May tropospheric noise in satellite radar data affect decision making results?

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ABSTRACT

Meteorological and air pollution conditions affect the satellite positioning signals. To investigate the uncertainty introduced in these signals in various meteorological and air pollution conditions, a GPS station and another one for meteorological and air pollution monitoring have been established in the area of the University of Patras Campus at Rion, next to Patraikos and Corinth Gulf (NW Peloponnisos, Greece).

INTRODUCTION

The study area is characterized by high variability sequences from hot to cold weather, low to high relative humidity and clear to cloudy and/or Saharan dusty atmosphere, as a result of its particular geographical and topographical features. The weather conditions, the air pollutants and the constituent gases of the atmosphere, as well as other meteorological parameters (atmospheric and water vapor pressure, temperature, relative humidity etc.) affect the electromagnetic signal of the GPS satellite transferred to the receiver's antenna. So the signal's velocity becomes lower than it would be in vacuum and the time needed to reach the GPS receiver is increased. These effects are often known as delay. Since most of the delay occurs within the troposphere, it is called tropospheric delay. Assuming that the neutral atmosphere is both horizontally stratified and azimuthally symmetric, we have focused at the delay that is experienced in the zenith direction, named tropospheric zenith delay (TZD). [1]

METHODOLOGY

GPS measurements (EUREF - PAT0_12622M00) by a station installed at the University of Patras Campus (Fig. 1) with a 30-s sampling rate were processed. Coordinates of a 3-h interval and zenith tropospheric delay with a 30-s interval were computed using the PPP algorithm provided by the CSRS online PPP service of the Natural Resources of Canada [2].

Figure 1 Map of major Patras area. (Source: http://www.ploigos.gr)

Figure 2 Satellite images from MODIS showing Sahara's dust events over Patras (Source: https://earthdata.nasa.gov/labs/worldview/)

The PM concentrations are available from the Air Pollution Monitoring Station of the Environmental Engineering Laboratory installed in the same area. For the present work, the period from 01/05/2013 to 15/06/2013 was selected because of the two episodes of Saharan dust occurred during this period (Fig. 2).

Abstracting the mean value of TZD data from each TZD value, the DTZD fluctuations have been produced. Figure 3a,b shows the 1-h mean values of PM_{10} concentrations in correspondence to 1-h DTZD fluctuations. PM_{10}, $PM_{2.5}$ and PM_1 concentrations, as well as TZD values were averaged to get 1-h, 3-h, 6-h, 12-h and 24-h moving average values and the correlation coefficients between PM concentrations and DTZD fluctuations have been computed and shown in Fig. 4 for the period from 16/05/2013 to 15/06/2013 when two episodes have happened. Alternatively, approximately the same correlation levels were found by selecting only the pairs with PM concentrations greater than 20, 15, 10 μg m^{-3} between 24-h averages of PM_{10}, $PM_{2.5}$ or PM_1, respectively, and DTZD values.

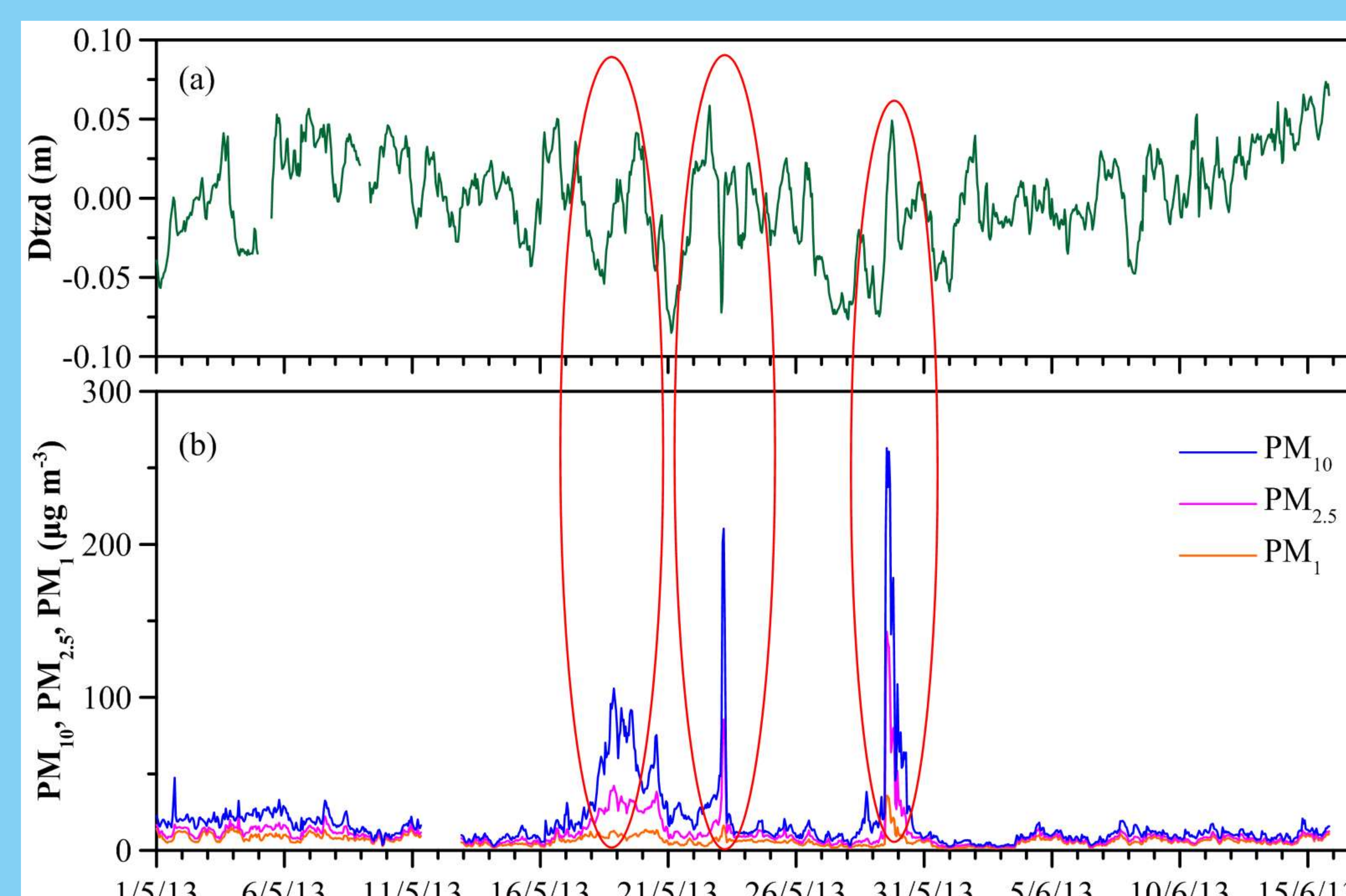

Figure 3 (a) Fluctuations of Zenith Tropospheric Delay (m); (b) PM_{10}, $PM_{2.5}$, PM_1 concentrations (μg m^{-3}) for the period May 01 - June 15, 2013.

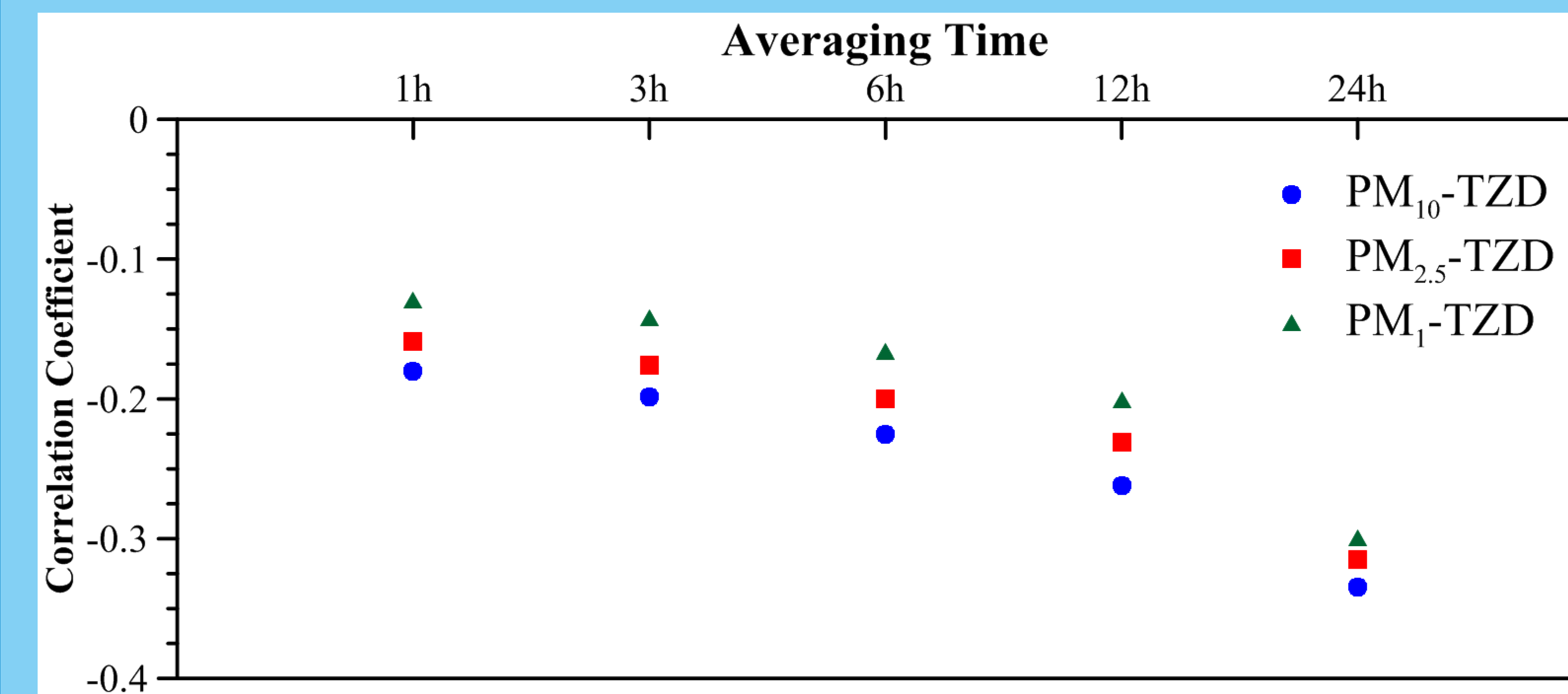

Figure 4 Correlation between PM_{10}, $PM_{2.5}$, PM_1 data and the GPS signal delay during the period from 16/05/2013 to 15/06/2013

It is evident that the Saharan dusty weather affects somewhat the signal TZD, although the correlation coefficient is kept in the range (-0.13,-0.33), decreasing from 1-h to 24-h averages similarly for PM_{10}, $PM_{2.5}$ and PM_1.

CONCLUSIONS

The tropospheric delay due to the Saharan dust concentrations seems to exist in rather insignificant levels, as the correlation coefficients remain in the range (-0.13,-0.33) for the three particulate sizes examined. Data show that the correlation between apparent displacements and particulate concentrations is negatively decreased from 1-h to 24-h averages. An overall estimate is that dust levels may affect the propagation of satellite signals, but since it is not the only factor, many other effects influence the signal TZD increasing the magnitude of the delay fluctuations. A more detailed study of signal uncertainties concerning events of Saharan dust influx and of tropospheric delay, which may influence the decision support systems implemented in water resources management and other applications, is in progress.

ACKNOWLEDGEMENTS

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