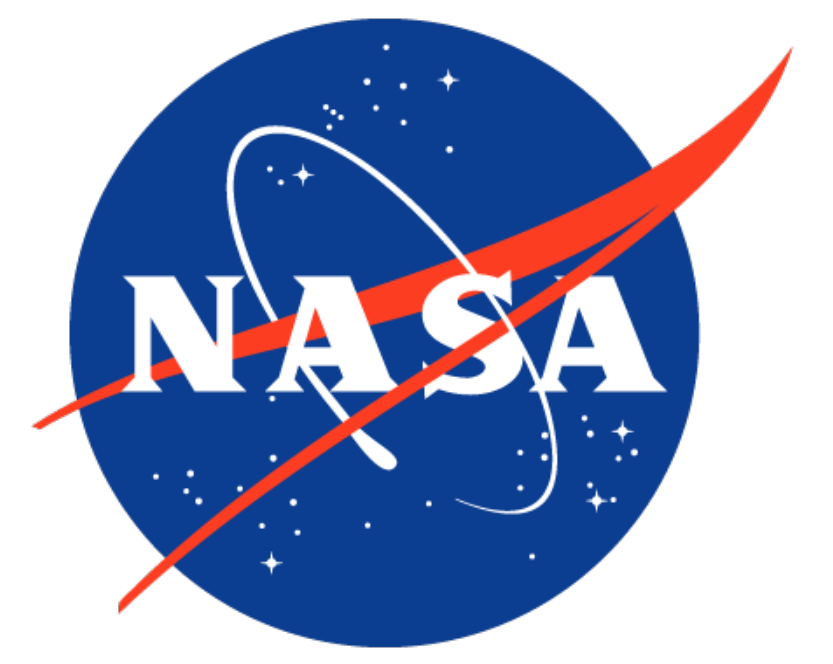


Geodetic GPS Processing with only Civil Signals

Ries, P.,^{1,a} Hemberger, D.,¹ Komanduru, A.,¹ Peidou, A.,¹ Sibthorpe, A.,¹ Murphy, D.¹

¹Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA

^a Corresponding Author, paul.a.ries@jpl.nasa.gov <http://gipsyx.jpl.nasa.gov>



Motivation

Space geodesy applications for GPS depend on having multiple frequencies available to compensate for ionospheric variations, but for more than two decades GPS satellites only transmitted civil codes on a single frequency (C1C). While unable to decode the encrypted dual-frequency GPS P(Y) code, civil users have been able to perform semi-codeless tracking on both L1 and L2 frequencies (C1W and C2W) to enable dual frequency applications based on the characteristics of the P(Y) signal.

The 2019 and 2021 Federal Radio Navigation Plans state that those characteristics may be ended once two years have passed with least 24 operational satellites transmitting on L5, which may come as soon as 2028.

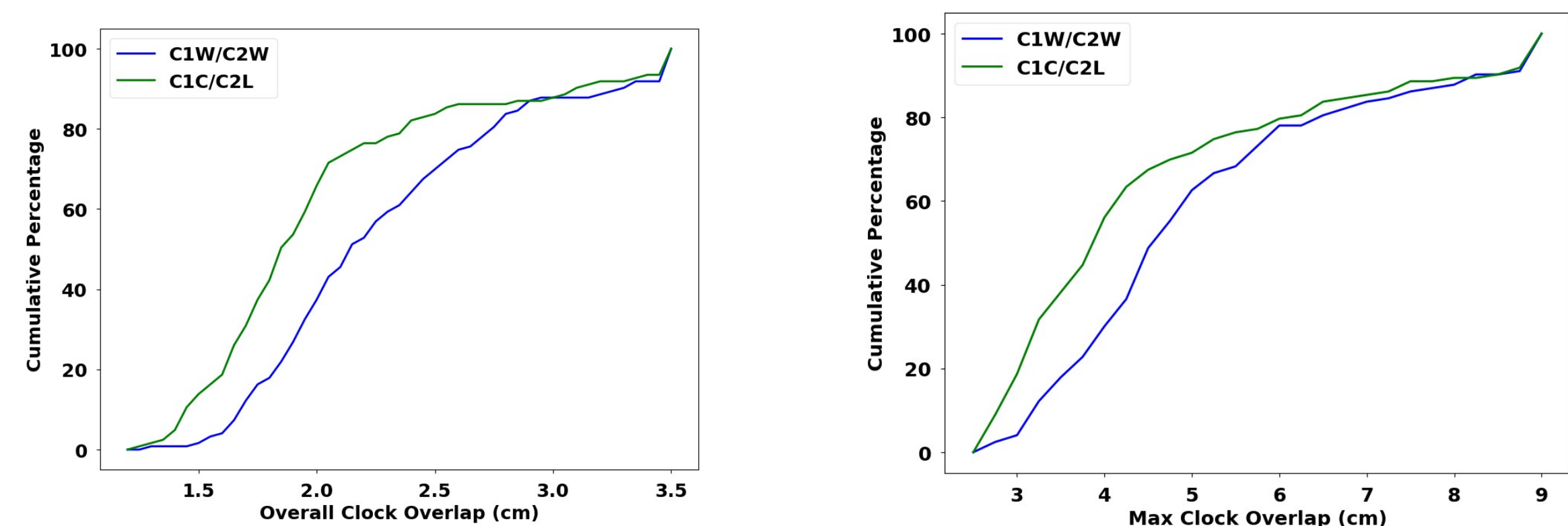
POD

Setup

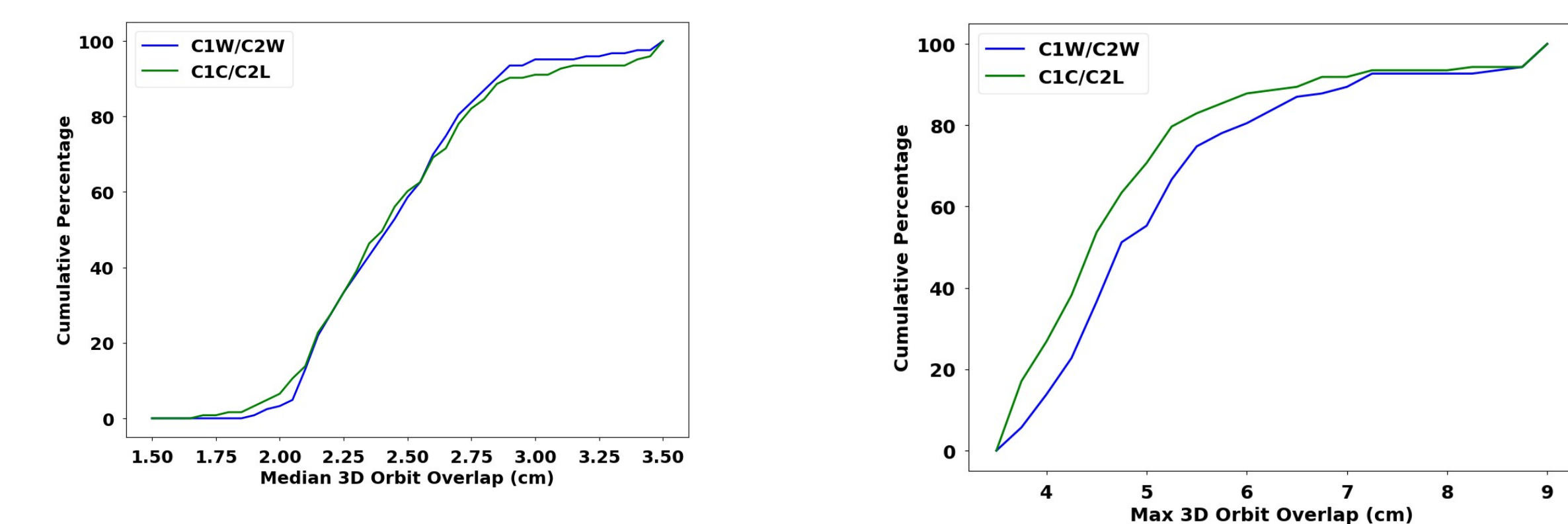
- Similar to JPL Rapids, GipsyX software
- 30 hour arcs per day, 6 hours of overlap for consistency checks
- 120 stations, IGS20 CM frame constraint
- 24 satellites, all transmitting [LC]2[XLS]
- C1C/C2L primary code pair
- C1C/(C2X/C2S) stations also included
- Solve for transmitter biases from C1C/C2[XS] ionosphere free combos to C1C/C2L combination
- 2024-02-01 through 2024-05-31

Results

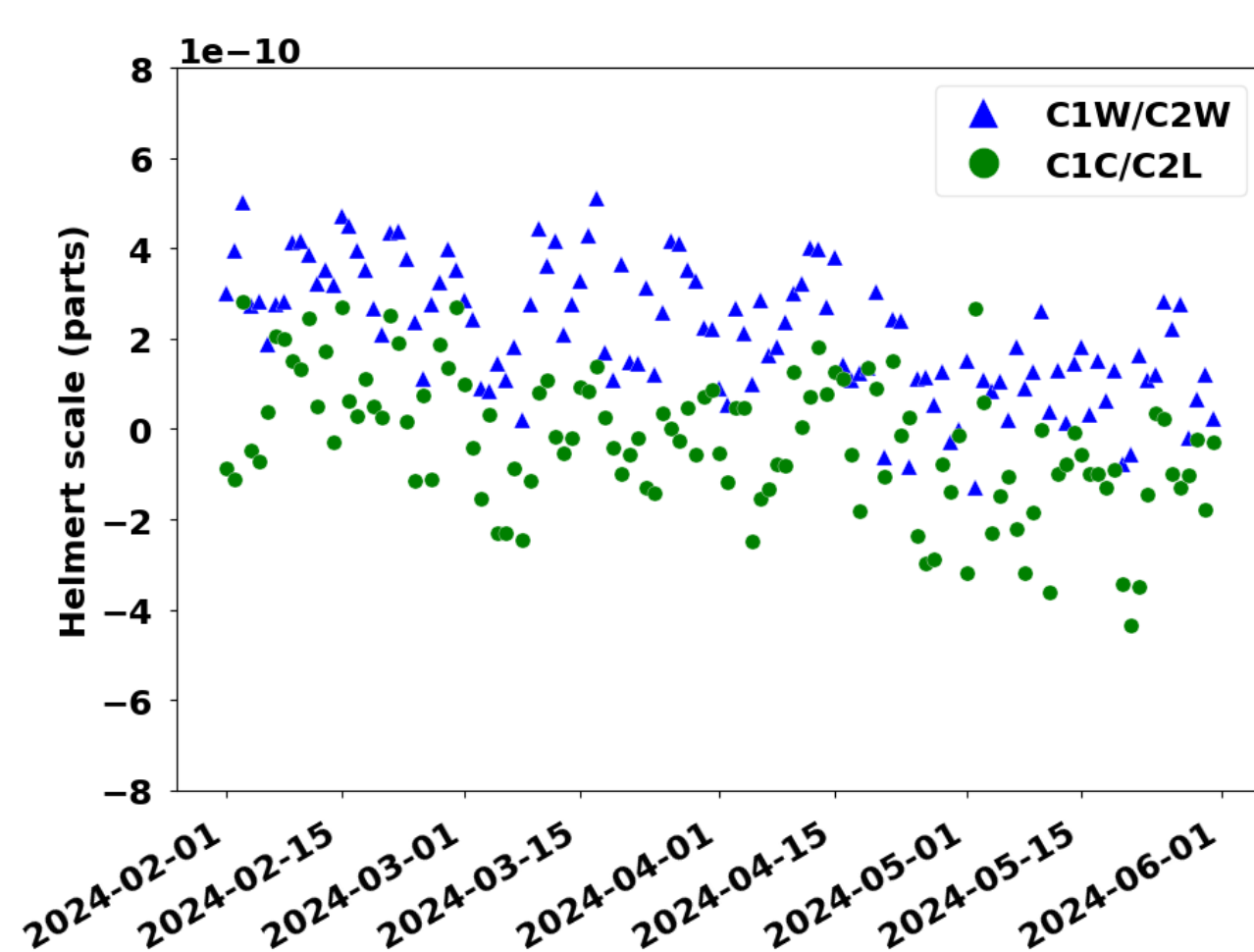
- Improved overall and maximum clock RMS with civil signals only
- Better clocks on IIRM and newer blocks?
- fewer/better-controlled biases



- improved maximum orbit overlaps, similar median orbit overlaps



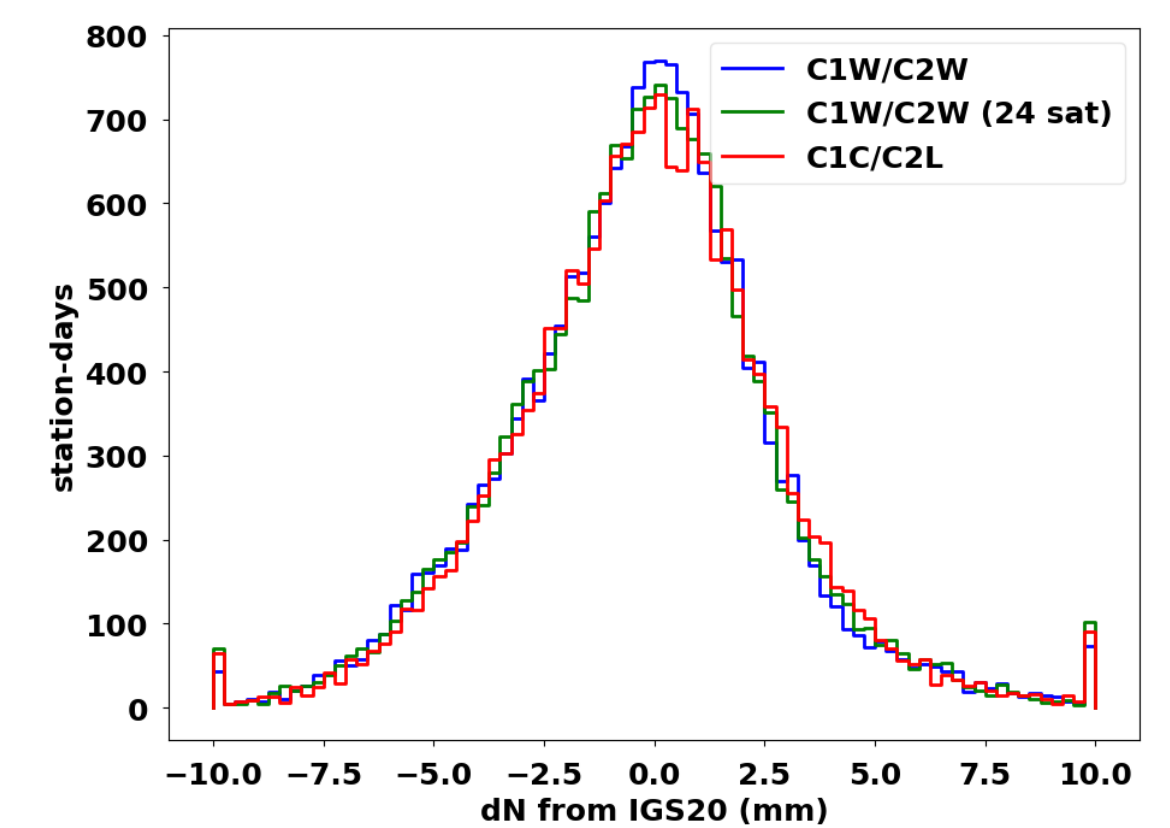
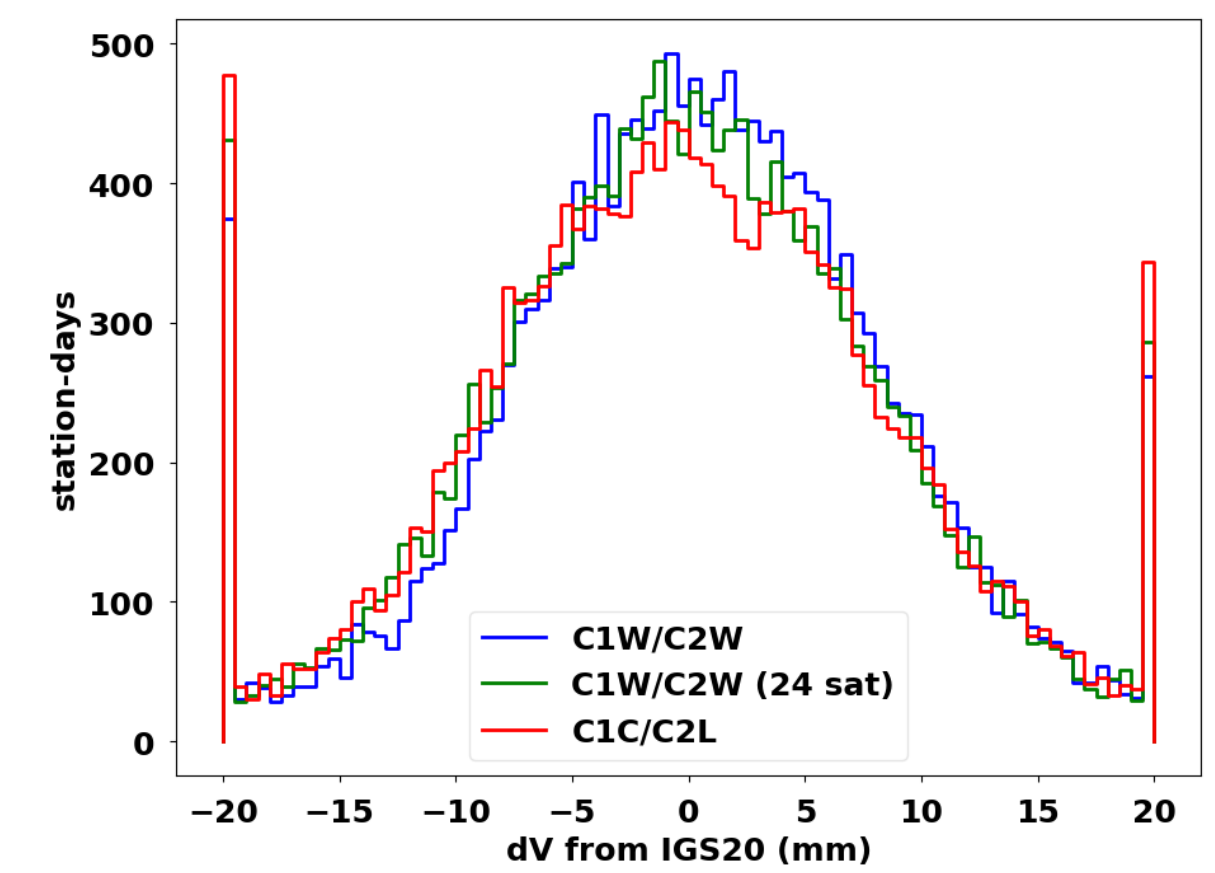
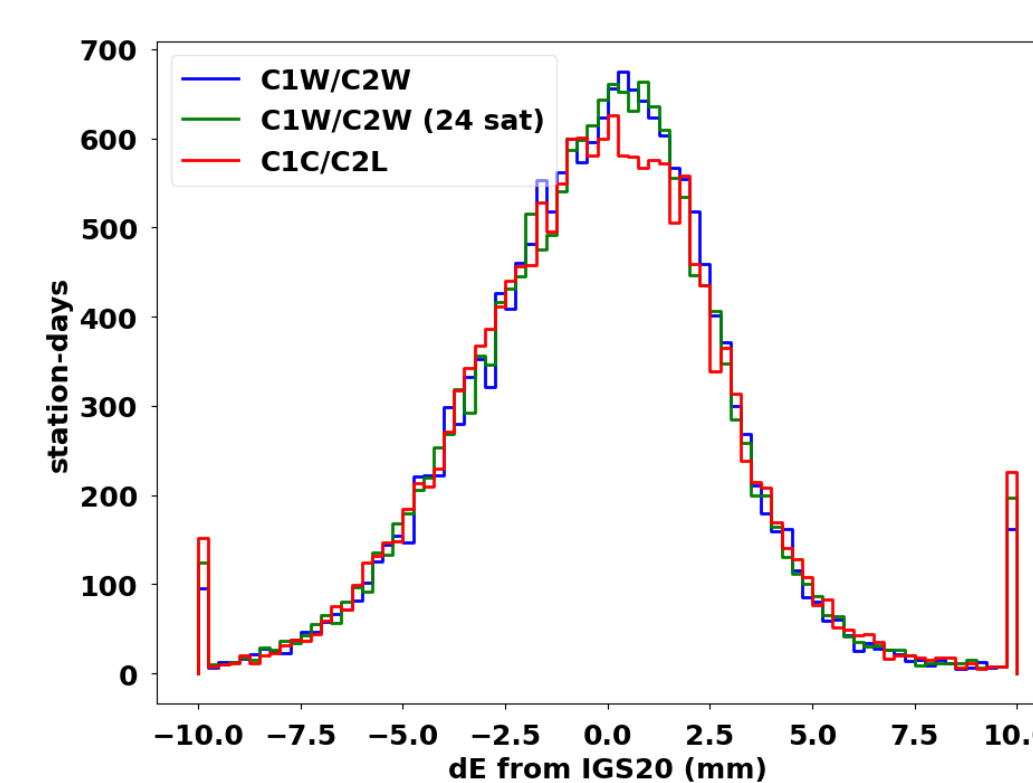
- Better scale, but analysis suggests station-selection issue



PPP

Setup

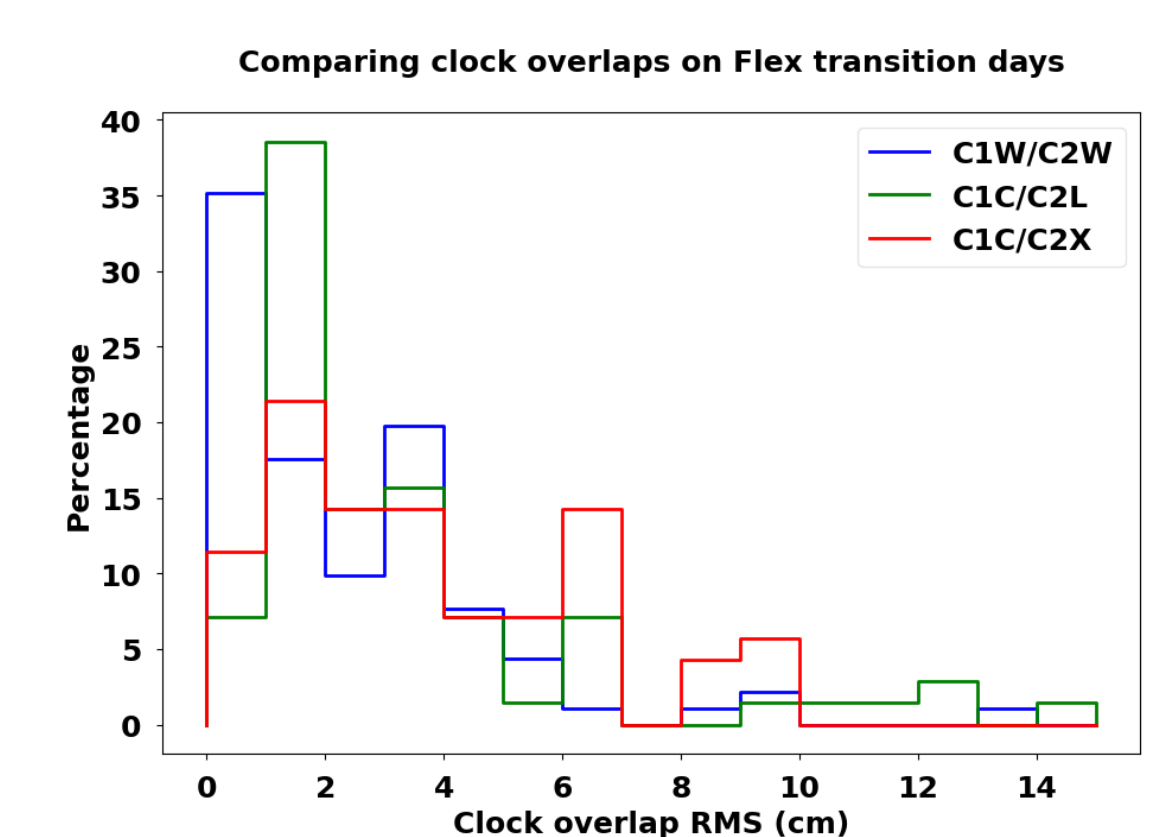
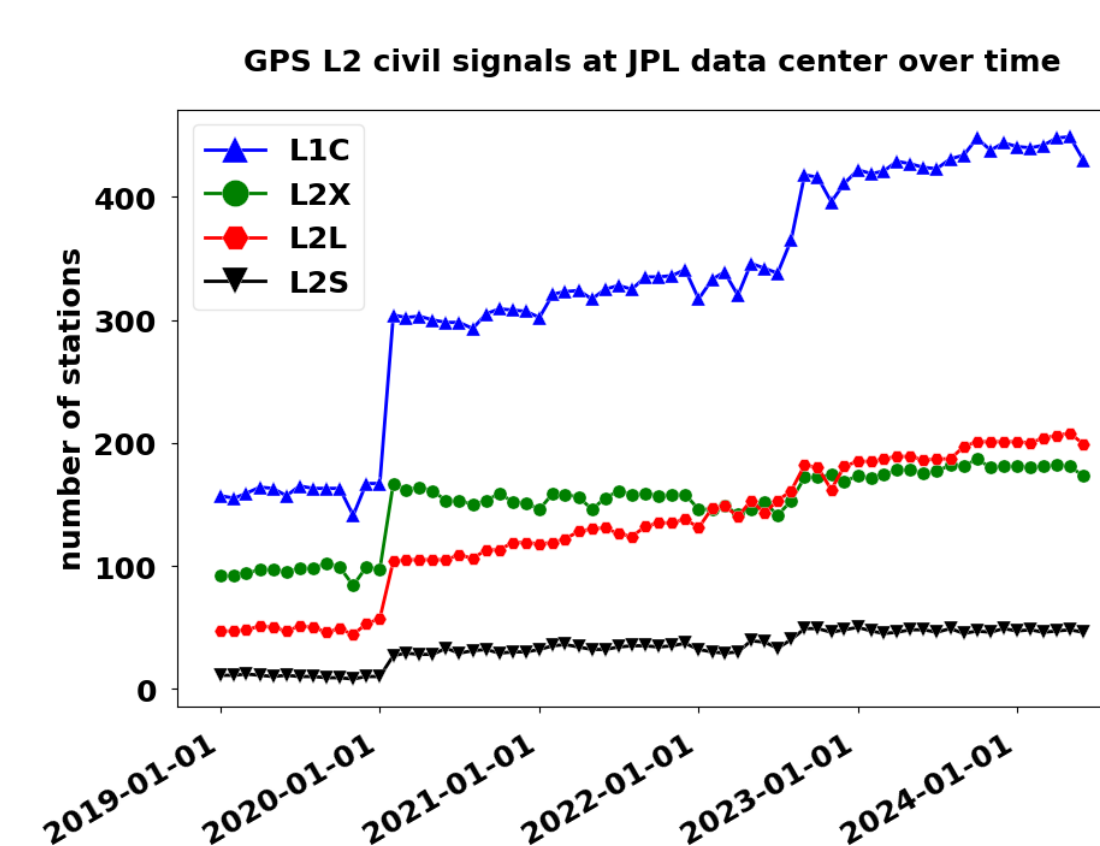
- IGS20 frame stations/solutions
- 3 different orbit and clocks:
 - JPL C1W/C2W Rapids
 - JPL Rapids (24 L2 civil sats)
 - Civil-only process described under "POD"



Results

- High quality PPP possible with only civil signals
- Civil-only slightly worse than C1W/C2W even when using same 24 satellites
 - GipsyX ignores C2X biases in ambres presently, degraded ambres (E and V) for ~50% of sites
 - C2S stations have poorly determined biases
 - Stations with tracking issues on civil codes (e.g. SIN1)

C2L vs C2X



- C2X was more common than C2L, but C2L overtook circa 2023 and is growing
- Ran 3 pairs of days with bad clock overlaps due to changes in flex power mode with C1C/C2X as primary
 - C1C/C2L seems to handle these changes somewhat better than C1C/C2X or C1W/C2W

Conclusions

- Geodetic applications with GPS could continue even if codeless tracking were disabled today using C1C and C2L
- Civil-only orbit and clock products appear to have better quality than codeless ones
- IGS analysis centers and coordinator should start planning now for transition to civil GPS codes
 - Identify target primary pair
 - Encourage manufacturers and operators to favor desired pair

References

Esper, M., Chao E., Wolf C. (2020) 2019 Federal Radionavigation Plan. US Department of Defense.

Acknowledgements

This research was performed at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration. Funding provided from the Space Geodesy Project