Noise in GPS time series: The contribution of random walk noise
Motivation

• Widely used GPS error model: *flicker noise* + *white noise*

• The community uses traditional MLE (TMLE) methods (CATS, Langbein 2004), which first remove trend, implicitly assuming that trend is signal

• TMLE estimates of random walk are very low

• Random walk, if present, dominates the velocity uncertainty
We analyze the whole network simultaneously in a Kalman Filter

Assumptions:

- areas of no tectonic signal (plate interiors)
- no strain rates (+/- GIA)
- trend with respect to NA plate is noise
- spatially incoherent noise

Noise parameters are estimated by MLE
Synthetic testing on 10 station (North and East), 10 years of data each
very low random walk

power (dB)

frequency, 1/day

Mean Data
Flicker Noise
Random Walk
White Noise
Total Noise
Mean Data

Flicker Noise

Random Walk

White Noise

Total Noise

medium random walk

power (dB)

total noise

frequency, 1/day

flicker noise

random walk

white noise
The graph shows the power spectrum for different types of noise: mean data, flicker noise, random walk, white noise, and total noise. The x-axis represents frequency in units of 1/day, while the y-axis represents power in dB.
white noise:

flicker noise:
random walk:
rate uncertainty:

![Box plot showing rate uncertainty](image)
Preliminary results with real data:
(from various networks provided by Chuck DeMets, NA fixed reference frame)
North components:
Estimated noise components

- **white noise**: 1 mm
- **flicker noise**: 3.9 mm/yr^{0.25}
- **random walk**: 1.3 mm/yr^{0.5}
Compare to traditional MLE
Velocity uncertainty vs Residual velocity for individual stations

Velocity uncertainty vs Residual velocity for individual stations

1:1 line

1:2 line

residual velocity (mm.yr)

velocity uncertainty (mm/yr)

Tmle

KFmle
Random walk and monumentation

SAG1 (CORS), estimated random walk 2.5 mm/yr^{0.5}

GODE (IGS), estimated random walk 0 mm/yr^{0.5}
Conclusions and future work

• Our network approach shows promise
• Characterizing noise is easier if signal is known
• Detrending affects the noise estimate
• We show a preliminary correlation of random walk with the monument type

• Include more stations for analysis
• Include GIA signal
• Group stations by monumentation type
• Experiment with integrated random walk