Impact of Operations on Data Analysis (Part 1)

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Thanks to Sara Hardin, Ed Himwich, Axel Nothnagel

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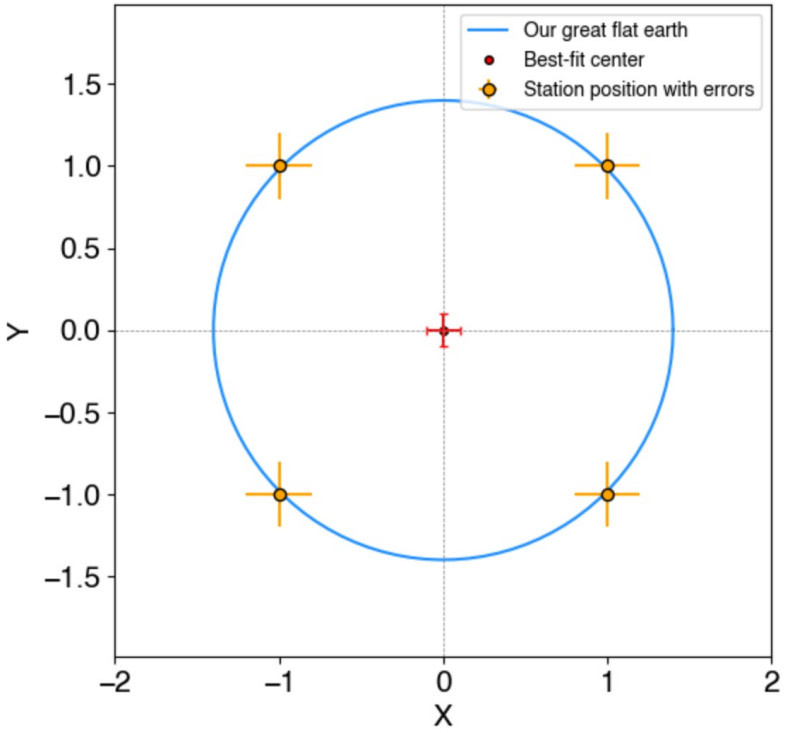
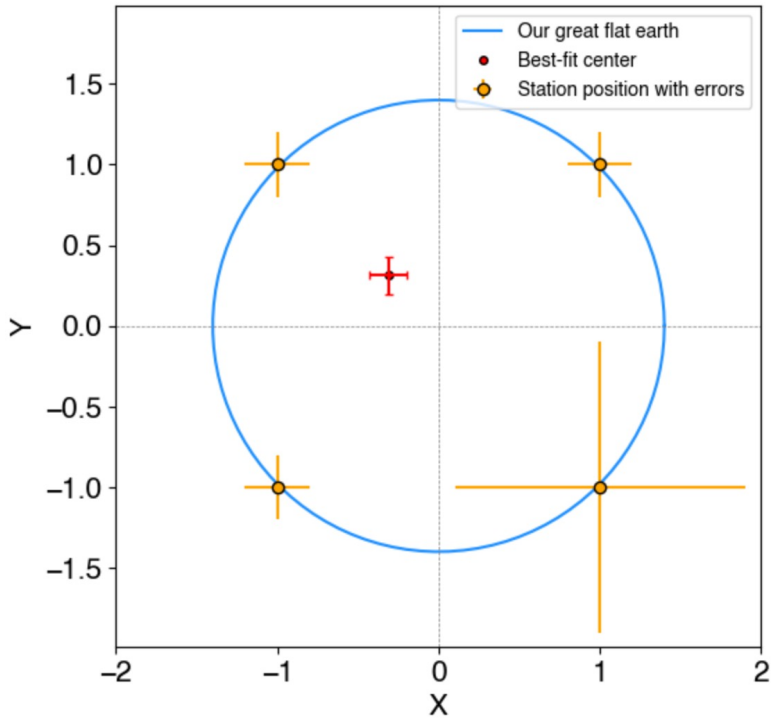
Impact of station “quality” on TRF realization

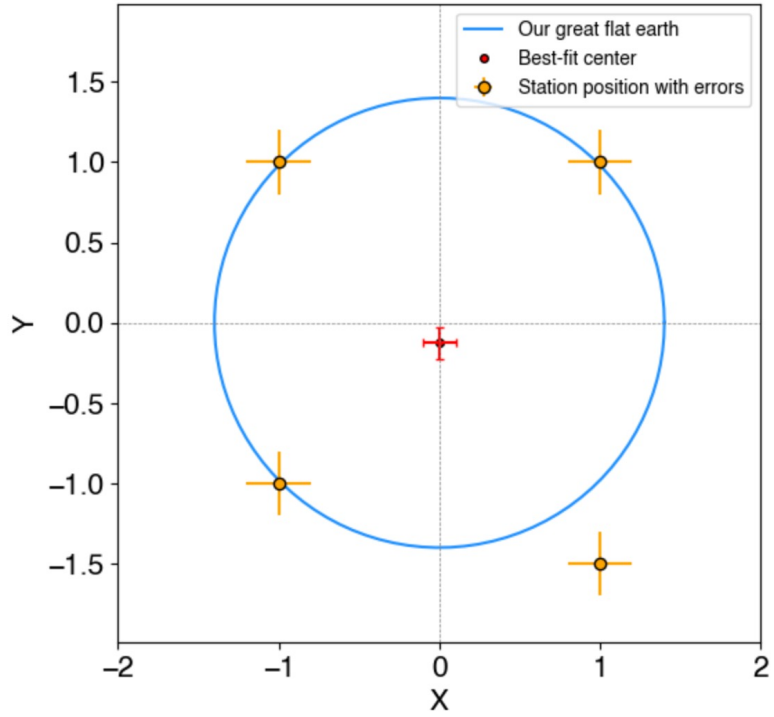
TRF with all good stations



TRF with a station with less precise coordinates



TRF with a station with less accurate coordinates



Station “quality” here means precision (center), accuracy (right), and/or both

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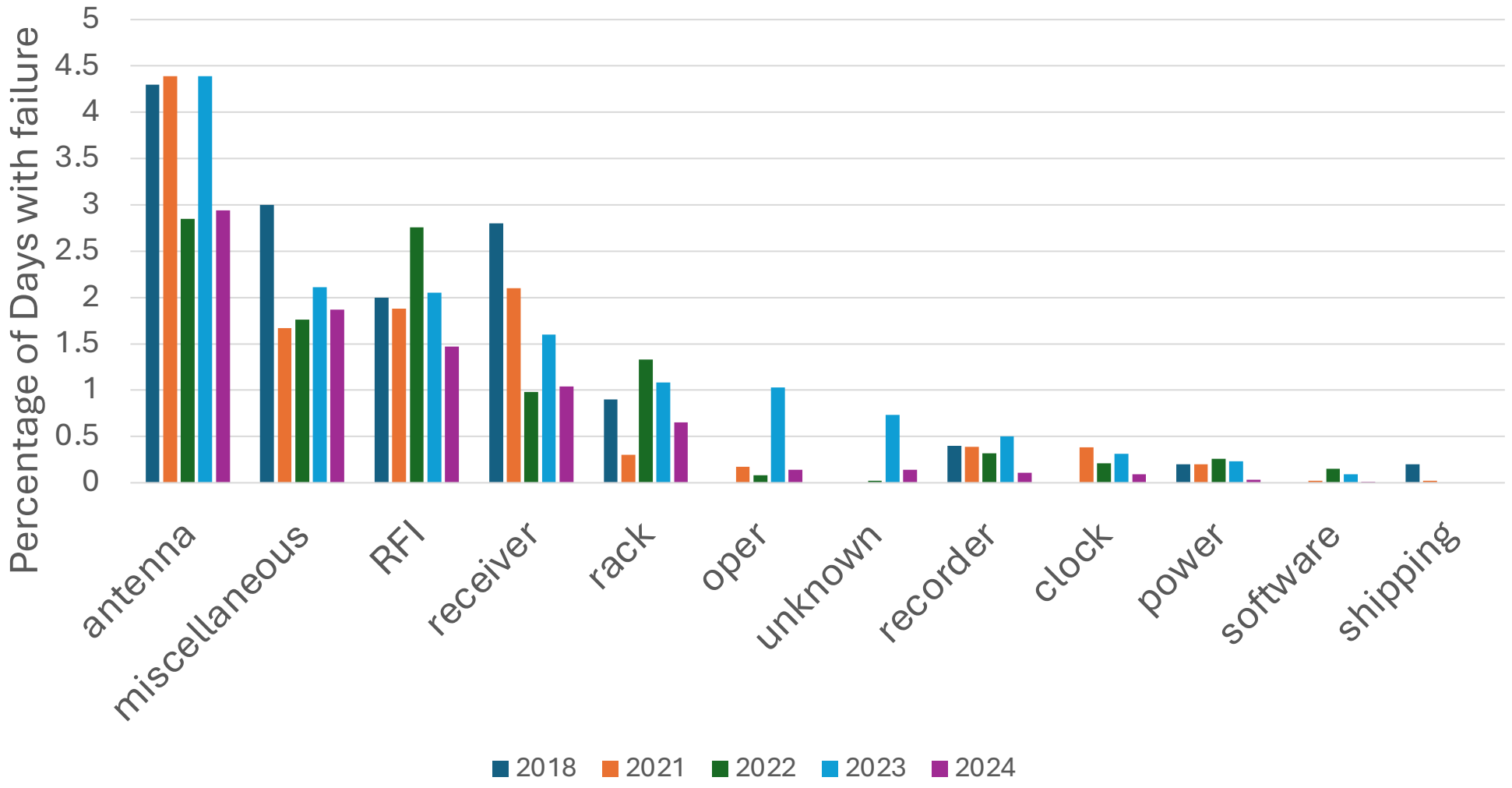
How have the VGOS stations been performing?



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See TOW session by Burns

Correlator/Station report

- Provides an initial idea about station performances
  - Warm receiver
  - Antenna slewing problems
  - Station not operational, i.e., “down” or unreliable
  - Cable calibration is not working
  - Phase-calibration signal absent or highly variable
  - No met data
- Provides insights about the data quality
  - Channel or band removed
  - Low SNR, no-detection

Analysts know what to expect

+ Which station(s) to down-weight in the analysis

+ Which station(s) to use as a clock reference

+ Which cable-cal to use

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What do VGOS data analysts see?

- Group delay per baseline
- Group delay uncertainties
- Cable calibration data
- Weather data (Met data)
- Correlator/Station Report

Measured vs Modeled

$$\tau = \tau_g + \tau_{clk} + \tau_{ins} + \tau_{ion} + \tau_{trop} + \tau_{rel} + \tau_{other} + \in$$

- **Signal** (geometry => position)
- Rest is **“noise”**
  - Clocks
  - Ionosphere
  - Troposphere
  - Electronics, etc.

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Factors that affect geodetic precision: delay error

$$\sigma_\phi \approx \frac{1}{SNR}\ (phase) \qquad \boldsymbol{\sigma_\tau} = \frac{\sigma_\phi}{\Delta\upsilon_{rms}}\ (group\ delay = geodesy)$$

$$SNR \propto S\ \frac{1}{\sqrt{SEFD_1\ SEFD_2}}\sqrt{2\ \Delta\upsilon\ T_{int}}$$

- $\sigma_{\phi,\tau}$: observation error (sigma; the smaller the better)
- *SNR*: signal-to-noise ratio (the larger the better)
- $\Delta\upsilon_{rms}$: effective bandwidth (the larger the better)

- S: source flux density (the larger the better, typically <= 1 Jy)
- $SEFD_{1,2}$ at antenna 1,2 (the smaller the better, VGOS specification 2,500 Jy)
- $\Delta\upsilon$: bandwidth (the larger the better, VGOS 2-14 GHz)
- T_{int} : integration (recording time) of observation (the longer the better)

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Geodetic precision and a warm receiver

- If one station's receiver is warm, that station's SEFD might typically go up by a factor of 3. Therefore, the average sigma would go up by a factor of $\sqrt{3}$, or about 1.7. A station position estimate that would have been precise to about 1-3 mm would instead be precise to about 2-5 mm.
- A warm receiver with an SEFD 3 times normal is equivalent to observing 1/3 of the time.
- Target (minimum) SNR values are typically 20 at X-band, and there are no fringes if SNR falls below about 7. With an SEFD 3 times normal, the no-fringes SNR becomes 12.
- A warm receiver at one station usually will not destroy an experiment as is, but it may prevent fringes to a high SEFD station if it was scheduled with a lower SNR target.

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Other effects that increase SEFD

- Pointing off by one half of a full-width-half-maximum (FWHM) drops the response of the antenna by a factor of 2, and so doubles the SEFD, and the sigma is increased by $\sqrt{2}$.
- If the focus is off, the same rule applies, if the response is down half, the SEFD is doubled and the sigma is increased by $\sqrt{2}$.
- Poor image rejection
  - Frontend, doubles the noise level in all channels, so increases sigma by $\sqrt{2}$ (also does bad things to phase-cal: adds spurious signals)
  - VC/BBC, doubles the noise level in that channel, so increases the sigma by about a small amount, but also adds spurious signals

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Variable phase-calibration signal

- Should be about 1% in power
- Too strong reduces sensitivity and produces spurious signals
- See TOW session by Rajagopalan

Missing channels

- Each lost channel reduces the VGOS data yield by about 3% (7% in S/X legacy)
- In addition, it can compromise the delay resolution function (Rogers, 1970; cf. Nothnagel memo)
- Recommended VGOS channel drop order TBD (cf. Himwich/Corey “dropping channels gracefully” memo for S/X legacy; #6, 11, 7, 2, 5)

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Missing a session

- If you don’t observe, please send an e-mail message to ivs-ops
- It is important so that correlators don’t delay correlation waiting for data that will never arrive.
- Bottom line: send a message to ivs-ops

More on reporting in Part 2 by Sara Hardin

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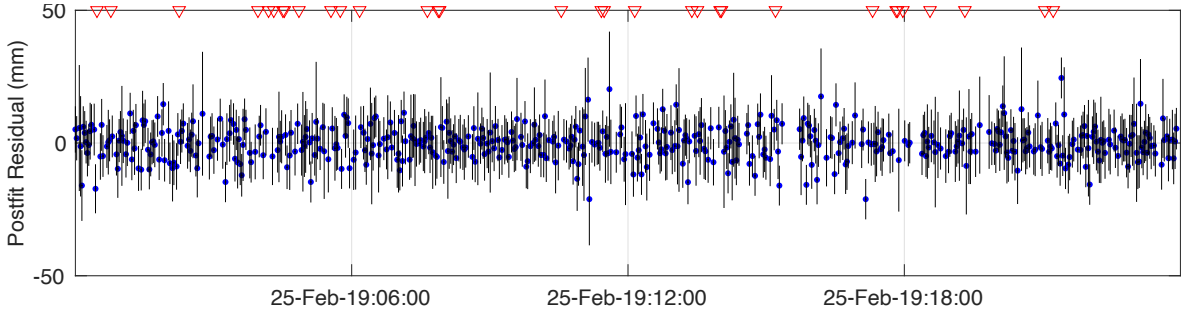
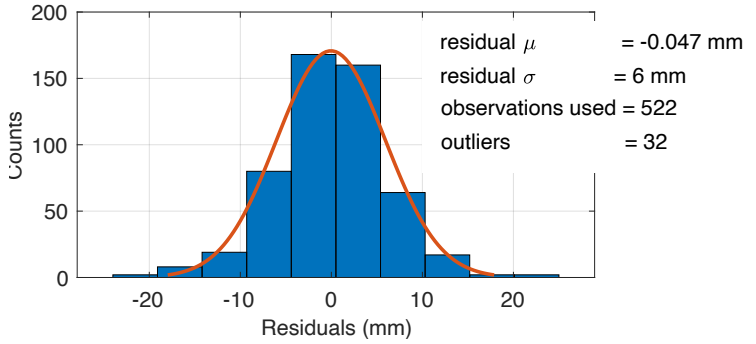
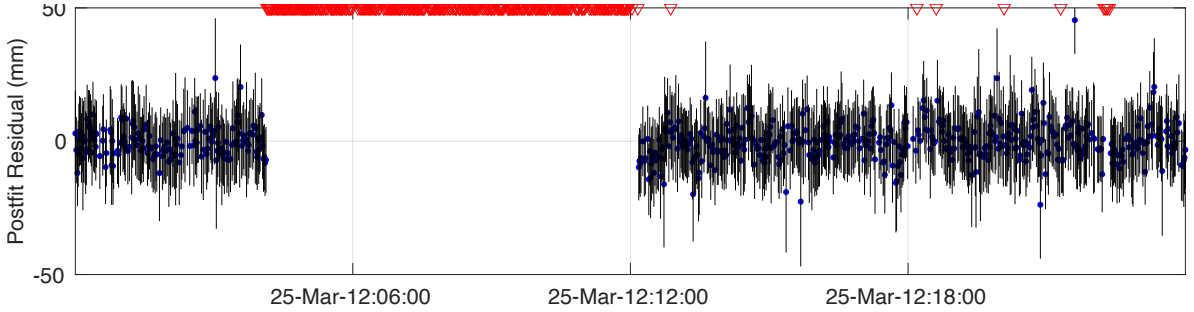
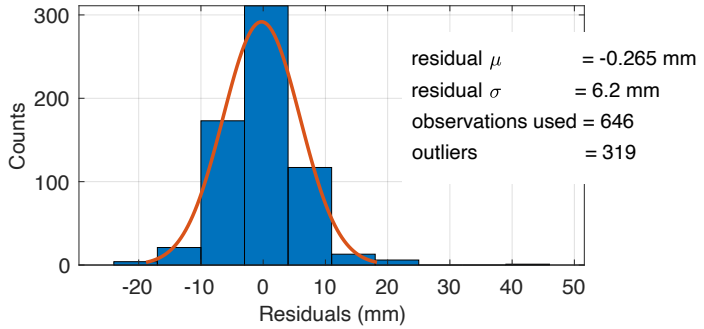
Missing band(s) and channel(s)



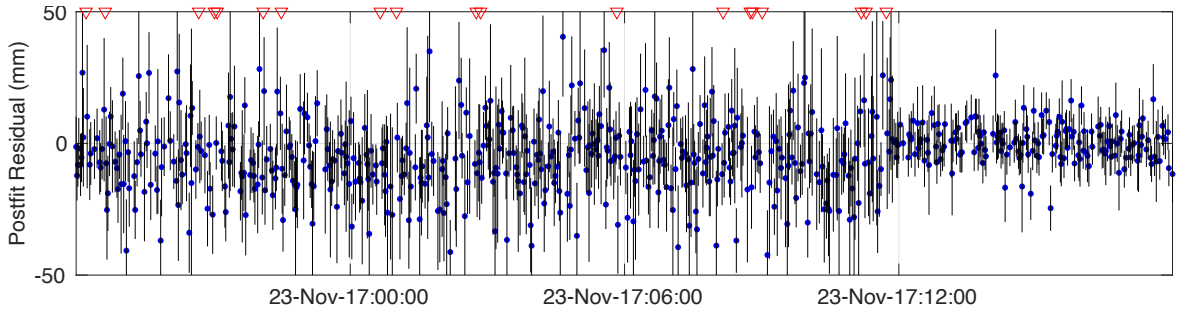


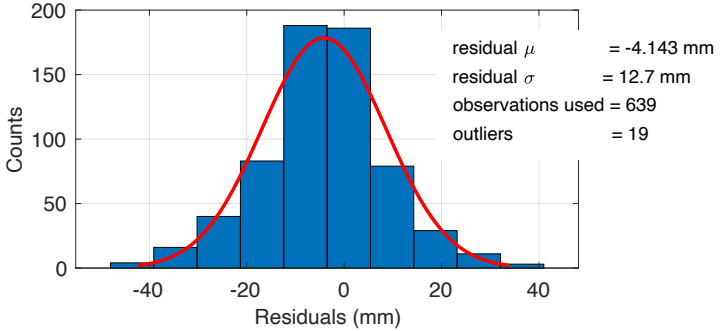
A : BandA Y-pol phasecal tones variable amplitude.
A : Removed channel from fringe fitting: h





A: Azimuth drive failure 071-0407a to 071-1210b, no fringe detections.
A: Removed channel h from fringe fitting due to low amplitude.





A: No data in bandA prior to scan 321-1153
A: Channels abcdefgh excluded from fringe fitting prior to scan 321-1153

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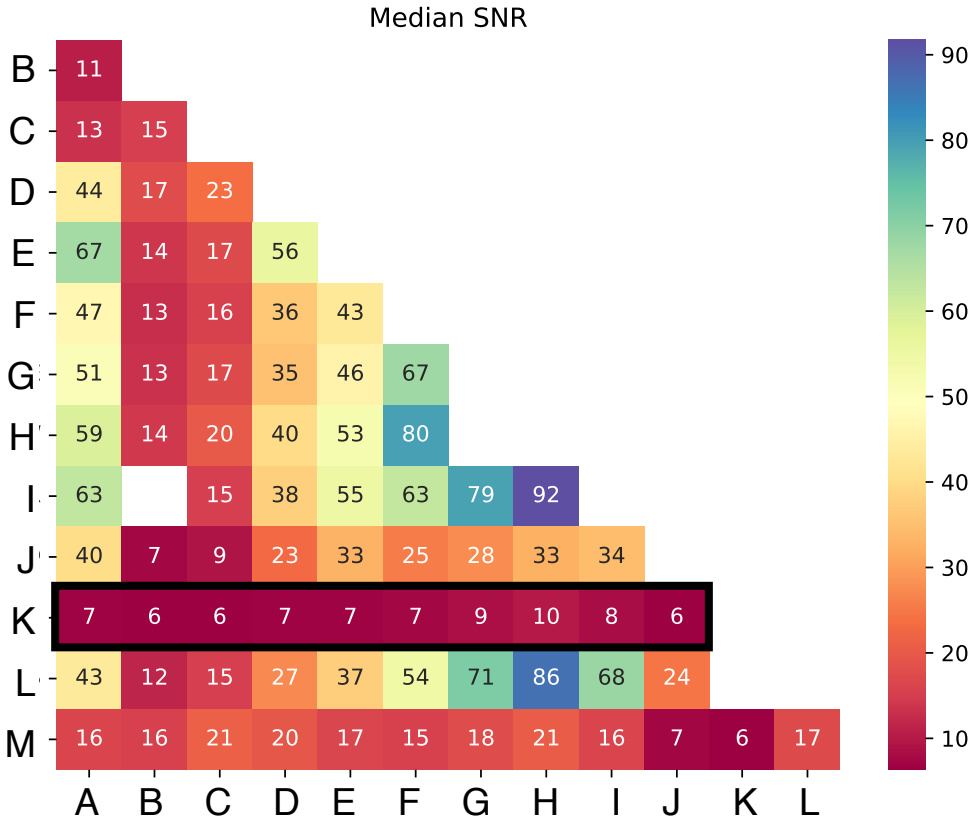
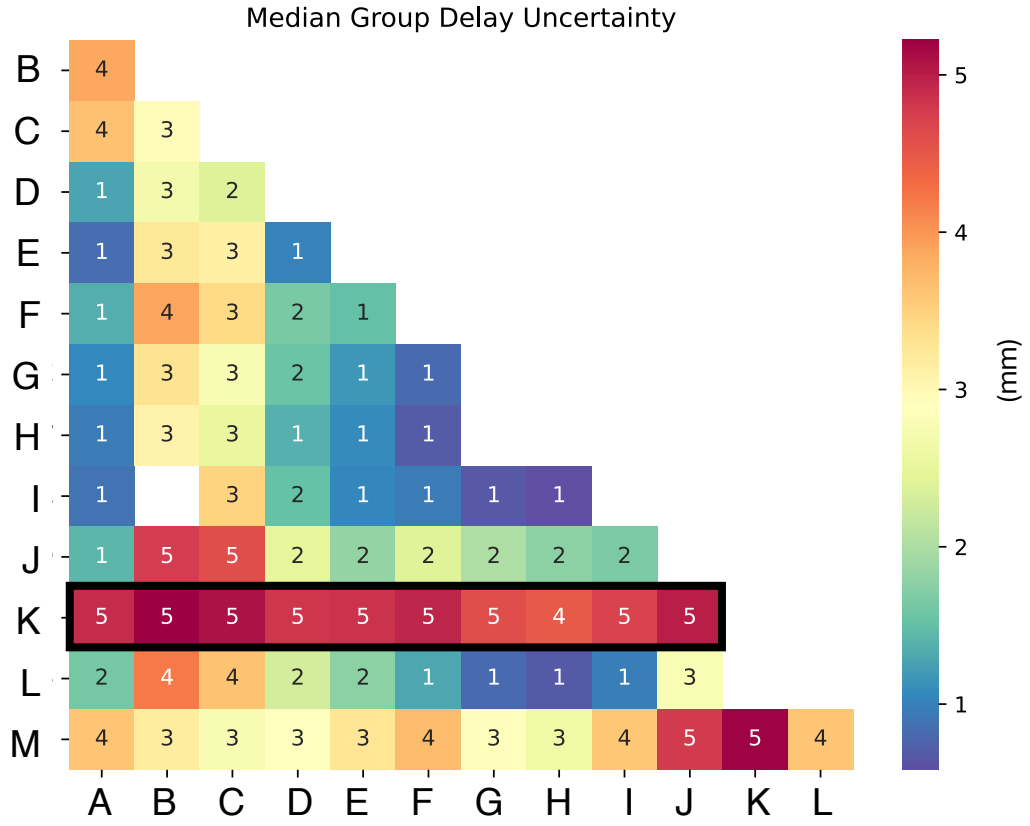
SNR vs. group delay uncertainty





Station K: Very low SNR. Many non-detections.
Station B: Phasecal amplitudes variable in bandB. Removed channels g,h,z,C from fringe fitting.
Station J : X-pol phasecal highly variable.
Station M: Missed scan. Removed channel I,C.

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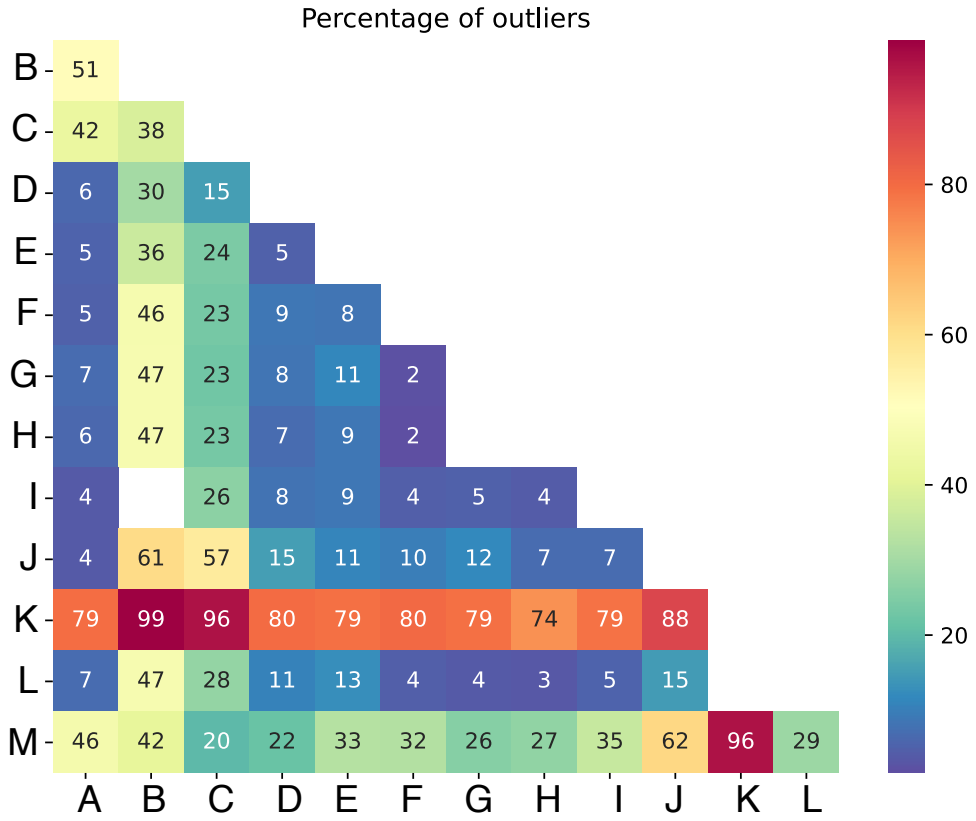
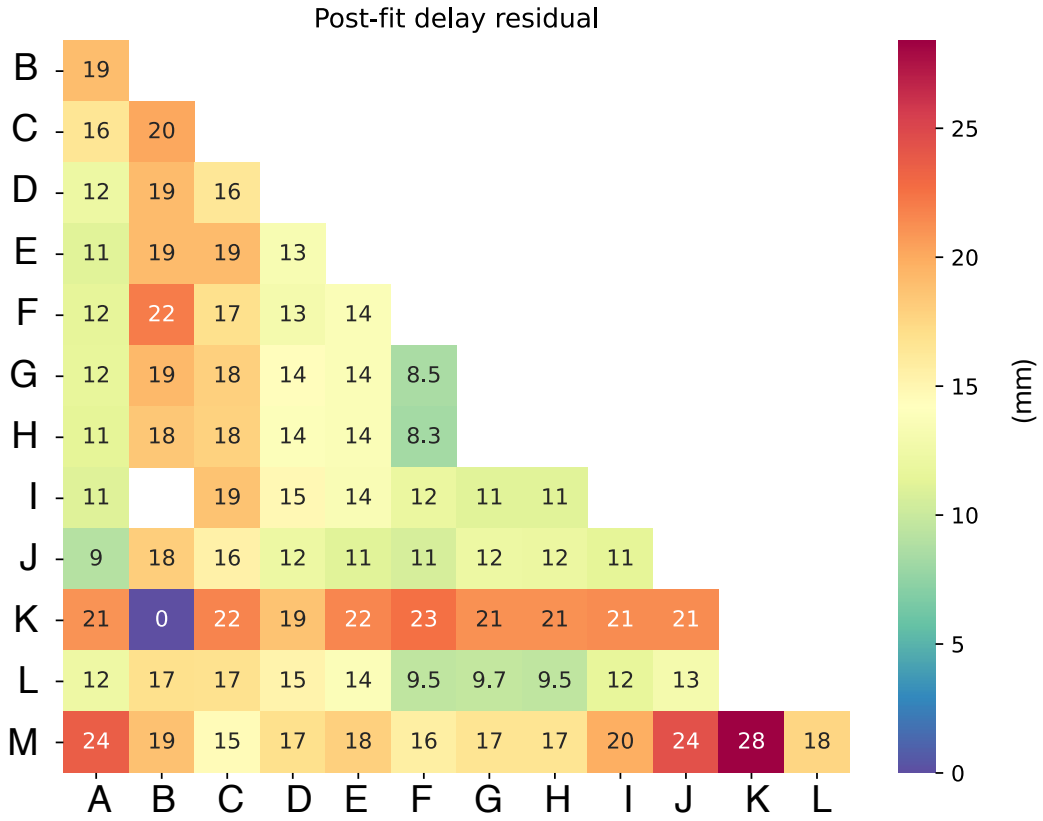
Deleted observations vs. post-fit delay residuals





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