AMAZALERT

A research project on impacts of climate change and land use change in Amazonia

Factsheet

Issue 3

October 2013

New data on the temperature response of photosynthesis in the Amazon forests: first results

Dynamic vegetation models generally predict that in a warming climate, photosynthesis and hence forest productivity and resilience will decline. We aim to test the assumed temperature dependence that is causing these predictions. During two field campaigns measurements of leaf photosynthesis have been carried out in two rainforest plot that have been subjected to artificial drought for an extended period. Temperature dependence of photosynthesis, both on short and long time scales, has been assessed in this way. First results do not support a decline in photosynthesis as assumed in the models, but more data are needed for definitive conclusions.

AT A GLANCE

- Measurements have been done on more than 50 leaves, in a drought exposed and a control plot.
- Each measurement set results in a temperature response curve for key parameters of photosynthetic capacity.
- Subsets of leaves were heated with about 1-2 degrees temperature increase over extended periods.
- Heated leaves were measured again after 7 months
- First results do not support decline in photosynthetic capacity with increasing temperature.

Introduction

Long-term computer simulations of the sensitivity of Amazon forests to climate change often show tendencies of the forests to degrade with increasing temperatures. The reasons for this model behaviour include a predicted increase in respiration with temperature, but also a decrease in photosynthesis. The latter is a consequence of the assumed optimum temperatures for photosynthesis, usually assumed between 25 and 30 degrees, originating from data on temperate, not tropical vegetation.

As the positioning of this optimum is crucial for the temperature sensitivity of vegetation, we aim to establish these from original data taken in Amazon forests. In particular, we aim to establish the temperature dependence of the underlying photosynthetic capacity parameters, both at short time scales (immediate response) and long time scales (acclimation across seasons).

During September/October 2012 (dry season) and in May 2013 (wet season) we measured the response of leaf-level gas exchange to short-term variation in leaf temperature; CO_2 and light response curves were carried out to derive photosynthetic parameters (e.g., J_{max} and V_{cmax}) under different temperature levels. Measurements were taken in the control and drought exposed plots in the long-term moisture manipulation experiment carried out in the Caxiuana National Forest, Brazil, which will allow us to investigate the combination of drought and leaf heating on gas exchange.

Photographs on the right:

1) Leaf with heater plate mounted underneath

2) Researchers performing photosynthesis measure-ments using LI-Cor 6400 gas exchange equipment

Graphs on the right:

Showing the measured and averaged photosynthetic capacity rates Vcmax and Jmax along temperature, for October 2012 (initial, pre-heated state), and for non-heated and heated leaves in May, 2013 (see legend). Data are also shown separately for the control plot (top) and the droughted plot (bottom). Data consist of measure-ments on different species.

Method

Leaf heating system:

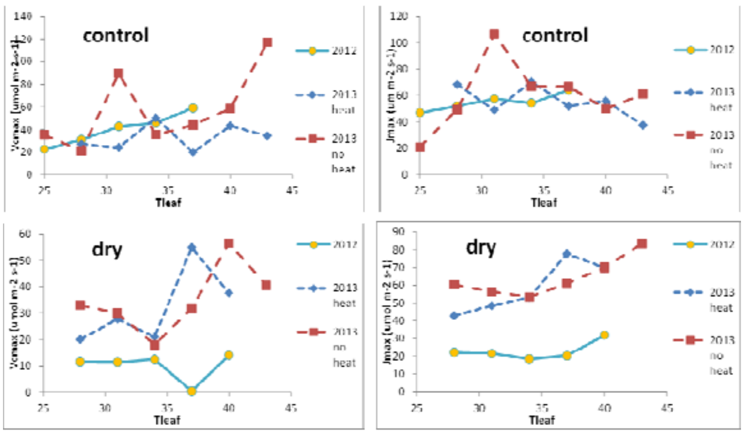
We used electric resistance heaters to establish continuous warming. Each heater had a 75 cm long, 10 Ω con-stantan wire folded into a 4x10 cm rectangular iron wire frame. The frames were closed with aluminium tape and wrapped in aluminium foil. Three volts were run through the wire (1.2W). The heaters were placed approximately 2 cm below the leaf by attaching them to the petiole and branch with iron wire extending from the frame.

At the control and dry plot respectively 3 and 2 tree species were selected. Depending on the distance of the trees to the tower, sun and shaded leaves were selected for measure-ments. Together and nearby each heating element an element was installed below a leaf without any heating to measure the influence of the element itself on the leaf. And at the same spot a leaf was selected as a reference (no element installed below).

The heating effect of the leaf heaters was verified by a set of thermocouples attached with Micropore tape to the lower surface of a subsample of leaves.

Light and CO_2 response curves:

Leaf gas exchange was measured with a LI-6400 portable photosynthesis system (LI-COR, Lincoln, NE, USA), under different combinations of CO_2, temperature and light levels on young, fully expanded leaves.



Results and Discussion

These are first results only. A subsequent measurement campaign in October 2013 is to increase confidence and completeness of the temperature data, and alternative analysis methods should confirm the present analysis. Also, weighting of average parameters should be improved to quantify uncertainty. However, these results suggest that Vcmax does not decline with temperature and possibly increases up to over 40 ˚C. The temperature dependence of Jmax is even more uncertain as a result of the analysis method, but here a weak optimum can be observed around 35 ˚C, in the control plot. The effect of leaf heating is weak if at all present and, counter-intuitively, seems to induce a *lower* optimum. The effect of artificial drought on these temperature dependences is unclear. Although the relationships with temperature differ, no clear pattern can be distinguished.

Conclusions

Initial analysis of the first two field campaigns on temperature dependence of Amazon forest photosynthetic temperature dependence have been shown. These first results do not support a decline in photosynthesis as assumed in the models, but more data are needed for definitive conclusions. If the observed patterns persist in subsequent analysis and other experiments, this means that vegetation models may need to be adjusted as the forests of the Amazon would be less sensitive to temperature increases as previously assumed. Consequently, predicted forest decline associated with temperature increase would be less severe.

References

Doughty, C. E., and M. L. Goulden (2008), Are tropical forests near a high temperature threshold? J. Geophys. Res., 113, G00B07, doi:10.1029/2007JG000632

Galbraith, D., Levy, P.E., Sitch, S., Huntingford, C., Cox, P., Williams, M. and Meir, P. (2010), Multiple mechanisms of Amazonian forest biomass losses in three dynamic global vegetation models under climate change. New Phytologist, 187(3): 647-665.

Huntingford, C., Zelazowski, P., Galbraith, D., Mercado, L.M., Sitch, S., Fisher, R., Lomas, M., Walker, A.P., Jones, C.D., Booth, B.B.B., Malhi, Y., Hemming, D., Kay, G., Good, P., Lewis, S.L., Phillips, O.L., Atkin, O.K., Lloyd, J., Gloor, E., Zaragoza-Castells, J., Meir, P., Betts, R., Harris, P.P., Nobre, C., Marengo, J. and Cox, P.M.(2013), Simulated resilience of tropical rainforests to CO2-induced climate change. Nature Geosci, 6(4): 268-273.

Lloyd, J. and Farquhar, G.D.(2008),Effects of rising temperatures and [CO2] on the physiology of tropical forest trees. The Royal Society, 363: 1811-7.

Written by

Wilma Jans and Bart Kruijt,
Wageningen UR (see below),
also supported by **Steel Vasconcelos,**
EMBRAPA CPATU,
Belem (PA), Brazil

Project Coordinator AMAZALERT

Dr. Bart Kruijt
Alterra, Wageningen UR,
Wageningen, the Netherlands
Bart.Kruijt@wur.nl

AMAZALERT (2011-2014) is co-funded by