# Reducing the Impact on the Geoid of Systematic Errors in the DEM and Computational Approximations in Terrain Reductions

by

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Presented at the Spring 1999 meeting of the American Geophysical Union
Boston, Massachusetts
June 2, 1999

## History of terrain approximations at NGS:

- GEOID96 used:
  - Faye anomalies rather than Helmert
  - Planar Earth for TC computation
  - "line mass" FFT code
  - 30" DEM, originating from DTED level 1

- Methods of repair:
  - High resolution DEM
  - True Helmert computations (spherical)
  - "prism mass" FFT code

# DEM: *USGS* vs *NIMA*

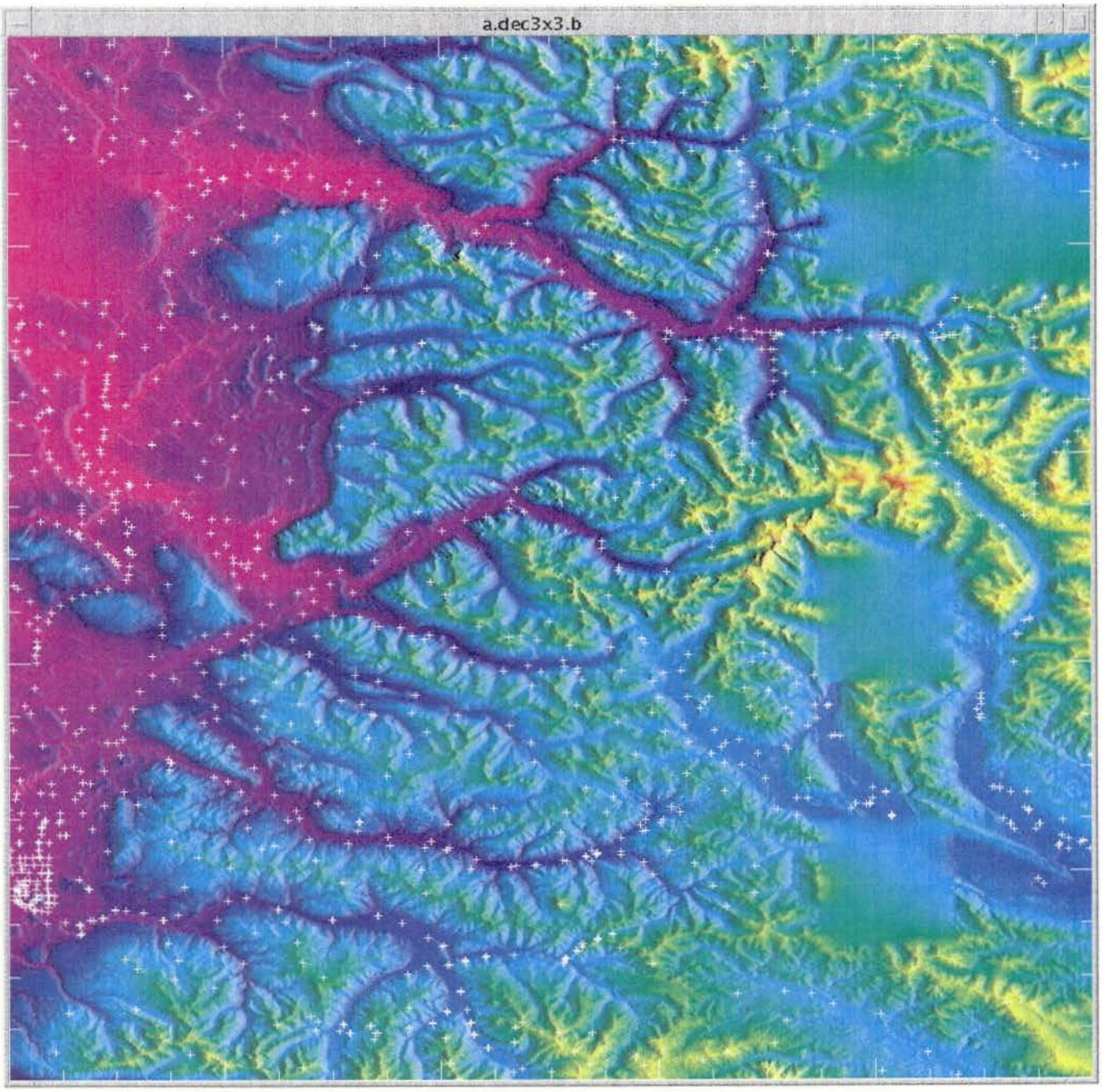
| | USGS | NIMA (DTED level 1) |
|---|---|---|
| Resolution: | 30 m (1"-2") | 3" |
| Grid: | UTM | lat/lon |
| Availability: | Free on WWW | Proprietary |
| Format: | SDTS | DMA DTED |
| Vertical Datum: | Well defined (usually NGVD29) | Unknown (ellipsoid & WGS84 geoid?) |
| Horizontal Datum: | Well defined (usually NAD 27) | Unknown(WGS84? WGS72?) |
| Sources: | 1:24 k maps or photogrammetry | 1:250 k maps or one of 25 other sources |
| Biggest Problems: | * 1% to 2% of files have blunders.<br>* No Q.C.?<br>* No data outside U.S.A. | * Does not contain true 3" spectral info.<br>* Poorly identified datum info. |

# Tests of Ultra-High Resolution DEMs

1) DEM heights vs. heights stored in the NGS gravity database

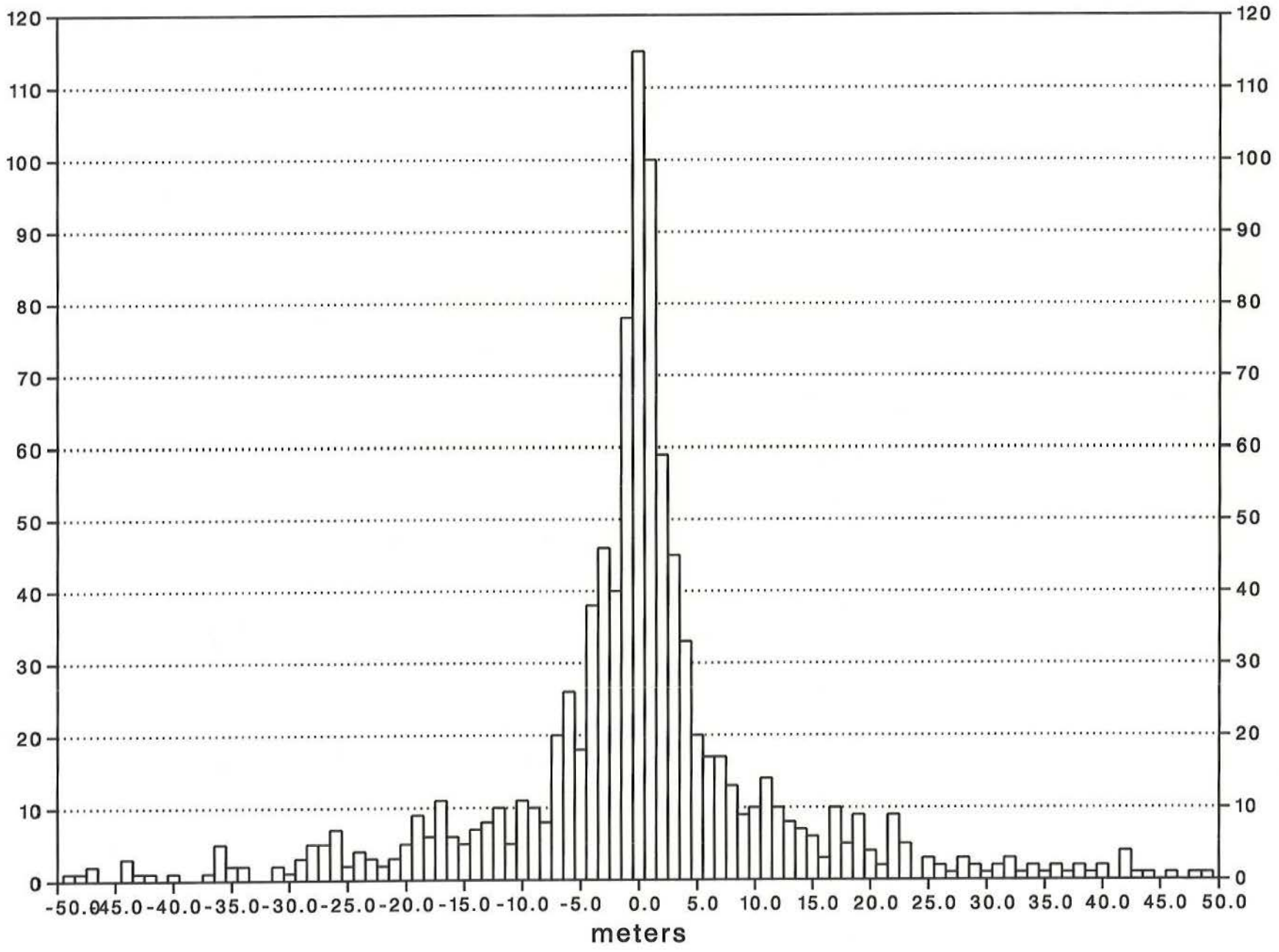
2) Terrain corrections from the DEM and their impact on the geoid

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

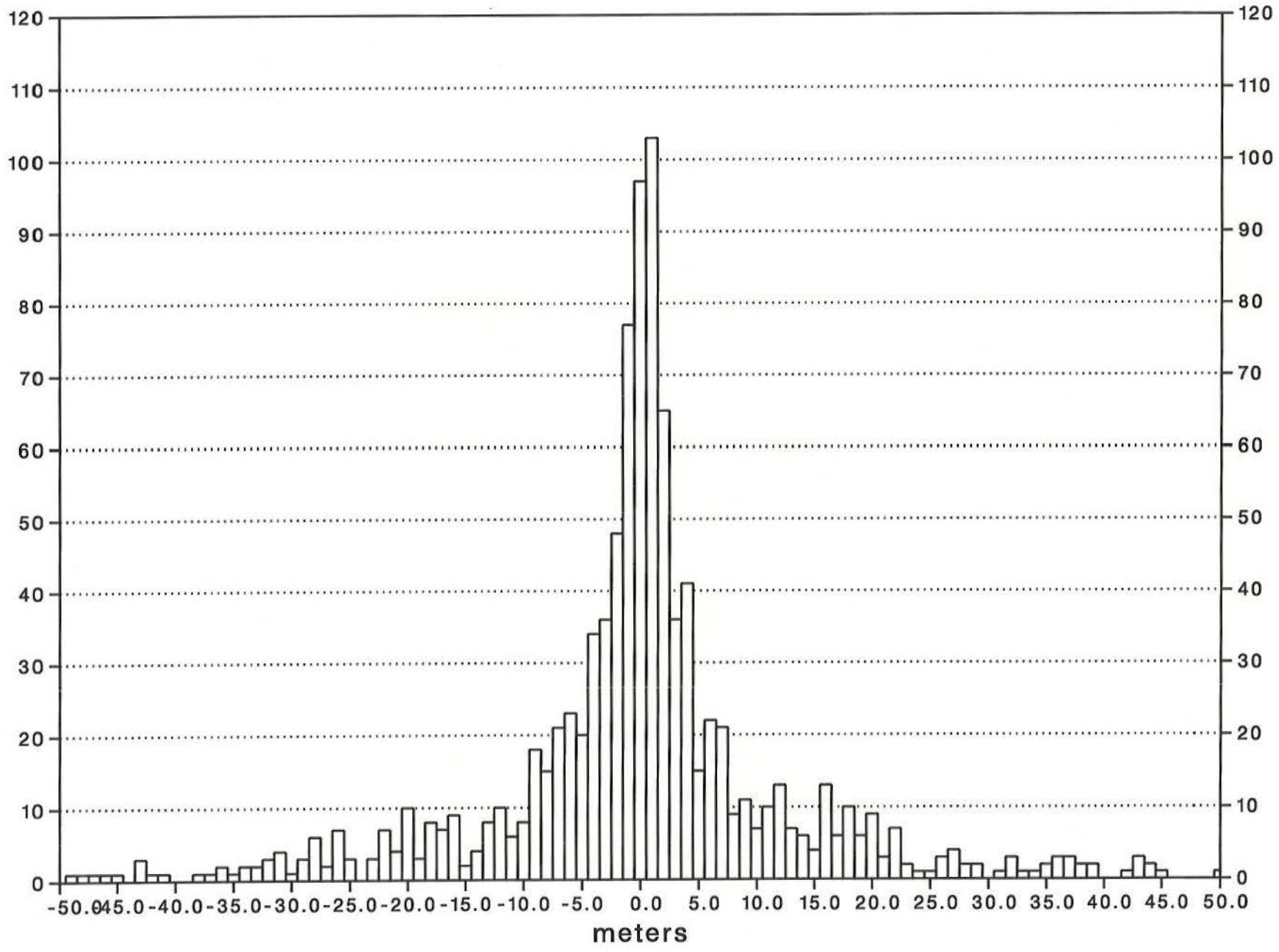



# 1076 Gravity Points

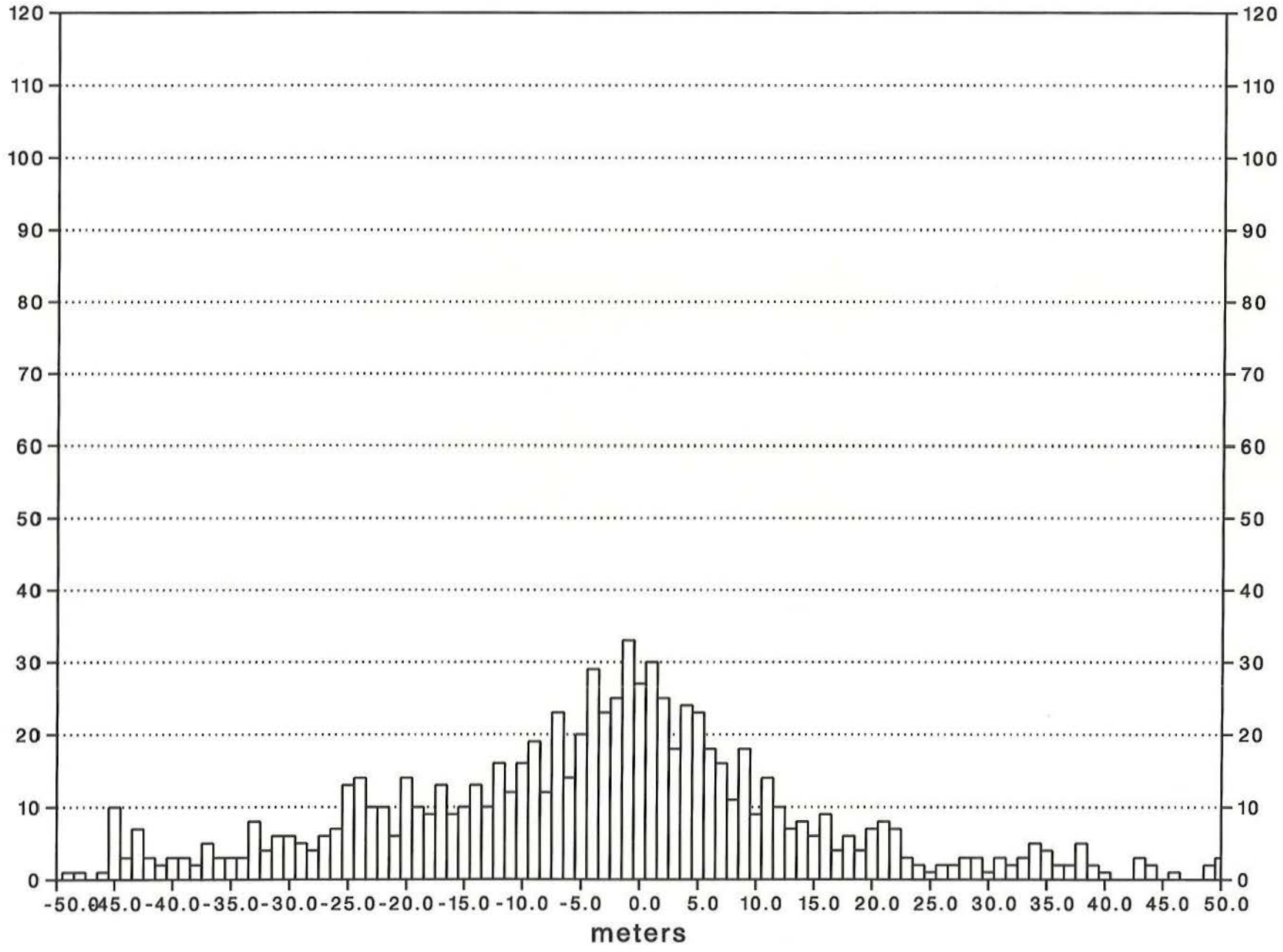
# Mismatch, USGS 1" vs. Gravity DB, area A



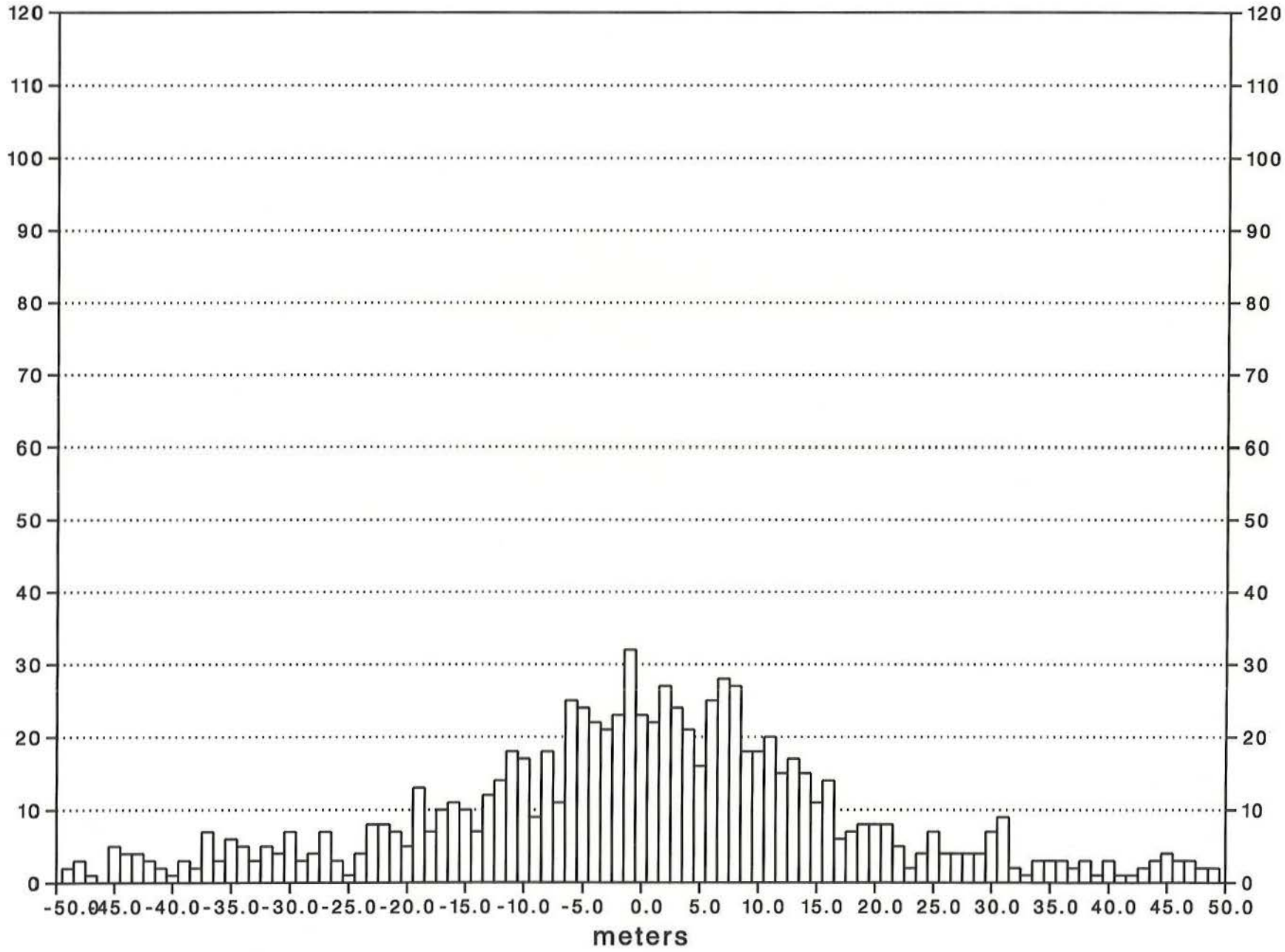
# Mismatch, USGS 1"->3" vs. Gravity DB, area A



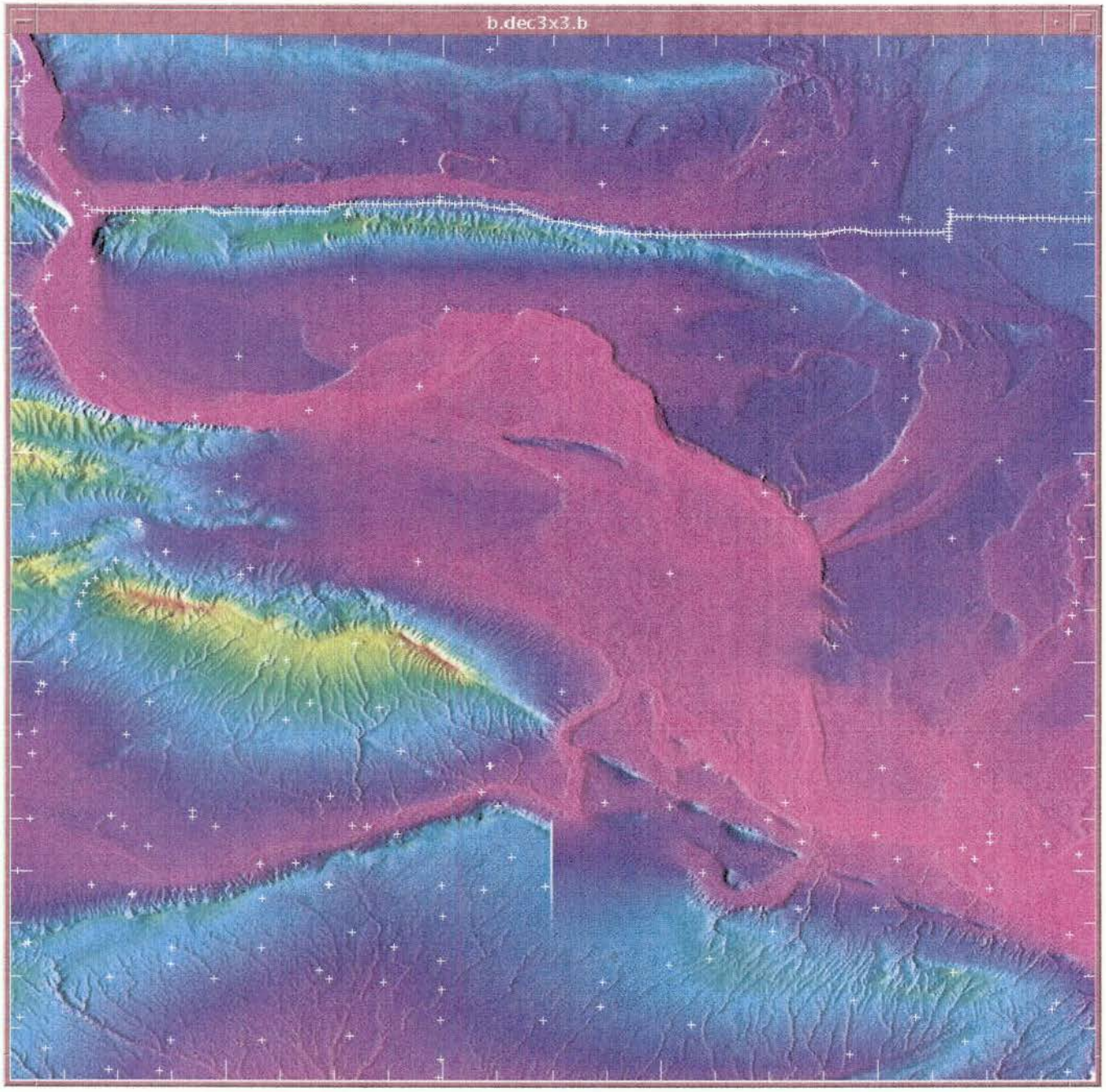
# Mismatch, USGS 1"->30" vs. Gravity DB, area A



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

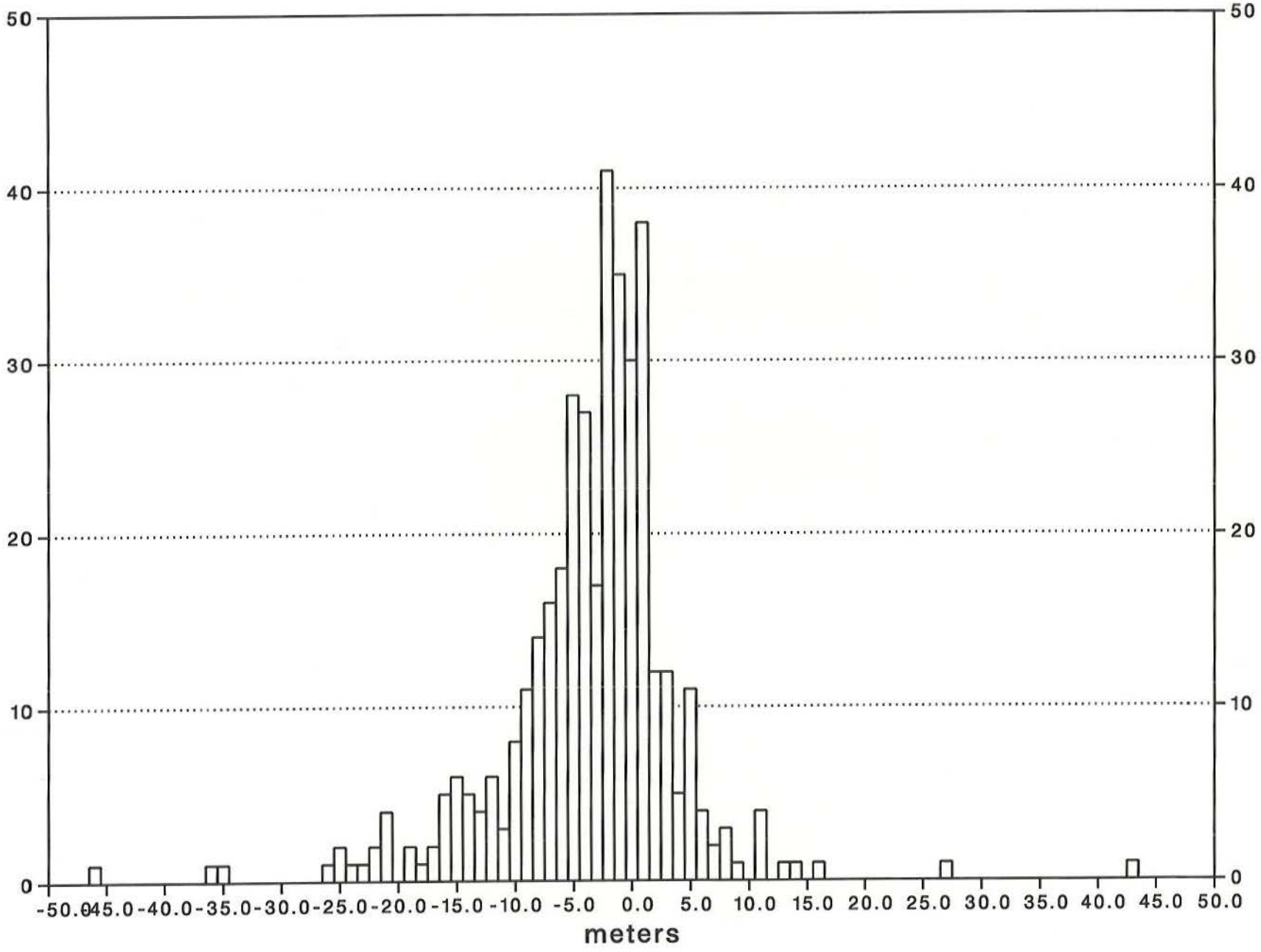


# Test Area B: 46/47 N, 240/241 E

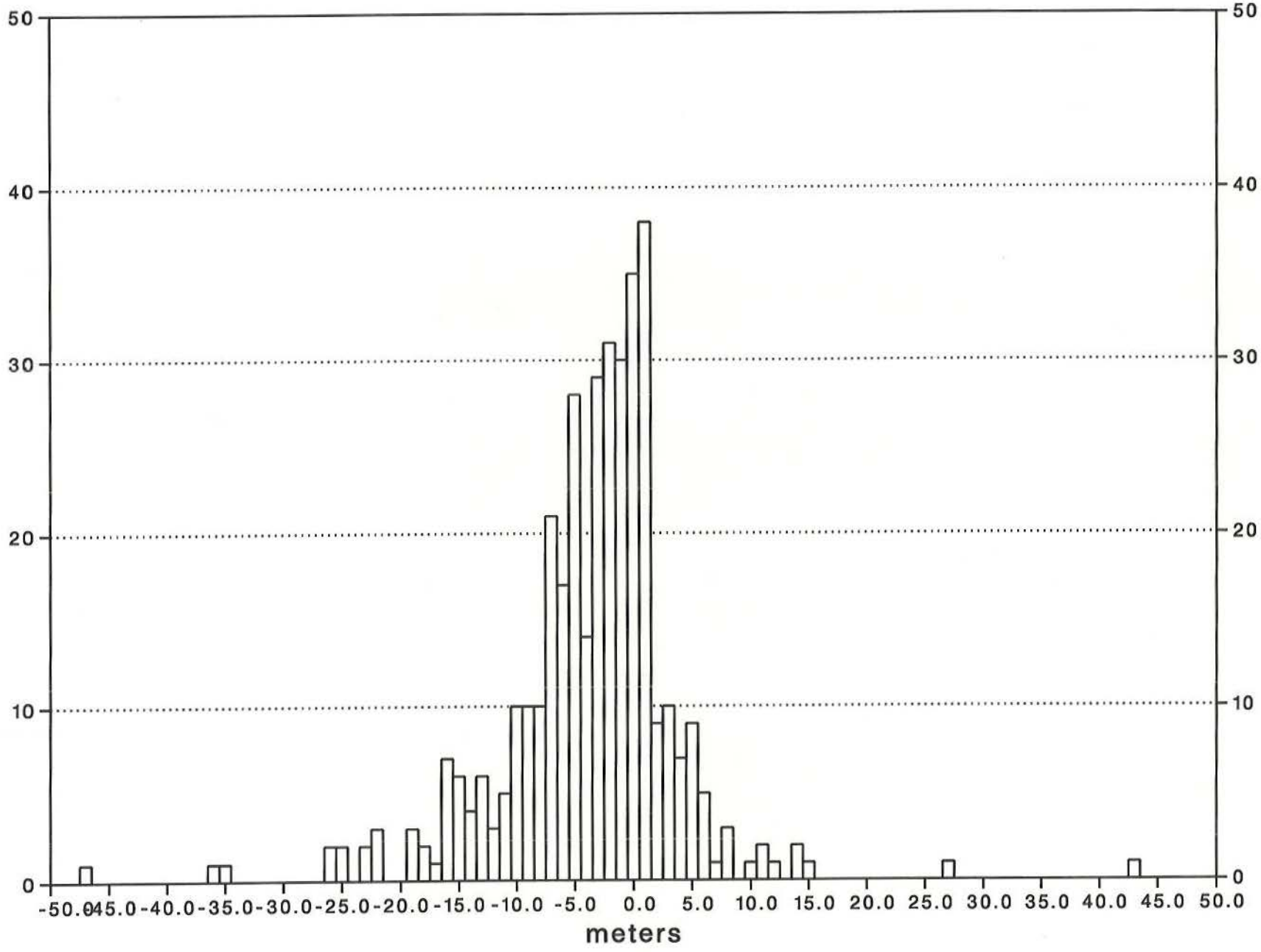



# 397 Gravity Points

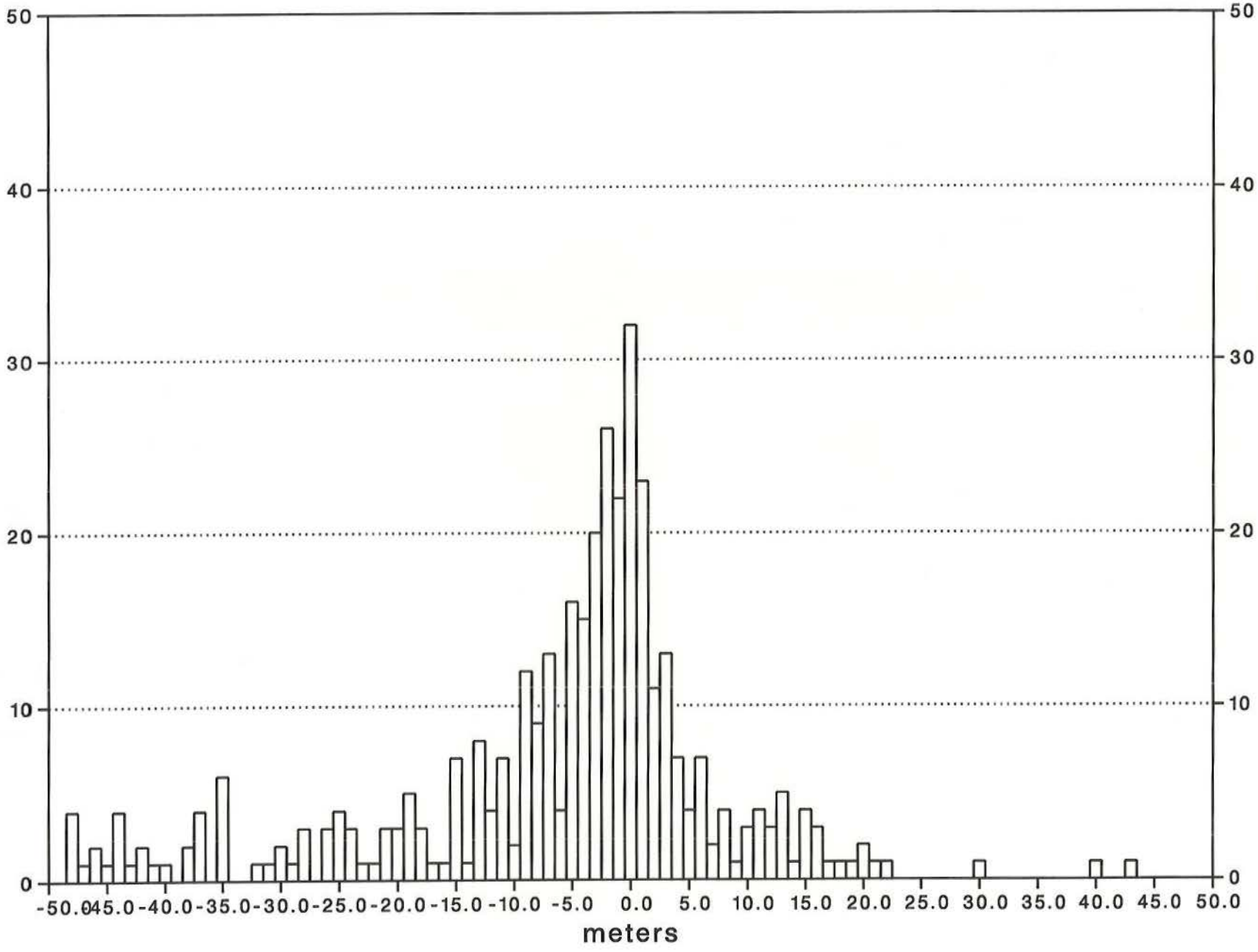
# Mismatch, USGS 1" vs. Gravity DB, Area B



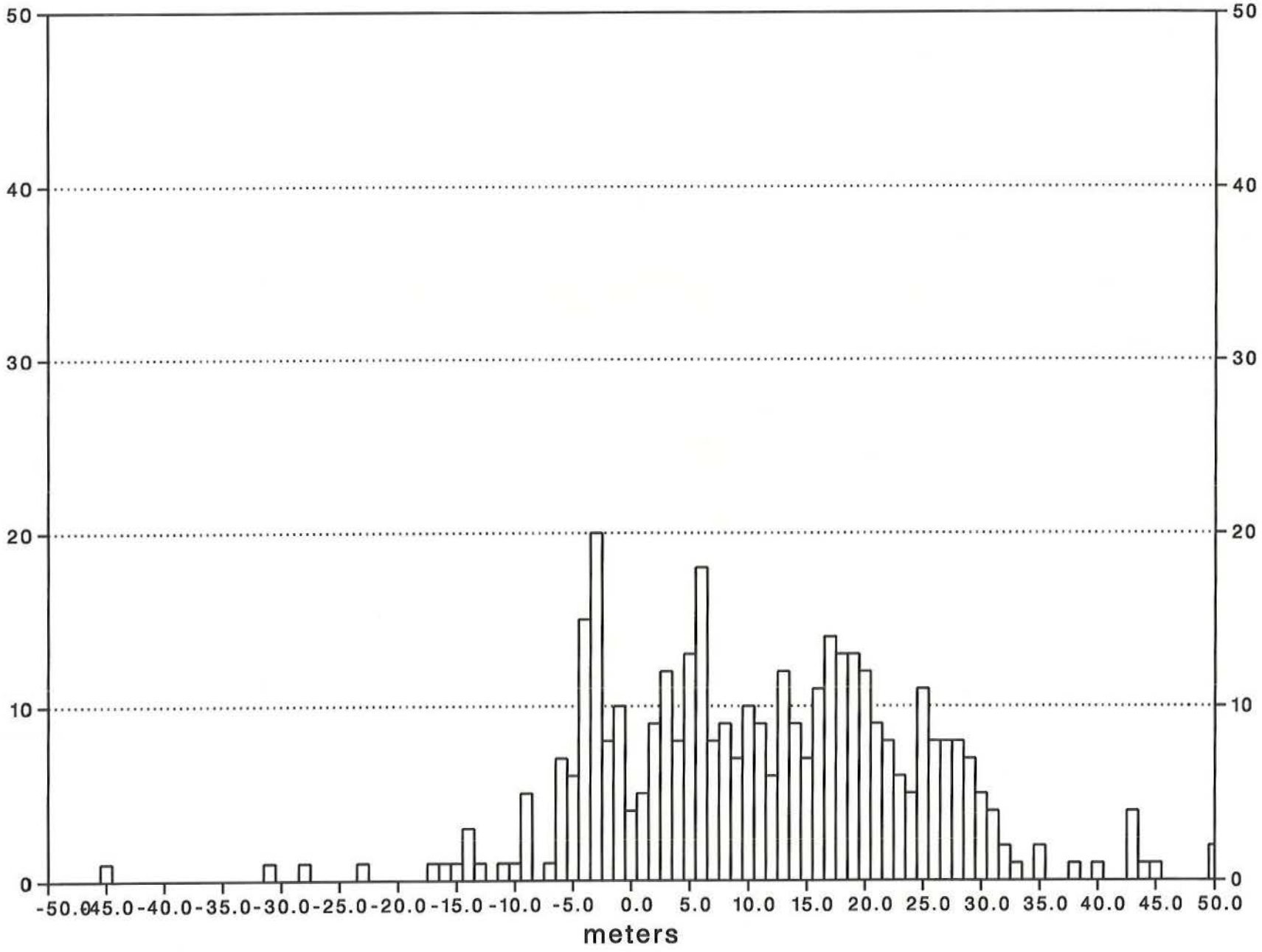
# Mismatch, USGS 1"->3" vs. Gravity DB, Area B



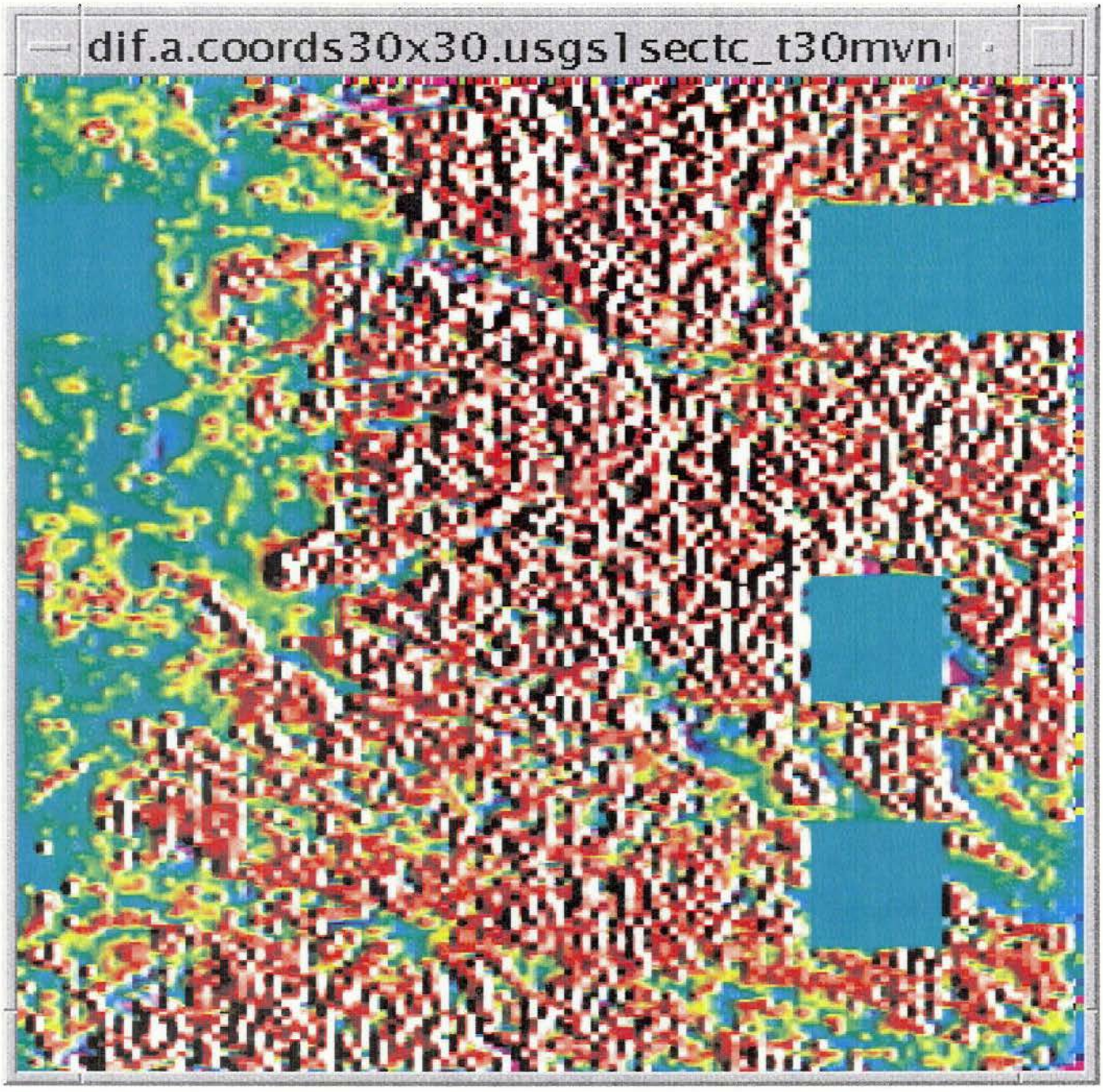
# Mismatch, USGS 1"->30" vs. Gravity DB, Area B



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



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




## USGS 1" TC minus TOPO30 30" TC

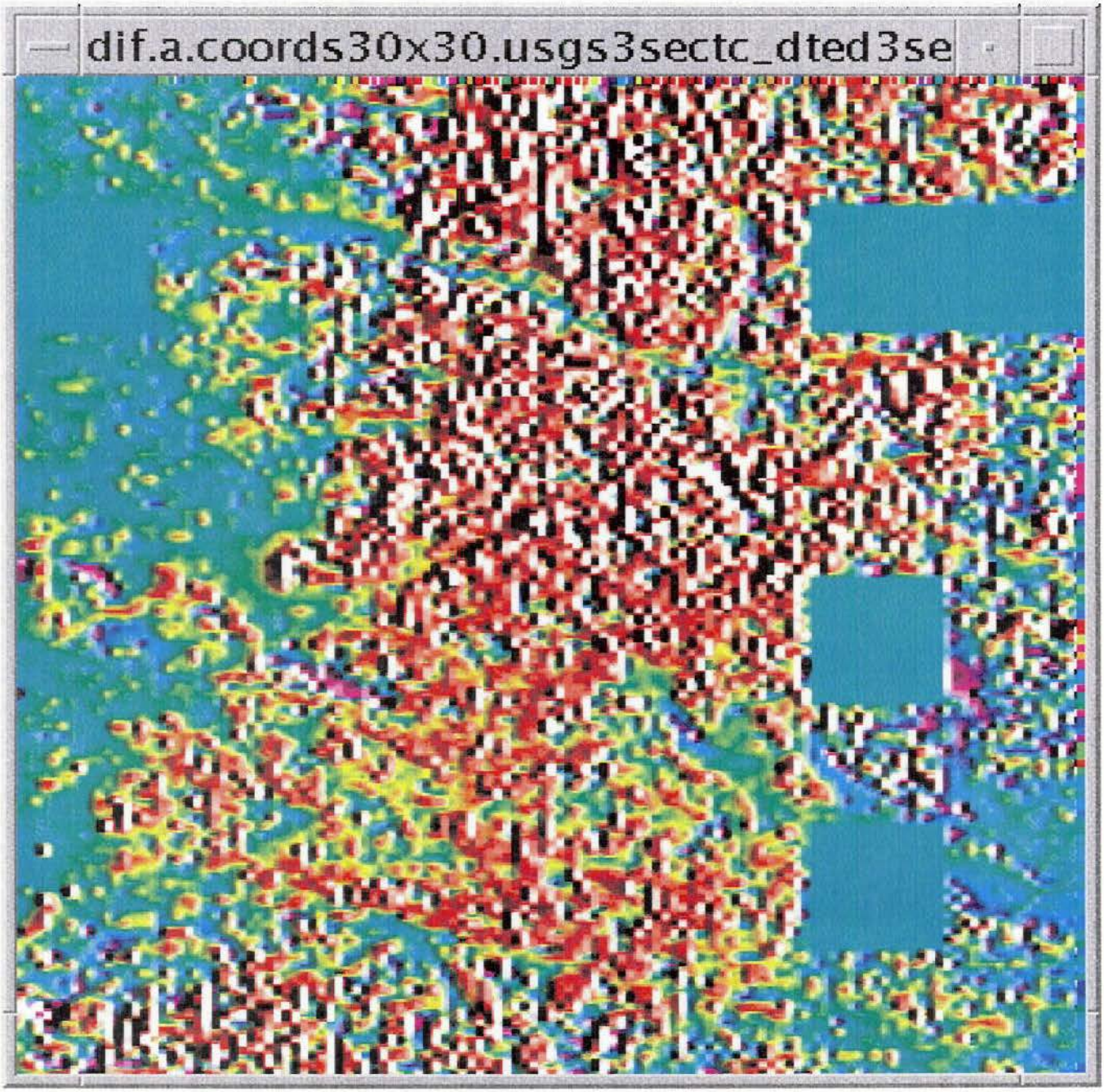
## ave = 1.4 mGal  max = +20 mGal

# 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

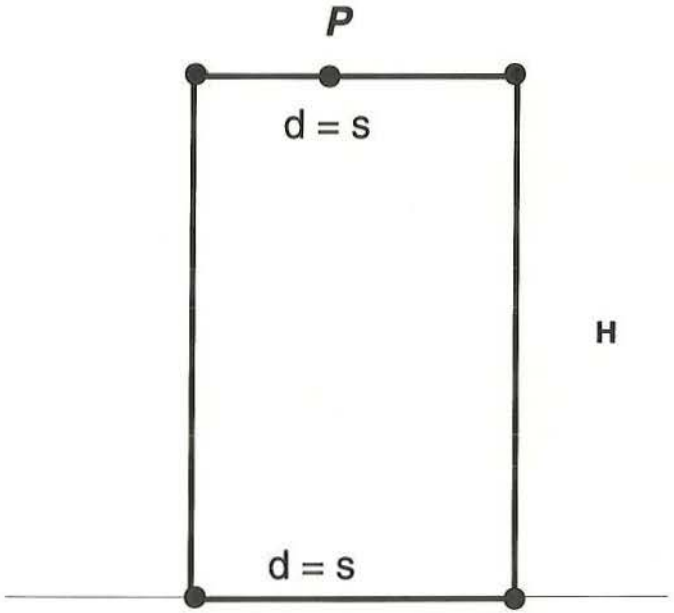
## ave = .72 mGal  max = +18 mGal

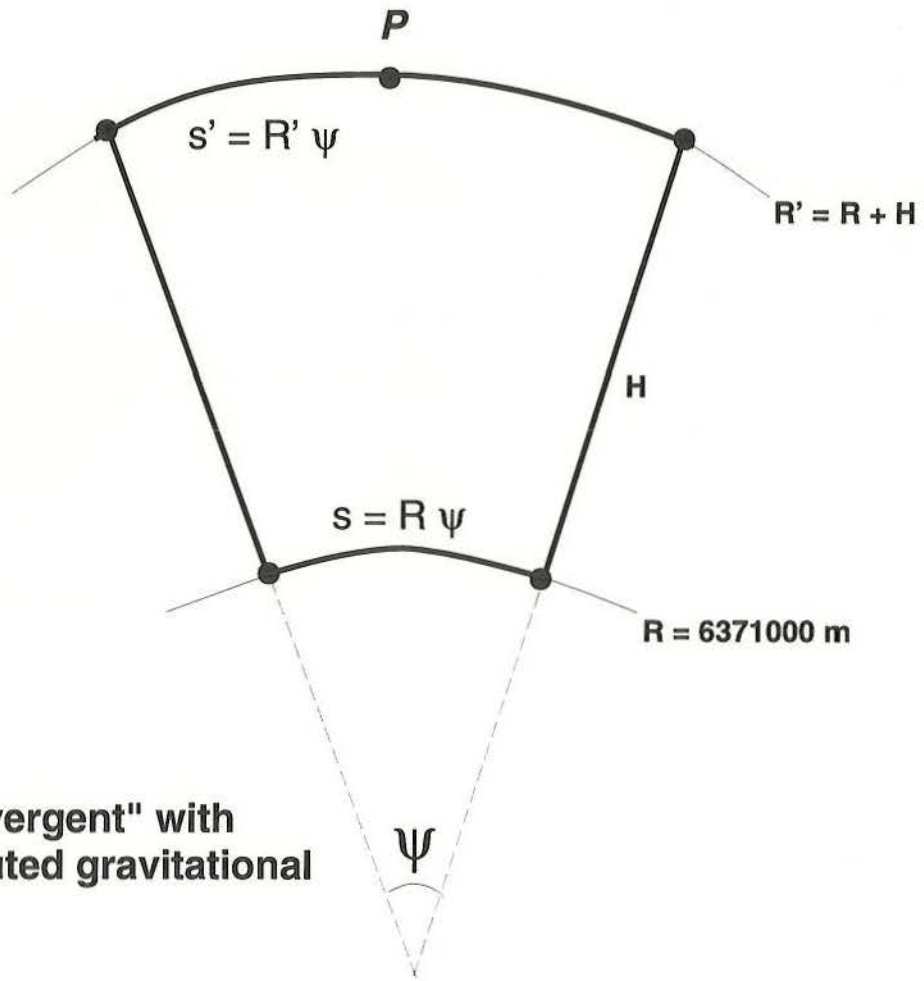
# Test Area A: 47/48 N, 237/238 E
# GEOID Impact


## USGS 3" TC minus NIMA 3" TC

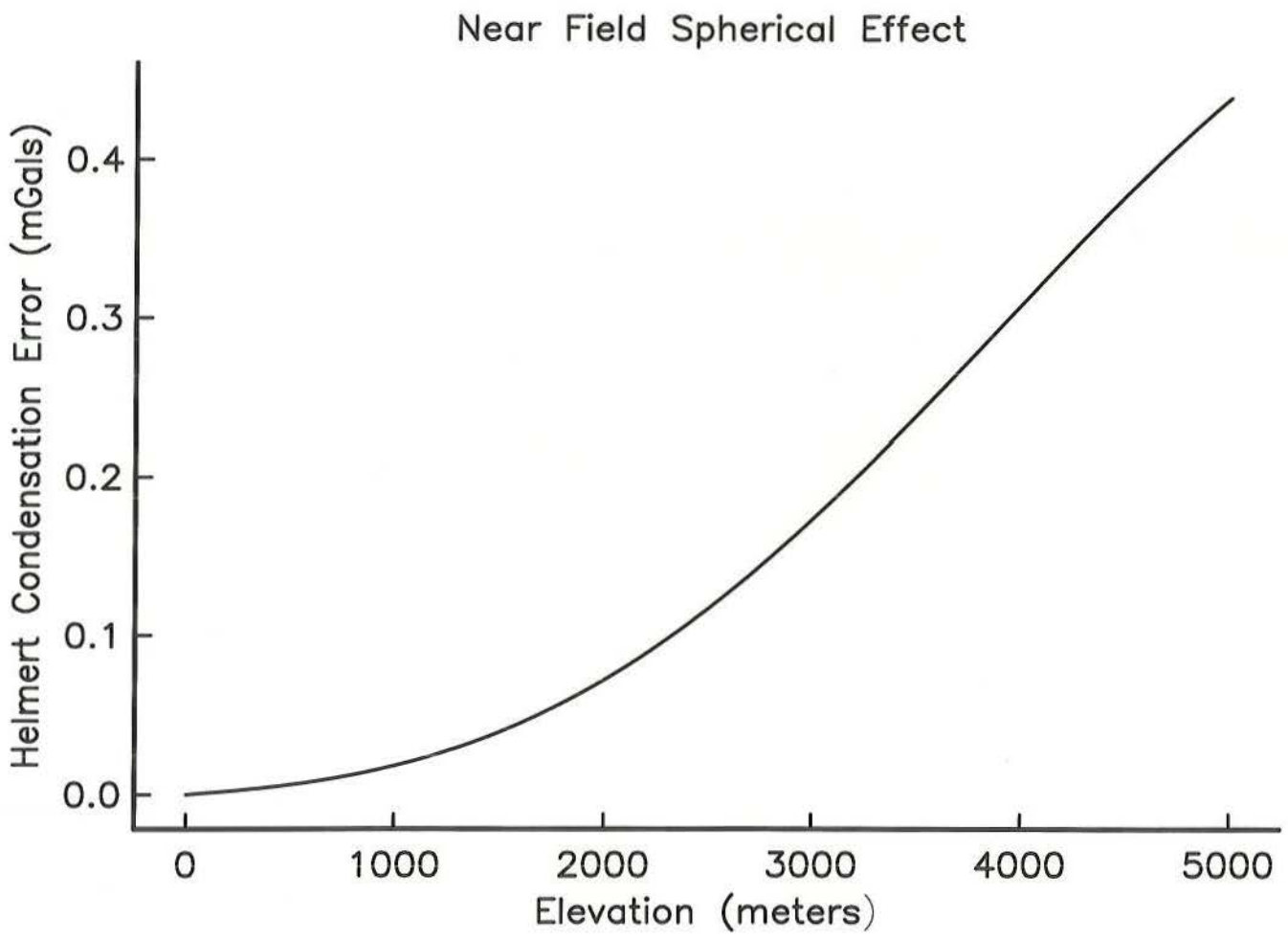
## max = 5.8 cm  >1 cm out to 200 km

# Near Field Spherical Effect

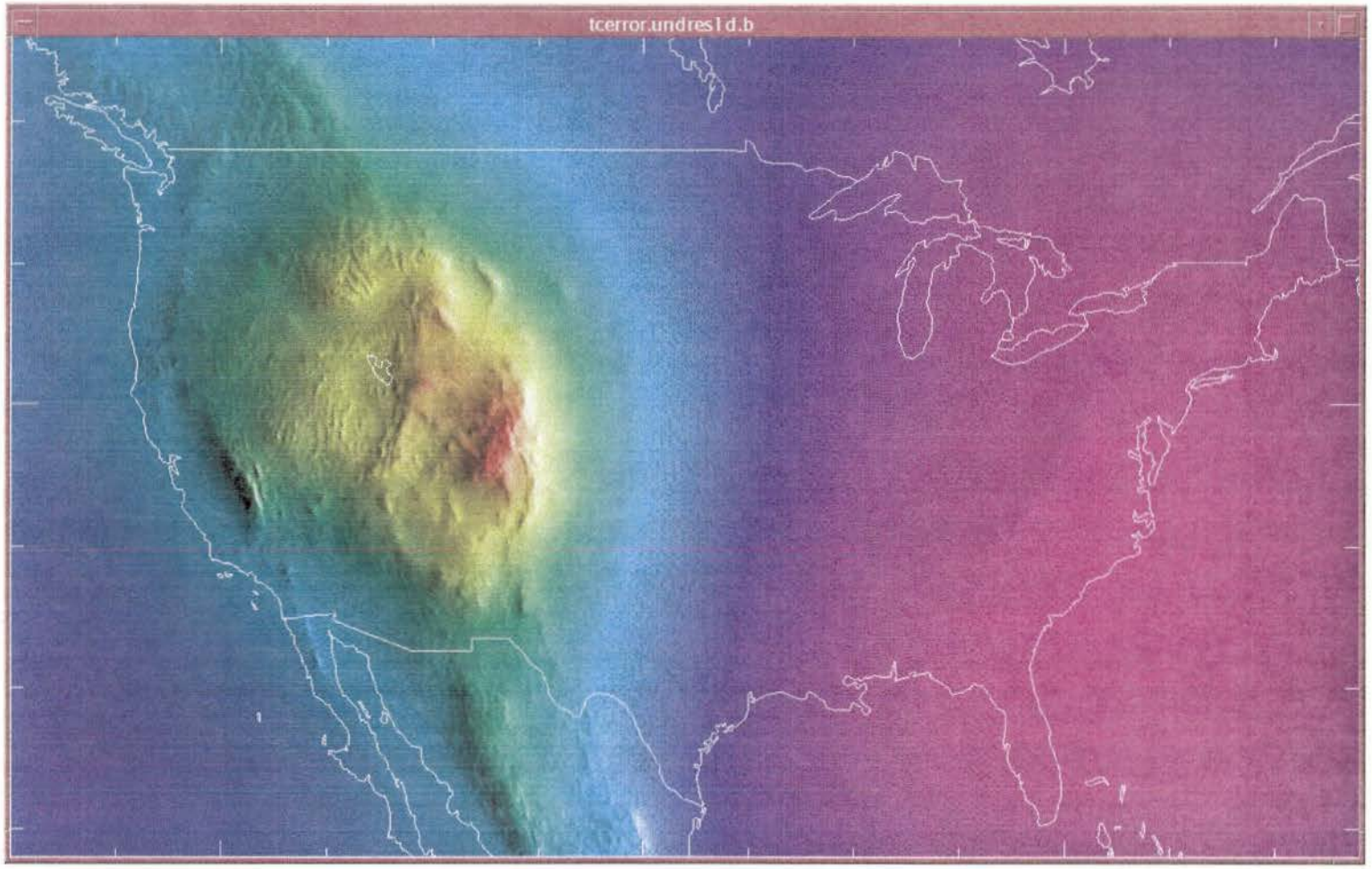



**Volume and mass distribution become more "divergent" with increasing ψ and increasing H. Therefore computed gravitational attraction also diverges.**


Near Field Spherical Effect
Helmert Condensation Error (mGals)
0.4
0.3
0.2
0.1
0.0
0
1000
2000
3000
4000
5000
Elevation (meters)

# 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 $0° < \psi < 0.5°$
    3) Use 30" DEM for $0.5° < \psi < 4.0°$
        - Cumulative error of not using 3" = 0.01 mGal
    4) Use 5' DEM for $4.0° < \psi < 180°$ (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**