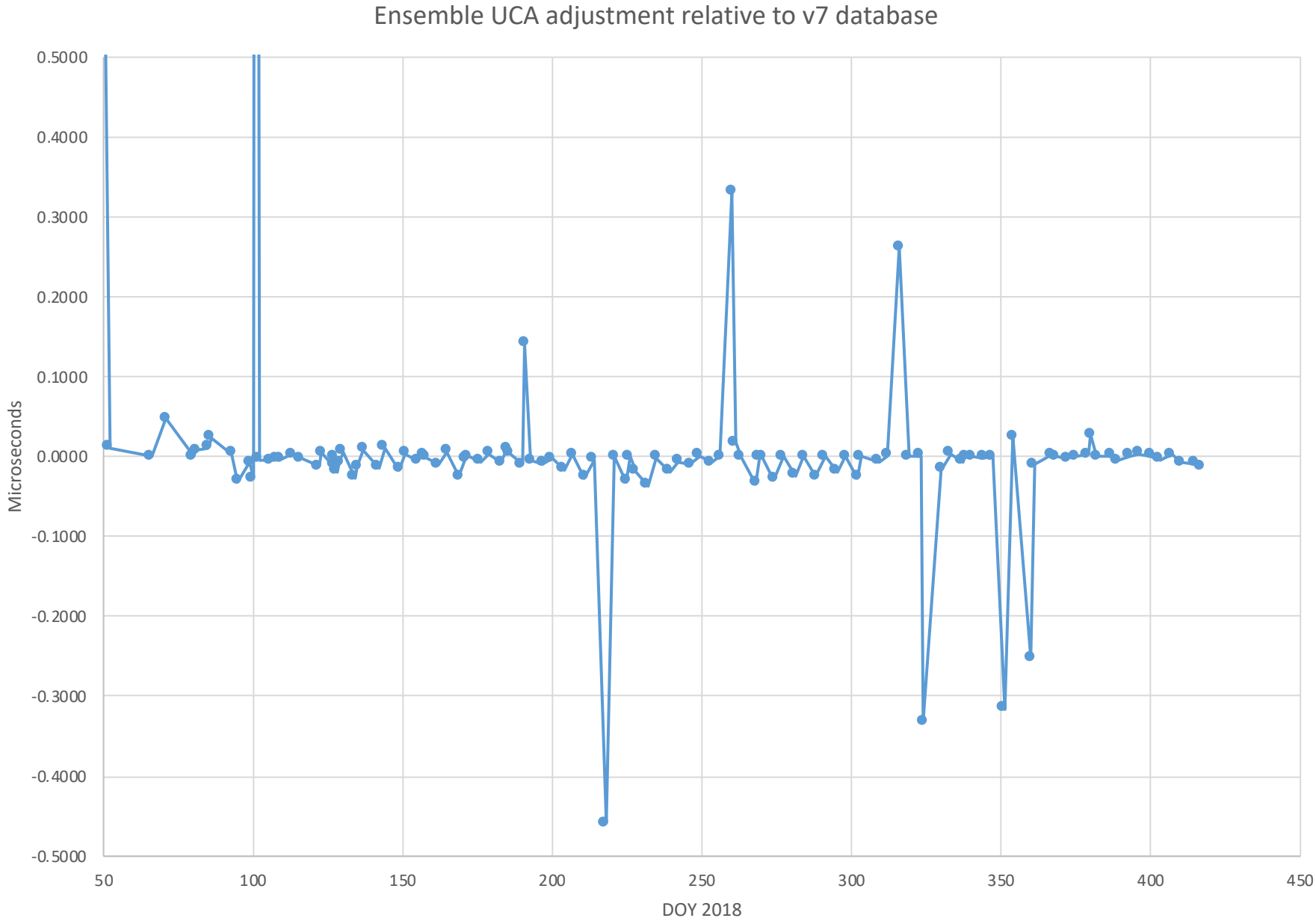
Peculiar Offsets (POs) – Review of S/X

- Roughly speaking, POs represent the signal path delay at each station
  - "Peculiar" to each station, depends on IF cables, back-end, formatter, GPS receiver, counter, etc.
  - "Offsets" added by the correlators to the measured station sampler epoch: `fmout-gps`.
  - Are necessary to time-tag the data correctly.
  - Do not depend on the Maser to back-end cable, Maser, or 5 MHz uplink to the front-end for phase-cal
- Correlation is insensitive to an overall shift in the POs
  - This is a so-called Universal Clock Adjustments (UCA)
  - Changes all the time-tags by the same amount
- A UCA affects UT1 at a one-to-one level
  - Increasing the *time-tags* by +1 μs changes UT1 by -1 μs
  - We are trying to keep the UCAs consistent at 0.1 μs level, for UT1 precisions of ~1 μs
- Unfortunately we have no measurements of actual signal path delays
  - When UT1 was relatively imprecise this was not a significant issue
  - Dominated by IF cable and digital electronics delays
  - The PO for KPGO 20m in the 1990s was arbitrarily set to zero
- We have stayed roughly consistent with that
  - We have had a few incorrect UCAs of several microseconds
  - There are several incorrect at the level of a few 100 ns

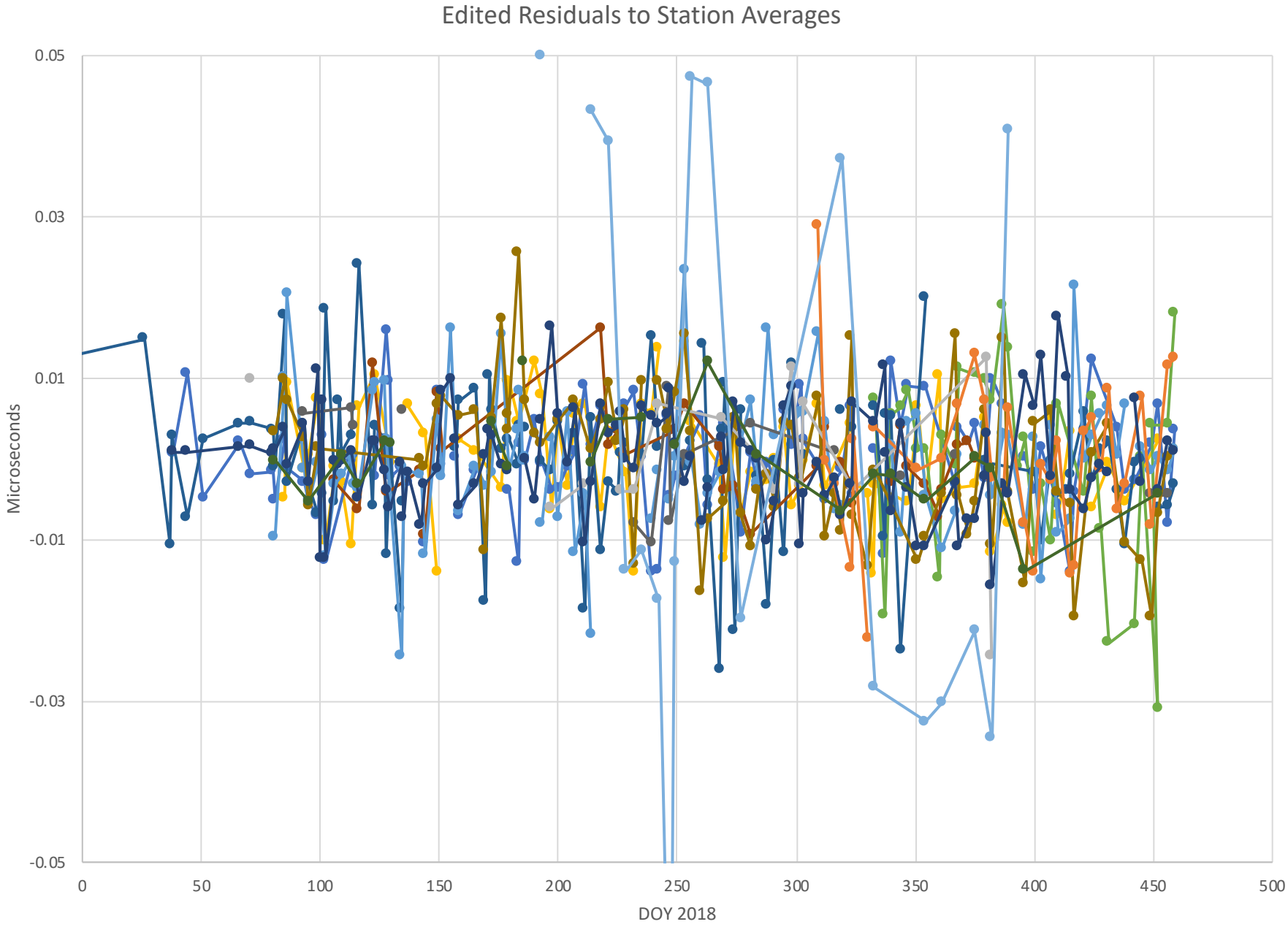
Ensemble Averaging of POs

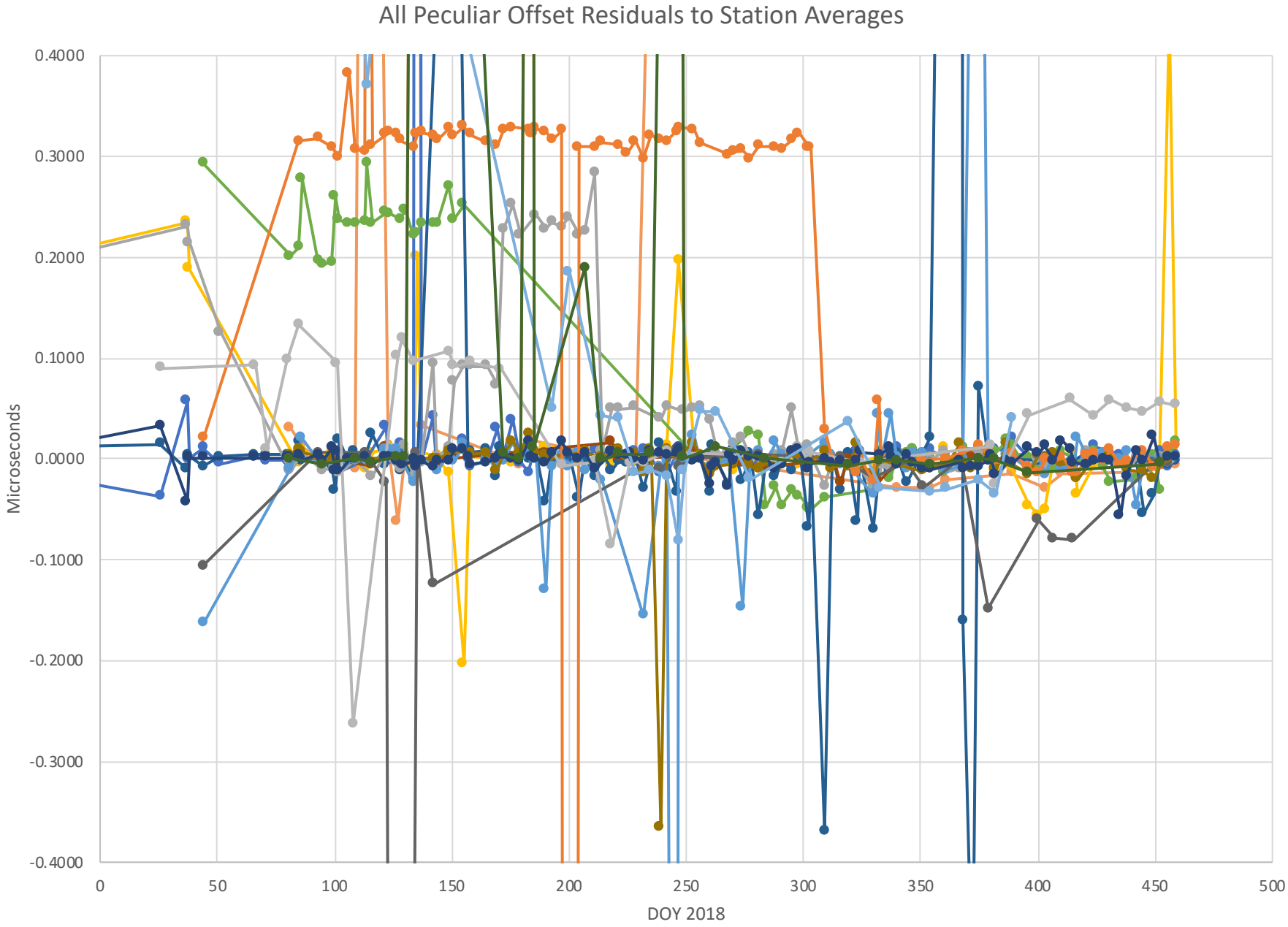
- Problem:
  - Correlators tend to use a single station as the clock reference
    - All other station's clocks are adjusted to make the correlation consistent
  - This makes us sensitive to a PO shift at the reference station
    - This leads to a shift in UT1.
- Solution:
  - Form an ensemble average using all the stations
    - Identify and remove outlier stations
    - Should also give better stability by averaging "good" stations
- The next slide shows the UCA errors over the last year
  - This is the change if the ensemble average had been used.

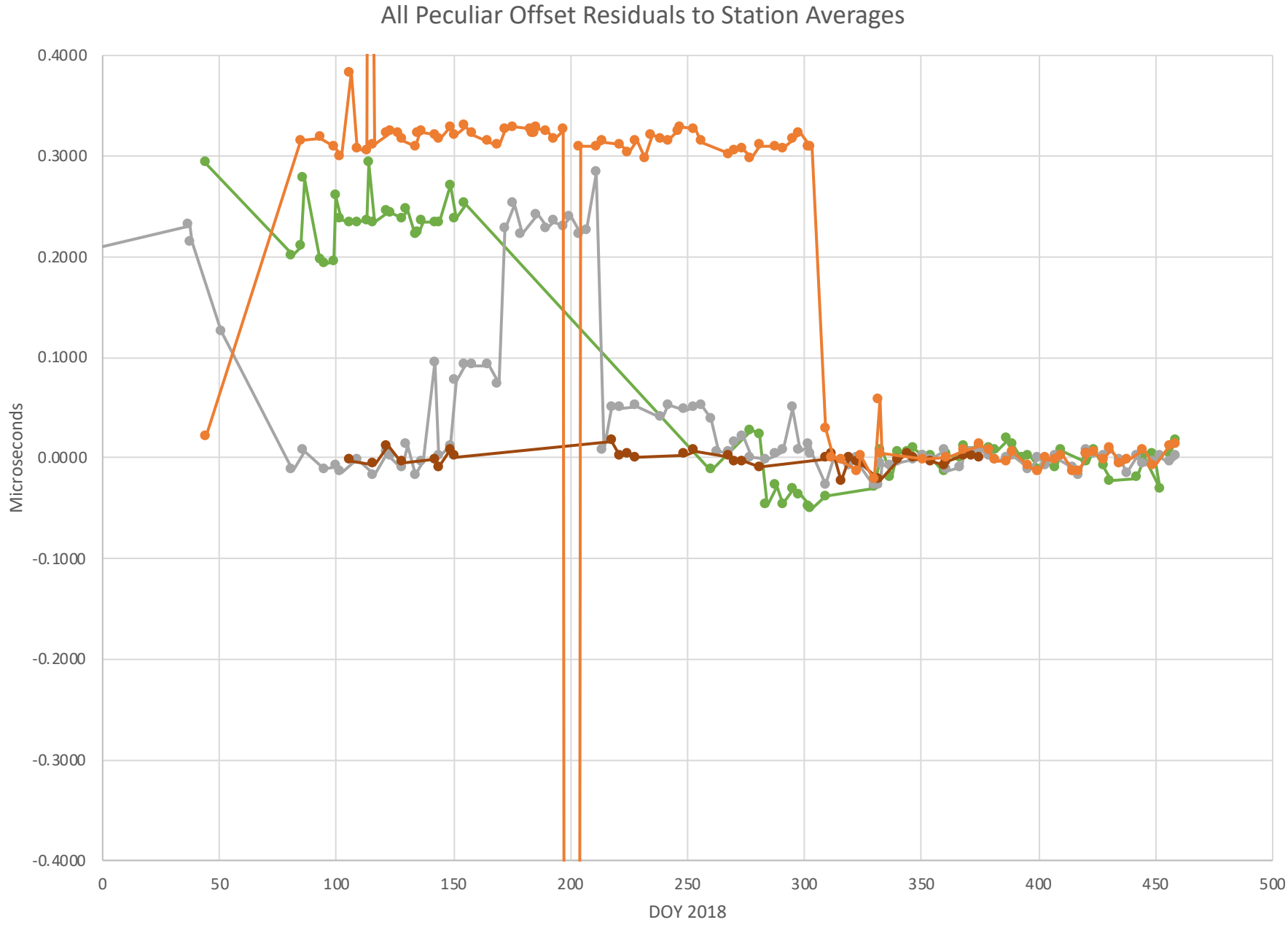

Ensemble UCA adjustment relative to v7 database
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
-0.1000
-0.2000
-0.3000
-0.4000
-0.5000
Microseconds
50
100
150
200
250
300
350
400
450
DOY 2018

Stability of POs

- The next three slides show the level of variation of the station POs
- The first slide shows the variation with significant outliers removed.
  - Generally the variation is at the ± 10 ns level peak-to-peak
  - Some stations, one (light blue) in particular, have larger variations
- The second slide has no outliers removed
  - There are cases of individual stations have significant jumps for an experiment
  - There are cases of stations varying systematically over time
    - Particularly the orange, green, and gray lines
- The third slide shows just those three stations and one simpler station (red) to make them easier to pick out.
- These are not criticisms of the stations, just examples of what can happen


Edited Residuals to Station Averages
0.05
0.03
0.01
-0.01
-0.03
-0.05
Microseconds
0
50
100
150
200
250
300
350
400
450
500
DOY 2018


All Peculiar Offset Residuals to Station Averages
0.4000
0.3000
0.2000
0.1000
0.0000
-0.1000
-0.2000
-0.3000
-0.4000
Microseconds
0
50
100
150
200
250
300
350
400
450
500
DOY 2018


All Peculiar Offset Residuals to Station Averages
0.4000
0.3000
0.2000
0.1000
0.0000
-0.1000
-0.2000
-0.3000
-0.4000
Microseconds
0
50
100
150
200
250
300
350
400
450
500
DOY 2018

VGOS Peculiar Offsets (POs)

- Very similar to S/X POs, but some differences:
  - Some significantly different IF cable delays for different bands
  - Affected by Phase-Cal (PC) delay used to align the bands
    - Uplink 5 MHz path to PC generator (not calibrated by CDMS)
    - Maser-to-sampler 5 MHz path
    - Both these usually have small changes within an experiment
      - May change significantly between experiments
  - Affected by the `sampler_delay` parameters
    - Select the ambiguity (200 ns) of the PC delay
- The clock setting procedure
  - Should keep the POs consistent to ± 100 ns
  - We hope to improve this in the future