Response to Interactive comment on "Influence of wave phase difference between surface soil heat flux and soil surface temperature on land surface energy balance closure"

Dear Anonymous Referee #2

We greatly appreciate your efforts and your helpful comments in reviewing our article. We have incorporated all of your comments in the revised manuscript.

We respond below in blue to your comments item-by-item.

General comments: This paper gives some new thoughts on the way to solve (understand) the concerned 'surface energy balance closure failure'. However, it needs a substantial revision before it could be published. I was surprised by the major conclusion: 'The sum of sensible heat flux (H) and latent heat flux (LE) is always less than surface available energy (Rn-G0), even if all energy components are accurately measured, their footprints are strictly matched, and all corrections are made.' The first half of this saying (H+LE < Rn-G0) is commonly true in many filed measurements, especially with eddy-covariance method in the observation of H and E; But if with ': : :all corrections' made the problem is still kept, then the classical principle of 'energy conservation' would be negated?

It seems that we failed to provide a clear presentation of our new thoughts in the original article. Based upon your comments and those given by other reviewers, we added detailed explanations into the revised article.

Major comments:

1. The principle of 'energy conservation' is independent of neither spatial nor temporal scale. For a specific layer (volume) as concerned in 'surface energy balance' investigation, all possible budget components should be 'balanced' in any time scale, as commonly 10 minutes to one day, but not related to the changing phases of each component. The 'imbalance' is from, in present stage, the inabilities of observation instruments (including Eddy-covariance system) as well as data processing procedure.
2. In Section 2.2 of this paper, the authors assume that the components Rn, H, and LE 'have identical phases with soil surface temperature'. Even the authors mentioned later it is 'in reality not', following derivations were still based on the assumption. This is a misleading. The 'surface temperature' used in their analysis (as in Figure 6) was very likely measured by a 'radiation thermometer' or calculated from OLR (by a

downward long-wave radiometer). It is sure with the same phase as OLR. 'In reality', surface temperature measured by any direct method has always a phase delay to the Rn, meanwhile, the G0 is always in advance. The 'surface' we talked is not infinitesimal thin but actually a volume with some depth, where we investigate the energy budget.

We accept the principle of energy conservation. This revised article attempts to explain experimental energy balance closure failure. In energy balance closure analysis, we usually neglect the wave phase difference between surface energy components and soil surface temperature. For example, soil surface temperature (T) reaches its peak (Tmax) at about 12:00 (local time) while the corresponding Rn, H and LE may reach peak values at about 12:00 (local time), but the corresponding G0 probably occurs at about 10:00 (local) for a moist soil surface condition. For a dry soil surface, the corresponding G0 may occur at about 09:00 (local time). In this way, when we close surface energy components for T (12:00), we should use Rn (12:00), H(12:00), LE(12:00) and G0(09:00) rather than Rn (12:00), H(12:00), LE(12:00) and G0(12:00) for dry soil surfaces. The same principle applies to moist soil surfaces, in that we should use Rn (12:00), H(12:00), LE(12:00) and G0(t) for energy balance closure for T(12:00) where 9:00<t<12:00.

Minor comments:
1. P.1091, line 6. Please refer more recent papers by Foken. I suggest that the authors read carefully the recent papers by Foken et al., also the papers by Oncley et al., Jacobs et al, etc., to understand the issue in more depth.

Yes. We did that. We agree that Professor Foken and Drs. Oncley, and Jacob et al. did wonderful jobs in studying and explaining surface energy balance. Unfortunately, no one has yet to explain or elaborate on why surface energy components achieve better balance in the morning than in the afternoon. This paper just attempts to give an alterative perspective.

2. If the authors are going to prove their findings in section 2.2, then the theoretical basis described in Section 2.1.2 is enough. The complicated formulation in 2.1.1, although it was from an excellent work by the same author, just does not give more help here. The convection of liquid water in upper soil layer may have minor effect on the calculation of ground heat flux, but has almost no effect in proving the new finding in this paper.

Section 2.1.1 is important for forming a theoretical basis of the phase difference. This article does not address the issue that the convection of liquid water in upper soil layer influences ground heat flux calculation. The influence of convection of liquid water in the upper soil layer on ground heat flux calculation depends on soil water content and surface cover status.

3. P.1097 mentioned the calculations of H and LE by 'gradient + resistance' method (as the bulk method in many models). This is not the case commonly used in study the energy imbalance nowadays. Actually, people are very concerned the possible inability (and corrections) of eddy-covariance method in measuring fluxes, even it is still now the best method in flux observations.

The purpose of these sentences is only to support our assumption that both H and LE may have identical (or similar) diurnal phase variation as does the soil surface temperature. We did not state that the bulk method can be used in the study of the energy imbalance. We agree with the possible inability (and corrections) of eddy-covariance method in measuring fluxes, but this inability cannot help explain why surface energy components achieve better balance in the morning than in the afternoon. It means that further work must continue to identify the source of this imbalance.

4. The left of Figure 3 (i.e., before 10:30 the closure ration > 1, while in afternoon, <1) has no observation support.

Figure 3 is a theoretical result under the assumptions of Eqs. (9.1 through 9.3, and 9.4') for dry soil surfaces. Oncley *et al*. (2007) characterized the imbalance results obtained in the EBEX-2000 and found that the imbalance quickly grows to nearly its midday value although these sites are moist, which experimentally supports our Figure 3.

5. The data for Figure 6 may not be a good example. From the GAME-Tibet data web site, that day was not a 'clear' day, but with some cloud and even some rain in late afternoon. The result is that we could not clearly see the peaks of each energy component (and Tsfc). Even for GAME-Tibet, there are still plenty choices. You can also use those from the EBEX data set.

Yes, we reselected data collected on July 16, 2008, which was a sunny day, for our analysis, and accordingly revised the text and updated Figs. 4 and 5.