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Earth System Dynamics
Discussions

Interactive comment on "Modelling the Ruin of Forests under Climate Hazards" *by* Pascal Yiou and Nicolas Viovy

Anonymous Referee #1

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Review of Yiou

The authors adapt the 'ruin' theory of finance to that of forest growth. Using the base of the Cramer-Lundberg ruin model they develop a simple model to estimate tree survival/growth based on exposure to heatwaves/droughts. The work is interesting and novel but I struggled a bit with understanding what it is gaining over more conventional approaches to estimate ecosystem sensitivity to climate. I have three main issues with the paper. First, what is the true benefit of adopting this approach over, for e.g. a process-based model or one based on a simple statistical approach? This wasn't effectively conveyed in the paper. While the approach is obviously novel, it is needed to show that this is more than novelty for novelty's sake. Second, there is little attempt to evaluate if the model's outputs are reasonable. I think some attempt to evaluate the

results will be helpful. There was a small amount (e.g. L 180) but given the quantified thresholds and different behaviour between growth strategies, I think more could be done. Lastly, what exactly the model was predicting wasn't clear. At various points it was death of trees (presumably, L 52) or perhaps growth (L 181). They are, of course, linked but they are not the same thing. This conceptual muddiness makes for challenging reading. Lastly I would strongly suggest a toy problem to show how this model works on a known system. Since I think this paper is publishable, I suggest major revisions but it does need a large overhaul prior to that.

Specific comments:

Line 21 - What body of literature in the last few years? There is only one ref and it is from 2005.

L31 - I think 'ruin' needs to be properly defined. It is not a typical term in the papers of ESD and I am not yet sure at this point in the paper how I should interpret it.

L42 - Is this meant to imply that xylem embolism only kills branches and can't kill entire trees?

L45 - But trees typically carry far more carb reserves than needed to refoliate many times over, commonly dying with large reserves still intact. Also it is not clear whether carbon starvation is the leading cause of death in many cases (e.g. Rosas et al. 2013, Piper 2011, Rowland et al. 2015),

L50 - There needs to be a clear definition of 'ruin'. The farther I read the more convinced I am that this terminology needs to be more clearly set.

L52 - What is meant by 'disappearance of trees'? There death and total respiration?

L55 - what does 'average capital' mean here?

L59 - how is hazard defined in the context of this paper? It is a term that has many interpretations.

L65 - Please spend some time making this more intelligible to readers from the natural sciences. Pretty much nobody who reads ESD will come from a financial background so it is worth the word count to better expand on the terminology. E.g.'balance between competing companies' - what companies? 'the capital vanishes' - whose?

Eqn 1 - shouldn't pt have the t subscripted?

L71 - I suggest dropping the 'horizon' terminology. This might be a carryover from the insurance models but this is not a common way to talk about this in ecosystem modelling.

L79 - other insurance companies bidding for the same clients to sell insurance to?

- Small point, consider the tenses used. There are several instances of future tense that don't make sense. They make the reader wonder if this is going to appear in some future paper or ?

L102 - does this mean you don't let them allocate resources to their stems? So they can't grow?

L 104 - Fix the cite Handeregg.

L108 - does the p0 change spatially? How is it determined? Does B have an upper limit? Assumedly it is constrained such that p(t) >= 0 as I am not sure what a negative p would mean since the loss is supposed to come from the S term.

L118 - is there any ref you can use for proof of this here?

L155 - Can it be expanded upon how tho estimate these parameters from observations? It is one thing to suggest the possibility but I think it is more helpful to try and relate these parameters to something more grounded.

Section 2.2 - this whole section is a bit abstract. It would be beneficial to have included a toy example. Even a simple financial one where we could see how these equations play out. I would like to see that included especially with a figure. I think that would

benefit the paper and help the reader wrap their head around these concepts. After all, this is the first paper to intro the concept in the eco modelling lit.

L156 - So what units would all of these have? I am unsure what an Rmax means, 100%? If %, then of what?

L 161 - is this missing an "and" so would be 'and one of the trajectories with a ruin'?

L 164 - 'reserve units' - this seems like we should be able to use real units here.

Fig 1 a,b - please make it so that it is possible to get some info from this figure. Have multiple y-axis (sep plots) as right now it is not useful. Also I don't really understand how this works. Since it is 5-median-95 then I understand why the median is above the 5 and 95. But this looks like the actual 95 quantile realization was chosen (rather than the representative behaviour). Why not choose the mean and then give us the average behaviours? Right now it just looks like so much noise. As far as I can tell this figure is trying to make an important point that the model can capture differences due to aniso/iso strategies, so I think it is worth the effort to make it more convincing.

L177 - The model used here doesn't equate any reserves to stem (line 102). Is there any paper to point to that has directly linked the two? Does the Cailleret paper then do that? As written that isn't clear.

L181 - But aren't the simulations showing the decrease in reserves and not growth? If you are equating the reserves to growth, what does it mean when they trend to 0? No growth for a tree doesn't necessarily mean death but earlier that seems to be what is suggested (line 52). This whole paragraph is playing it very loose with terminology and relating poorly defined components of the ruin model with different real world observations. This needs to be tightened up considerably to be made consistent.

Fig 2 could be made into a table and my suggested toy example be added as a figure. Fig 2 has little interesting information that a table couldn't show.

Table 1 - HW = heatwave?

L239 - These numbers make me think you should then be able to go into the literature to find out how reasonable these are. Are there any reports that would substantiate what your model has found?

L241 - repeated text that makes it confusing.

Fig 4 - how is the avg reserve before ruin >0 when ruin was defined as R(t) = 0 (lines 70, 101)? How much before ruin is used in the calculation? I think this needs a time period defined and specified. Is 4e meant to have ruin year for the y axis label?

General - I would suggest that instead of 'cash' and 'credit' the terms be more ecological like 'aniso' and 'iso', it would help the reader place into context.

L 244 - Since the stat significance is mentioned here. Would it make sense to indicate in the figure which differences were significant?

L248 - I would not use 'globally' but rather something like 'On the whole'. Globally can be read as in, well, globally.

L256 - It does provide an estimate for sure, but I see little attempt here to evaluate the estimates. Can more effort be putting into evaluating the differences between the two strategies and whether any observations support the model results?

Refs cited:

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Rosas, T., Galiano, L., Ogaya, R., Peñuelas, J. and Martínez-Vilalta, J.: Dynamics of non-structural carbohydrates in three Mediterranean woody species following long-term experimental drought, Front. Plant Sci., 4, 400, 2013.

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Malhi, Y., Grace, J., Mencuccini, M. and Meir, P.: Death from drought in tropical forests is triggered by hydraulics not carbon starvation, Nature, doi:10.1038/nature15539, 2015.

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