Observed effects of atmospheric water vapor on long-term Changes of diurnal temperature range over China

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Objective

1. The widespread decrease of DTR over many land areas result mostly from a faster increases in daily minimum temperature (Tmin) than daily maximum temperature (Tmax), with most of the decrease occurring prior to 1980 [*IPCC, 2001, 2007*].
2. As the most important greenhouse gases (GHGs) in the atmosphere, change in water vapor can lead to an asymmetry in the DTR due to its absorption of the solar radiation in the near infrared. Increasing atmospheric water vapor in terms of surface observed humidity increases both nighttime and daytime temperatures and thus has small effects on DTR over most land areas except the northern high latitudes [*Dai et al.*, 1999].
3. Although such effects are relative small on a large-scale averaging, the local effects of the atmospheric water vapor on the DTR for seasonal and long-time scales is still less clear. Furthermore, an analysis of the relationship between atmospheric water vapor and the DTR at local scale is very important for understanding the mechanisms of water vapor feedback which is very critical to the prediction of future climate change.
4. In this study, we will quantify how strong the effects of atmospheric water vapor has on the long-term DTR changes over China using more homogenized surface weather and sounding observations.

Data and method

1. New homogenized daily maximum temperature (Tmax) and daily minimum temperature (Tmin) from 549 Chinese stations with no miss record during 1960–2008 [*Li and Yan*, 2009] but now updated to 1960-2011.
2. The tropospheric PW integrated from surface to 300mb utilized in this study is derived from daily radiosonde humidity data homogenized by *Dai et al*. [2011], which was recorded by 131 stations over China, and also updated to 2011.
3. Monthly anomalies were computed as deviations from the long-term mean of the study period (1969-2011) for each month. Trends and their statistical significance at individual stations were estimated using the Mann-Kendall Tau-b non-parametric technique including Sen's slope method [*Sen*, 1968]. To obtain regional mean values, the monthly anomalies were first interpolated onto a 1°×1° lat-lon grid using the ordinary Kriging technique [*Phillips et al. 1992*] and then the gridded data were averaged using the grid-box area as weight to derive regional means.

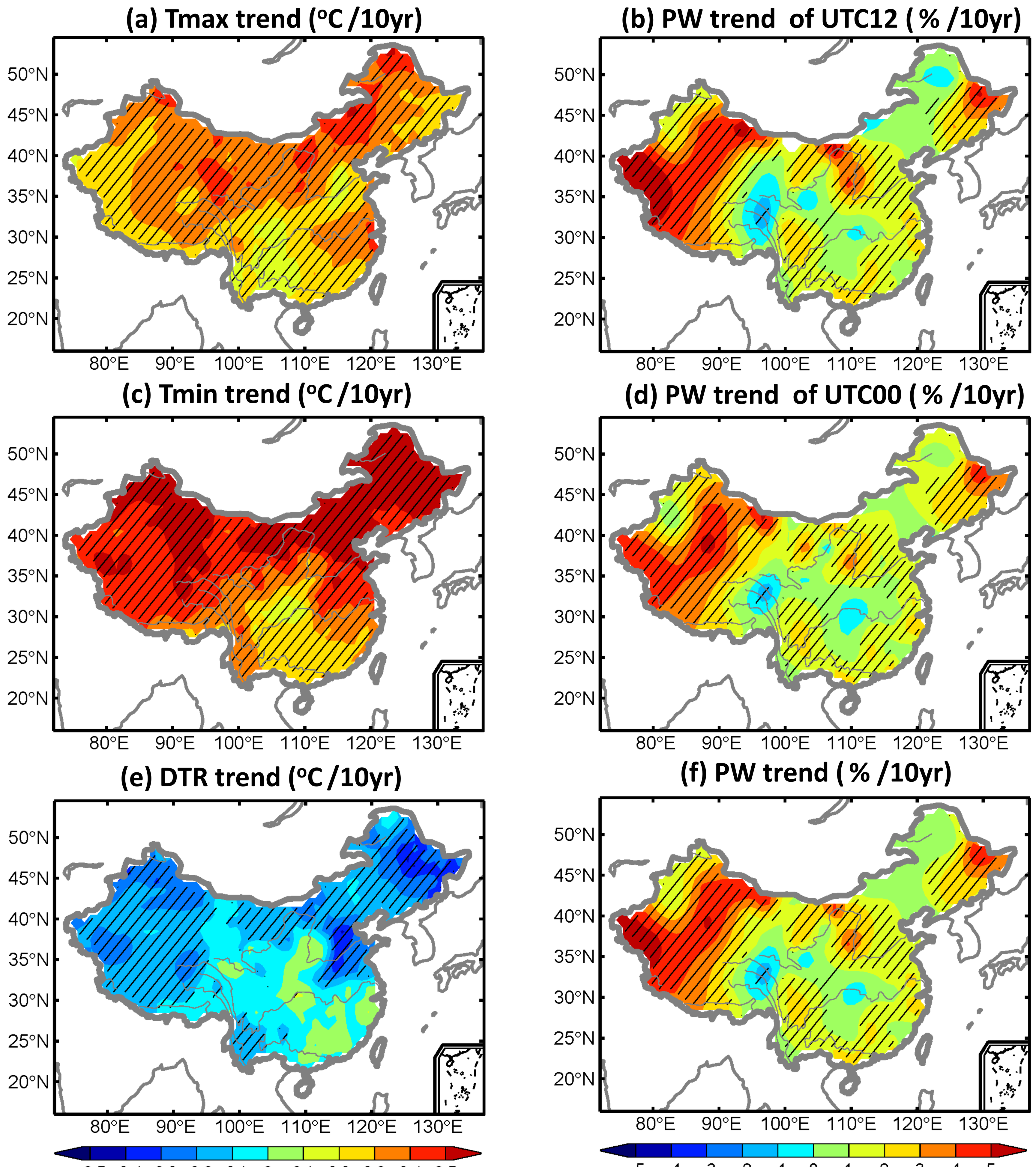

Fig 1. Spatial distributions of the linear trends of monthly anomalies for Tmax, Tmin, and DTR (left panels), along with the PW trends (right panels) during 1969-2011 over China. The stippled areas are statistically significant at the 5% level. The correlations between each row panels are 0.09, 0.31, and -0.34, respectivley.

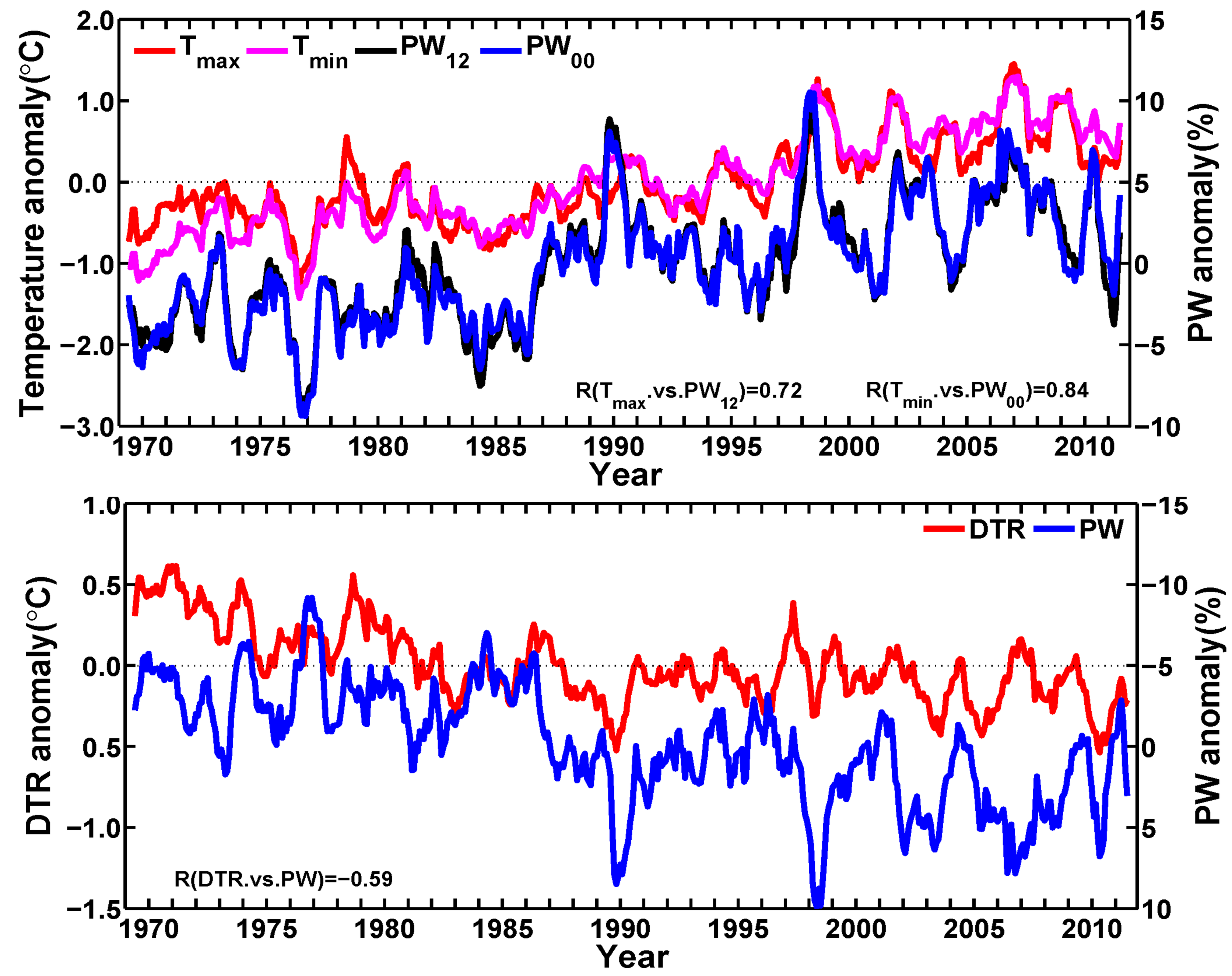

Fig 2. Time series of 11-point moving averaged Tmax, Tmin, and the DTR anomalies, along with the PW (up to 300hPa) anomalies over China, and the *R* is the correlation between them.

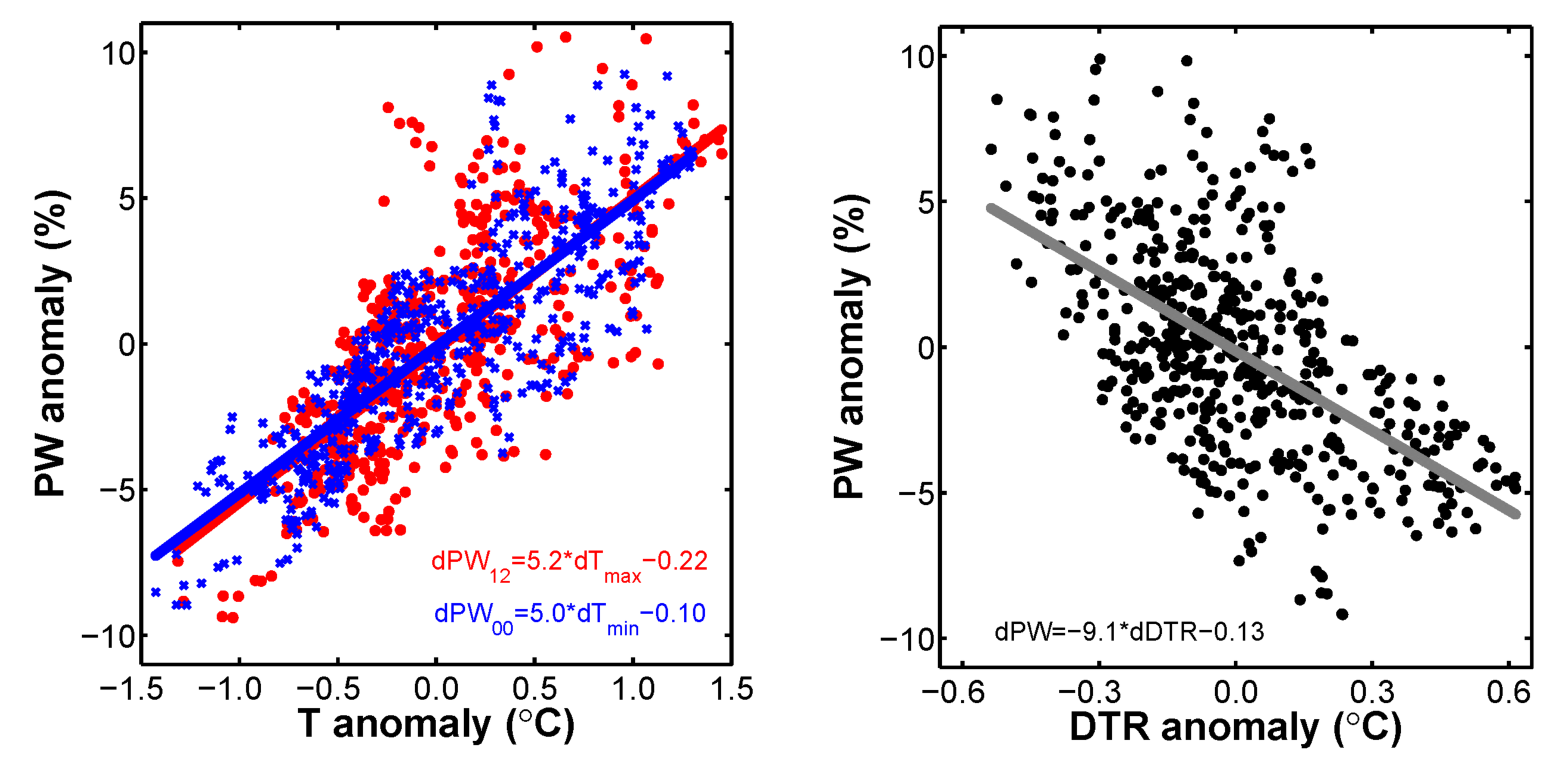

Fig 3. The scatter-plots of PW .vs. Tmax and Tmin anomalies, and of PW .vs. DTR anomalies.

Results and conclusion

1. The DTR shows downward trends by about 0.1-0.5°C decade^{-1} over most of China during 1969-2011, and by more than 0.5°C decade^{-1} over northern China, which results mostly from a faster increase in Tmin than Tmax. In contrast with the DTR, the surface-to-300-hPa PW exhibits a statistically significant trends of 2~5% across the most of China, but the upward trends of more than 5.0% decade^{-1} in the most of northern China as well. The PW trends largely determine the geographic patterns of the DTR long-term trends, especially for the most of northern China where the trends magnitude is larger.
2. The significantly upward changes of the Tmin is more correlated to the increasing changes of PW of UTC00 than that of the Tmax to the PW of UTC12. And thus the decreased changes of DTR are significantly anti-correlated to the increased changes of the PW, and about 36% (r=~-0.60) of the DTR variance is explained by the PW with a dPW/dDTR slope of ~9.1% K^{-1}. The damping effects of PW on the long-term DTR changes also have a seasonal dependency, which is more significantly in warm season than in cold season.
3. Despite the independent high-quality surface observed Tmin and Tmax along with the homogenized sounding observations we used, what mechanisms responsible for the relations between the DTR and the PW till need to further explore, which is beyond the scope of the current study. One must be cautious not to generalize the current relations of the PW to the long-term DTR changes to regions outside the China.
4. It also remains unclear whether similar relations can be generalized to other regions. Hence, future studies should pay more attentions to explore the effects of PW on the long-term changes of DTR as well as the mechanisms of interaction between them at the global scale based on multi-data source, such as the global atmospheric reanalysis and the climate modeling.