Responses to reviewers

We are very grateful to the three anonymous reviewers for their constructive comments of the manuscript.

Referee #1

1. *Actually the first Budyko curve was in terms of net radiation and not potential evaporation. This should be mentioned because there was no drying power in the original framework!*

It is true that there was no drying power in the original framework and in some subsequent works, e.g. Choudhury (1999), Donohue et al. (2007). Consequently, a comment will be added to recognize that.

2. *p2 line 29-31: I would remove this sentence on potential evaporation because it is inconsistent with the assumption that it is used for the wet evaporation.*

Some additional comments will be made to clearly specify which is the original Priestley-Taylor equation with a fixed coefficient $\alpha_w = 1.26$ (used to calculate wet environment evaporation E_w in the AA model) and which is the Priestley-Taylor type equation (used to calculate potential evaporation E_0) with a variable coefficient α_0.

3. *p3 line 2 see also Lintner et al. 2015 for an analytical expression of alpha (in fact similarities or differences with this expression should be discussed in the context of the retrieved alpha as a function of the shape parameter of the Budyko curve - at least qualitatively).*

In fact, as far as we understand, the analytical expression of alpha in Lintner et al. (2015, Eq. 13) applies to α_w which defines the wet environment evaporation E_w and set to 1.26 in the AA model used in our analysis. Our analytical expression of alpha (Eq. 22) applies to α_0 (which defines potential evaporation E_0) and not to α_w.

4. line 8: should mention Szilagyi, J., and J. Jozsa (2009), Complementary relationship of evaporation and the mean annual water energy balance, Water Resources Research, 45(9), doi:10.1029/2009WR008129.

This reference is relevant and will be added.

5. *line17 p4: we know this is not correct b>1, please comment or add.*

We have made new calculations with a not-fixed value of b. It is not very complicated, in fact. In the revised paper, all the equations will be modified by including the parameter b. The value of b will be discussed at the end of the paper in the light of the recent paper of Brutsaert

(2015). His generalized form of the complementary relationship suggests that b= 4.5 would be more appropriate to account for the asymmetry of the CE relationship.

6. *reformulate line 26: rather "as a consequence of land-atmosphere interactions " ...." as expressed by the CR".*

The referee is right. This part of the phrase will be changed.

Referee#2

1. *In this manuscript, the authors introduced a new parameter α_0 into the complementary relationship between potential evaporation and actual evaporation. In fact, E_0 estimated by equation (3) and Ep estimated by equation (2) are equivalent in this manuscript. Therefore, α_0 represents the ratio between radiative item and aerodynamic item in the potential evaporation calculated by the Penman equation. The variation in α_0 can be revealed according to Penman equation. Therefore, more discussion was required to show the theoretical significance of this manuscript. In application of estimating actual evaporation, this method has a precondition, which is to determine α_0 according to Budyko curve. However, the Budyko curve has an ability of estimating actual evaporation. What is the objective of estimating α_0 using the Budyko curve and then estimating actual evaporation using the CE?*

Maybe the text was not sufficiently explicit and clear, but our objective is not about estimating actual evaporation, or at least it is not our main concern. Having defined the Priestley-Taylor coefficient α_0 in the way of Eq. (3), as a means to estimate potential evaporation Ep, we simply show there is a functional relationship between this coefficient α_0 and the shape parameter λ of the Budyko curve, this relationship being a direct consequence of the CE. This point will be made clearer in the new manuscript.

2. *According to equations (6), (7) and (3) (If E_0 and Ep are equivalent), it can yield*

$$E = (2\alpha_w - \alpha_0)\frac{\Delta}{\Delta+\gamma}R_n$$

Where α_w =1.26, α_0 is determined by aridity index and the parameter λ, which is a constant in a special catchment because of constant aridity index and the parameter λ. Therefore, E only depends on Rn (temperature has a small impact on Δ and γ). The rationality needs more discussion.

The equation is correct, but we cannot say that E only depends on R_n, since α_0 is a function of λ and of the aridity index Φ. We can simply say that in a given catchment characterized by fixed values of λ and Φ, E depends on Rn and on λ and Φ trough α_0.

3. *In this manuscript, α_0 was named the Priestley-Taylor coefficient to calculate potential evaporation, and at the same time, another Priestley-Taylor coefficient α_w = 1.26 in the*

Priestley-Taylor equation was used to calculate the wet environment evaporation. It is likely to cause confusion.

It is the point which should be made clearer. In fact, in our analysis two Priestley-Taylor coefficients are defined in relation to the CE relationship: one (α_w) is used to define the wet environment evaporation E_w and the other (α_0) to calculate the potential evaporation E_0, which is a substitute for E_p.

4. *The timescale should be pointed out when relate the BT to CE, because the BT is general used on the long-term time scale or annual scale.*

It is true that the Budyko curves were initially derived and used on long time scales, but they have been downscaled to the season or the month by some authors (Zhang et al., 2008; Du et al., 2016; Greve et al., 2016). As pointed out by Lintner et al (2015, p2120), observational data confirm that the CE relationship holds on daily to annual timescales. Some comments will be added in the revised manuscript.

5. *Turc-Budyko curves should be replaced with Budyko-Type curves*. OK

6. *P.4, line 24, more explanation on $\alpha_w \leqslant \alpha_0 \leqslant 2\alpha_w$ are required.*

This is a direct consequence of the CE relationship (Eq. 6 with b= 1) replacing E_p by E_0.

Referee #3

1. *Different definitions of "potential evaporation" need distinguishing. First: in the Budyko framework, "potential evaporation" is defined as energy supply for evaporation, which is estimated by solar radiation, Penman equation, or Priestley-Taylor equation. They were used in same equations without distinguishing their differences. So, the question is, why Penman evaporation is used in Eq. (1), and denoting Priestley-Taylor evaporation indirectly through the complementary relationship?*

In fact, when Penman's equation is used to estimate potential evaporation E_p simultaneously in the CE relationship and in the Budyko function, the question does not exist. It is when E_0 (Priestley-Taylor equation with a given coefficient α_0) is used instead of E_p (Penman), that the problem arises and our analysis becomes relevant.

2. *Why using Priestley-Taylor equation by Eq. (3) and (7)? What is the difference? Please give more explanations.*

The CE relationship involves two kinds of "potential" evaporation, a "true" potential evaporation represented by Penman equation (E_p) and estimated by E_0 (α_0) and a wet environment "potential" evaporation estimated by E_w (α_w). Both E_0 and E_w are estimated via the same form of the Priestley-Taylor equation, but with different coefficients (α_0 and α_w). This will be added to the new manuscript.

3. *What is the purpose or significance of the work? Improving evaporation estimation? Help to determine the Priestley-Taylor coefficient?*

As previously discussed, our main purpose is not improving evaporation estimation, or maybe indirectly. It is determining the Priestley-Taylor coefficient α_0 (the one expressing potential evaporation E_0) as a function of the parameters defining the Budyko function (λ and Φ).

4. *Some generalized complementary relationship (Brutsaert, 2015, Han et al., 2012) were proposed in recent publications. However, the advection-aridity model of Brutsaert (1979) is used to denote the complementary relationship model in this paper. As a result, the linking proposed in this paper may be not generalized.*

As already said in our response #1.5, we have decided to make new calculations with a not-fixed value of b in the complementary relationship (it is not so complicated). Consequently the new linking proposed will be based on a more general form of the complementary relationship.

5. *In section 3, the drying power of the air is used, and the psychrometric constant and the slope of the saturated vapor pressure curve at air temperature have to be taken as variables. If using the aerodynamic term instead, the relationship may be more clear.*

The relationship would be certainly a little bit clearer. However, temperature has a relatively small impact on γ and Δ. And more importantly, E_a has a physical significance per se (equivalent to R_n in the Penman equation), which is not the case for the aerodynamic term. It is the reason why we prefer to keep E_a.

References

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