Anonymous Referee #1

This research presents estimations of the the radiative budget and surface energy balance calculated by combining remote sensing data (LANDSAT) with algorithms based on radiative and atmospheric surface layer theory. I think the results are potential very interesting due to the importance of the Tibetan plateau in hydrometeorological phenomena, and in addition due to the difficulty of these measurements due to the remote location and the extension of the plateau. However the lack of a systematic error analysis on the retrievals and the uncertainties associated to the applications of the algorithms make the results lacking the necessary robustness for that sort of studies. Closely related to this point, it is the use of only 8 LANDATA scenes which in my opinion it is not enough to obtain reliable statistics (figs 3 and 4). I recommend therefore that they elaborate and add this error analysis study and they add more scenes to do a more reliable intercomparison between in-situ and TESEBS. Below, I include some points that need to be addressed in agreement with my major concerns abovementioned:

Response: Because clouds often occur over the mountain area, we found the best 8 scenes in 2008 for this study. Another reason is TM/ETM sensor has a failure of the Scan Line Corrector from 2003. When the satellite data is selected, the meteorological dataset is also needed to check whether it has observation at the satellite passing over time. All these limited the number of TM/ETM data used in this study.

Meanwhile, if you have a look at figure 2, thousands of data points are included. The statistics values are reliable, especially the slope is around 1 and MB is -7.8W/m^2, which shows that the model perform well. Actually, another manuscript about the uncertainties of the algorithms was recently accepted for publishing in Journal of Applied Meteorology and Climatology (http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-12-056.1). The uncertainties were studied by sensitivity analysis. In that paper, we focused on improvement of the turbulent heat flux. While in this paper, the focus is on the radiation computation over complex topography. So most attention should be paid to the evaluation of radiation algorithm. Because TESEBS will be used by the remote sensing community, so we insist to evaluate the result based on satellite data and in-situ measurement. This limits the number of points in fig. 3 and 4.

1.- Soil heat flux (section 2.2) is very difficult to be measured. Could the authors provide some information on the error associated to the in-situ measurements and their estimations? (figure 4c)

Response: The ground heat flux is calculated from the heat flux plate, soil moisture and soil temperature. The soil heat flux at the surface is calculated by adding the measured flux at 10cm depth to the energy stored in the layer above the heat flux plates. The heat storage between the flux plate and surface was computed as a summation of heat storage in all the layers. The soil material was divided into mineral and water compounds. The organic contribution was not included in the computation of heat capacity due to absence of canopy above the station ground. The volumetric water content in the soil at 0cm, 0.1, 0.2, 0.4, 0.8, 1.6m depth were measured. The heat capacity was computed by:

$$C_{si} = C_d * (1 - \theta_{vi}) + \theta_{vi} * C_w \qquad (1)$$

where C_d is the heat capacity of a dry mineral soil ($1.9 \cdot 10^6$ J m^{-3}K^{-1}), θ_{vi} is soil water content on a volume basis, and C_w is the heat capacity of water ($4.12 \cdot 10^6$ J m^{-3}K^{-1}).

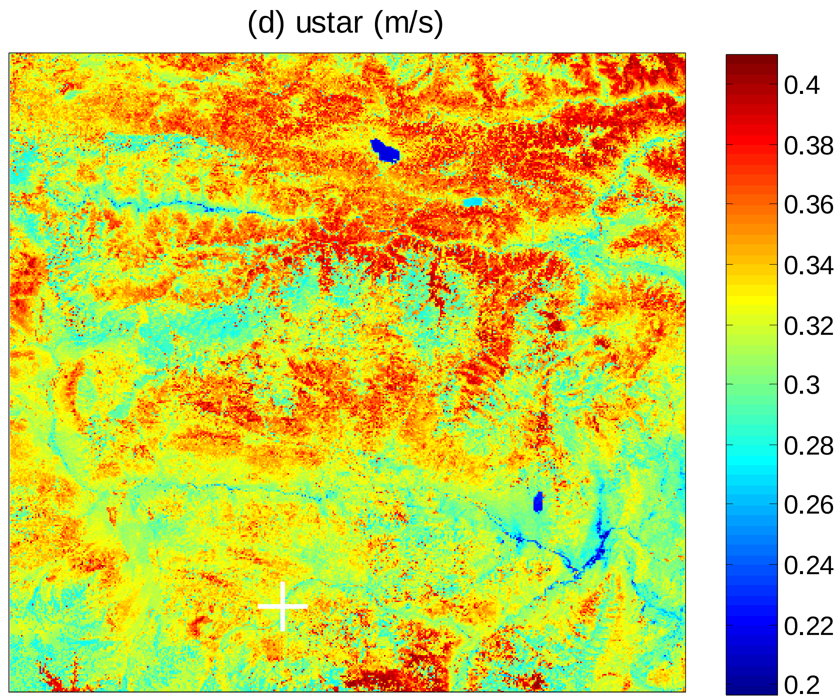
$$Gsfc = G10cm + \sum_{i=10cm}^{0cm} \frac{(\Delta Tsi * Csi * d)}{t} \qquad (2)$$

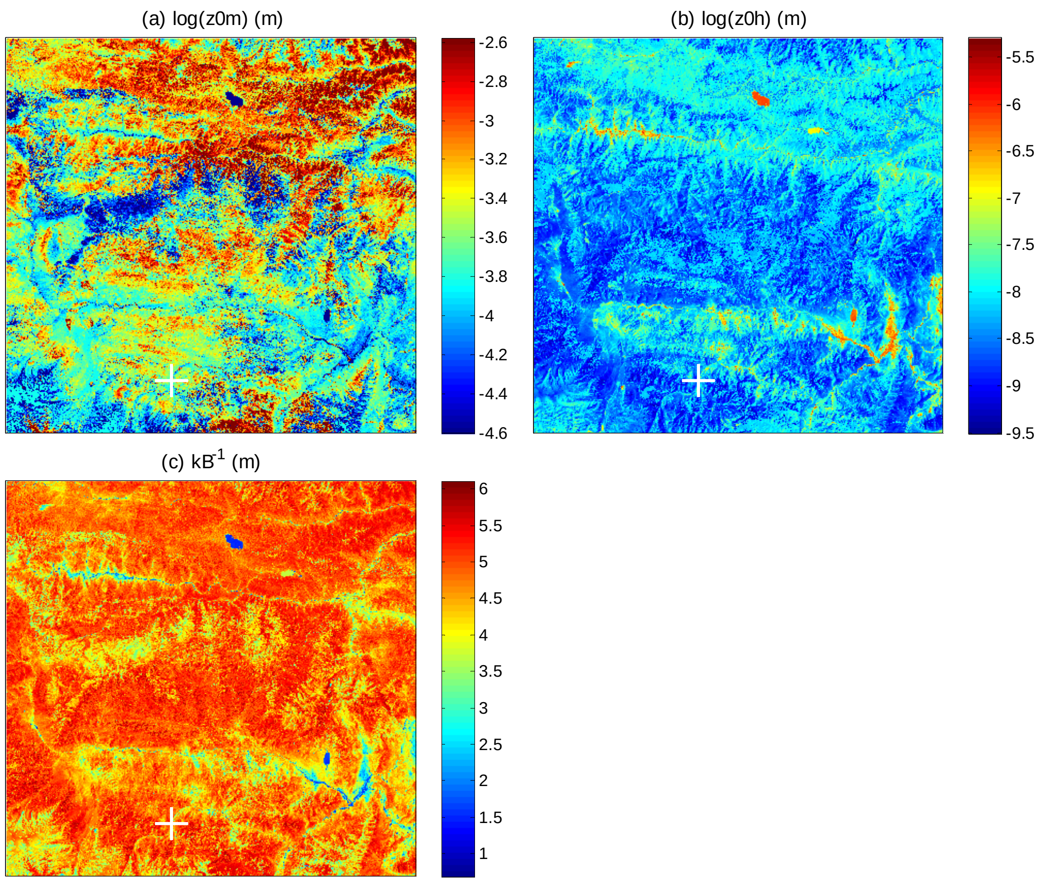
The d and t in equation 2 is given values of 0.01m and 1800s separately, ΔTsi is the temperature change of i soil layer in time t. $G10cm$ is the flux measured by the flux plate buried at 10 cm depth.
The soil temperature was measured at depths of 0, 10, 20, 40, 80 and 160 cm. The soil temperature and moisture were interpolated to 0.01m vertical resolution. The soil heat flux was measured using soil heat flux plates (HFP01) buried at a depth of 10 cm. The soil heat flux at the surface is calculated by adding the measured flux at 10cm depth to the energy stored in the layer above the heat flux plates.

2. The retrieval (section 2.3) of the heat flux depends on turbulent variables like the friction velocity that strongly depends on the location (in case of the in-situ measurements) or the model parameters (roughness lengths) and formulation. How do they account for these issues?
Response: As we know u* is related to the momentum roughness length (z0m) and meteorological condition, z0m was determined by the canopy height and structure. Massman 1997 has developed parameterization equations between momentrum transfer and canopy structure (characterized by constants C1, C2, C3, Cd and LAI). The relations were already shown in Su 2002. LAI needs to be derived by remote sensing. The canopy height is derived by the equation in our JAMC accepted paper:

$$HC = HC_{min} + \frac{HC_{max} - HC_{min}}{(NDVI_{max} - NDVI_{min})} * (NDVI - NDVI_{min}) \ ,$$

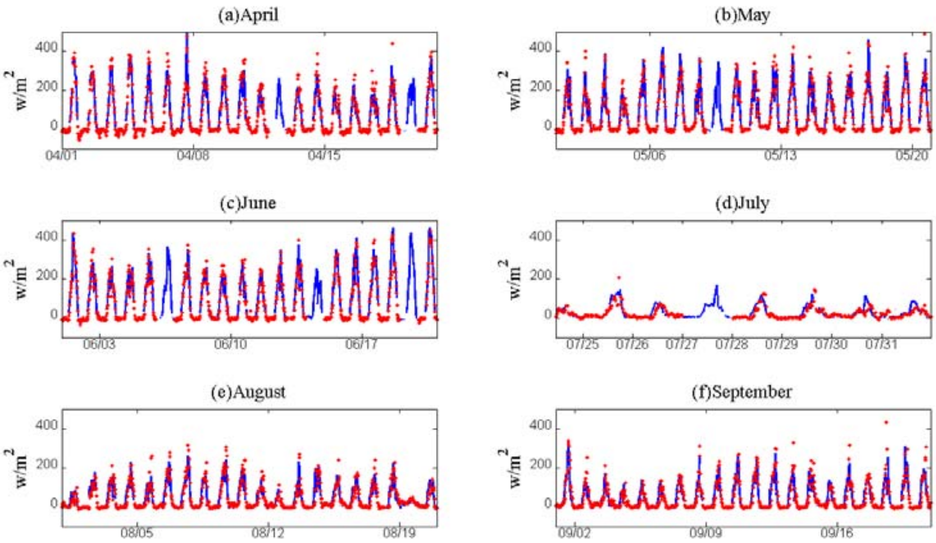
The canopy height (HC) distribution map is derived from NDVI. NDVI map comes from satellite observation. So in SEBS, u* is computed with the aid of remote sensing dataset. We think the heterogeneity of friction velocity can be described by considering the distribution of roughness length. The maps of friction velocity, z0m, z0h and KB_1 on 10:30 (LT) on 09 April 2010 were shown in the following two pictures. From these pictures, it can be seen that the roughness length distribution is consistent with topography and land covers.


(d) ustar (m/s)
0.4
0.38
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2

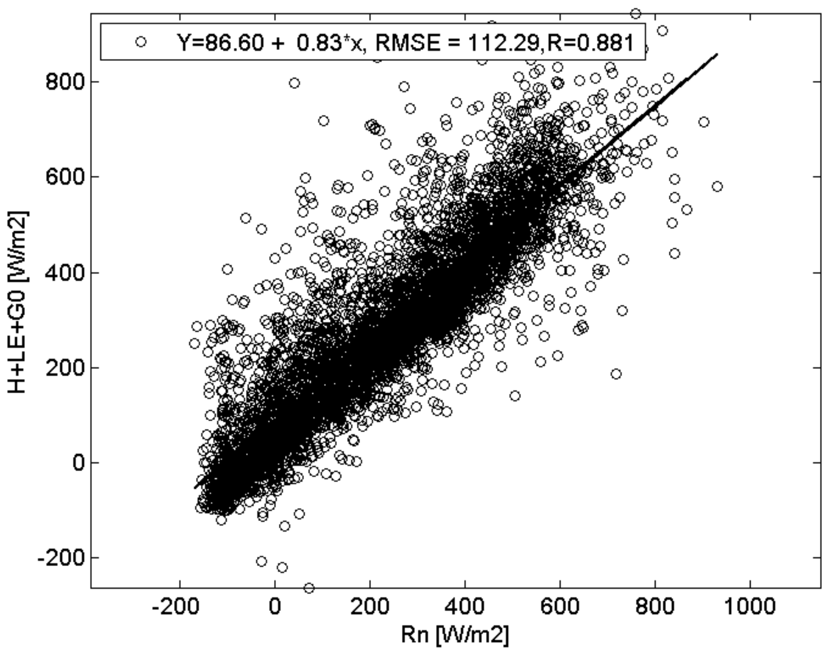

(a) log(z0m) (m)
-2.6
-2.8
-3
-3.2
-3.4
-3.6
-3.8
-4
-4.2
-4.4
-4.6
(b) log(z0h) (m)
-5.5
-6
-6.5
-7
-7.5
-8
-8.5
-9
-9.5
(c) kB^{-1} (m)
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1

3.- At section 3.3, they stated that the model TESEBS is capable to represent the temporal development of the surface energy balance (SEB). This discussion requires much more elaboration since the reader is left alone with quite a lot of questions:
- Is the SEB close? (in all the 8 cases) - What is the uncertainty error associated to the four components SEB? - What is the component with larger uncertainty?

Response: That TESEBS is capable to represent the temporal development of the surface energy balance is shown in the following picture, which will be published recently in JAMC. Time series of observed sensible heat flux was in blue line and SEBS output values was in red point.

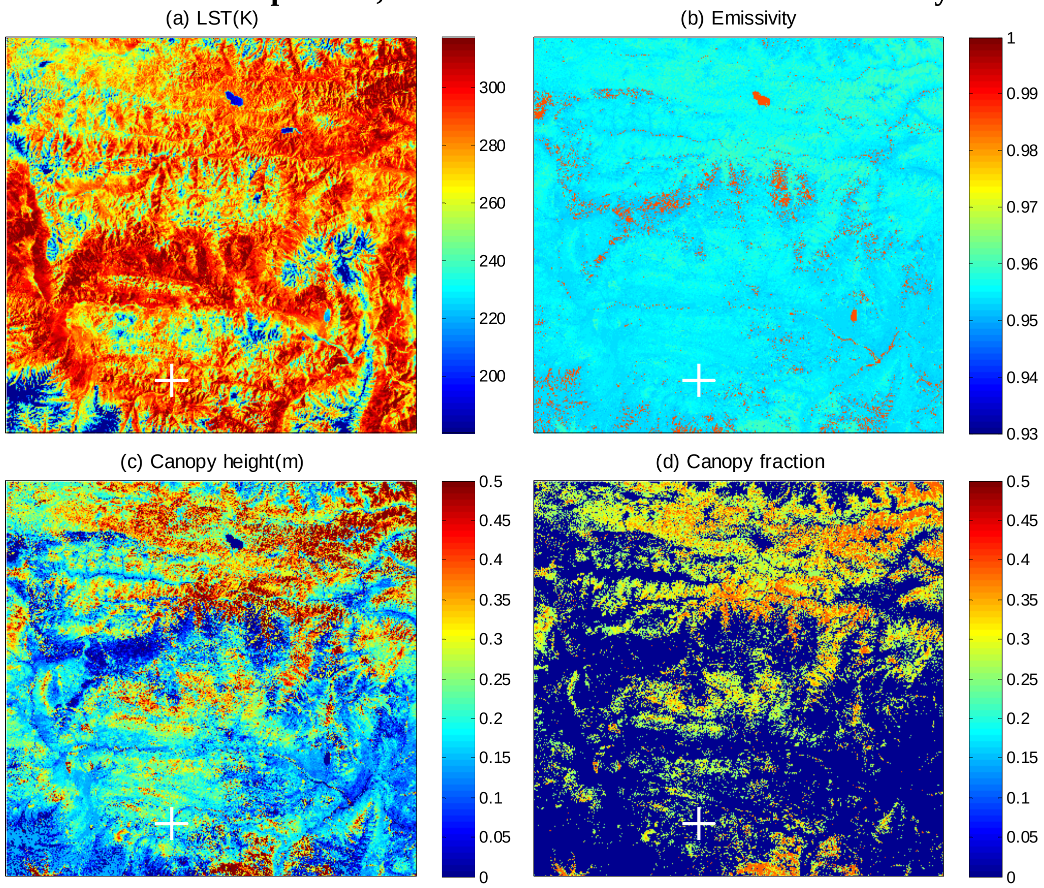


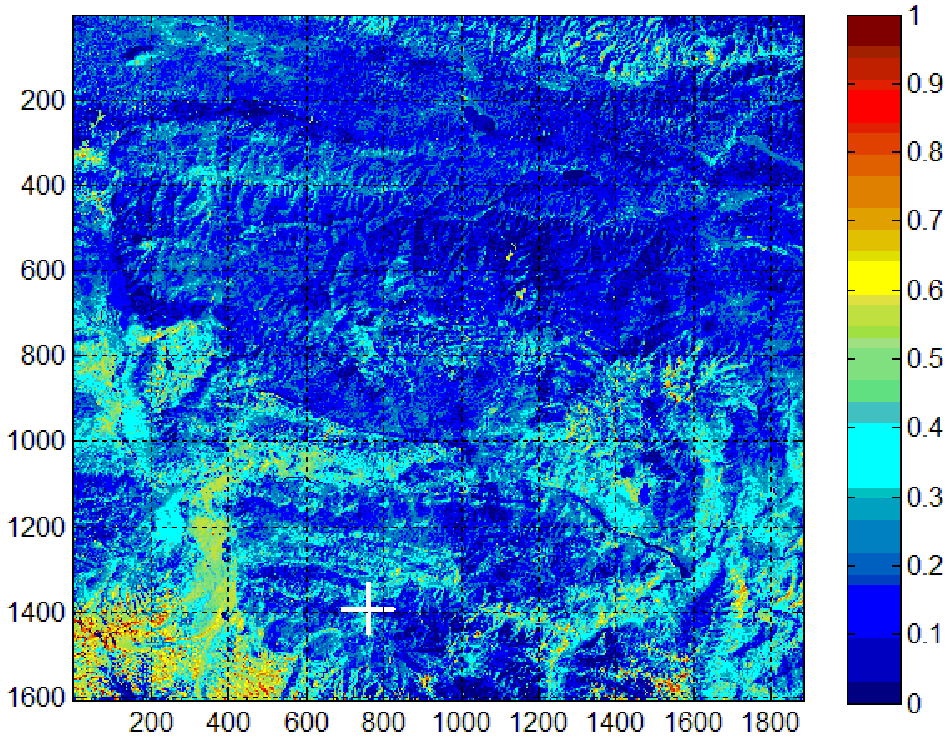
In most fluxes observation sites, the surface energy is unbalanced. The difference in the fluxes staion is the how much the energy is unbalanced. At our site, the energy balance is around 80%, which is normal compared to other fluxes station.It's also difficult to answer which one is the biggest uncertainty. What we are doing is trying to



improve accuracy of each item in the surface energy balance equation.

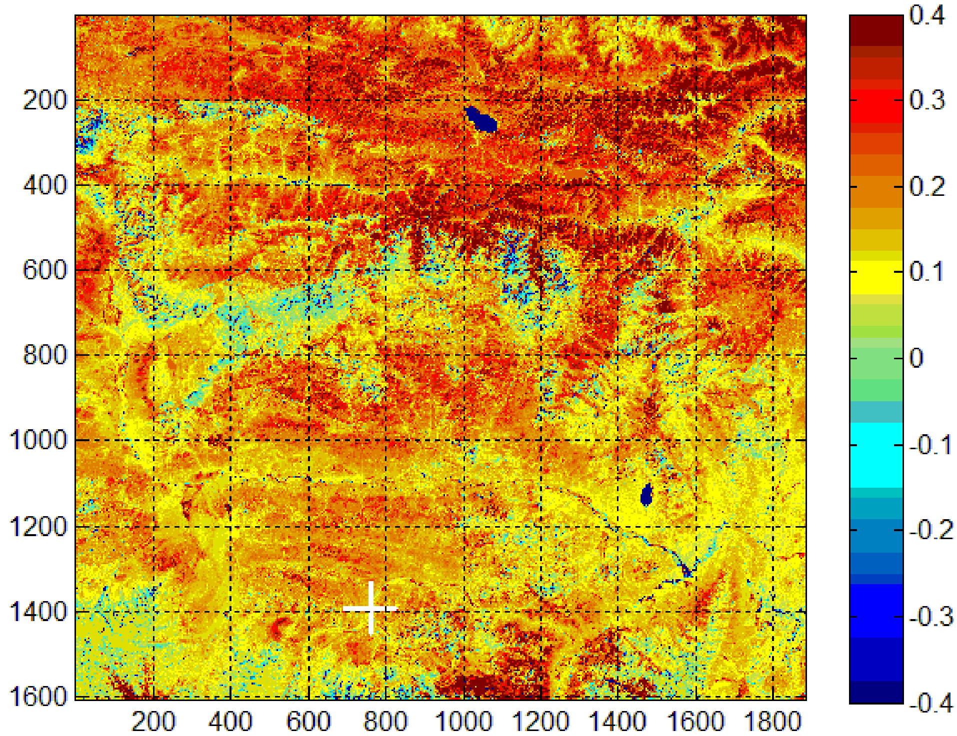
4.- In section 3.4 they addressed how to include land surface heterogeneity. The influence of the non-uniformity of the surface conditions (albedo, soil moisture, roughness length,...) depends strongly on the spatial scale of the heterogeneities. Which spatial scales of heterogeneity are they including? Are the relevant ones for their retrieval?
Response: The following spatial heterogeneity information has been considered. The variable includes: land surface temperature (LST), land surface emissivity, canopy height, canopy fraction, albedo, NDVI, and topographical heterogeneity (DEM, surface slope and aspect). In the method of deriving the surface radiation, the transmitivity distributed information is also included. The spatial heterogeneity of transmitivity for beam, diffuse and reflected radiation are also included separately. Spatial heterogeneity information of above each variable at 10:30 (LT) on 09 April 2010 are shown in the following pictures. By combing these heterogeneous information as much as possible, it`s taken as to be more close to the reality.



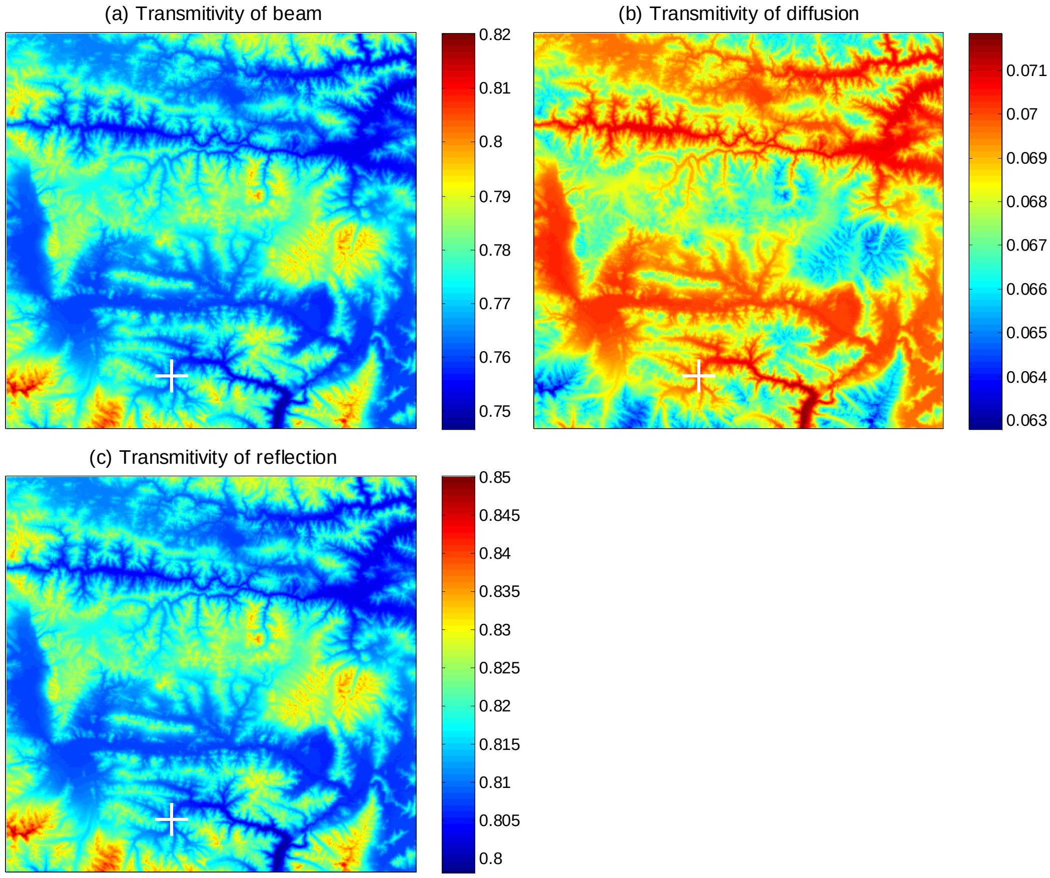


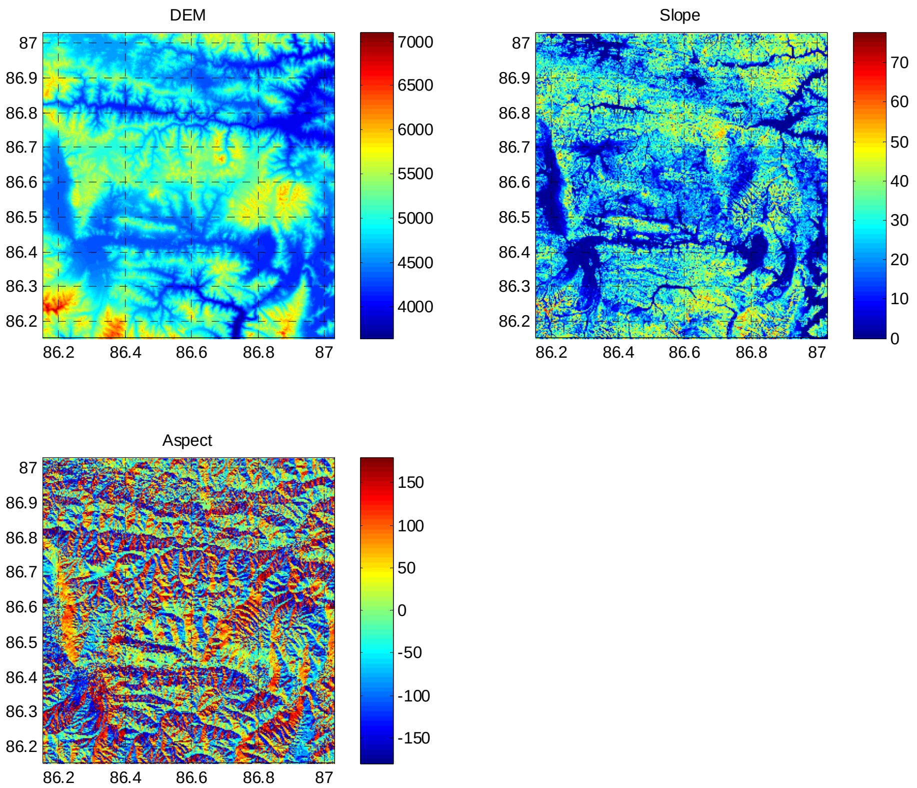
200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000
1200
1400
1600
1800
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Albedo


200
400
600
800
1000
1200
1400
1600
200
400
600
800
1000
1200
1400
1600
1800
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4

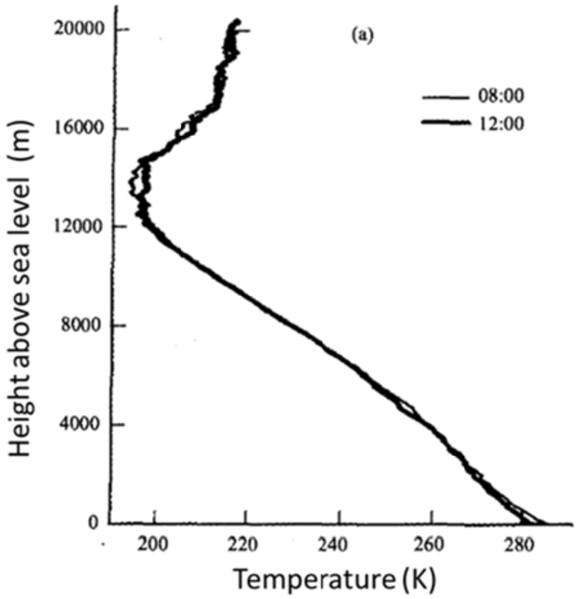
NDVI


(a) Transmitivity of beam
0.82
0.81
0.8
0.79
0.78
0.77
0.76
0.75
(b) Transmitivity of diffusion
0.071
0.07
0.069
0.068
0.067
0.066
0.065
0.064
0.063
(c) Transmitivity of reflection
0.85
0.845
0.84
0.835
0.83
0.825
0.82
0.815
0.81
0.805
0.8



5.- At section 3.5, they assumed a constant temperature lapse rate and boundary layer height. These assumptions are not well justified. A “back-of-the-envelope” calculations using the sensible heat flux estimated at Figure 1 shows that for values larger than 100 W/m2, one obtains boundary layer heights larger than 1200 m. They therefore need to further justify their assumptions and perform a sensitivity analysis of the radiative budget and SEB in case they apply different values.

Response: In 2007, it was observed that the average lapse rate of troposphere at this region is around 0.6 k/100m. The result is included in Chen X., Yaoming Ma etc. The Rainy Season Character of Troposphere at Mt. Qomolangma Region. *Plateau meteorology* (in Chinese). Vol. 26, p: 1280-1286, 2007. The figure is below:



The boundary layer height is an input variable for sensible heat flux calculation. Actually this parameter is used to judge whether MOS or BAS will be used to calculate sensible heat. According to experience, the difference is small. It`s not suggested to inversely adjust the boundary layer height according to magnitude of sensible heat flux in this study. The boundary layer height has no relations with radiative budget and other fluxes in TESEBS.

6.- As mentioned before, Figures 6 and 7 require a complete and thorough analysis of the errors associated to their estimation. By not including this information, the results are of difficult application.

Response: There are no solar beam, diffuse, and reflected radiation measurements at the station, which make it difficult to evaluate these three variables. The result in figure 7 is evaluated by in-situ observation which is shown in figure 3. Because the original code is developed one of the co-author. They already validated this method in several papers. So we take it feasible to be used here.