

**Recent Advances in the Acquisition
and Use of Terrain Data for
Geoid Modeling over the
United States**

by

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History of Terrain Approximations at NGS

1) Data Quality

- Coarse (*30 arcseconds* horiz. resolution)
- Systematic Errors (*biases* over huge areas)

2) Data Use

- *Faye* Anomalies = Helmert Anomalies
- *Planar* coordinates
- *Point-mass* FFT
- *TC* = Remove 3-D/Restore condensed mass

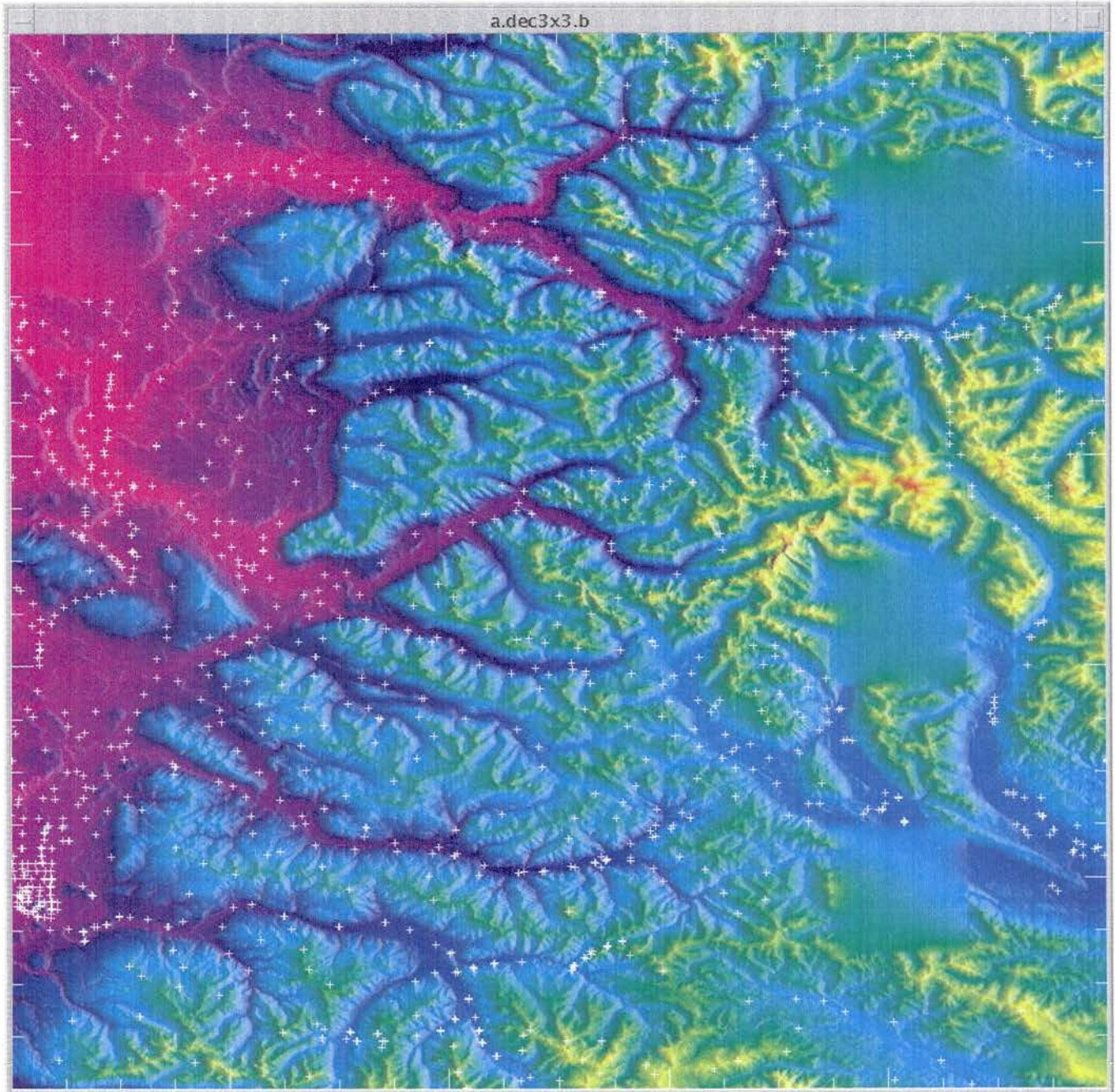
DEM: USGS vs NIMA

	<u>USGS</u>	<u>NIMA</u> (<u>DTED level 1</u>)
<u>Resolution:</u>	30 m (1"-2")	3"
<u>Grid:</u>	UTM	lat/lon
<u>Availability:</u>	Free on WWW	Proprietary
<u>Format:</u>	SDTS	DMA DTED
<u>Vertical Datum:</u>	Well defined (usually NGVD29)	Unknown (ellipsoid & WGS84 geoid?)
<u>Horizontal Datum:</u>	Well defined (usually NAD 27)	Unknown(WGS84? WGS72?)
<u>Sources:</u>	1:24 k maps or photogrammetry	1:250 k maps or one of 25 other sources
<u>Biggest Problems:</u>	<ul style="list-style-type: none">* 1% to 2% of files have blunders.* No Q.C.?* No data outside U.S.A.	<ul style="list-style-type: none">* Does not contain true 3" spectral info.* Poorly identified datum info.

Tests of Ultra-High Resolution DEMs

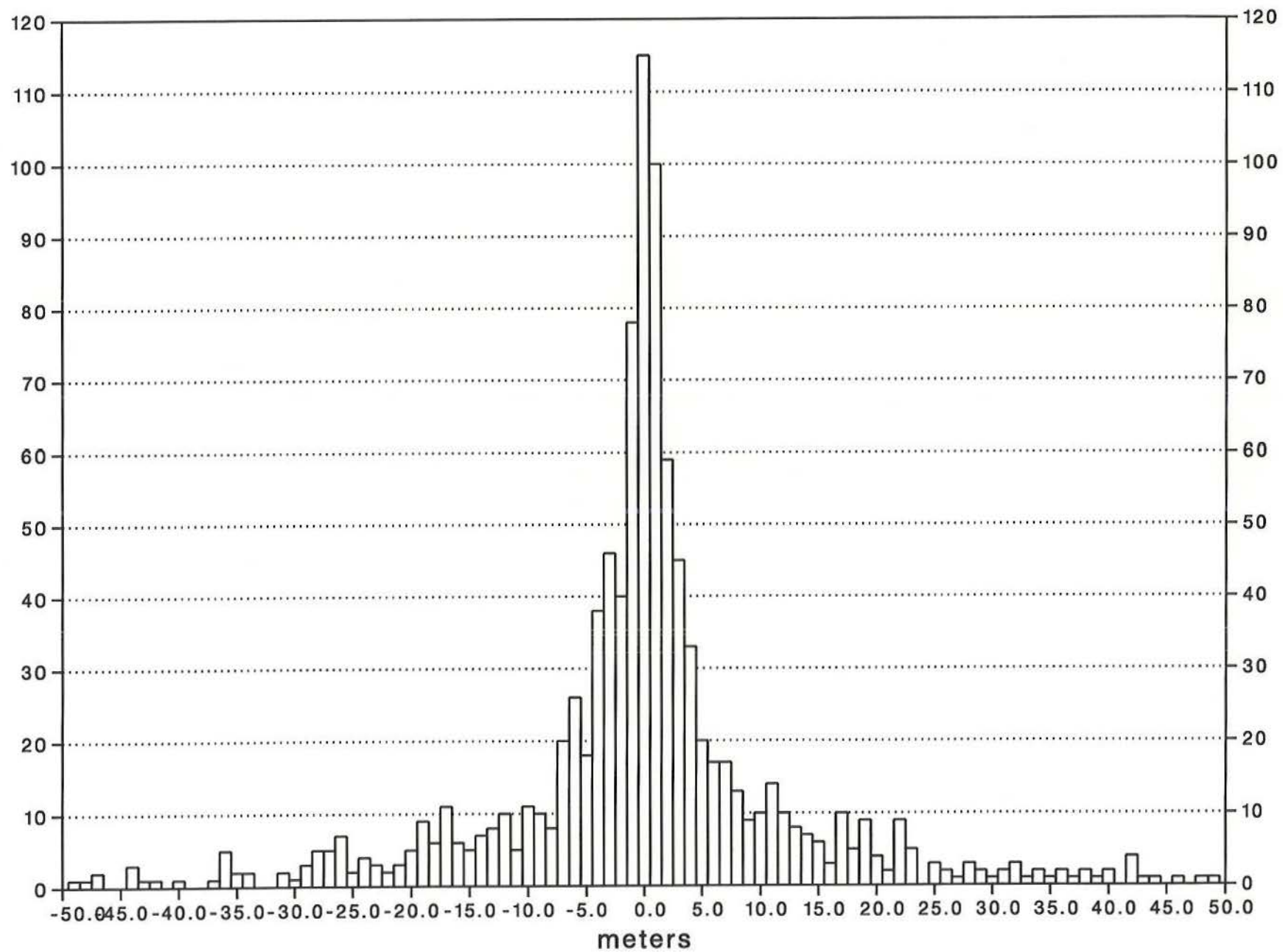
- 1) DEM heights vs. heights stored in the NGS gravity database**
- 2) Terrain corrections from the DEM and their impact on the geoid**

Test Area A: 47/48 N, 237/238 E

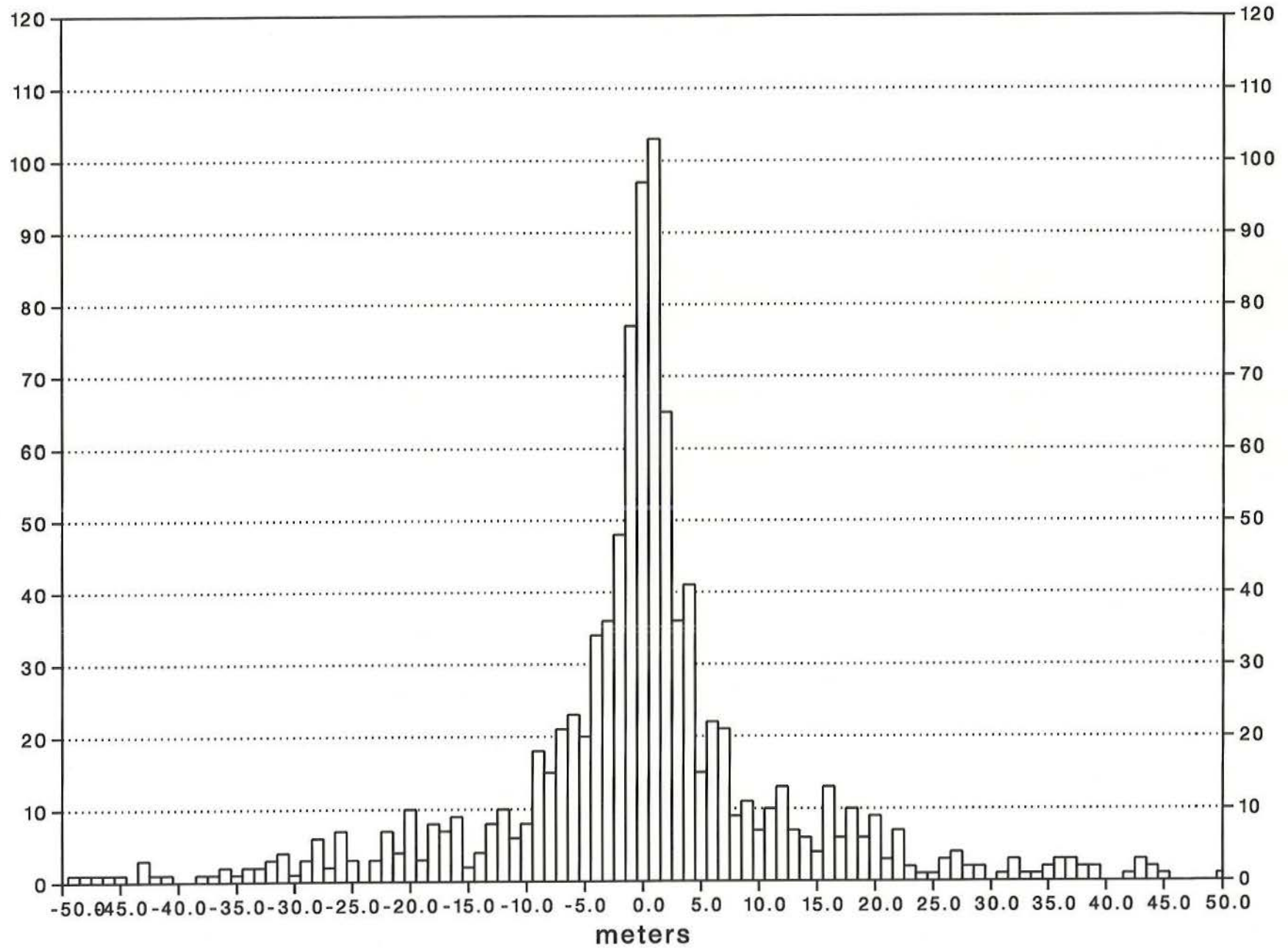


1076 Gravity Points

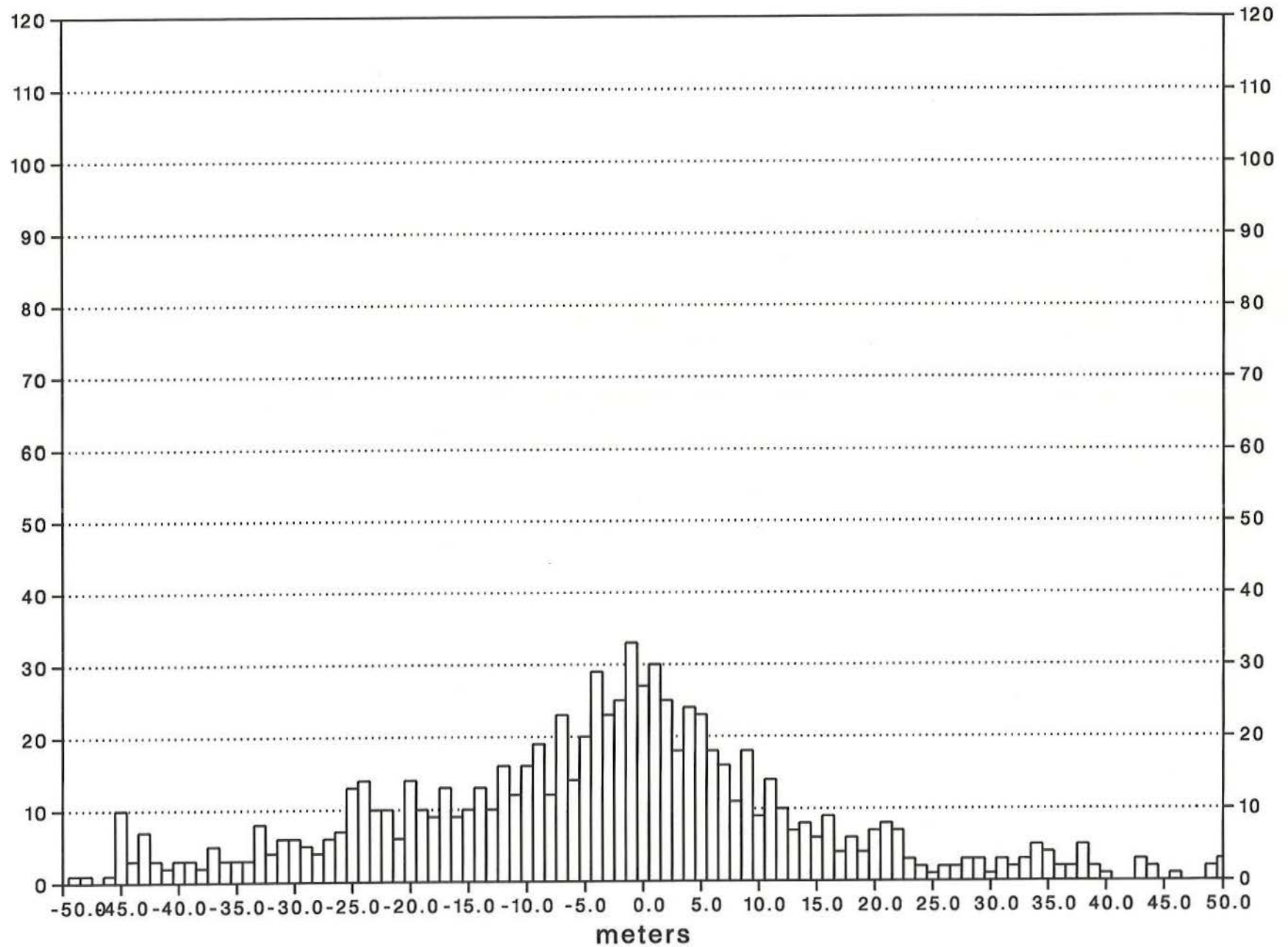
Mismatch, USGS 1" vs. Gravity DB, area A



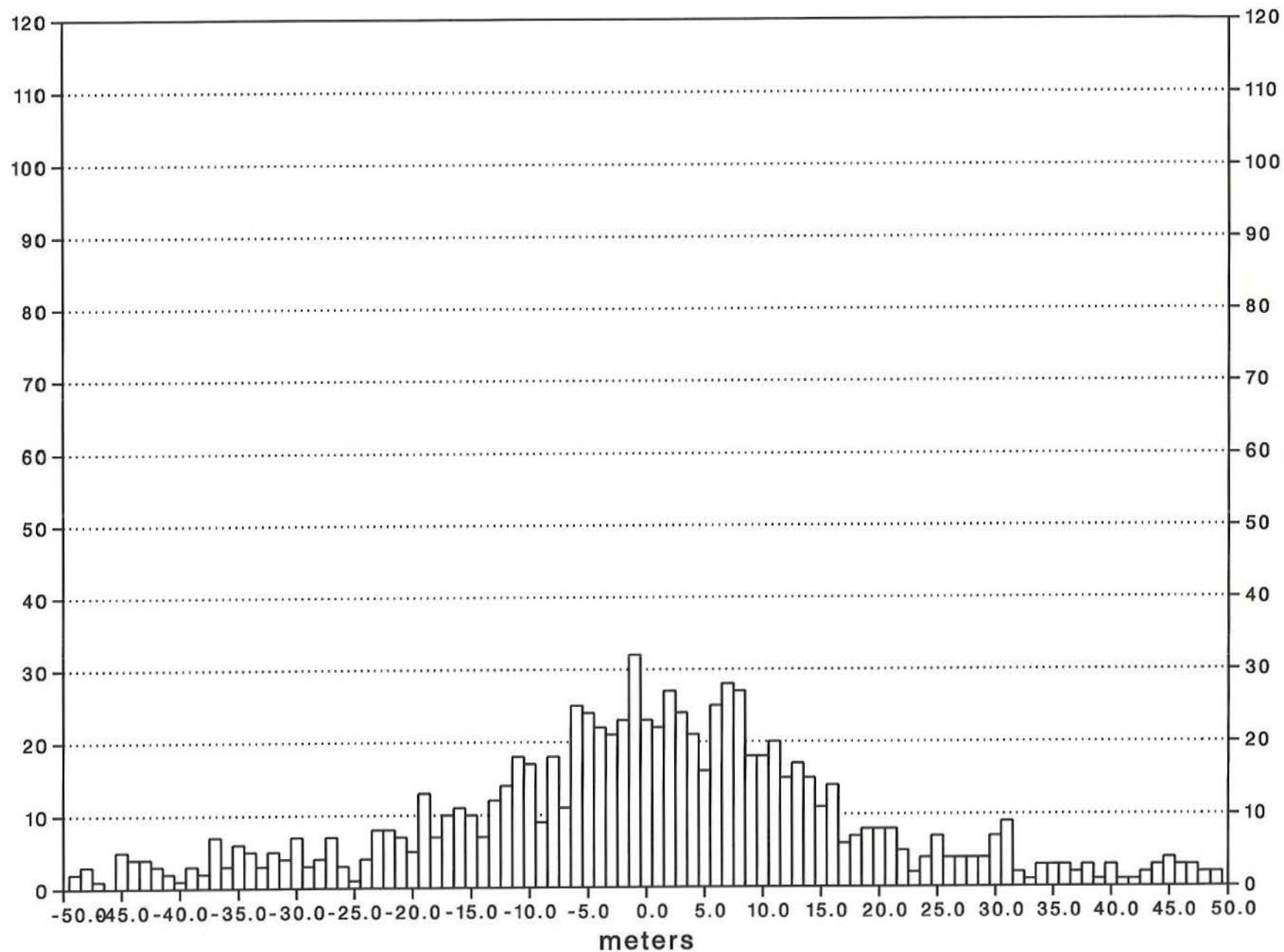
Mismatch, USGS 1"->3" vs. Gravity DB, area A



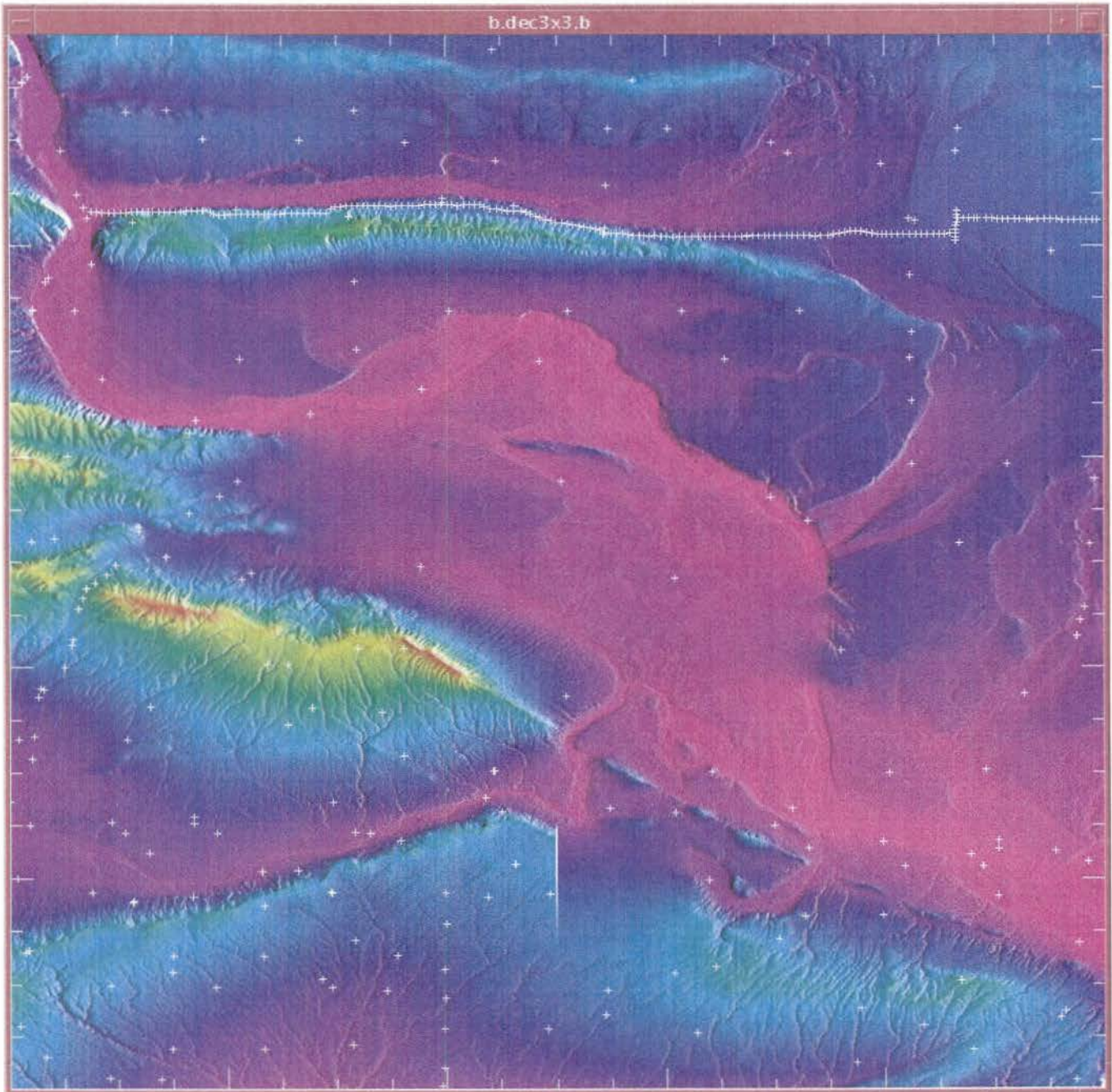
Mismatch, USGS 1"->30" vs. Gravity DB, area A



Mismatch, DTED1 (3") vs. Gravity DB, area A

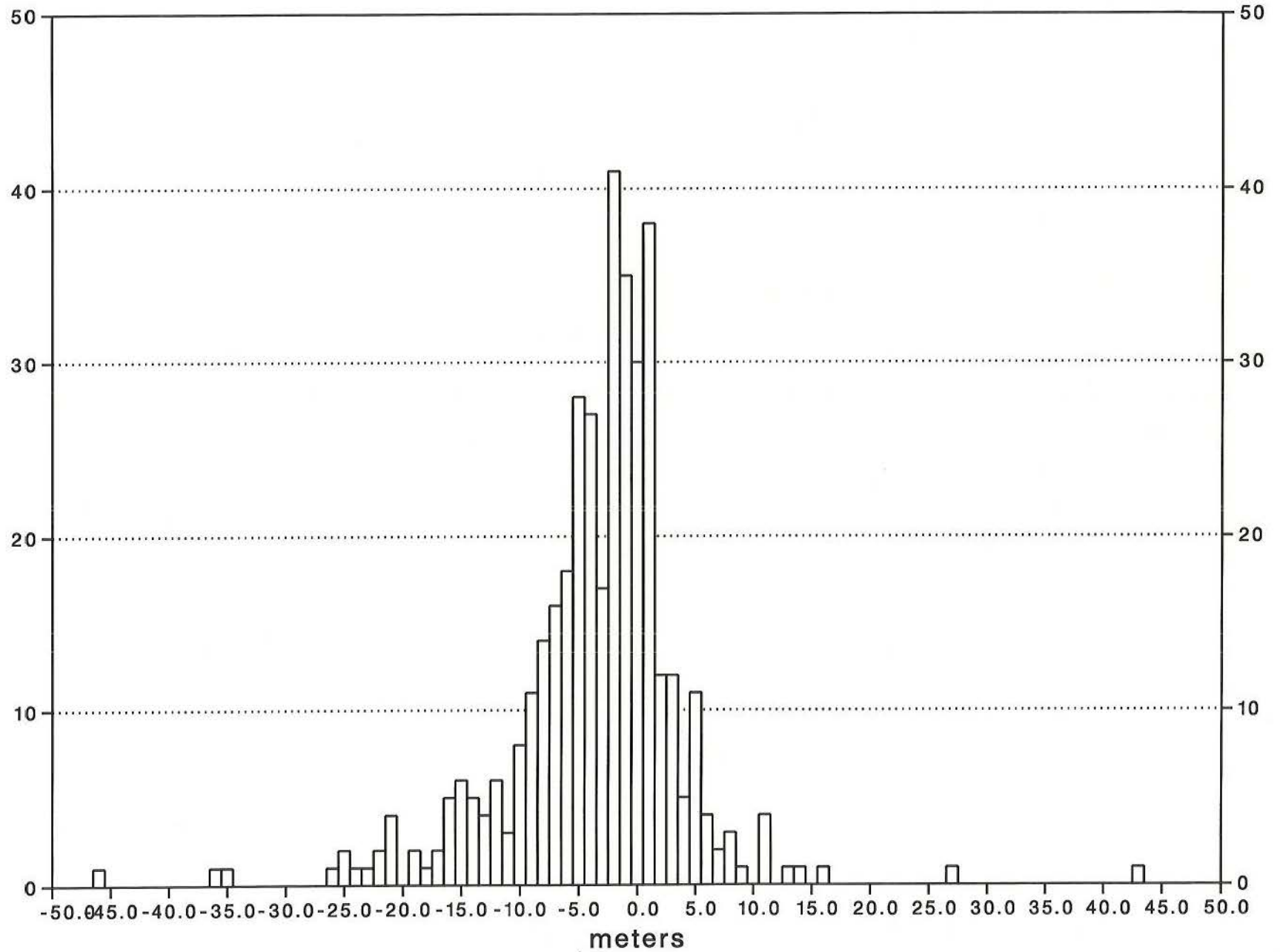


Test Area B: 46/47 N, 240/241 E

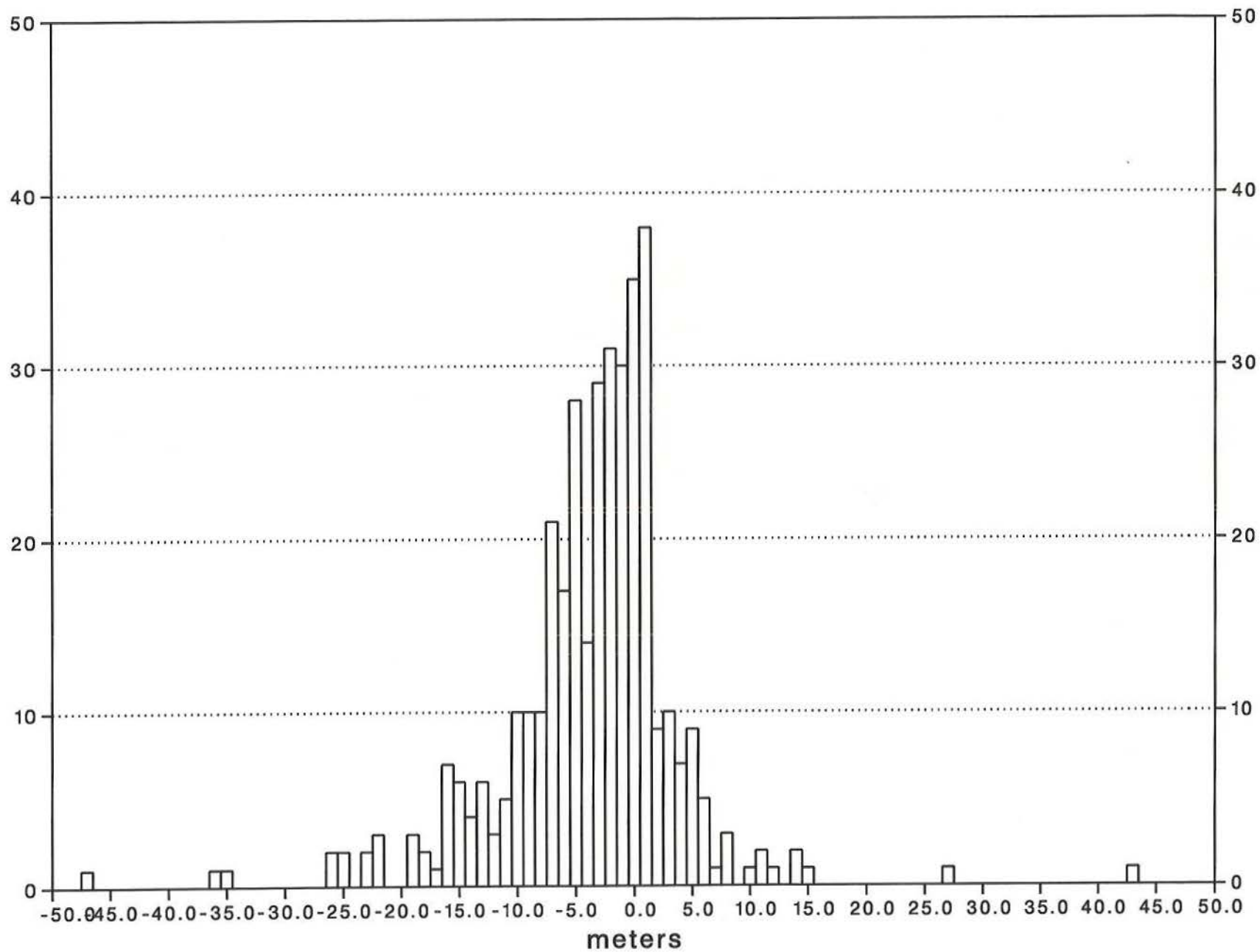


397 Gravity Points

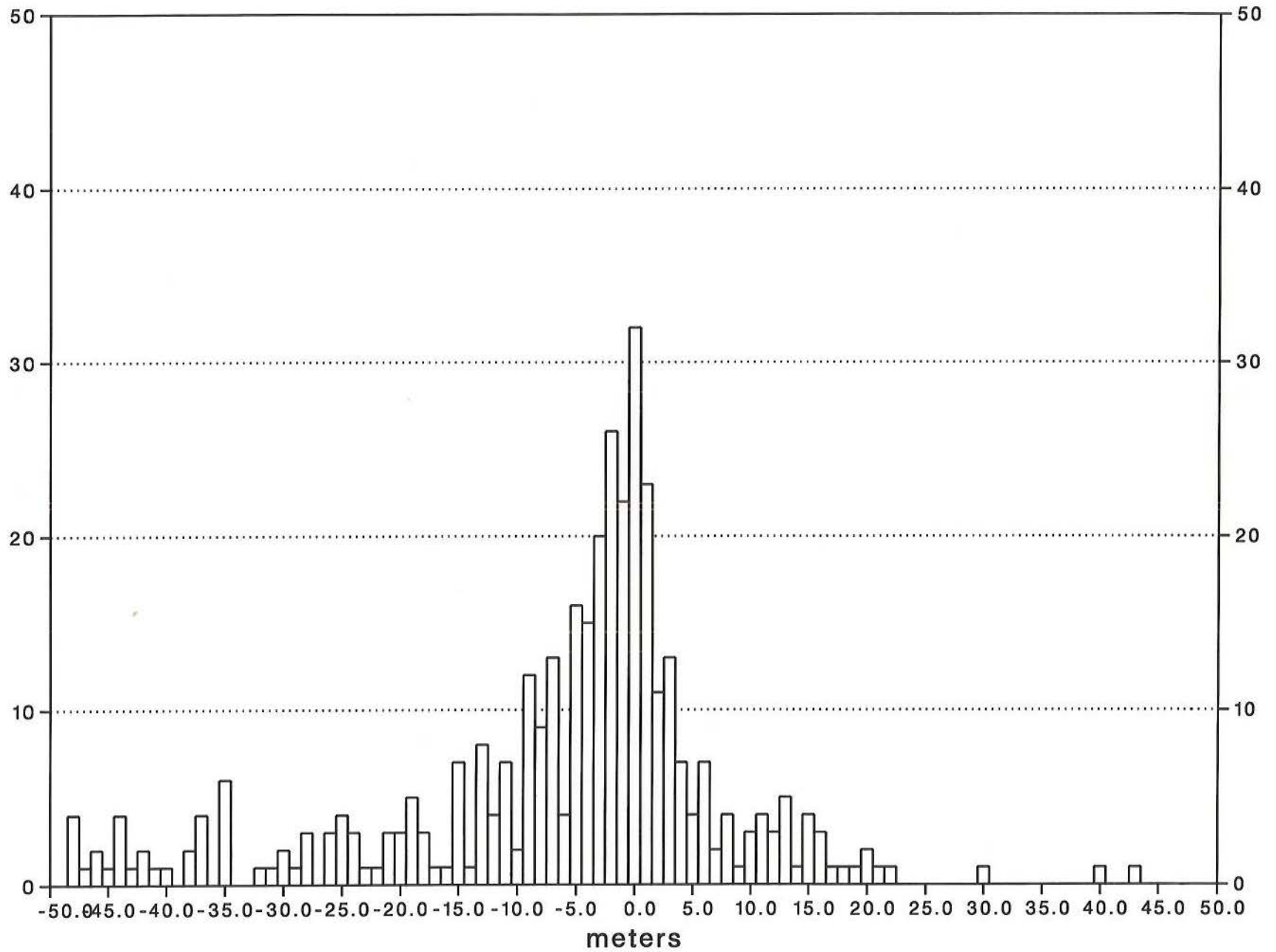
Mismatch, USGS 1" vs. Gravity DB, Area B



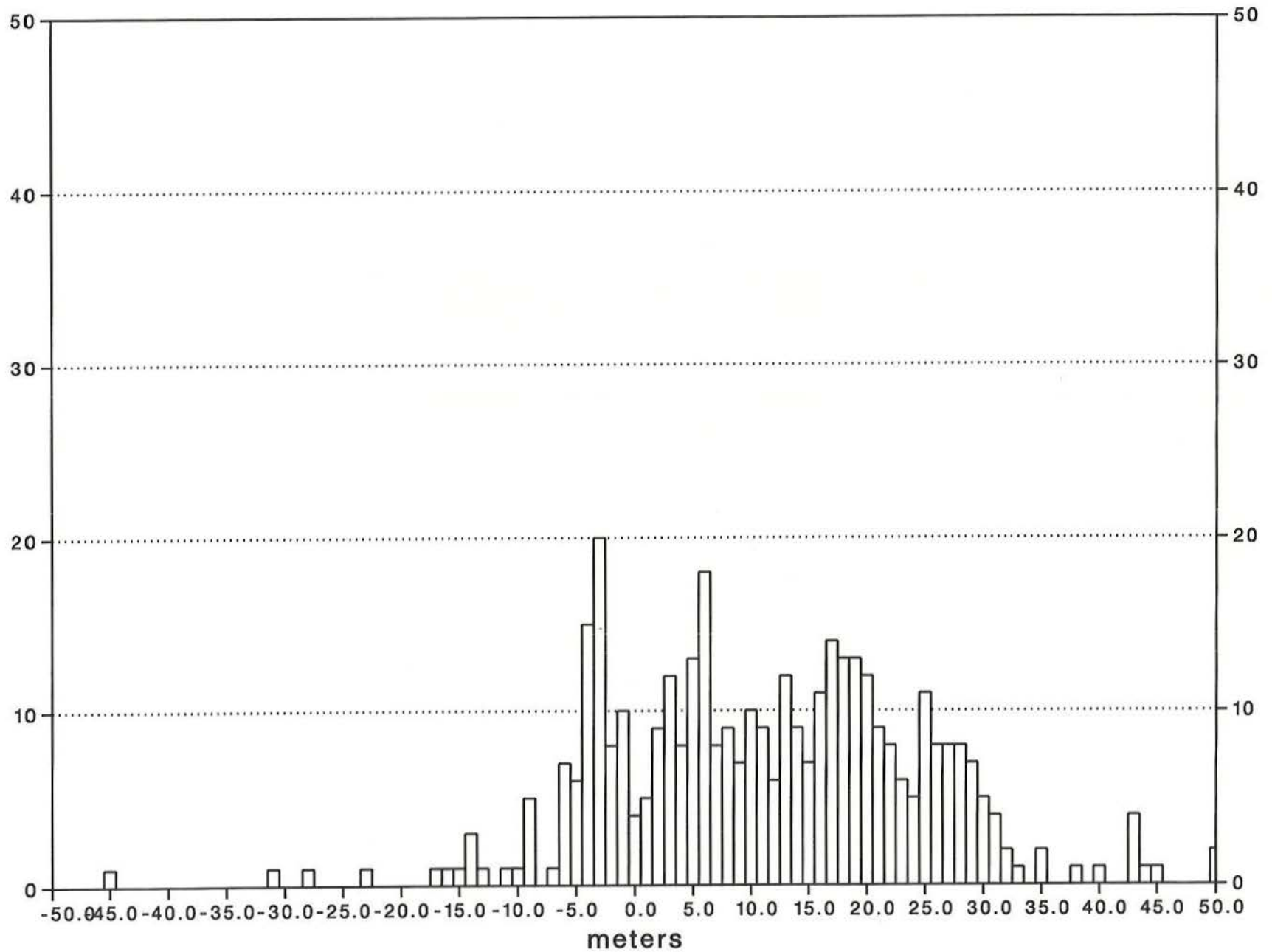
Mismatch, USGS 1"->3" vs. Gravity DB, Area B



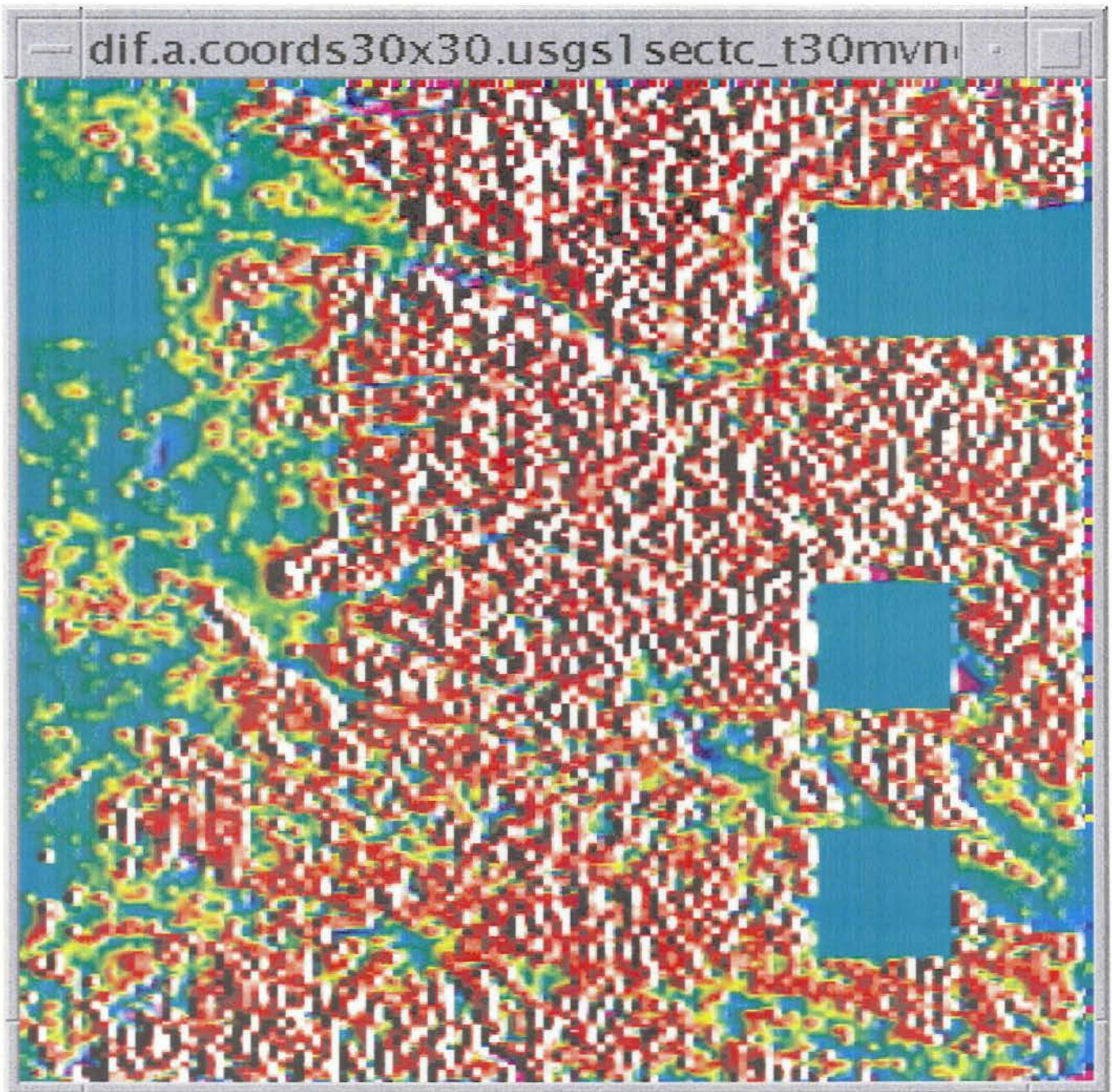
Mismatch, USGS 1"->30" vs. Gravity DB, Area B



Mismatch, DTED1 (3") vs. Gravity DB, Area B

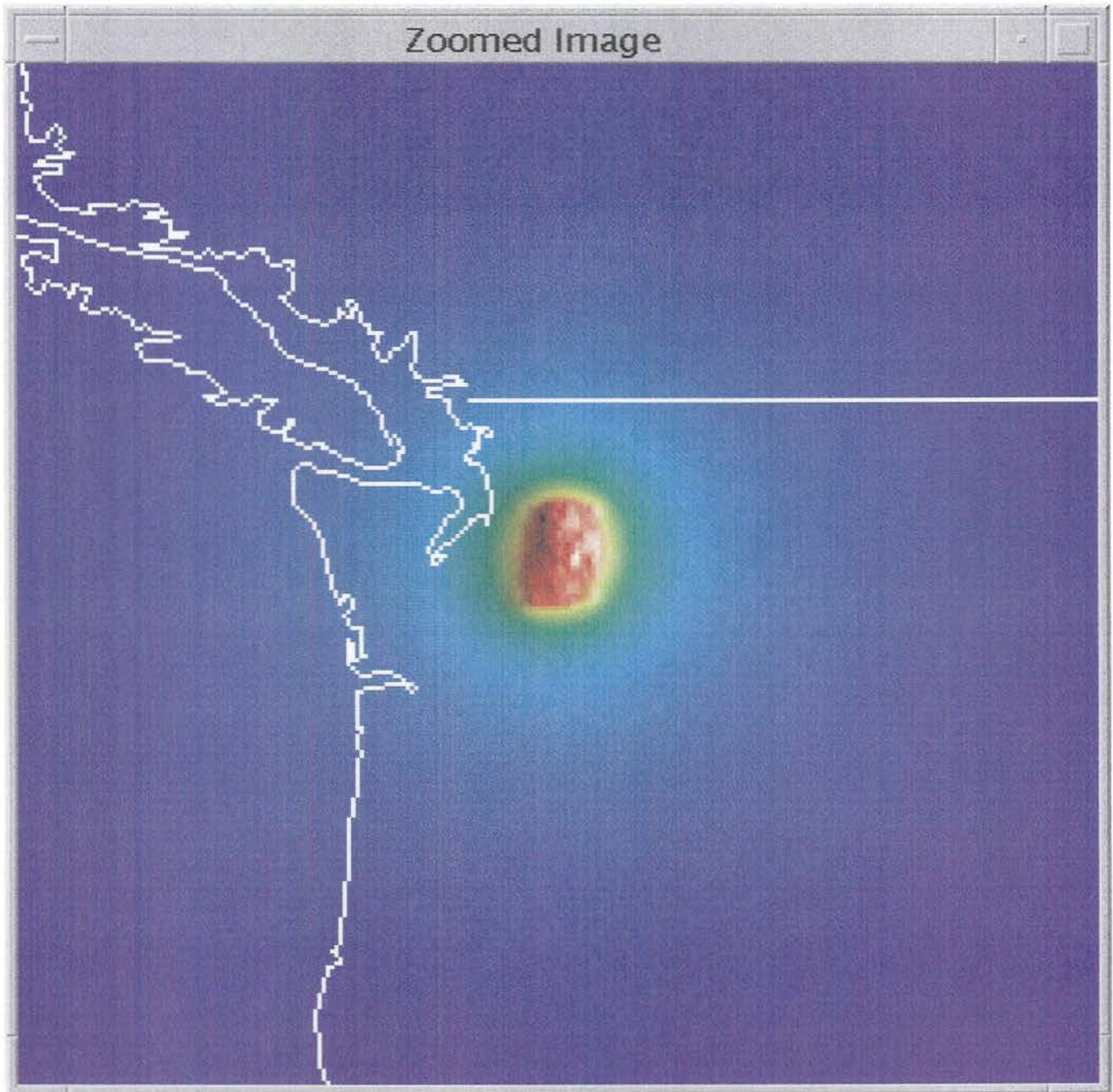


Test Area A: 47/48 N, 237/238 E



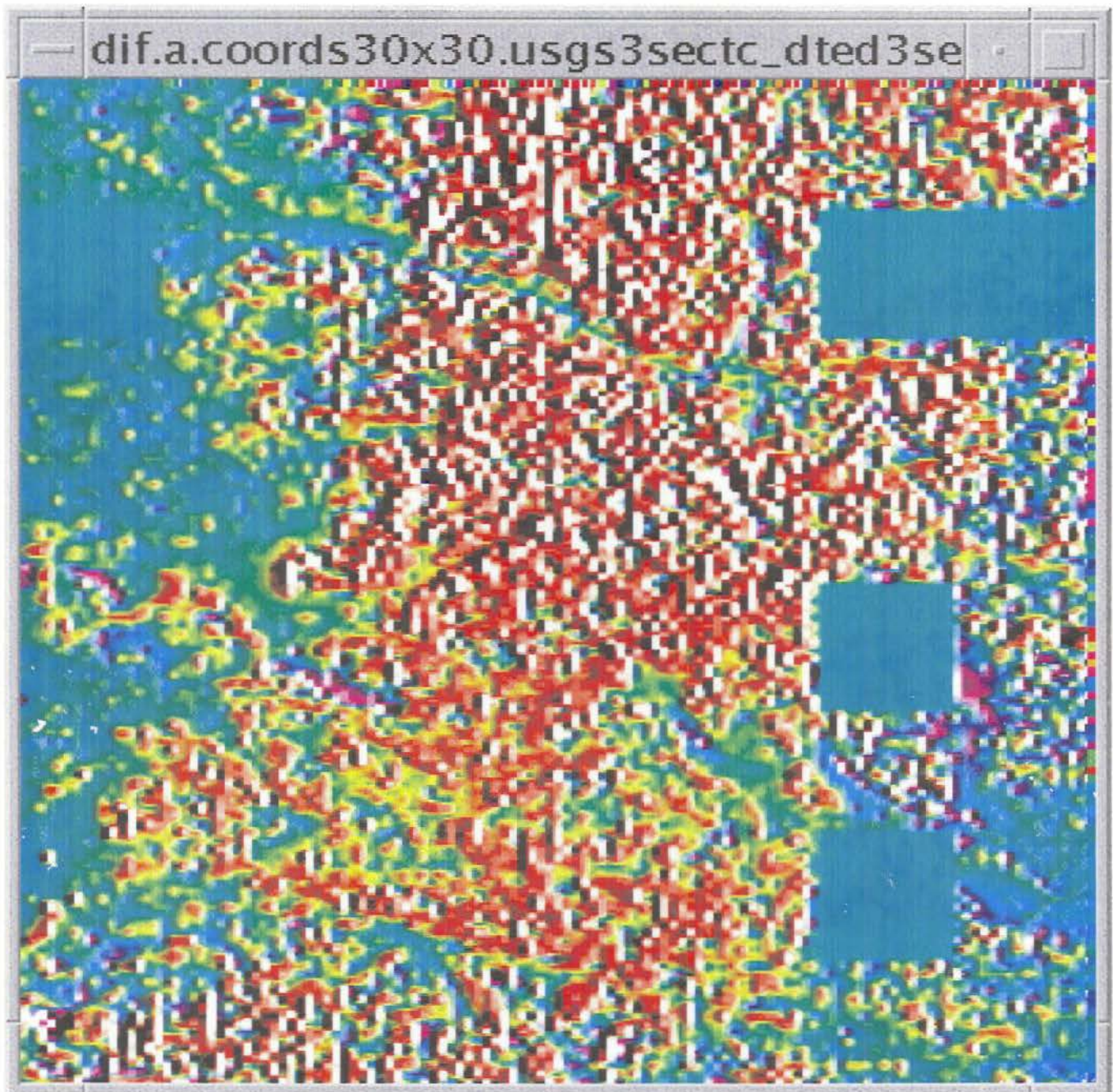
USGS 1" TC minus TOPO30 30" TC
ave = 1.4 mGal max = +20 mGal

Test Area A: 47/48 N, 237/238 E
GEOID Impact



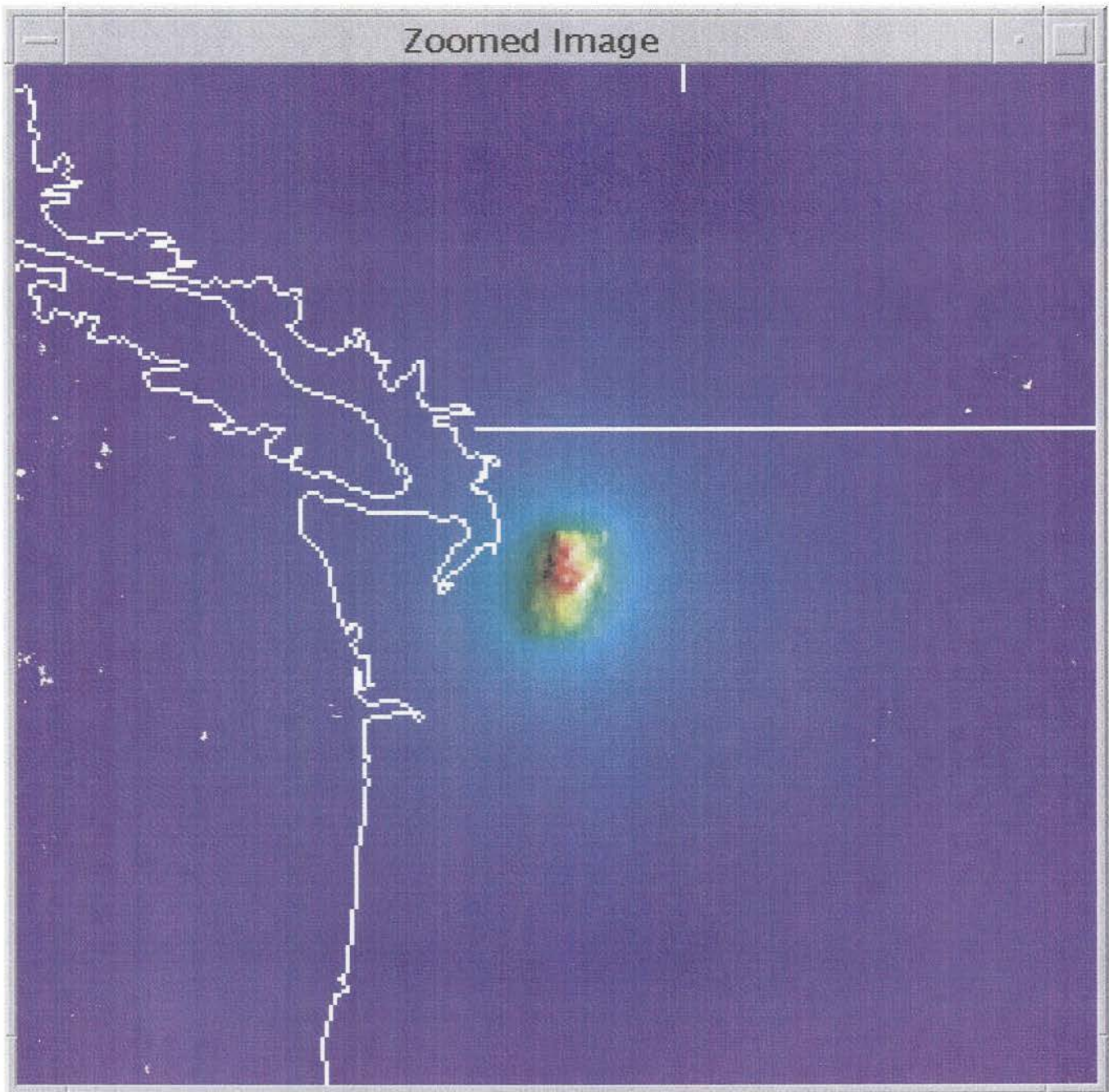
USGS 1" TC minus TOPO30 30" TC
max = 9.4 cm >1 cm out to 400 km

Test Area A: 47/48 N, 237/238 E



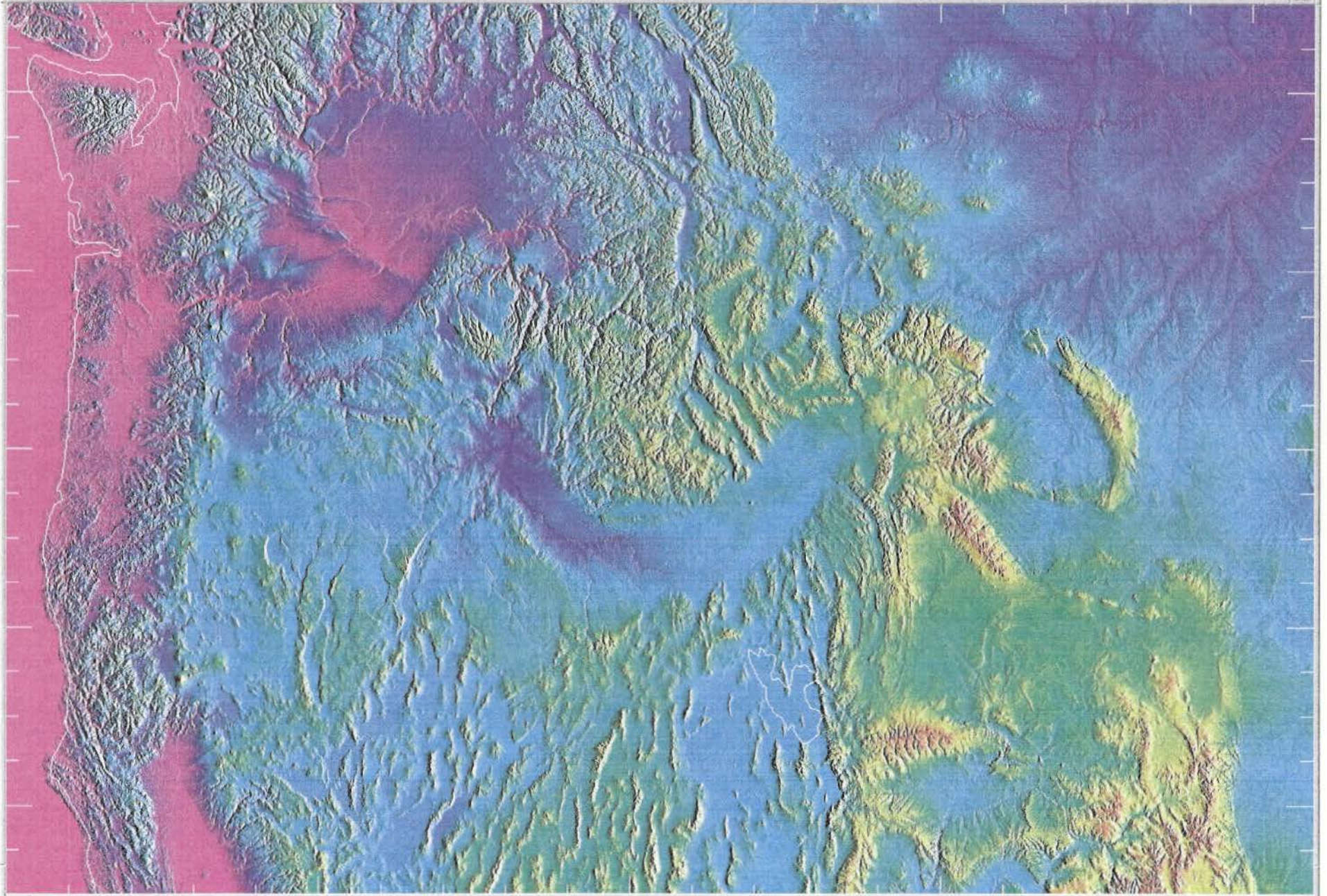
USGS 3" TC minus NIMA 3" TC
ave = .72 mGal **max = +18 mGal**

Test Area A: 47/48 N, 237/238 E
GEOID Impact

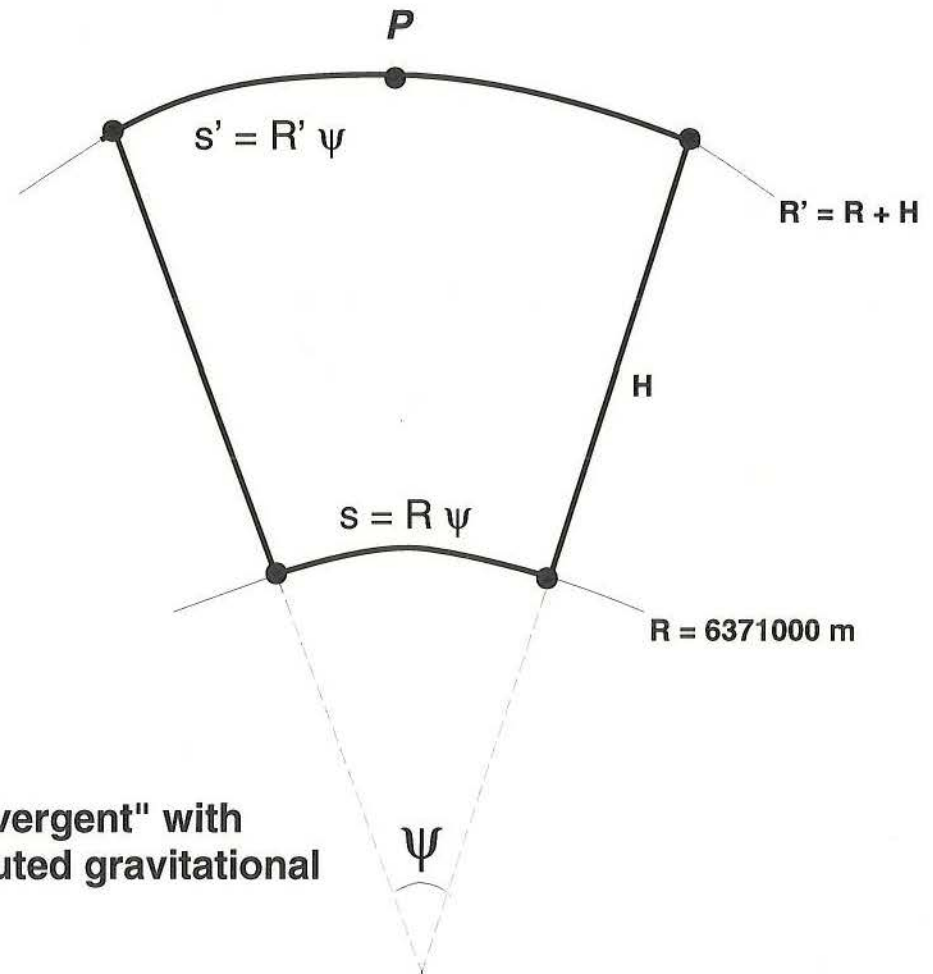
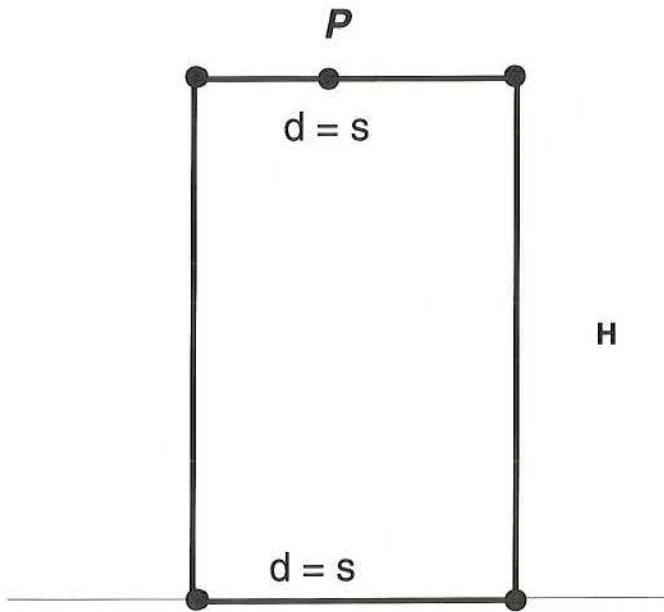


USGS 3" TC minus NIMA 3" TC
max = 5.8 cm >1 cm out to 200 km

dem_n39_15x15.b

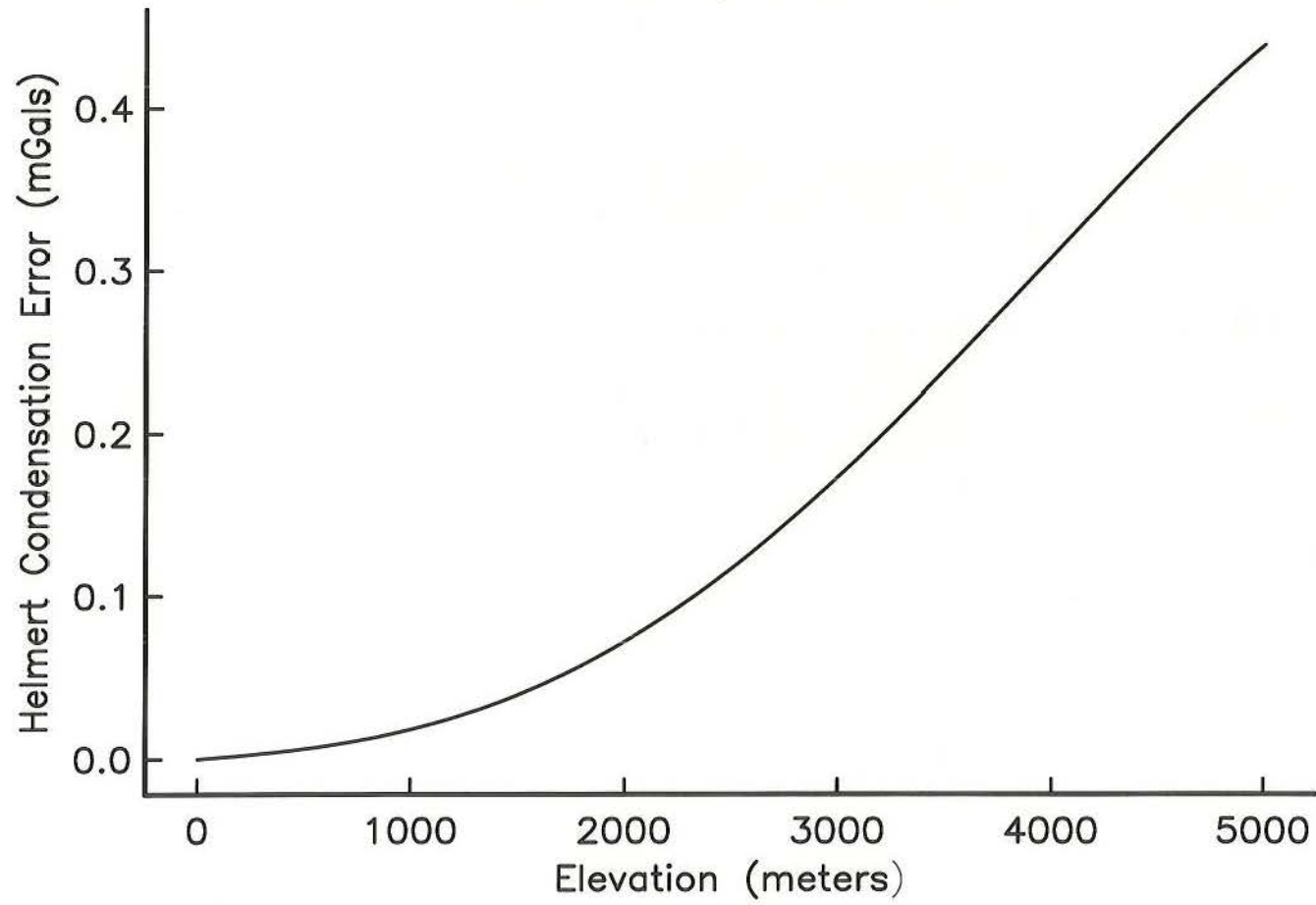


Near Field Spherical Effect

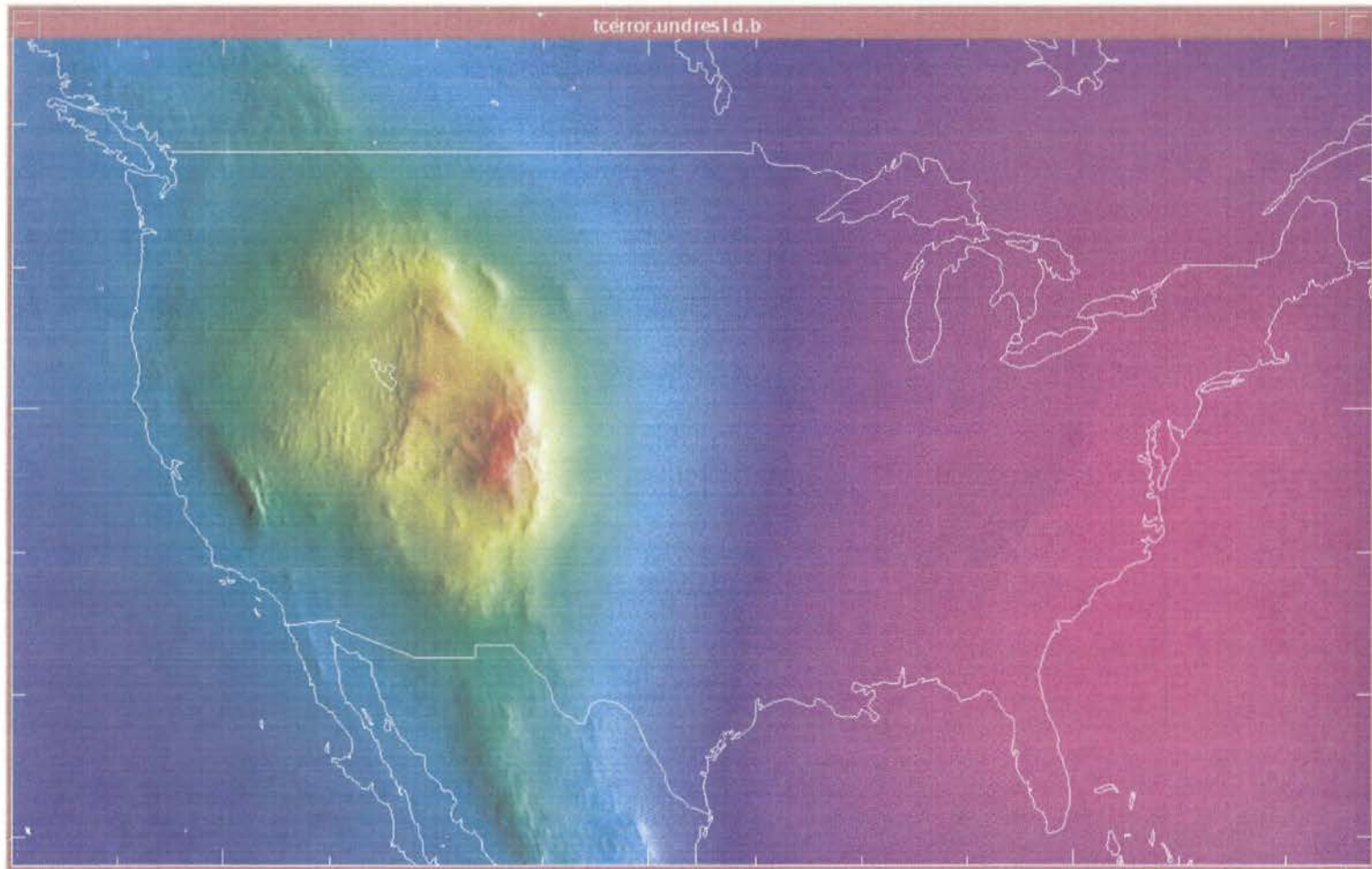


Volume and mass distribution become more "divergent" with increasing ψ and increasing H . Therefore computed gravitational attraction also diverges.

Near Field Spherical Effect



Near Field Spherical Effect on the Geoid



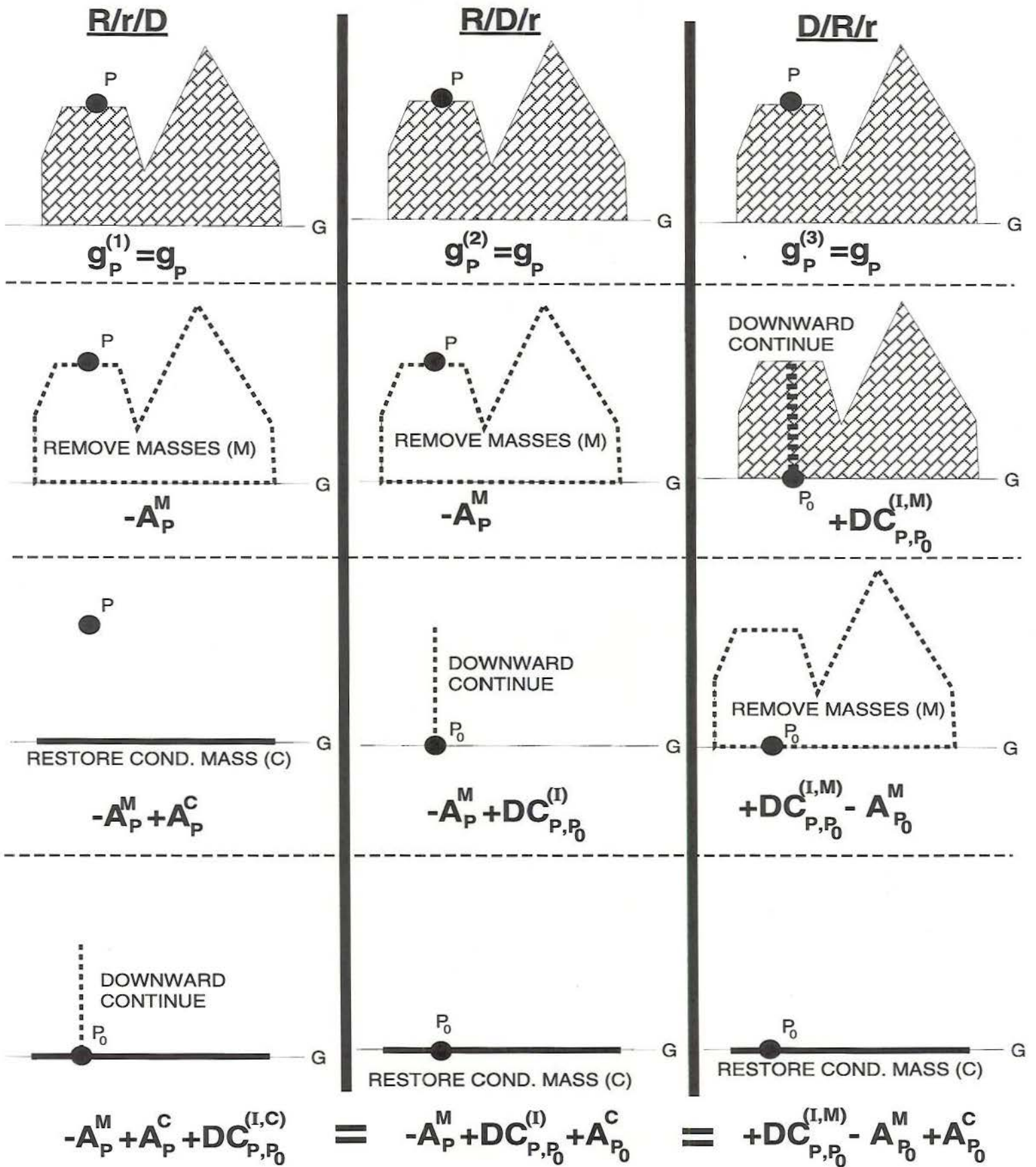
Ave = 3 mm, Range = 0 cm to +7.5 cm

Preliminary Space Domain Tests

- Show how best to remove 3-D masses and restore condensed mass layer in space domain
- Tested in multiple terrain types
- Results (Paper in draft form):
 - 1) Use spherical coordinates
 - 2) Use 1" or 3" DEM for $0^\circ < \psi < 0.2^\circ$
 - 3) Use 30" DEM for $0.2^\circ < \psi < 4.0^\circ$
 - Cumulative error of not using 3" = 0.01 mGal
 - 4) Use 5' DEM for $4.0^\circ < \psi < 180^\circ$ (and use FFT or Spherical Harmonics)
- Make extensive use of elliptic integrals and parallel CPUs

Summary and Conclusions

- **Use spherical coordinates for all terrain computations**
- **Switch to USGS 30 meter DEM, regridded at 1''**
- **Confirm FFT with space domain computations**
- **Capture global terrain signal through a combination of varying resolutions and computational methods**



For Downward Continuation:

- I = Masses Interior to Geoid
- C = Condensed Crustal Masses
- M = Original Crustal Masses

Naming Convention of gravity reductions:

- R = Remove Crustal Masses
- r = Restore Condensed Crustal Masses onto geoid
- D = Downward Continue from original station to geoid