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Combining 3-D digital elevation data with climate classification to assess the stochastic properties of GPS-derived Zenith Total Delays

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In the following research, we introduce a completely new methodology to better understand the properties of Zenith Total Delay (ZTD) estimates from Global Navigation Satellite Systems (GNSS), in this case Global Positioning System (GPS), observations. In general it is assumed that the stochastic character of the ZTD estimates reveal similar behavior for stations situated nearby. The spatial patterns derived by interpolation of the ZTDs over larger areas, may then be further assessed in terms of climate or weather conditions. In this research we combine 3-D digital elevation data and maps, generated based on the Shuttle Radar Topography Mission (SRTM) and Open-StreetMap data, to provide the 3-D land cover and topography around 217 GPS stations of the European Reference Frame (EUREF) Permanent GNSS Network (EPN). We make use of the ZTD time series derived from the latest reprocessing campaign performed by the EPN analysis centers. The homogenized daily ZTD time series, spanning 25-years at maximum, are modelled assuming a linear trend and seasonal signals. As it was previously proven by the authors, the stochastic part is optimally described using a combination of white and first-order autoregressive noise and is characterized by the standard deviation of noise, the autoregressive noise coefficient and the fraction of the autoregressive noise in the above-mentioned combination. Those three parameters are then interpolated to provide the continuous pattern over Europe. We employ the interpolated fields to identify stations characterized by outlying parameters, i.e. the pattern did not agree with value estimated for individual station within 3-sigma error bar. In this way, we eliminate stations VLNS (Lithuania) along with EVPA (Ukraine), ISTA and TUBI (both in Turkey), which do not agree with the continuous fields for, respectively, standard deviation and autoregressive coefficient. Then, the continuous fields are validated using the 3-D digital land cover models, the K¨ppen-Geiger climate classification and seven pairs of neighboring stations situated within tens of meters from each other. We find that the parameters describing the stochastic behavior can be well-explained for the 25 non-behaving ZTD time series by the local infrastructure (airports, large buildings) or the regional environmental conditions (large forests or water reservoirs). These stations should be excluded in future when the GPS-derived ZTD estimates are to be assimilated into numerical weather models or interpreted in terms of climate change.