P1.12 ANALYSIS OF DIURNAL EVAPORATIVE FRACTION BEHAVIOR

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INTRODUCTION

Many experimental and modeling studies have stated that the evaporative fraction (EF), which is the ration between the latent heat flux and the available energy at the surface, could be assumed as a diurnal constant.

On the one hand, few experimental studies are available, and generally those studies are limited to a few days of measures, because it is both expensive and difficult to maintain long term fluxes measurement. On the other hand, the several existing modeling studies generally assumed a one-source Penman-Monteith modeling of evapotranspiration and a soil heat flux expressed as a fraction of the incoming net radiation. However, first the effect of vegetation cover is important on EF, therefore a Penman-Monteith approach can only give partial information on the EF behavior. Second, the natural phase difference between soil heat flux and net radiation can lead to dramatic change in EF value, and cannot be overlooked, even with high vegetation cover.

1. MODEL DESCRIPTION

In this study, we have been using a double-source Soil Vegetation Atmosphere Transfer model with a diffusive representation of the soil. This model is dubbed ICARE SVAT and was created in the framework of the SUDMED project in Marrakech, Morocco, by Gentine P., Chehbouni A., Boulet G., and Merlin. O, in 2002-2003.This model is particularly adapted to study sparse vegetation especially in semi-arid regions. The main parameters of the model were calibrated either in situ or using fluxes and temperatures measurements on 2 wheat parcels located nearby Marrakech, in 2002-2003. This model will help us understanding the functioning of both the soil and canopy contribution to EF. The following parts exhibit the result of the SVAT EF output for different LAI, soil moisture and climatic conditions.

2. EF DIURNAL COURSE

2.1 LAI and soil moisture dependence

Evaporative fraction exhibits a typical concave-up shape with a minimum generally located at 1PM, as seen on Fig. 1. First EF is shown to be a strongly increasing function of soil water content, as expected. Second EF is only weakly increasing with Leaf Area Index. Moreover, the EF diurnal behavior is clearly anti-symmetrical. For high soil moisture contents, EF is pretty constant in the early morning; however EF increases sharply in the afternoon. Therefore, if EF is assumed to be constant and determined in the midst of the day, this will underestimate evapotranspiration (ET). On the other side, the diurnal course of EF is pretty different for low soil moisture values. EF is sharply decreasing in the early morning and is more symmetrical than in the high soil moisture, with a pretty equivalent increase in the late afternoon. Again an estimation of the value of EF in the midst of the day and assuming it to remain constant, would lead to an underestimation of evapotranspiration.

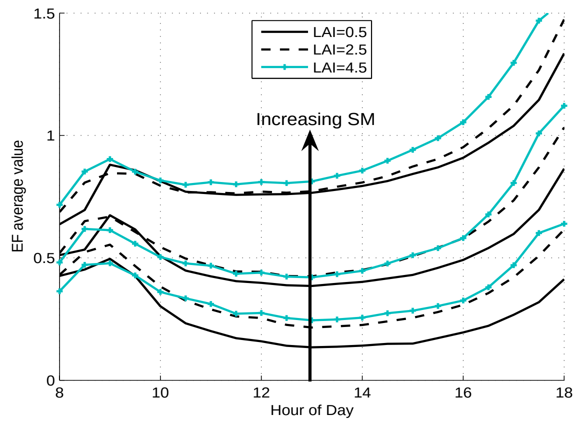

Fig. 1: Mean diurnal cycle of modeled Evaporative Fraction, from January 4th 2003 to May 21st 2003, for constant surface soil moisture (SM) values of 0.1, 0.2 and 0.3 $m^3.m^{-3}$, and constant LAI values of 0.5, 2.5 and 4.5.

2.2 Soil and vegetation influence

The general anti-symmetrical course of EF is due to 2 main factors. First the soil and canopy influence on EF will depend on the considered time of the day. The soil canopy evaporative fraction, which is defined as the ratio between the soil evaporation and the available energy at the ground surface, is generally increasing in the early morning. Then it is slowly decreasing during the rest of the day until it sharply increases before sunset. The canopy evaporative fraction, which is defined as the ratio between the plant transpiration and the net radiation of the canopy, is pretty constant during the first part of the day and tends to increase sharply in

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the afternoon. Thereby, the EF non constancy is mainly due to the soil response in the morning whereas the sharp increase in the late afternoon is principally due to the canopy component.

2.3 Heat flux phase difference repercussion

The second factor contributing to the EF anti-symmetry is the phase difference between the net radiation and the soil heat flux. In most recent EF modeling studies, the soil heat flux was expressed as a fraction of the net radiation f.Rn. However, it has been shown [Santanello & Friedl 2003], that the soil heat flux G is clearly anti-symmetrical during the day. G is usually maximum in the mid-morning and minimum, and even negative, in the second part of the afternoon. As seen on Fig. 2, the net radiation Rn is generally maximum at 12PM, solar time. Therefore using G as a fraction of Rn, will generally lead to an underestimation of the soil heat flux in the morning and an overestimation in the afternoon. Consequently, EF using G=f.Rn, will underestimate EF in the morning and overestimate EF in the afternoon. Moreover a proportionality assumption won't be able to take into account the anti-symmetrical behavior of EF and its sharp decrease in the early morning, and reciprocally its sharp increase in the late afternoon.

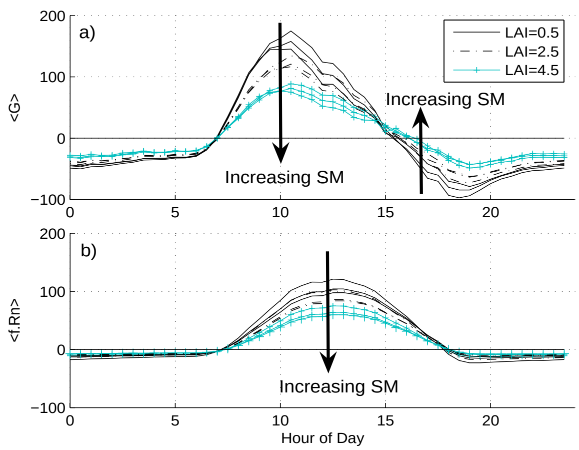

Fig. 2: Mean daily cycle of the SVAT modeled soil heat flux (a) and soil heat flux taken as fraction of the net radiation (b); for soil surface moisture values of 0.1, 0.2, 0.3 $m^3.m^{-3}$.

3. ENVIRONMENTAL FACTORS

To really understand EF, the consequence of a change in meteorological forcing (such as wind speed, air temperature, solar incoming radiation, specific moisture) has also been investigated. Therefore, the cross-correlation of EF and the different climatic factors has been calculated for different LAI, and using the natural dynamic of soil moisture. This cross-correlation enables us to have more physical understanding of the EF behavior. One of the results is that EF is almost insensitive to any wind speed variation confirming Lhomme's [1999] results. Another important result is that EF is extremely correlated to the difference between the nadir radiative temperature and the air temperature. This constitutes an important result for remote sensing application of EF. Thereby, this temperature difference could be used as an indicator of the EF value.

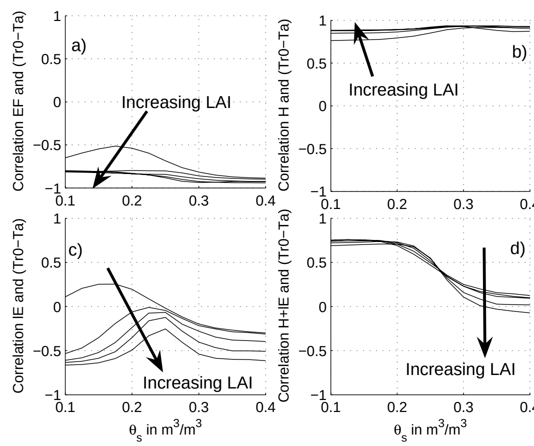

Fig. 3: Cross-correlation between (a) EF, (b) H, (c) lE, (d)H+lE and the difference between the radiative and air temperatures over the January 4th-May 21st 2003 modeling period for constant LAI values of 0.5, 1.5, 2.5, 3.5 and 4.5.

CONCLUSION

It has been found in this study that EF constancy assumption can lead to pretty large evapotranspiration estimation errors. This error is first due to the diurnal different response of the soil and canopy to the incoming energy. Moreover, the phase difference between the soil heat flux and net radiation has to be taken into account to avoid large EF modeling errors. The meteorological factors tend to have some very different impact on EF and will be discussed. Finally, the repercussion of the constant EF assumption on evapotranspiration will be discussed during the presentation.

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