Using GEOID99 and GPS to Determine Orthometric Heights in the United States

by

Dru A. Smith, Ph.D.
Daniel R. Roman, Ph.D.
National Geodetic Survey

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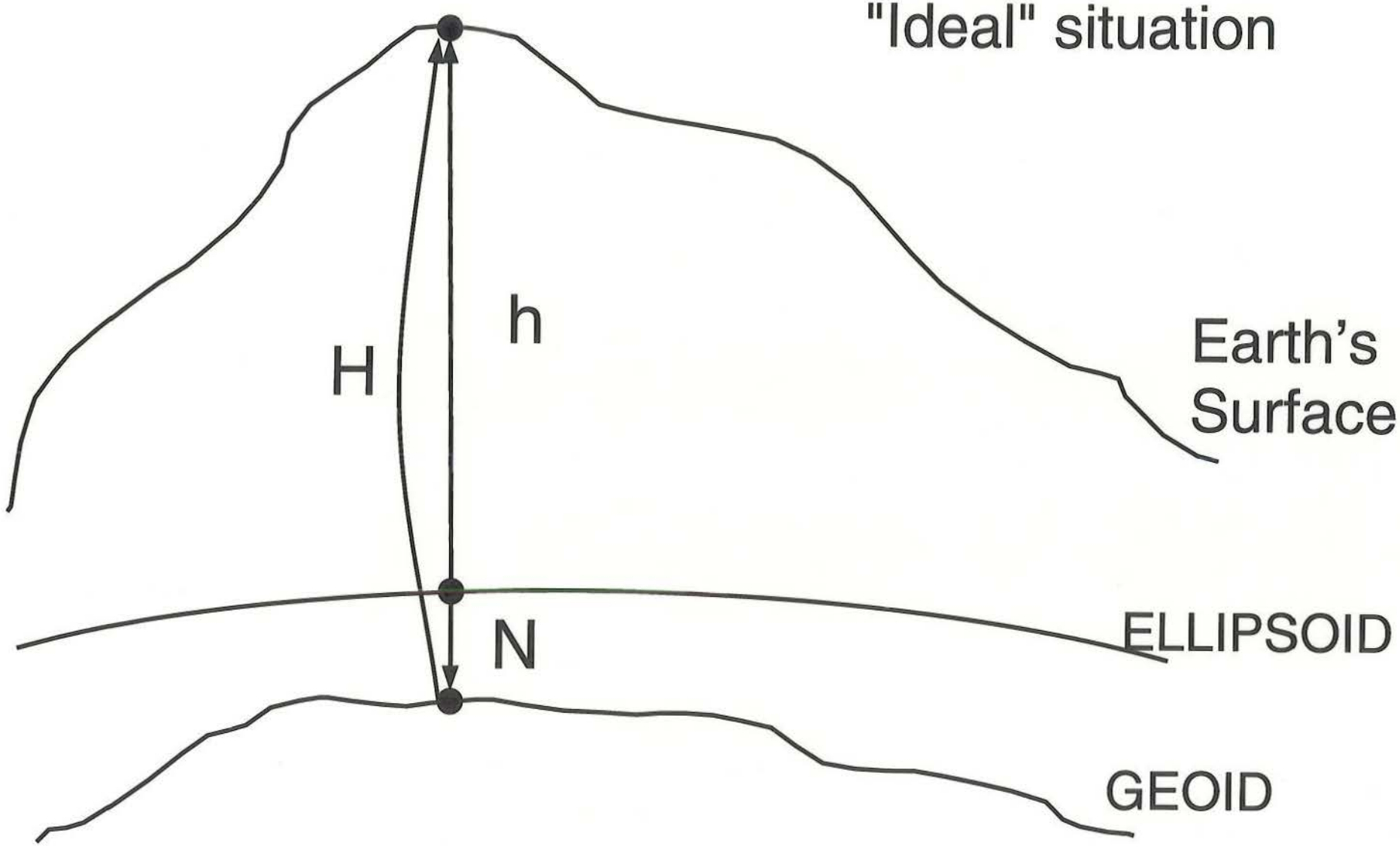
- Review of USA Height Systems

- Creation of GEOID99 model

- GPS-derived orthometric heights from GEOID99

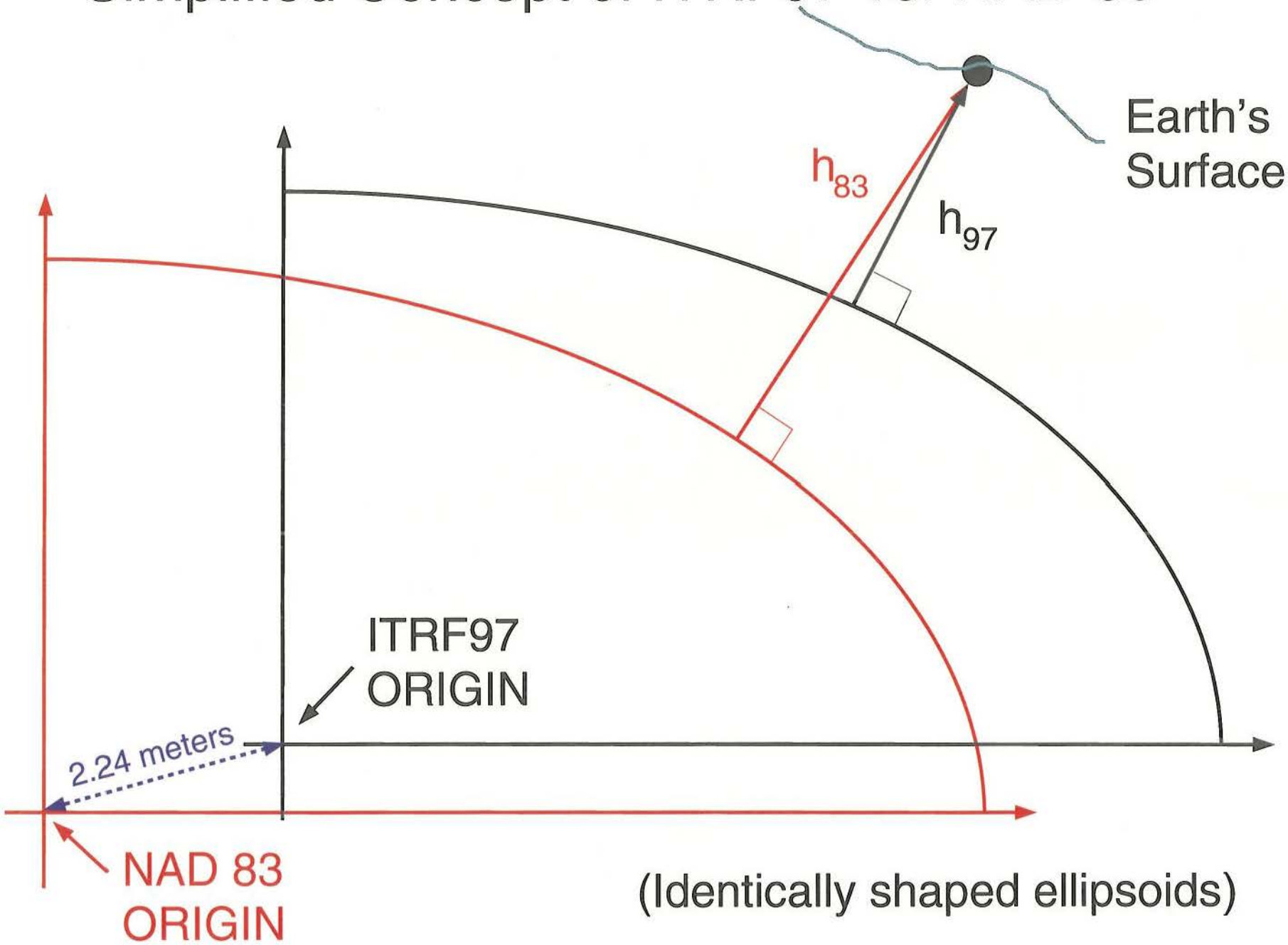
- Future Directions

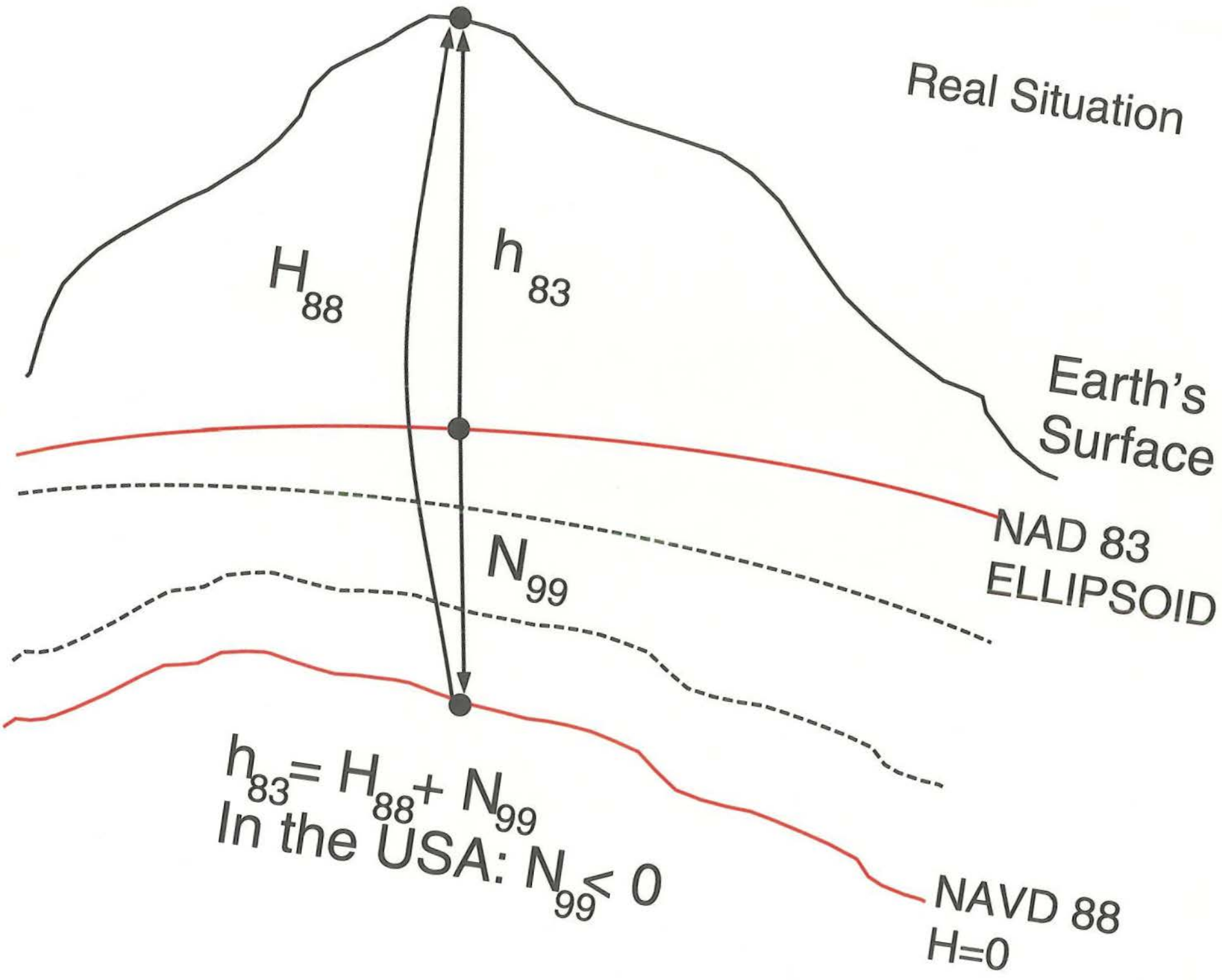


$h = H + N$

In the USA: $N < 0$

Simplified Concept of ITRF97 vs. NAD 83




Real Situation
H_{88}
h_{83}
Earth's Surface
NAD 83 ELLIPSOID
N_{99}
$h_{83} = H_{88} + N_{99}$
In the USA: $N_{99} < 0$
NAVD 88
H=0

GEOID99 basic information

Input data

- 2.0 Million gravity observations (1.6 from the NIMA evaluated gravity database)
- 0.6 Million altimetric gravity anomalies
- EGM96 (NASA/NIMA)
- 1 km DEM supplemented by 30 m DEM in Northwest USA
- 6169 GPS heights on leveled benchmarks

Theory

- Faye anomalies $\cong$ Helmert anomalies
- Remove/Compute/Restore using EGM96 and 1-D FFT
- Collocation to model h-H-N long wavelength systematic differences

Output Grids

- 1 arc-minute grids
- CONUS: up to 58 degrees North
- Alaska, Hawaii, Puerto Rico/Virgin Islands

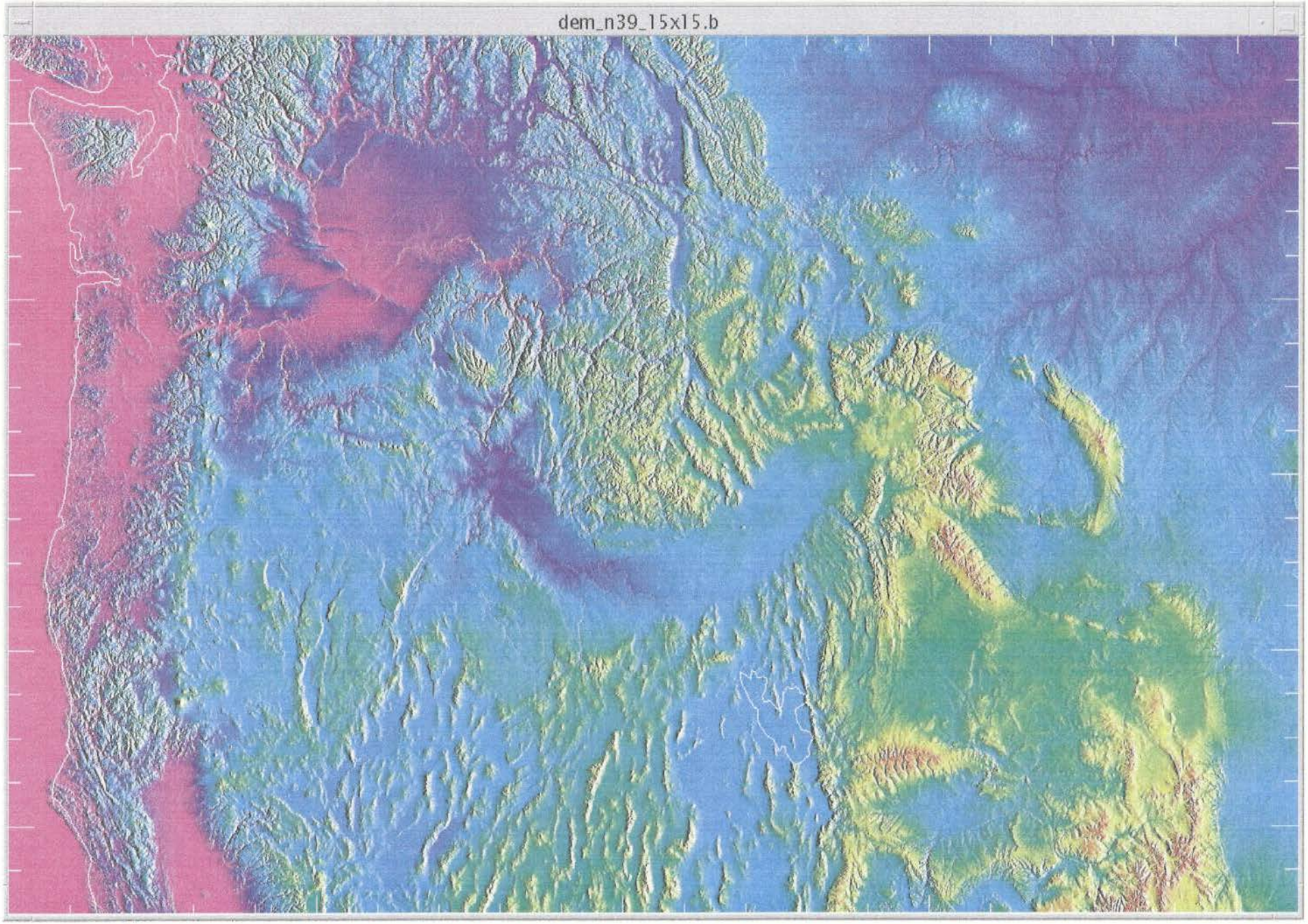
30 meter DEM in Northwest USA

- USGS makes 30 meter DEMs available in 7.5 minute quadrangular areas on UTM grid

- NGS acquired, cleaned, and regridded the data onto 1 arcsecond grid in the region 39/49 North and 231/256 East (NGSDEM99)

- Decimated 3 arcsecond DEM used for terrain corrections

- Geoid impact of new DEM in Northwest USA:
  - ~14 cm (1 σ) locally (max +/- 40 cm)
  - ~7 ppm tilts (1 σ) (max +/- 200 ppm)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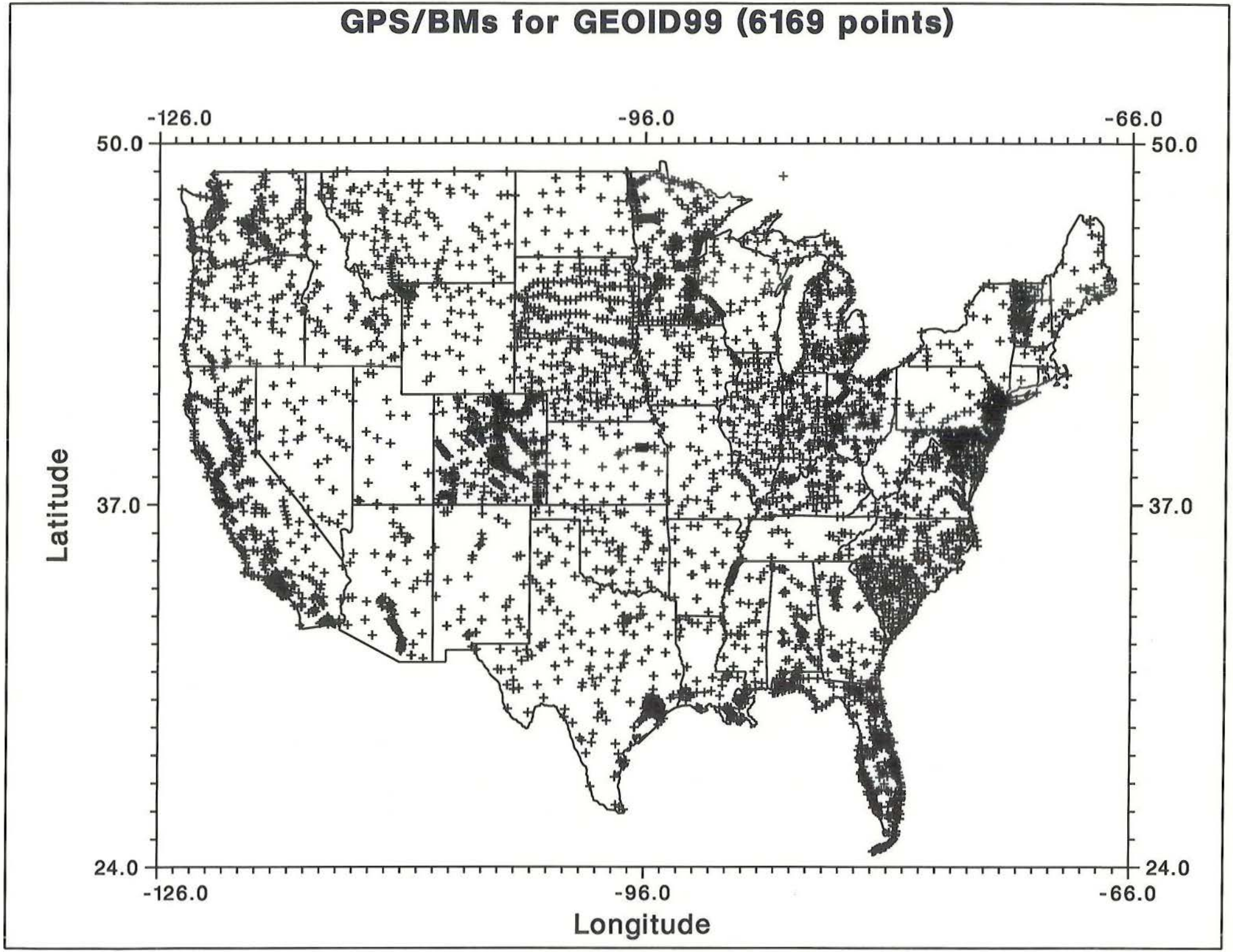

GPS/BMs for GEOID99 (6169 points)
-126.0
-96.0
-66.0
50.0
37.0
24.0
Latitude
Longitude

GPS on Benchmarks

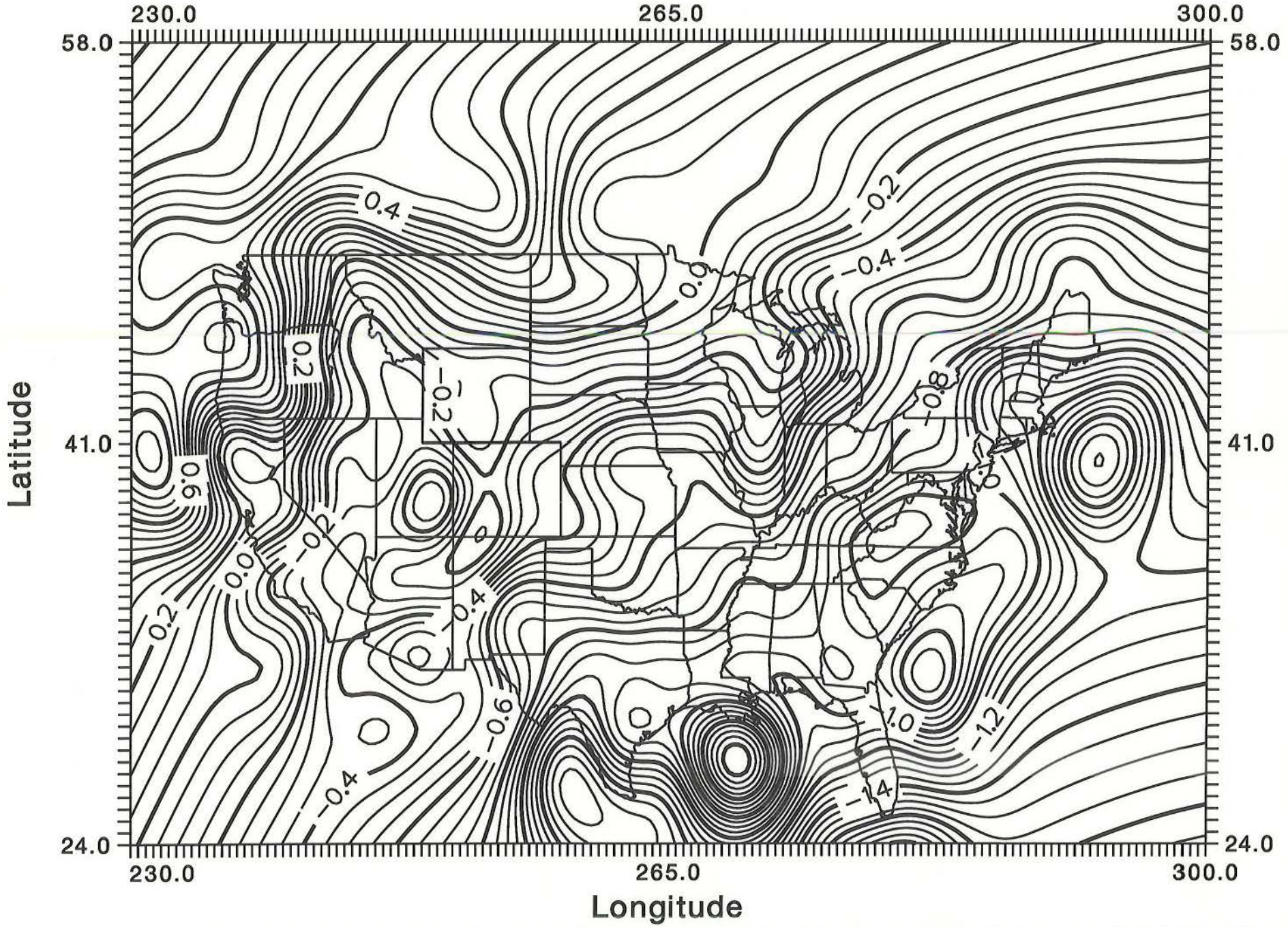
- 48 CONUS HARNs completed, including 6169 GPS measurements on leveled benchmarks.

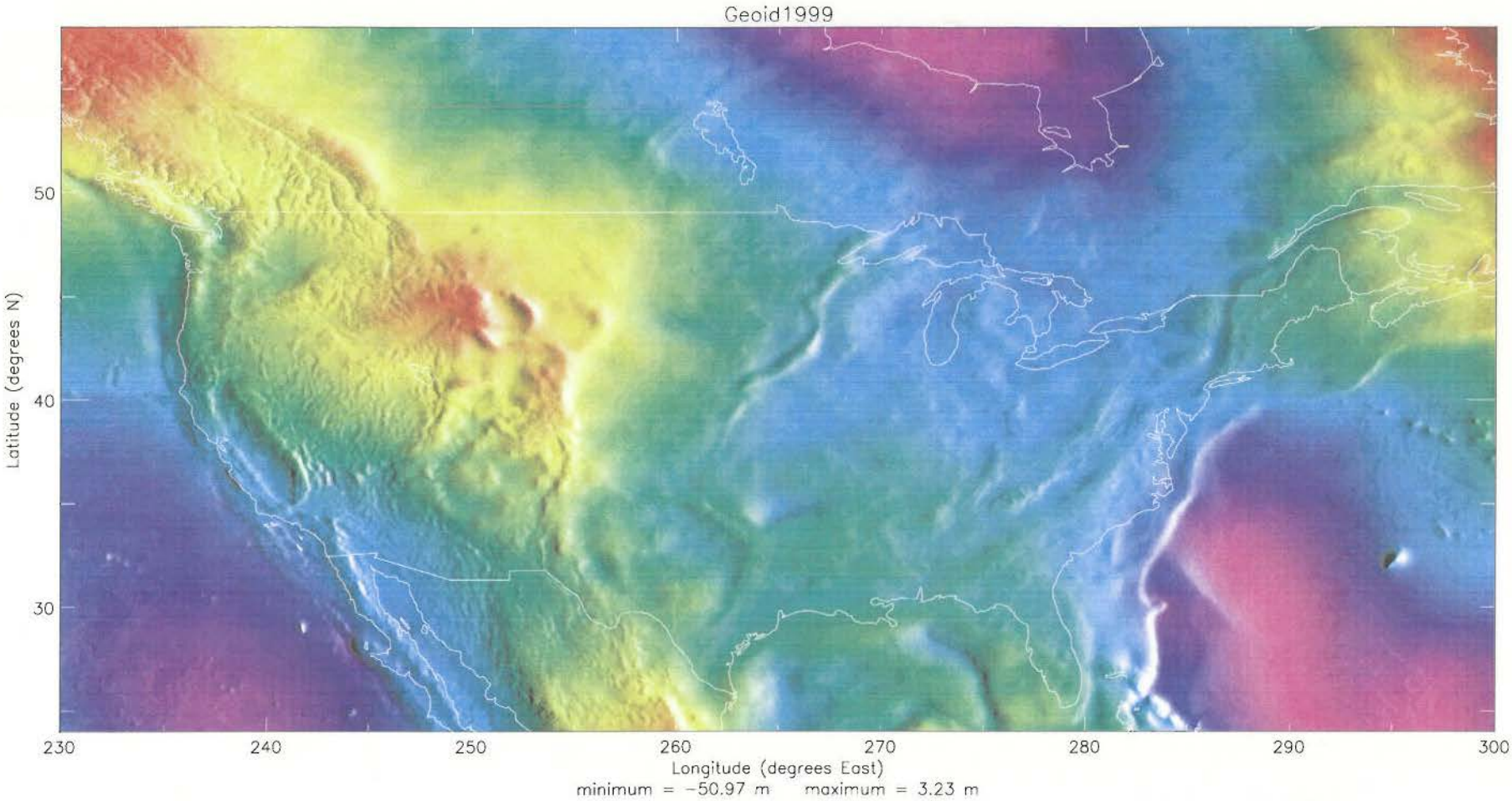
- G99SSS gravimetric geoid vs. GPS/BMs
  - Bias: 52 cm
  - Tilt: 0.15 ppm, 327 degrees azimuth
  - RMS after bias/tilt removal: 18.2 cm

- Collocation used to model the residuals yields GEOID99

- GEOID99 vs. GPS/BMs
  - Bias: 0 cm
  - Tilt: 0.0 ppm
  - RMS: 4.6 cm

Conversion Surface G99SSS -> GEOID99




Geoid1999
50
40
30
Latitude (degrees N)
230
240
250
260
270
280
290
300
Longitude (degrees East)
minimum = −50.97 m maximum = 3.23 m

GEOID96 vs GEOID99

	GEOID96	GEOID99
Grid	2'x2'	1'x1'
North edge	54°	58°
DEM	TOPO30 (30")	corrected TOPO30 and 1" NGSDEM99
TCs	30"	3" and 30"
GPS/BMs	2951	6169
NAVD 88 bias	-31 cm	-52 cm
RMS wrt GPS/BMs	5.5 cm	4.6 cm

GPS/GEOID vs Leveling
Cost Savings Example

- Baltimore County Example Project

- GPS/GEOID compared in parallel with Leveling

- Cost analysis indicates using GPS/GEOID yielded a savings of $125,000(¥ 13,443,750) for this one county.

- There are thousands of counties in the USA

FUTURE GEOID ITEMS

- Rigorous Helmert anomaly computations

- 1" DEM for entire USA

- Incorporation of rock density models

- Future geoid model areas may include any of:
  Canada, Greenland, Caribbean, Mexico, South America

- Annual models (?) to keep geoid current with latest GPS measured heights

GEOID99 Availability

http://www.ngs.noaa.gov/GEOID/GEOID99/geoid99.html

CD-ROM (Mid-November):

Information Services Branch
NOAA/National Geodetic Survey, N/NGS12
1315 East-West Highway, Station 9202
Silver Spring, MD 20910-3282
U.S.A.
voice: 1-301-713-3242
fax: 1-301-713-4172