Biogeosciences Discuss., 8, C5282–C5291, 2012
www.biogeosciences-discuss.net/8/C5282/2012/

Biogeosciences Discussions

Interactive comment on "Process based model sheds light on climate signal of mediterranean tree rings" *by* R. Touchan et al.

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Received and published: 12 January 2012

In this manuscript, Touchan and Co-Authors investigate whether tree-ring width chronology of *Pinus halepensis* from Tunisia can be accurate simulated as a function of climate alone, using a mechanistic model. The manuscript is quantifying the importance of several environmental factors to simulate tree-growth of *P. halepensis* using a multi-parameter mechanistic model. These factors are day length and daily temperature and precipitation. The process-based model used for this study is the Vaganov-Shashkin model (VS-model) of tree-ring formation. Previous studies have already evaluated the ability of this model to estimate tree growth and the model is now becoming widely used.

General comments

The title of the manuscript reflects its content. The study is technically adequate and well written. However as a general consideration, I found that the Authors do not explain their criteria to choose the model's parameters and do not relate the current findings with the Mediterranean literature. These are in fact my major concerns related to this manuscript. But, I am confident that the Authors can easily solve it by adding additional information to the manuscript.

Specific comments

1. Although the manuscript is clearly organized, the description of the model might be slightly improved. I would suggest that the Authors give some bibliographic support for the choice of some parameters, since this selection is a crucial step to obtain a robust model. For example, the value of "Minimum cambial cell growth rate" (*Vcr*) is of extreme importance to understand the behavior of tree growth throughout the year:

Vcr = 0.2 -> One short growing season (in spring) with winter dormancy in cambial activity (temperate Mediterranean type).

Vcr = 0.1 (the value selected by the Authors) -> Tree with a double stop (in winter and summer) and two growth peaks (spring and autumn), that is the typical bimodal growth of some trees in the Mediterranean areas (adapted Mediterranean type).

Vcr = 0.05 -> Only one stop (in summer) and a bimodal growth pattern.

Vcr = 0.005 -> Tree growth all year round.

Curiously, these values of *Vcr* identify the four types of tree-growth proposed by Cherubini et al. (2003) for tree-ring formation in Mediterranean environments (after, Liphschitz and Lev-Yadun 1986). Additionally, the duration of the growing season is extremely dependent on the parameters of the model (e.g. *Vcr*).

2. In the discussion of the results, the Authors underline that the "high positive cor-

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relation ($r = 0.63$, $p < 0.001$)" found between the initial chronology and the estimated chronology for the verification period (1959-1981) "confirms that VS-model can be used to estimate a non-linear tree-growth response to climate changes in the past for specific local drought conditions". However, no comparison with the traditional "response functions" was performed. Could the Authors compare the VS-model with the "response functions"? This kind of comparison could support the idea that the VS-model performs better than "response functions", when both temperature and precipitation could be the limiting factor (see Fig. 3).

Throughout the discussion the Authors compare their results with only two previous studies, those from Kleeberg and Koplitz-Weissgerber (1983) and Vaganov et al. (2006). Please relate your findings with those of Anchukaitis et al. (2006), Evans et al. (2006), Vaganov et al. (2006), Touchan et al. (2008), de Luis et al. (2011), Nijland et al. (2011) and Touchan et al. (2011). Additionally, a reduced number of references was used (27), and some of them are quite old (Page 11096 Line 29, Page 11097 Lines 1, 19, 21, 31, Page 11098 Lines 15, from 1955 to 1989). The update of the literature should be done and some Mediterranean studies included in the Discussion section.

3. The Authors considered that the growing season "is assumed to end [in June-July] when the integral growth rate Gr(t) falls below 0.1". They explained that the cause why "growth does not resume is day-length (or solar irradiance), which decreases in September", "despite partial growth rates gT(t) and gw(t) being favorable for resumption of growth again after August (Fig. 4)". However it is now largely recognized, or at least suggested, that cambial activity in *Pinus* species could occur all year round. According to de Luis et al. (2011) "the duration of the growing season might be extended up to 11 months in *P. halepensis* in warm semiarid conditions of Spain". It should be discussed why it is not the case here.

4. Moreover, how many missing rings or intra-annual density fluctuations (IADFs) were found? Trees from Mediterranean environments with recurrent summer drought easily produce IADFs. According to de Luis et al. (2011) "in summer, the cambial cell pro-

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duction occurred at a very low rate, but an increased production of xylem cells took place in September when the amount of precipitation was twice as high as the long term average". This kind of relation between late summer precipitation and the IADFs formation was found in *Pinus* species elsewhere (Campelo et al. 2007; Vieira et al. 2009; de Luis et al. 2011). Therefore I suggest that IADFs occurrence and the second growth peak (see Fig. 4) should be discussed. Please add more comments on the capacity of this mechanistic model to detect intra-annual changes in the lumen area of tracheids (IADFs). These points are crucial to the whole study. Please reassure the Readers about all of these points.

5. Several studies have found two periods of activity (the so-called bimodal pattern) coinciding with periods of favorable temperatures and precipitation (see Camarero et al. 2010; Gutiérrez et al. 2011). Additionally, Touchan et al. (2007) have shown that precipitation in May-June, when temperatures are close to optimum, is controlling tree-ring growth (in a linear fashion). According to Fig. 3 there are 4 important phases as a function of the day of the year (DOY):

i) During the first 4 months of the year temperature is the limiting factor.

ii) In May and June tree-growth is limited by soil moisture and temperatures are nearly optimal.

iii) During July and August both factors could be the limiting factor for tree-growth.

iv) After the summer soil moisture become again the main limiting factor.

These 4 phases suggest a bimodal growth pattern and are clearly separated in time suggesting that multiple linear regressions using month climate variables will produce good estimates of tree-growth. Therefore, I suggest that the Authors compare the mechanistic model used in the present manuscript against simple/multiple linear regressions.

6. According to the Authors of the manuscript the "optimal parameters have been cho-

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sen manually by trial and error using the model and average daily variation of model soil moisture from 1959–2004". However, the mechanistic model is guaranteed to fit well in the calibration period by definition, because the model's parameters are tuned using data from this period. The true test of the robustness of a given model is obtained in the verification period, for which results are independent of statistical model development; the verification period should not *ever* be "inside" of the calibration period. Therefore, I suggest that the Authors clarify this point if their objective with the "split-sample procedure" was to evaluate the strength of the obtained model, as suggested in abstract (Page 11090, Line 6).

Technical corrections

Page 11089, Title. "Process based model sheds light on climate sensitivity of Mediterranean tree-ring width".

Page 11090, Line 3. "*halapensis*" -> "*halepensis*"

Page 11090, Line 6. "We use two periods to calibrate (1982–2004) and verify (1959–1981) the model." -> "In order to test the strength of the model, we use two independent periods to calibrate (1982–2004) and verify (1959–1981) the model." Please keep this sentence consistent with the methods section (Page 11093, Line1–5).

Page 11090, Line 8. "(r =0.76 p<0.001)" -> (r = 0.76 p < 0.0001, n = 23 years).

Page 11090, Line 25–26. I am not sure that the word "practically" is valid in this context.

Page 11091, Line 1. "*halapensis*" -> "*halepensis*"

Page 11091, Line 1–3. Please add the reference Anchukaitis et al. (2006).

Page 11091, Line 20–21. "(Touchan et al., 2008)" -> "(Touchan et al., 2008b)".

Page 11091, Line 20-23. Please give the coordinates and altitude of the study area and provide the altitude of the weather station.

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Page 11091, Line 22. “Jandouba” -> “Jendouba”

Page 11092, Line 8. Function gl(t) should be defined.

Page 11092, Line 13. Function f(P) should be defined, since a constant (k1) is associated to this function (see Table 1).

Page 11093, Line 4. “(AD 1959–2004)” -> “(1959–2004)”

Page 11094, Line 4. I am not sure that the expression “limiting influence of climatic variables” is valid in this context.

Page 11094, Line 15–16. “Accordingly, our results suggest that cambial activity stops in the middle of July and does not resume until next year (Fig. 4), (. . .)”. By “reading” the Fig. 4 I suggest the following change: “Accordingly, our results suggest that cambial activity stops in the middle of July and could not resume until next year (Fig. 4), (. . .)”.

Page 11095, Line 13–14.”. . .from 0.0005 to 0.007 (with step 0.0005). . .” -> “. . . from 0 to 0.007 (with step 0.001). . .”

Page 11095, Line 17–18. “Such a change of drainage coefficient was strongly reflected in the tree-ring growth response.” -> “Such a change of drainage coefficient was strongly reflected in the estimated tree-ring growth.”

Page 11095, Line 23–24. “*halapensis*” -> “*halepensis*”

Page 11096, Line 6-18. Please consider the present comments to re-phrase this sentence.

Page 11096, Line 20-21. This sentence should be change to better illustrate the results and the findings of the present manuscript.

Page 11096, Line 21. “(. . .) how tree growth there is forced by climate” -> “(. . .) how tree growth is controlled by climate”

Page 11098, Line 11–12. “Rossi, S., Deslauriers, A., Griar, J., and Seo, J.-W.: Critical

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temperatures for xylogenesis in conifers of cold climates, Global Ecol. Biogeogr., 17, 696–707, 2008." -> "Rossi, S., Deslauriers, A., Gričar, J., Seo, J.-W., Rathgeber, C., Anfodillo, T., Morin, H., Levanic, T., Oven, P., Jalkanen, R.: Critical temperatures for xylogenesis in conifers of cold climates, Global Ecol. Biogeogr., 17, 696–707, 2008."

Page 11099, Table 1. Was the optimal parameters shown in this table used for the calibration period? According to the text (P11093, Line 1:3) these optimal parameters were manually selected for the period of 1959–2004. However, the calibration and verification period should be different (independent), and only the "calibration period" should be used to determine the optimal parameters, otherwise it does not make sense to verify the robustness of the model over an "independent period" or "verification period".

Page 11099, Table 1. "C1" -> "k1" "C2" -> "k2" "C3" -> "k3"

Page 11099, Table 2. The period used to calculate the descriptive statistics of simulated tree-ring curves obtained by different values of drainage coefficient was 1978-2004 (Fig.5). Please elucidate why was not used the calibration period (1982–2004)? Additionally, an explanation about the "valid N" should be given. The column "valid N" assume always the same value, therefore should be deleted and the "valid N" or the period (1978–2004) add to the figure legend. In my opinion a new column should be added to give the correlation between the initial chronology and the estimated curve using different values of drainage coefficient.

Page 11101, Fig. 1. Add a new graph to plot gl(t) as a function of day of the year (DOY). This piece of information is extremely important to clearly evaluate the content of the manuscript, since the Authors stated that "gl(t) is the common limiting growth factor beginning in late August" (see Page 11094, Line 19–20). Please add a title to the y-axis: "Growth rate, relative units".

Page 11102, Fig. 2. Add the r^2 for the verification period. For the calibration period the significance level is 0.0001.

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Page 1103, Fig. 3. Please see the below comments on Fig. 4. A curve illustrating the gI(t) should be added to the plot. Please indicate the title of the y-axis.

Page 11104, Fig. 4. Explain why it was used a "negative exponential smoothing" rather than a LOWESS (locally weighted scatterplot smoothing). Please give the smoothing parameter (α). I suggest that a different smoothing parameter (α) should be used, in order to obtain a less rough curve, since the smooth curve should not detect sudden changes in the growth. Additionally, a smooth curve for each year should be plotted in order to identify when the growing season ends and to clarify a hypothetical bimodal nature of the tree-growth pattern in *P. halepensis*.

Page 11105, Fig. 5. Please indicate the title of the y-axis.

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