Geophysical Research Abstracts
Vol. 21, EGU2019-14811, 2019
EGU General Assembly 2019

Semi-arid forest performance under future conditions: The role of increasing [CO_2] under hotter and drier conditions

Nadine Ruehr (1), Allan Buras (2), Fedor Tatarinov (3), Eyal Rotenberg (3), Dan Yakir (3), Marielle Gattmann (1), Benjamin Birami (1), and Rüdiger Grote (1)

(1) Karlsruhe Institute of Technology, IMK-IFU, Garmisch-Partenkirchen, Germany (nadine.ruehr@kit.edu), (2) Technical University of Munich, School of Life Sciences Weihenstephan, Freising, Germany , (3) Weizmann Institute of Science, Earth and Planetary Science, Rehovot, Israel

Semi-arid forests have an important role in the global carbon (C) sink, but yet are assumed to be especially sensitive to projected climate change. In particular forest trees growing under extremely dry conditions, such as the Yatir forest, a large Aleppo pine planation within the Negev desert. Albeit slow growth and low productivity, the Yatir forest constitutes a relatively large C sink. However, up to now we know little on the forest's sensitivity to future conditions, in particular the responses of increasing [CO_2] under hotter and drier conditions.

Here, we applied a process-based ecosystem model (LandscapeDNDC), which was parameterized and initialized with species and site-specific data. The model was evaluated with ecosystem gas exchange observations (2010–2015) and forest inventory data, and we found a close agreement between observed and modeled daily gross primary productivity (GPP), tree density and stem diameter. To study the responses of the pine plantation under predicted future conditions, we derived [CO_2], temperature, precipitation, relative humidity and radiation data from three statistically downscaled (spatial resolution 1km^2) climate model scenarios (based on CMIP5) for two major representative concentration pathways (RCP 8.5 and RCP 4.5) in daily resolution (1970–1999, 2010–2029 and 2070–2099). We used this data to run the LandscapeDNDC model and evaluated the effects of climate change scenarios with and without [CO_2] increase on GPP and tree stem growth responses. Additionally, we compared the derived [CO_2] sensitivities of the model to experimental results from Aleppo pine seedlings grown under different [CO_2] treatments.

The climate models under RCP 8.5 (930–970 ppm [CO_2] in 2100) showed a clear trend in decreasing annual precipitation (30–80 mm), while annual temperatures are predicted to increase strongly (4–6°C) at the forest site between 2000 and 2100. This trend of hotter and drier conditions was reflected in reduced GPP and lower growth rates (lower stem volume). However, we found elevated [CO_2] to largely offset this decrease, resulting in slight reductions of GPP and tree stem biomass under predicted future conditions. We refer this strong [CO_2] sensitivity of the model to water savings caused by a larger water-use-efficiency (WUE) under increasing [CO_2], due to lower stomatal conductance at similar to higher C uptake. This increase in WUE was also reflected by the experimental results, which additionally indicated a better performance of elevated [CO_2] trees under moderate stress, which alleviated under severe heat or drought conditions.

In summary, we find that an intensification of summer drought and heat as predicted by the climate models, could further reduce the already low GPP and tree growth rates under semi-arid conditions, but increasing [CO_2] will attenuate some of these effects, most likely through increasing WUE, as confirmed by experimental results.