Response to Referee #2

General Comments

The authors present a very detailed review on the studies and developments of the complementary relationship of evaporation. Although the review is very detailed and scientifically well supported on the existing literature, I think it is too heavy due to the load of parameters introduced and unexplained, the long list of studies mentioned and a weak coherency when enumerating the studies. Can the authors make this easier for the reader to read through?

Response: In the revised manuscript, we will rearrange the manuscript, and try to make it easier for the reader to read through. Section "**2 Symmetric complementary relationship**" and "**3 Efforts in maintaining a linear complementary relationship**" will be combined to one section "**Linear complementary relationship**" to make it more coherent. The parameters will be introduced and explained more clearly in the revised manuscript.

Furthermore, I am completely missing the incites and perspectives from the authors. It would be very nice to see the opinion from the authors regarding the benefits of the framework. I suggest an extra section discussing 1) the best approach according to the authors criteria, 2) the future of the CR for E estimation, and 3) a comparison highlighting the advantages, disadvantages and opportunities of using the CR principle against other methods of Evaporation estimation that are not mentioned here. After this, the review should be ready for publication.

Response: In the revised manuscript, we will give a clear point of view on the different approaches: the asymmetric CR is a significant improvement of the symmetric CR, and the generalized **complementary principle via nonlinear functions is the recent development. We will also compare the** two generalized complementary approaches in a new subsection and give our perspectives. We will add a new section discussing the current practice and future development of the CR for E estimation, and compare it with other methods (the Penman approach, the Budyko approach and others) on the advantages, disadvantages and opportunities of using the CR principle. At last, we propose a suggestion of integrating these approaches for a new generation of evaporation estimation method.

Specific Comments

L. 24 State if it is a positive or negative feedback.

Response: We will revise this sentence as "this principle originated from the negative feedback of areal evaporation on evaporation demand (Bouchet, 1963)".

L. 27 To understand, so the differences between Epa and Epo is just that Epa is small and local and Epo large-scale? Can you provide more explanation on what these two variables really mean since they are so important for this discussion? Specially for understanding Figure 1.

Response: The major differences between *Epa* and *Epo* are that they correspond to different atmosphere characteristics. *Epa* corresponds to the atmosphere in contact with current non-saturated evaporating surface as the overpassing air is not affected by the small saturated surface, whereas the atmosphere corresponding to *Epo* is in contact with the large-scale saturated surface. Thus, the surface water availability can be detected from the relative magnitude of *Epa* and *Epo* (as shown in Figure 1), and *E* can be estimated without the knowledges of the surface. We will provide more explanation in the revised manuscript.

L. 32 What complex formulations?

Response: The formulations of *Epa* and *Epo* are introduced in Section 3.1. We will add a tip in the revised manuscript.

L. 35-39 Please rephrase, it is difficult to understand. L. 38 If there is a Penman calculation variable Epen, then how do you estimate Epa and Epo, that is different from Penman. Please specify.

Response: It should be noted that E_{pa} and E_{po} are theoretical concepts, and need to be formulated when applying for practical problems. The generalized complementary function comes in two ways. Brutsaert (2015) adopted a polynomial function to describe the relationship between *E*, E_{pa} and E_{po}, and suggested to formulate E_{pa} and E_{po} by using Penman's potential evaporation (E_{Pen}) and Preistley-Taylor’s minimal advection evaporation to formulate, respectively. By contrast, Han and Tian (2018) abandoned the theoretical concept of E_{pa} and E_{po}, yet used a sigmoid function to describe the relationship among *E*, Penman's potential evaporation (E_{Pen}), and its radiation term (E_{rad}), which can be directly used for practical problems. We will rephrase these sentences to make them clear.

Table 1. Nice table!, but refer to the Appendix for the unexplained parameters.

Response: We will add it below the table.

L. 69 why “basin-wide water balance” results? You said before that Epa is from a “small saturated surface”.

Response: Epa was derived from a hypothetical theoretical concept of “small saturated surface”, which means that the “small saturated surface” does not affect the atmosphere, and Epa is determined by the atmosphere corresponding to current unsaturated surface. In application, Epa is calculated by using the meteorological variables corresponding to current unsaturated surface, and is used to calculate the basin-wide actual evaporation. In the revised manuscript, we will make the statement more clear.

L. 70-75 But have these estimates been validated in some way?

Response: Yes. We will introduce the validation of the AA approach "has been validated based on hourly (Parlange and Katul, 1992; Crago and Crowley, 2005), daily (Brutsaert and Stricker, 1979; Ali and Mawdsley, 1987; Qualls and Gultekin, 1997), monthly (Xu and Singh, 2005; Lemeur and Zhang, 1990; Hobbins et al., 2001), and annual (Ramirez et al., 2005; Yu et al., 2009) data from either plot-scale lysimeters and eddy-covariance measurements or basin-wide water balance-derived results."

L. 75 When they found that it is overestimating or underestimating E, how did these studies obtain the real E then?

Response: In the revised manuscript, we will add the potential causes of the bias "imperfect formulations of E_{pa} and/or E_{po}, external energy sources, or even the nonlinear nature of the complementary principle were considered as potential causes of this bias (Qualls and Gultekin, 1997; Hobbins et al., 2001; Han et al., 2008, 2012)." Please refer to Section "2.4 Efforts in maintaining a linear complementary relationship through rational formulation of E_{pa} and/or E_{po}", and "3.2 Sigmoid function relating E/E_{Pen} to E_{rad}/E_{Pen}" for the methods to obtain the real E.

L. 78 IMPORTANT. Since you are constantly introducing many parameters related to actual or potential evaporation, please include in the appendix a detailed explanation on the difference between each E parameter. For instance, to know how Epan differs from Epa.

Response: Generally speaking, E_{pa} and E_{po} are theoretical concepts, whereas Epan, Epen, Ept and others are the specifications of them. We will explain it in the appendix.

L. 88 Do you mean that they change in opposite directions with increasing water availability?

Response: Yes. We will change "while" to "whereas" to make the sentence more clear.

L95 "the governing changes"

Response: We will change it in the revised manuscript.

L. 98 Why does Morton say that it is unrealistic and does not have proof, and argue against it, since you are performing a review on the subject.

Response: Morton derived the CR by two assumptions: the net radiation will not change with the surface, and the heat and vapor eddy transfer characteristics are identical for E and E_{pa}. Szilagyi (2001) relaxed the second assumption of Morton (1983). LeDrew (1979) argued that Morton's two assumption do not necessarily hold, and pointed out that the symmetric CR is physically unrealistic by using a diagnostic model of the energy fluxes within a closed system. We will rephrase these sentences in the revised manuscript.

L. 113 You mention an asymmetry, but before you were talking about symmetry?

Response: It should be “symmetric”. We are sorry for the typo.

L. 136 So when is E_PT different from Epo. In other words, more clarity between these terms.

Response: In theory, E_{po} is the theoretical potential evaporation when the land surface is saturated, and should be calculated with a proper formula by using “potential” meteorological variables corresponding to the saturated surface. The Priestley-Taylor equation has been widely accepted to represent evaporation from extensive saturated surfaces, by using meteorological variables corresponding to these saturated surfaces (Brutsaert, 1982; Priestley and Taylor, 1972). This way it was suggested to represent E_{po} (Brutsaert and Stricker, 1979). We will make the statement more clear in the revised manuscript.

L. 135-156 IMPORTANT I find these paragraphs hard to read and somehow “boring”. As in a review, it would be very good if you can try to articulate all the studies in a more consistent way so that it does not become a list of studies and references each with a brief explanation. Also, many, many terms that have not been previously explained, only in an appendix. As it is, the review paper is now more focus to experts in the CR that common hydrologists.

Response: We will rephrase this paragraph to make is more consistent and easy to read. In the first paragraph, the first problem of using EPT to denote Epo is pointed, and is explained as “predicting the hypothetical surface or air temperature corresponding to the extensive saturated surface is critical for rational defining E_{po}”. Then, three works aiming to settle this problem are introduced one by one: Morton (1983), Szilagyi and Jozsa (2008), and Aminzadeh et al. (2016).

Next, another problem is pointed as “Advection is another factor influencing E_{po}. However, E_{PT} does not fully consider the effects of advection, which are inevitable in reality (Morton, 1983, 1975; Parlange and Katul, 1992).” The works of Morton (1983) and Parlange and Katul (1992) are introduced.

Section 3. I don’t see the rationale behind the selection of the subtitles 3.1 and 3.2. A brief explanation is needed. Why these subtitles, I assume 3.1 are the symmetric approaches and 3.2 the asymmetric ones? Think on the reader that is reading this review.

Response: We will combine section 2 and 3 and change the order of former subsection 3.1 and 3.2. We believe it will be more rationale following this order:

2.1 Concept of symmetric complementary relationship;

2.2 Proofs of symmetric CR;

2.3 Asymmetric linear CR as an extension;

2.4 Efforts in maintaining a linear complementary relationship through.

The new 2.4 is for both the symmetric and asymmetric CR.

L.164 so b=1 means symmetry?

Response: Yes. We will add this in the revised manuscript.

L. 167. “The asymmetric CR is widely used?” Can you make a paragraph saying in your point of view which approach is better and why, symmetric or asymmetric?

Response: We will delete this sentence and add a paragraph as:

The asymmetric CR is a significant improvement of the symmetric CR, and the opposite changes of E/E_{po} and E_{pa}/E_{po} against E/E_{pa} were treated as an enhanced illustration of the CR (Hu et al., 2018; Zhang et al., 2017; Ma et al., 2015; Brutsaert et al., 2019; Szilagyi, 2007). The performances on evaporation estimation are improved by calibrating the asymmetry parameter *b* (Kahler and Brutsaert, 2006; Han et al., 2008; Huntington et al., 2011; Ma et al., 2015). Efforts have also made to calculate b by using the meteorological variables, which enhance the predict ability of the CR (Szilagyi, 2015; Szilagyi, 2007; Aminzadeh et al., 2016). However, the changes in *b* imply a potential nonlinear characteristic of the CR Han (2008); Lintner et al. (2015). The observed values of E/E_{po} and E_{pa}/E_{po} even exhibit a positive correlation under wet conditions at several flux sites, which challenges the CR (Han and Tian, 2018). But previous studies on the validity of CR have two limitations. First, the true correlation between Epa+ and E+ would be masked when they are both plotted against moisture index (Pettijohn and Salvucci, 2009; Lintner et al., 2015). Second, the wet conditions where the two curves of E/E_{po} and E_{pa}/E_{po} approach were seldom focused, which may hide the true correlation under wet environments.

Can you make a similar Table 1 but for the non-linear relationships? I think that you mention many approaches that are not included in Table 2.

Response: We will make a Table for the nonlinear generalized complementary functions as:

Table 2. Different formulas for normalized complementary functions

Type	Formula*	References
Linear	$y=\alpha(1+\frac{1}{b})x-\frac{1}{b}$	Brutsaert and Stricker (1979)
	$y=(1+\omega)x$	Lhomme and Guilioni (2010, 2006)
Sigmoid	$y=\frac{1}{1+c_1e^{d(1-x)}}$	Granger (1989), Han et al. (2011)
	$y=\frac{1}{1+m(\frac{1}{x}-1)^n}$	Han et al. (2012)
	$y=\frac{1}{1+m(\frac{x_{\max}-x}{x-x_{\min}})^n}$	Han and Tian (2018)
Concave	$y=\frac{1}{1+k(\frac{1}{x}-1)+l}$	Katerji and Perrier (1983) , Han et al. (2014b)
	$y=(2-c)\alpha^2x^2-(1-2c)\alpha^3x^3-c\alpha^4x^4$	Brutsaert (2015)

* $x=E_{rad}/E_{Pen}$ and $y=E/E_{Pen}$. the other symbols are parameters.

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