Geophysical Research Abstracts
Vol. 12, EGU2010-15256-3, 2010
EGU General Assembly 2010

Variation of effective roughness and validity of existing canopy flow models; an analysis of Monin-Obukhov Similarity Theory in Surface Energy Balance System (SEBS)

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Surface energy balance equations are the heart of physically based remote sensing evapotranspiration schemes. Although there was much efforts for quantification of energy balance components using in-situ or remote sensing measurements, importance of proper estimation of effective roughness parameters for momentum (z_{0m}) and heat (z_{0h}) transfer in flux-gradient relationships of Monin-Obukhov Similarity Theory (MOST) in many applications are left aside. The fact is that the effective roughness length for momentum (z_{0m}) and heat (z_{0h}) transfer are variable in time and space and quantification of their variability is of great importance. The objective of this research is to gain realistic values of roughness length. This entails a study in z_{0m} and kB^{-1}, as z_{0h} can be quantified through $z_{0h} = z_{0m}$/exp(kB^{-1}).

A simple iterative optimization scheme is utilized for retrieving effective roughness parameters from MET-FLUX tower measurements of SMEX02 and EAGLE2006 campaigns. Then, a comparison is made between optimized effective roughness parameters and an existing canopy flow model (Su, Schmugge et al. 2001).

Temporal variations of z_{0m} and z_{0h} revealed that they are changing during the course of day and during the crop phenological development and are sensitive to meteorological conditions as well as the source/sink states. Results showed that optimized z_{0m} and kB^{-1} values exceeding the constant values proposed in the literatures.

Comparison with (Su, Schmugge et al. 2001) model revealed that even with the best observed meteorological and crop phenological parameters required by this model and with the use of direct MOST equations (excluding the need for net radiation and soil heat flux), there are differences between the results of this model and optimized ones. (Su, Schmugge et al. 2001) model shows constant z_{0m} (0.02 for soybean and 0.07 for corn) and kB^{-1} (5.5 for soybean and 6 for corn) while their actual respective (optimized) z_{0m} values reach to 0.11 (for soybean) and 0.6 (for corn) and corresponding kB^{-1} values to 13 (for soybean) and 10 (for corn). Using the modeled values instead of retrieved values result an error of $27Wm^{-2}$ in calculation of sensible heat flux for both crops. Finally, an analysis of the effectiveness of the assumed equations and their constant coefficients is made.

Su, Z., T. Schmugge, et al. (2001). "An Evaluation of Two Models for Estimation of the Roughness Height for Heat Transfer between the Land Surface and the Atmosphere." Journal of Applied Meteorology 40(11) 1933 – 1951.