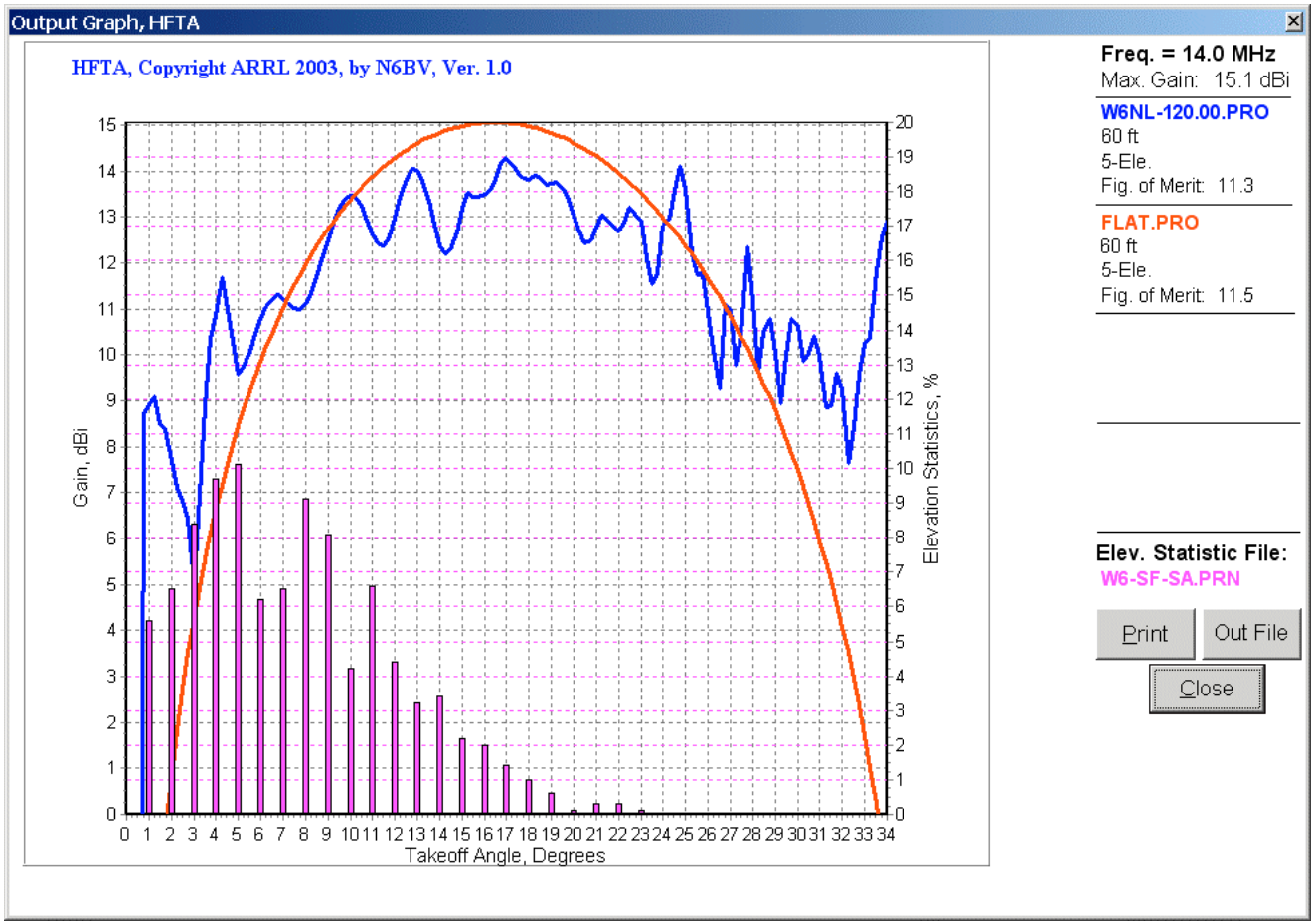
The responses are different for the two databases on 15 meters. Note 32' height is good for W6NL to Europe.

Looking Around at W6NL



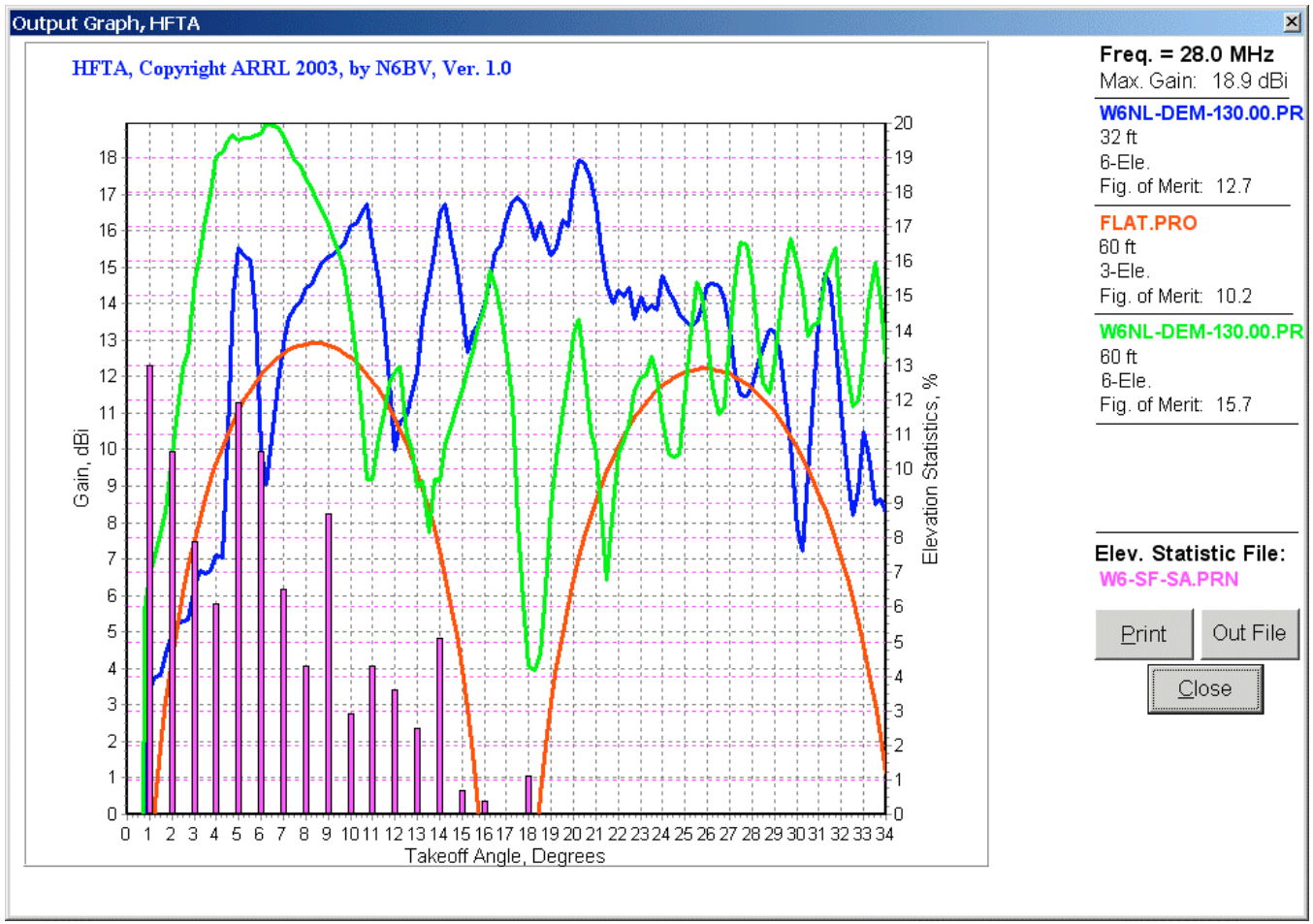
The ground slopes down in all directions. Still, the South American terrain looks weakest.

W6NL to S. America, 20 M



Not bad at all to South America on 20 meters, but not dominant, as in other directions.

W6NL to S. America, 15 M

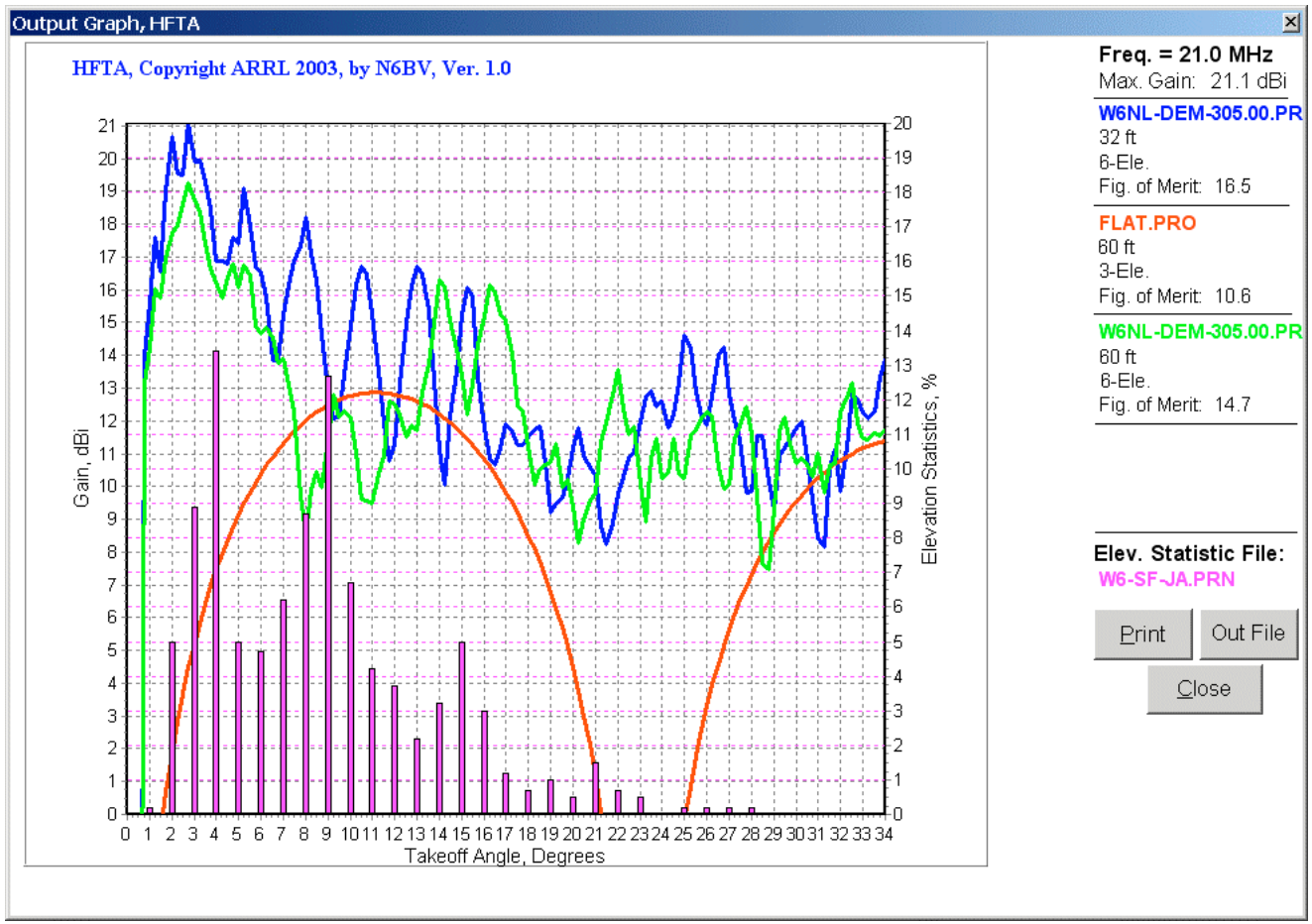


Yagi at 32’ is not bad to South America on 15 meters, but not dominant, as in other directions. 60’ is better.

Dropoffs

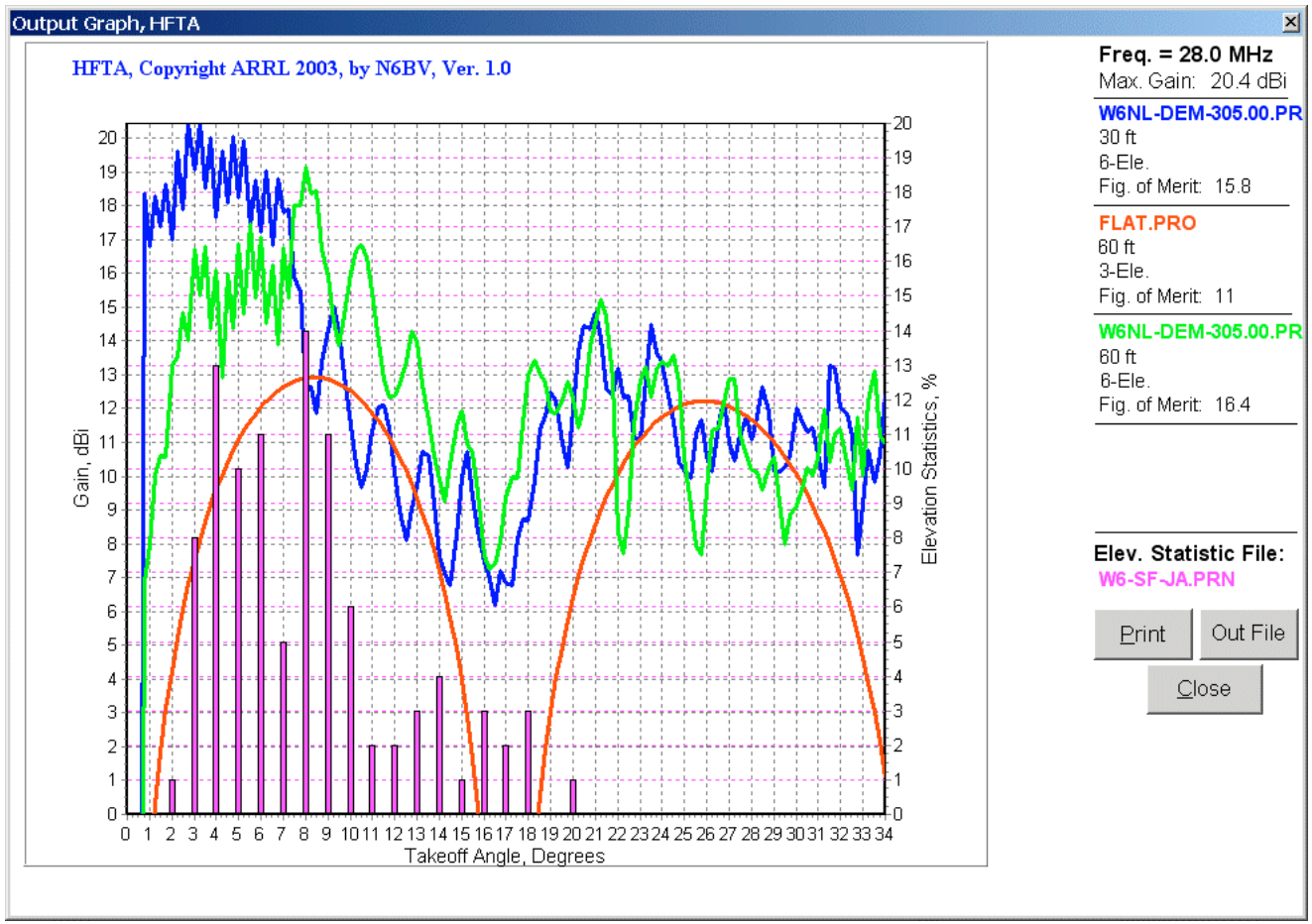
- As I said before, tower heights over flat terrain are easy to optimize -- while mountaintops can be non-intuitive.

60’ Is Too High on 15 M to JA



The 32’ Yagi is better than the one at 60’. (Again, don’t feel bad for W6NL. See typical 3-element flatland Yagi at 60’ for comparison to Japan!)

60’ *Not* Too High on 10 M to JA



The 60’ Yagi is now slightly better than the one at 30’, as shown in FOM to Japan.

Figure of Merit?

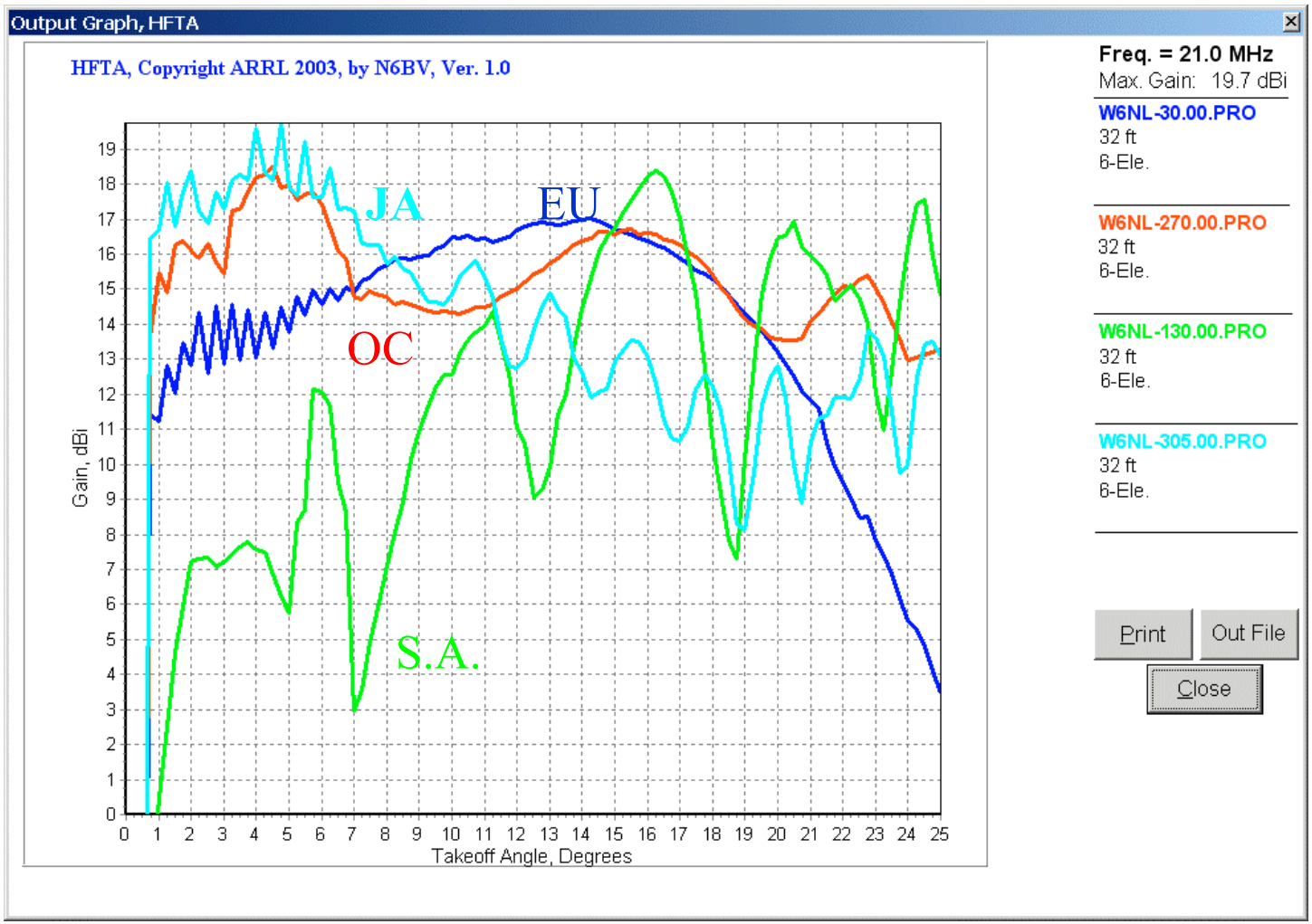
- Figure of Merit (FOM) is a convenient, but one-dimensional, look at system performance at a particular azimuth.
- FOMs vary with different target QTHs, at the same antenna height.

FOMs at the Same Height, Different Directions

W6NL on 15 meters, 32’ height, 6-element Yagi

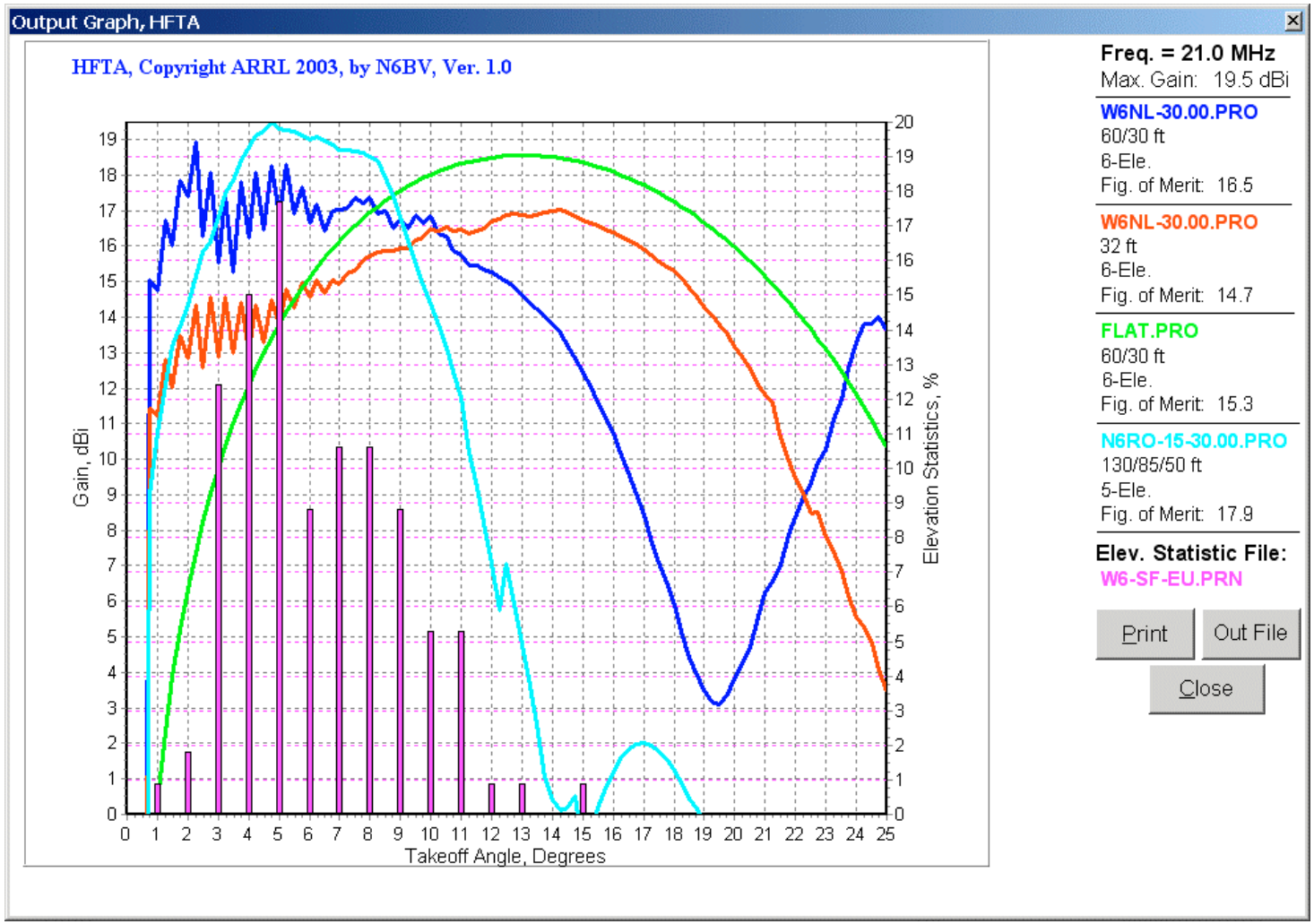
- to Europe: FOM = 14.7 dBi
- to S. Africa: FOM = 13.3 dBi
- to S. America: FOM = 10.2 dBi
- to Japan: FOM = 16.5 dBi
- to Oceania: FOM = 16.1 dBi

Responses at the Same Height



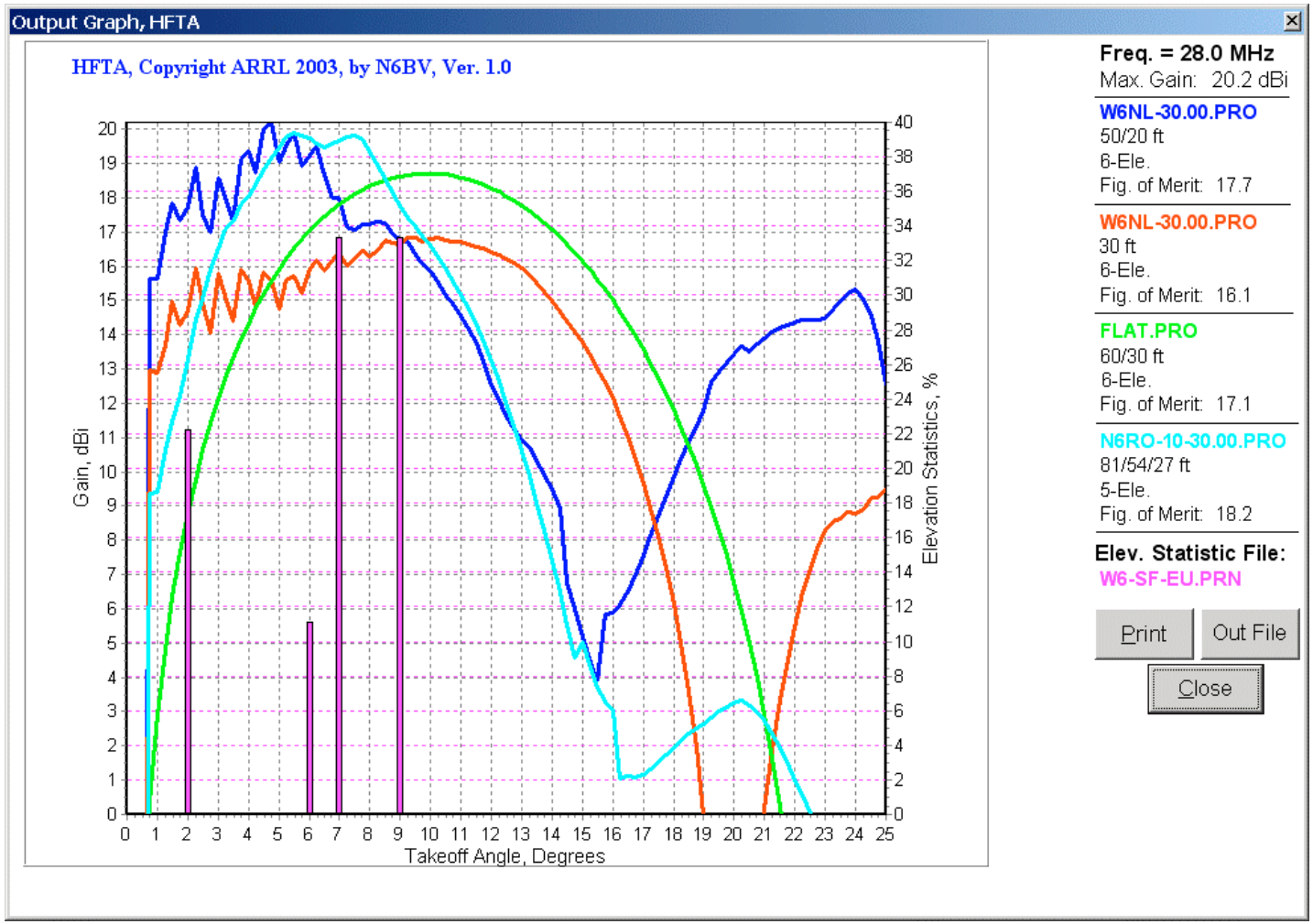
One height does not fit all, with different terrain profiles in different directions.

What About Stacks at W6NL?



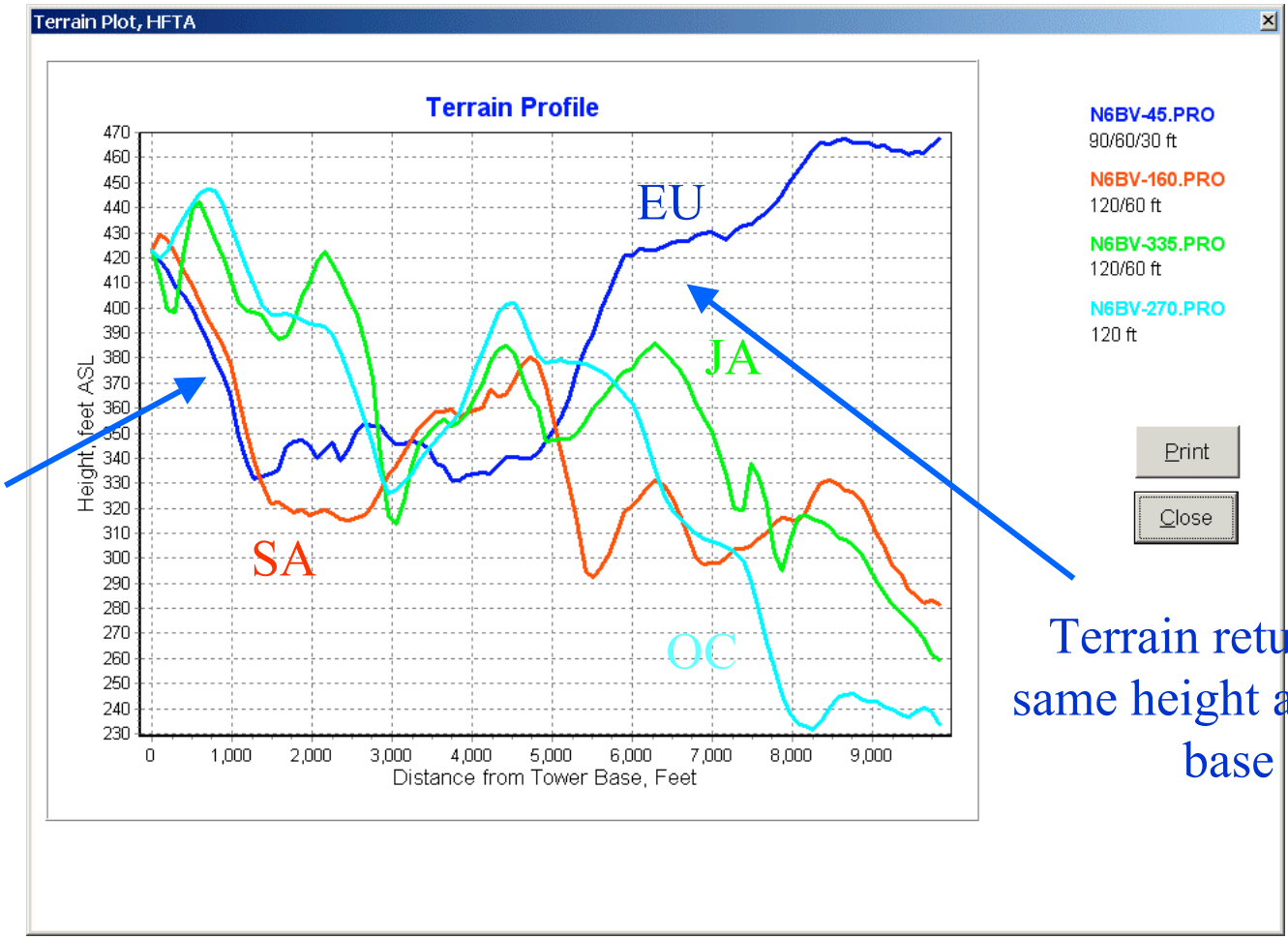
Yes, stacks would help some into Europe on 15 meters.
Note N6RO 15-meter stack for comparison.

10-Meter Stacks at W6NL?



Stacks would also help into Europe on 10 meters. Note N6RO 10-meter stack. Mountains aren't *always* best.

My Old New Hampshire QTH

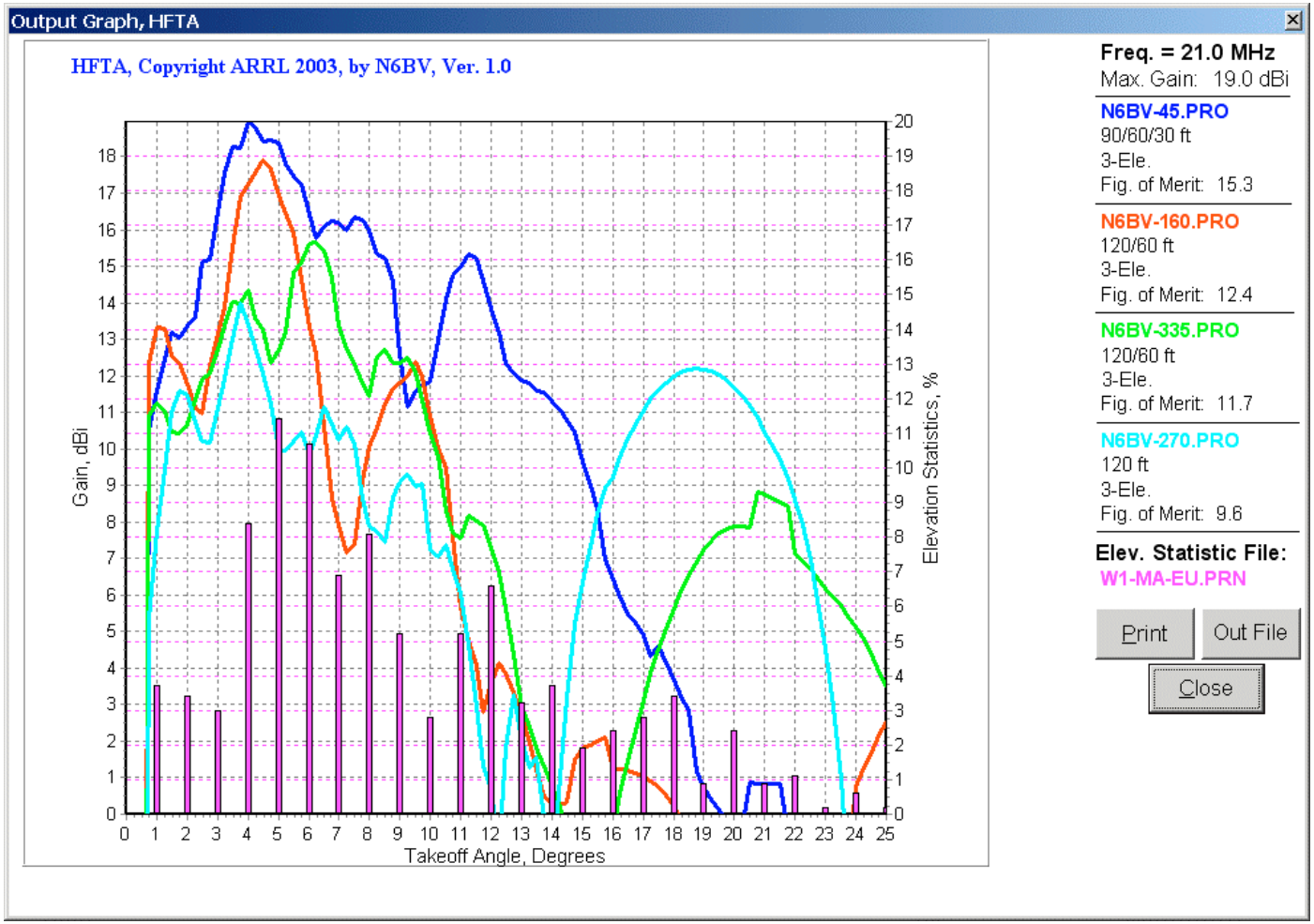


Gentle 3-deg. slope to Europe

Terrain returns to same height as tower base

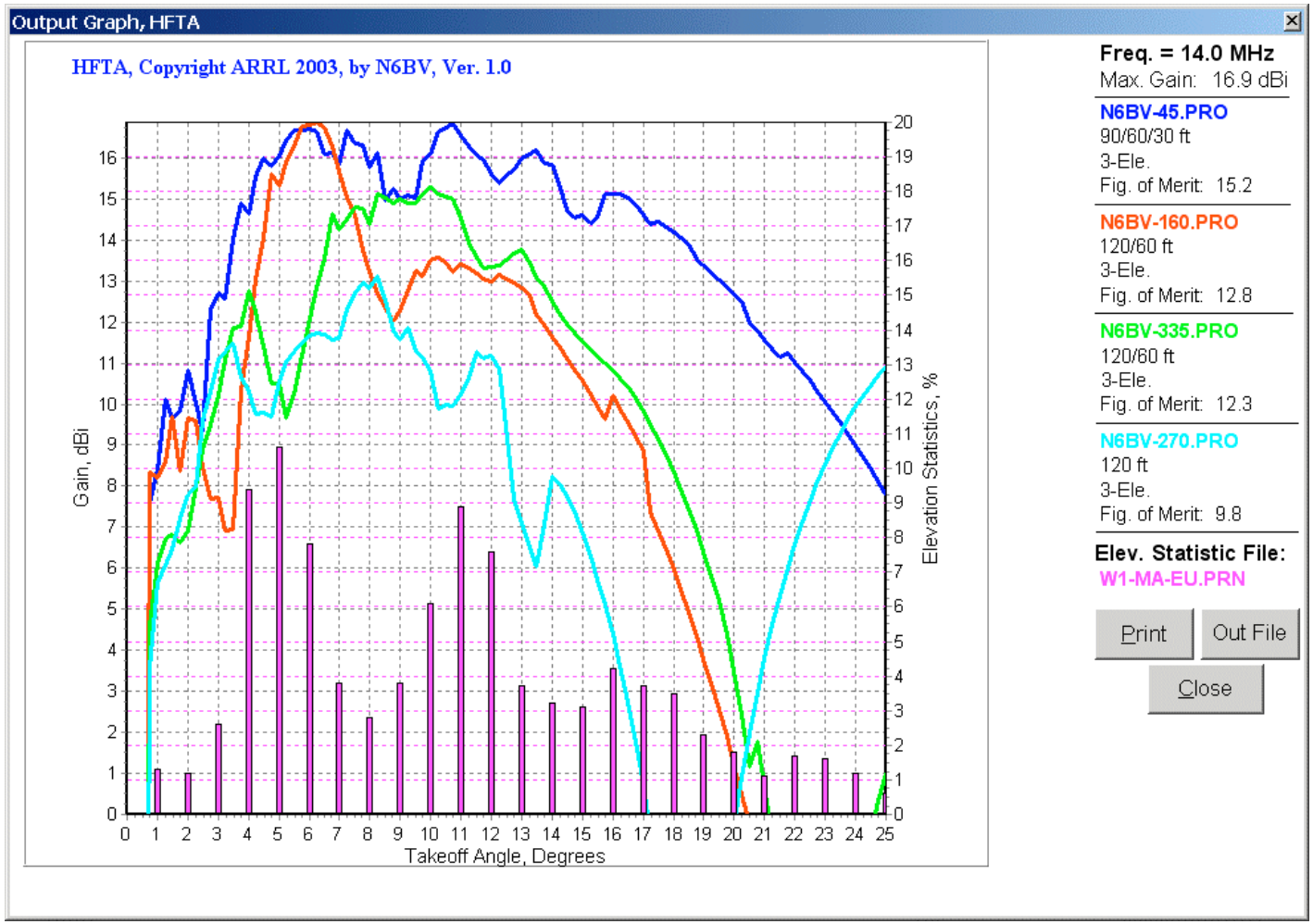
Terrain to Europe and South America was best; shot to Japan was worst; shot to Oceania was marginal.

N6BV/1 on 15 Meters



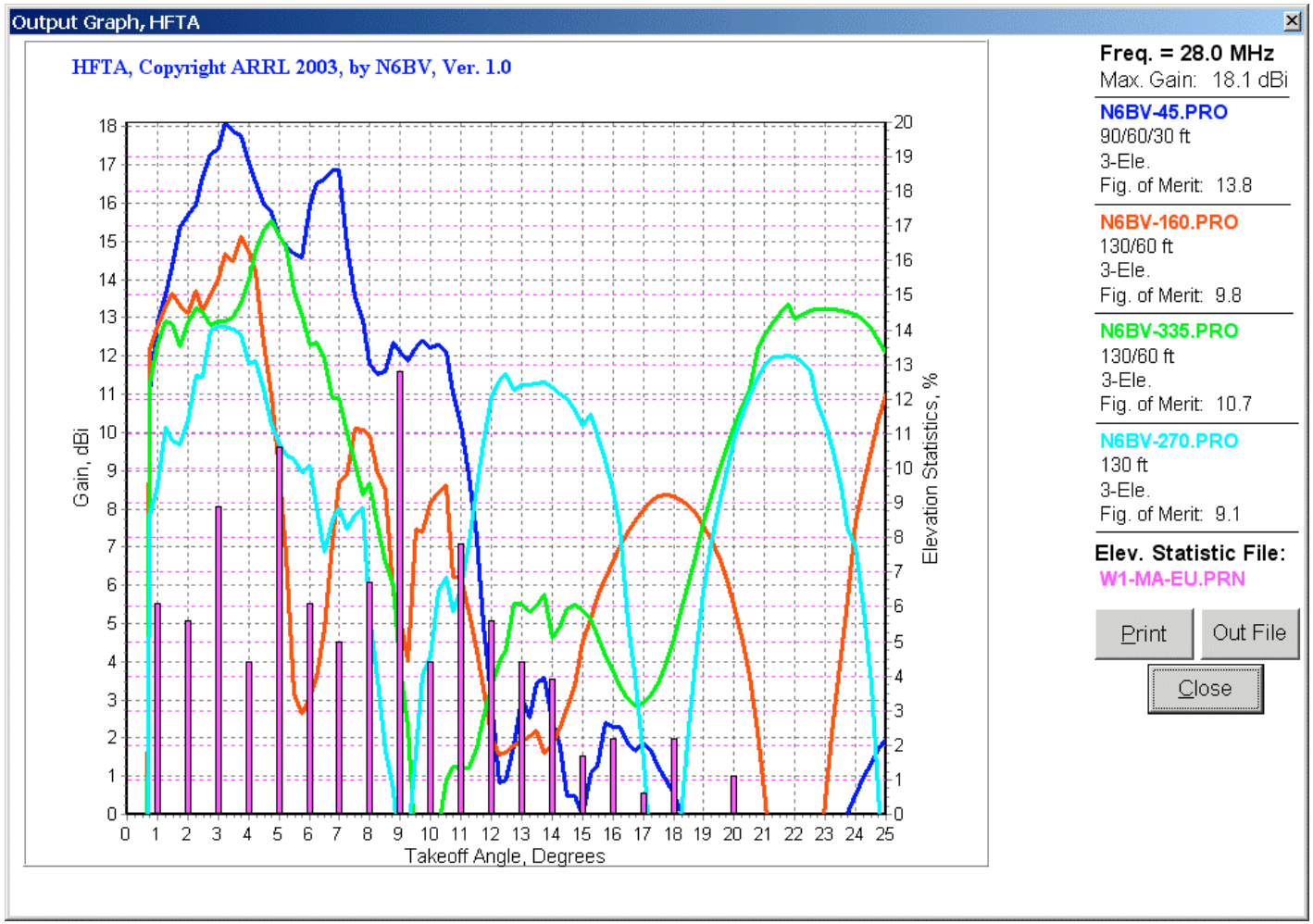
Different antenna combinations for different directions.
15 meters really played into Europe. FOMs for Europe.

N6BV/1 on 20 Meters



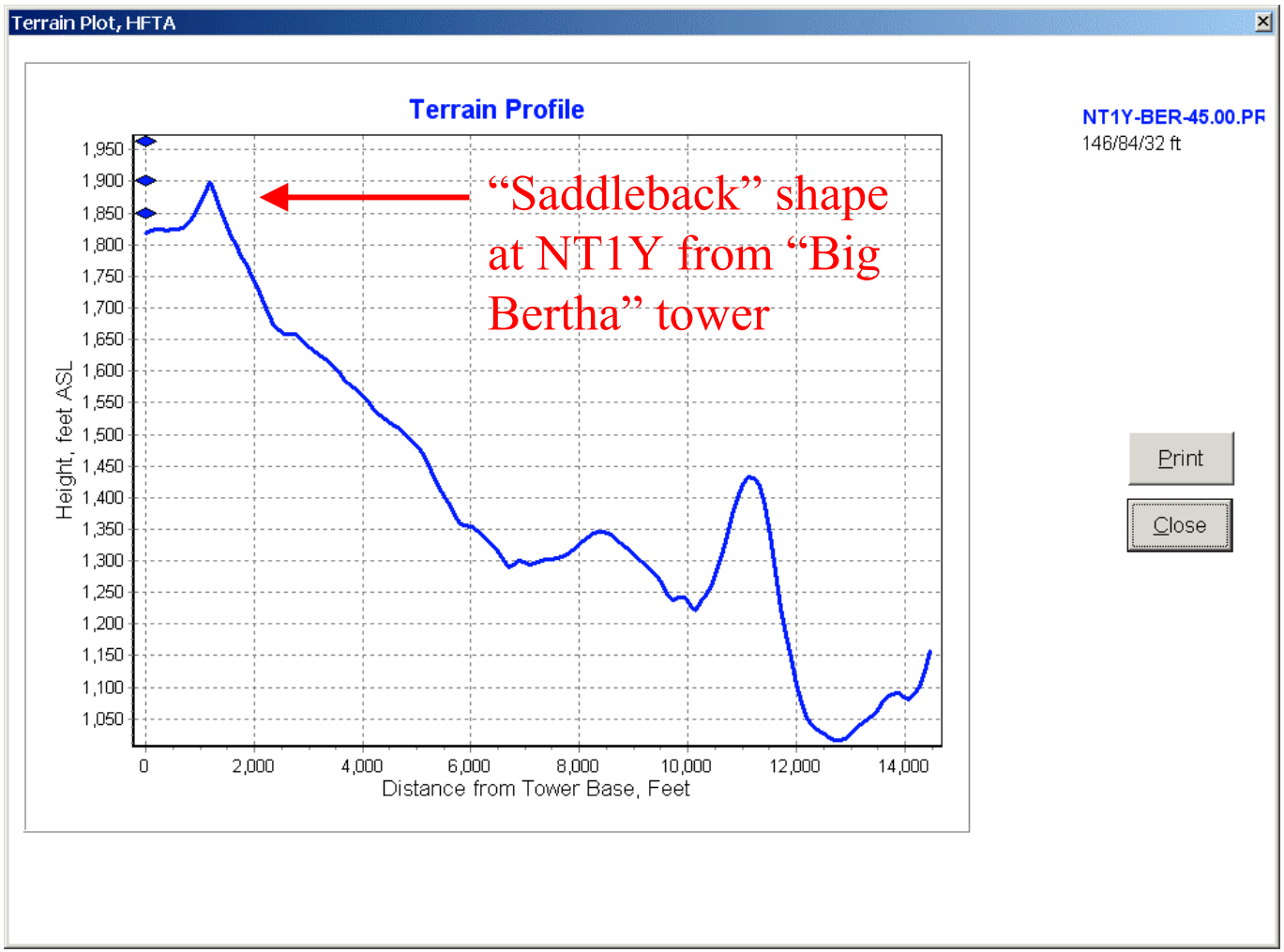
20 meters was fantastic into Europe! 20 meters into Japan was marginal at low angles.

N6BV/1 on 10 Meters



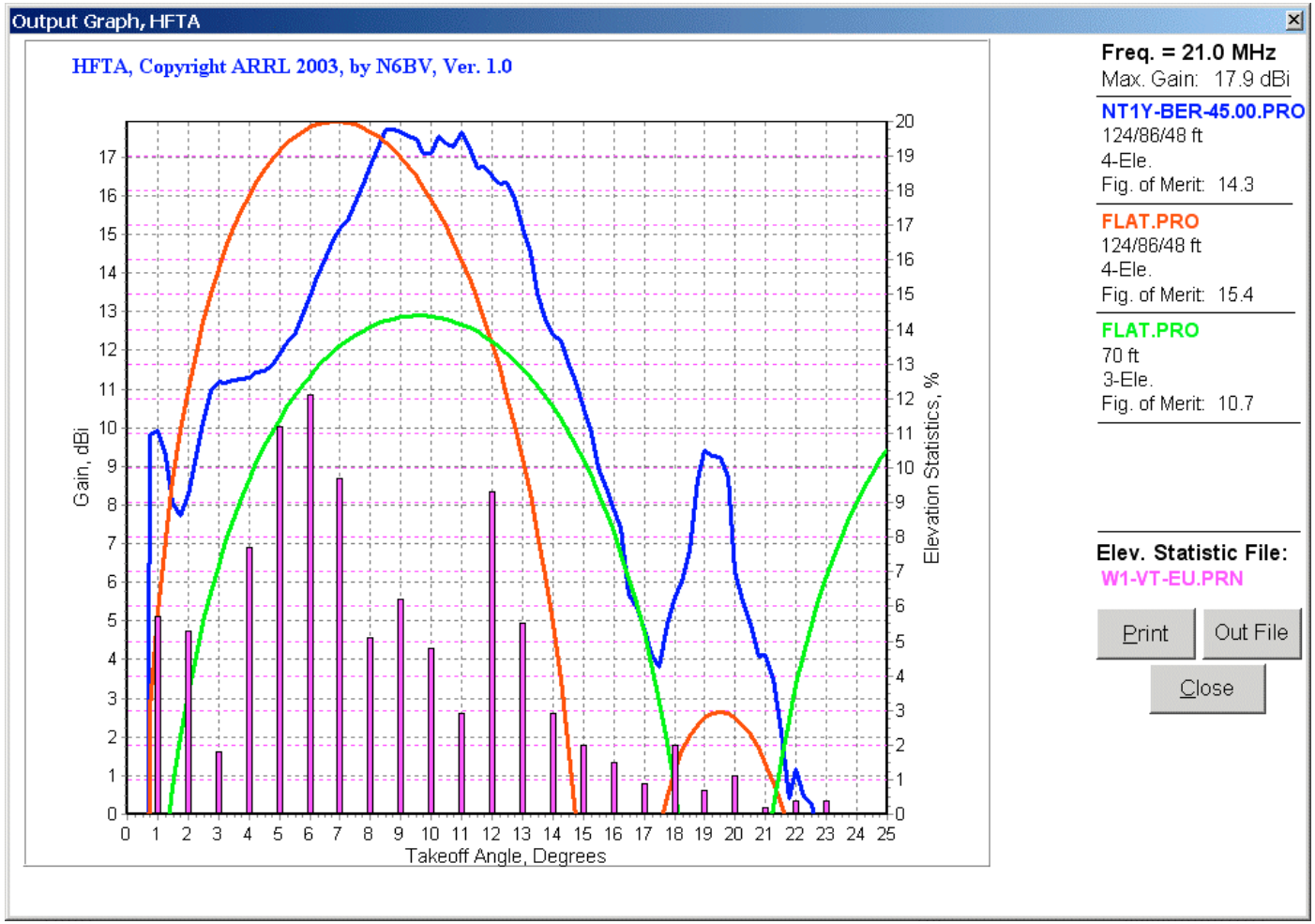
10 meters was great into Europe. 10 meters into Japan was OK at low angles. S. America best on 60' Yagi.

“Saddleback” Terrains



At about 1200’ the saddleback terrain configuration didn’t look that bad, but it does affect the launch of signals.

“Saddleback” Terrains



The saddleback-shaped terrain definitely affects the launch of signals. This is the “Big Bertha” tower.

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.
- 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...