Report on Colorado geoid comparisons

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Model contribution groups

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Introduction

• Objectives
  a) How well do the geoid models agree?
  b) How do they compare with independent GPS/leveling data?
  c) Geopotential numbers and their accuracies

• Participants: IHRS, IAG SC2.2, ICCTJSG 0.15 & JWG 2.2.2

• Additional groups will have their models ready for a later study.
Reference models recommended

• GOCO05S (n=2, 280) (Mayer-Gürr, T. et al, 2015)
• xGEOID17 RefB (n=2, 2190) (Wang, Y.M. et al, 2017)
• xGM16 (n=2, 719) (Pail, R. et. al, 2017)

Note: EIGEN6C4 (n=2, 2190) (Föster et al. 2014) was not suggested in IHRF_Basic_req_V0.3, but was used by one group
GRAV-D (MS05) + surface gravity
Geoid Height Diff. along GSVS17
Geoid diff. (model – mean)
223 benchmarks, Unit in meters

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.470</td>
<td>-0.148</td>
<td>0.202</td>
<td>0.911</td>
<td>-0.075</td>
<td>-0.466</td>
<td>-0.021</td>
<td>-0.802</td>
</tr>
<tr>
<td>STD</td>
<td>0.221</td>
<td>0.056</td>
<td>0.014</td>
<td>0.043</td>
<td>0.036</td>
<td>0.024</td>
<td>0.023</td>
<td>0.202</td>
</tr>
<tr>
<td>Min.</td>
<td>0.969</td>
<td>-0.317</td>
<td>-0.234</td>
<td>0.776</td>
<td>-0.135</td>
<td>-0.504</td>
<td>-0.080</td>
<td>-1.262</td>
</tr>
<tr>
<td>Max.</td>
<td>1.943</td>
<td>-0.021</td>
<td>-0.172</td>
<td>1.008</td>
<td>-0.019</td>
<td>-0.392</td>
<td>0.058</td>
<td>-0.524</td>
</tr>
<tr>
<td>Range</td>
<td>1.074</td>
<td>0.296</td>
<td>0.062</td>
<td>0.232</td>
<td>0.116</td>
<td>0.112</td>
<td>0.138</td>
<td>0.738</td>
</tr>
</tbody>
</table>

STD values of NGS historical GPS/leveling data comparisons at 194 marks

| STD | 0.361 | 0.082 | 0.051 | 0.071 | 0.078 | 0.051 | 0.053 | 0.206 |
Height Anomaly Along GSVS17

![Graph showing height anomaly along GSVS17 marks.](image-url)
Height Anomaly Diff. (model-mean)

-0.05
-0.1
-0.15
-0.2
-0.25
-0.3

0 50 100 150 200

GSVS17 Marks (West to East)
Height anomaly diff. (model – mean)
223 benchmarks, Unit in meters

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
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<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.157</td>
<td>-0.163</td>
<td>0.944</td>
<td>-0.042</td>
<td>-0.429</td>
<td>-0.153</td>
<td>-0.467</td>
<td></td>
</tr>
<tr>
<td>STD</td>
<td>0.020</td>
<td>0.010</td>
<td>0.039</td>
<td>0.038</td>
<td>0.020</td>
<td>0.021</td>
<td>0.463</td>
<td></td>
</tr>
<tr>
<td>Min.</td>
<td>-0.206</td>
<td>-0.188</td>
<td>0.802</td>
<td>-0.103</td>
<td>-0.466</td>
<td>-0.198</td>
<td>-1.457</td>
<td></td>
</tr>
<tr>
<td>Max.</td>
<td>-0.117</td>
<td>-0.142</td>
<td>1.018</td>
<td>0.027</td>
<td>-0.388</td>
<td>-0.065</td>
<td>0.166</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0.089</td>
<td>0.046</td>
<td>0.216</td>
<td>0.130</td>
<td>0.078</td>
<td>0.133</td>
<td>1.623</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Geoid/height anomaly models from 8 groups are compared.

• The degree-zero is not applied consistently by different groups.

• The models agree within 3 cm to 10 cm in terms of standard deviation with respect to the mean, 2 models are treated as outliers.

• Models agree with the historical NGS GPS/leveling data in the range of 5 to 8 cm, excluding two outliers.
Conclusions (continued)

• The GRAV-D data was not included in few groups’ models. It should be used in the final models.

• Need to pay attention to geoid differences at short wavelengths.

• Are corrections (e.g., atmospheric, geoid-quasigeoid separation) applied consistently between groups?

• Models received are computed using the Stokes integral, the Least Squares Collection solutions are desired.
Future Work

• Cleanup the GRAV-D data and resample it into 1Hz; make it available to all groups.
• Provide the groups the mean profiles of geoid undulation and height anomaly.
• Standardize the procedure for degree-zero implementation on the geoid and geopotential numbers.
• Complete the study after the GSVS17 data becomes available (hopefully before IUGG 2019).