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Can environmental loading effects be an artifact in tectonic velocity obtained from GPS measurements?

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In the Pyrenees mountain range between France and Spain some GPS campaign measurements have been carried out to determine the present day tectonic velocity in this region. The expected signal is at the level of 1mm/yr. The velocity determination is based on the comparison of the results of the high precision positioning obtained from each campaign measurements. One of the challenges of measuring signals of this tiny signal magnitude is to remove all the sources of noise to achieve the best precision possible in the GPS data analysis. In our case, the observation campaigns are very short (a few days in duration) and sparse in time. Thus, it is necessary to be careful with the data processing and to remove every kind of possible artifact that can modify the final velocity results. However, some of effects cannot be corrected or removed at the data processing level, such as load effects. In this study, we analyze how the different loading effects could affect the determined GPS tectonic velocity in this region. We used predicted time series of displacements computed from atmospheric, non-tidal oceanic, and continental water storage load effects. In the particular case of atmospheric loading, we also investigate the effect of the local topography which is not negligible in such a mountainous area. For instance in our study area, the loading effects can induce surface displacements in the range of 3-9 mm in horizontal and 11-23 mm in vertical coordinates. Here to emphasize their effects, we examine in detail the predicted surface displacement time series of the loading models at the epochs of the GPS campaigns and compute each effect in terms of velocity. We also looked at the extreme cases by computing virtual campaigns from the models to find their largest effects. Finally, the velocities estimated from the loading results are compared to the GPS velocity solutions to conclude if ignoring loading effects in the GPS data processing would add signal to the velocity computation and thus affect their geodynamical interpretation.