NGS Absolute Antenna Calibration: Problems with L2

... a possible explanation

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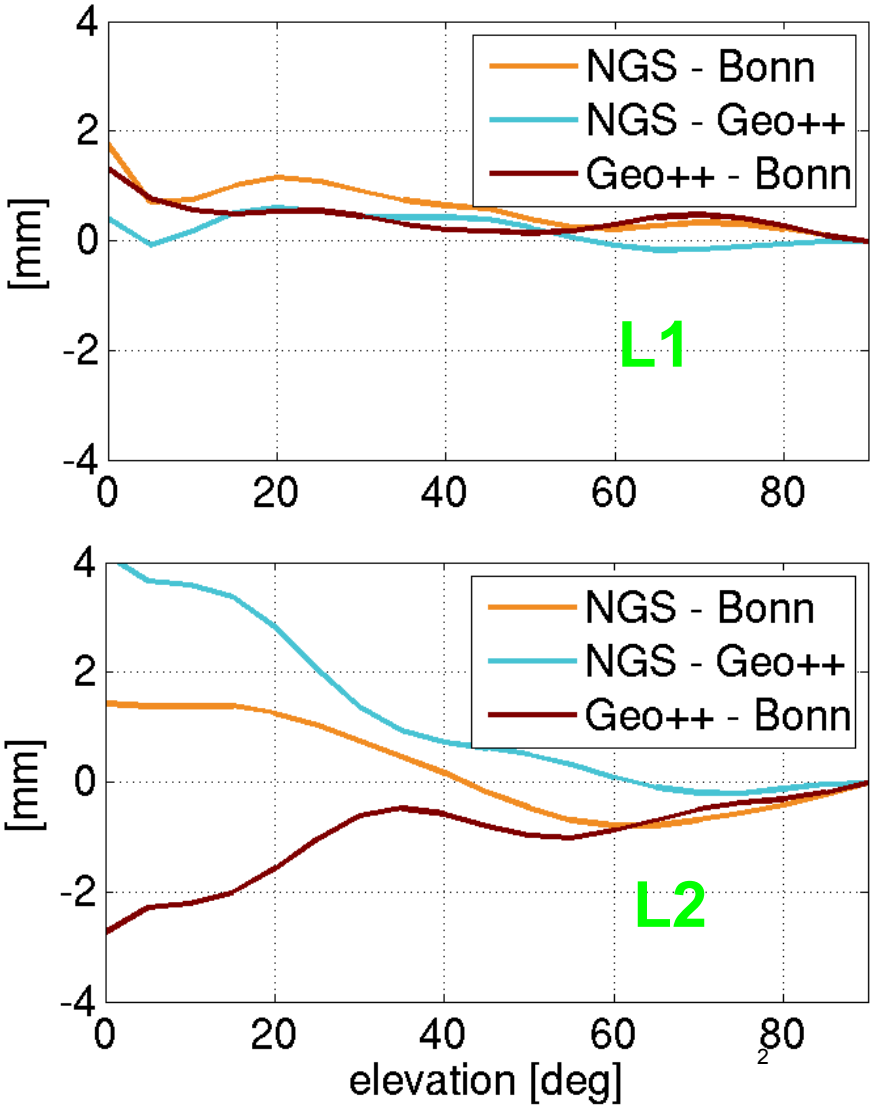
* these plots show the difference in total (PCO+PCV) calibrations

The Problem: TRM59800.00 on L2

At the 2012 IGS workshop I presented comparison of NGS, Bonn and Geo++ absolute calibrations for Trimble chokerings (TRM59800.00).

When differencing NGS total* absolute calibrations from Geo++ and Bonn:

- sub-mm differences on L1 (good agreement)
- several mm differences on L2 (poor agreement)



Question: can the raw data explain differences in L1 and L2 phase center results?

Background: For NGS calibrations, the fundamental data type is time-difference of single-differenced phases (TDSD):

1. Collect phase data at reference (stationary) and test antenna. A robot moves the test antenna.
2. Remove geometric effects and phase windup
3. Form single difference (SD) phase (ref minus test)
4. Form time difference of single difference (SD_t1 - SD_t2), where deltaTime ~ 8 seconds

TDSD = Antenna_Phase_Center_antenna_under_test
+ delta_multipath + delta_ + delta_noise + delta_phase_bias

Question: can the raw data explain differences in L1 and L2 results?

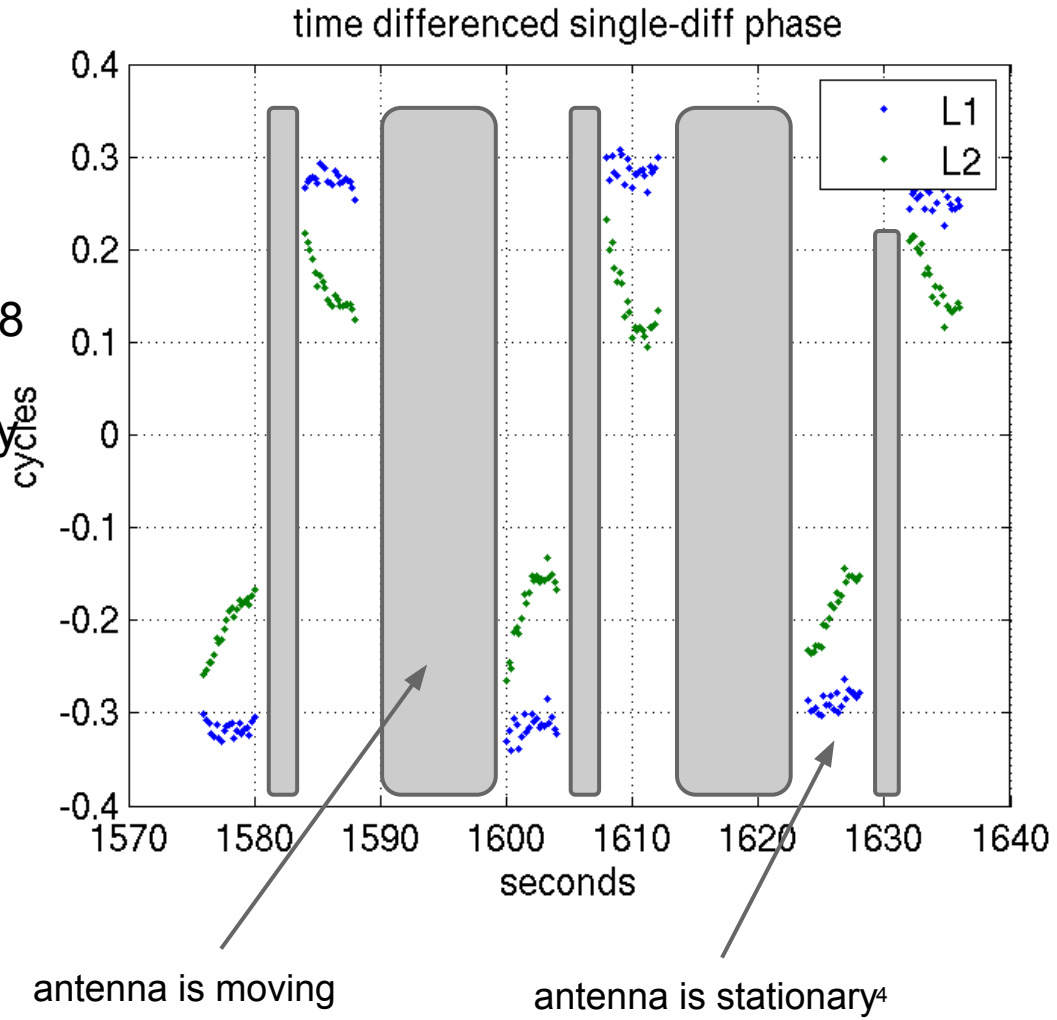
Plot: example TDSD data from a TRM59800.00 test where

- data are sampled at 5 Hz
- robot initiates motion every ~ 8 seconds
- moving ~4 seconds, stationary ~ 4 seconds

When the antenna is not moving:

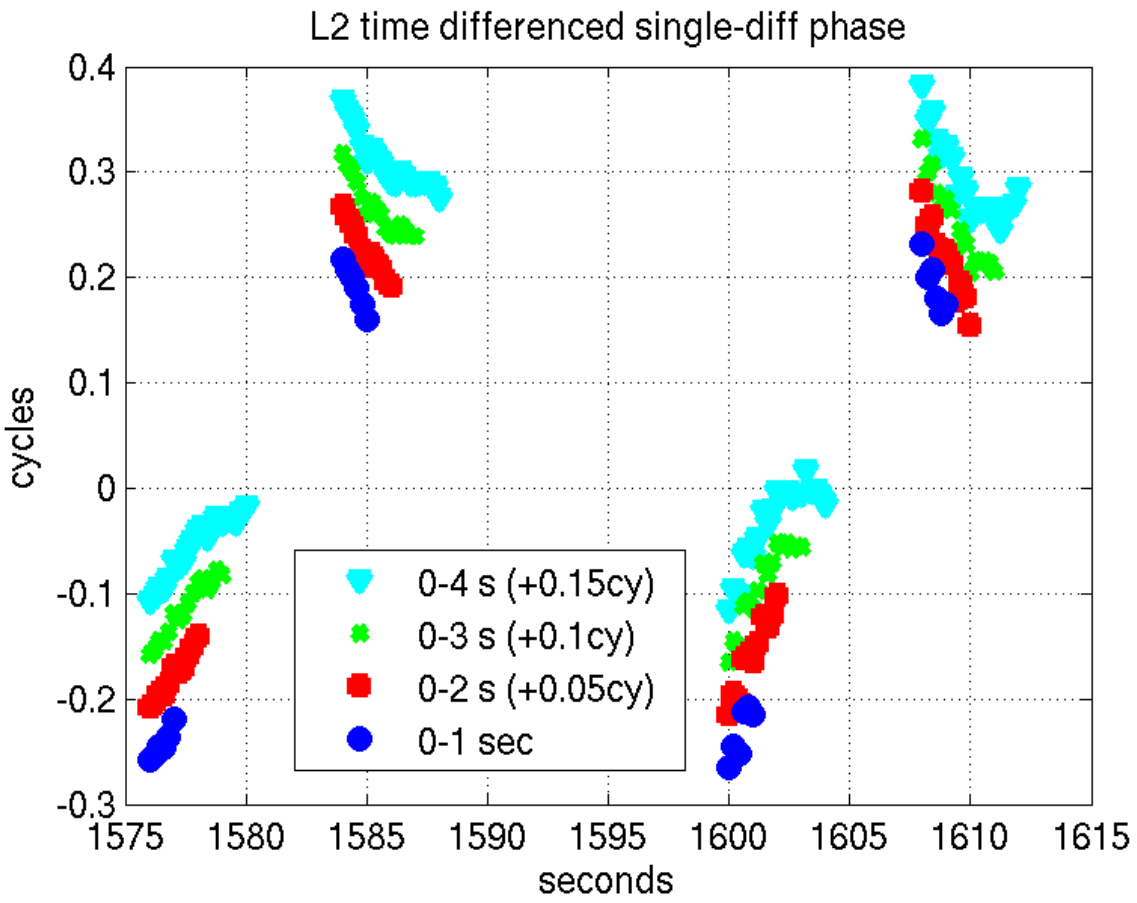
- L1 is constant mean
- but L2 drifts!

New Q: what is the effect of L2 drift on PCV?



TEST L2 DRIFT EFFECT ON APC: solutions with subsets of stationary data

- window data by amount of time *after* antenna stops moving
  - 0-1 sec
  - 0-2 sec, etc.
- independent solution with each TDSD subset
- compare against using 0-4 sec (all data; standard method)



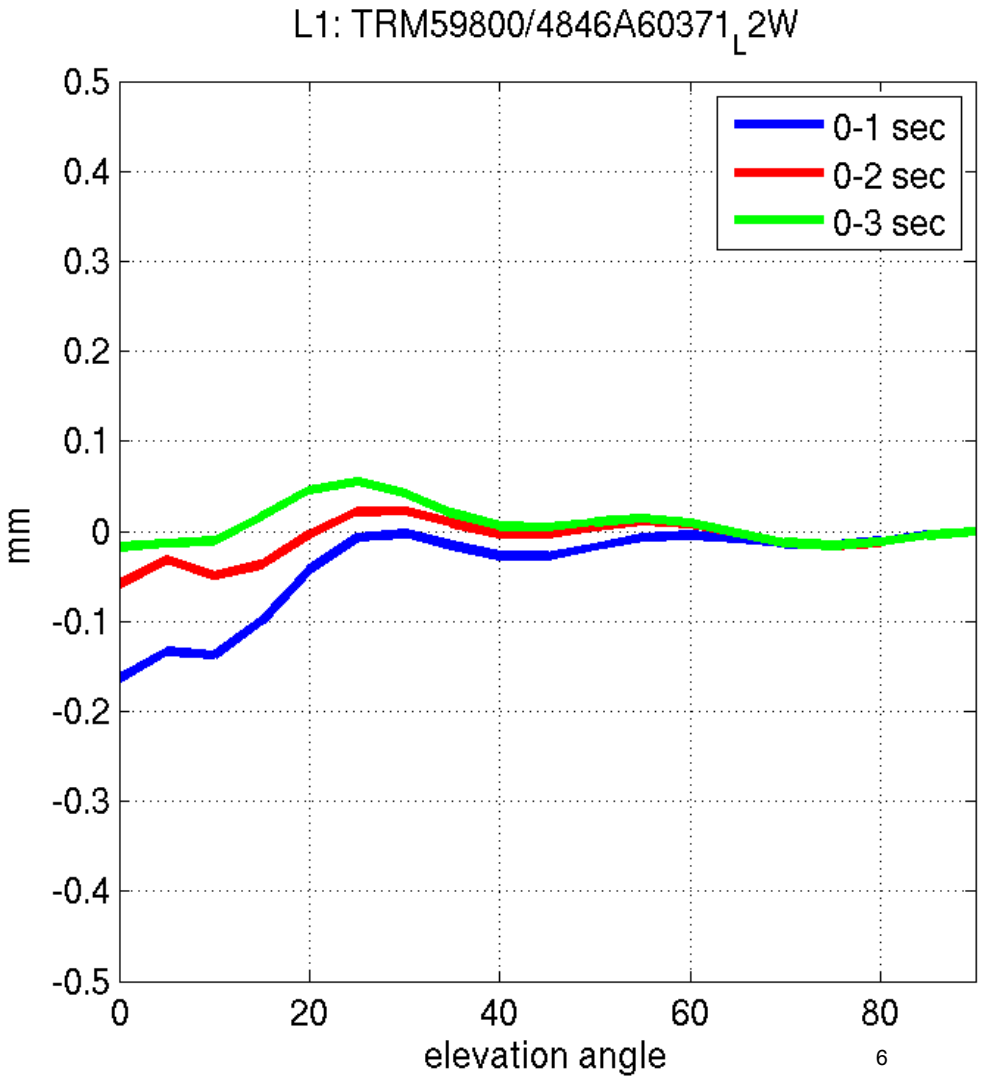
plotted data are offset for clarity

TEST: using subsets of stationary data

Plot: APC (subset) minus APC(4 sec of data)

A1: sub-mm effect on L1

(desired result given stable L1 when antenna is stationary; small differences due to data noise/averaging?
)



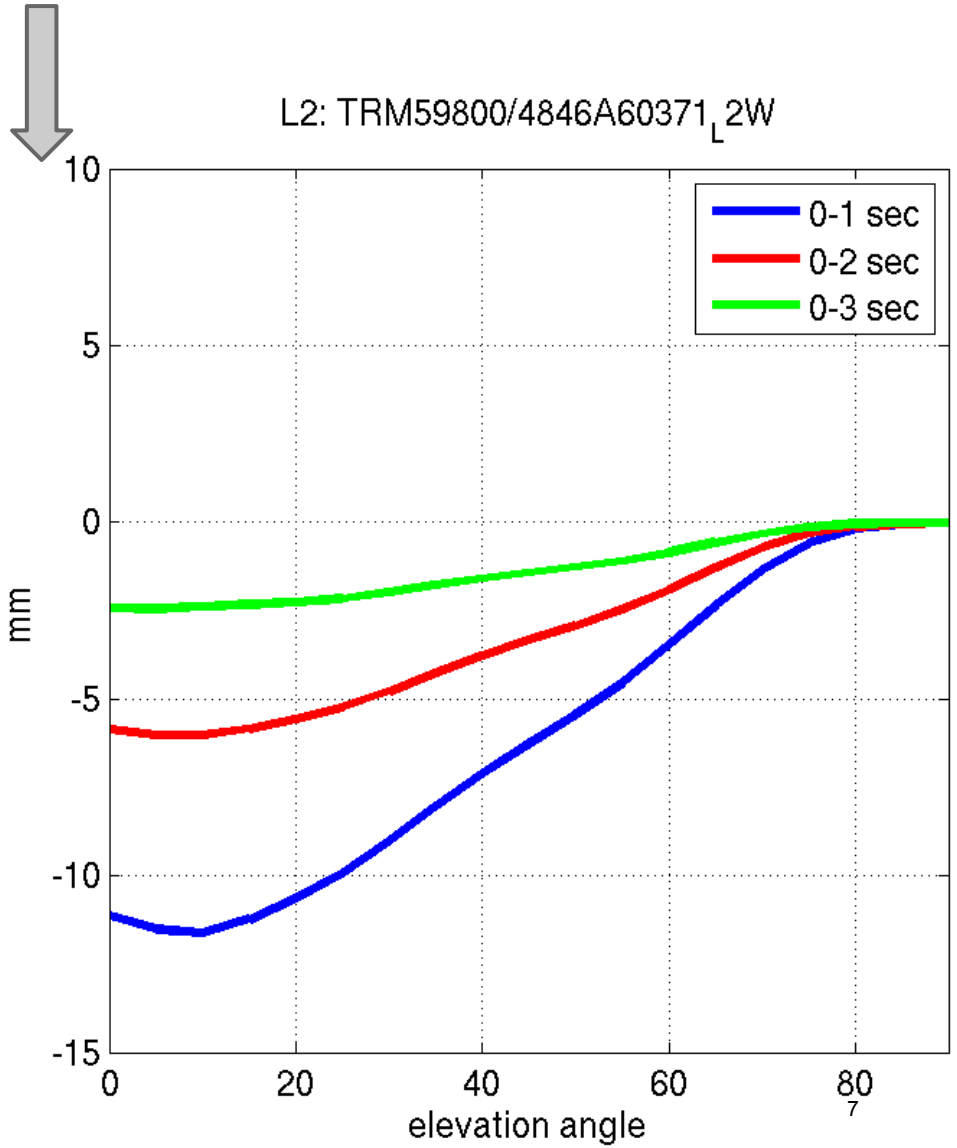
TEST: using subsets of stationary data

Plot: APC(subset) minus APC(4 sec of data)

A2: BIG effect on L2

(trend with elev is consistent with vertical PCO, thus original theory presented at IGS Workshop)

Y-axis scale is 2.5 centimeters!!!



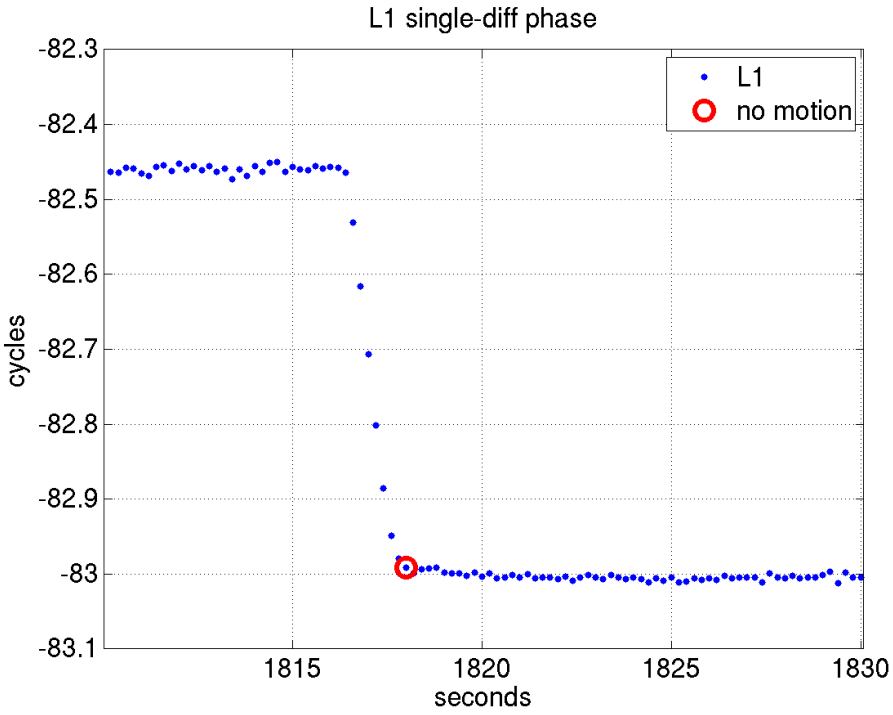
THEORY: L2 tracking loop responsible for drift

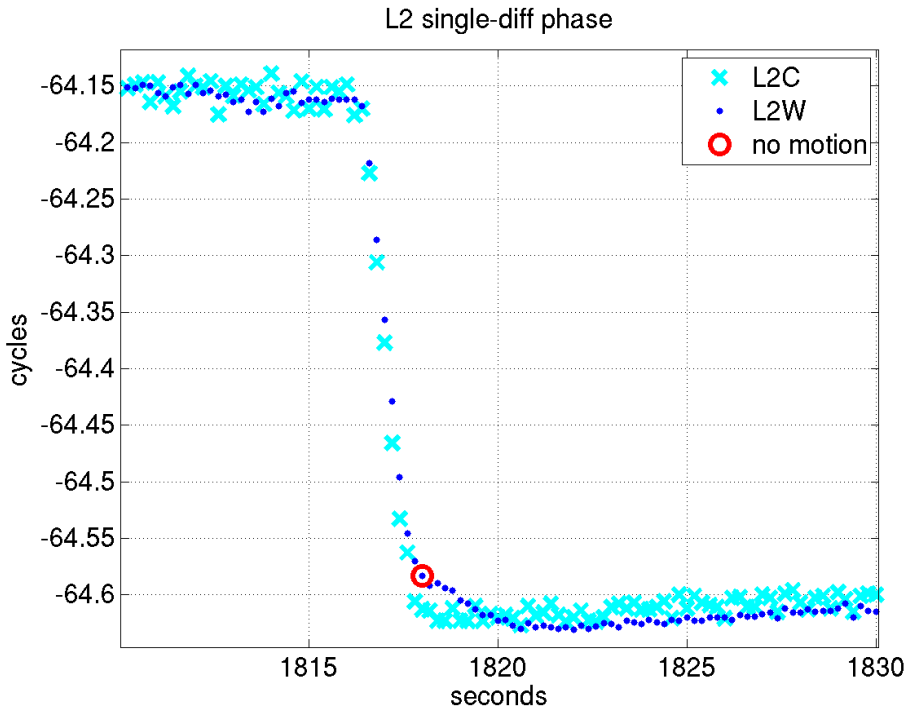
TEST: contrast different L2 phases (available in RINEX 3.x)

- L2W data type used in *all* previous results = *codeless tracking*, needs time to "settle in"
- L2C data type (C2) is available for Block IIR-M satellites; L2C uses the code, therefore tracking loop should behave similar to L1

```
G   11 C1C L1C S1C C1W S1W C2W L2W S2W C2  L2  S2        SYS / # / OBS TYPES
R    6 C1C L1C S1C C2C L2C S2C                          SYS / # / OBS TYPES
S    3 C1C L1C S1C                                      SYS / # / OBS TYPES
```

L2W vs L2C: single-differenced phase



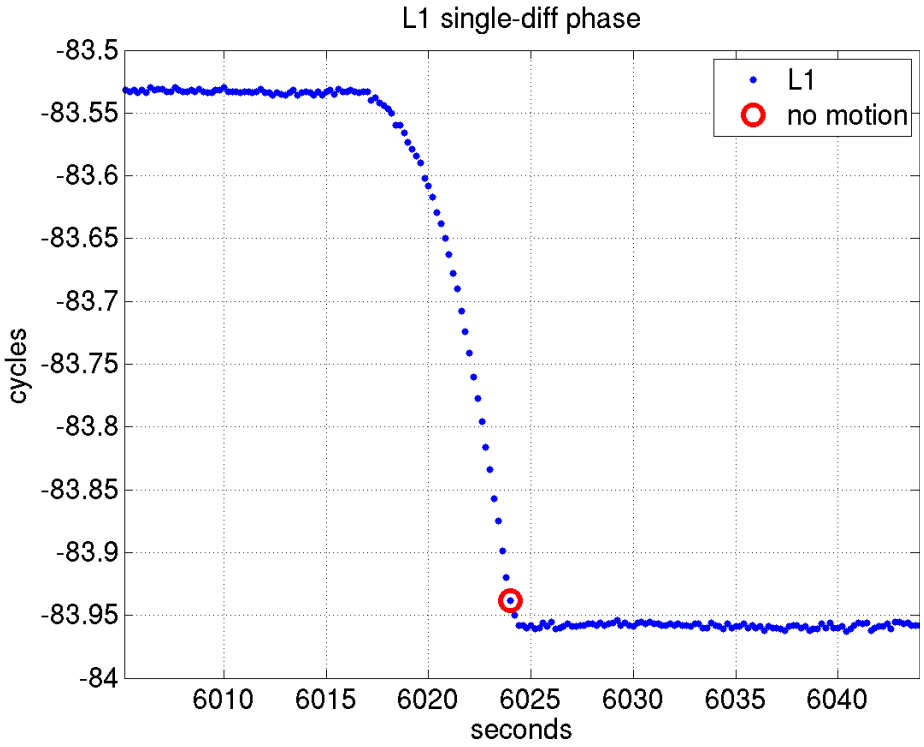


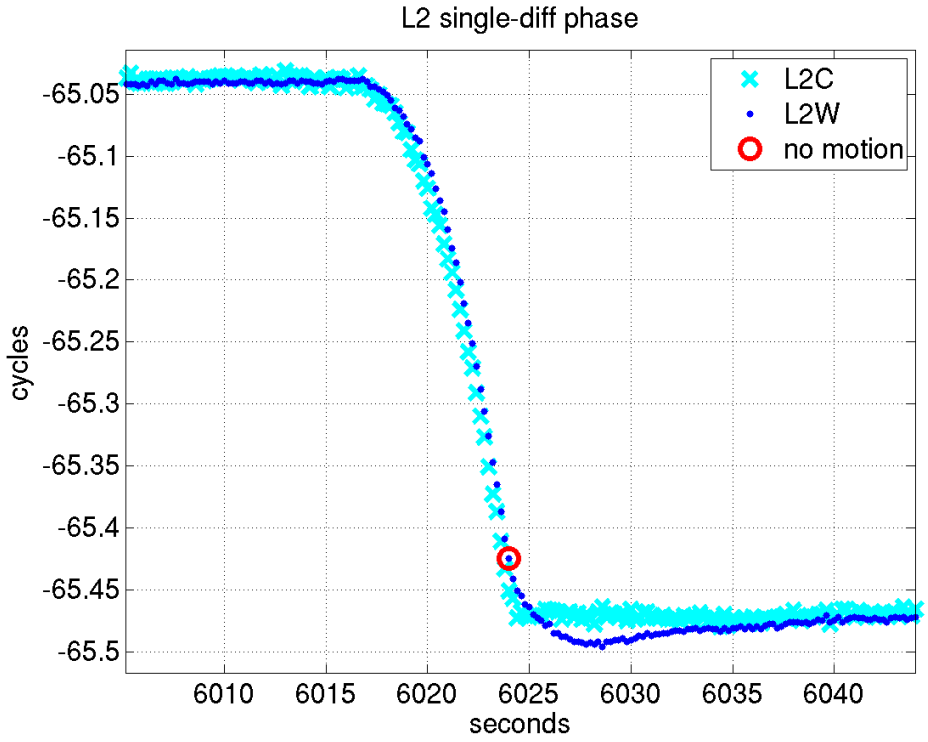
Plots show single-differenced data, before the time-differencing operation, for a test where antenna was moved every 10 minutes.

L1 data are used to determine time at which antenna stopped moving (red circle).

Once antenna is stationary, L2C is constant mean, L2W is still drifting.

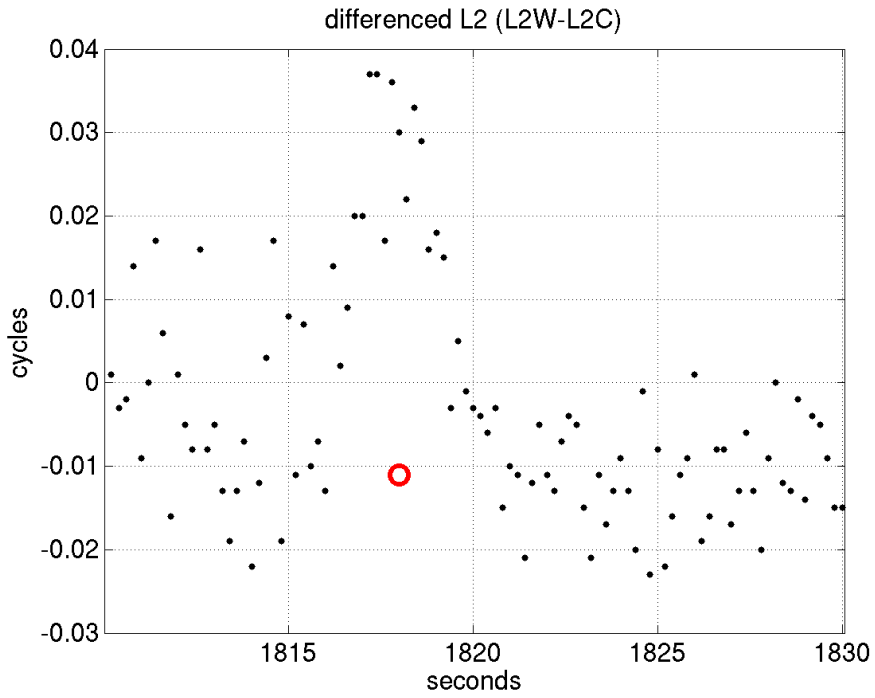
L2W vs L2C: single-differenced phase (another example)

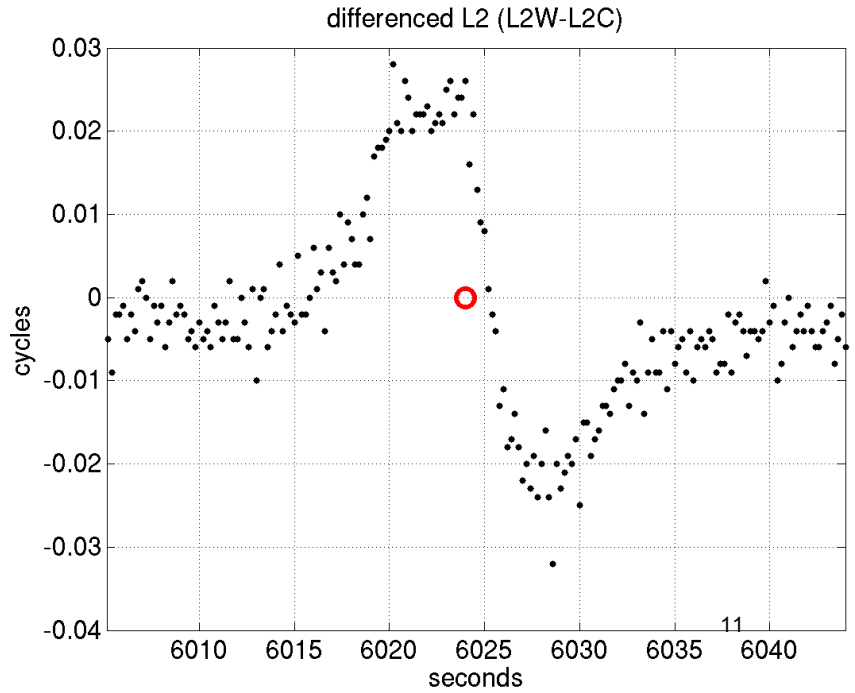




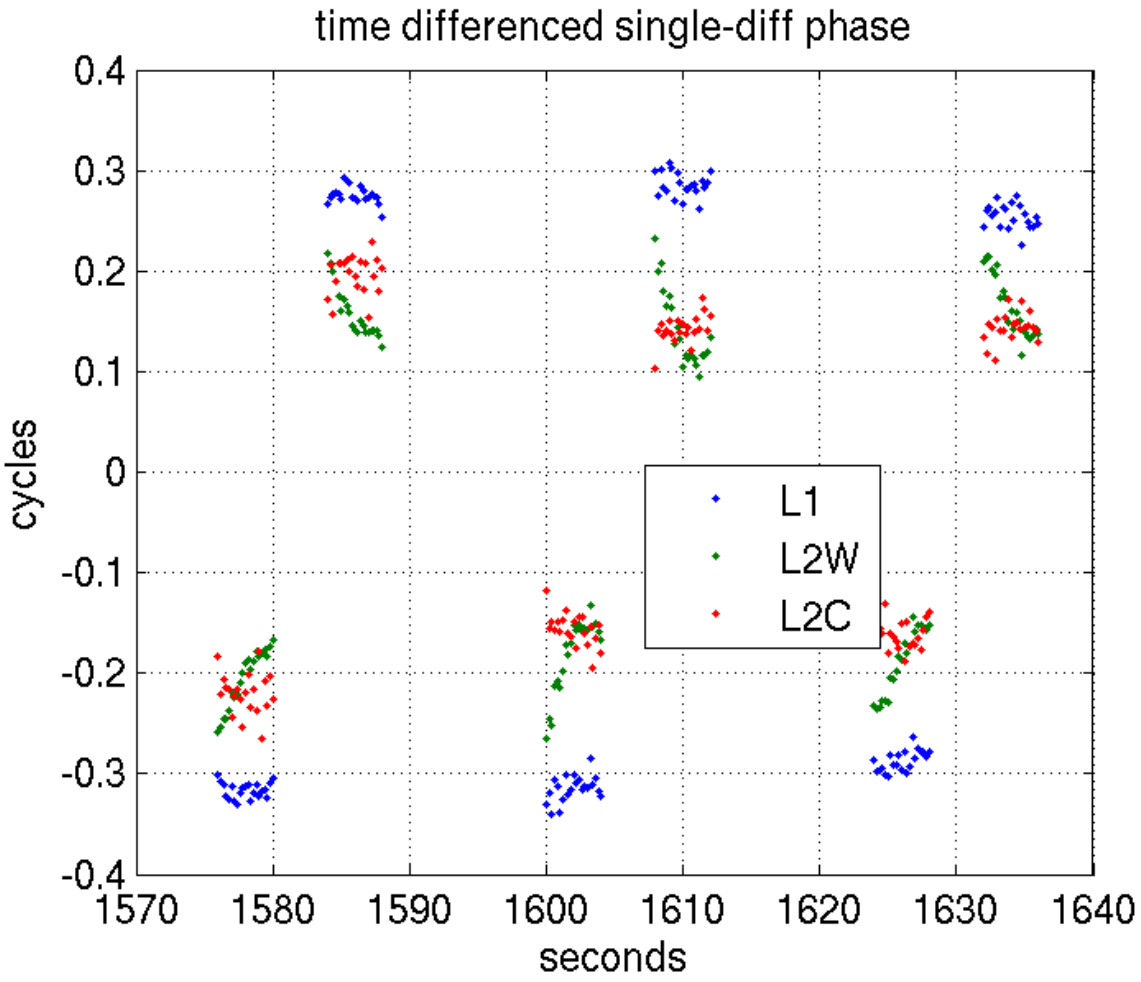
L2W vs L2C: single-differenced phase

The L2W-L2C difference demonstrates that current **L2W tracking may take 5-10 seconds to achieve constant mean** after antenna has stopped moving.



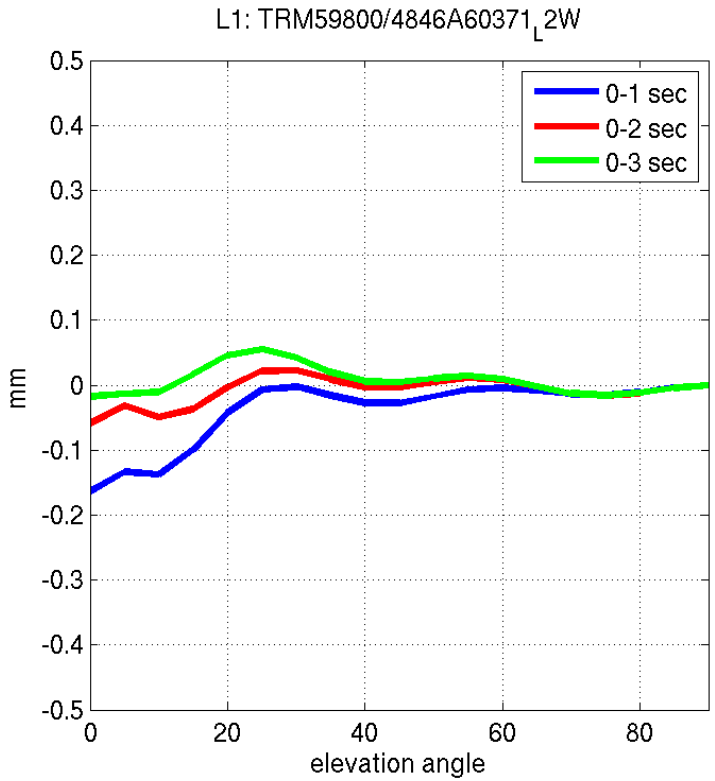


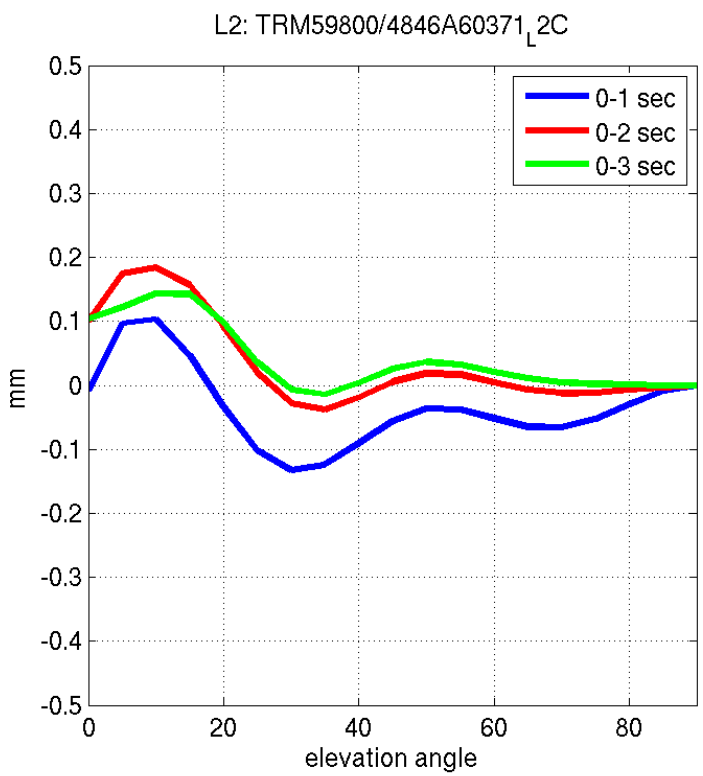
Q: differences between L2C and L2W TDSD phase?



Q: what happens if I use (drift-free) L2C TDSD data?

TEST AGAIN: using subsets of stationary data





Difference of L1 and L2 subset solutions vs. 0-4 sec "all data" are all sub-mm.

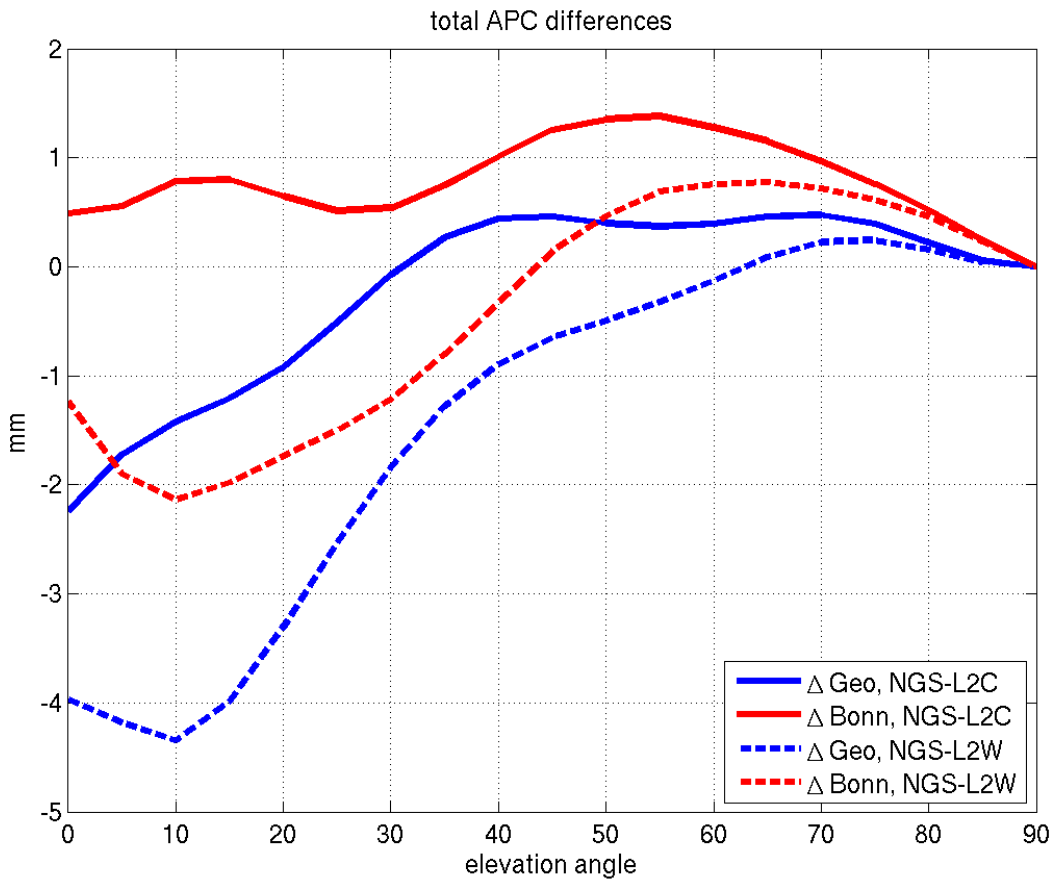
A: L2C and L1 PCV differences are equivalently stable.

Q: does L2C solution agree with Geo++ / Bonn?

Compare L2 NGS results against Geo++ & Bonn

- dashed line = L2W
- solid line = L2C

A: L2C APC differences <u>much</u> closer to zero mean



** NGS solutions shown here use only Block IIF sv's whereas Geo++ is all-in-view... probably differences in data distribution/coverage*

What's next?

- Devise new protocol to use L2 data with constant mean
  - Block IIR-M sv's only and L2C
  - Tune tracking loops to minimize/eliminate L2W drift
  - Optimize antenna motions to minimize drift time
  - Leave tracking loops as-is, but wait >= 10 seconds for L2W to stabilize *(this may violate time-differencing assumptions for multipath and differential hardware bias)*
- Test other receivers
  - tracking loop tunability
  - L2W stabilization time
- Re-run antennas used in Geo++/Bonn/NGS calibration comparison.