JIVE
Joint Institute for VLBI
ERIC

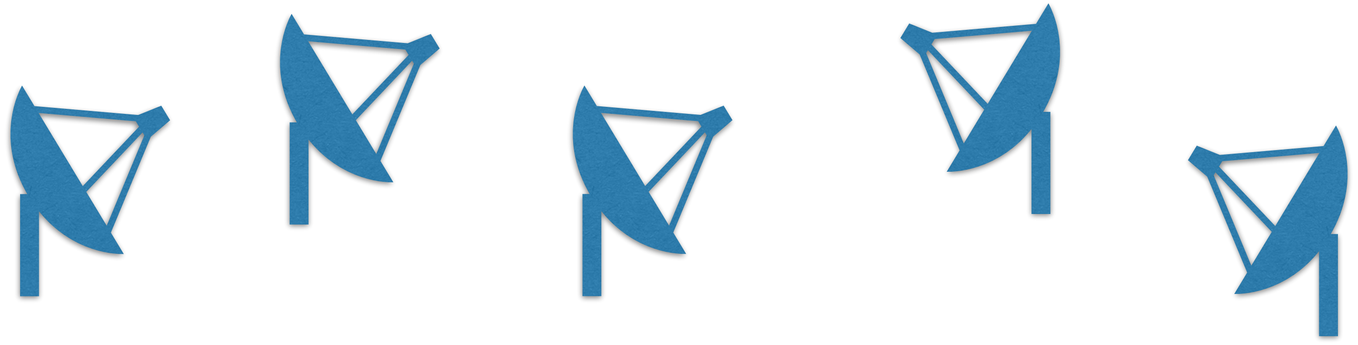
SFXC and Geodesy

SFXC Workshop

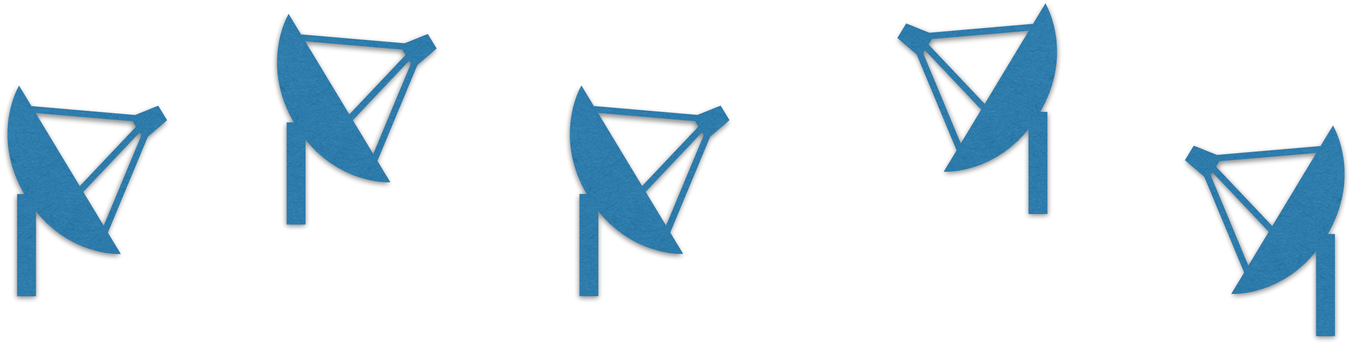
Mark Kettenis, 23 September 2025

Astronomy

Astro/Geo (subarraying)



Geodesy (subnetting)



Geodesy (subnetting)

Geodesy Schedules

Subnetting/Subarraying

- Overlapping scans: “scans” property in control file
  - Makes sure we pick the right scan for a time
  - Means we need to correlate single scans

```
scan No0001;
   start = 2024y307d20h30m00s;
   mode = sess324.K2048globgeo;
   station = At : 0 sec : 78 sec : 0.000000000 GB :   : &ccw : 1;
   station = Hh : 0 sec : 82 sec : 0.000000000 GB :   :   : 1;
   station = Jb : 0 sec : 60 sec : 0.000000000 GB :   : &n : 1;
   station = Mh : 0 sec : 100 sec : 0.000000000 GB :   : &n : 1;
   station = Mp : 0 sec : 60 sec : 0.000000000 GB :   : &ccw : 1;
   station = O6 : 0 sec : 253 sec : 0.000000000 GB :   : &n : 1;
   station = Sr : 0 sec : 98 sec : 0.000000000 GB :   : &ccw : 1;
   station = T6 : 0 sec : 253 sec : 0.000000000 GB :   : &n : 1;
   station = Ur : 1 sec : 172 sec : 0.000000000 GB :   : &n : 1;
   source = 0528+134;
endscan;
scan No0012;
   start = 2024y307d20h30m00s;
   mode = sess324.K2048globgeo;
   station = Br : 0 sec : 277 sec : 0.000000000 GB :   : &n : 1;
   station = Fd : 0 sec : 277 sec : 0.000000000 GB :   : &n : 1;
   station = Hn : 0 sec : 239 sec : 0.000000000 GB :   : &n : 1;
   station = Kp : 0 sec : 108 sec : 0.000000000 GB :   : &n : 1;
   station = La : 0 sec : 104 sec : 0.000000000 GB :   : &n : 1;
   station = Nl : 0 sec : 92 sec : 0.000000000 GB :   : &n : 1;
   station = Ov : 0 sec : 109 sec : 0.000000000 GB :   : &n : 1;
   station = Pt : 0 sec : 105 sec : 0.000000000 GB :   : &n : 1;
   station = Sc : 0 sec : 60 sec : 0.000000000 GB :   : &n : 1;
   station = Ys : 0 sec : 113 sec : 0.000000000 GB :   : &n : 1;
   source = 1904+013;
endscan;
scan No0022;
   start = 2024y307d20h33m26s;
   mode = sess324.K2048globgeo;
   station = Kp : 0 sec : 115 sec : 0.000000000 GB :   : &ccw : 1;
   station = La : 0 sec : 113 sec : 0.000000000 GB :   : &ccw : 1;
   station = Mh : 0 sec : 110 sec : 0.000000000 GB :   : &ccw : 1;
   station = Nl : 0 sec : 110 sec : 0.000000000 GB :   : &ccw : 1;
   station = Ov : 0 sec : 118 sec : 0.000000000 GB :   : &ccw : 1;
   station = Pt : 0 sec : 114 sec : 0.000000000 GB :   : &ccw : 1;
   station = Sc : 0 sec : 110 sec : 0.000000000 GB :   : &ccw : 1;
   station = Sr : 0 sec : 115 sec : 0.000000000 GB :   : &ccw : 1;
   station = Ys : 0 sec : 120 sec : 0.000000000 GB :   : &cw : 1;
   source = 0615+820;
endscan;
```

Geodesy correlation

Phase Cals / Pulse Cals

- 1MHz pulse train -> Harmonics give us peaks at 1MHz intervals
  - Other frequencies exist
- Detect and track instrumental delays
- Extract at backend or correlator
- SFXC implements extraction for two typical cases:
  - Phase Cal frequency aligned with band edge
  - Phase Cal frequency at small offset (i.e. 10 kHz)
- Enable extraction with "phasecal_file" and "phasecal_integr_time"options in control file
- "phasecal_file": “file:///home/kettenis/N24L2/N24L2_No0004.pc",
  “phasecal_integr_time”: 10.0,
- Some computational overhead associated with this process

Geodesy Postprocessing

sfxc2mark4

- VEX2 support under development
- Phase Cal amplitude scaling isn’t quite correct
  - Unclear what HOPS/fourfit expects here
- Geodesy uses 1-letter station codes
  - Standard codes exist for a small set of geodesy stations
  - Use —code-file option to define mapping from 2-letter station codes

Geodesy Postprocessing

Mark4 data format

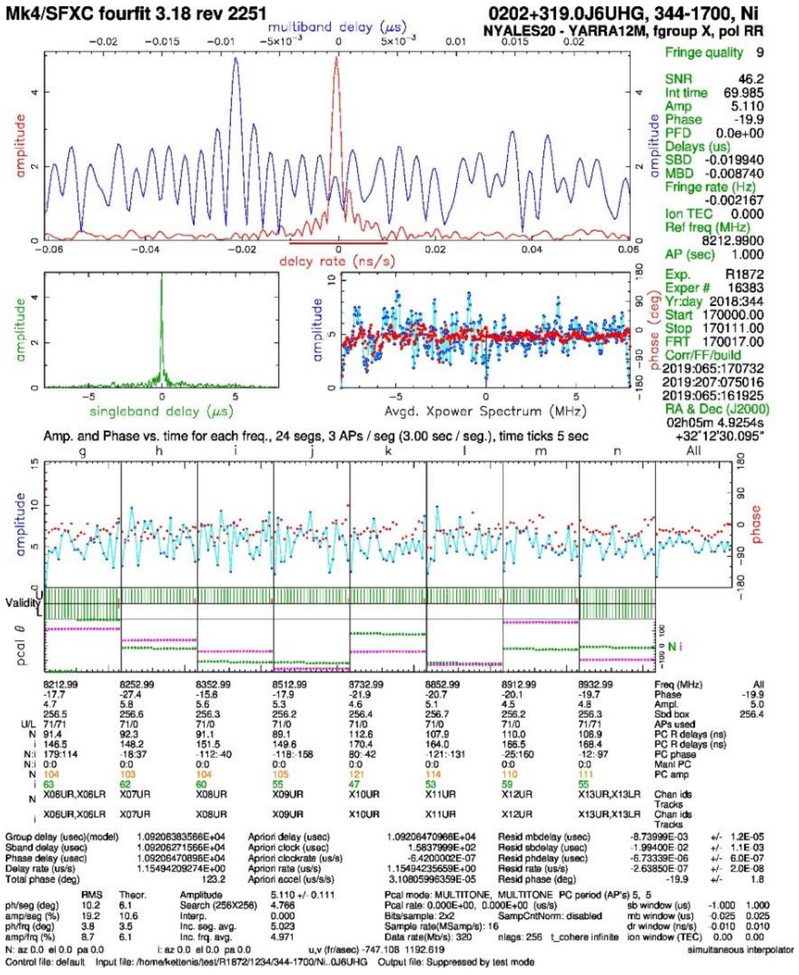
- Somewhat archaic collection of (mostly) binary files
  - <source>.<timecode>: OVEX
    - VEX-like description of observation
  - <station1>..<timecode>: “type-3” per-station information
    - model, extracted phase cal tones
  - <station1><station2>..<timecode>: “type-1” per-baseline information
    - visibilities
  - <station1><station2>.<pol>.<band>.<timecode>: “type-2” fourfit output
    - fringe-fit results

Geodesy Postprocessing

HOPS

- HOPS 3.26 is the latest public release
- HOPS 4 under development; at this point not support by SFXC
- Includes fourfit tool for fringe-fitting
- Produces rich (but complicated) plots
- fourfit output can be converted into vgosDb

HOPS results



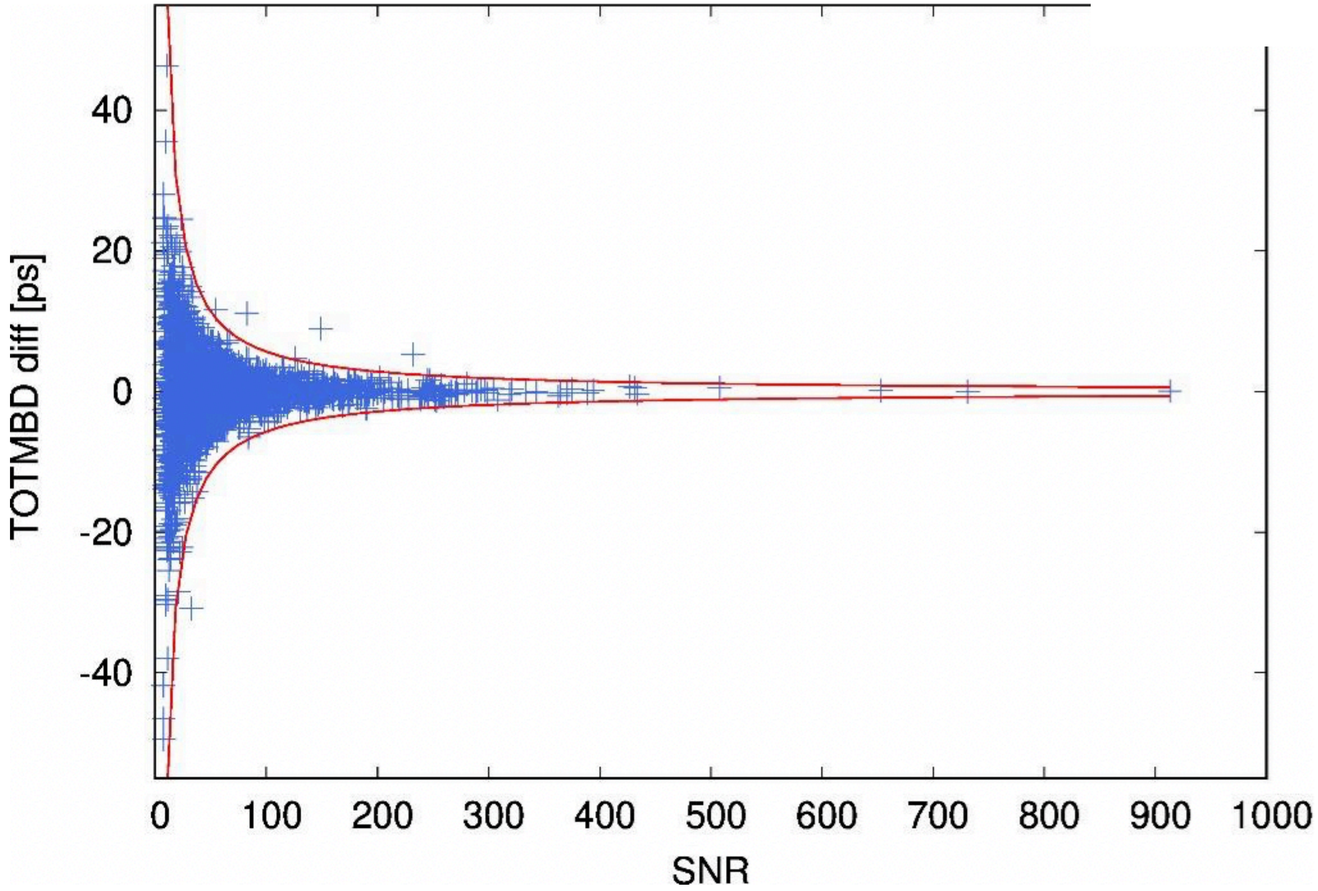


Figure 5. TOTMBD differences vs. SNR for X-band. The red curves represent ±1σ; it can be seen that with a few exceptions all of the differences are below this standard error. (Gomez et al. 2019)

EVN station positions

EC064 and EC076

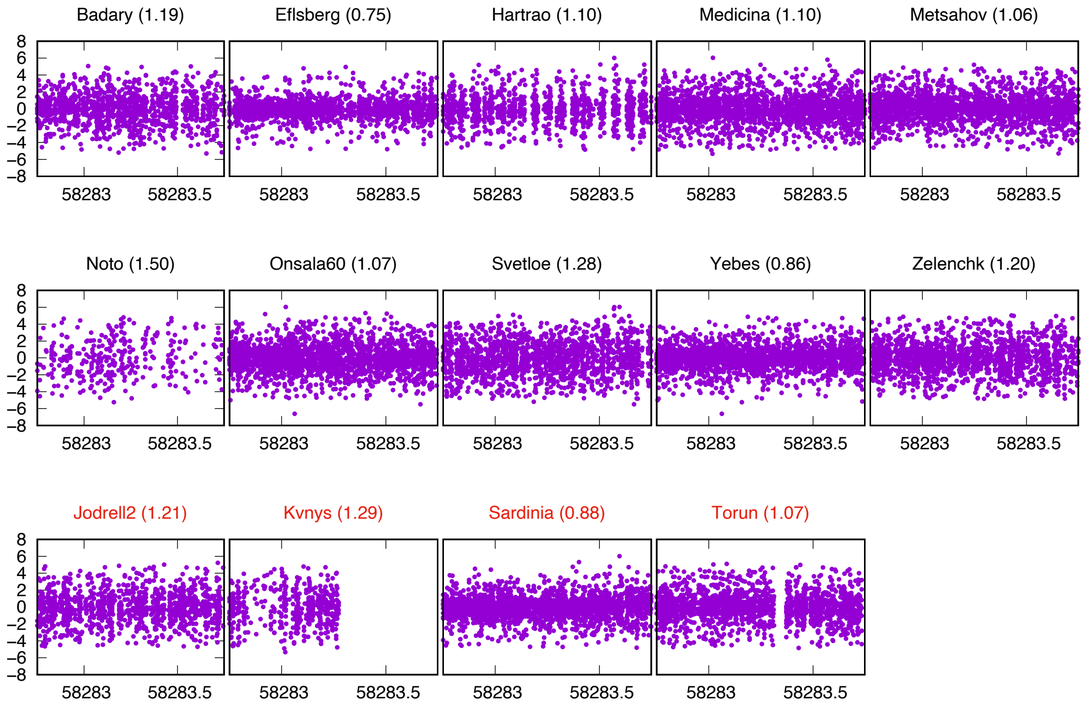


Fig. 1: Post-fit residuals per station in cm and weighted RMS in parenthesis. Each point represents an observation on a baseline that includes the mentioned station.

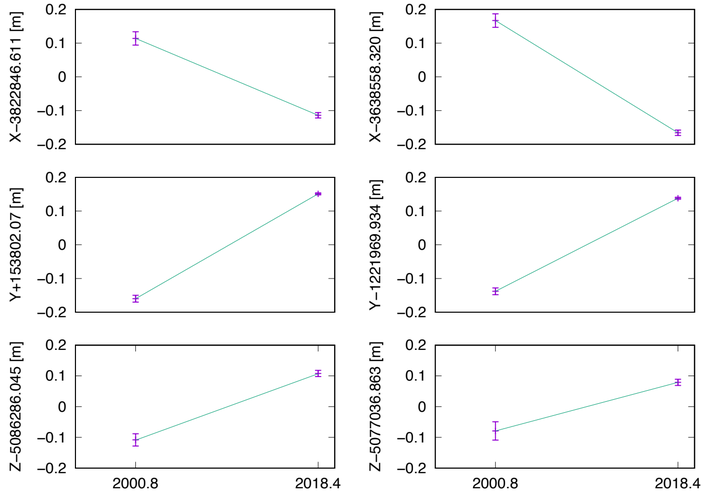


Fig. 2: Velocity components estimated for Jodrell2 (left) and Torun (right).

Gomez et. al 2021

Questions?

Geodesy tutorial

https://jradcliffe5.github.io/sfxc_workshop_2025/geodesy.html