

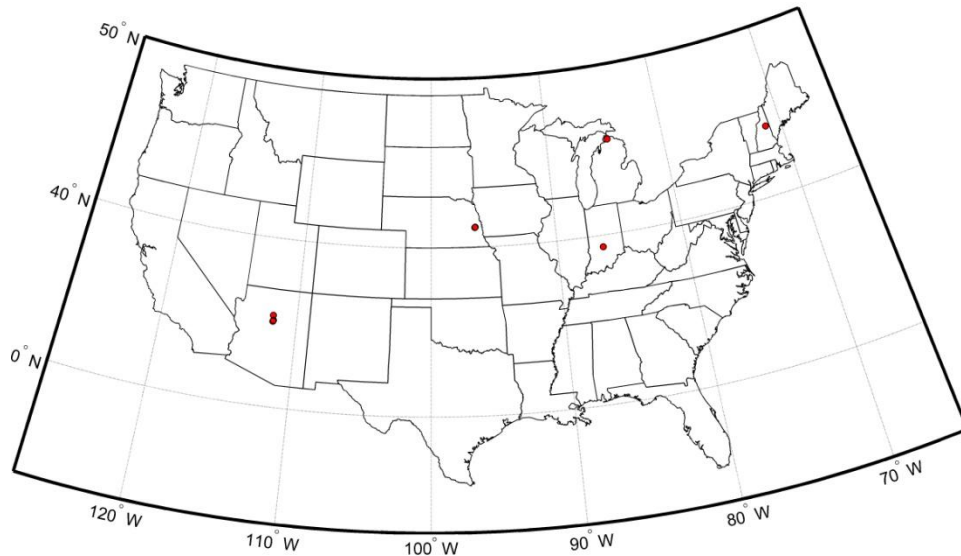
Comment1: P1651: Ln 10-29: The authors list a variety of previous models which have been developed and published in the literature. This information would be much easier to digest and compare in a tabulated format with the name of each model, type of parameterization, variable list then reference. To provide a better motivation for the development of a more advanced model as presented in this manuscript, the authors should outline inaccuracies and shortcomings of all the previous models which have been listed with associated uncertainty if available.

Response: *This work is focusing on developing an easy to use and simple regression model for estimating diffuse Photosynthetically Active Radiation (PAR) (400-700nm) using easy to measure environmental variables. In this study we use a much larger data set than any previous studies covering a much larger geographic area and ecosystem types. We have presented the short comings of the existing models and our goal for development of this model in the introduction section. We agree with the reviewer that presenting a detailed overview in the form of a table will be helpful for the readers, but we feel that such an intense treatment of literature is suited for a review type paper. The primary goal of our paper is model development and that is what we strive to achieve in this work.*

Comment2: P 1651, In 26: As stated later on at the start of Section 3, the BRL model is similar to that presented here. This should be highlighted in the introduction as it appears on reading Section 3 that this work is in fact an extension of the BRL model using more variables.

Response: *The BRL model is developed for estimating shortwave diffuse radiation fraction and so in its original form cannot be used to model diffuse PAR. In this work we are adopting the particular form of the equation which can capture the particular shape of the relationship between PAR diffuse fraction and PAR clearness index. Since we have to make comparison with a PAR diffuse fraction model, we selected a cubic model (Jacovides et al., 2009) to make a meaningful comparison. A sentence will be added to introduction section to indicate this.*

Comment3: P 1652, In 16: A figure needs to be included showing the location of the 9 Ameriflux sites so that the reader can gauge the quality of the sampling with respect to latitude and elevation. Six of these sites seem to be at 2 locations as given in Table 1. How are these sites different given their close proximity? Is there sufficient coverage to be sure that the parameterization gives good results across the US?



Diffuse PAR is a variable which is not measured in standard meteorological observatories and it is also not a standard variable measured in the AmeriFlux sites. Only very few sites in the network have these sensors and we used data from such sites. We included the multiple sites from the same location as they represented different management conditions and ecological disturbances (Flagstaff, NM sites) and different crop management practices (Agricultural sites in Mead, Nebraska).

Comment4: P 1653, In 4: Where does RE come from? Maybe from a geo-stationary or earth orbiting Satellite or a measured solar spectrum (e.g. Atlas-3)? How do you account for the fluctuation in RE due to e.g. the 11-year solar cycle or is this irrelevant for this work?

Response: *Extra-terrestrial irradiance (RE) is modeled as a simple equation (equation 1). This type of relationship was used in many previous studies as it is simple and requires only the geographic location and time of day. This relationship doesn't take into account the sun spot activity cycle. Most of the studies that would require diffuse PAR as a variable will be studying intra or inter annual variability and study periods seldom exceed decades. Hence sunspot activity will not be an important factor in this model development.*

Comment5 P1653, In 6-9: This implies clear-sky only measurements are exploited which seems odd considering that the diffuse component increases with respect to cloud cover. Why is fractional cloud cover not a parameter which affects the parameterization?

Response: *The data set used in the study comes from the Ameriflux sites, which are primarily ecosystem carbon and energy flux measurement sites. These sites mostly have simple radiation sensors (Net radiation components and PAR) and only few sites feature sensors for measuring diffuse PAR. Fractional*

cloud cover data is not readily available as it will require data generated by a human observer, complex instrumentation or from a satellite derived product. The model is primarily intended for aiding researchers in understanding ecosystem response in terms of carbon and energy exchange in relation to the diffuse PAR fraction with data recorded at the site. Hence we choose the variables collected at the site as independent variable for the model. We fully agree with the reviewer that cloud fraction has an important role in determining the diffuse fraction, but we feel that inclusion of clearness index as a model driver, which is related to the cloud fraction will account for the effects of cloud fraction.

Comment6: P1654, In 6: Why throw out data points of RH 100% then?

Response: Relative humidity of 100% indicates condensing conditions and this can cause dew/water droplets to form on the optics of the sensor. This can cause errors in the measurement of direct and diffuse radiation components from the BF3 sensor which is used in all the sites considered in this study. For the same reason we avoided all conditions when the rainfall exceeded 5 mm.

Comment7: P1654, In 16: Is there any wavelength dependence or plant type dependence of this albedo value and, if so, how is this treated considering that scattering (i.e.) the diffuse component is also dependent on wavelength.

Response: Albedo generally refers to the ratio of outgoing to incoming radiation in the shortwave range (0.15-4 μm). Albedo of vegetated surface can vary from 0.05 to 0.25 and for agricultural sites there can be changes in albedo as the crops gets harvested exposing the bare soil. Changing seasons can also influence albedo as a snowpack has a much higher albedo (0.4 to 0.95) compared to a vegetated surface. Since albedo is an indicator of surface changes, we included this as a driver for the model. PAR reflectivity would be an apt variable to use instead of albedo, but since this variable is not routinely measured at the flux sites, we used albedo which is more commonly available.

Comment8: P1655, In 5: It would also be logical to compare against the BRL model to show that the authors have actually made improvements to the basic algorithm.

Response: The BRL model is developed for estimating shortwave diffuse radiation fraction and so in its original form cannot be used to model diffuse PAR. In this work we are adopting the particular form of the equation which can capture the particular shape of the relationship between PAR diffuse fraction and PAR clearness index. Since we have to make comparison with a PAR diffuse fraction model, we selected a cubic model (Jacovides et al., 2009) to make a meaningful comparison.

Comment9: Pg1656, In 16-17: Is this due to the longer path length through the atmosphere increasing scattering? What is the ratio for diffuse/direct. This implies that the parameterization works well until the direct/diffuse falls below a certain threshold.

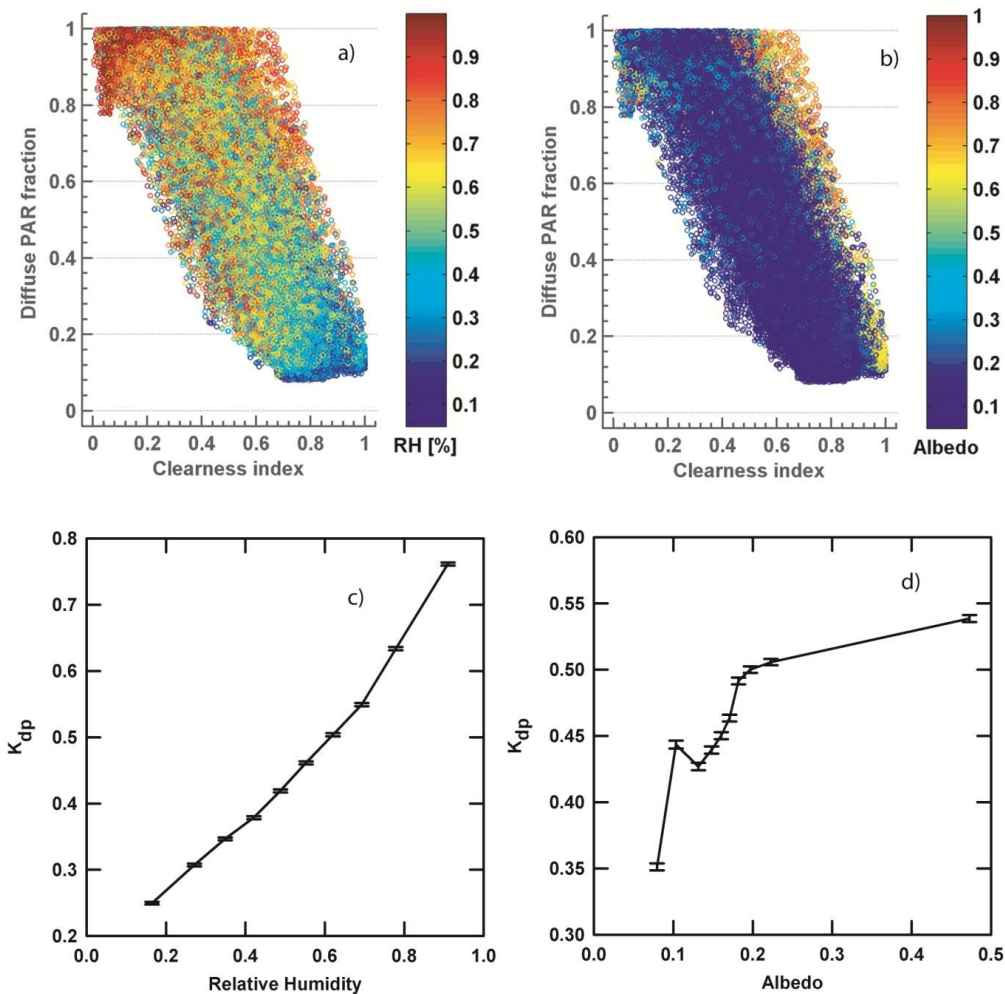
Response: The logistic model we develop under performs when we have higher solar elevation angles (noon time) and when the clearness index reaches a value around 0.7. This point represents a clear sky condition above which the diffuse PAR fraction stays constant with increasing total PAR. Other diffuse radiation models (piece wise regression) have used this transition point to (Leuning et al., 1995) prescribe different model coefficients. We are not completely sure about the reviewers question "what is the ratio for diffuse/direct", but we could improve the discussion session, by including more detailed explanations as given in the first few sentences of this response.

Comment10: Pg 1657, ln 1-5: This implies there should be a different set of co-efficient for each season. Why was this not done when it could improve the parameterization?

Response: Our main goal was to develop a very simple model to aid researchers in synthesizing the impact of diffuse PAR fraction on ecosystem carbon exchange. We agree with the reviewer that developing coefficients for each season will provide a much improved parameterization, but it will make the model difficult and cumbersome to use. The model in its presents form has 10 coefficients and seasonal fitting could increase them by four or five fold.

Comment11: Figures 1a and b are not presented well as this is a scatter plot masking any type of relationship between the parameters. The authors need to bin the data with respect to relative humidity.# and then provide a mean plus standard deviation of the data point.

New figures are added as shown below which have data binned into classes and presented as the reviewer requested.



Comment12: Figure 2: Same comment applies as for figure 1.

Response: *The Figure 2 represents the actual fit of the model to the data. Binning both the measured and modeled data will produce two lines and this will not reveal how the logistic model captures the variability in the diffuse fraction compared to the cubic model. The panels a) and b) reveal how the second fit corrects some of the errors which could occur with a single logistic fit. Hence we believe that scatter plots are more appropriate for this figure.*

Comment13: Figure 3: Suggests with the correct set of variables the negative bias could reach >25%? If true please expand the text related to Fig 3.

Response:

We can include the following text to explain things more clearly in this section.

The model underestimates the diffuse PAR fraction and the highest mean underestimation is about -15.7%. This was observed when the sine of the solar elevation angle was close to 1 (noon time) and when the clearness index value is about 0.7. These periods correspond with the lowest diffuse PAR fraction which can lead to uncertainties in the diffuse fraction measurement which could propagate to the model. Albedo values around 0.13 also produced large errors in the model prediction as this represents a mean value of most vegetated surface and factors other than albedo contributes to the model errors. Albedo plays an important role when the surface is more reflective increasing the diffuse PAR fraction.