Accuracy of GPS Positioning in the Presence of Large Height Differences

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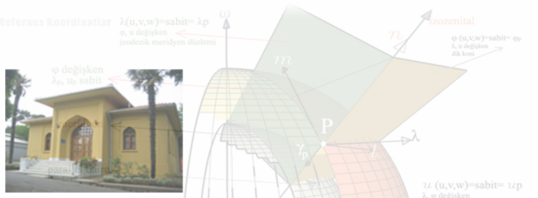
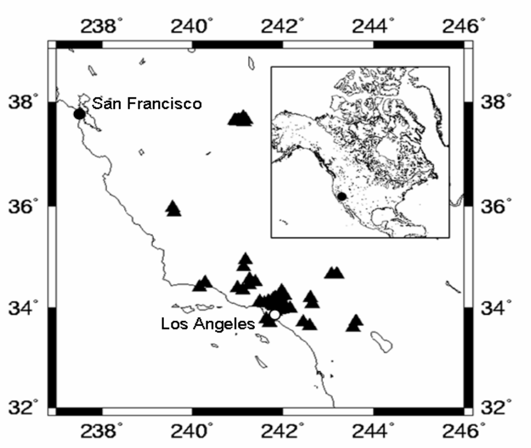


Background

- 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’

Experiment



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

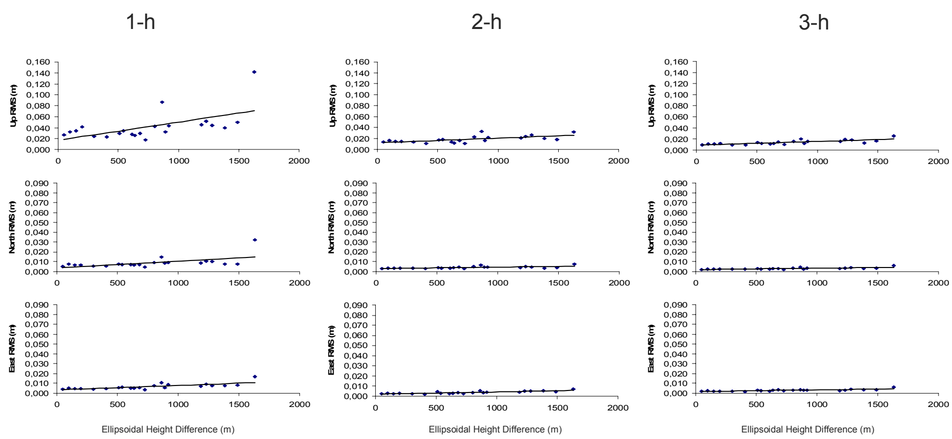
Processing Strategy

- 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 and 24 h).
- For each subset of data, PPP applied
- True position from average of 24-h sessions
- Solution RMS for n, e, and u from this true position
- Solution exceeding 3RMS: Outlier

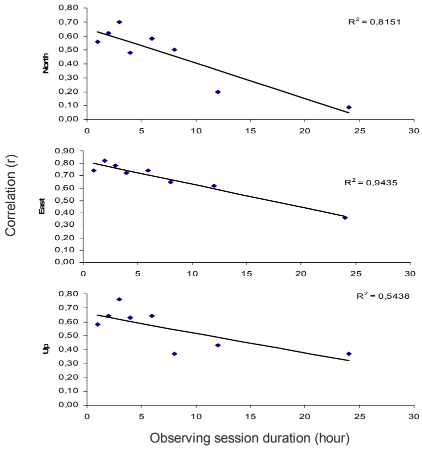
Outlier Statistics

T	*Theoretical Number of Solutions*	*North*			*East*			*Up*		
		Used	Rejected	%	Used	Rejected	%	Used	Rejected	%
1	6240	5633	548	9.7	4910	1271	25.9	6181	659	10.7
2	3120	3003	94	3.1	2967	130	4.4	3097	97	3.1
3	2080	2022	44	2.1	2028	38	1.9	2066	30	1.4
4	1560	1546	28	1.8	1523	23	1.5	1546	19	1.2
6	1040	1037	15	1.4	1023	14	1.4	1037	5	0.5
8	780	763	12	1.6	769	7	0.9	776	4	0.5
12	520	514	3	0.6	514	3	0.5	517	1	0.2
24	260	257	0	0	257	0	0	257	0	0

Solution RMS vs Height Difference



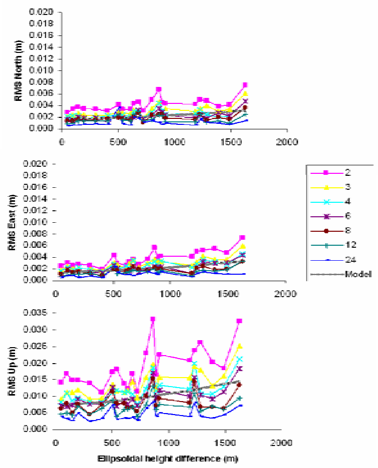
Correlations vs session length



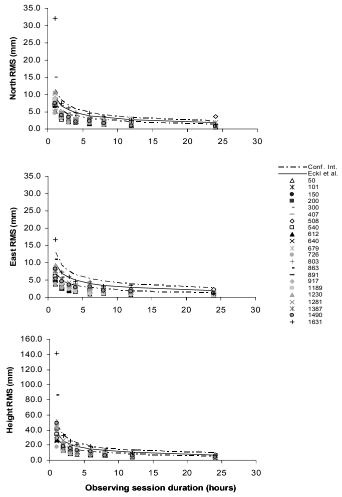
Accuracy Prediction – Eckl et al. 2001

$$S_n(\Delta h, T) = [a_n / T + b_n \Delta h^2 / T + c_n + d_n \Delta h^2]^{0.5}$$

Model fit to 6 h solutions



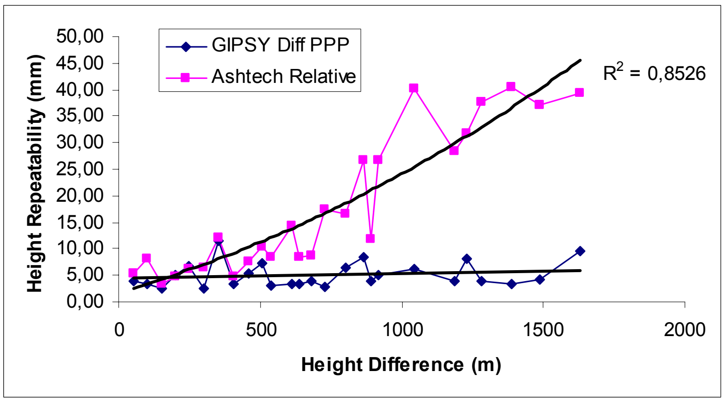
Comparison with Eckl et al. 2001



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)



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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