

Interactive comment on “Annual cycle in Scots pine's photosynthesis” by Pertti Hari et al.

Response to K. Jõgiste (Referee)

The work presents substantial ideas about autotrophic production processes of the forest ecosystem. The testing of the theory has the central position in the scientific analysis. Basic assumptions in the model are presented in a strict order to capture essential logical behavior of the system.

Introduction: the idea about the modelling is presented! Page 3, line 5 – 6: What do we mean as an “ecological level” here? The modelling attempt based on the physiological data can aim the different level starting from one single organism stretching to landscapes and global ecosphere?

We meant trees in their natural environment with the ecological level. Since it was so vague term, we revised it to “*field conditions i.e. into trees living in their natural environment*” in the revised manuscript.

Theory development! Page 3, line 27: How the Finnish summers are supposed to be mild? The geographical extent of the country is very wide.

We agree, there is a difference in the temperature between southern Finland and Northern Finland, especially in degree days i.e. in the length of the warm season. However, except for the very southernmost coast, the whole country belongs to subarctic climate type according to the Köppen-Geiger climate classification that defines summer in this region to be mild. In addition, the difference in the mean maximum temperature in the summer is not that great. Thus we would still like to state that the summers are mild. However, we have re-phrased the section and included a references in the revised manuscript. Now, it states “*for example Finland has mostly a subarctic climate according to Köppen-Geiger climate classification (Peel et al. 2007) meaning that summers are quite mild, daily maximum temperatures...*”.

The evolutionary dynamics of life processes is highly varying: the idiosyncratic response of an organism, species or population to environmental conditions contains many possible solutions. I would like to have a more detailed comment on the limits of physiological reaction to annual cycle in light and temperature variation including extreme cases (page 4, line 16)? BTW: the population variation has been mentioned in the discussion part: page 10, line1. Results of the work discuss the variation at different levels: would it be useful attempt to describe variation with known and unknown source separately?

The acclimation responses specifically discussed here are related to the seasonal dynamics of photosynthetic machinery, adapted to the harsh climate, and we show that they are providing resilience for the systems also during extreme conditions in the stressful winter-to-spring transition period. This has been clarified in the revised ms. However, we are not discussing the potential of these systems to provide protection in other times or for extreme events which last for longer periods, e.g. during summer droughts, although to certain extent these mechanisms also operate during the growing season. We consider this aspect to be out of the scope of this particular paper, although it is an interesting topic in itself. We are actually preparing an independent manuscript on the topic (Matkala et al, under preparation).

The methodology presented in the form of definitions and axioms is a brilliant idea. The wording and structure of the definitions and axioms can be improved in several cases.

According to your notice, we have reorganized the wording in the definitions 1 and 3 as well as in the axioms 1-4. In practise, we have 1) changed the word order to be more easy (for example 'We call as the photosynthetic machinery' was in the revised manuscript changed into 'The photosynthetic machinery is...'). In addition, we tried to avoid the repetition of the phrase 'pigments, membrane pumps and enzymes' by using 'the photosynthetic machinery' that is already defined in the Definition 1. These changes clearly improved the readability of the axioms and definitions.

Definition 3 introduces the "emergent property": how this properties are organized (hierarchy, spatial or temporal generalization)?

This is an interesting aspect but after a consideration, we decided that we will keep the definition rather short and clear. However, the new wording of the definition introduces the hierarchy of the properties more clearly than the old one.

Old: 'The action of the biochemical regulation system generates an emergent property, in the concentrations of active enzymes, membrane pumps and pigments, called the annual state of the photosynthetic machinery.'

Revised: 'The state of the photosynthetic machinery is the emergent property created by the actions of the biochemical regulation system controlling the concentrations of active enzymes, membrane pumps and pigments.'

I am a little confused by use of term "linear" (page 6)? What do we mean here: the linear function?

We mean that the relationship between efficiency of photosynthetic light and carbon reactions is linear. We clarified this in the revised manuscript above the equations 1 and 2.

Results: One can judge the match between observed and predicted photosynthesis dependence on the cloudiness to be rather good. Why the highest overestimation happens in the afternoon with intermittent cloudiness (Figure 3A)?

True, interesting remark! However, we thought that the overestimation is so small that it is most probably generated by normal random variation and did not discuss on it in the manuscript.

Does the data from Värriö Subarctic Research Station include extreme cases or disturbance events: e.g. low temperature during the vegetation period or extreme droughts?

We have experienced a prolonged season with low soil moisture in 2013 which was exceptional in the area. Usually the area is very humid since precipitation exceeds evapotranspiration. The preliminary analysis shows that the low soil water did affect radial stem growth but did not hinder photosynthesis - actually the highest GPP was recorded on that year, probably due to air temperature that was higher than usually. The presented model did not show decreased performance during the low moisture conditions in 2013. Low temperatures with even freezing records visit the site almost every summer but those days do not pop up as decreased

performance in the analysis either. These observations will be published in an independent manuscript (Matkala et al, under preparation).

What are the actions mentioned in the discussion (page 11, line 4)? Semantically action refers to purposeful and systematic interplay between components of the system! Although the action (or operation) of the system can be interpreted as evolutionary developed property of a living organism, the biochemical mechanism (enzymes, pigments, membrane pumps) as such lacks the purpose oriented action?

We consistently use the 'action' (of the biochemical regulation system) through the manuscript when discussing on synthesis or decomposition of the necessary, active compounds. There might be also some other term suitable such as 'functioning' but we are somewhat pleased with *action* since we believe that the tree actively regulates these substances which we can predict by the changes in the environmental factors.

In conclusion: the presented modelling is only a minor part of the research conducted during many years. The wider and more profound presentation of the study can be found in other printed sources. Material presented with current manuscript is an elegant demonstration of powerful methodological tools to create better comprehending of complex nature of living world. I do recommend to accept the paper with some modifications.

Minor comments I suggest some improvements to the abstract: the repetition of "theory" in concluding sentence should be avoided.

True, we reformulated it into the revised manuscript as "Our theory gained strong support in the rigorous test."

Number of measurements: 30000 datapoints during a summer (page 9, line 18): is it connected to total record 130000 (page 11, line 30)?

We had a mistake there since in the number should be 130 000. It is corrected in the revised manuscript.

Acronyms at the Acknowledgement part are understandable only for very few specialist: nevertheless the Google can provide more or less correct hints. Still, what is SMARI?

We agree that the acknowledged acronyms are quite unclear for most readers but at the same time, they are not that essential for them either. We corrected the misspelled SMARI to SMEAR I.