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Precipitable water vapor from GPS tropospheric path delays over the Eastern Mediterranean: trends, diurnal and long-term variability

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Global Navigation Satellite System (GNSS) tropospheric path delays provide an important tool for studying Precipitable Water Vapor (PWV) variations. Here, we process and analyze PWV time series extracted from the Survey Of Israel Active Permanent Network (SOI-APN) GNSS ground receivers in the Eastern Mediterranean region. We derive the annual and seasonal PWV diurnal cycles along with the PWV long-term trends, annual and inter-annual variations. The data period spans from 5 to 21 years, ensuring its suitability for studying the PWV variations at different time scales. For the diurnal cycles, we focus on the summer months (JJA), where the Mediterranean Sea Breeze (MSB) plays a dominant role in transporting humidity inland. We find that for most stations, the diurnal amplitude in summer is the highest compared to the seasonal mean. Moreover, using the PWV peak hour in the coastal and highland stations, we detect a frontal MSB propagation from the coastline eastward inland combined with northern winds enhancement due to the Coriolis force. The peak hour is also correlated with the distance from the Mediterranean Sea shore, substantiating the MSB's role as a key driver of the PWV diurnal variability during summer months. In addition, a strong correlation between the PWV diurnal cycle and the atmospheric Mixing Layer Height (MLH) diurnal variations is found using ceilometer data, suggesting that the MLH modulates the PWV. For the annual cycles, the PWV monthly mean values and variability are high in the summer months (JJA) however, Sep and Oct supersede the JJA values where Oct has the highest variability in all stations. We suggest that the Red-Sea Trough (RST) synoptical system plays a dominant factor in shifting the mean PWV annual peak values from the summer months to Oct. This is further substantiated by harmonic analysis which reveals a non-negligible semi-annual mode with peaks at Apr and Oct when the RST synoptical system is most frequent. The PWV inter-annual variations as represented by the monthly mean anomalies are consistent between all stations, thus suggesting a common regional driver. Moreover, a comparison between the PWV station average anomalies and the ERA5 (the European Centre for Medium-Range Weather Forecasts' latest global reanalysis) regional mean anomalies show a correlation of 0.95. Furthermore, a correlation of 0.72 was found between the regional mean moisture flux anomalies at 750 hPa taken from ERA5 and the station average PWV anomalies, implying that moisture flow

accounts for most of the inter-annual variability, however the significance of the 750 hPa pressure level remains ambiguous. In the long term, we find an increasing regional mean trend of ~ 0.5 mm/decade for the whole data period (1998-2019) whereas for the last decade (2010-2019) we find a mean trend of ~ 1 mm/decade suggesting an accelerated moistening of the Eastern Mediterranean region.