

Localized Impacts of Very-High Resolution Digital Elevation Data on Geoid Modeling

by

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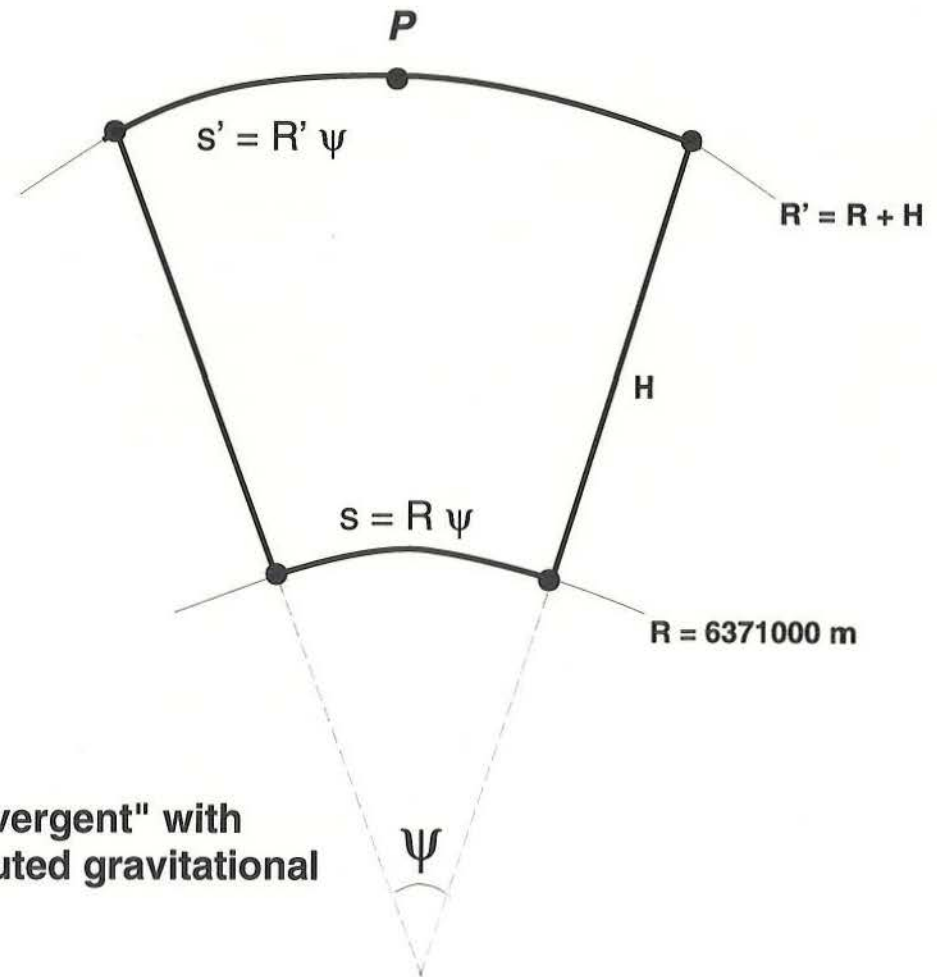
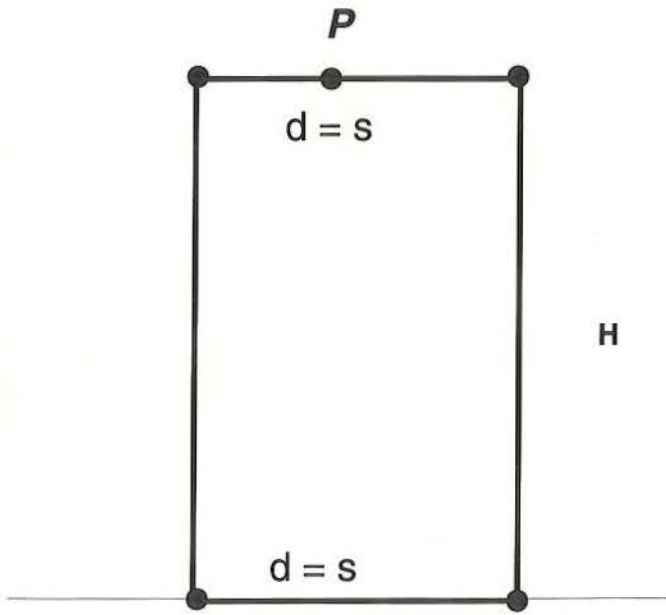
NOAA/National Geodetic Survey

Presented at the May 1999 meeting of the Canadian Geophysical Union
Banff, Alberta, Canada
May 10, 1999

Frequently Used Approximations:

- Planar Earth
- Terrain Corrections approximating removal of 3-D masses and restoration of condensed layer
- FFT
- Coarse horizontal resolution in DEM

Near Field Spherical Effect

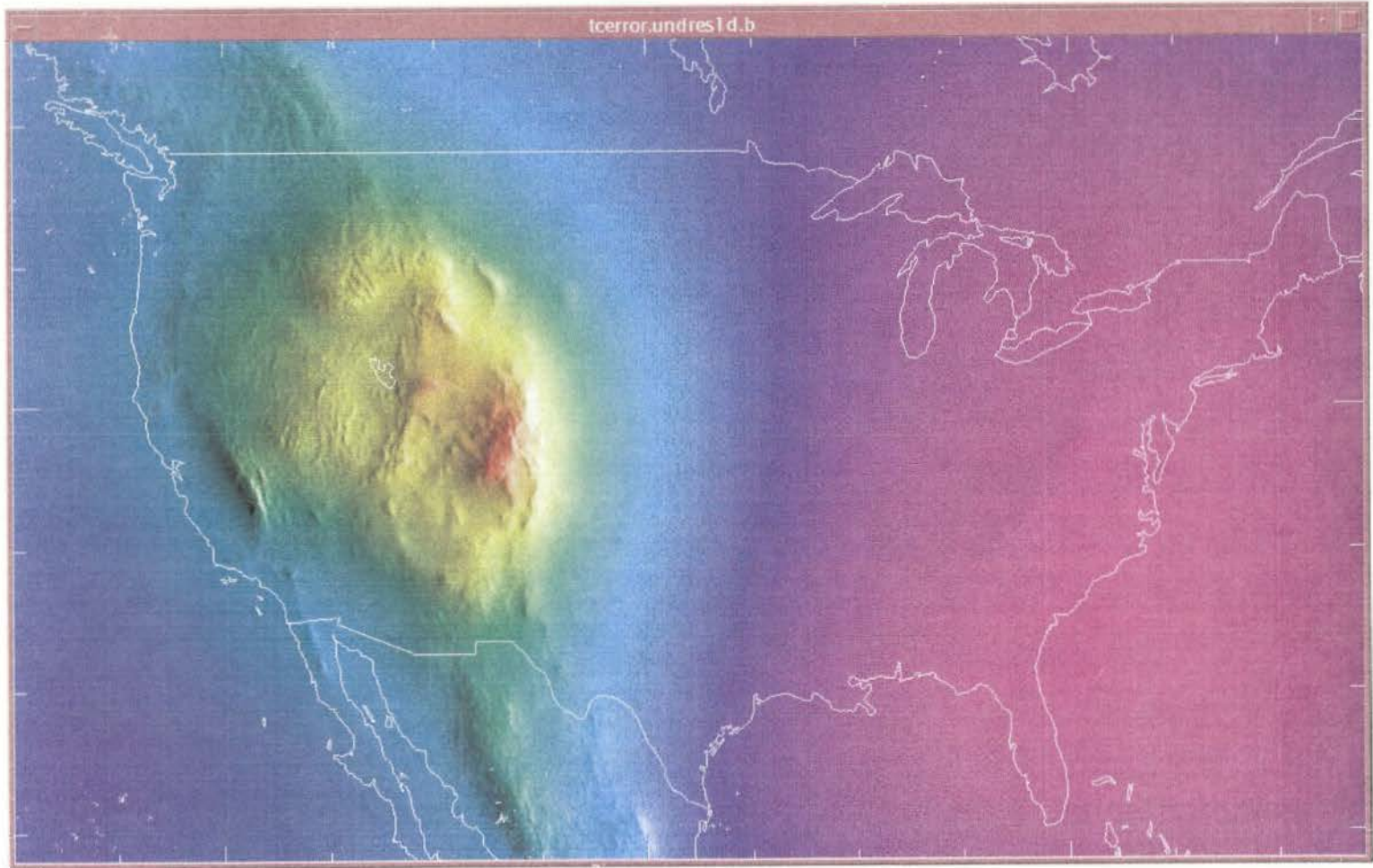


Volume and mass distribution become more "divergent" with increasing ψ and increasing H . Therefore computed gravitational attraction also diverges.

Near field spherical effect (mgals)

	<u>1"</u>		<u>30"</u>	
<u>Height</u>	<u>Planar</u>	<u>Spherical</u>	<u>Planar</u>	<u>Spherical</u>
<u>100 m</u>	-1.523	-1.523	-9.910	-9.908
	+11.194	+11.193	+11.194	+11.194
	= 9.671	=9.670	=1.284	=1.284 ⁶
	<u>Diff = .001 mGal</u>		<u>Diff=.002 mGal</u>	
<u>1000 m</u>	-1.635	-1.634	-38.772	-38.774
	+111.940	+111.957	+111.940	+111.961
	=110.305	=110.323	=73.168	=73.187
	<u>Diff = .018 mGal</u>		<u>Diff=0.019 mGal</u>	
<u>5000 m</u>	-1.644	-1.645	-47.175	-47.203
	+559.701	+560.141	+559.701	+560.160
	=558.057	=558.496	=512.526	=512.957
	<u>Diff = .439 mGal</u>		<u>Diff = .431 mGal</u>	

Near Field Spherical Effect on the Geoid



Ave = 3 mm, Range = -1.8 cm to +5.7 cm

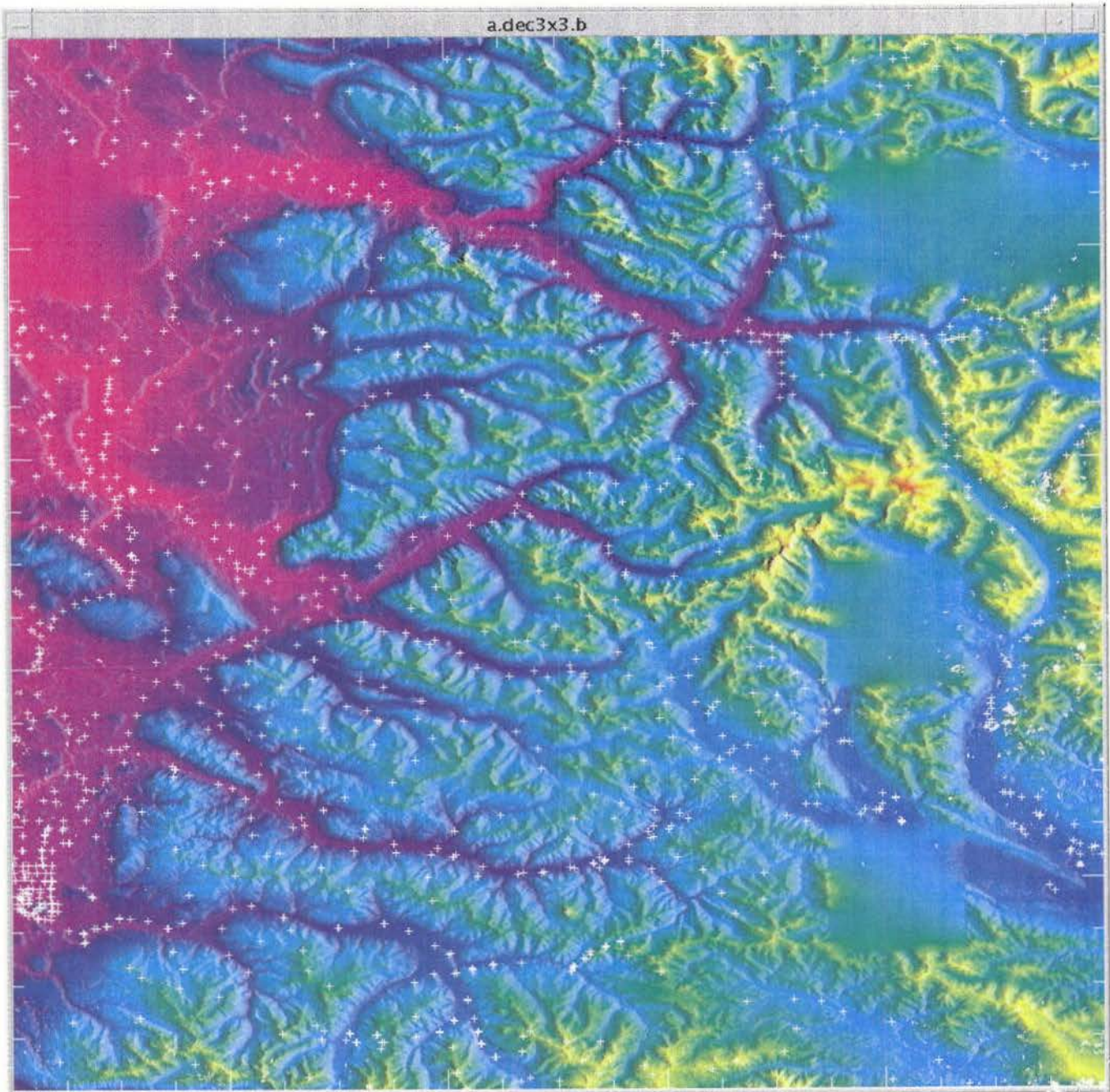
DEM: USGS vs NIMA

	<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 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>	* 1% to 2% of files have blunders. * No Q.C.? * No data outside U.S.A.	* Does not contain true 3" spectral info. * Poorly identified datum info.

Tests of Ultra-High Resolution DEMs

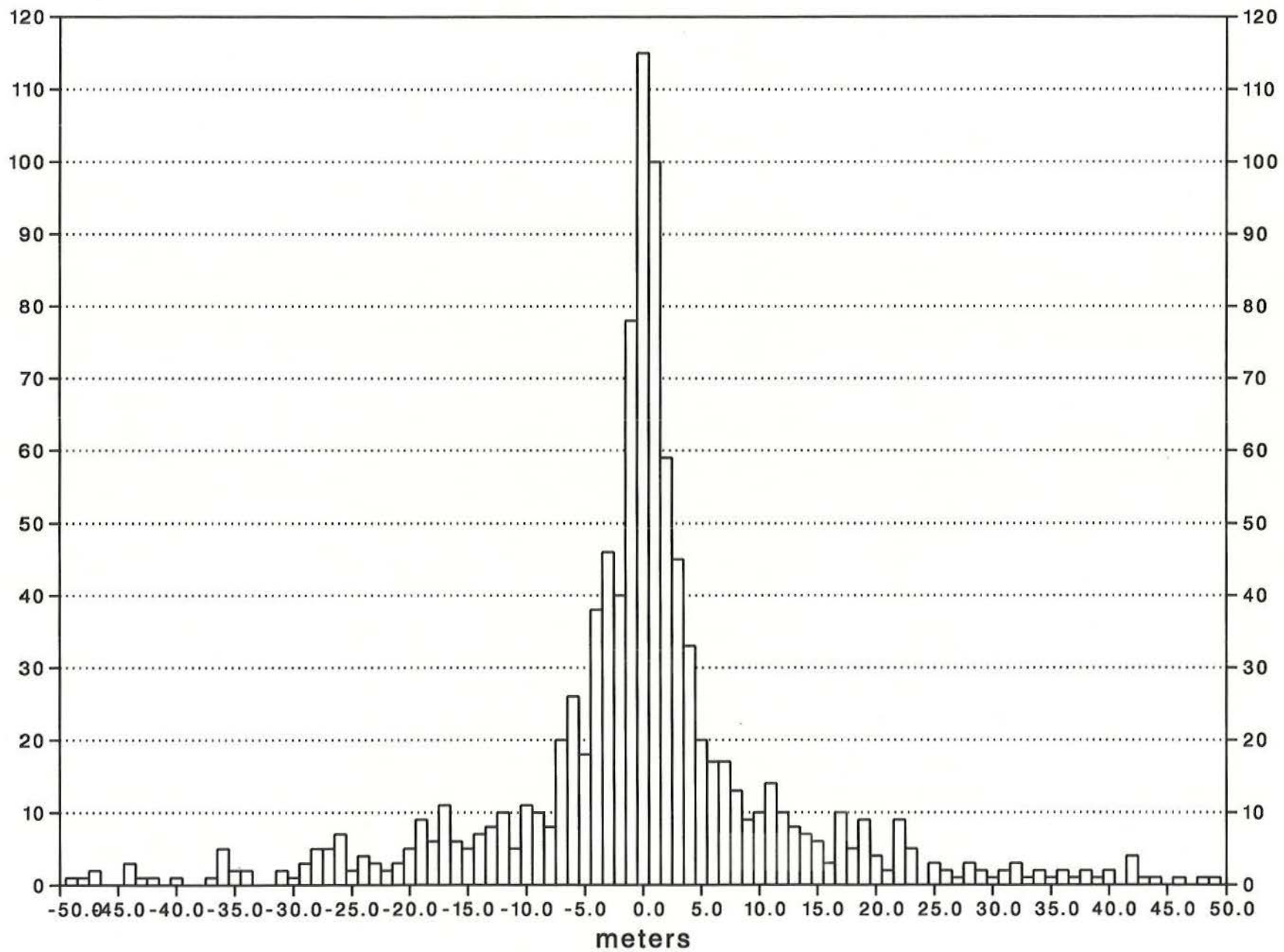
- 1) DEM heights vs. heights stored in the NGS gravity database**
- 2) Terrain corrections from the DEM and their impact on the geoid**

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

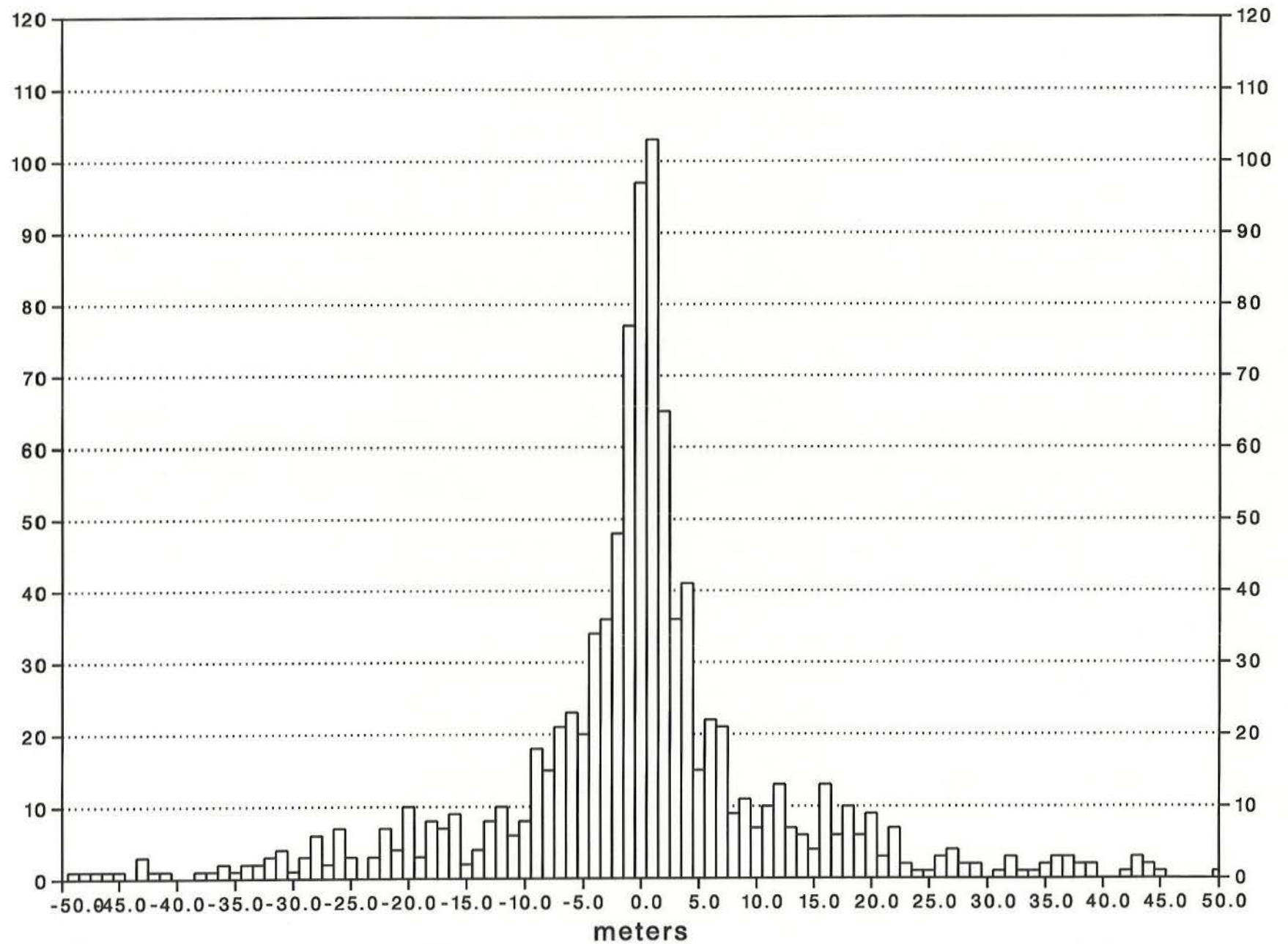


1076 Gravity Points

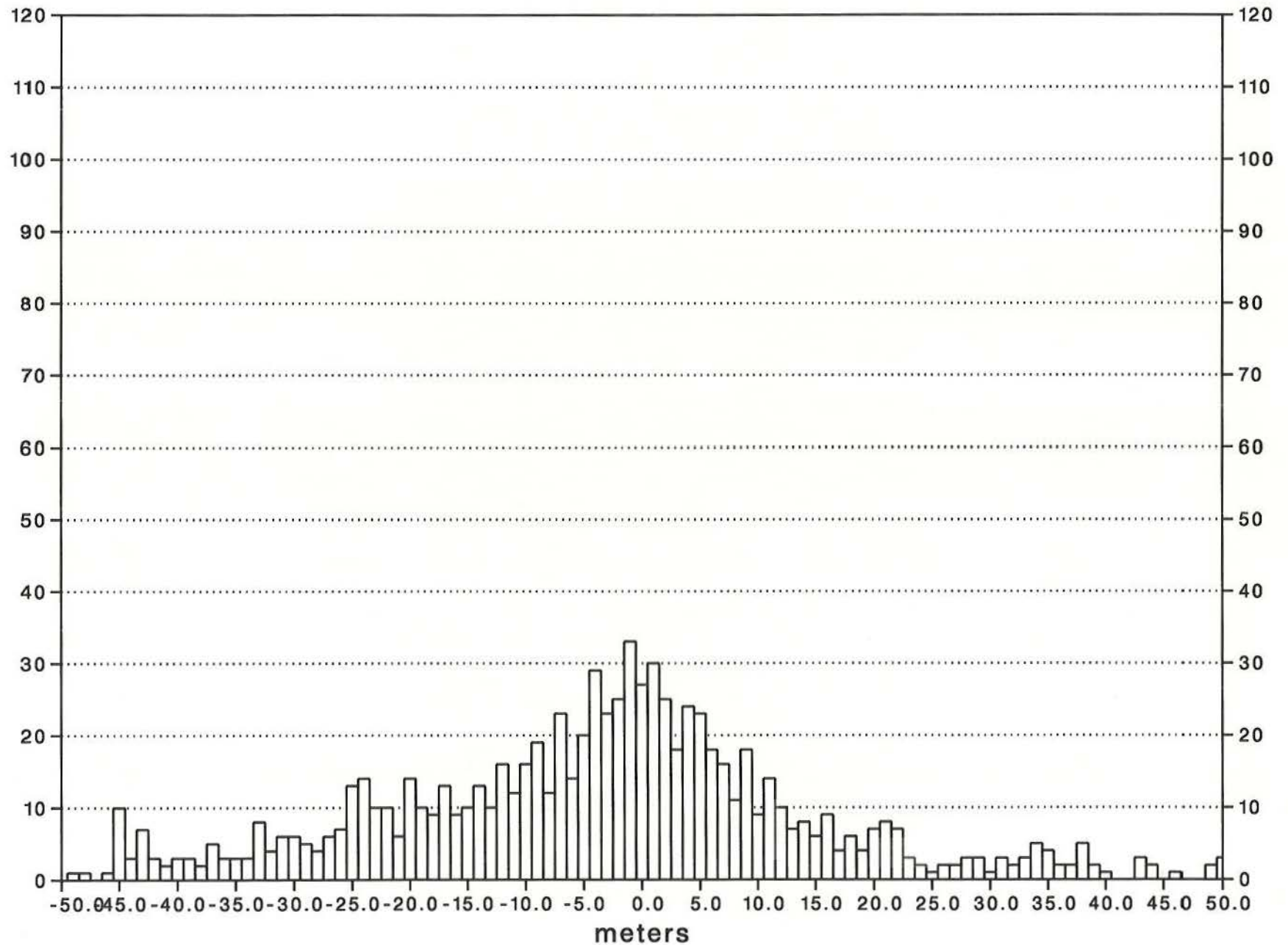
Mismatch, USGS 1" vs. Gravity DB, area A



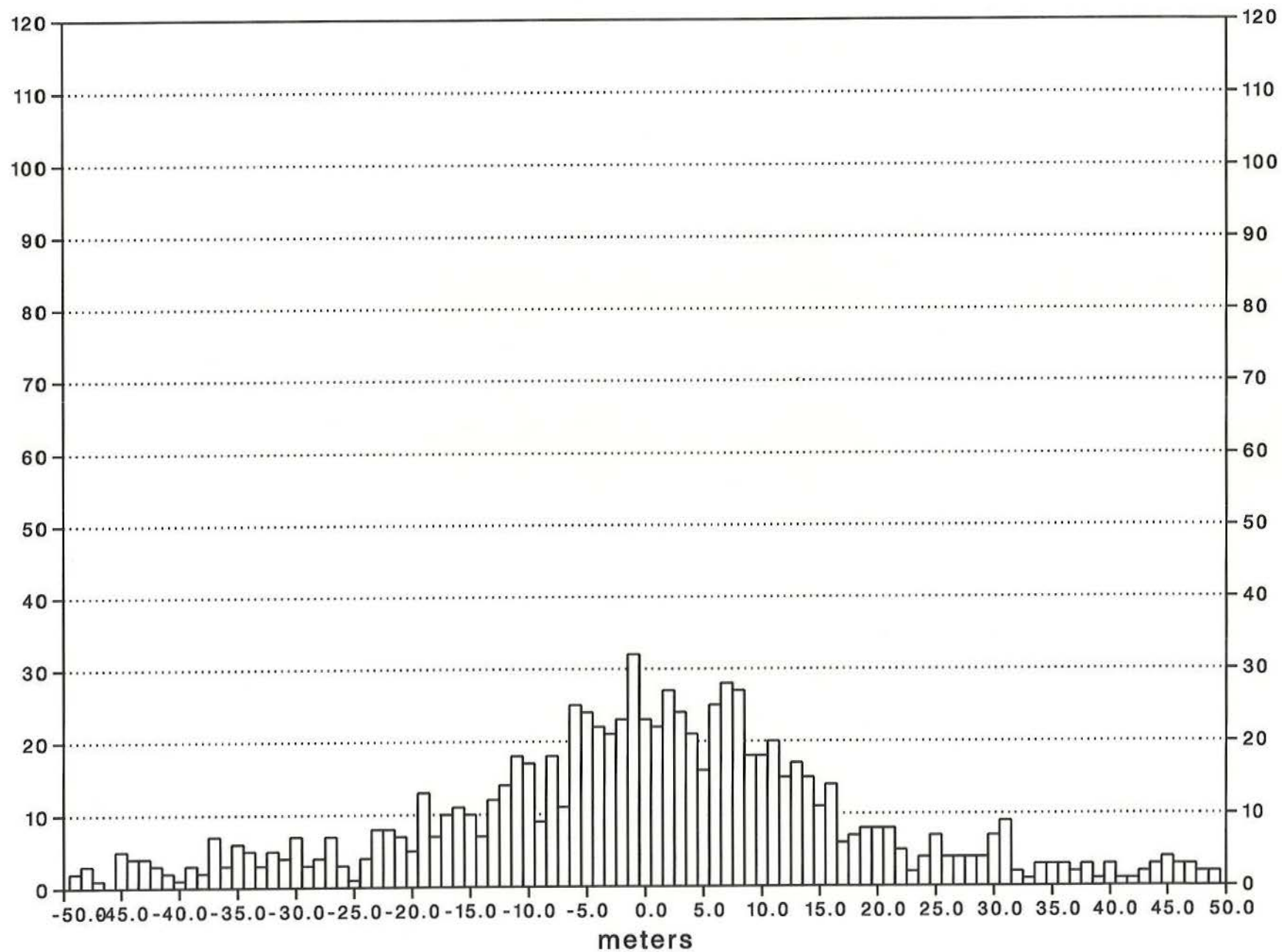
Mismatch, USGS 1"->3" vs. Gravity DB, area A



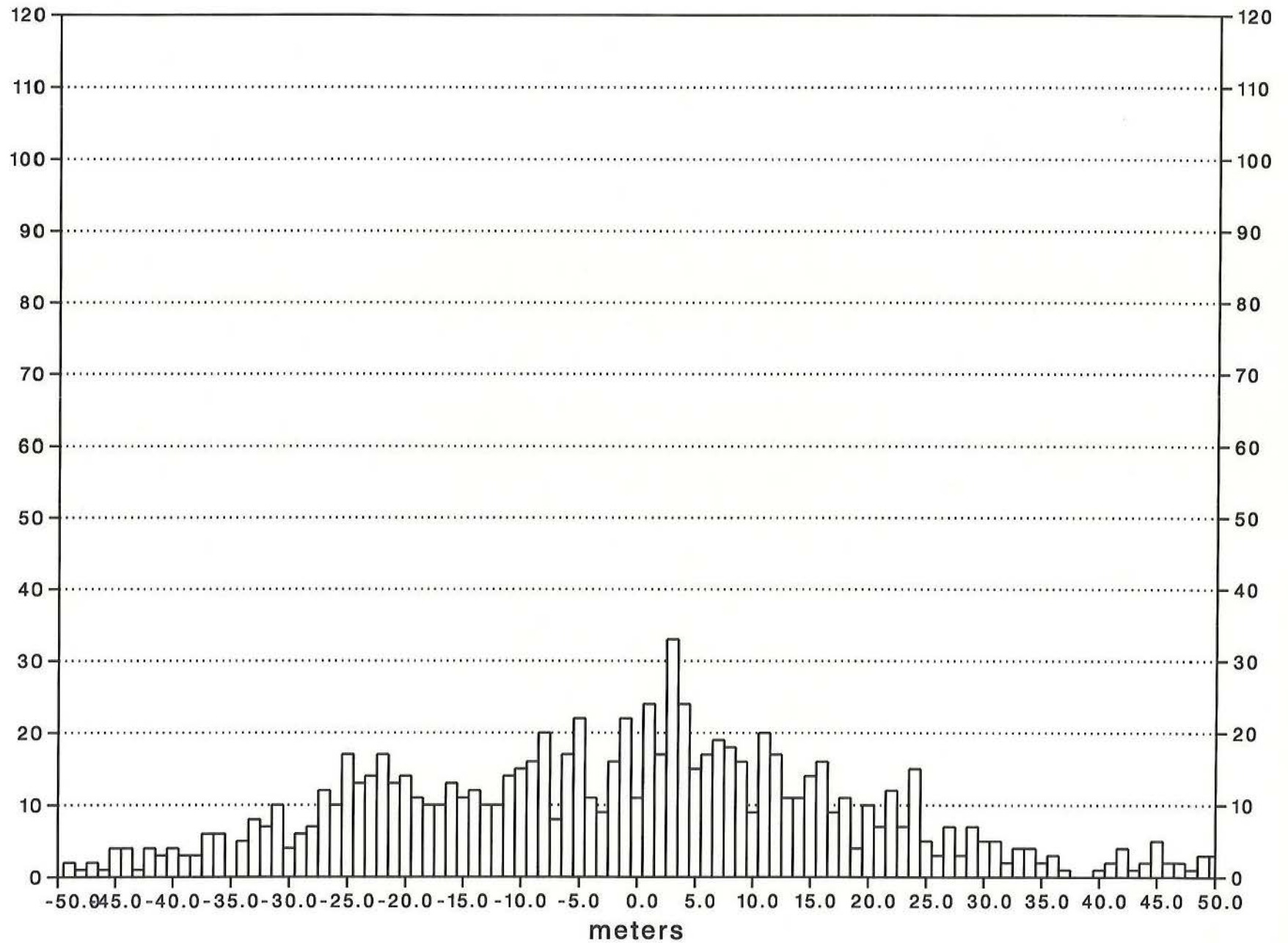
Mismatch, USGS 1"->30" vs. Gravity DB, area A



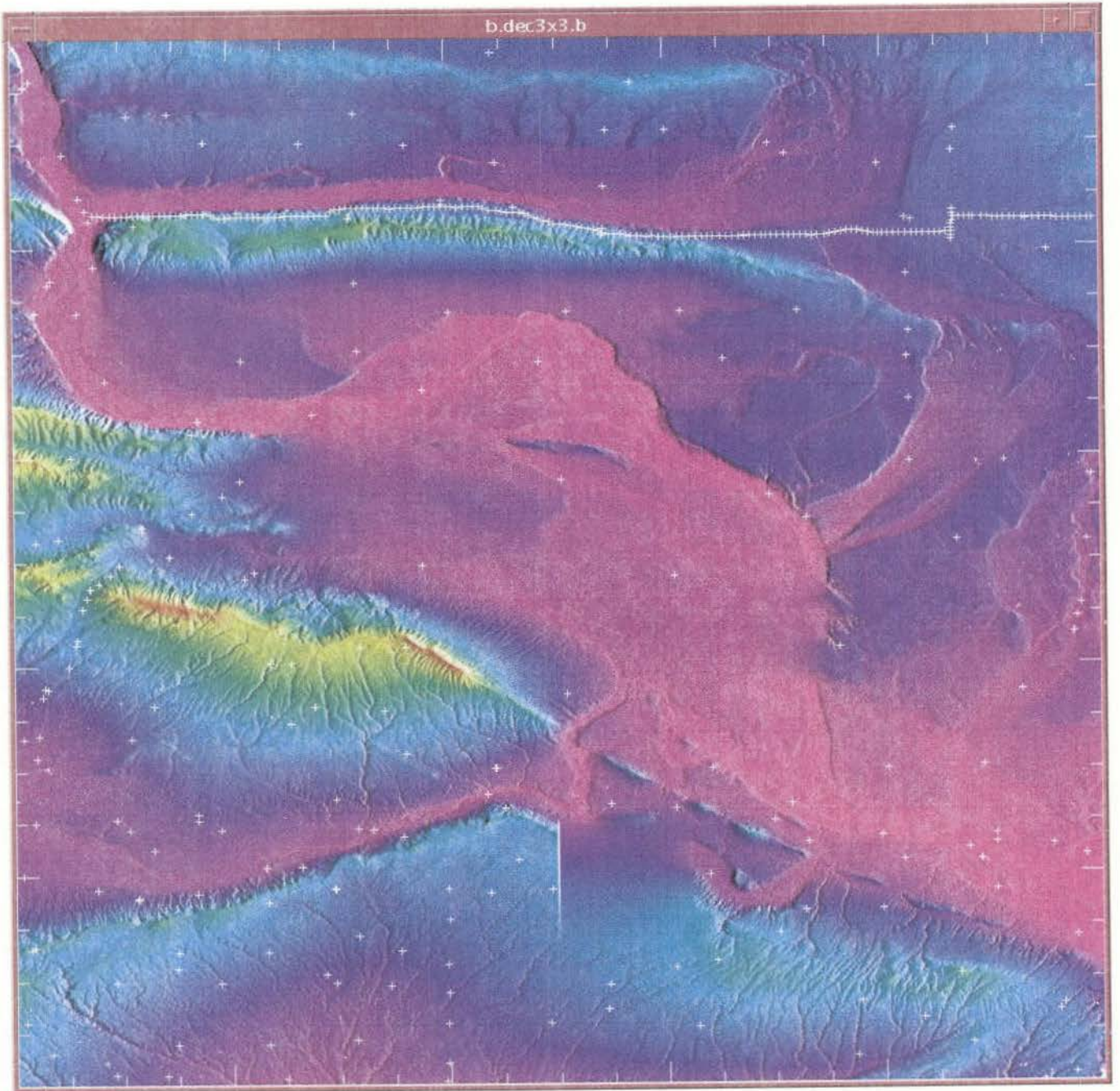
Mismatch, DTED1 (3") vs. Gravity DB, area A



Mismatch, USGS 2" vs Gravity DB, Area A

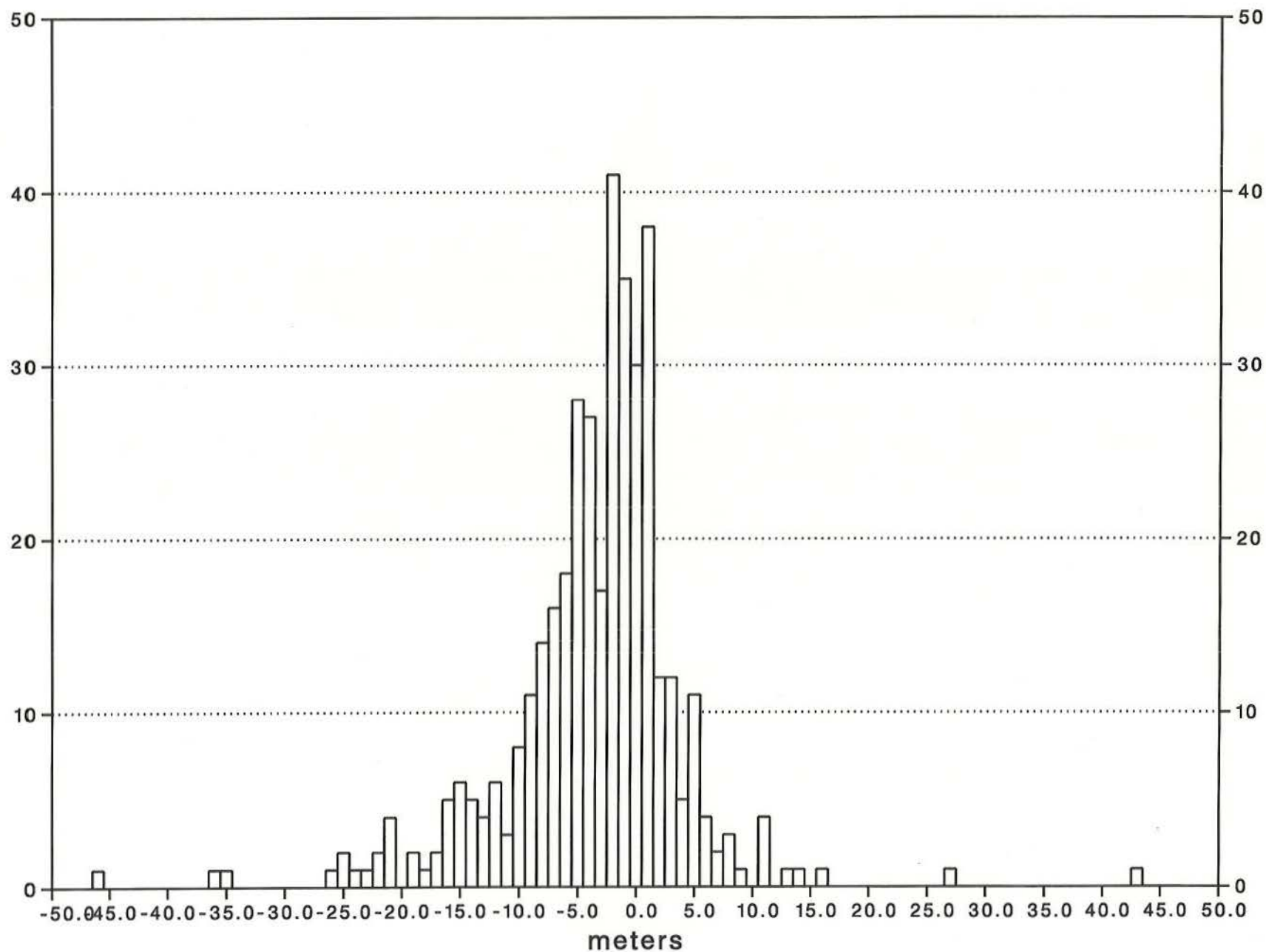


Test Area B: 46/47 N, 240/241 E

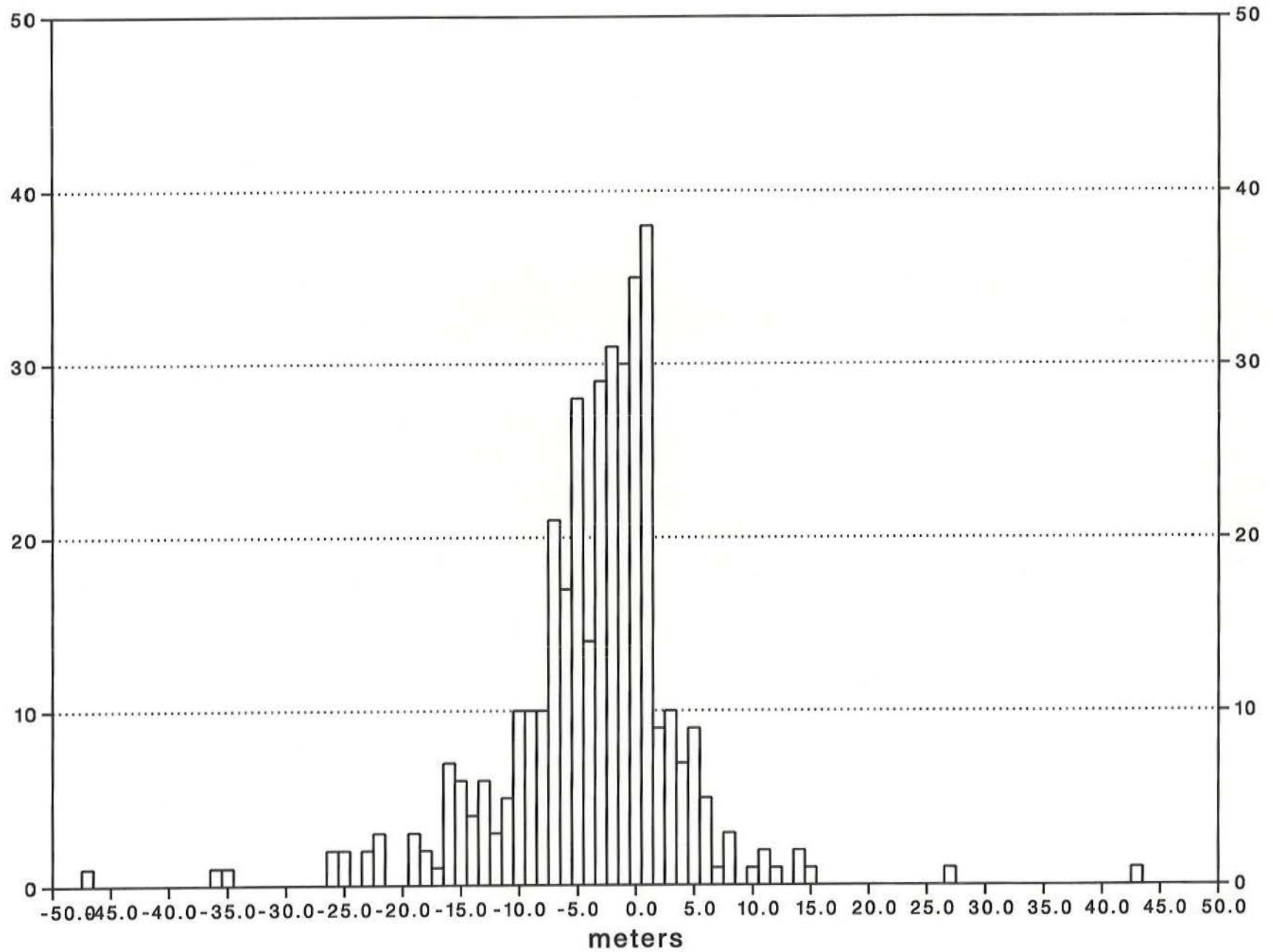


397 Gravity Points

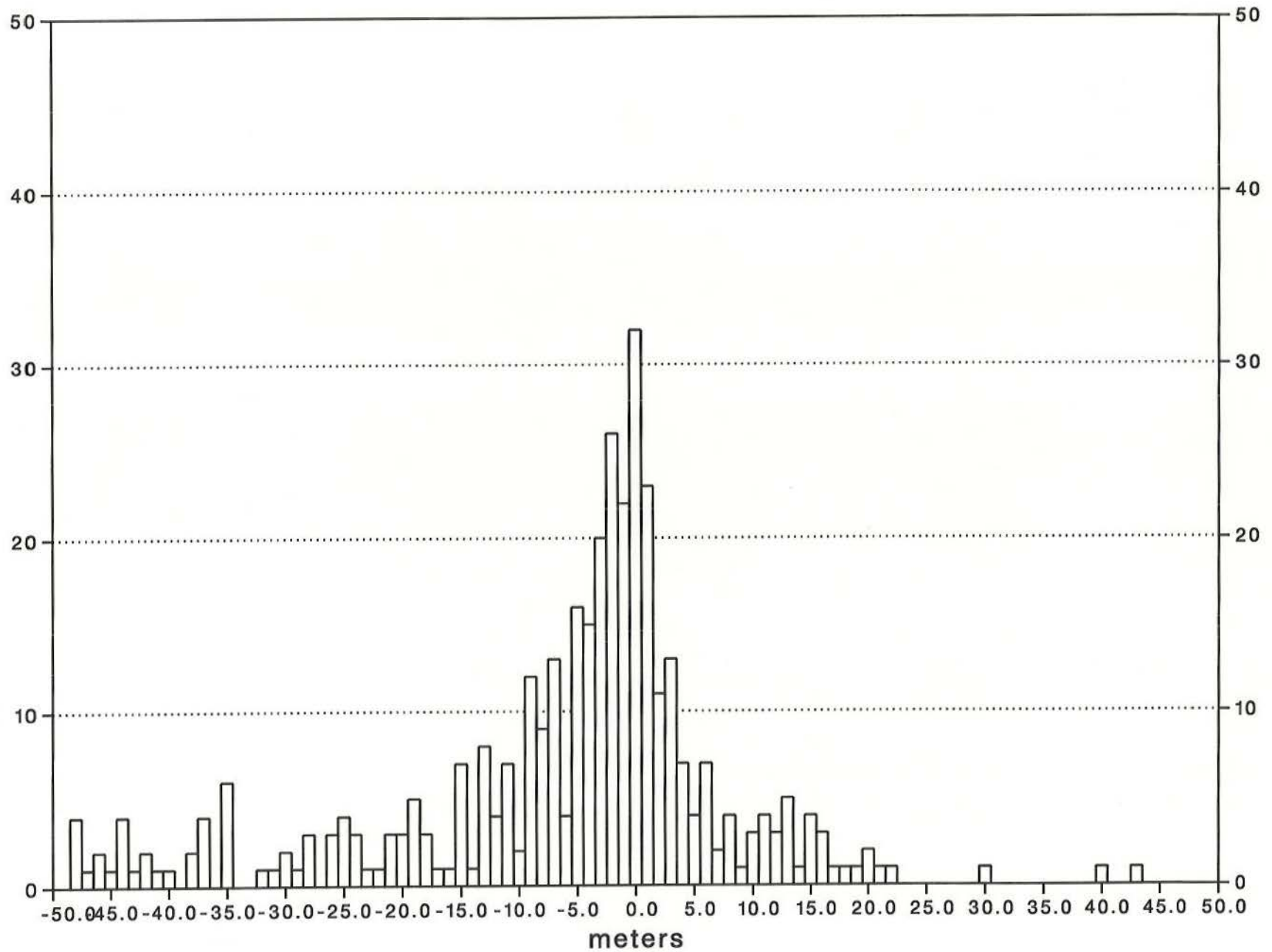
Mismatch, USGS 1" vs. Gravity DB, Area B



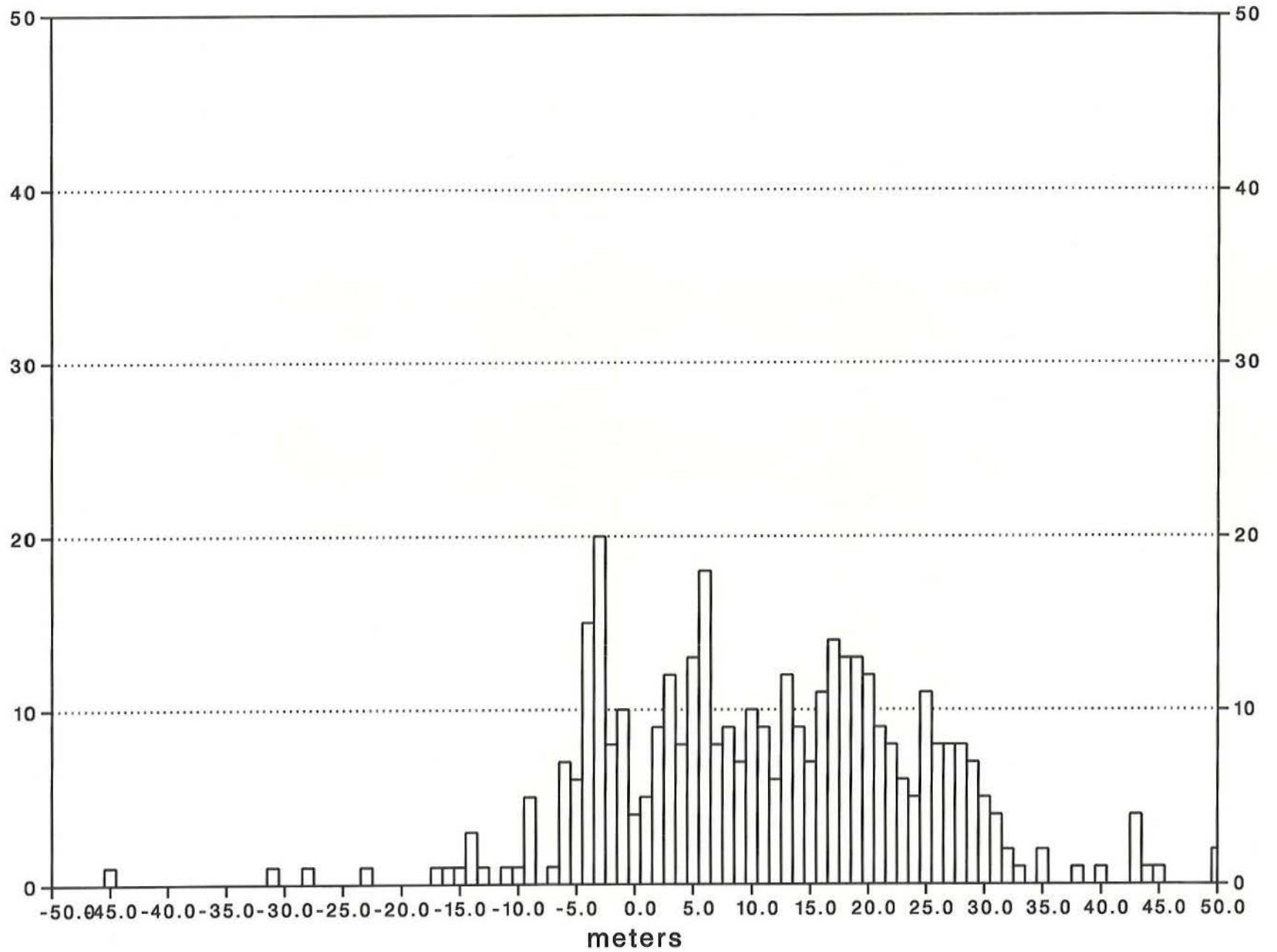
Mismatch, USGS 1"->3" vs. Gravity DB, Area B



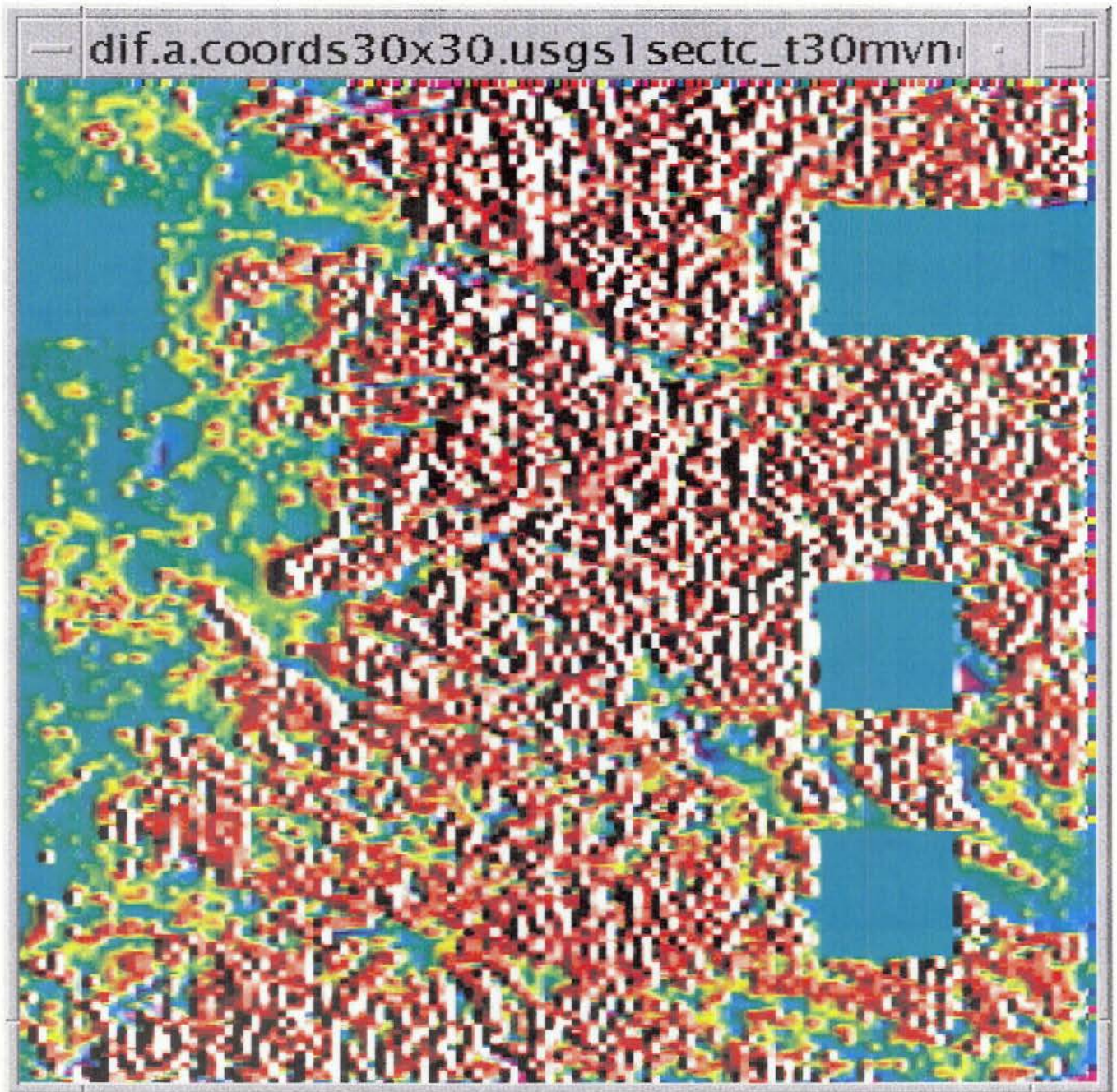
Mismatch, USGS 1"->30" vs. Gravity DB, Area B



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



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



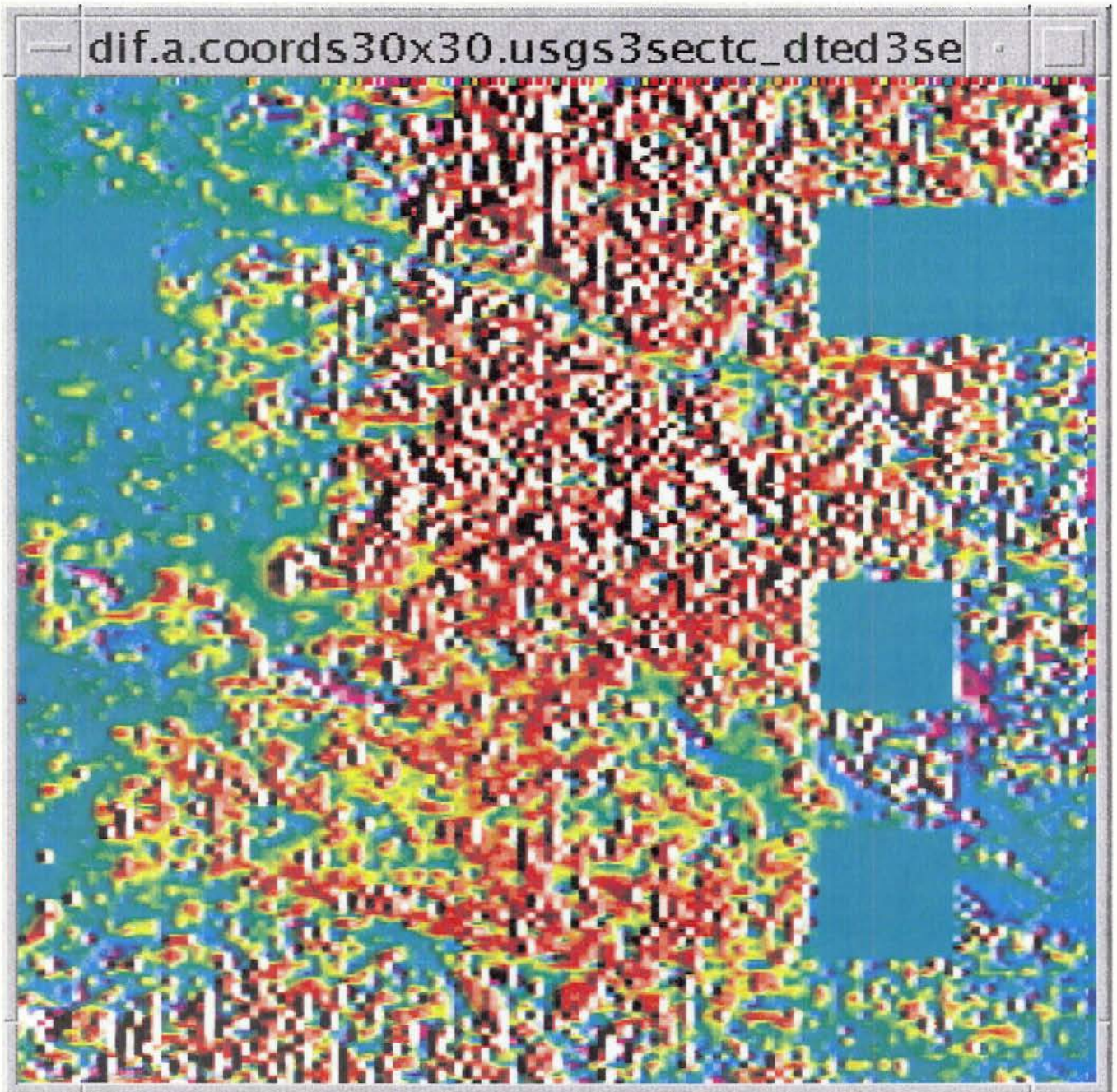
USGS 1" TC minus TOPO30 30" TC
ave = 1.4 mGal max = +20 mGal

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



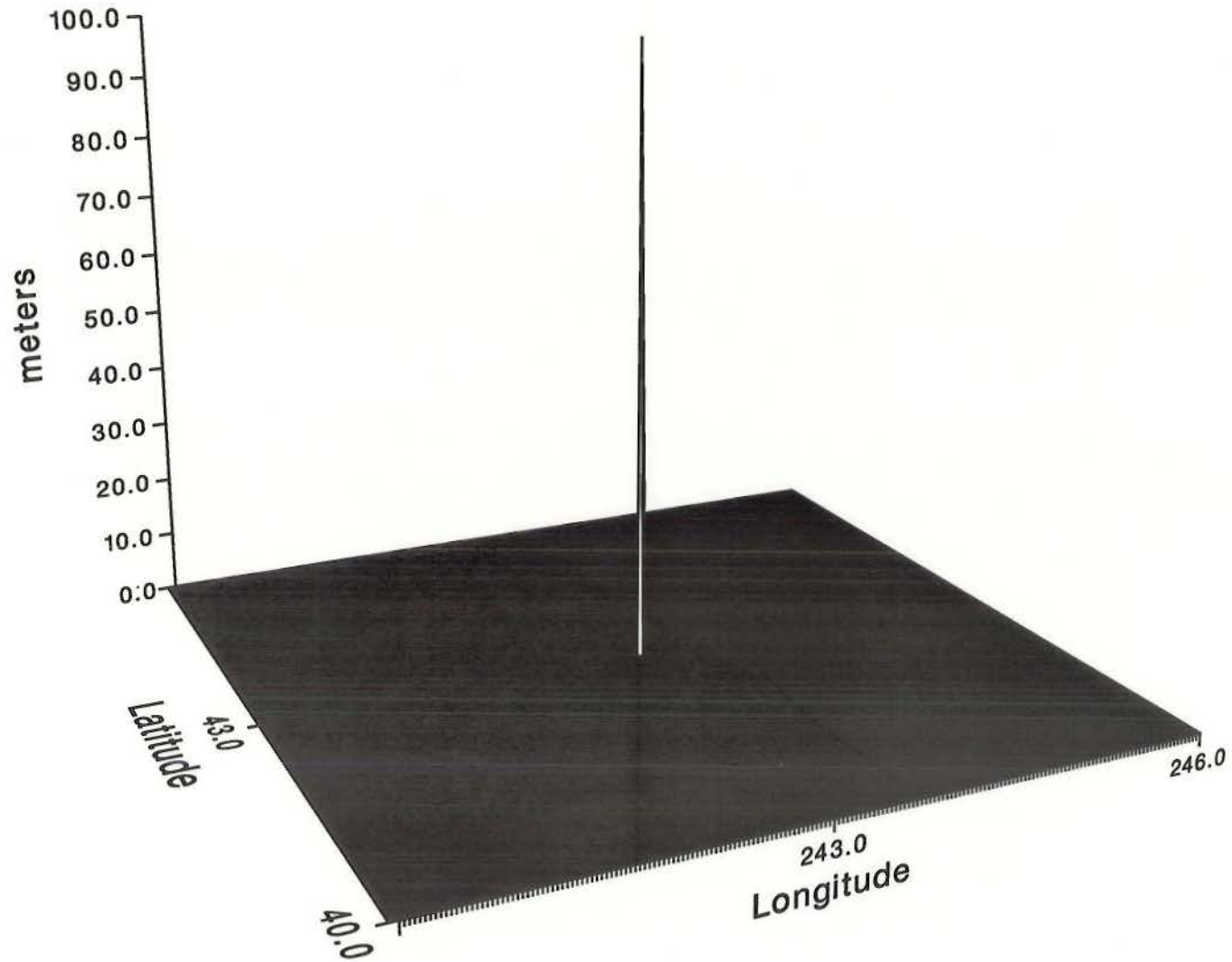
USGS 3" TC minus NIMA 3" TC
ave = .72 mGal max = +18 mGal

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

100 meter spike test



FFT vs Space Domain, 100 m spike TC test

<u>Psi</u>	<u>FFT</u>	<u>Space Domain</u>	<u>Difference</u>
0	32.00 mGal	9.80 mGal	22.2 mGal
1"	5.40	0.40	5.0 mGal
2"	0.67	0.16	0.51 mGal
3"	0.20	0.08	0.12 mGal
4"	0.08	0.05	0.03 mGal

FFT vs Space Domain, 10 m spike TC test

<u>Psi</u>	<u>FFT</u>	<u>Space Domain</u>	<u>Difference</u>
0	0.320 mGal	0.350 mGal	0.030 mGal
1"	0.054	0.056	0.002 mGal
2"	0.007	0.007	0.000 mGal
3"	0.002	0.002	0.000 mGal
4"	0.001	0.001	0.000 mGal

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 $0^\circ < \psi < 0.5^\circ$
 - 3) Use 30" DEM for $0.5^\circ < \psi < 4.0^\circ$
 - 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

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