Orthometric Heights from GPS and the GEOID99 high resolution geoid model for the United States

by

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- Review of Height Systems
- Creation of GEOID99 model
- Comparison with GEOID96
- Future Directions
h = H + N
In the USA: N < 0
Real Situation

Earth's Surface

\[ h_{83} = H_{88} + N_{99} \]

In the USA: \[ N_{99} < 0 \]
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 ≈ 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
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
GPS/BMs for GEOID99 (6169 points)
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:
  - \(~14 \text{ cm} \text{ (1 } \sigma \text{) locally (max } +/- 40 \text{ cm)}\)
  - \(~7 \text{ ppm tilts (1 } \sigma \text{) (max } +/- 200 \text{ ppm)}\)
## GEOID96 vs GEOID99

<table>
<thead>
<tr>
<th></th>
<th>GEOID96</th>
<th>GEOID99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid</td>
<td>2'x2'</td>
<td>1'x1'</td>
</tr>
<tr>
<td>North edge</td>
<td>54</td>
<td>58</td>
</tr>
<tr>
<td>DEM</td>
<td>TOPO30 (30&quot;)</td>
<td>corrected TOPO30 and 1&quot; NGSDEM99</td>
</tr>
<tr>
<td>TCs</td>
<td>30&quot;</td>
<td>3&quot; and 30&quot;</td>
</tr>
<tr>
<td>GPS/BMs</td>
<td>2951</td>
<td>6169</td>
</tr>
<tr>
<td>NAVD 88 bias</td>
<td>-31 cm</td>
<td>-52 cm</td>
</tr>
<tr>
<td>RMS wrt GPS/BMs</td>
<td>5.5 cm</td>
<td>4.6 cm</td>
</tr>
</tbody>
</table>
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

WWW (Sept. 30):
http://www.ngs.noaa.gov/GEOID/geoid99.html

CD-ROM (Mid-October):
Information Services Branch
NOAA/National Geodetic Survey, N/NGS12
1315 East-West Highway, Station 9202
Silver Spring, MD 20910-3282
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