Accuracy of GPS Positioning in the Presence of Large Height Differences

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Background

- Large height difference between baseline points
- First mentioned by Gurtner et al. 1989
- Shön 2007 developed a correction model for landslides
- We study the effect in detail
  - for ‘observing session duration’
  - make inferences for ‘GPS accuracy studies’
GPS Data

- SCIGN and other networks in the region
- Through SOPAC Archives
- RINEX format, 30 sec sampling rate, 15° elevation angle
- JPL
  - Precise orbits
  - Clock errors
  - Earth orientation parameters
GPS Software

- Developed by the NASA
  - GIPSY OASIS II
- Precise Point Positioning (PPP) – Zumberge et al. 1997
  - Differential PPP; assumed to be equivalent to ‘Relative Positioning’
  - Range of Baseline Lengths; 10-15 km
  - Ambiguity Resolution applied (Blewitt 1989)
  - Troposphere: Niell Mapping Func., Random Walk
  - Ionosphere: Lc
  - Ocean Loading: HG Scherneck, M.S. Bos
  - Reference Frame: ITRF 2000

Processing Strategy

- 10 days of data observed in May and June 2003 (GPS days 150 through 159).
- data subdivided into mutually non-overlapping sessions
- observing session \( T (1, 2, 3, 4, 6, 8, 12 \text{ and } 24 \text{ h}). \)
- For each subset of data, PPP applied
- True position from average of 24-h sessions
- Solution RMS for \( n, e, \text{ and } u \) from this true position
- Solution exceeding 3RMS: Outlier
### Outlier Statistics

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<th>Theoretical Number of Solutions</th>
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<th>East</th>
<th>Up</th>
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<td>Rejected</td>
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</table>

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### Solution RMS vs Height Difference

#### 1-h

#### 2-h

#### 3-h
Correlations vs session length

Accuracy Prediction – Eckl et al. 2001

\[ S_n(\Delta h, T) = \left[ a_n / T + b_n \Delta h^2 / T + c_n + d_n \Delta h^2 \right]^{0.5} \]
Model fit to 6 h solutions

Comparison with Eckl et al. 2001
Practical aspects

- Research software
  - Use min 3 h for flat surfaces
  - Extend measurements up to 12 h for mountainous areas
  - When height difference ~ 1500 m
    - Session length 3 h
    - Confidence level 95%
    - Accuracy ~ 4 cm

Commercial software – 24 h (Sanli et al. 2005)

![Graph showing height repeatability vs. height difference]
Conclusions

- Good for survey planning
  - Network optimization
  - GPS Levelling
- Monitoring studies affected
  - Land slides
  - Volcanoes
  - Tall buildings
  - Dams
  - Bridges etc.
- A new constraint for accuracy assessments
- GPS Accuracy improved in Sanli and Engin 2007!
- Consider unified modeling

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