The Effect of SCIGN Domes on the Vertical Phase Centre Position in Routine Processing of GPS Data

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IGS 2004

Outline

- Effect of Domes
- Raising the Dome
- Overview WCDA Network, Data Analysis
- Results from PGC5 – Dome Induced Steps
- The Dome Effect
- Concluding Comments

Effect of Domes

Clear Acrylic Dome (EMRA)

- ~1.5cm change in vertical
- no discernable change in horizontal component

SCIGN Dome (SCIS) :

- ~2.0cm change in vertical
- no discernable change in horizontal component

Similar vertical shifts have been observed in other IGS Networks (e.g. Iceland)

Notes wrt Dome Induced Shifts:

- Vertical offset values are not a “calibrated” value (analysis dependant).

Effect of a Raised Dome

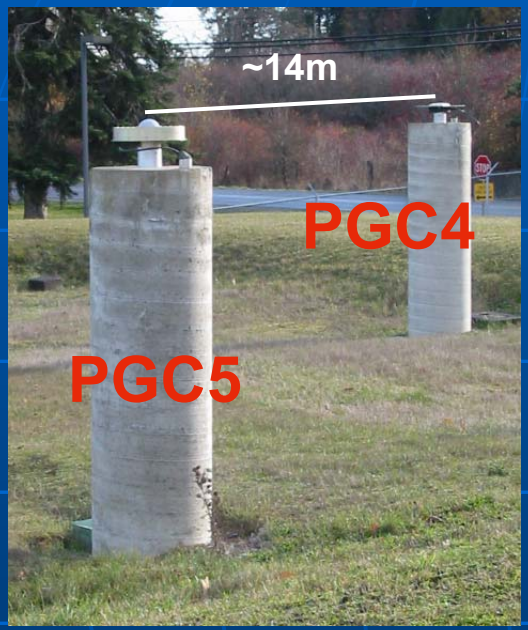
• Thesis: Mount SCIS dome so that the centre of curvature coincides with the mean position of the L1/L2 phase centres of the Dorne Margolin element

• Dome raised by 0.036m (3.6cm)
• Dome raised using machine screws
• L1/L2 phase centre values from IGS PCV table

• Caveats:
  • mounting may introduce unaccounted for near-field MP
  • used relative not absolute phase centre values for the Dorne Margolin choke ring antenna

NRCan

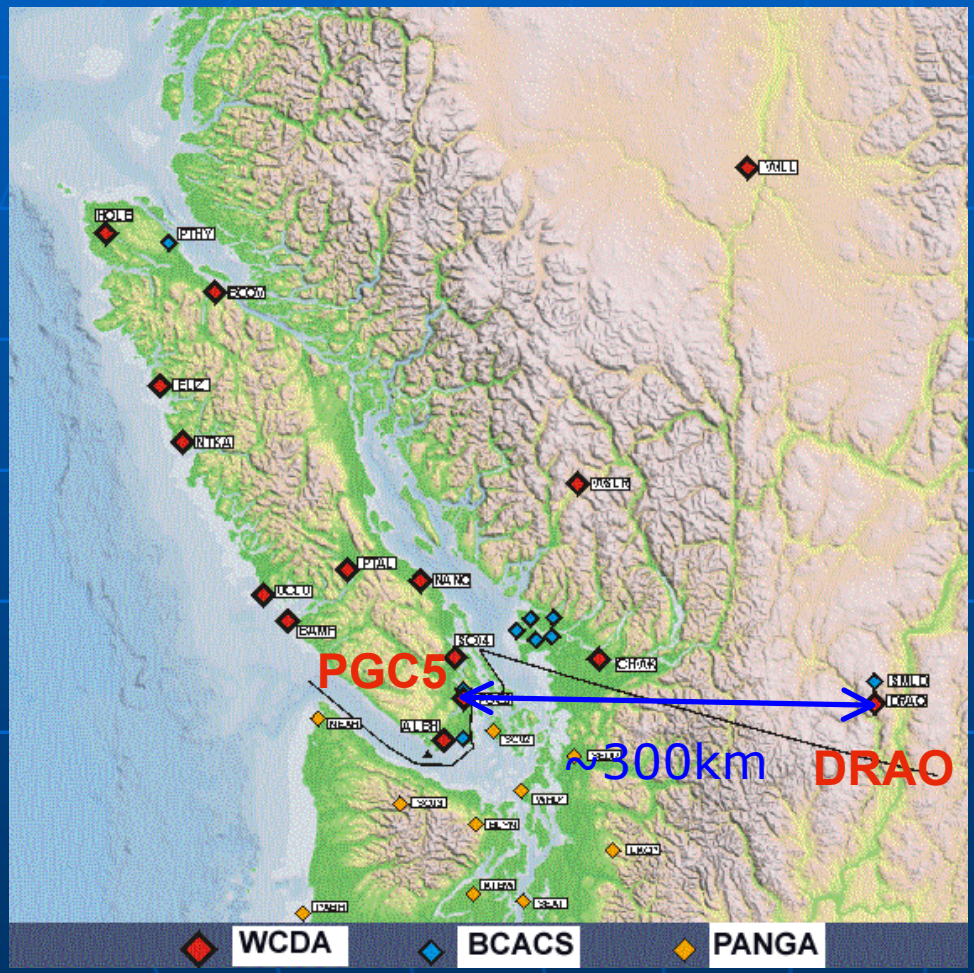
WCDA Test Facility:
PGC4 and PGC5 Monuments



- PGC4 operated by BCACS (RTK Net) – Trimble
- PGC5: WCDA site (TIGA) – LEIAT504 DM Antenna
- Piers anchored to buried concrete reservoir

- Concrete piers located ~14m apart
  - ➢ no tropospheric decorrelation
  - ➢ PGC5: Dome changes
  - ➢ PGC4: no changes
  - ➢ able to resolve apparent change in tropospheric delay due to dome changes at PGC5
  - ➢ noise on PGC4-PGC5 differential Zenith Delay ~2mm

Routine WCDA Network Analysis



INCLUDES DATA FROM:

- WCDA Network
- BCACS Network
- PANGA Network

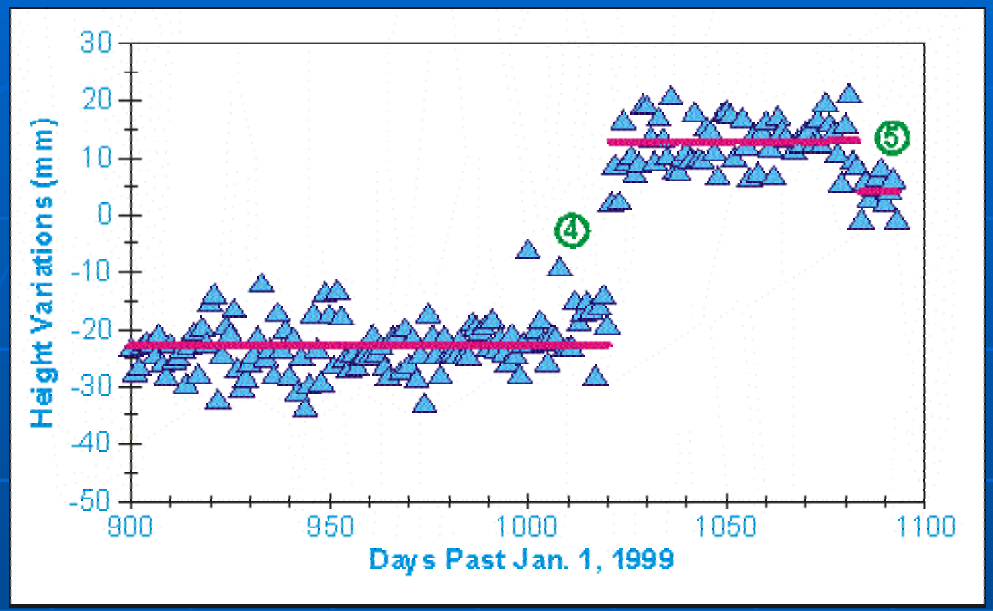
DOME TEST CONFIGURATION

- Dome Tests at PGC5
- Daily Network Solutions wrt DRAO:
  - 24 hour solutions
  - hourly estimates of tropo delay
- Bernese 4.2

GPS Processing

Processing Strategy	Double-difference baselines formed relative to DRAO
GPS Observable	L3 (LC) phase
Ambiguities	Fixed, resolved using QIF strategy
Adjustment	Network
Orbits and EOP	Final IGS orbits & poles
Elev. Cutoff Angle	10 degrees
Elev. Dep. Weighting	Yes, according to cosine of the zenith angle
Solution Sampling Rate	120 s
Zenith Tropo Delay	Stochastic, piecewise constant (1hr est.)
A Priori Tropo Model	Saastamoinen
Troposphere Mapping	Wet Neill
Troposphere Gradient	Yes (6hr estimates)
Solid Earth Tide	On
Ocean Tidal Loading	On (Pagiatakis)
Antenna PCV's	Yes

Steps Coincident with Changes at PGC5

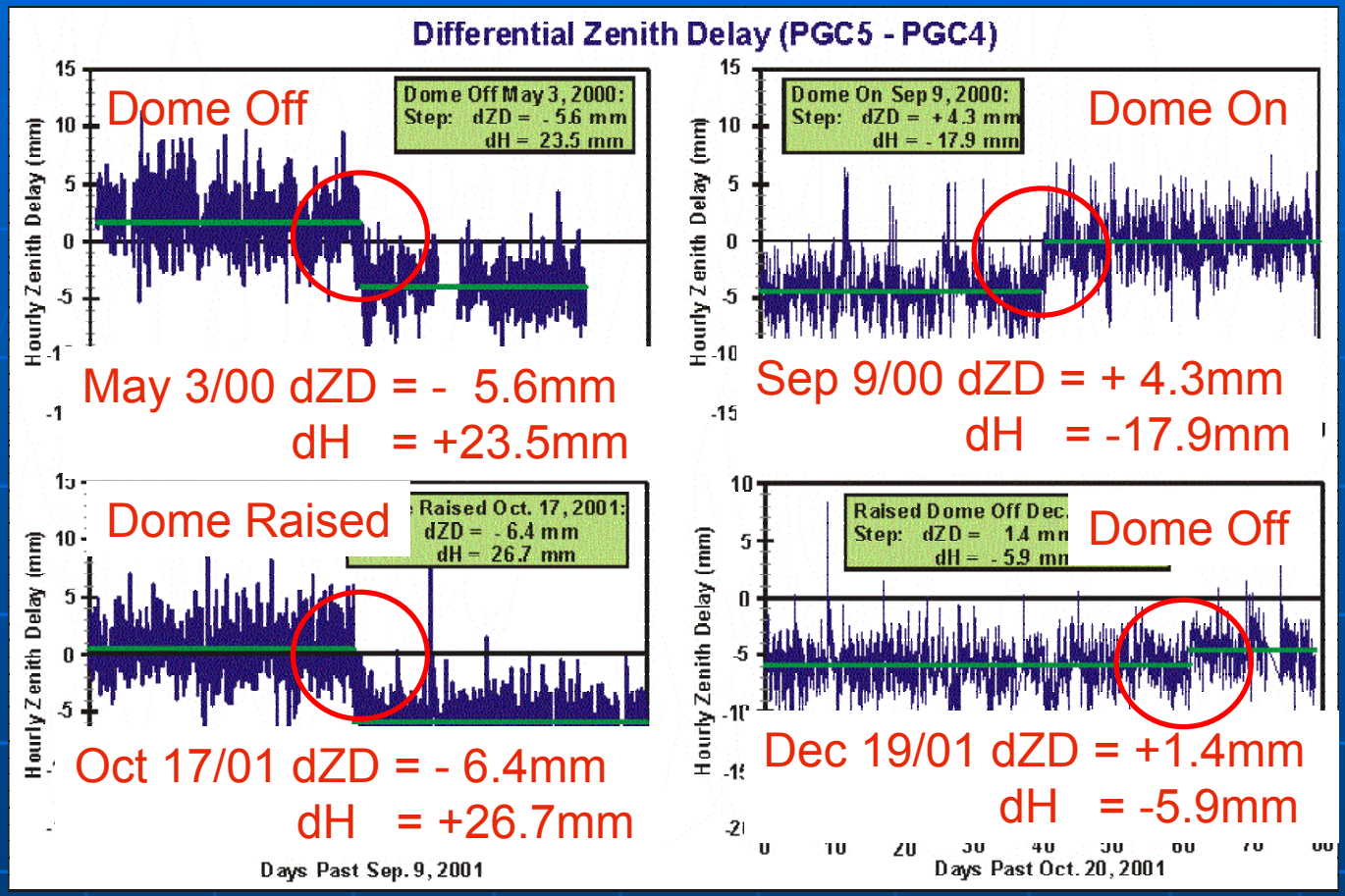


- linear trend and annual signal removed

#	DATE	DOME	APPARENT HEIGHT CHANGE Observed	*ZD-Inferred
1	1999-07-13	On	- 22.3 +1.4 mm	N/A
2	2000-05-03	Off	+22.4 +1.4 mm	+23.5 +12.4 mm
3	2000-09-09	On	- 20.5 +1.5 mm	- 17.9 +13.0 mm
4	2001-10-17	Raised	+35.5 +1.7 mm	+26.7 +12.2 mm
5	2001-12-19	Off	- 8.9 +3.1 mm	- 5.9 +11.3 mm

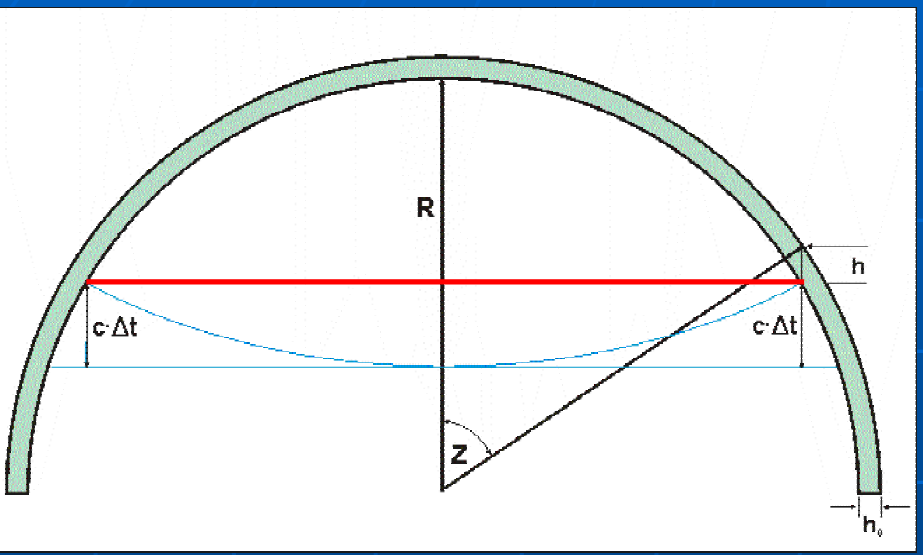
**ZD-Inferred height changes are calculated from the observed changes in the zenith delay scaled by Santerre's nominal 1/cosZ factor for mid-latitudes (~4.2)*

Differential ZD Offsets
PGC5 – PGC4



- PGC4 antenna unchanged during test period
- PGC4 ZD estimates used as reference for PGC5 to resolve ZD changes due to dome (at PGC5)
- It is clear that the presence of a dome biases the tropospheric delay estimate
- It is significant that raising the dome has an effect analogous to removing the dome, thus mitigating the effect of the dome

Dome Delay Effect



The length of travel through dome (h):

$$h = h_0 / \cos Z$$

where h_0 = thickness of dome

Z = Zenith angle

The dome delay (Δt) compared to travel through free air:

$$\Delta t = h/c_m - h/c = h(c - c_m) / cc_m$$

Substituting: $c_m = c / r_m$ gives:

$$\Delta t = h(r_m - 1) / c$$

and $h = h_0 / \cos Z$ gives:

$$c\Delta t = h_0 (r_m - 1) / \cos Z$$

where: r_m = index of refraction of dome material

- $c\Delta t$ gives the distance delay along the wavefront as one moves away from the axis of symmetry
- $c\Delta t$ has a 1/cosZ dependence

➢ if the phase centre of the antenna is NOT coincident with the centre of curvature of the dome, then the delay due to the dome is mapped into the tropospheric delay.

Conclusion

- The SCIS domes will affect the GPS vertical position
- The use of SCIS domes biases the tropospheric zenith delay resulting in an apparent shift in the L3 estimate of station height
- Domes can introduce an elevation-dependent (1/cosZ) delay
- The effect of introducing a SCIGN dome can be mitigated by:
    - adjusting the vertical position of the dome
    - A simple ~3.5 cm extension of the cylindrical base of the dome may prove effective in minimizing spurious vertical shifts

Recommendations / Future Work:

- This effect be further investigated, preferably prior to manufacture of antenna domes for PBO
- Repeat this test:
    - try PCV's for choke ring / dome (NGS);
    - calculate dome height wrt Absolute Phase centres
    - use techniques to mitigate near field multipath effects (RF skirt)
    - other?

and finally …..

Domes are a necessary reality to protect antennas from :

- Vandalism
- Snow
- Nesting and Feeding birds
- Accumulation of leaves, water, ice, …
- etc.

Time varying effects including the above are probably more serious than calibrated offsets introduced by domes

Propose that the IGS devote resources to influence the design of antennas / domes for GNSS receivers

Please note Poster upstairs

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