

## Behavior of multipath in GPS carrier phase residuals

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The Multipath, phase shift of carrier wave observation, is one of the biggest error sources in GPS estimates especially in determining unknown variables such as zenith tropospheric delay and coordinates with intervals less than one day. It is induced by interference between the direct waves from GPS satellite to antenna phase center and the indirect waves reflecting on some objects or surface which have large dielectric constant. We study behavior of carrier phase residuals obtained by using 'zero difference method' applied to double difference residuals in Bernese GPS software developed by UCAR (University Corporation for Atmospheric Study /GST (GPS Science and Technology) group).

We can see elevation- and/or azimuth- dependent systematic oscillation whose magnitude reaches more than 10 mm in the LC (the ionosphere-free linear combination) carrier phase residuals. The former and the latter are seen in the sites whose antennas locate near rooftop and lightning conductors, respectively. These variations are successfully simulated with Elosegui (1995)'s multipath model and its application for the multipath induced by the pole reflection. Biases in zenith tropospheric delay (ZTD) expected by multipath effect is less than 1 mm when ZTD is estimated with intervals of three hours. The contaminated carrier phase residuals with multipath and/or phase center variation of antenna can be cleaned by using stacking map of the carrier phase residuals.

The results suggest that evaluation of carrier phase residual in GPS observation and correction of these biases are required in real-time millimeter-precision positioning and atmospheric sensing.

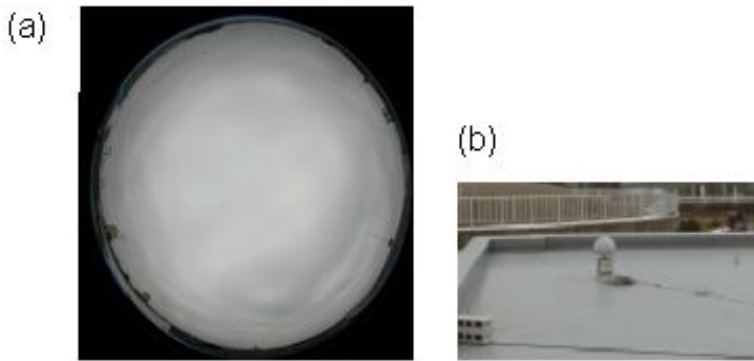


Fig. 1 (a) Landscape and (b) sky images showing the environment around the site GM68. The antenna is set near rooftop.

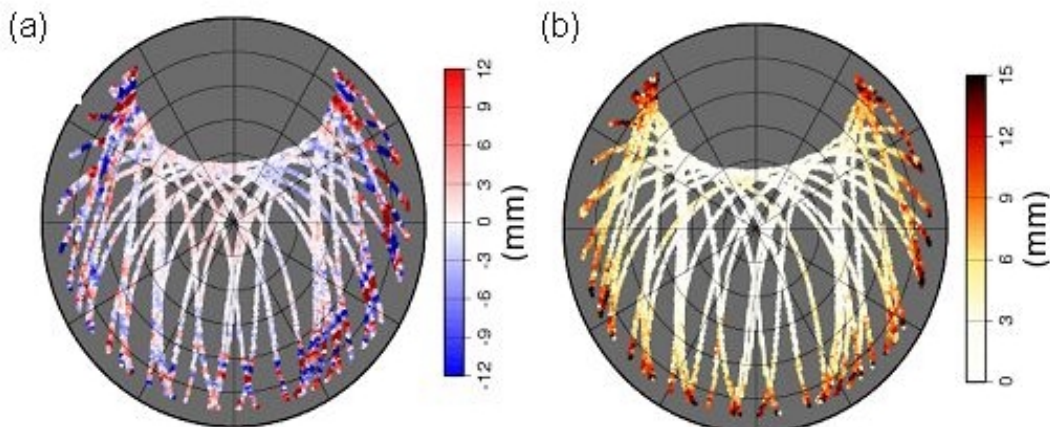


Fig. 2 (a) Stacking map of LC carrier phase residuals and (b) standard deviation of (a).

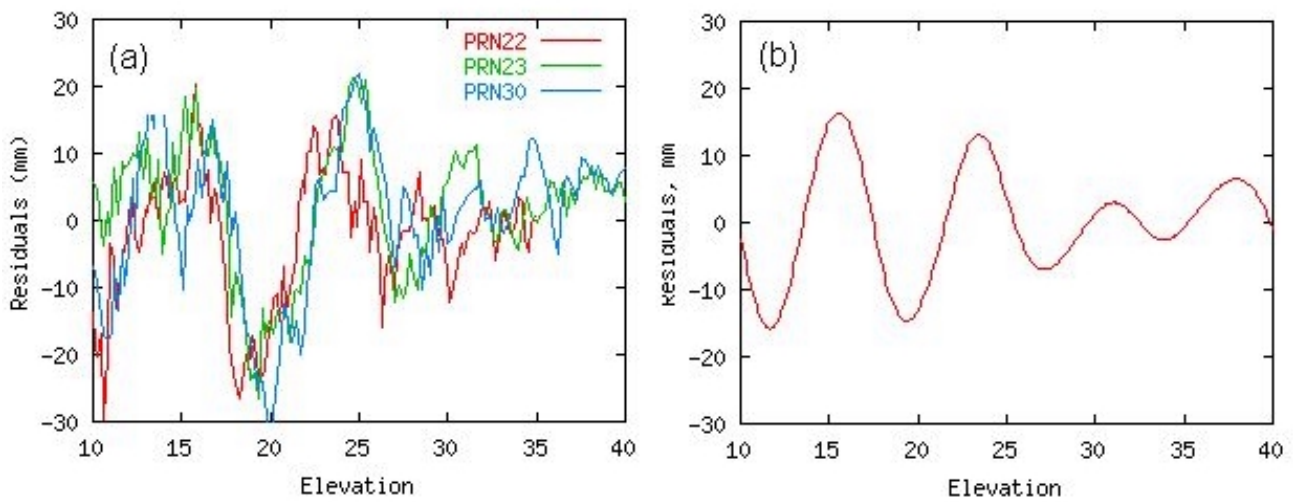


Fig. 3 (a) Time-series of carrier phase residuals in satellite 22, 23, and 30 (site GM68, OCT 18, 2000) and (b) Elevation dependency reproduced by multipath model.