

Reply to hess-7-C461-2010

Dear anonymous referee #2,

We are grateful to you for your valuable and fruitful comments that help to improve our manuscript (hess-2009-275). On behalf of co-authors, I reply to the interactive comments on our manuscript named “Evaluation of Penman-Monteith model applied to a maize field in the arid area of Northwest China” by you (hessd-7-C30-2010) as following:

Notes: The contents of reply to the comments from the anonymous Referee #1 by co-authors were marked with blue text.

General comments:

The manuscript evaluated two canopy resistance models using eddy covariance data. It is an interesting work, and the result may be helpful to improve the key parameters of P-M model in arid regions. However, this paper still needs a major revision.

Major comments:

(1) Eq. (2) is not reasonable. The stability correction function and roughness length for heat transfer should be derived for half-hour data. Please see Thom (1975) and Liu et al.(2007).

Assuming neutral stability conditions, the aerodynamic resistance can be computed by Monin-Obukhov similarity as:

$$r_a = \frac{\ln\left[\frac{(z-d)}{z_0}\right] \ln\left[\frac{(z-d)}{z_{oH}}\right]}{k^2} \cdot \frac{1}{u}$$

where z (m) is the reference level at which the horizontal wind speed u (m s^{-1}) is measured; d is the zero plane displacement height (m), and is taken equal to $0.67 h_c$ (Brutsaert, 1982); z_0 is the roughness length for momentum (m), approximated as $0.123 h_c$ (Brutsaert, 1982); z_{oH} is the roughness length governing transfer of heat and vapour (m); k is the von Karman’s constant, equal to 0.41.

The application of the equation for short time periods may require the inclusion of corrections for stability. Liu et al., (2007) have proposed the comprehensive approaches to determine r_a . However, Brutsaert (1982) suggested that z_0 is related to the mean height (h_c) of a crop canopy by the relationship $h_c/z_0=3*e$, where e is the natural number. So, the roughness parameters for z_0 to a crop can be estimated as:

$$z_0 = 0.123h_c$$

In addition, using $d+z_{oH}$ as the level of the evaporative surface can lead to overestimation of r_a (Pereira et al., 1999). Therefore, as an alternative, the aerodynamic resistance r_a can be computed from the top of the canopy as (Pereira, et al., 1999)

$$r_a = \frac{\ln\left[\frac{(z-d)}{z_0}\right] \ln\left[\frac{(z-d)}{(h_c-d)}\right]}{k^2} \cdot \frac{1}{u}$$

where h_c is the height of the crop (m).

This calculated value of r_a better reflect the logarithmic wind, vapour, and temperature profiles occurring over the crop surface (Pereira, et al., 1999). This adjustment partially compensates for differences which commonly occur between the stability correction and non-stability correction, and was applied widely for well-watered crop condition (Rana, et al., 1997; Katerji and Rana, 2006). In our study site, the volumetric soil water content was high and more than $0.27 \text{ m}^3\text{m}^{-3}$ in the root zone during the entire maize growing season. Therefore, the Pereira (1999) approach was applied to determine the aerodynamic resistance over the top of canopy in this study.

Even so, this adjustment access is not considered as the best solution to quantify accurately r_a , as well as “a big leaf” assumption. And more importantly, in the sections of “4.5 Diurnal variation of latent heat flux” and “5 Conclusion”, we have discussed the weakness of this calculated value of r_a using Monin-Obukhov similarity to estimate the aerodynamic resistance with the assumption of neutral stability, which affect the performance of P-M model in this study. We should increase our emphasis on further investigations and studies to determine r_a under stable and unstable conditions in the next work.

Therefore, we should add the results of new research proposed by Liu et al. (2007) into the section of “4.5” and “5”, and specify the uncertainties in simulating evapotranspiration in the crop field using P-M model.

In every case, we are grateful to the anonymous referee #2 for his/her valuable comments about the stability correction function and roughness length for heat transfer to determine r_a .

Reference

- Brutsaert, W.: Evaporation into the Atmosphere: Theory, History, and Application, Kluwer, Boston, 299pp., 1982.
- Pereira, L. S., Perrier, A., Allen, R. G., ASCE, M., Alves, I., 1999. Evapotranspiration: concepts and future trends. *Irrigation and Drainage Engineering*, 125, 45-51.
- Katerji, N., Rana, G., 2006. Modelling evapotranspiration of six irrigated crops under Mediterranean climate conditions. *Agricultural and Forest Meteorology*, 138, 142-155.
- Rana, G., Katerji, N., Mastrorilli, M., Moujabber, M., Brisson, N., 1997. Validation of a model of actual evapotranspiration for water stressed soybeans. *Agricultural and Forest Meteorology*, 86, 215-224.
- Liu S. M., Lu, L., Mao, D., Jia, L., 2007. Evaluating parameterizations of aerodynamic resistance to heat transfer using field measurements, *Hydrology and Earth System Sciences*, 11, 769-783.

(2) Eq.(11) is not right. Please check it.

Eq. (11) should be changed as

$$A_m = A_{m,\max} \left\{ 1 - e^{-[g_m(C_i - \Gamma)/A_{m,\max}]} \right\}$$

(3) Does the post-processing of flux data contain all the necessary corrections? Such as convert sonic temperature to actual temperature correction, frequency response correction, etc.

The post-processing of flux data includes all the necessary corrections, such as convert sonic temperature to actual temperature correction, frequency response correction, WPL correction. The detailed description can also be found in Kolle and Rebmann (2007).

Kolle, O., and Rebmann, C.: Eddysoft - Documentation of a Software Package to Acquire and Process Eddy Covariance Data, Jena, Technical Reports – Max-Planck-Institut für Biogeochemie 10, 85-88pp., 2007.

(4) The gaps of flux data have been filled by LUT or MDV method in the manuscript. Are these filling data used in the comparison in Fig.7? If the answer is yes, it is not suitable.

These filling data are not used in the comparison in Fig.7.

(5)The maximum air temperature is more than 46_C in Fig.4, it is too high. The site maximum temperature is 39.1_C in the site description (section 3.1).

Due to the air temperature data-entry mistake during the drawing program, Fig. 4 (c) is a wrong. We have changed the Fig. 4(c).

By the way, it deserves noting that the sensitivities of different sensor may be contributed to differences in air temperature data. For instance, in section 3.1, the air temperature was measured by a HMP45D temperature probe (Vaisala, Helsinki, Finland) with the maximum value of 39.1 °C, while in Fig. 4 (c), that was measured by Li-6400 (LI-COR Inc., Lincoln, NE, USA) with the maximum value of 39.6 °C. On the whole, however, the difference in air temperature measured by HMP45D and Li-6400 is very little in our study.

(6) How many is the Energy Balance Ratio (EBR) of flux data in Fig.7? When the measured and simulated latent heat fluxes are compared, the EBR should be taken into account.

During the maize growing season, the mean EBR was 86.23%, the energy balance closure deficit is likely to be small.

$$EBR = \frac{\sum(\lambda E + H)}{\sum(R_n - G - S)}$$

Therefore, we should take the energy balance closure into account, and add the descriptions of *EBR* into the section 4.5.

(7) Both of the two canopy resistance models are in agreement with the measurements under the dry soil condition, while under the wet soil condition, there are large scatters for J-D model in Fig. 7. Please explain it.

The J-D approach is based on plant physiology (i.e., leaf stomatal control is the quite complex and complicated process); the parameterization of J-D model may contribute to the uncertainty of the simulated results. For example, the actual minimum value of leaf stomatal resistance is very difficult to obtain, although many leaves were observed by Li-6400; for

scaling leaf stomatal resistance to bulk canopy resistance, it is assumed that the PAR decays exponentially as a function of the leaf area index, while, in fact, the distribution of PAR in the canopy profile is related to the angle and orientation of maize. So, there are large scatters for P-M model with J-D approach. And detailed description can be found in the section of “5. Conclusion”, and the statement about it may be slightly unclear, we should revise the description.

In general, the performance of P-M model with J-D bulk canopy approach was better than that with N-P approach when soil was dry before irrigation, and inversely is the case when soil was wet after irrigation.

Minor comments:

(1) There are many writing mistakes in the manuscript, and some sentences are not fluent. Page 462, line 6: “P-M mode” should be “P-M model”; Page 468, line 15-16: “ $T_{sk}=298$ ” should be “ $T_{sk}=298K$ ”; Page 470, line 27: “50 m apart”, what’s meaning? Page 476, line 23: “and inversely is the case when soil was wet after irrigation”, the sentence should be “and inversely when soil was wet after irrigation”.

Page 462, line 6: “P-M mode” should be “P-M model” indeed.

Page 468, line 15-16: “ $T_{sk}=298$ ” should be “ $T_c=298K$ ”.

Page 470, line 27: the sentence should be “Data were recorded on a personal computer inside of a small hut 50 m from the site”.

Page 476, line 23: the sentence should be “On the other hand, Fig. 8 also indicates the P-M model performed better with the J-D bulk canopy approach than with the N-P approach when the soil was dry (before irrigation). Under wet conditions after irrigation, the N-P approach yielded better results.”

(2) Do T_s in Eq.(6) and T_c in Eq.(12) represent surface/ leaf/canopy temperature? How to measure them?

The symbols of T_s in Eq. (6) and T_c in Eq. (12) represent surface (representative both canopy and soil) and canopy temperature, respectively. Surface and canopy temperature was measured with PS12AF1 surface Pyrometer (Keller HCM GmbH, Ibbenbüren-Laggenbeck, Germany). And the related description is found in the section of “3.2 Field measurements”.

In addition, the measured canopy temperature by PS12AF1 is in agreement with the actual canopy temperature when the canopy covers fully soil surface ($T_s \approx T_c$), while, it is found that there are some distortion when the canopy is sparse during the early stage of maize growing season. In order to resolve the problem, the regression relationship was established between canopy temperature and air temperature for the site and period when the canopy covers fully the soil surface. Then, the resulting equations were used to fill in the canopy temperature during the period of sparse canopy.

We should add the detailed description of T_s and T_c measurement.

(3) The instrument introduction of EVINS Environmental Monitoring system in page 471-472

seems confusable. I suggest a table should be listed.

We can reduce it and summarized in a table.