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Estimates of Zenith Total Delay trends from GPS reprocessing with autoregressive process

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Nowadays, near real-time Zenith Total Delay (ZTD) estimates from Global Positioning System (GPS) observations are routinely assimilated into numerical weather prediction (NWP) models to improve the reliability of forecasts. On the other hand, ZTD time series derived from homogeneously re-processed GPS observations over long periods have the potential to improve our understanding of climate change on various temporal and spatial scales. With such time series only recently reaching somewhat adequate time spans, the application of GPS-derived ZTD estimates to climate monitoring is still to be developed further. In this research, we examine the character of noise in ZTD time series for 1995-2015 in order to estimate more realistic magnitudes of trend and its uncertainty than would be the case if the stochastic properties are not taken into account. Furthermore, the hourly sampled, homogeneously re-processed and carefully homogenized ZTD time series from over 700 globally distributed stations were classified into five major climate zones. We found that the amplitudes of annual signals reach values of 10-150 mm with minimum values for the polar and Alpine zones. The amplitudes of daily signals were estimated to be 0-12 mm with maximum values found for the dry zone. We examined seven different noise models for the residual ZTD time series after modelling all known periodicities. This identified a combination of white plus autoregressive process of fourth order to be optimal to match all changes in power of the ZTD data. When the stochastic properties are neglected, ie. a pure white noise model is employed, only 11 from 120 trends were insignificant. Using the optimum noise model more than half of the 120 examined trends became insignificant. We show that the uncertainty of ZTD trends is underestimated by a factor of 3-12 when the stochastic properties of the ZTD time series are ignored and we conclude that it is essential to properly model the noise characteristics of such time series when interpretations in terms of climate change are to be performed.