Response to Reviewer 1

We thank Reviewer 1 for helpful comments. Reviewer 1's comments are in black, and our responses are in red:

The manuscript comprehensively evaluates different approaches about the Priestly-Taylor α parameter. Considering the broad application of P-T equation in quantification of evaporative fluxes at different scales, the study can potentially provide insights for hydrology and climate modeling approaches. However, there are some aspects in the study that need clarification or should be addressed by the authors.

- Acknowledging that the definitions of wet surface and potential evaporation are always controversial as reflected in different studies, I think the description in line 56 tacitly ignores the key role of atmospheric forcing and its coupling with land surface; in other words, if the surface was truly saturated then the measured meteorology would have been different.

This manuscript is primarily looking at evaporation from surfaces we are (relatively) confident are actually wet. Figure 1, Table 1, and Figure 3 apply to such wet surfaces. The hypothetical wet surface evaporation comes in when using the Complementary Relationship to calculate evaporation from a wide range of surfaces in Figure 4.

When asking "What would happen if conditions were the same as they are, except…..?", it is important to define what stays the same. Most interpretations of the Priestley-Taylor equation assume the available energy stays the same and the air temperature stays the same (i.e., Brutsaert, 1982, 2005, 2015).

However, Szilagyi and Jozsa (2008) and Szilagyi and Schepers (2014) give good arguments for the idea that a small wet patch also maintains the same skin temperature while the region dries out, as long as the available energy and the wind speed are held constant. Szilagyi, Crago and Qualls (2016) argue that this wet patch skin temperature should be used to determine the saturation vapor pressure slope (Δ) when estimating equilibrium evaporation.

This hypothetical saturated surface skin temperature is crucial for estimating equilibrium evaporation. Qualls and Crago (2020), following Philip (1987) note that equilibrium evaporation is simply the smallest possible evaporation rate from a saturated surface for a specified available energy and surface temperature. In a graph of vapor pressure versus temperature, Philip (1987) showed that wet surface evaporation is at its lowest when a line from $[T_0, e^*(T_0)]$ to (T_a, e_a) is tangent to the saturation vapor pressure curve at wet patch skin temperature T_0.

Putting this together, the hypothetical wet surface temperature T_0 of a drying surface can be estimated using (12), and equilibrium evaporation can be estimated from that T_0 in addition to $(R_n\text{-}G)$. Thus, there are good reasons to think that real wet surface evaporation would be similar to our hypothetical values. Alternative views are discussed in:

Tu and Yang, 2022, On the estimation of potential evaporation under wet and dry conditions, WRR 58(4), https://doi.org/10.1029/2021WR03148.

Szilagyi, 2022, Comment on "On the estimation of potential evaporation under wet and dry conditions, WRR, https://doi.org/10.1029/2022WR033264.

Yang, Tu, and Roderick, 2022, Reply to Comment on "On the estimation of potential evaporation under wet and dry conditions, WRR, https://doi.org/10.1029/2022WR033674.

- In the present structure of the manuscript and representation of section 2.2, it is a bit difficult to follow the linkage of the work with CR approach (of course a direct application of Priestly-Taylor α parameter is there). As already reflected in the title, the manuscript has a very clear objective. Perhaps rewriting of that section and better representation of the results around Figure 4 will improve the coherency of the manuscript.

To help make this connection, at the end of the first paragraph of section 2.2, we plan to add: "Thus, an estimate of the Priestley-Taylor α is an integral part of the CR, and the performance of CR models making use of the four different hypotheses regarding α can serve as a further test of the hypotheses."

- Eq. (6) and line 167: I think the $\leq$ sign on the RHS is not intuitive here. Air is already saturated at equilibrium condition; $\alpha=1+\gamma/\Delta$ implies LE=Rn-G; this means H is zero or Ta=Ts. Since both surface and air are already saturated (i.e., RH=1), this means vapor pressure gradient suddenly approaches zero and evaporation stops!

Just to clarify, equilibrium conditions refer to $\alpha=1$, not to $\alpha=1+\gamma/\Delta$. Regarding $\alpha=1+\gamma/\Delta$, H=0 implies that potential temperature is constant with z, rather than actual temperature, so there can be a small e-gradient even when H=0. However, we have changed from $\leq$ to simply <, since the point is to establish that α cannot go higher than $1+\gamma/\Delta$.

When $\alpha > 1+\gamma/\Delta$, it implies that H<0. The reasoning for this limit was given by Priestley and Taylor (1972) : "In the absence of advection…..it is unlikely that an inversion will prevail so as to make H negative." That is, over a period of a day or longer, it is unlikely that H<0 while LE>0 unless there is strong advection warming and drying the air above the wet surface. An example would be warm and dry continental air blowing across a cool ocean, violating the "absence of advection" criterion (Priestley and Taylor, 1972).

- Line 128: simply even at equilibrium condition, part of available energy will be exchanged via sensible heat flux.

Yes, there will be positive sensible heat flux throughout the range $1 \leq \alpha < (1+\gamma/\Delta)$. On this line of the manuscript we are trying to explain WHY there will be some sensible heat flux.

- Line 188: surface drying within the CR approach implies drier and "warmer" near surface air as part of available radiative energy not used by LE is now released in form of sensible heat flux.

Yes. There are two sides of the same coin. Our explanation focuses on the water availability while yours focuses on how the available energy is allocated.

- Line 35: is not it Bouchet (1963)?

Yes. We will correct the reference.

- Line 64: it might be helpful to elaborate more on the objectives in Crago and Qualls (2013) and clarify differences.

We plan to change the wording to: “The objective here is to gain a better conceptual understanding of alpha (c.f., Crago and Qualls, 2013).”

- In general, the quality of figures and representation of information (especially statistical attributes in legends) remains a bit low. Captions can benefit more from direct interpretation of the results.

We plan to modify the graphs so that the text in the graphs is easier to read.