Response to Reviewer 1

In this research, by collecting and analyzing precipitation (P), pan evaporation (Epa) and potential evaporation (Ep) data at 259 stations in the US, the authors find that (1) Epa shows a negative correlation with P; (2) the negative correlation between P and Epa is more significant in arid region; (3) P and Ep are independent. These conclusions have been reported in many previous literatures (Hobbins et al., 2004; Ramírez et al., 2005; Kahler and Brutsaert, 2006; Brutsaert et al., 2015). It seems that what the authors did is to prove these findings without new perception or substantial contribution.

Thank you for your comments. According to the previous studies, Hobbins et al. (2004) studied the relationships between P, Ep, and Epa at watershed scale; Ramírez et al. (2005) coupled site scale pan evaporation with watershed scale E and P; Kahler and Brutsaert (2006) and Brutsaert et al. (2015) used the site scale data at Flint Hills region of Kansas. By systematically investigating the relationships between P, Ep and Epa with data from 259 weather stations across the US, our study is able to confirm the finding of these previous studies with field data at continental scale. Also, we combine the Bouchet's complementary relationship with Budyko's framework to generate the Bouchet-Budyko curves, which is able to follow the trend of the data cloud of P/Ep vs. Epa/Ep.

By combining Budyko equation and CR equation mathematically, they claim that they find the connection between the two frameworks. But except for putting the theoretical curves and data clouds together, no further analysis is provided. There are too many qualitative descriptions in the manuscript without quantified analysis and evidence.

Thank you for your comments. The connection between Budyko's framework and CR is essentially that the lower CR curve can be mathematically derived from Budyko equation (Eq. 4), assuming that we can use precipitation to represent moisture availability (Ramírez et al, 2005). Then based on the complementary relationship between Epa and E, the upper CR curve can also be derived (Eq. 6). By putting the theoretical curves and data clouds together, we are able to show that the Bouchet-Budyko curves are following the trend of the data clouds, which will be the first step of validation of the mathematical derivations. We also added description of the process-scale explanation about the two frameworks in the manuscript to provide more information about this connection: "Process-based speaking, the CR suggests a connection between evaporation and "apparent" potential evaporation (Fig. 1a), which is driven by the energy feedbacks between atmosphere and land surface. During the drying process at the land surface, the excessive energy that is not used for evaporation will be available for the increase of sensible heat, and therefore the rate of "apparent" potential evaporation will be further raised (Brutsaert and Parlange, 1998; Brutsaert, 2005; Aminzadeh et al., 2016). This connection between Epa and E also suggests a connection between Epa and P, since the water supply from precipitation will affect the rate of evaporation. In terms of the Budyko framework, Ep and P are used as the representations of energy supply and water supply respectively. The ratio between Ep and P is the primary controlling factor of the ratio of E over P in watersheds at long-term mean annual time scale (Fig. 1b). The ratio of Ep over P is also called the aridity index, which represents the dryness of the climate in a watershed. The ratio of E over P increases with the increase of aridity index, indicating that more water from precipitation will become evaporation

rather than runoff under drier climate (Arora, 2002). No connection between Ep and P is suggested in the Budyko framework."

L188-194: what's the source of temperature (should be used to calculate _ and)? what's the spatial resolution of net radiation? did you take the Ep data for the grid where the station is located as the Ep data for the station? It will caused great uncertainty. Is there radiation data collected at the weather stations?

Thank you. The Ep calculation is done by Zhang et al. (2010). We collect Ep data from their dataset. In their paper, the data sources are explained in details. Temperature is derived from NCEP-NCAR Reanalysis (NNR). The spatial resolution of net radiation is 1° by 1°. Yes, we take Ep data based on the latitude and longitude of each weather station. The radiation data is not available at most of the weather stations in this study. We agree that the remote-sensing Ep data may not be as accurate as the field measurement data. In future studies, we will collect net radiation data to further validate our findings. The discussion about the accuracy of the remote-sensing Ep data is provided in the Discussion section: "The remote-sensing data of E_p may not have the same level of accuracy as the field measured P and E_{pan} and the value of α in the Eq. (7) may vary from location to location (Chen and Brutsaert, 1995; Brutsaert and Chen, 1995). This may explain the deviation of some data points from the curve in Fig. 7."

Line215-219: please provide detailed statistics to support your conclusion, like the percentage of significant P_Epa correlation, the mean P, the mean aridity index in the western and eastern regions. The same for L238-239, please provide the statistics for Ep variability and P variability.

Thank you for the suggestion. The percentage of significant P, Epa correlation is 43%. The statistics information is added, including mean P and mean Ep of eastern and western regions, respectively: "In the 259 weather stations, 93% of the stations have a negative correlation between P and E_{pa} (Fig. 4a), but only 43% of the stations are statistically significant ($p<0.05$; Fig. 4b). All significant P, E_{pa} correlations are negative. The weather stations located in the western region (regions with longitude higher than the weather station average longitude of W 94.81°) are more likely to have a significant P, E_{pa} negative correlation than in the east (regions with longitude lower than W 94.81°). This spatial difference may be related to climate characteristics: the eastern region has higher precipitation (averagely 105.5 mm/month) and lower "apparent" potential evaporation (averagely 145.3 mm/month), while the western region has lower precipitation (averagely 44.6 mm/month) and higher "apparent" potential evaporation (averagely 203.5 mm/month)."

The discussion about P and Ep variability in the eastern and western regions are deleted since the difference is not very distinguishable.

L219-220, L231-232 and L310: it seems that most of your results are similar to previous researches or have be reported before.

Thank you. Yes, these results are similar to the findings of previous studies, which is encouraging. By systematically investigating the relationships between P, Ep and Epa with data

from 259 weather stations across the US, our study is able to confirm the finding of these previous studies with field data at continental scale.

L244-245: As you classify the US into western and eastern parts, or northwestern, southwestern, northeastern and southeastern parts, I don't think there is any need to color the data points according to their latitudes and longitudes. Why not just use four colors?

Thank you. We use western/eastern or the four quadrants to discuss the results, but the color coding is able to show the continuous change of P, Ep and Epa across the US. So with the color coding, more information can be presented, comparing with using four colors.

I cannot tell if "Southeastern region of the US has a wide range of precipitation; while points of the northeastern region are more concentrated" from fig5.

Thank you. This description is deleted.

L312: the boundary is 'Ep=Epa'

Thank you. The description is revised.

L344-345: please add quantitative analysis herein. Why it is 'when P/Ep is lower than 1' instead of 'when P/Ep is lower than 1.5'? how did you define 'signifcant E _Epa relationship'?

Thank you. This is an interpretation we made based on the trend of the curve. When P/Ep is lower than 1, the difference between E and Epa becomes increasingly larger, indicating a more significant complementary relationship between the two variables. We will collect actual evaporation data to further validate this interpretation. With both Epa and E data, more quantitative analysis will be conducted, but it is beyond the scope of this study.

L349-350: what does 'fits with' mean herein? In my point of view, you just provide some curves that located in the data clouds.

Thank you. The deviation of data points from the curve may be related to the accuracy of remote-sensing data and the variability of the pan coefficient from location to location. Nevertheless, our study is able to show the trend of the data cloud is following the trend of the curve. We revised the statement to "The collected data of P, Ep and Epan is following the general trend of the upper Bouchet-Budyko curve (Fig. 7)".

L359-360: To use the combination of Budyko equation and CR equation, you must take care about the time scales, i.e., Budyko equation is merely applicable at long time scale.

Thank you. Yes, the Budyko framework is mainly applicable at long-term mean annual time scale. In recent years, there are studies trying to extend the Budyko framework to annual and intra-annual time scales (Wang and Alimohammadi, 2012; Zhang et al., 2008; Chen et al., 2013). Following their idea, we believe it is possible to link the Budyko framework with the CR.

Description about the applicable time scale of the Budyko framework is added: "Furthermore, the Budyko framework, which is originally applicable at long-term mean annual scale, has been extended to shorter time scales of annual (Wang and Alimohammadi, 2012; Zhang et al., 2008) and intra-annual (Chen et al., 2013)."

L364-367: recommend to delete these nonsense.

Thank you. This part is deleted.

Fig1(a): the label of x axis should be 'P'.

Thank you. We use the E/Epa as the x axis in Fig. 1 to be consistent with the original CR. Later on in the paper, we discuss about the change of x axis in CR from E/Epa to moisture availability, and then to P: "The x-axis of the complementary relationship is a ratio between E and E_{pa} (Bouchet, 1963). Ramírez et al. (2005) used the water-energy framework to link the CR with Budyko approach and changed the x-axis in the CR to moisture availability. Following this idea, several studies have used precipitation or wetness index (P/E_p) to represent moisture availability in the CR (Yang et al., 2006; Roderick et al., 2009). In this study, we also use P to represent moisture availability in the CR."

Fig6: please mark the locations of these four stations in Fig3.

Thank you. Fig. 3a is modified to highlight the four example stations.

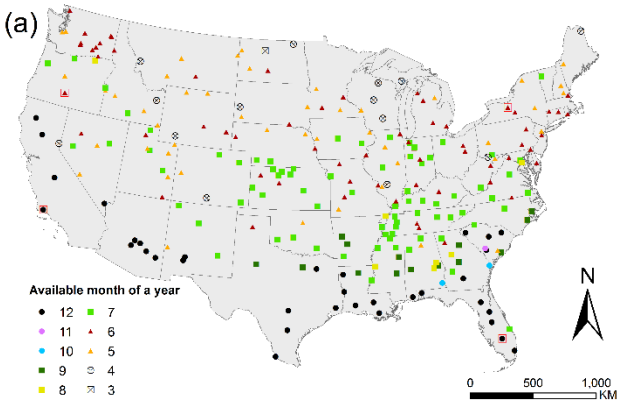

Fig. 3. **(a)** Map of 259 weather stations. The available month of a year of pan evaporation data for each weather station is presented using legends with different colors and shapes. Four representative weather stations are selected from the four quadrants of the US respectively, which are highlighted with red squares.

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