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Intercomparison of PWV from MODIS, radiosonde and GPS at Ankara TUSAGA-Active station

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Introduction

Water vapor is essential due to its role in determining the distribution of clouds. Therefore, to investigate the climate, meteorologists and climatologists monitor the distribution of the water vapor in the atmosphere. There are several observation systems to estimate precipitable water vapor (PWV): radiosonde, GPS and Moderate Resolution Imaging Spectroradiometer (MODIS). Radiosondes monitor the water vapor with a high accuracy and vertical resolution, but with low temporal and spatial resolution. On the other hand water vapor is estimated using GPS at a high level of accuracy with high temporal and spatial resolution. It is based on the computation of the tropospheric zenith delay (ZTD) which consists of wet (ZWD) and dry (ZHD) components. The first component (ZWD=ZTD-ZHD) is converted to the water vapor by the weighted mean temperature equation (T_m) or the conversion factor (Q). The last one MODIS on NASA Terra and Aqua platforms collect global water vapor daily with a spatial resolution of 1x1 km (at nadir) and an accuracy of 5-10%.

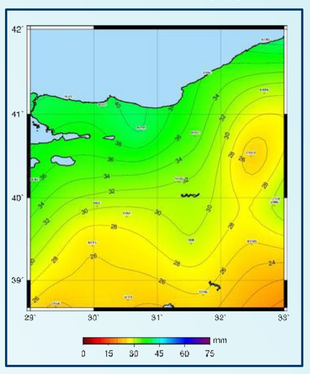
Data Sets

GPS

A test network is used for deriving the total zenith delay (ZTD) and precipitable water vapour (PWV) of Ankara TUSAGA-Active station for the period from June 2013 to December 2013. It composed of 5 IGS stations and 20 TUSAGA-Active stations (Figure 1).

For estimating ZTD of Ankara TUSAGA-Active station (ANRK), the network is processed by Bernese GNSS Software v5.0.

ZHD is computed from meteorological observations, then it is subtracted from ZTD (i.e. ZWD=ZTD-ZHD). Once ZWD is estimated, PWV_{GPS} is computed using the weighted mean temperature (T_m) or the conversion factor (Q) models. (Figure 2)



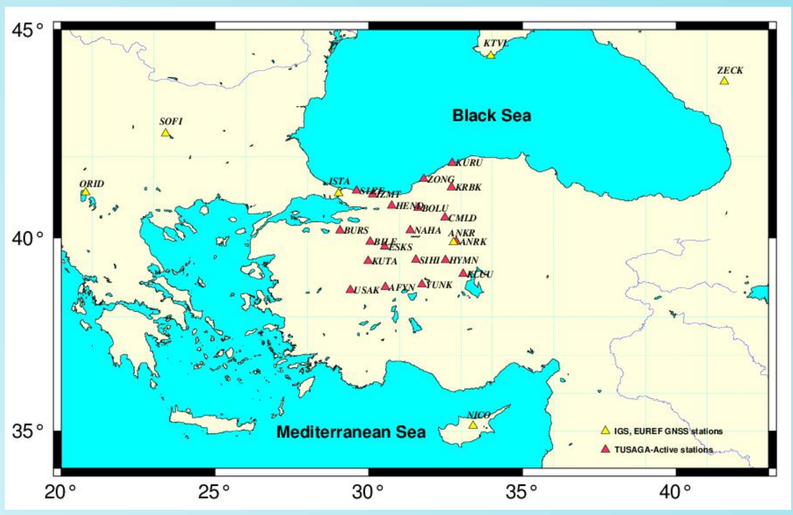


Figure 1 The GNSS network for ZTD estimation

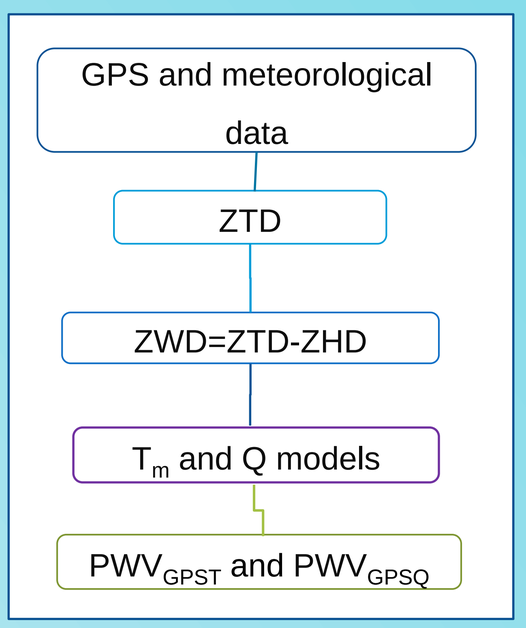


Figure 2 PWV_{GPS} processing steps

T_m and Q conversion models for Turkey:

T_m=48,546+0,796T_s (Mekik and Deniz 2017)

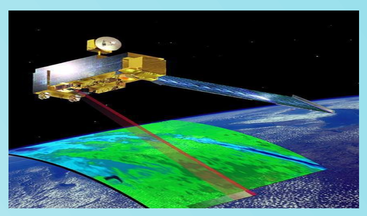
$$Q_{BEU} = [5.7053 - 0.0067\,(T_s - 287.7620] + 0.0130\,\theta + 0.0833\,H + 0.0709\sin\left(2\pi\frac{t_D}{365}\right) + 0.1195\cos(2\pi\frac{t_D}{365})]$$

Radiosonde

Radiosonde data from June 2013 to December 2013 are obtained from the University of Wyoming website (http://weather.uwyo.edu/upperair/sounding.html).

MODIS

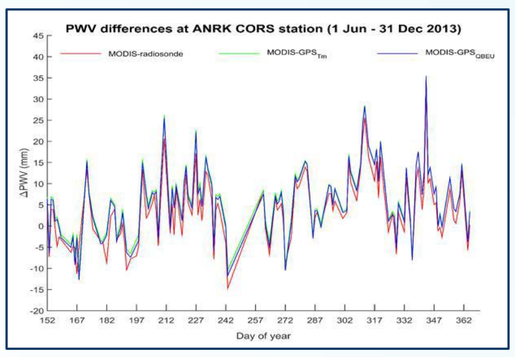
Terra MODIS near-infrared data from June 2013 to December 2013 are obtained from the The Level-1 and Atmosphere Archive & Distribution System (LAADS) ftp site (ftp://ladsweb.nascom.nasa.gov/allData/51/MOD05_L2/).

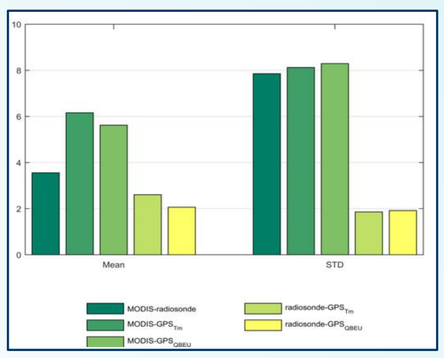


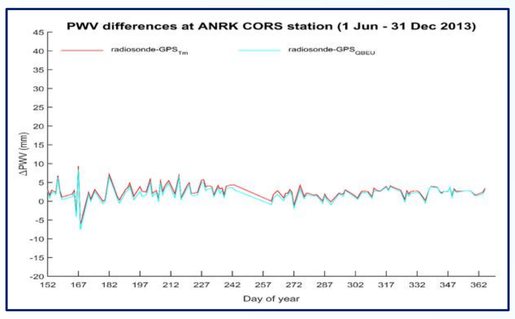
Results

- PWV obtained from MODIS of Ankara TUSAGA Active station (ANRK) (PWV_{MODIS}) is compared with the co-located radiosonde station (PWV_{rad}) and GPS estimated PWV values (PWV_{GPST} and PWV_{GPSQ}).
- PWV_{MODIS} is obtained from the Terra MODIS near-infrared water vapor products (MOD05_L2) under cloud free conditions and cloudy conditions.
- PWV_{GPS} and PWV_{rad} values at the MODIS acquisition time are estimated by cubic spline interpolation.

Cloud free condition

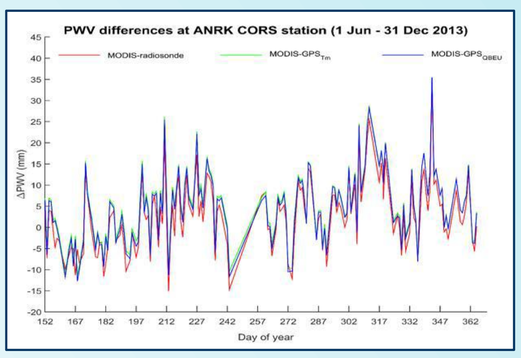


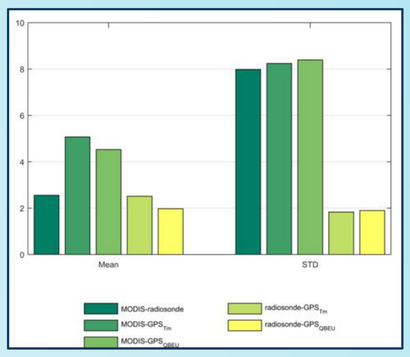


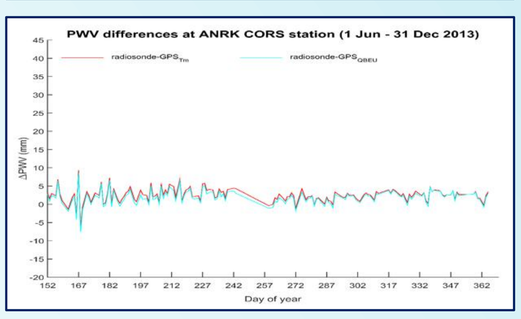


Cloud free condition	mean (mm)	std. (mm)	corr. (%)
MODIS-Rad	3.56	7.86	93.39
MODIS-GPST	6.16	8.13	93.39
MODIS- GPSQ	5.62	8.29	93.39
Rad- GPST	2.60	1.86	90.98
Rad- GPSQ	2.06	1.92	90.98

Cloudy condition







Cloudy condition	mean (mm)	std. (mm)	corr. (%)
MODIS-Rad	2.56	7.98	91.35
MODIS-GPST	5.07	8.24	87.61
MODIS- GPSQ	4.53	8.40	87.68
Rad- GPST	2.51	1.83	87.61
Rad- GPSQ	1.97	1.90	87.68

Conclusions

- The differences of PWV_{MODIS} under the cloudy conditions relative to PWV_{rad} are smaller than those between PWV_{MODIS} and PWV_{GPST}, PWV_{MODIS} and PWV_{GPSQ}.
  - PWV_{MODIS} and PWV_{rad} (91%) agree better with each other than with PWV_{GPST}, PWV_{GPSQ} (~87%).
  - PWV_{rad} is in good agreement with PWV_{GPST}, PWV_{GPSQ} (%87).
- The differences of PWV_{MODIS} under the cloud free conditions relative to PWV_{rad} are also smaller than those between PWV_{MODIS} and PWV_{GPST}, PWV_{MODIS} and PWV_{GPSQ}.
  - PWV_{MODIS} is compatible with PWV_{rad}, PWV_{GPST}, PWV_{GPSQ} (93%).
  - PWV_{rad} agrees with PWV_{GPST}, PWV_{GPSQ} (%90) which is consistent with the results of Deniz et al 2017.

References

- Mekik, C. and Deniz, I. (2017), Modelling and validation of the weighted mean temperature for Turkey. Met. Apps, 24: 92–100. doi:10.1002/met.1608
- Deniz, I., Mekik C. and Gurbuz G., Comparisons of PWV derived from GNSS and radiosonde observations, COST ES1206 Workshop, ESTEC-Noordwijk, Netherlands, 21-23 February, 2017.
- http://radiosondemuseum.org/what-is-a-radiosonde/
- https://podaac.jpl.nasa.gov/Terra.