Using low-cost receivers for multi-GNSS time-transfer

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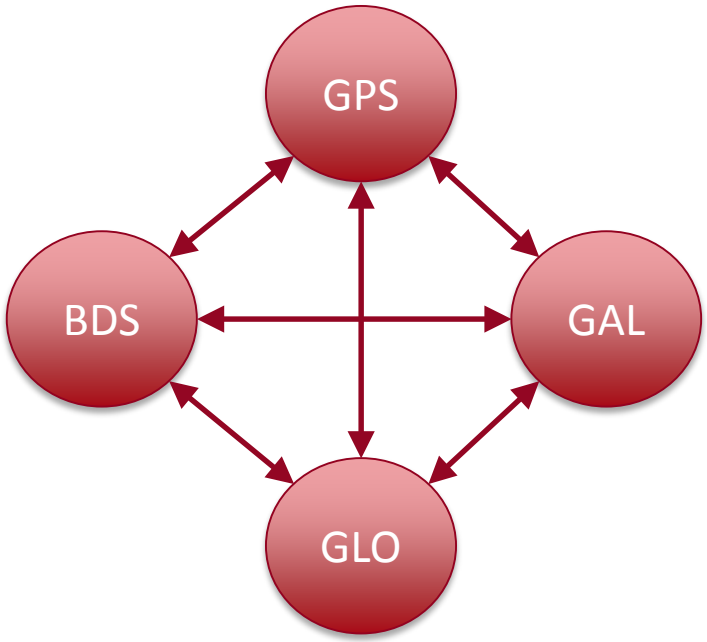
Why use low-cost receivers ?

Some applications do not need the highest accuracy and precision eg traceable time-of-day via Network Time Protocol is only accurate at the output to microseconds.

Open Traceable Time Platform –
a low-cost ($<2K) time transfer system
(Tuesday poster session)

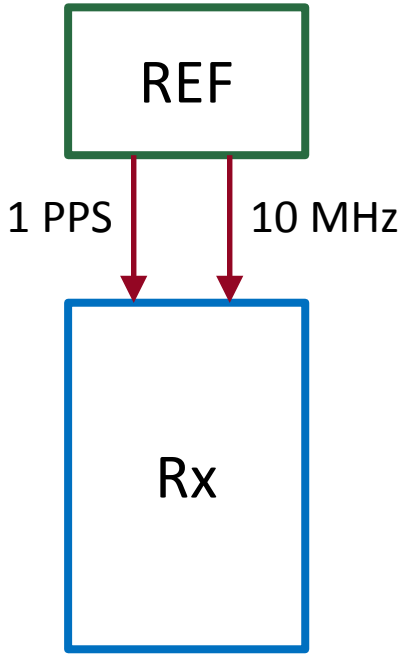
Why use multi-GNSS ?

- Potential to improve time-transfer stability with extra satellites
- Validation of GNSS time by inter-comparison of the GNSS



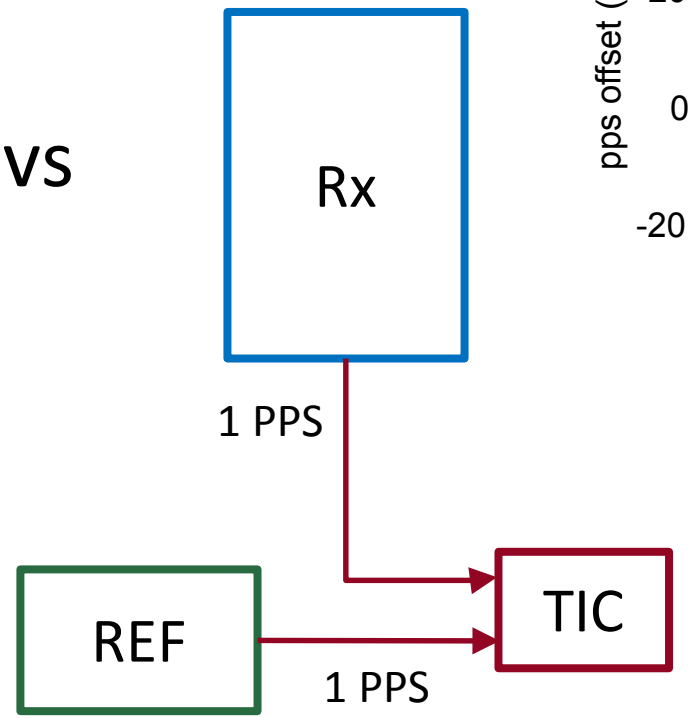
Separate receiver for each GNSS is practical.

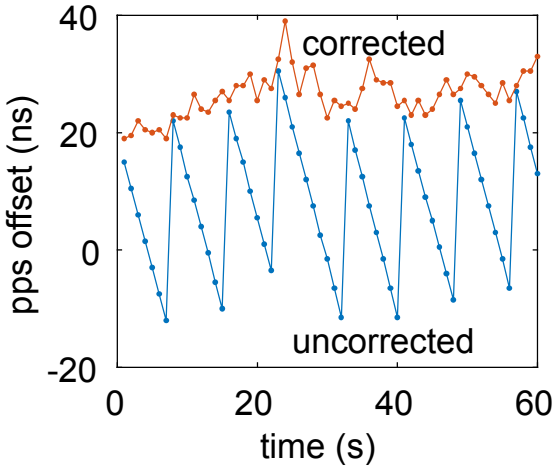
Limitations of low-cost receivers



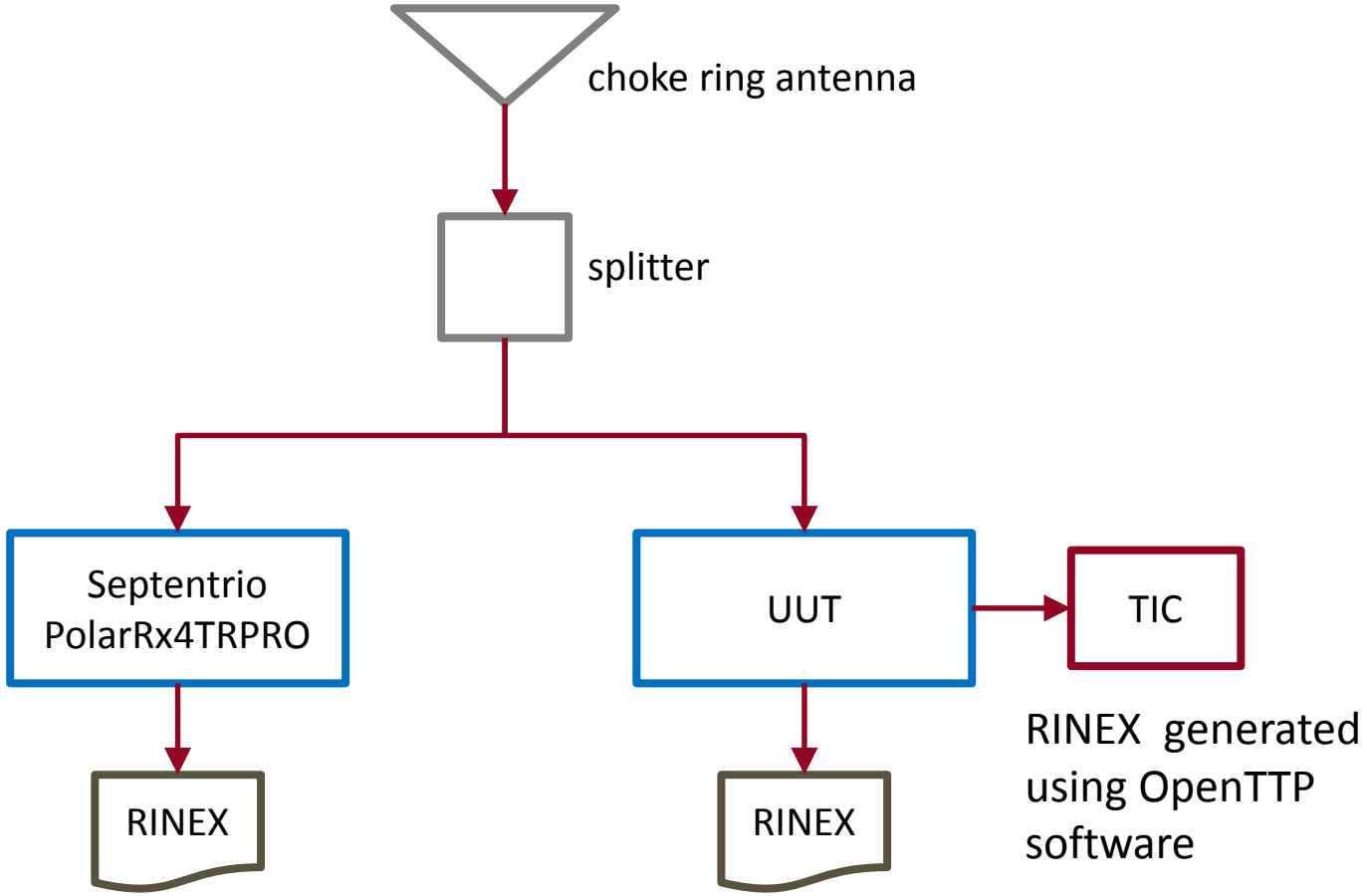
Typical timing receiver

VS





Setup for characterization of receiver noise



This facilitates comparison of receivers at the sub-ns level

Receivers tested

NVS NV08C-CSM			ublox NEO-M8T				ublox ZED-F9P			
GPS	GLO	BDS	GPS	GLO	GAL	BDS	GPS	GLO	GAL	BDS
L1C/A	L1OF	B1	L1C/A	L1OF	E1-B/C	B1	L1C/A	L1OF	E1-B/C	B1I
							L2C	L2OF	E5b	B2I
32 channels			72 channels				184 channels			

The smaller number of channels means that this receiver cannot track all three GNSS concurrently.

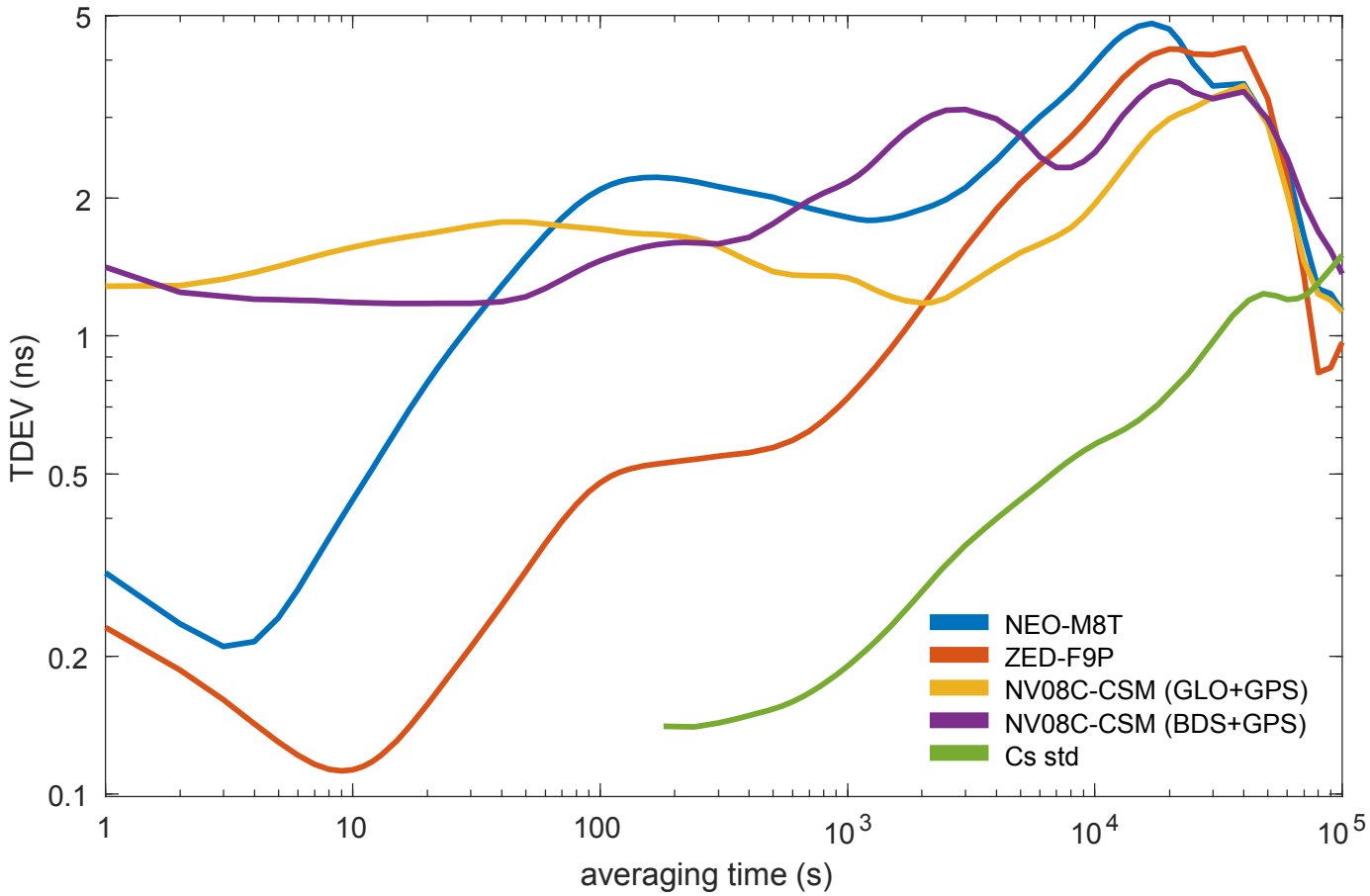
Maximum of three GNSS can be tracked.

All GNSS can be tracked concurrently.
GPS L2C tracked, so about 2/3 of visible satellites are tracked dual frequency.

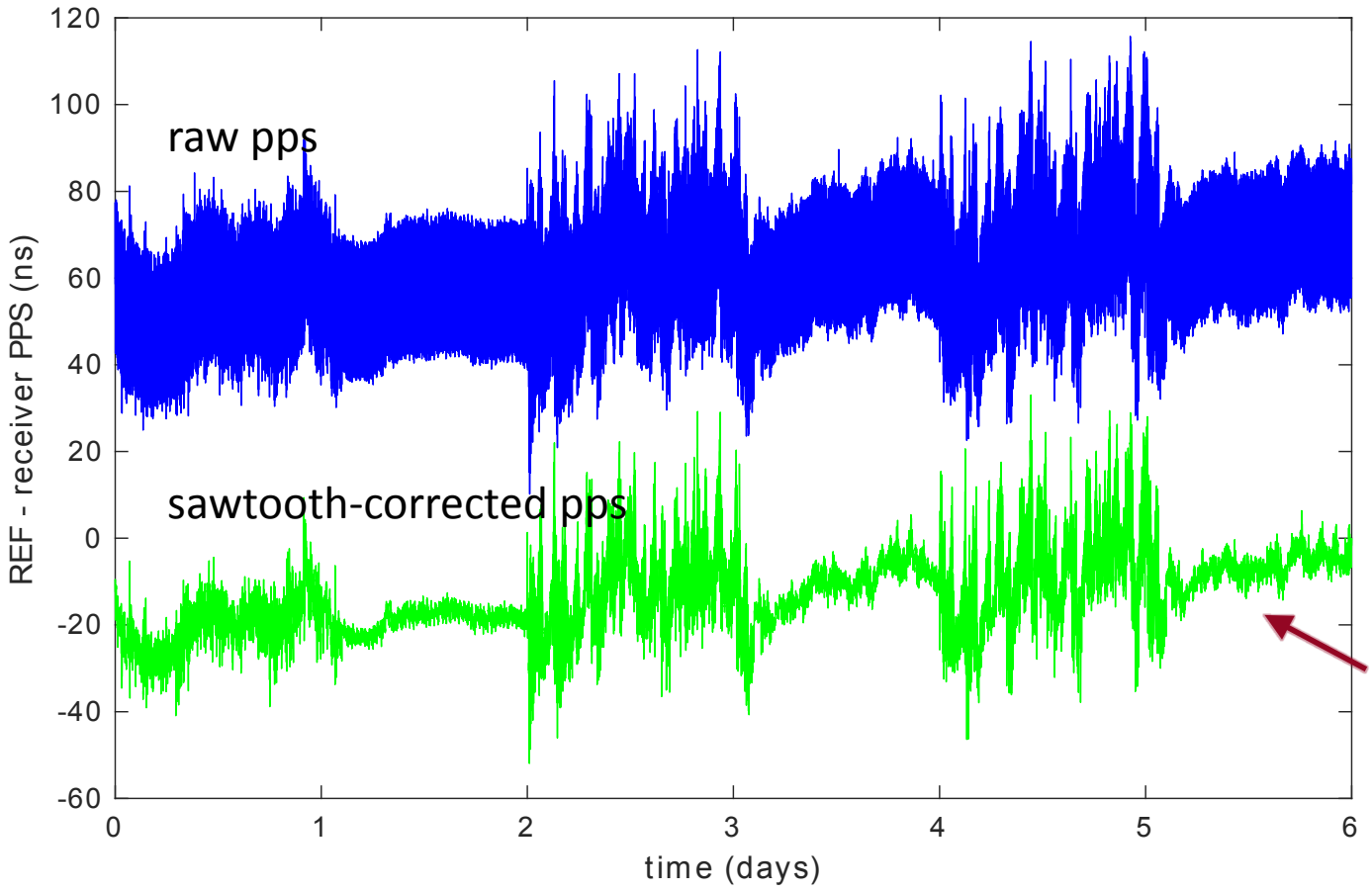
Configuration of receivers

	NVS NV08C-CSM	ublox NEO-M8T	ublox ZED-F9P
Reference timescale for pseudorange measurements	? appears to be the corresponding GNSS system	GPS	GPS
PPS alignment	UTC	GPS	GPS
GNSS combinations	GPS GPS + GLONASS GPS + BeiDou	GPS + Galileo GPS + GLONASS GPS + BeiDou	GPS + GLONASS + Galileo + BeiDou

Effectiveness of the sawtooth correction



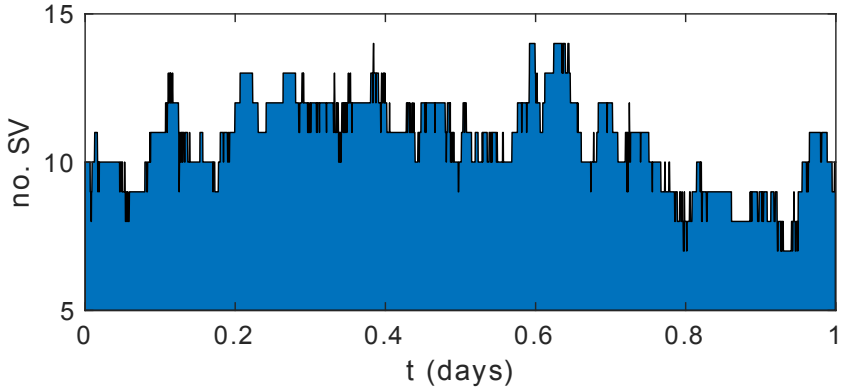
NV08C-CSM pps problems



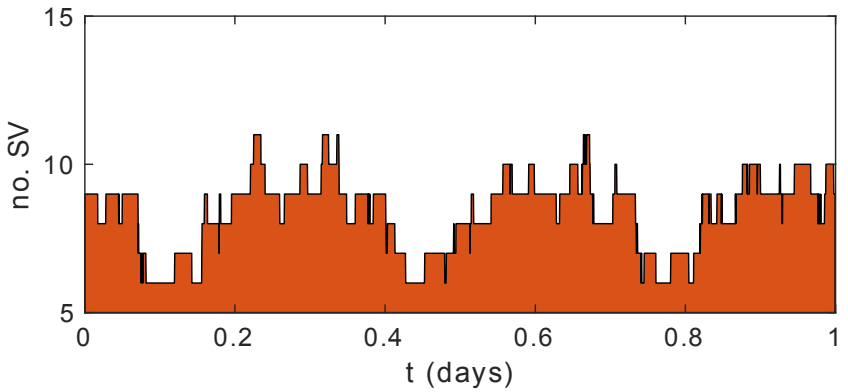
TDEV similar to ublox for $\tau < 1000s$

Satellite visibility: ublox ZED-F9P

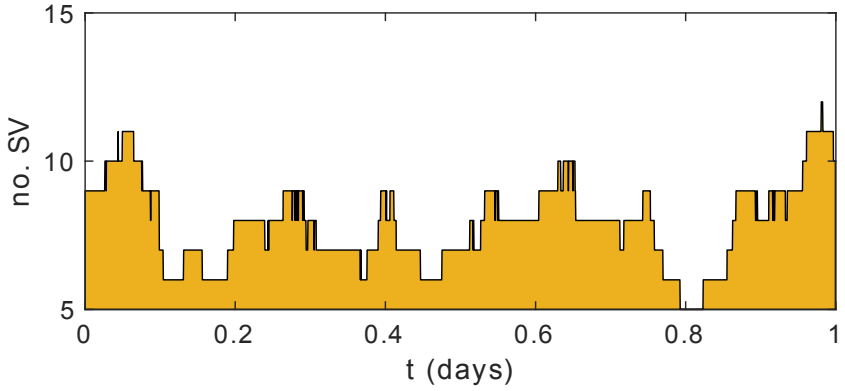
GPS



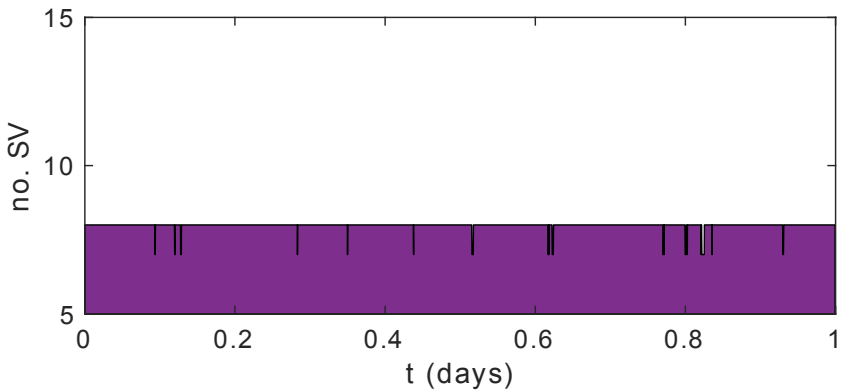
GLONASS



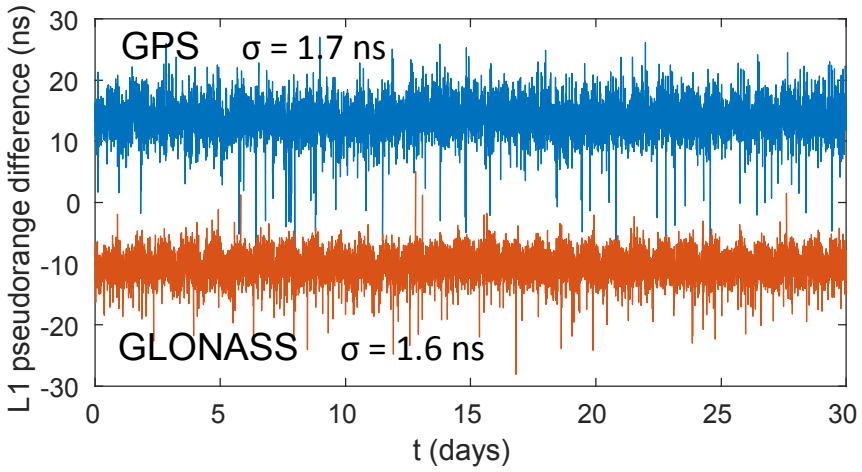
Galileo

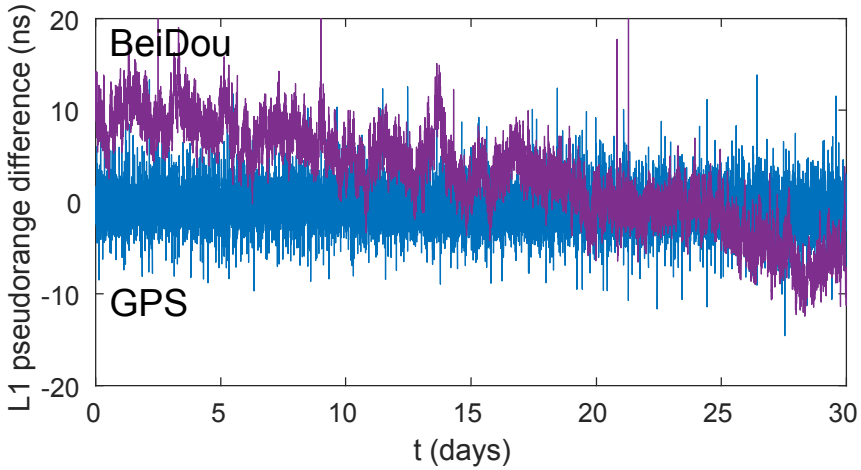


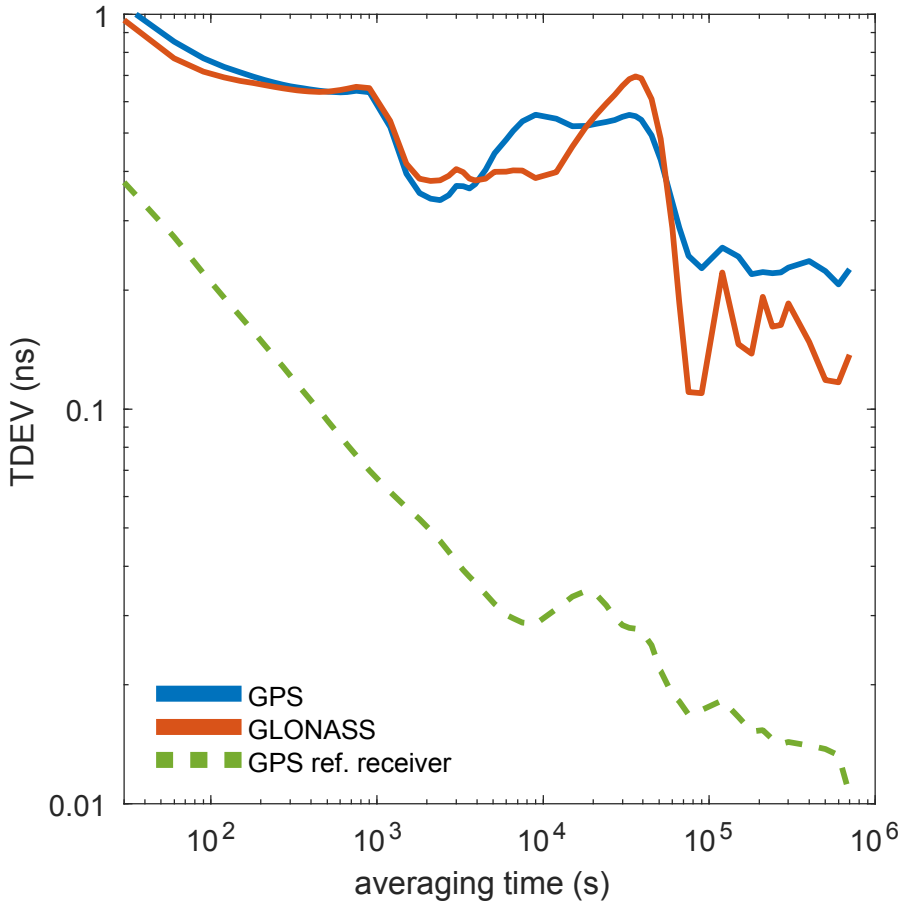
BeiDou



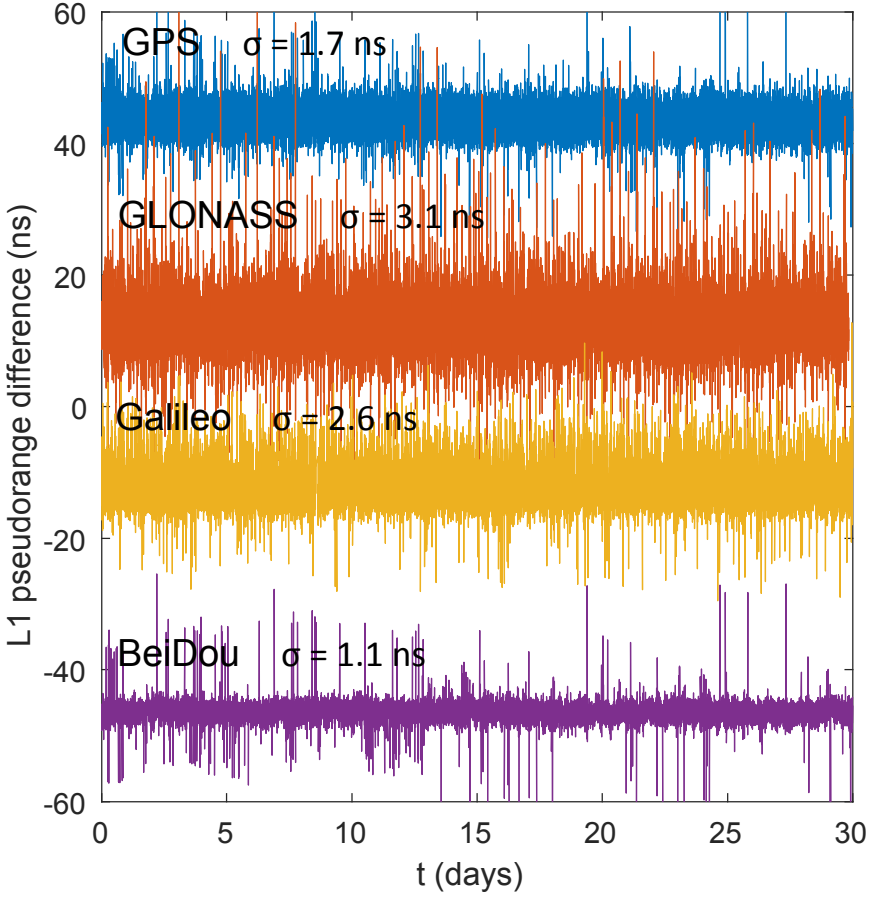
Receiver noise: NVS NV08C-CSM

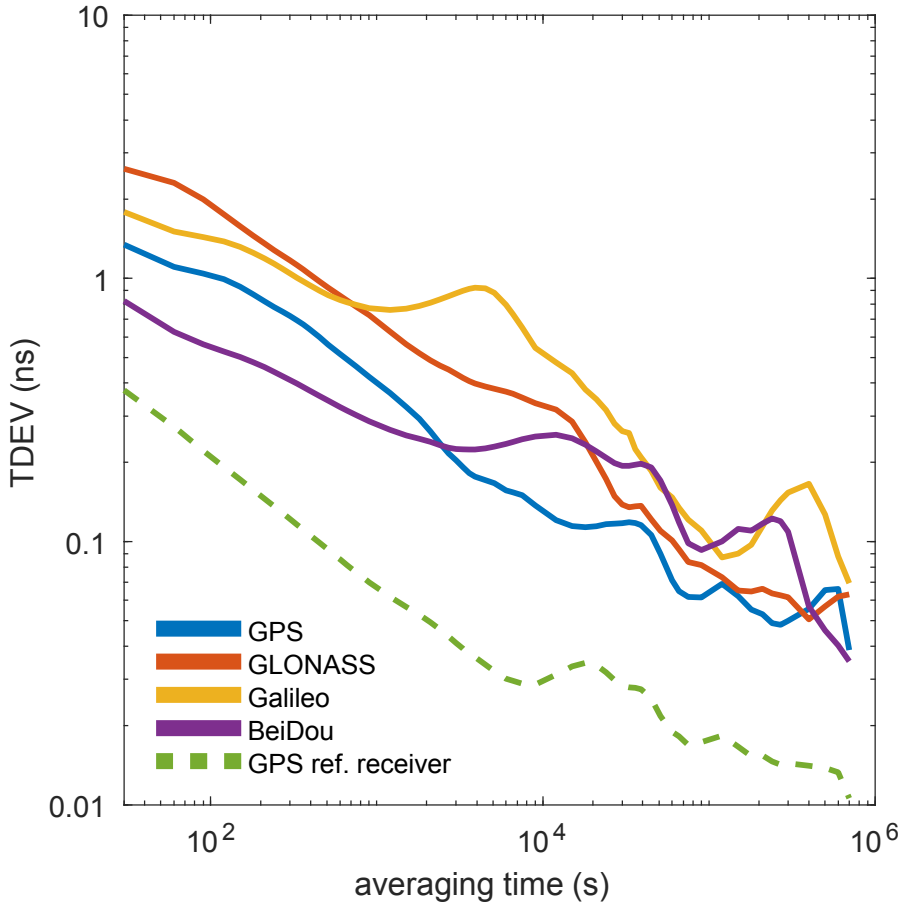




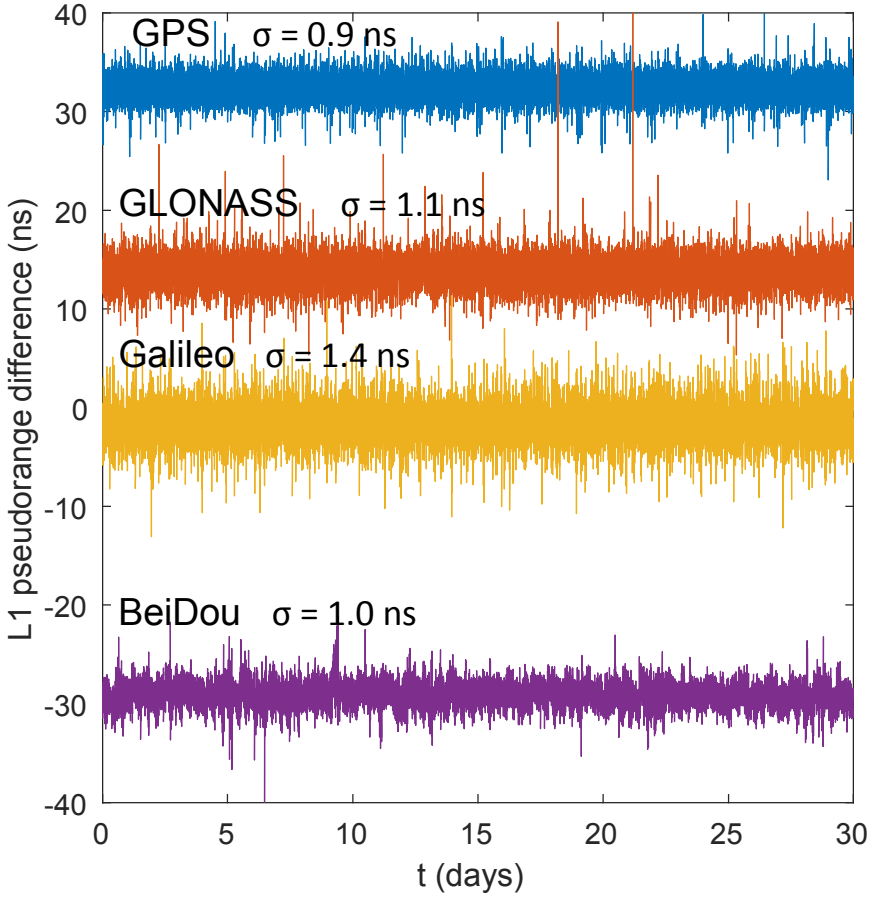


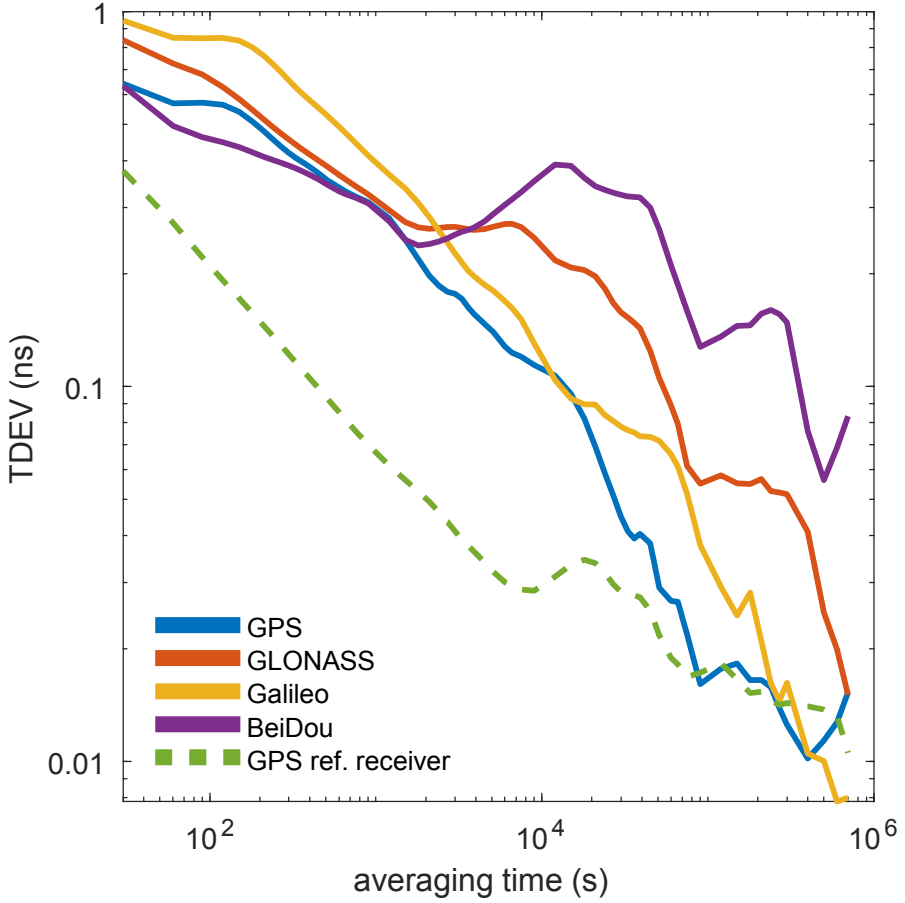
Receiver noise: ublox NEO-M8T



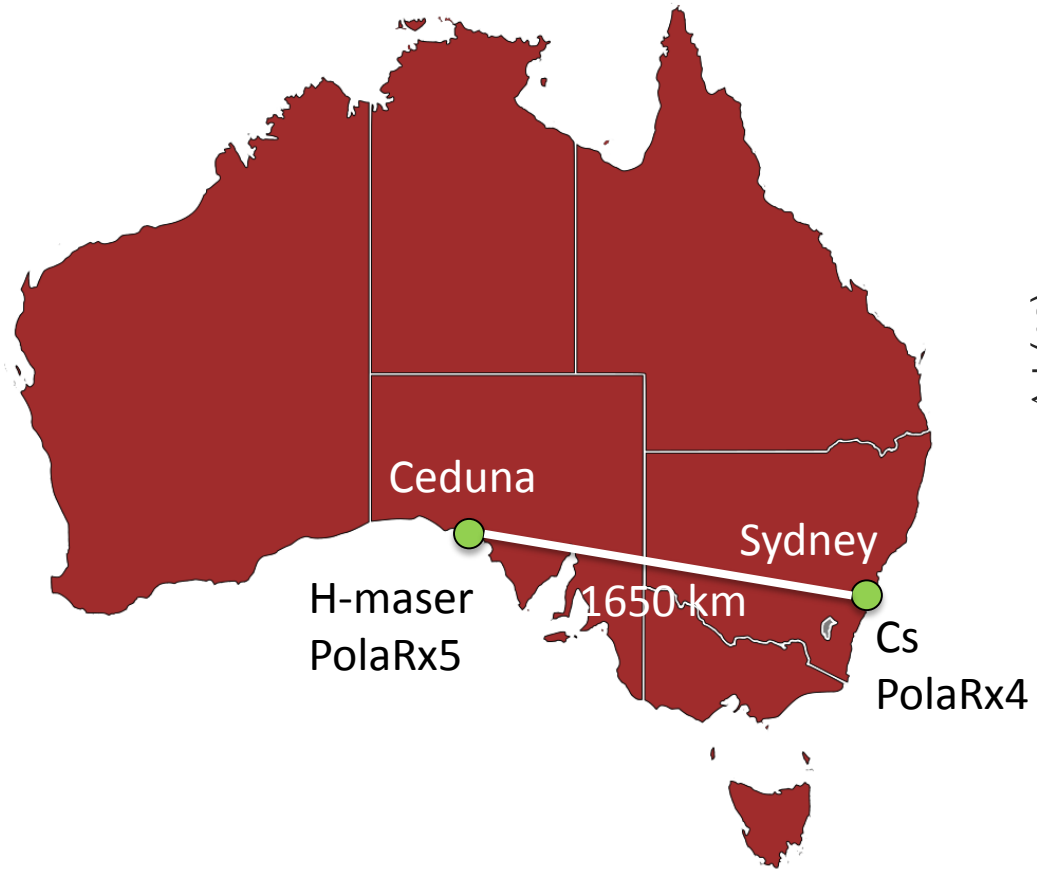


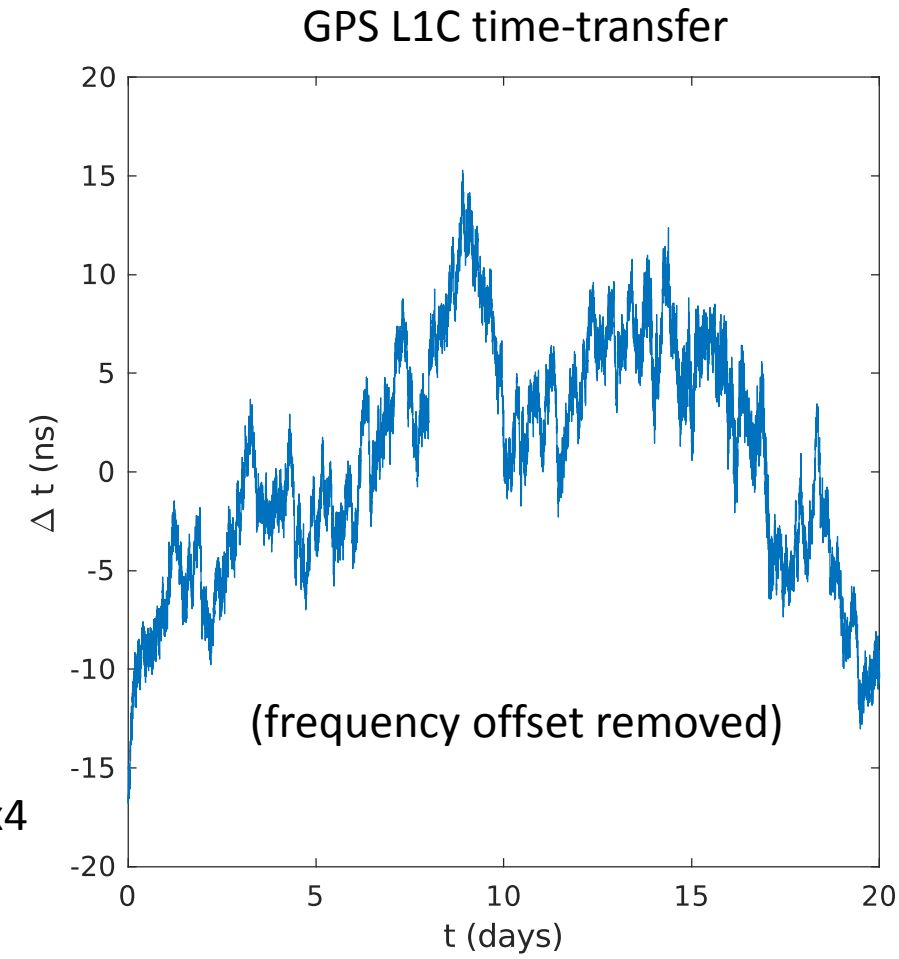
Receiver noise: ublox ZED-F9P



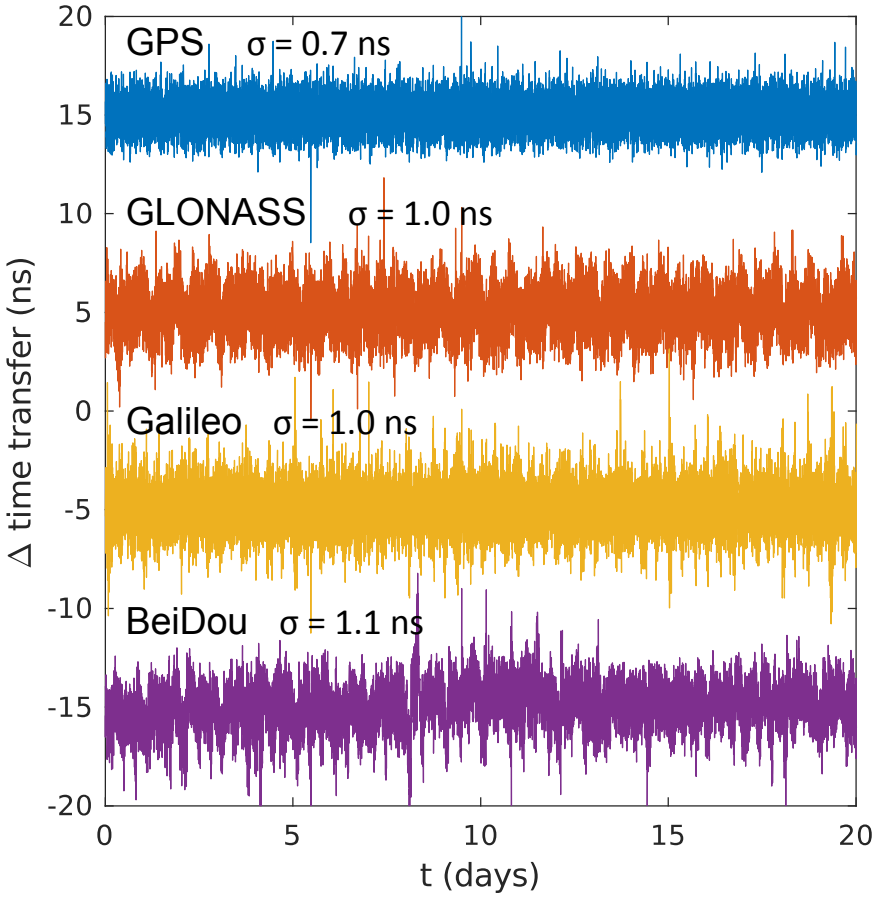


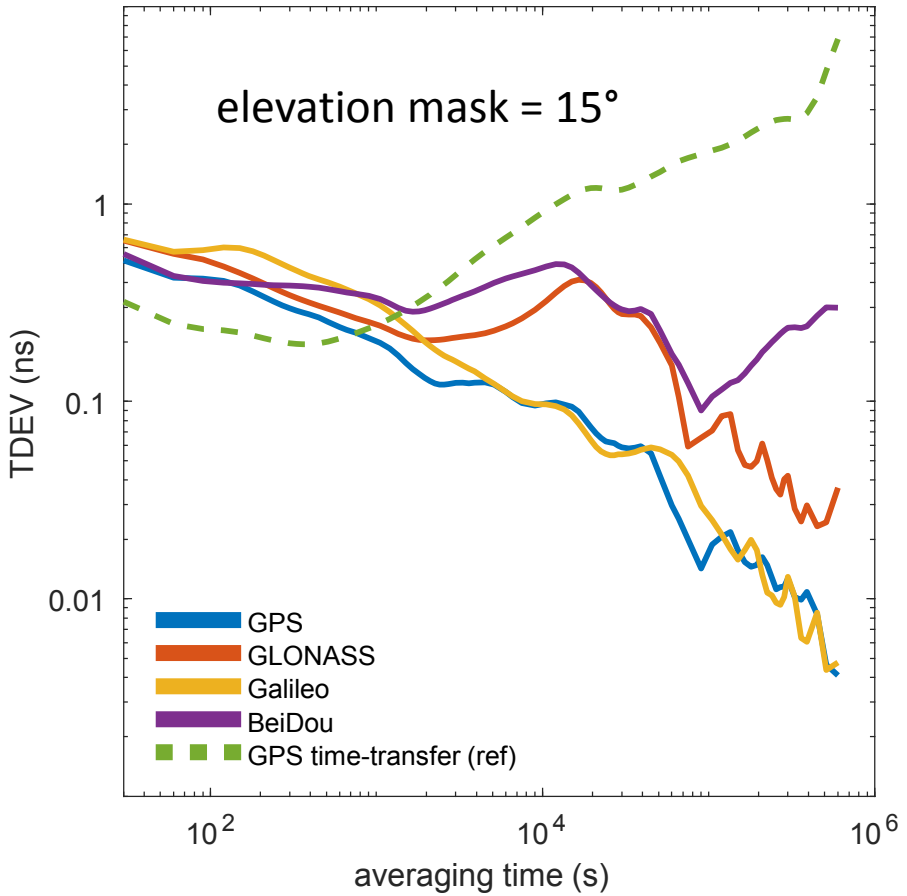
Single frequency time-transfer between Sydney and Ceduna





L1 time-transfer comparison





Summary

- We deliver traceable time and frequency to our customers with time-transfer systems based on low-cost receivers.
- The quality of the sawtooth correction is critical to the stability at averaging times less than 1000 s.
- Receivers have their individual quirks and it can sometimes require detective work to identify eg the receiver's reference timescale
- Single-frequency receivers have adequate performance for our applications.
- New multi-GNSS, dual frequency receivers offer some significant improvements over the single-frequency receivers we are currently using.

“Time Frame II “ John Beasley

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