

## ***Interactive comment on “A conceptual dynamic vegetation-soil model for arid and semiarid zones” by D. I. Quevedo and F. Francés***

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General comments

- i) The aim of this paper is to represent the vegetation dynamics with a conceptual dynamic vegetation-soil model (CDVSM).
- ii) The review of the vegetation modelling is quite exhaustive as well as the model description.
- iii) The key point of the paper is the relation which links the relative biomass production with the effective transpiration  $T$  and the vegetation water stress (VWS) [Daly, et al., 2004].

iv) The model parameter was calibrated using annual relative biomass data. Then a sensitive analysis of CDVSM is proposed in order to investigate on the role of soil types, effective root depth, precipitation and potential evapotranspiration on the relative biomass production.

v) Further analysis shows the variations of relative biomass production along the year, recording its maximum value in spring and minimum in autumn.

#### Specific comments

i) Two tanks interconnected were considered using the water balance equation and the appropriate dynamic equation for all considered fluxes. The first one for the interception and the second one for the upper soil moisture modelling. In my opinion the use of the first tank is not necessary. In many works [Laio, et al., 2001] a simple threshold is used for this purpose.

Many authors, as Laio et al. (2001) and ourselves, use a threshold to simulate the interception process. In our case, the threshold is represented by the volume of this first tank (see eq. 1). Due to the strong dependence between the water intercepted and the biomass, this tank must be explicitly considered and its total capacity must be related with the biomass dynamic (R in eq. 1 and the computation of  $I_{mx}$  with eq. 11).

ii) While the model calibration is carried out at annual scale, nothing is said about the seasonal variability of the rain, the maximum net assimilation and the potential transpiration rate. It is not clear if the seasonal variability is considered (or not?) at monthly scale (as shown in figure 3) or if 4 seasons are considered (as in figure 6). Those information are fundamental for the soil moisture reproduction and consequently for the estimation of vegetation water stress.

Seasonal variability is taken into account in the simulation, since the model time discretization is always daily. Therefore, the precipitation and potential evapotranspiration inputs have this temporal scale.

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Concerning the maximum net assimilation,  $A_{n,mx}$ , it is a vegetation parameter (eq. 8) and in the final calibrated model is not a function of the season. Actually the model has the possibility of an  $A_{n,mx}$  as a function of the daily temperature. However, not significant improvements were obtained in the case study compared with a constant value, because the temperature range in the study area is not in fact a restrictive factor: as it is shown in Figure 3, the mean daily temperature is always above 10°C.

In Figure 3 we want to show the intra-annual behaviour of precipitation, potential evapotranspiration, mean, minimum and maximum temperature. This figure was made using the inputs daily series of each variable. In Figure 6, we show the behaviour of relative biomass, vegetation water stress, transpiration, bare-soil evaporation and available water content for each season. This figure was made using also the daily results from simulation model.

iii) The model gives the same order of magnitude of the relative biomass production (figure 4). It does not seem to reproduce the historical sequence and consequently the dependence from the soil moisture dynamics.

In Figure 4 we show the evolution of the leaf biomass ( $R$  times  $B_{pot}$ ) along the 36 years of simulation at daily scale. After stabilization (around 1975), the oscillations in leaf biomass are due to the available water's dynamic ( $H_2$ ). The 18 dots (two of them are superimposed) in this figure are the mean values of around 20 measurements of leaf biomass after a fire in different locations with similar climate obtained by Cañellas and San Miguel (2000) with an age after a fire assignment. Therefore, these data can not reproduce the particular daily hydrometeorology of our location, but can be used (and it was used) to calibrate the vegetation evolution starting from no vegetation at annual scale. In particular, it was calibrated the exponent  $c$  in eq. 8, which is the most unknown parameter.

iv) Moreover must be pointed out that the VWS as defined in eq. (8) is a static definition of vegetation water stress. Since the calibration is done at annual scale, the dynamic

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water stress [Porporato, et al., 2001] seems to be more appropriate.

In spite of calibration was done at annual scale, is very important to keep in mind that simulation discretization is daily, so, the static definition of vegetation water stress estimated at daily scale is the proper one to represent its dynamic.

v) The sensitive analysis, which is the core of this study, is very interesting. Here, a single mean annual potential evapotranspiration (PET) of 1250mm and a single value of annual precipitation (P) of 514 mm are used. It is not specified if and how a seasonal variability of the latter is considered. If not, the results could differ a lot.

The values of 1251.75 and 511.45 mm, are referred to mean annual values of potential evapotranspiration and precipitation, obtained from the original daily series. In the sensitive analysis, the simulations were done changing the daily PET and P proportionally to each mean annual value.

vi) The results concerning the PET influence should be emphasized. Reducing the PET the mean soil moisture content increase exponentially, thus producing a reduction of VWS. The latter should imply an increase of R, while it seems insensitive.

The referee is right; this is a very interesting result. In equation 8, we can see that leaf biomass production (related with the relative biomass production dR) depends on transpiration (T) for the growth and vegetation water stress (VWS) for losses. At the same time, T is limited by potential evapotranspiration (PET) and the previous evaporation from interception (Y1), as it is shown in eq. 4. Also, the temporal variability of PET and P must be considered in the actual system response.

In the case study if PET is reduced, T is also reduced in spite of the available water (H2) and relative biomass (R) increase (Figure 5d). This response is because:

a) A reduction of available energy for evapotranspiration (PET) is restrictive for the actual transpiration b) The increase in available water (or reduction in VWS) reduces the leaf losses, much more than the reduction in leaf production due to the reduction of T,

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resulting in a positive increase in leaf biomass

And the contrary is also interesting due to the implications in a climate change scenario with higher temperatures and higher PET: there is an increase in T but a small decrease in R.

These results will be stressed in the new text.

vii) In the section 5 seasonal vegetation behaviour is discussed, so the rain, the temperature and the maximum net assimilation are implicitly considered as time dependent. Please specify those climate parameters (the same as in figure 3?).

As it is explained in the first paragraph of this section we simulate with the same set of parameters reported in table 1, the same climatic conditions showed in figure 3, but with an initial condition of R equal to 0.73.

viii) The seasonal assimilation dynamic is conceptually well reproduced, but there are no data to demonstrate this result. The R minimum should be in the winter season because of the dormancy. Instead the authors find a minimum in autumn. This particular behaviour could be related to the seasonality of the maximum net assimilation, which is not declared.

Unfortunately, in Figure 6 seasons are defined for complete months, i.e.: the whole September was considered as autumn. With the proper initiation for each season, the minimum leaf biomass (related with R) is in summer, as we expected. Temperature is introduced in the model through PET and the possibility of a variable  $A_n$ ,  $m_x$ . There is not a minimum in winter by dormancy, because the temperature range in the area is not a restrictive factor in winter.

Figure 6 does not include the leaf biomass production, which can be related to  $dR$ , and it can be confused with the actual leaf biomass (related to R). Next Table reproduces the monthly means for P (precipitation), H2 (available soil water content),  $dR$  and R:

Month	P [mm]	H2 [mm]	$dR/dt$ [-]	R [-]
1	54.92	20.99	3.46E-04	0.754
2	45.71	17.73		

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2.21E-04 0.763 3 44.04 13.69 8.54E-05 0.767 4 50.73 10.98 1.26E-05 0.768 5 38.87  
9.27 -3.01E-04 0.764 6 26.06 6.34 -3.29E-04 0.754 7 13.02 2.32 -3.65E-04 0.744 8  
22.91 4.11 -2.04E-04 0.714 9 73.72 10.29 1.02E-04 0.712 10 106.39 17.35 3.28E-04  
0.719 11 69.55 21.75 4.39E-04 0.731 12 65.34 21.87 3.84E-04 0.744

As it is shown in the previous table, R has a maximum in April and a minimum in September. Concerning the biomass production (dR) the maximum is in November and the minimum is in July. Despite the leaf production is higher, there is less biomass in autumn than in winter because the initial R at the beginning of autumn is the minimum value. These results are in agreement with our knowledge about the phenology of the *Quercus coccifera* L. for the climate represented by the meteorological series used in this work.

On the other hand, the precipitation series is characterized by presenting a maximum in October and a minimum in July and the soil moisture has a maximum in December and a minimum in July.

Obviously, the differences between the inputs and outputs must be explained by the complete model conceptualization, but it seems clear the biomass (R) and biomass production (dR) of our model applied in the study area has a strong dependence on available water content (state variable) and precipitation (input variable).

The biomass production (dR) will be added in the corrected Figure 6, and the previous table with the mean monthly values and some comments will be introduced in the final text.

Technical corrections

i) The figure 2 is not necessary. Cite [Rodriguez-Iturbe and Porporato, 2004]

The figure will be eliminated.

ii) In figure 4 it would be useful to specify the (RMSE) of annual relative biomass simulated with CDVSM compared with biomass field observations (also in the text)

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The RMSE is equal to 0.49 and will be added in the text.

iii) Daly, E., et al. (2004), Coupled dynamics of photosynthesis, transpiration, and soil water balance. Part II: Stochastic analysis and ecohydrological significance, *Journal of Hydrometeorology*, 5, 559-566.

Corrected.

iv) Laio, F., et al. (2001), Plants in water-controlled ecosystems: active role in hydrologic processes and response to water stress - II. Probabilistic soil moisture dynamics, *Advances in Water Resources*, 24, 707-723.

Corrected.

v) Porporato, A., et al. (2001), Plants in water-controlled ecosystems: active role in hydrologic processes and response to water stress - III. Vegetation water stress, *Advances in Water Resources*, 24, 725-744.

Corrected.

vi) Rodriguez-Iturbe, I., and A. Porporato (2004), *Ecohydrology of water-controlled ecosystems: soil moisture and plant dynamics*, Cambridge University Press, Cambridge.

Corrected.

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