Response to Reviewer 2

GENERAL COMMENTS:
This paper is an observational study of the relationships between various idealized fluxes of evaporative demand as they are manifest in two paradigms: the Budyko framework and the complementary relationship between regional evapotranspiration and evaporative demand. While the paper does not break new theoretical ground beyond combining the complementary relationship and Budyko paradigms, it nevertheless provides essential, continental-scale verification of these relationships through observation, and, as such, should make a significant impact on the field. The authors are to be commended for avoiding the common pitfalls of working with pan evaporation data (for their Epa data): measurement uncertainty due to heterogeneity and the dataset's pronounced regional bias. To isolate the effects of artificial uncertainties introduced to their Epa analyses, they compare to a smaller, homogenized pan evaporation dataset. And they limit the period of analysis of their data to only those months for which they have complete data: they do not attempt to scale up to complete years, which would otherwise introduce spurious, unknown biases. The paper is written and structured well and requires only technical revisions.

Thank you for your comments and suggestions.

SPECIFIC COMMENTS: Following are the main issues to address:
1. In general, dealing with the hornet's nest of terminology is difficult but essential. The authors have done a tremendous job of introducing the various terms involved in the CR and the Budyko framework, and of keeping them distinct. However, to forestall initial confusion on the parts of readers who may already use different terminology (for example, what is called "apparent potential evaporation" here I call "potential evaporation," but what is called "potential evaporation" I call "wet environment evaporation"), they should state at the beginning of the Introduction that terms will be used in a way unfamiliar to some readers and then make reference to a table that compares them (I refer here to a table that was included in an earlier iteration of this manuscript).

Thank you for your suggestion. We added the table of terminology and description about the different evaporation terms: "The definitions of evaporation, potential evaporation and "apparent" potential evaporation in these different frameworks are summarized in Table 1."

Table 1. Types of evaporation in the Budyko framework and the original CR, and their redefined evaporation type based on generalized CR.

Budyko Framework	Bouchet's Complementary Relationship	Generalized Complementary Relationship
Evaporation	Evaporation	Evaporation (E)
Potential evaporation	Wet surface evaporation	Potential evaporation (E_p)
-	Potential evaporation	"Apparent" potential evaporation (E_{pa})

2. This is the only outstanding comment from the previous review I gave to this manuscript: No process-scale explanation of either the surface-atmosphere feedbacks that drive the complementary relationship (including asymmetry vs. symmetry in the CR), nor the attribution of the water and energy budgets in the Budyko framework. This should be the text for their Figure 1. Also, the spatial scale-dependent homogeneity assumptions and the physical land-atmosphere feedbacks that underpin the CR need to be explained, as do the timescale-dependent assumptions of the Budyko framework. This would explain both the independence observed between P and Ep but also the dependence of Epa on P.

Thank you for the suggestion. Description about process involved in Budyko and CR are added: "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."

3. While the authors have changed to using warm-season data only since the earlier iteration I reviewed, they should also use the full-year (annual) data where it is available, i.e., the southern states. This would only strengthen their observations and credibility.

Thank you for the suggestion. The full-year data is used as the warm season data in southern states. We added explanation about the warm season definition: "For stations in the southern states with all 12 months of available data in a year, the full year will be considered as a warm-season. For northern state stations with much less warm months, the warm-season is much shorter accordingly."

4. They demonstrate the inter-relations of Ep, Epa and P through time at single points, although this analysis seems less than satisfying as currently presented. Below, I have suggested different graphics.

SPECIFIC COMMENTS: Minor issues to address:
L 47: Here, by "surface vapor pressure" I believe the vapor pressure directly at the surface is meant here, rather than the more-familiar height of 2 m. If so, this should be specified.

Thank you. The definition of surface vapor pressure is clarified: "the vapor pressure at the water surface and adjacent near-surface area is saturated (Van Bavel, 1966; Brutsaert, 2015)."

LL 122-123: This is a little misleading as it makes it appear possible that Epa can be less than Ep in some circumstances.

Thank you. This sentence is revised: "'Apparent' potential evaporation will be higher than potential evaporation, especially under dry conditions; while it gradually approaches potential evaporation as the ratio of E over E_{pa} increases (Fig. 1a)."

LL 166-189: Nowhere is it specified what is meant by "warm-season." Is it the period at each pan for which air temperatures are above freezing, or May through-October for all pans, or something else?

Thank you. The definition of warm-season is added: "We collect data for the period 1984-2015 from a total of 259 weather stations (Fig. 3a). Since pan evaporation is collected only during warm months (when temperatures remain above freezing), the weather stations at cold regions have less than 12 months of pan readings in a year. We call the period of warm months in a year "warm-season"."

L 189: What is the value of the pan coefficient for Eq. (3), 0.7?

Thank you. The pan coefficient is set at 1.0.

L 190: That this is also called the "partial equilibrium evaporation rate" should probably be mentioned.

Thank you for the suggestion. The description about partial equilibrium evaporation rate is added: "As suggested by Morton (1976) and Brutsaert and Stricker (1979), potential evaporation can be estimated using the Priestley-Taylor equation (Priestley and Taylor, 1972), which is also called equilibrium evaporation (Brutsaert and Chen, 1995; Jiang and Islam, 2001)."

LL 193-195: What are the units, dimensions?

Thank you. The units are added: "where α is a coefficient to account for the effect of surface characteristics and vegetation, and is set to 1.26; Δ (Pa/°C) is the slope of the saturated vapor pressure curve; γ (Pa/°C) is the psychometric constant; R_n (W/m^2) is the net radiation; and G (W/m^2) is the heat flux into the ground."

LL 247-248: There are many more reasons than this that this dataset was homogenized, and they bear mentioning here.

Thank you. The description of the homogenized dataset has been revised to provide more in-depth information about its reasoning behind homogenization: "In order to minimize the data heterogeneity caused by station move and human errors, this dataset compiled pan evaporation data from 247 stations across the US with thorough quality control."

LL 275-276: I don't think these different mechanisms are ever explained; they should be.

Thank you. The physical mechanism of the relationships between P, Ep and Epa are discussed in the Discussion section: "As a result, our study indicates that energy supply and precipitation, the representation of water supply, are likely to be independent. This independence is currently under investigation with field data. It should be noted that the relationships between P and E_p and between P and E_{pa} we find in this study are not direct causal relationships, but rather the result of interactions between a number of physical variables, such as net radiation, wind speed, humidity, and so forth." The mechanisms need to be further investigated with field data, which is beyond the scope of this study.

LL 282-290: See comment on Fig. (6) below.

LL 310-311: The reasoning behind the asymmetry should be summarized here. E.g., symmetry (when b = 1) implies that all energy released as increased sensible heat as latent heat declines goes to increase Epa by the same amount that latent heat declines.

Thank you for the suggestion. Discussion about the asymmetry between Epa and E is added: "This asymmetry is discussed in previous studies (Kahler and Brutsaert, 2006; Brutsaert, 2015). One explanation of this asymmetry between E and E_{pa} is that the evaporation pan will receive more heat than the surrounding area (Kahler and Brutsaert, 2006)."

LL 336-339: I think this thought needs more development: perhaps a hypothesis as to a causal relationship?

Thank you for the suggestion. We agree that this thought needs to be further developed. At the current stage, our data analysis is able to show the relationships between P, Ep and Epa. The physical mechanisms and hypothesis development will be our next step.

Figure 6: I believe I called for these time-series plots in my review of an earlier version, but now I see that they are actually not that explicative. As presented these timeseries don't clearly demonstrate the inter-relations under discussion. In the long-term, multi-annual; complementarity is evident in Fig. (6c), but one has to look really hard to observe the CR at the inter-annual timescales, which is the scale to which the text refers. Perhaps it would be better to either plot these as X-Y scatterplots, or with each flux plotted as an anomaly around its climatological annual mean.

Thank you. Scatterplots are added in Fig. 6.
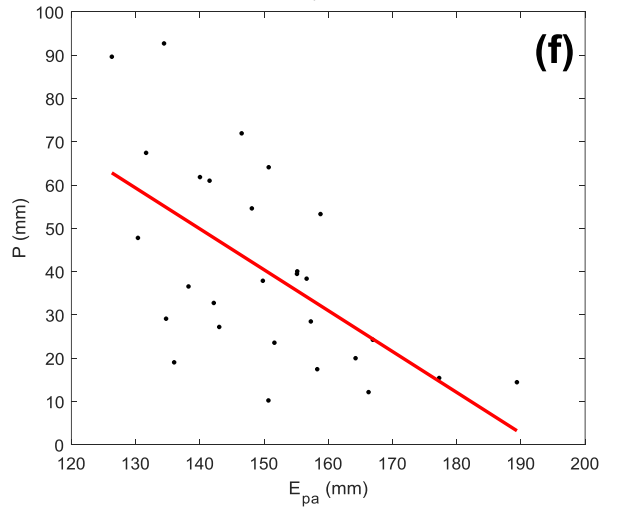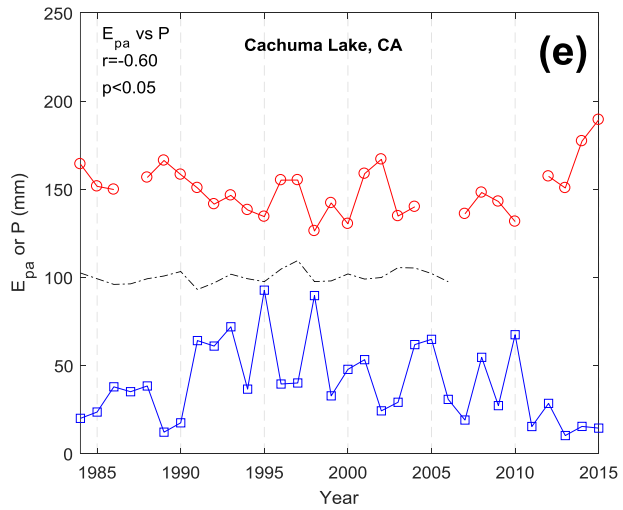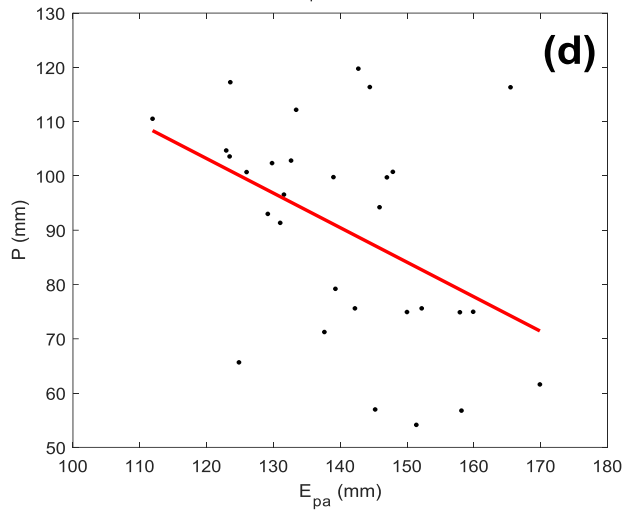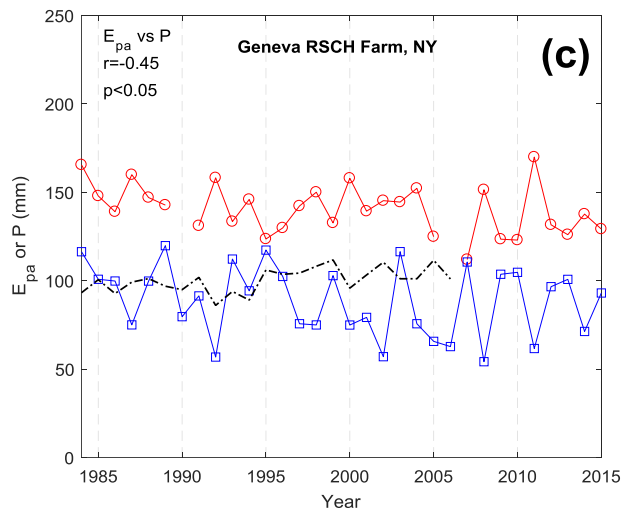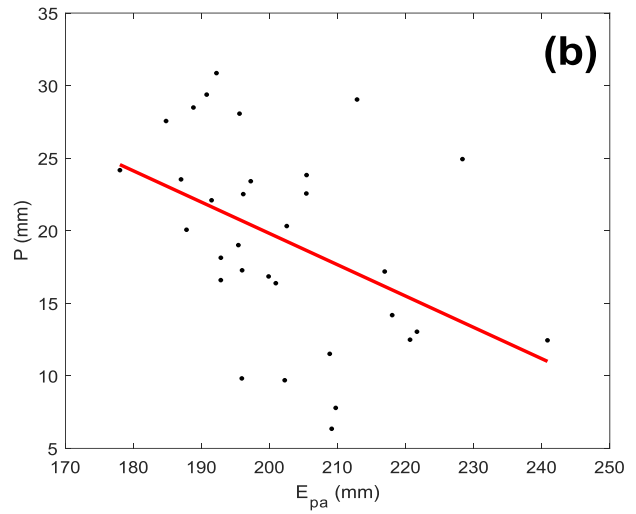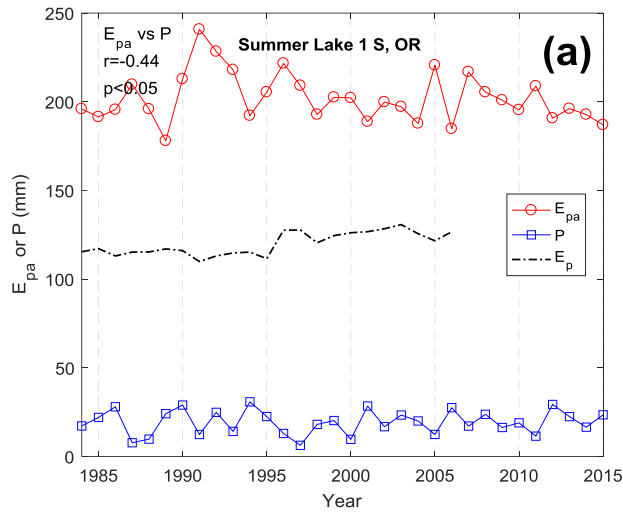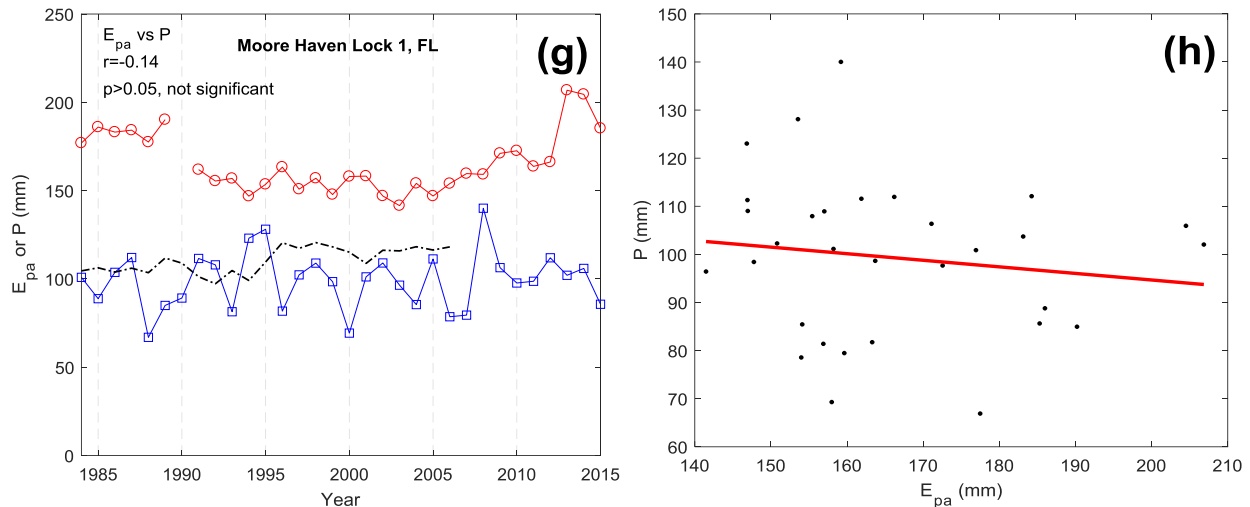
Fig. 6. Warm-season P, E_p and E_{pa} time series of four example weather stations in the study period of 1984-2015: **(a)** Summer Lake 1 S, OR (N 42°58', W 120°47'); **(c)** Geneva RSCH Farm, NY (N 42°53', W 77°20'); **(e)** Cachuma Lake, CA (N 34°35', W 119°59'); **(g)** Moore Haven Lock 1, FL (N 26°50', W 81°50'); and the scatterplots of P vs E_{pa} at the four example stations (**b, d, f, h**).

TECHNICAL COMMENTS: There are some hyphenation issues: there should be no hyphens after words ending in –ly, e.g., use "physically based" not "physically-based"; however, "warm season" should, in general, be hyphenatedâ˘Aˇ Ti.e., "warm-season"â˘Aˇ T particularly where it is used as a compound adjective (more often than not in this manuscript). "As well as" should always simply be "and." I have pointed out a few points where there was repetition.

Thank you for the comment. We did a thorough revision to correct those mistakes.

L 1: "Warm season" should be hyphenated, here and wherever it is used as a compound adjective throughout the manuscript (which is almost everywhere).

Thanks. It is changed to warm-season.

L 30: "Missing word: use ". . .93% of the study weather stations. . ."

Thanks. The missing word is added.

L 65: Use ". . .the Budyko framework and Bouchet's complementary. . ."

Thanks. This sentence is revised.

L 66: Use ". . .use the Fu equation. . ."

Thanks. This sentence is revised.

LL 78-81: This is repeated from earlier in this section.

Thanks. This part is deleted.

L 90 and 93: Use "relationships" – plural.

Thanks. It is corrected.

L 123: Use "conditions" – plural.

Thanks. It is corrected.

L 124: Missing word: use ". . .the ratio of E over Epa. . ."

Thanks. The missing word is added.

LL 142-147: To clean this section up to eliminate repetition and extraneous text, try: "Ep is a horizontal line in the CR that is parallel to the x-axis (Fig. 1a). Therefore, the modified CR indicates that P and Ep are independent. On the other hand, the upper curve of the CR, representing "apparent" potential evaporation Epa, declines along the x-axis, indicating that Epa and P are not ăA´lindependent. For a dimensionless CR, we ăA´lnormalize the x and y axes. The normalized CR describes the relationship between. . ."

Thanks. This section is revised.

L 149: Try "To connect the Budyko framework with the normalized CR toward formulating the. . ."

Thanks. This sentence is revised.

L 196: Here, "long-term" needs a hyphen (as does "warm-season").

Thanks. It is corrected.

LL 214-217: Try "In the 259 weather stations, 93% of the stations have a negative correlation between P and Epa (Fig. 4a), but only 43% are statistically significant ($p<0.05$; Fig. 4b). All significant P, Epa correlations are negative."

Thanks. This sentence is revised.

L 219: Try ". . .climate characteristics: the eastern region. . ."

Thanks. This sentence is revised.

LL 223-235: This is repeated from above.

Thanks. This part is deleted.

LL 228-229: Try "All the warm-season P vs. Epa relations (i.e., all years, all seasons, for a total of 5312 data) are shown in Fig. 5a."

Thanks. This sentence is revised.

LL 235-245: For clarity (and less superfluous text), try the following: "The right side of the cloud generally represents the northeastern and southeastern US (green and brown, respectively), while the left side of the cloud generally represents the northwestern and southwestern US (yellow and red, respectively). The left side cloud is more vertically oriented, indicating that the western US has higher Epa variability than P variability. The southwestern US has the highest Epa (red and orange). The northwestern US has much lower Epa (yellow). On the other hand, the right side of the cloud is more horizontally oriented, indicating that the eastern region has higher P variability than Epa. Unlike in the western US, the difference between the northeastern and southeastern regions is not clear. The southeastern region of the US has a wide P range; while points of the northeastern region are more concentrated."

Thanks. This part is revised.

LL 252-253: Try "Only 41% of the stations have statistically significant relationship (p< 0.05); all negative."

Thanks. This sentence is revised.

L 279: Try ". . .four weather stations from the four quadrants of the conterminous US to show the warm-season P,. . ."

Thanks. This sentence is revised.

L 281: Use "Epa" for "pan evaporation."
Thanks. It is corrected.

LL 281-283: Try "...only have Epa data for six or seven months of each year,. . ."

Thanks. This sentence is revised.

L 283: Delete "selected" here.

Thanks. It is deleted.

L 313: Try ". . .Bouchet-Budyko curve, above which Epa exceeds Ep."

Thanks. This sentence is revised.

L 329: Use "According to" instead of "Similar with."

Thanks. It is revised.

L 347: "Water-limited" should be hyphenated.

Thanks. It is corrected.

LL 370-372: This sentence is repeated from LL 354-356.

Thanks. This sentence is deleted.

L 377: Hyphenation: use "warm-season."

Thanks. It is corrected.

L 379: For ". . .in 93% of the study locations." just use ". . .at 93% of the stations."

Thanks. This sentence is revised.

LL 382-383: Delete the redundant phrase "on the relationship between warm season P and Ep"

Thanks. It is deleted.

Figure 3: The caption for panel (b) should specify that these are the homogenized data that overlap the 259-station dataset.

Thanks. The caption is revised: "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. **(b)** Map of 93 weather stations with homogenized pan evaporation data that overlap the 259-station dataset."

Figure 4: Hyphenation: use "point-scale" not "point scale" in the caption.

Thanks. It is corrected.

Figure 7: In the caption, state what the lower dotted line represents.

Thanks. The caption is revised: "Fig. 7. P/E_p vs. E_{pa}/E_p at 259 weather stations in the US for the period 1984 to 2015 for **(a)** warm-season data (N=5312), and **(b)** long-term average data (N=259). The data points are color coded based on their latitudes and longitudes. The three upper Bouchet-Budyko curves are plotted with different b values of b=1, b=2, and b=3, and with the same v value of v=2. The lower dashed line is the lower Bouchet-Budyko curve with v=2."