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Estimation of the scale lengths of turbulence from GPS single difference phase observations

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Signals from the Global Navigation Satellite System (GNSS) travel through the whole atmosphere and encounter fluctuations of the index of refraction. The long-term variations of the tropospheric refractive index delay the signals, whereas its random variations correlate with the phase measurements. The power spectral density of microwave phase difference can be derived from physical considerations by combining results from the Kolmogorov theory and electromagnetic wave propagation. Four different dominant noise regimes are expected. Their cutoff frequencies can be estimated with the unbiased Whittle Maximum Likelihood estimator; They provide information about the scale lengths of turbulence which are directly linked with the size of the eddies or swirling motion present in the free atmosphere. Dependencies of these parameters with the satellite geometry or the time of the day pave the way for a better comprehension of how tropospheric turbulence acts as correlating GNSS phase observations. The result is less empirical modeling of GNSS phase correlations to improve the positioning results and avoid an overestimation of their precision. We use GPS single differences from 290 m distant antenna positions recorded during two days in 2013 in a common clock experiment at the Physikalisch Technische Bundesanstalt in Braunschweig Germany to explain our methodology, based on adequate filtering of the residuals to mitigate multipath effects.