GPS: "*Where goeth thou*"

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Overview

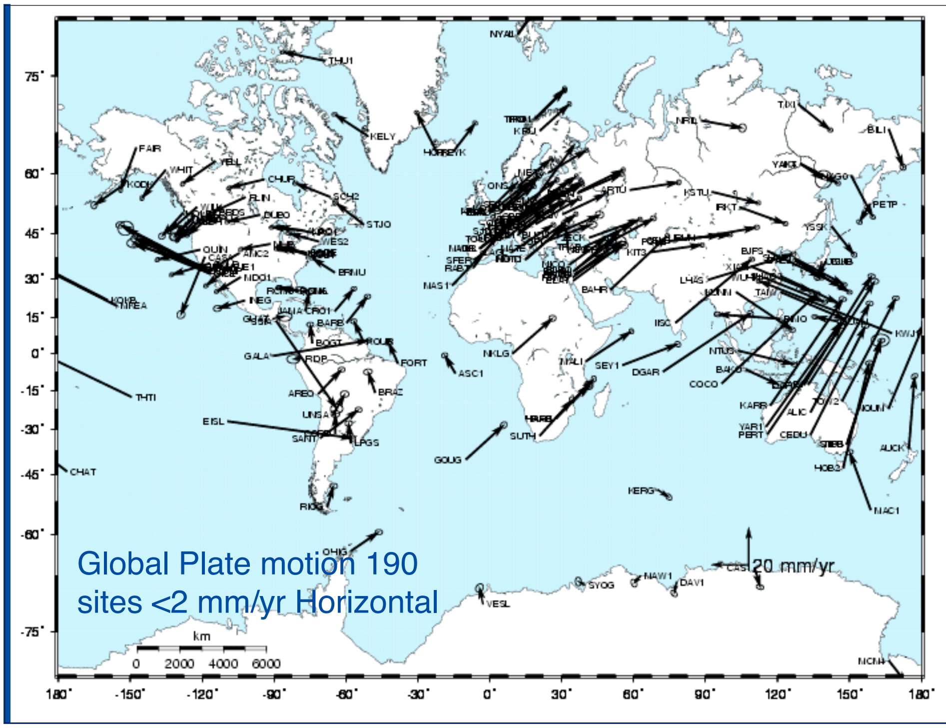
- This semester we have had two faculty talks on GPS results: Today
  - Analysis of accuracy of GPS
  - Motivations for improving GPS accuracy
  - Classes of problems we know we have in GPS and how we are addressing them
  - Effects of surface loads— sanity check on accuracy
- So far GPS accuracy/precision has been pushed three-orders of magnitude over its design specification—Why not try for four-orders of magnitude?

Motivation for improving GPS accuracy

- Types of high-precision GPS applications
  - Measurement of secular strain accumulation. Improved accuracy speeds up process, but not critical if not achieved.
  - Transient strain events (eg., Jeff McGuire's talk). Being commonly observed in subduction zone environments and post-seismic. Accuracy critical here for reliability and detectable magnitudes.
  - In both cases, studies may be global or regional.
  - Specific global, secular problem: Measuring motions of tide-gauges so that tidal records can yield "absolute" sea-level changes

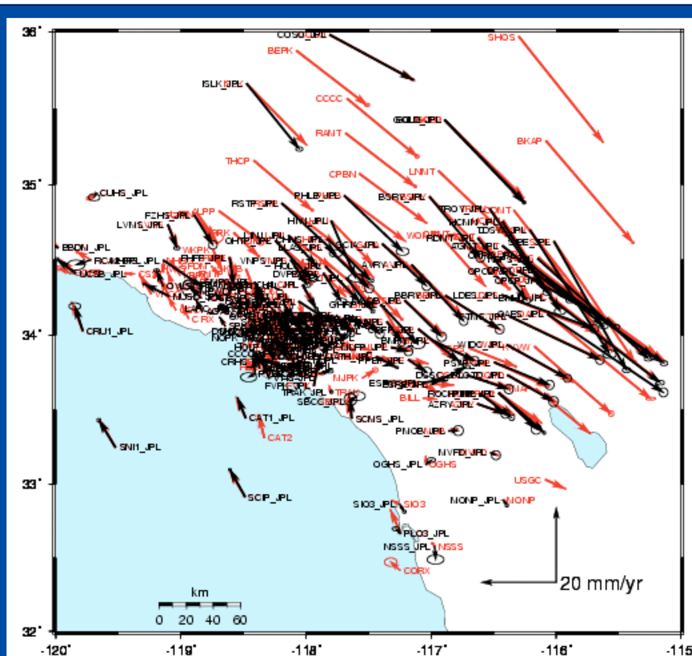
Motivations for improving accuracy

- Applications continued
  - Spacecraft and aircraft navigation for altimeter applications. Averaging altimeter results (eg., TOPEX mean level rate of change) requires long-term stability of orbital reference frame.
  - Atmospheric delay measurements for weather forecasting and long terms studies of average atmospheric water vapor.
- In general, the most stringent requirements come from global scale problems for both secular and transient measurements.



GPS Networks (Data and Results freely available from Internet)

- The International GPS service (IGS) uses about 140 stations to determine GPS satellite orbits
- Southern California Integrated GPS Network has 250 stations
- The National Geodetic Survey CORS network has currently 260 sites
- Japanese network >1000 stations
- Plate Boundary Observatory (PBO) could add 875 sites across Western US and Alaska in next 6 years.



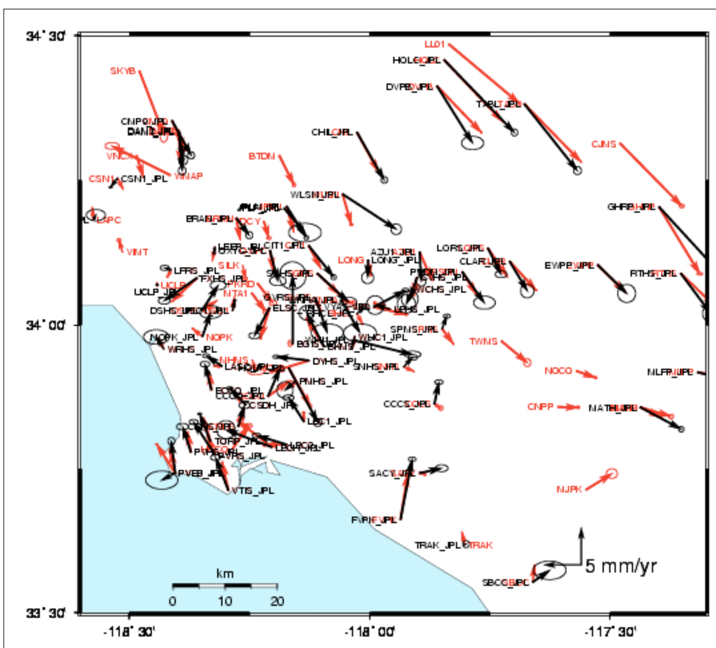
190 stations around LA.

Red SIO

Black JPL

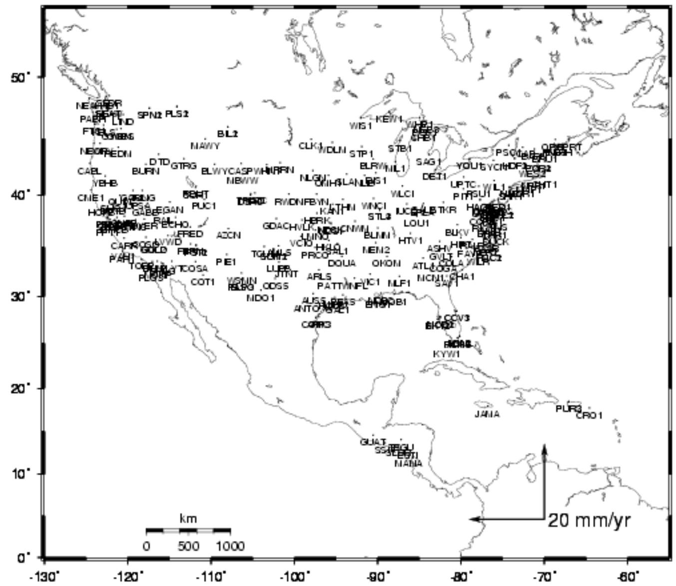
RMS diff

~1.2 mm/yr

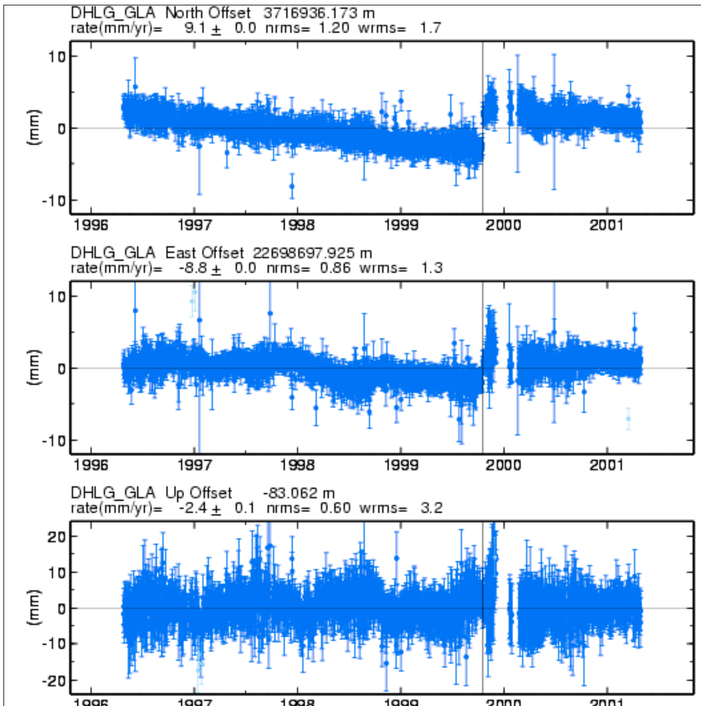


Detail in LA Basin

Sites which disagree tend to have systematic behavior in the time series.

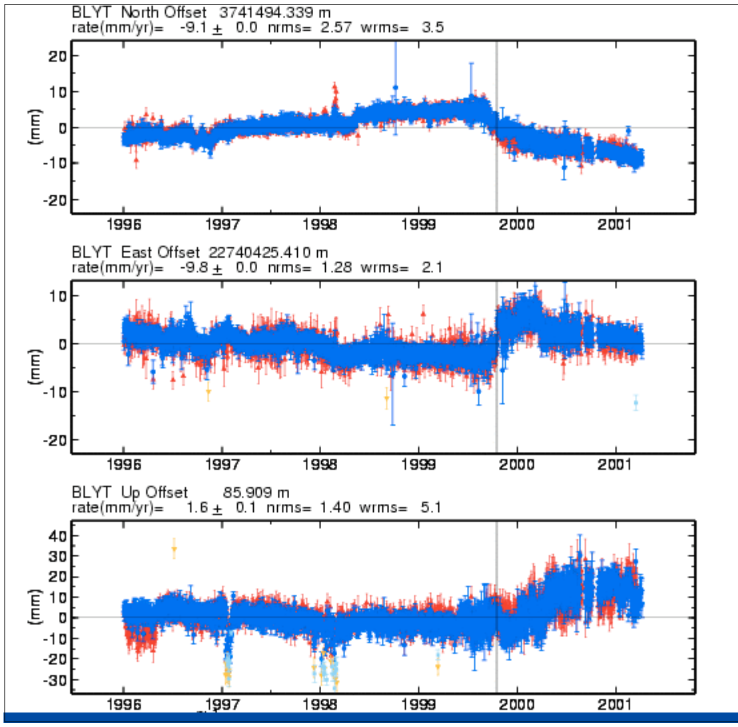


Distribution of CORS stations in US and region



Time Series:
North RMS 0.7 mm
East RMS 1.0 mm
Height RMS 3.2 mm

Coseismic displacement after Hector Mine earthquake

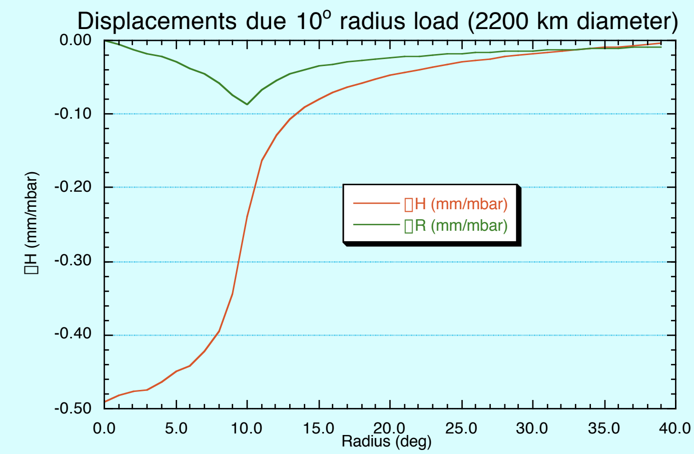


Results from Blyth on California Nevada Border

Reason for North change in rate before Hector mine not known

Origins of systematic variations

- Examine the effects of surface loading
- These calculations are the obtained by convolution of an elastic Green's function (Farrell, 1967) with surface loads.
- For large area loads, the deformations are dominated by vertical displacements are center of load
- Examine atmospheric pressure and ground water



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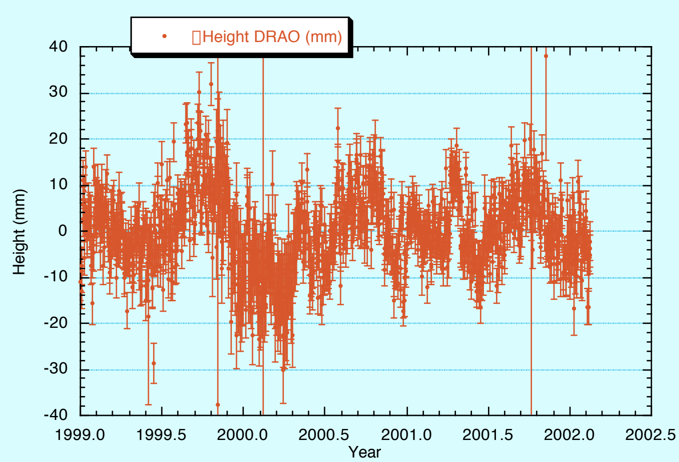
Height Changes at Penticton, Canada



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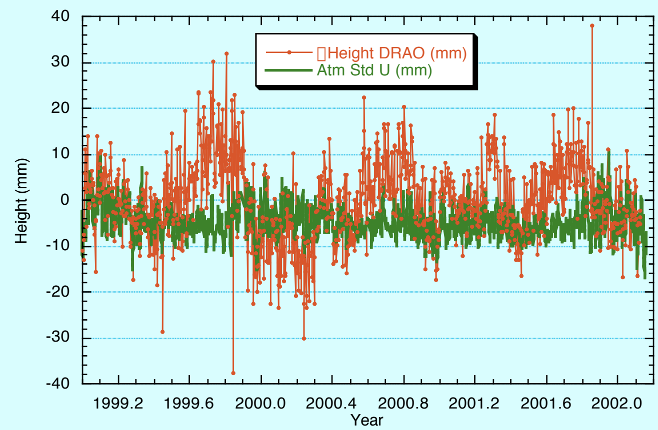
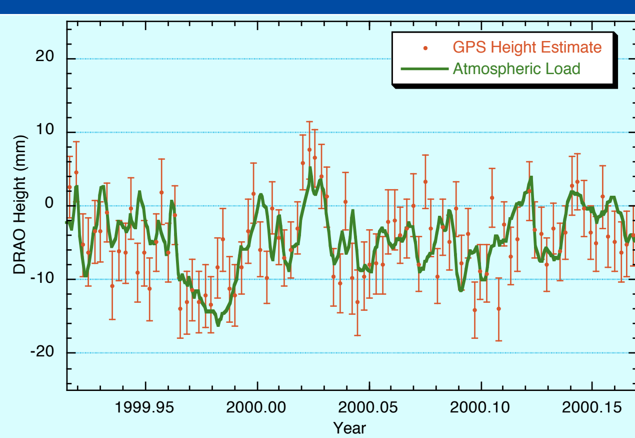
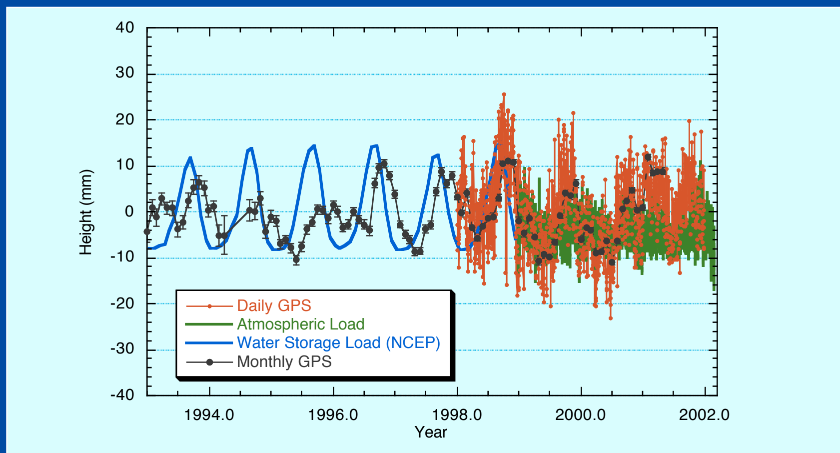
Penticton Height Changes with Atmospheric load



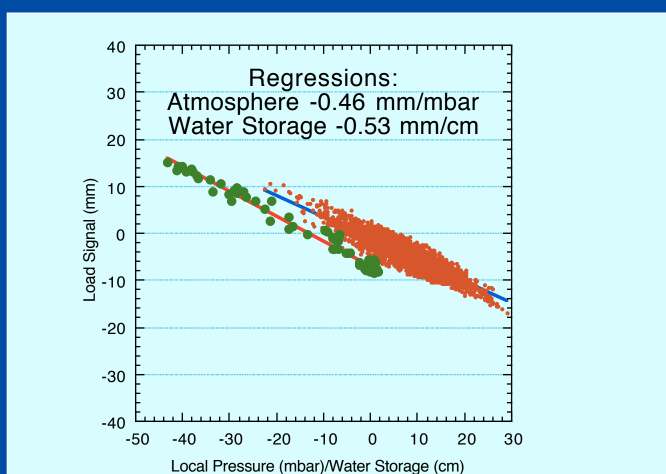
Penticton Zoom in Winter Months



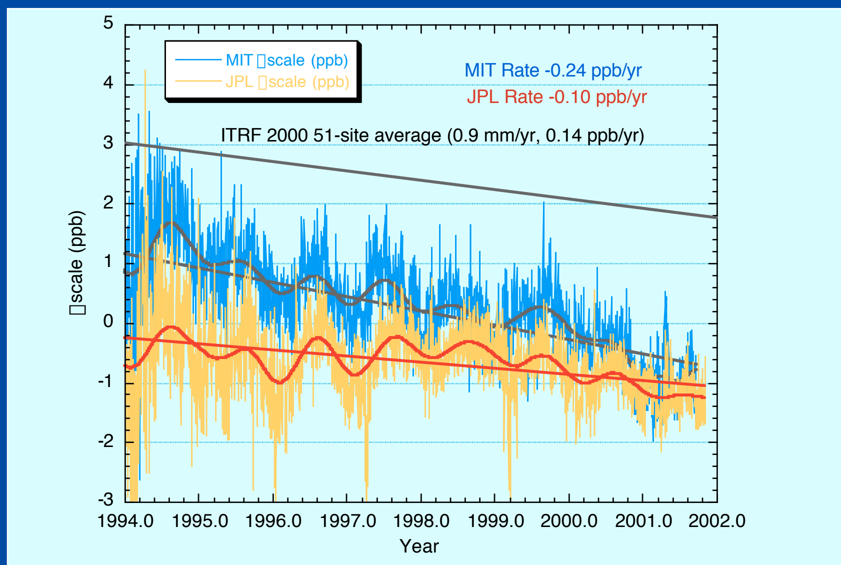
Water storage load displacement (NCEP)



Load Versus Local Signal



Impact of Global Scale



Conclusions

- GPS results have precision of order 1-2 mm even on large networks
- Systematic variations, reflecting possible accuracy problems, can be due to actual deformation processes
- Comparison with external models and improvements to GPS models and analysis could lead to routine sub-millimeter global positioning: 4-orders of magnitude better than design
- Gravity Recovery and Climate Experiment (GRACE) could provide “direct” measurements of loads