Survey-mode measurements and analysis

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Material from R. King, T. Herring, M. Floyd (MIT) and S. McClusky (now ANU)

Measurement Strategies I: Occupation Time

Given time and personnel constraints, what are the trade-offs between between spatial and temporal density?

Ideally, you would like for the white-noise position uncertainty for an occupation to contribute to the velocity uncertainty at a level less than the usually dominant long-period correlated noise.

Typical white-noise uncertainties (Horizotnal and Vertical) as a function of occupation time:

6-8 hrs: 2-2.5 mm H, 5-10 mm V

12-24 hrs: 1.0-1.5 mm H, 3-5 mm V

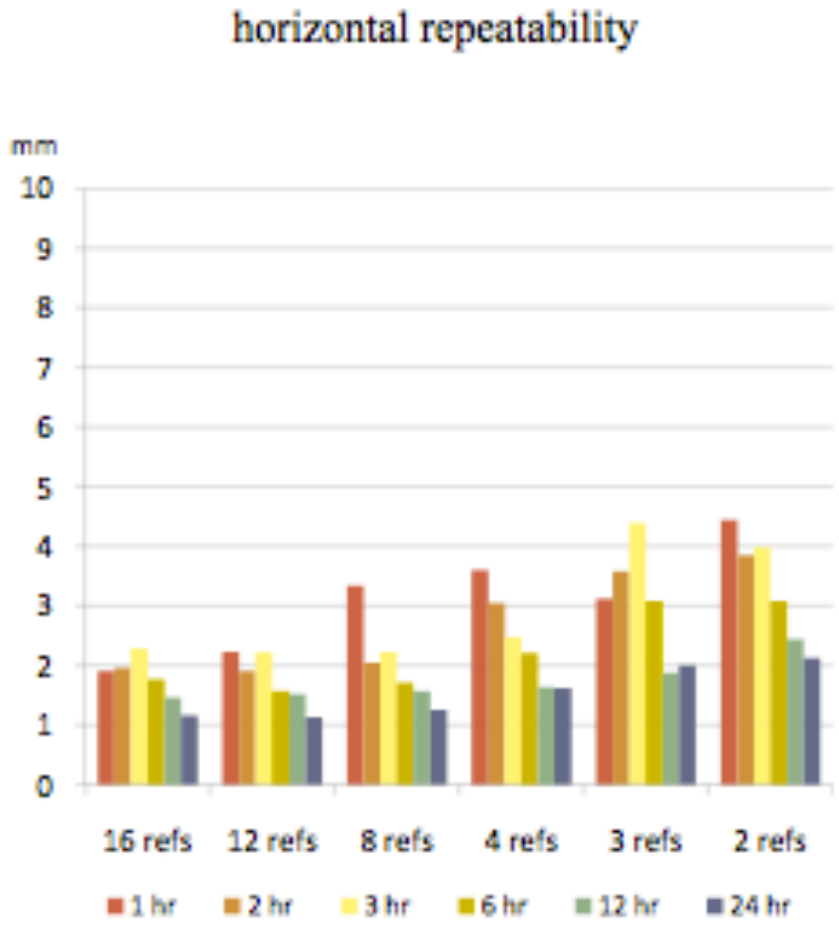
36-48-hrs: 0.7-1.0 mm H, 2-4 mm V

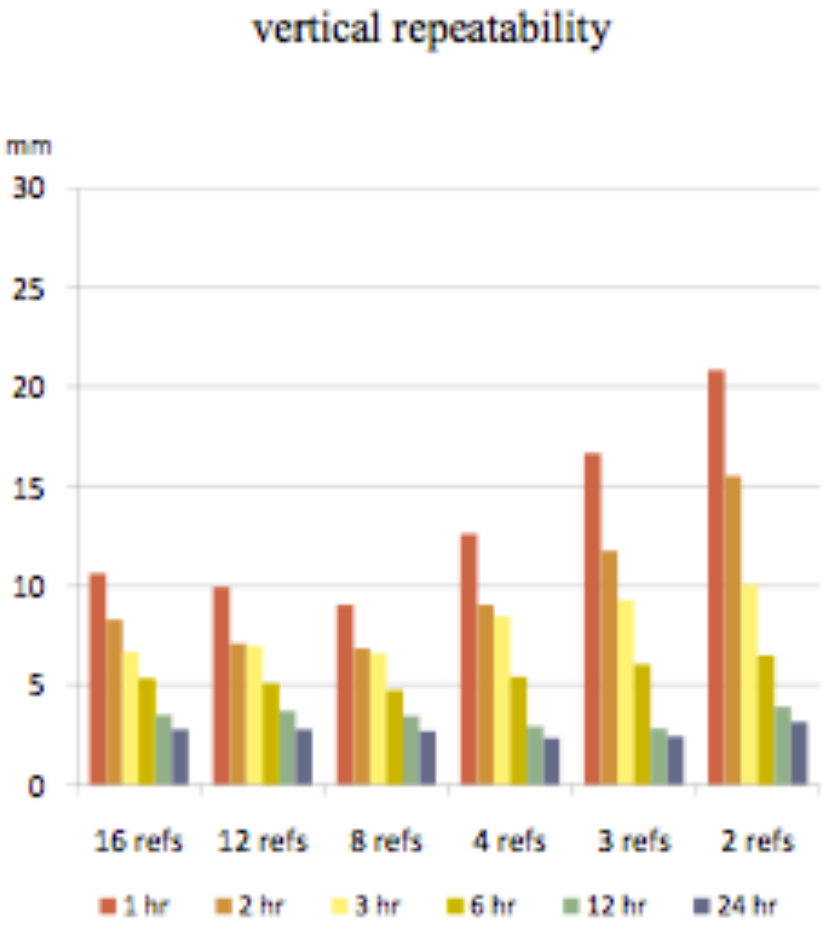
Observations over 3 or more days will give you more redundancy

Observations of 5 or more days will be necessary for mm-level vertical uncertainties

If your region has few continuous stations, you should consider running one or two survey-mode stations for the entire time of the survey to provide continuity

Precision v session length for network processing





Measurement Strategies II: Monuments and Instrumentation

Issues in site and antenna selection :

Monument stability

Accessibility

Ease of setup

Multipath

Vandalism

- There is no clear prescription for all cases; let's look at some examples

Three primary mounting options

Spike mount

Site VELA in the Soloman Islands.

Mast

Tech 2000 kit.

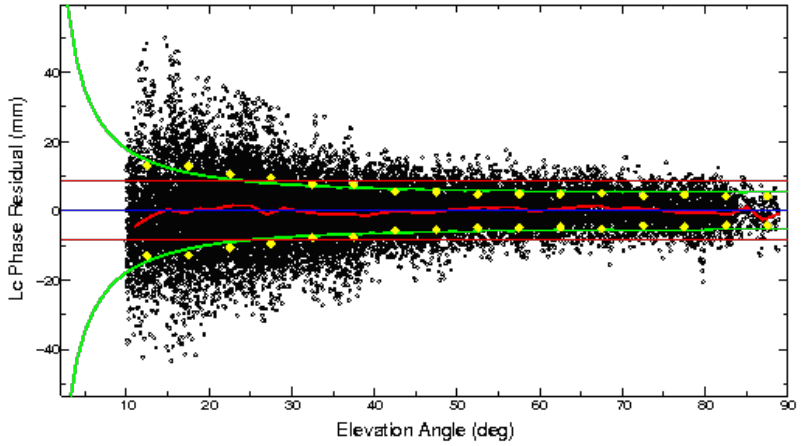
Tripod with optical or physical plummet

Courtesy UNAVO web page

Low mount in a good enviroment

STVP
Steven's Pass, Cascades Range in western Washington

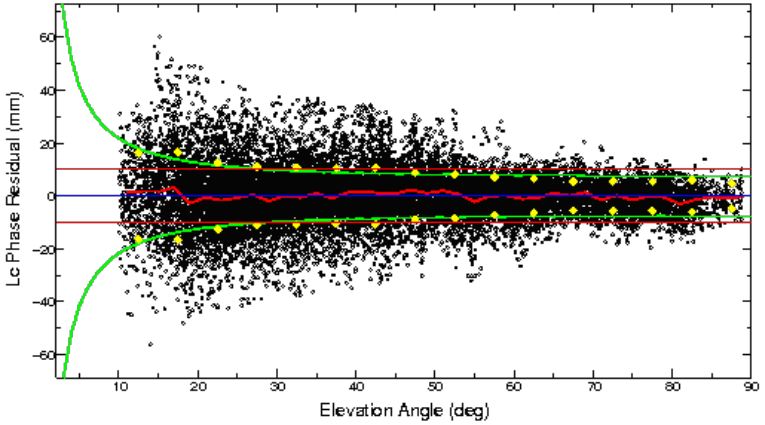
18-cm spike mount



No long-term repeatability yet, but 44 hrs of observations in 2012 give formal uncertainties 0.5 mm horizontal, 3 mm vertical. Note minimal long-period signal Scattering.

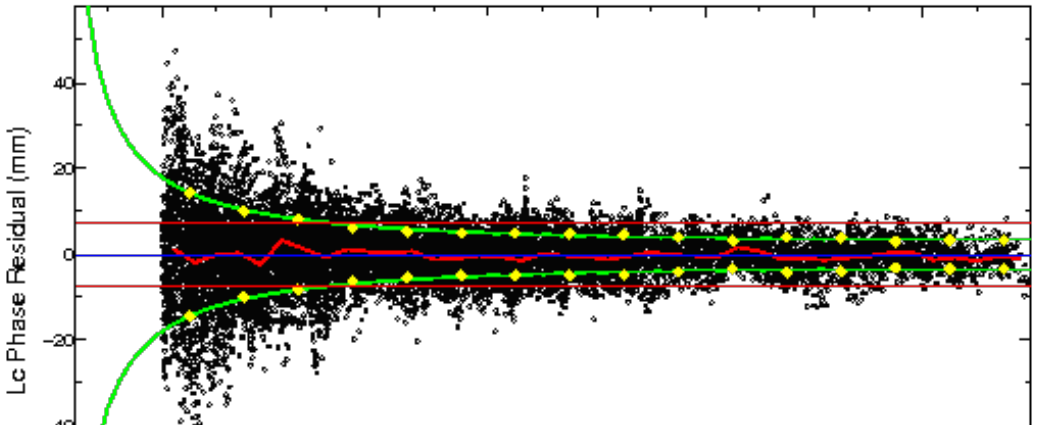
Low mount in a dirty environment

B059
Roadside meadow in western Washington
12.5-cm spike mount



Two 24-hr measurements in 2012 agree at 1 mm horizontal, 4 mm though formal uncertainties 2 mm, 10mm due to high random noise (diffuse multipath or water vapor?) Note minimal long-period signal scattering. Long-term scatter 3 mm horizontal, 5 mm vertical (monument instablity?)

High mount in a dirty environment



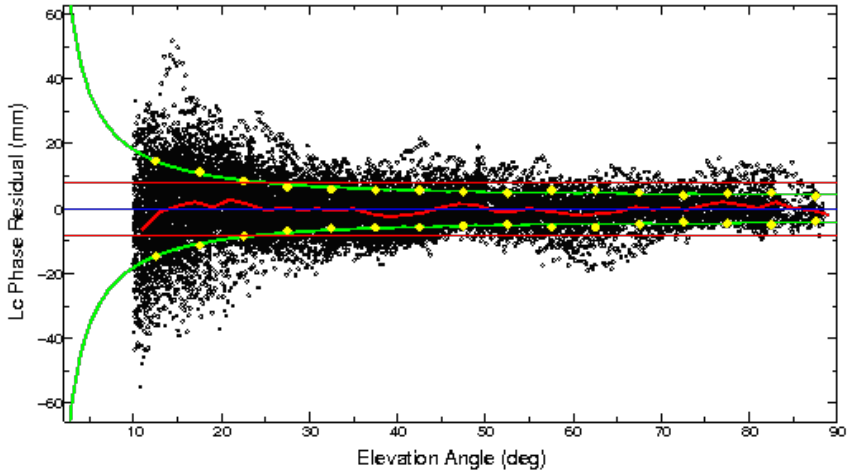
C033
Old survey mark in dirt in central Washington. Tripod mount. (Train blockage was short-lived)

2012 19-hr session and 5-hr session agree at 1.5 mm horizontal, 3 mm vertiical. Long-term repeatability 2 mm horizontal, 12 mm vertical.

Surprisingly little short-period multipath (dry dirt?)

Low mount on a slope

LYFR
Rocky river bank
in eastern
Oregon
12.5-cm spike
mount



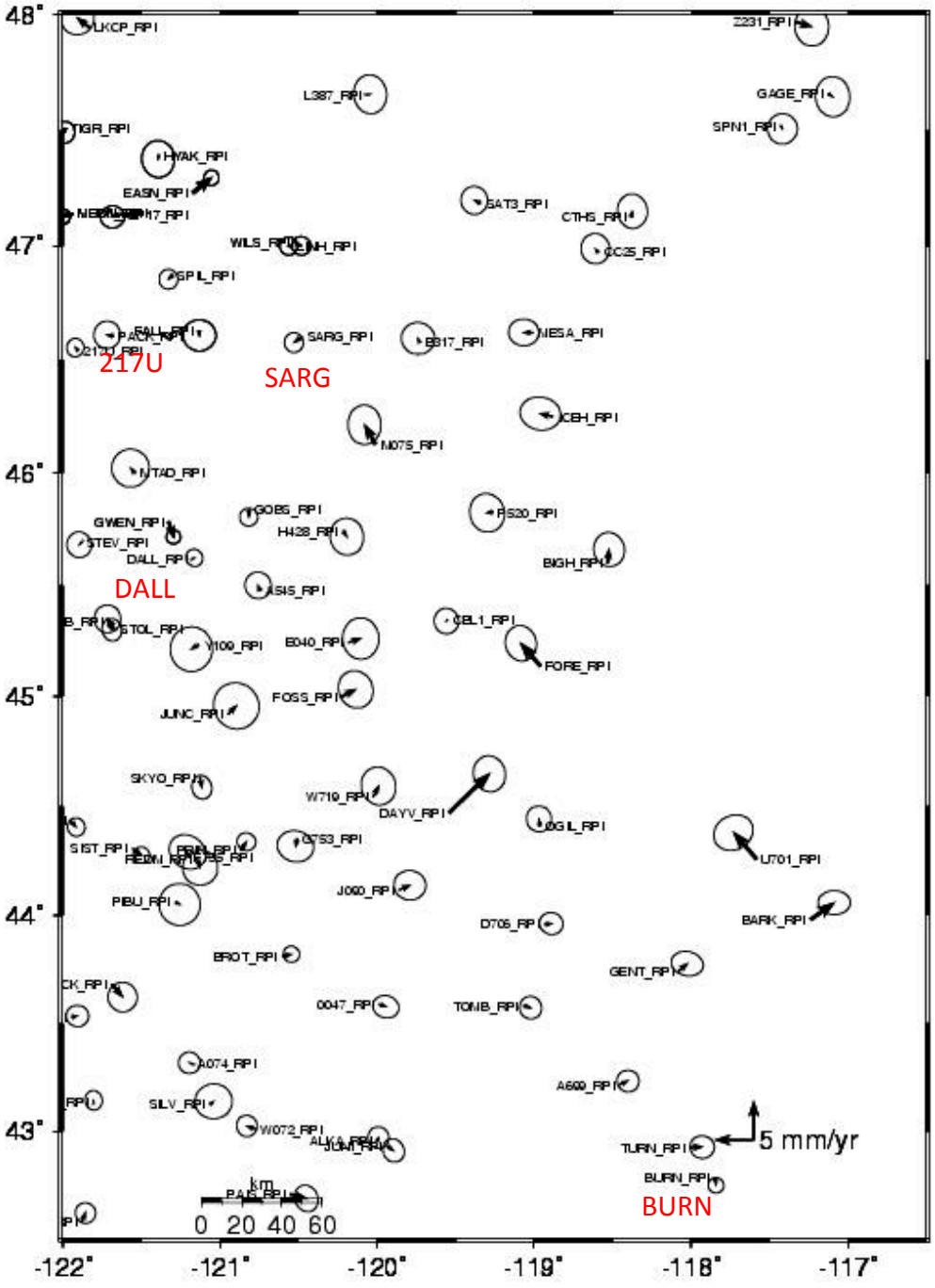
Single 14-hr session . Long-period multipath due to slope and/or reflective rocks ?

Special Characteristics of Survey-mode Data

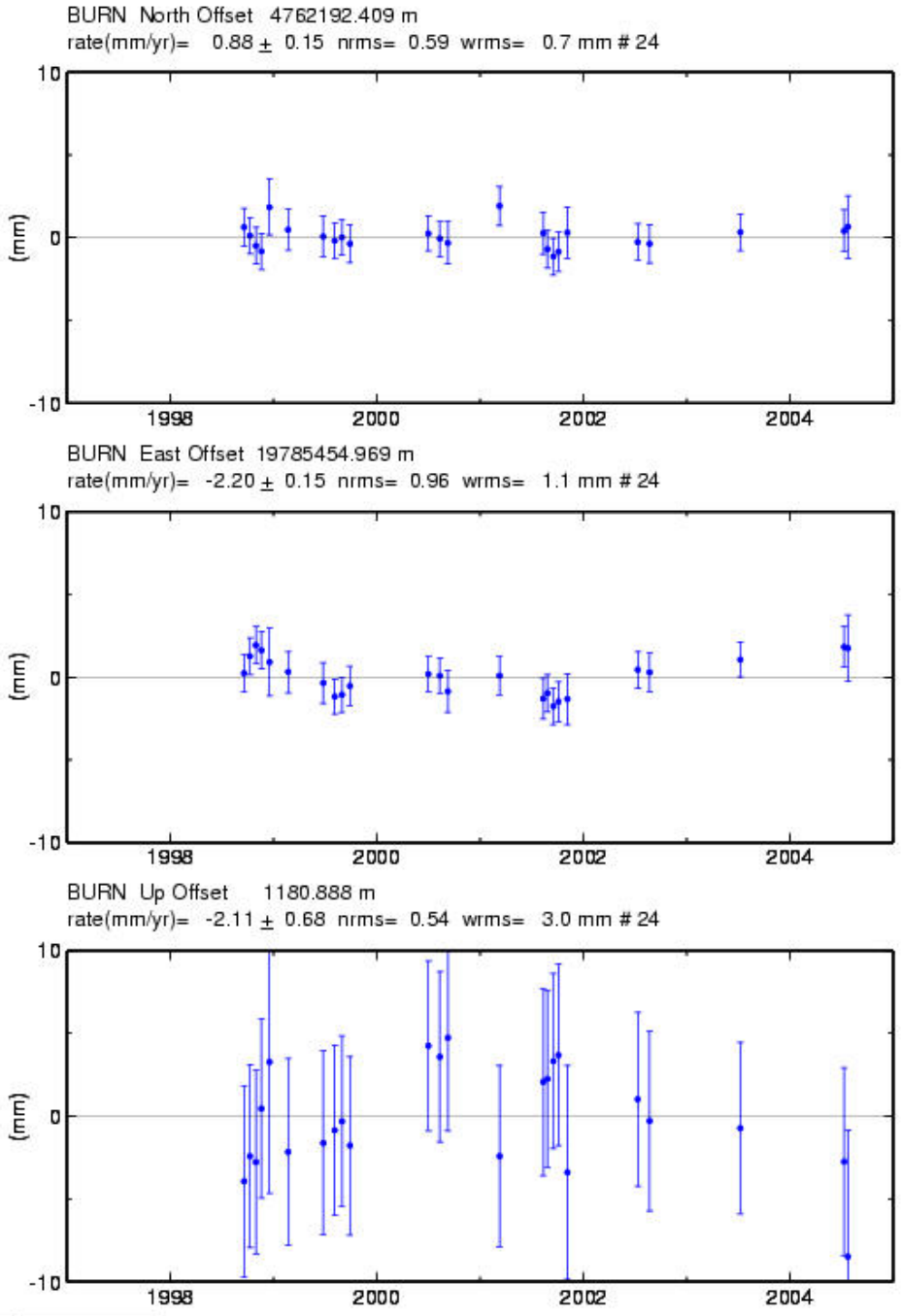
- Editing is critical: every point counts
- Usually combined with cGPS data to provide continuity and a tie to the ITRF
- Appropriate relative weighting needed in combining with cGPS data
- Antenna meta-data may be more complicated
- Heights may be problematic if different antennas used
- Seasonal errors behave differently than in cGPS data: best strategy is to observe at the same time of the year (unlike cGPS, which has minimal seasonal sensitivity at 1.5, 2.5, 3.5 ….years total span)

Analysis Strategy

- Generate time series and aggregated h-files for each survey
  - Use spans less than ~ 30 days to avoid biasing the position estimate from an in correct velocity
  - Include cGPS data only on days when sGPS data are available to maintain common-mode cancellation
  - Strenghens the sGPS positions estimates within each survey and allows better assessment of the long-term statistics
  - Edit carefully the daily values within each span
- Generate time series and a velocity using the aggregated h-files from a span of 3 or more years
  - Edit carefully the long-term time series
  - Add 0.5 of white noise (sig_neu) to the cGPS estimates from each span to avoid overweighting the cGPS position estimates
  - Use a separate (ie.g PBO) analysis of the daily cGPS time series to get the appropriate RW (mar_neu) values for each cGPS site; use the median RW for the sGPS sites.
- See sGPS_recipe.txt for detailed commands



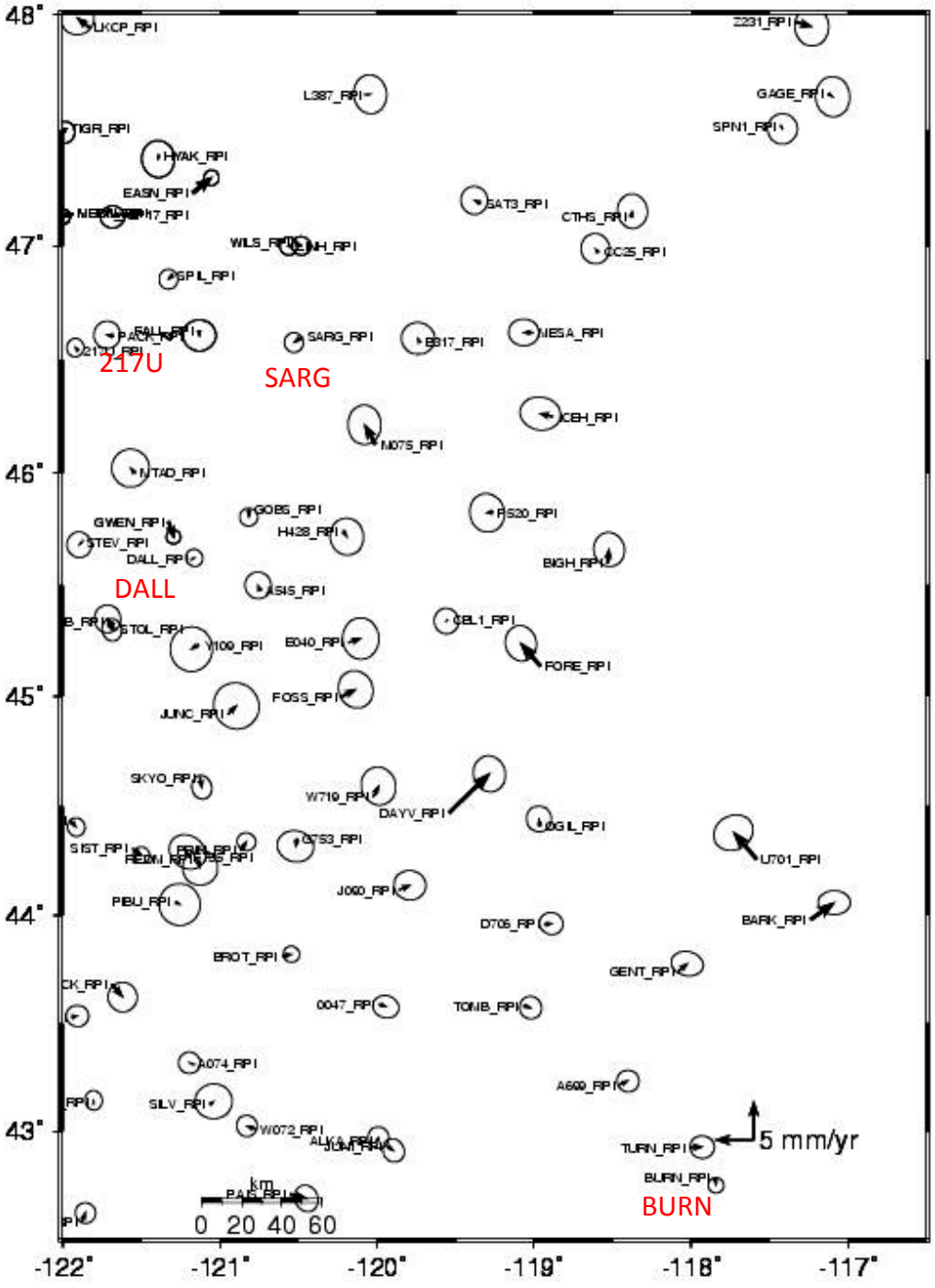
Locations of one continuous (BURN) and 3 survey-mode sites for time series shown in next slides



Time series of monthly position estimates for continuous site BURN

Wrms ~ 1 mm N,E
~ 3 mm U

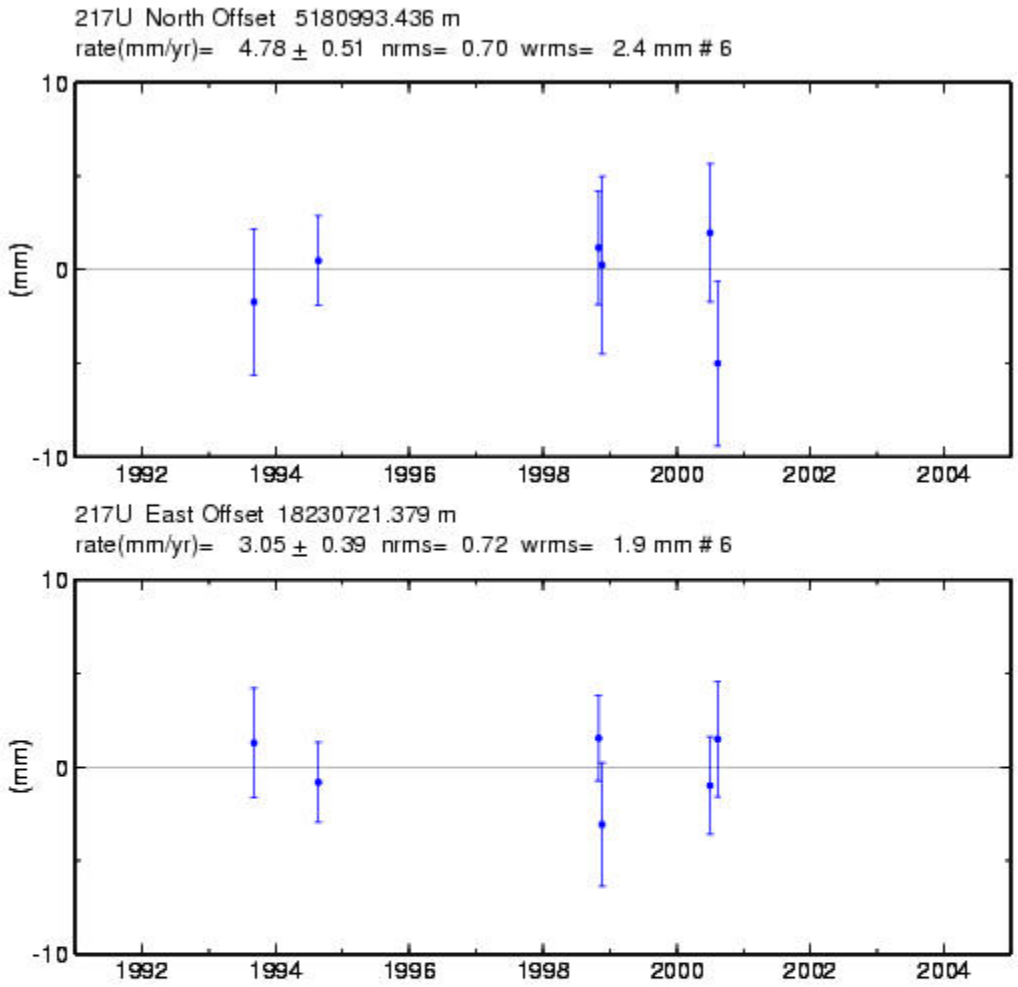
Rate uncertainties
< 0.2 mm/yr N,E
0.7 mm/yr U
do not include random walk added for velocity estimates



Next slide shows time series for survey-mode site 217U

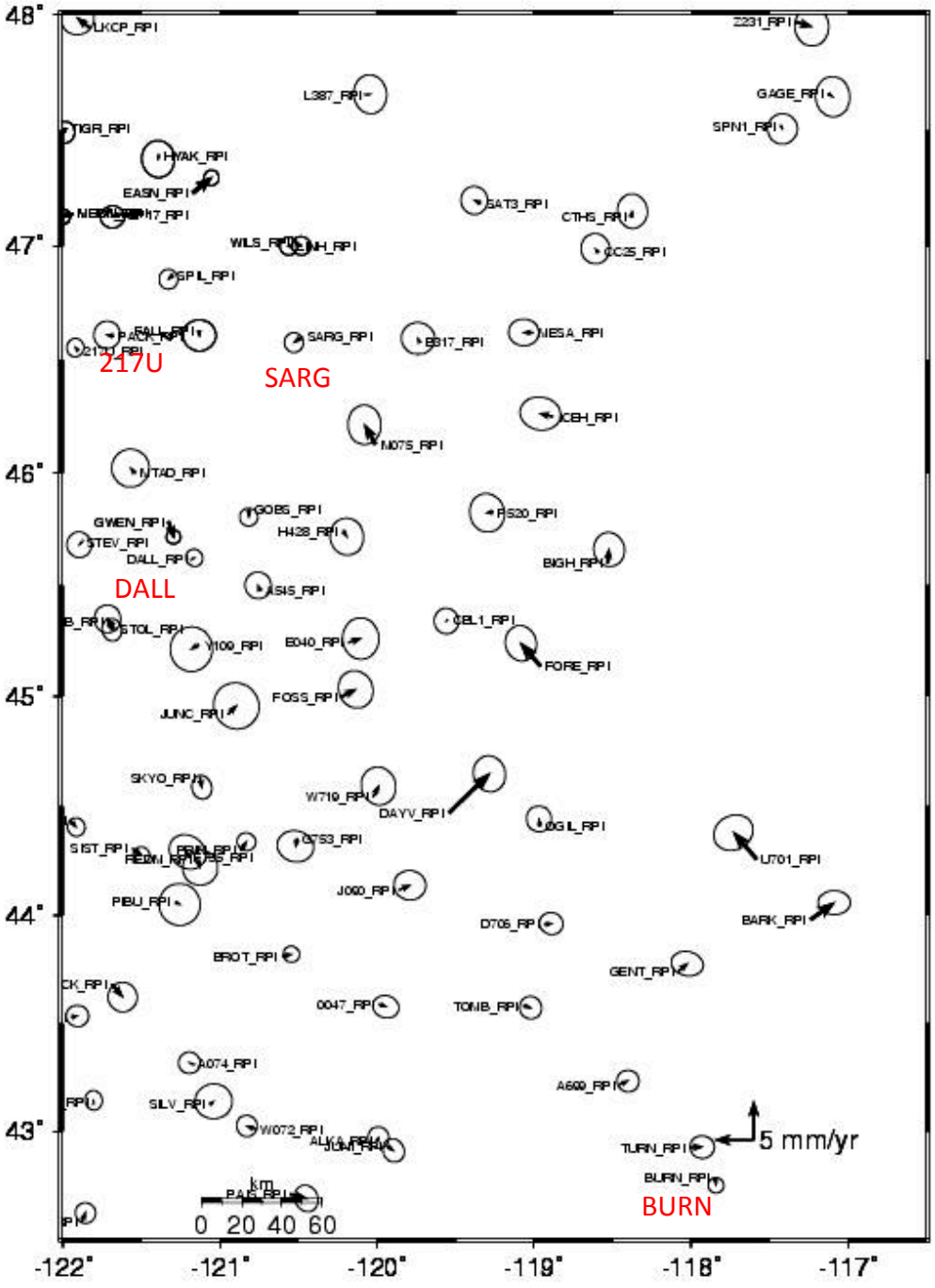
Note consistency with nearby sites

Time series for survey-mode site 217U



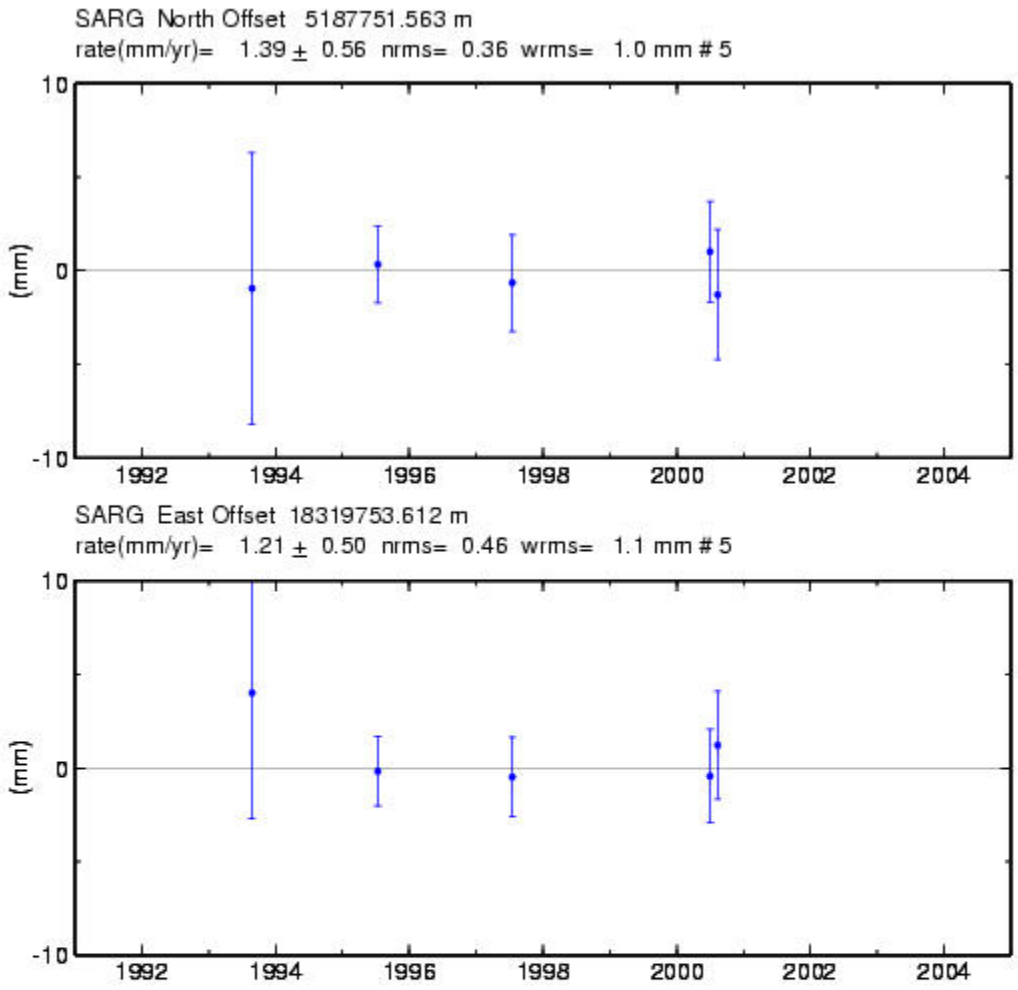
Position estimates based on 8-24 hr occupations

Note < 1 mm rate uncertainties due to 7-yr time span



Next slide shows time series for survey-mode site SARG

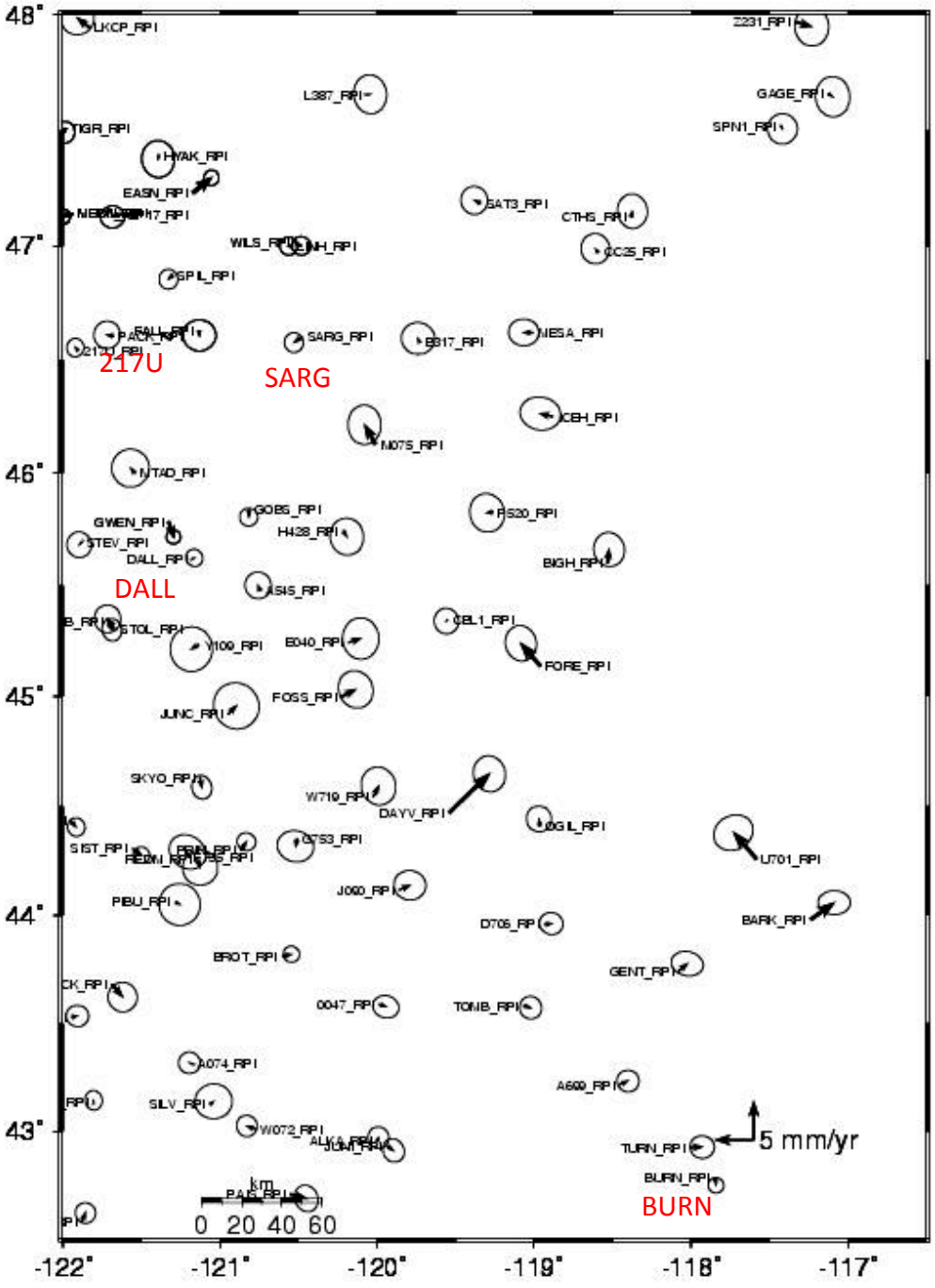
Horizontal time series for survey-mode site SARG



Position estimates based on 8-24 hr occupations

Note 1 mm wrms and

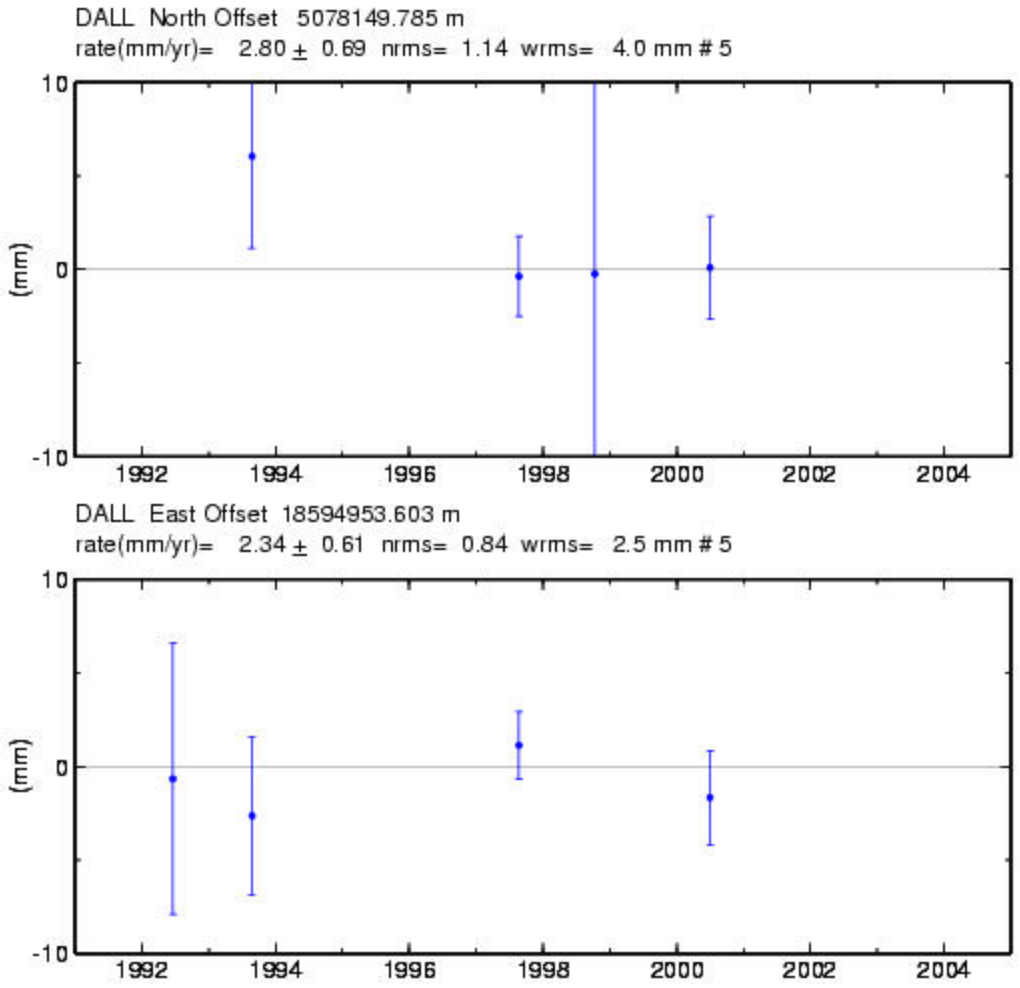
< 1 mm rate sigmas



Next slide shows time series for survey-mode site DALL

Note consistency with nearby sites except continuous site GWEN

Horizontal time series for survey-mode site DALL



Position estimates based on 8-24 hr occupations

Rate sigmas < 1 mm/yr and consistent with surrounding sites even with velocities determined essentially by two occupations 3 yrs apart