How Much CO_2 Can Forests Absorb in the Future?

Tropical rainforests absorb huge amounts of carbon dioxide. But how are increasing levels of this greenhouse gas likely to affect the forests' future growth? A large outdoor experiment in Amazonia aims to cast light on this issue by subjecting sections of the forest to elevated carbon dioxide levels. Ecosystem modeler Prof. Anja Rammig is part of the research effort.

Link
www.lsai.wzw.tum.de/en/home www.amazonface.unicamp.br/en/

Graphics: ediundsepp

Gesamter Artikel (PDF, DE): www.tum.de/faszination-forschung-30

Wieviel CO_2 können Wälder künftig noch aufnehmen?

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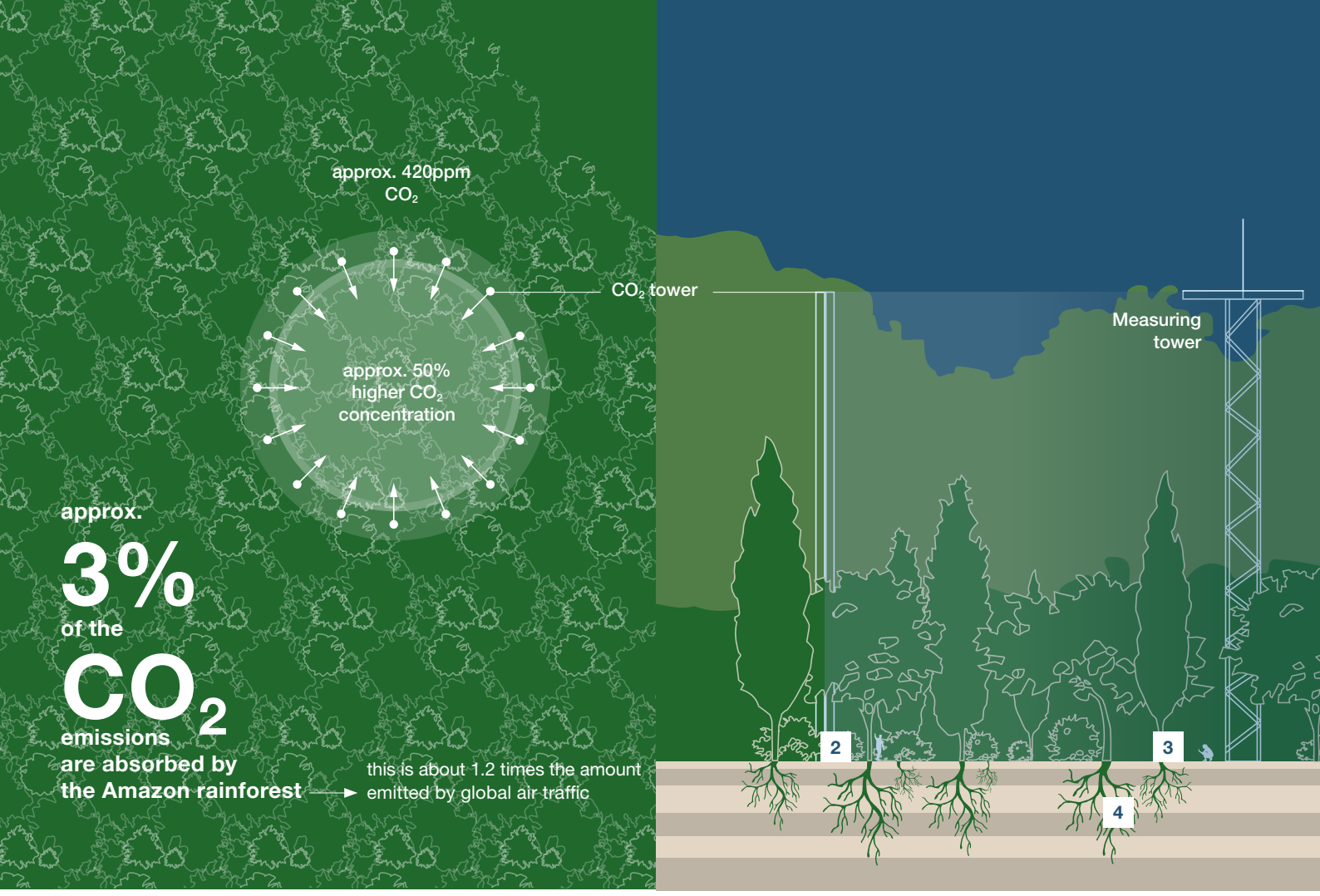
Der Amazonas spielt eine wichtige Rolle im Klimasystem der Erde. Er nimmt einen großen Teil des Klimagases Kohlendioxid (CO_2) auf und bremst so die Erderwärmung. Wieviel CO_2 der Amazonas in Zukunft speichern kann, ist ein wichtiger Parameter für globale Klimamodelle, aber bisher noch weitgehend ungeklärt.
Klimamodelle nehmen vereinfachend an, dass der Wald umso stärker wächst, je mehr CO_2 er aufnimmt. Ob das tatsächlich stimmt oder ob beispielsweise die Nährstoffversorgung ab einem bestimmten Punkt das Wachstum hemmt, klärt nun ein internationales Experiment, das ein definiertes Gebiet im Amazonas mit CO_2 begast. Mit dabei ist die Ökosystemmodelliererin Prof. Anja Rammig. □

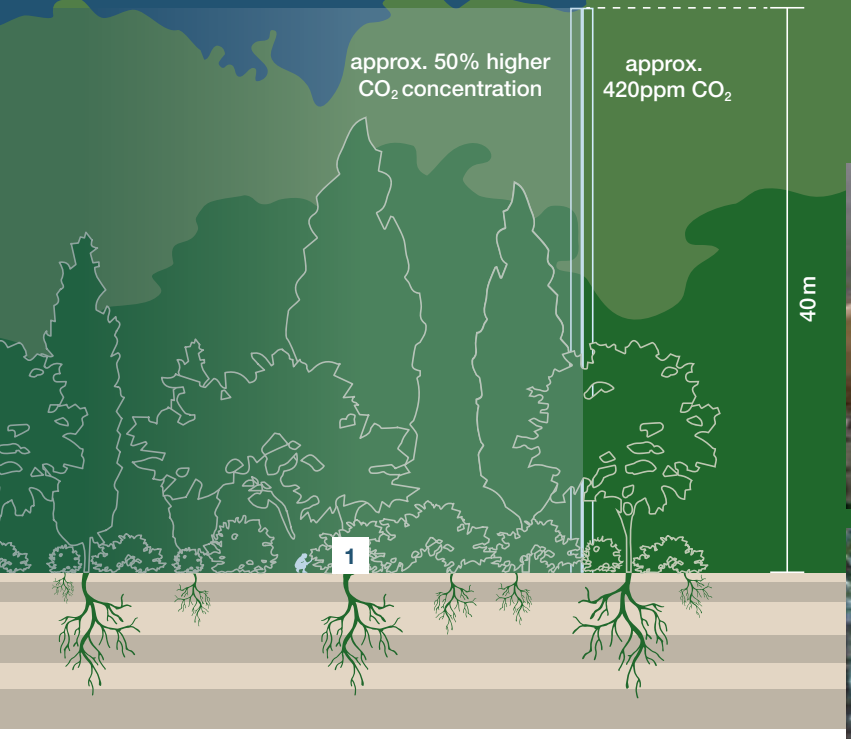


The Amazon rainforest is vast; a seemingly endless green carpet, sprawling over an area around 14 times the size of Germany. In addition to serving as a habitat for plants and animals, the rainforest plays a vital role in regulating the Earth's climate. This involves absorbing a large amount of the carbon dioxide (CO_2) released by humans burning oil, gas and coal. Without the Amazon, climate change would progress even faster. However, exactly how much carbon dioxide the Amazon rainforest will be able to store in the future remains largely unknown because, until now, there has been no field experiment investigating how this huge ecosystem processes the greenhouse gas.

A forest of gas-emitting towers

To date, climate models have relied on the assumption that increasing concentrations of carbon dioxide in the atmosphere would stimulate forest growth. Ultimately, plants absorb the gas from the air and convert it into energy-rich carbon compounds, i.e. sugars, through photosynthesis. They need these compounds to grow their biomass, such as stems and roots. A major international project is now conducting the first detailed examination of whether this assumption – more CO_2 equals more plant growth – actually holds. In the heart of the rainforest, not far from the Brazilian city of Manaus, numerous towers are under construction: 96 towers in total, each almost 40 meters in height. These towers will emit carbon dioxide, spreading it across sections of the forest. This will allow the researchers to simulate the elevated carbon dioxide concentrations expected by the middle of the century. Amazon Free-Air CO_2 Enrichment – AmazonFACE – is an open-air CO_2 fertilization experiment that, after around a decade of planning, has now entered the construction phase. The international team of researchers includes Anja Rammig, an expert in ecosystem modeling at TUM. "We provide the trees with far more CO_2 than usual, which allows us to measure the response of the whole ecosystem," she states. It is far from certain that the trees will actually grow better. As Rammig explains, it is also conceivable that tree growth will be stunted by nutrient deficiencies in the soil – which could occur if the increased growth leads to a reduction in vital phosphorus compounds.

Picture credit: João M. Rosa/AmazonFACE; Graphics: edlundsepp (source: Rammig/TUM)



Measuring photosynthetic activity in leaves

Measuring the circumference and sap flow in the tree trunks

Monitoring soil and root respiration

Analyzing changes in belowground processes, here root samples

A field project, not a lab experiment

Anja Rammig reconstructs the complex processes at work in ecosystems on computers in order to understand them better and make forecasts. This work involves translating natural processes into numbers, such as the quantities of carbon exchanged between the atmosphere, the leaves and roots of a tree, and the soil. These ecosystem models rely on measurement values and figures that depict reality. Until now, such data has been lacking. Researchers have previously conducted laboratory-based experiments, subjecting specific plants to elevated CO_2 concentrations. However, conducting an open-air experiment on an entire section of forest – on the living object, as it were – is another proposition altogether. It is, as Anja Rammig explains, the only way to record natural processes in all their complexity. Not least because elevated CO_2 concentrations can also have other far reaching effects. ▷

Prof. Anja Rammig

studied biology at FAU Erlangen and received her doctorate from ETH Zurich in environmental science in 2005. She then worked as a postdoc at the University of Lund in Sweden. From 2008 to 2015, Rammig conducted research at the Potsdam Institute for Climate Impact Research (PIK). She was appointed to the Professorship for Land Surface-Atmosphere Interactions at the TUM School of Life Sciences in 2015.

Central measurement tower inside the CO_2 rings that are currently being built

Picture credit: Astrid Eckert/TUM; AmazonFACE

More CO_2 – less rain?

Plants absorb CO_2 through stomates, which are tiny openings in their leaves. They also release water vapor through their stomates in a process called transpiration. If the air contains more carbon dioxide, the assumption goes, the plants can open stomates less. This would also reduce transpiration – which could become a problem for the entire Amazon rainforest. In effect, transpiration enables the forest to produce its own rain, as moisture that rises during the day pours down again at night. If transpiration rates from leaves fall, it could have a knock-on effect on the amount of rainfall. The result? A drier ecosystem. It is also these effects that the research team aim to investigate in the rainforest near Manaus.

The first towers have now been erected. Each plot under examination is surrounded by 16 towers. The plan is to examine six plots in total, with construction in two areas completed so far. The CO_2 taps are set to be turned on by the end of the year. The full AmazonFACE experiment is scheduled to run for around ten years, during which the research team will measure a variety of parameters – such as photosynthesis, water fluxes, tree growth, root growth, leaf growth and nutrient levels in the soil. The project is set to produce initial results at the beginning of 2024.

Anja Rammig hopes the project will provide a wealth of new data for her ecosystem models – models whose results are also incorporated into calculations of the Intergovernmental Panel on Climate Change (IPCC). “Our models can only ever be as good as the data we feed into them,” she says. “The ideal scenario would be if, in a few years’ time, the measurement results from the rainforest could be input directly into our models, enabling us to model processes in real time.” This would make it possible to forecast the fate of the Amazon rainforest, and the process of climate change, far more reliably than is currently the case. ■

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