STABILITY OF GLOBAL GEODETIC RESULTS

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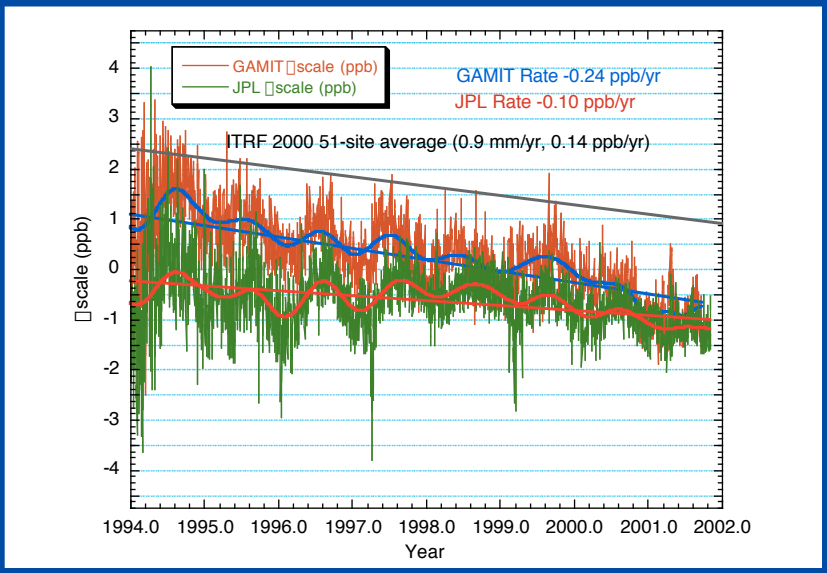
Overview

- Motivation for talk: Anomalies in apparent positions of phase centers of GPS satellites, and variations in global scale
- Analysis of GPS results with satellite phase center position estimated and ground antenna phase center models
- Comparison of scale variations with VLBI results

Motivation

- Launch of Block IIR satellite in July 1997 showed that the apparent phase center of satellite could over 1 m from the manufactures specification. Not until Oct 1999 when second Block IIR launched that this could be confirmed.
- So many years, use of anechoic chamber measurements for ground antennas causes large scale change (14 ppb)
- Scale rate estimates showed values that could be artifact or due to global deformation

Scale evolution from daily scale estimates

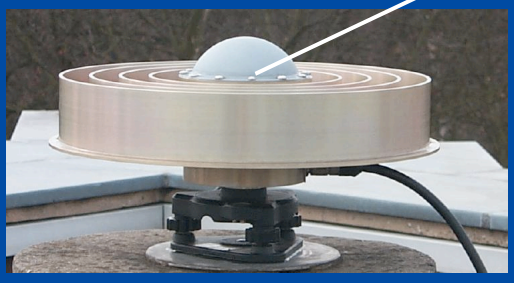


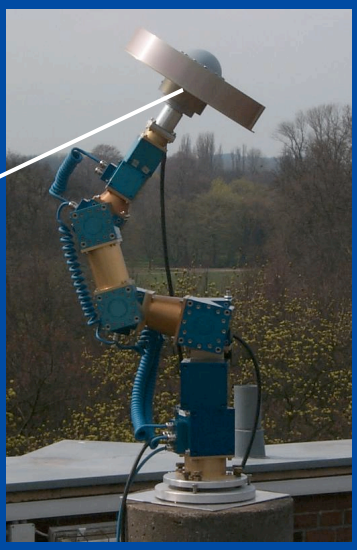
Analysis GPS phase centers

- Two locations need to be considered:
  - Ground antenna phase center pattern
  - Satellite antenna phase center
  - In both cases: Pattern must be referred to a physical location. Antenna Reference Point for ground antennas; position relative to center of mass for satellite.
- Recent insitu absolute phase center calibrations match most of the previous anechoic chamber results

Absolute calibration

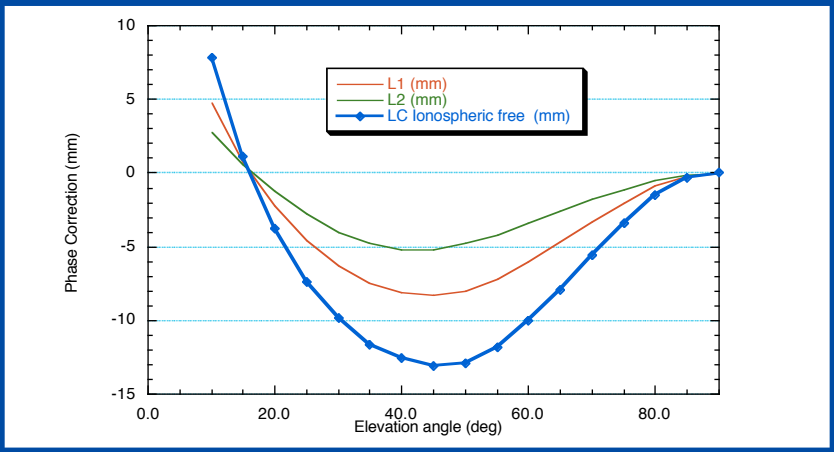
- Hannover System:



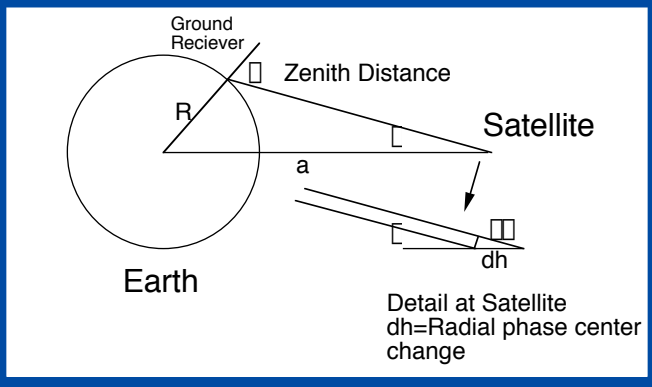


- http://www.ife.uni-hannover.de/~web/AOA_DM_T/

Absolute phase center corrections for choke ring antennas

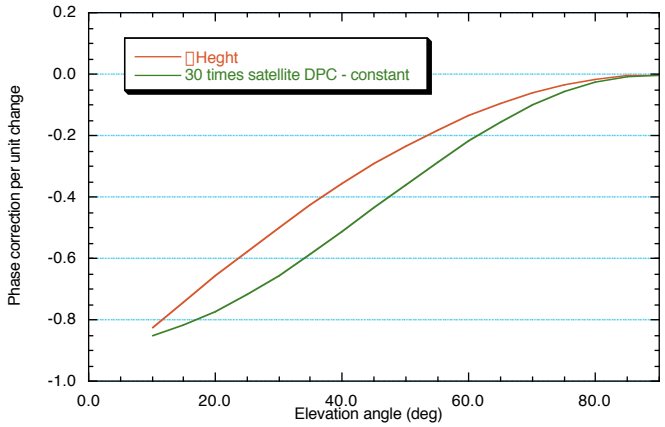


Effects of satellite phase center offset (radial)

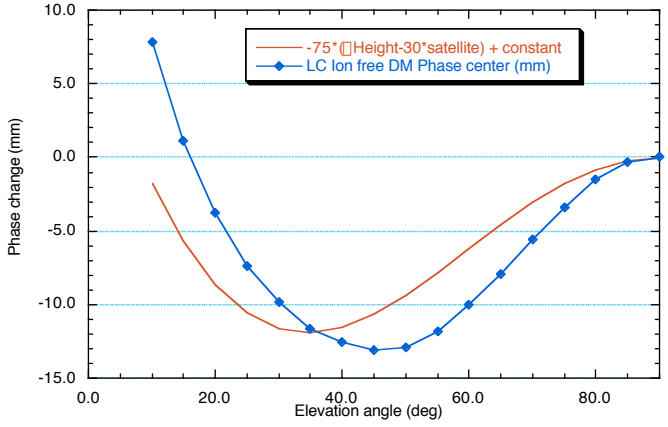


$\Delta\rho = dh \cos \zeta$; $\sin \zeta = (R/a) \sin \zeta$; $(R/a) = 0.24$

Similarity of satellite phase center and receiver height



Relationship between DM phase center and effects of station height and satellite PC



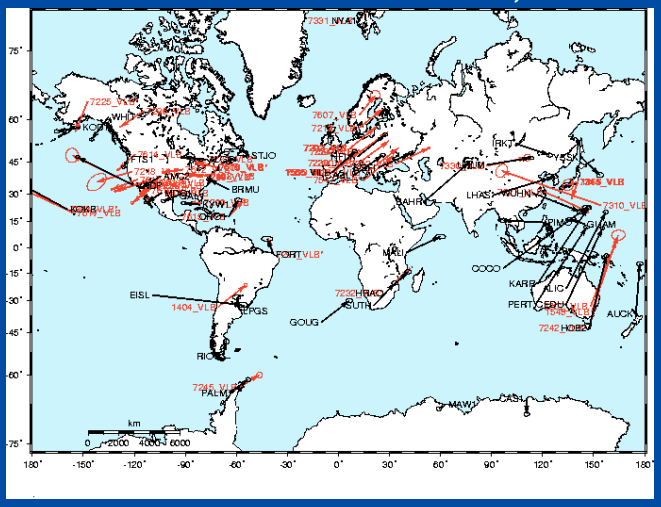
Summary of expected phase changes

- The absolute phase center corrections for choke ring antenna are ~20 mm
- Satellite radial phase center position changes map to 1/30 of station height changes when clock offset included
- Difference between satellite phase center change ands station height times 75 is comparable to choke ring phase center
- Expectation: meter level changes in satellite phase center position when choke ring phase center used.

GPS and VLBI analyses

- To understand these effects, we have performed the following analyses:
  - GPS scale variations using standard GPS analyses (zero phase center correction for choke ring; fixed satellite phase center). SOPAC h-files from sopac.ucsd.edu+JPL results)
  - Satellite phase center offsets; zero choke ring
  - Satellite phase center offsets with Hannover Choke ring model
  - VLBI SINEX file analysis for scale (now available at http://www-gpsg.mit.edu/~tah/VLBI_SINEX).

Networks used:
Black 45 GPS sites; Red VLBI



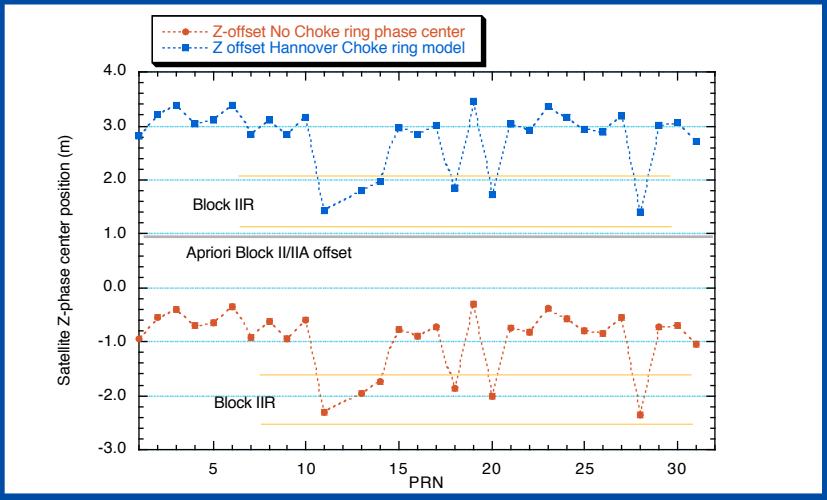
VLBI:

1885 sessions
1990-2000

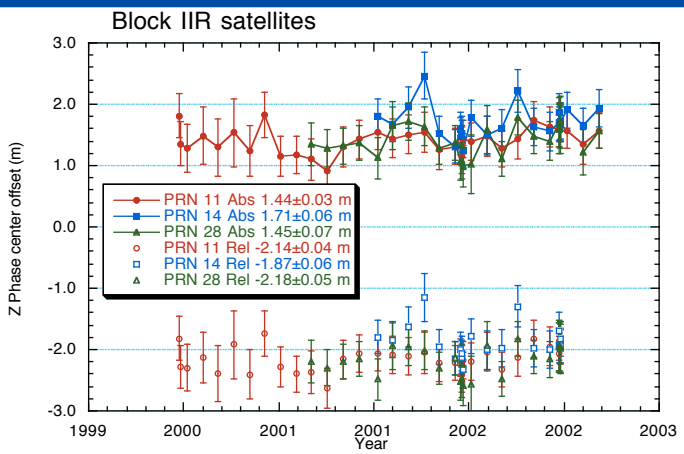
GPS:

Monthly
1999-2001

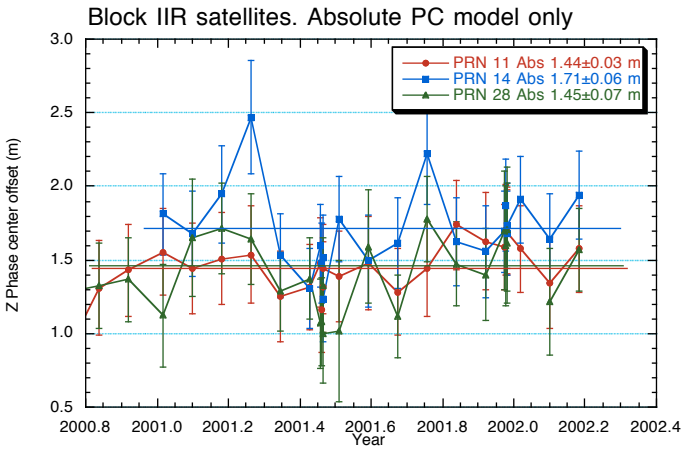
Estimated Satellite Z-offsets



Time series estimates

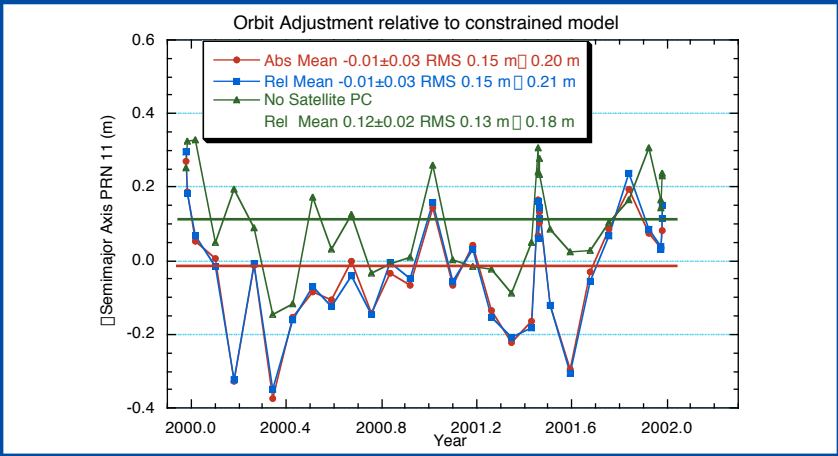


Zoom of Absolute series only



Effects on radial orbit position of satellite

Apriori orbit: No satellite or choke ring PC, sites constrained



Summary of phase center

- The effects of ground antenna phase center model only satellite phase center estimates are large (~3.6 meters)
- Block II/IIA definitely different from Block IIR and some indication of differences between satellites within the same type (differences are a few centimeters)
- Radial orbit changes are small (<1 cm on average). Interestingly better agreement of loose solution with constrained when satellite PC estimated (10 cm differences),

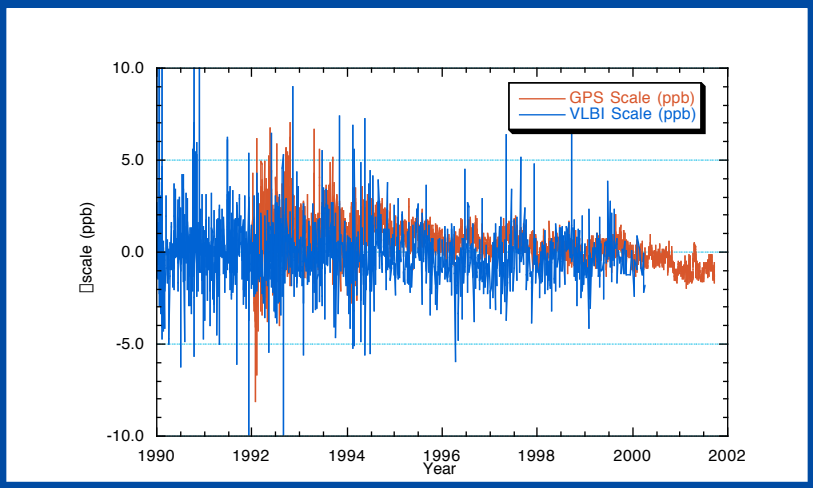
Scale effects

- From the different analyses and VLBI analysis we can estimate scale and its rate of change:

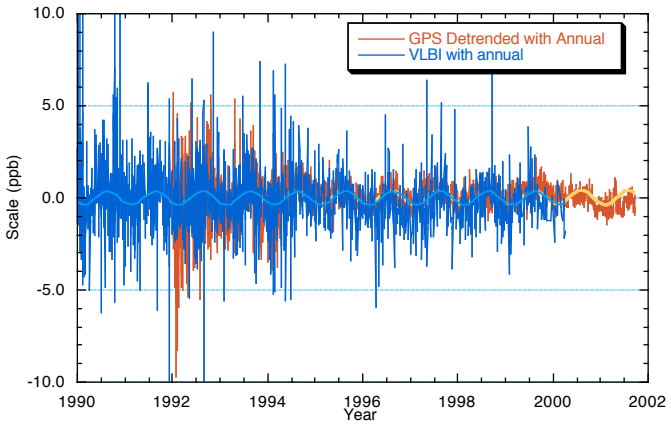
Soln	Scale	+-	Srate	+-
Abs	-6.04	0.25	-0.24	0.06
Rel	11.99	0.25	-0.22	0.06
VLBI	-0.21	0.04	-0.02	0.01

- Scale in ppb and scale rate ppb/yr (1ppb=6mm)

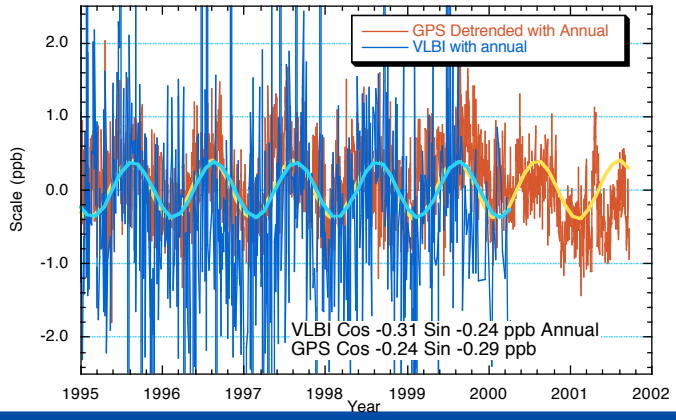
Temporal Variations in Scale



VLBI + GPS Detrended with Annual



Zoom of Previous Figure



Conclusions

- GPS has difficulty in separating ground antenna and satellite phase center effects and positions. Limits the accuracy of global geodetic results
- Precision of GPS much better
- Secular scale rates of loose GPS solutions
  -0.1 to -0.2 ppb/yr (0.6-1.2 mm/yr heights) probably artifact: not seen in VLBI
- Annual scale is probably real: Amplitude 0.4 ppb (2.5 mm): Water and atmospheric pressure loading are likely origin