What is the Amazon Tall Tower Observatory (ATTO)?

Understanding the role of the Amazon forest in the changing Earth system requires continuous, long-term observations of the exchange of energy, water, gases and particles between the biosphere and atmosphere.

Figure 1. The 325-meter-high tower is the flagship of the Amazon Tall Tower Observatory (ATTO). The tower is equipped with instruments to continuously measure greenhouse gases, reactive gases, aerosols, and energy and water fluxes at various heights.

Preface

ATTO, the Amazon Tall Tower Observatory, is a unique scientific platform for long-term research on the changing role of Amazon forests in the Earth system. Research at ATTO seeks to improve the fundamental understanding of the complex physical, chemical, and biological interactions between the world's largest expanse of tropical forest and the atmosphere. This research requires long-term observations spanning years to document the effects of climate change, as well as increasingly extreme weather conditions that alter these interactions. ATTO is an interdisciplinary project, with over 200 German and Brazilian scientists from different disciplines collaborating to study the dynamics of forest-atmosphere mixing, atmospheric chemistry, aerosols and clouds, forest carbon and nutrient cycling, biodiversity and response to disturbances in the same location.

History

The Amazon Tall Tower Observatory began in 2010 when the German and Brazilian governments signed a joint declaration to finance its construction. The original lead institutions were the Max Planck Institute for Chemistry and the Brazilian National Institute for Amazon Research. Major funding for the infrastructure and ongoing research comes from the Brazilian Ministry of Science, Technology, and Innovation, the German Federal Ministry of Research, Technology, and Space, the Max Planck Society with the Institutes for Biogeochemistry in Jena and Chemistry in Mainz, the Brazilian National Council for Scientific and Technological Development, and Brazilian state funding agencies (FAPESP, FAPEAM).

To study highly local forest-atmosphere interactions, two smaller towers were built first. An

81 m tall mast for the monitoring of aerosol emissions was built in 2010. Between 2011 and 2012, an 80-meter-tall tower was built for monitoring greenhouse gas emissions and leaf phenology. Both the mast and the tower are still in use, and they complement the lower vertical gradients measurements of the tall ATTO tower[1].

The foundation stone of the 325m-high Tall Tower was laid on August 15, 2014, and the official inauguration took place a year later. In 2020, during the COVID-19 pandemic, instrument installation was completed on the Tall Tower. During this time, Brazilian partners from the University of São Paulo established a cloud-aerosol observatory in an open white sand area in the proximity of the ATTO tower.

Location

The ATTO station is located approximately 150 km northeast of Manaus, Brazil. The ATTO region was chosen to be upwind of pollution associated with the city of Manaus and to represent an airshed with minimal recent land use disturbance. ATTO is located in an undisturbed forest within the Uatumã Sustainable Development Reserve (https://deims.org/0bde5983-b296-4237-abdb-8fcc90f165f5), and near plots that are part of the Long-term Ecological Research network in Brazil (PELD).

The area around ATTO includes topographic gradients typical of central Amazon lowlands, with upland areas dissected by steep slopes and rivers. The vegetation varies with topography, from extensive Holocene sediment floodplains exposed to several months of flooding ("igapó") to almost flat plateaus with nutrient-poor, well-drained soils covered by "terra firme" forests. Together, these vegetation types make up most of the area of the tower footprint, with an elevation gradient between the floodplain and the plateau uplands of up to ~100m. Also present are white sand forests that have short-statured vegetation; these forests represent an estimated 5% of the Amazon basin

Tower observations reflect local gradients in topography and vegetation

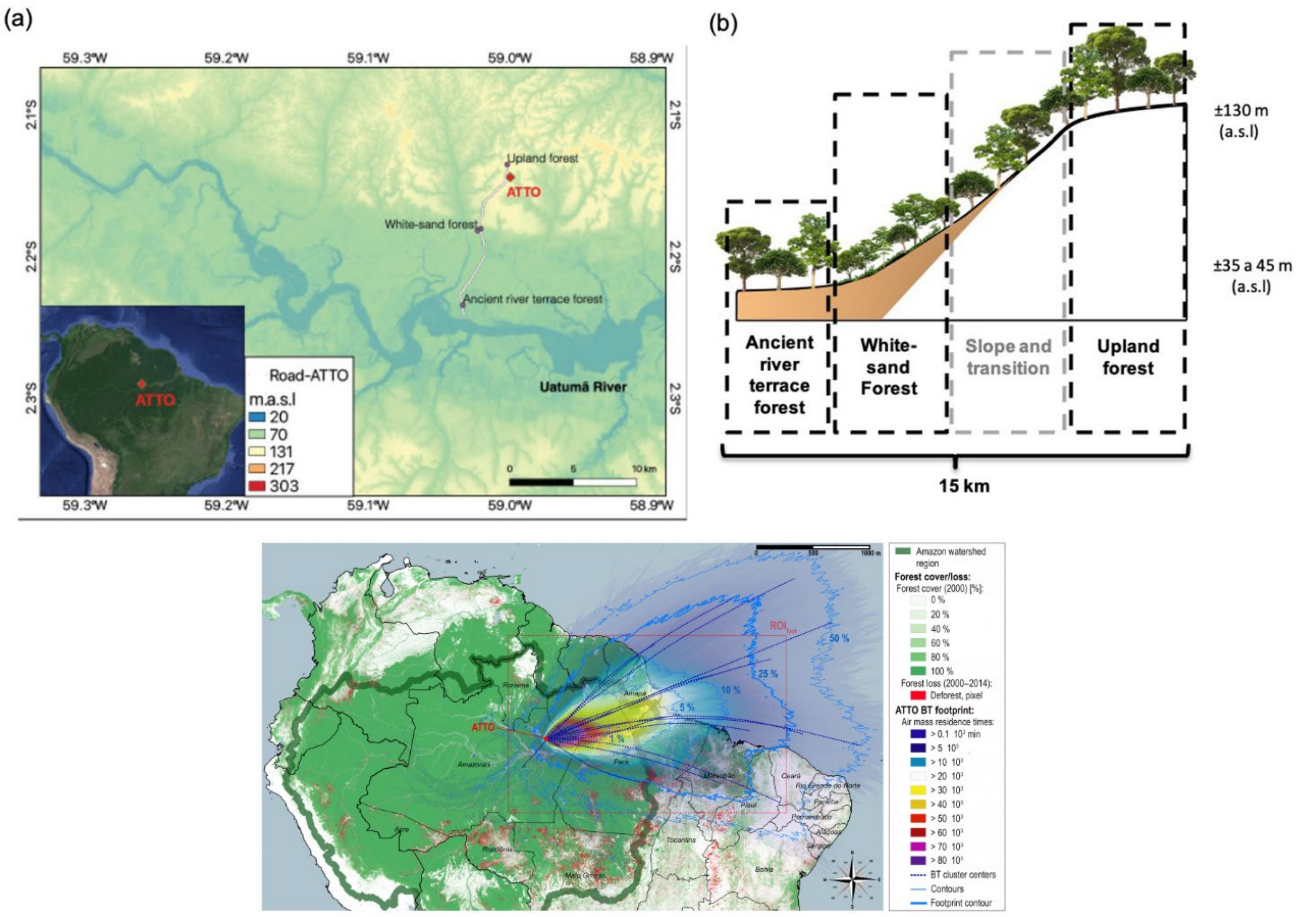

Figure 2. ATTO is located northeast of the city of Manaus (a). The area of ATTO includes an altitudinal and edaphic gradient of vegetation types (b), and the main footprint of the tower captures the signal from winds coming from over the Atlantic[2].

ATTO station

The field camp (Figure 3) lodges ATTO personnel responsible for the maintenance of the station and the scientific equipment and visiting researchers. Lodging accommodations provide room for the up to 45 people present during field campaigns to sleep in hammocks, a kitchen and dining locations, two workshops for construction and repairs, a climate-controlled office, several labs for sample preparation and equipment maintenance, and multiple shipping containers for storage.

Figure 3. Main lodging with accommodations for up to 45 people

Power is continuously supplied by diesel generators. Transport of supplies and people between Manaus and the station is done by trucks and boats. Additional heavy vehicles are also available at the site for the maintenance of the road and the transport of fuel. In 2023, a new satellite connection, including improved internet and data transfer, was installed.

The towers and instrumentation

The main 'symbol' of ATTO is the 325m high tower. The height of the tower allows integration not just of local forest, but extending up to several hundred square kilometers upwind, encompassing the influence of the heterogeneous ecosystems present in the region (see Figure 2). Together, the 325 m and two 80 m towers provide unprecedented platforms for sampling air and climate variables that integrate forest influence on the atmosphere both regionally and locally. A third tower was constructed in 2023 at the Campina site.

All towers have instruments to measure the exchange of energy, water and carbon using eddy covariance, with additional key meteorological parameters (temperature, humidity, soil moisture) and sampling inlets for analysis of gradients of gases and aerosols. Sensitive instruments for high-precision gas concentration measurements and characterization of aerosols are housed in 12 climate-controlled laboratories made from modified shipping containers (Figure 4).

Figure 4. Instruments and labs are accommodated in climate-controlled containers.

Permanent plots and elevation gradient

The extensive net of permanent vegetation plots is maintained by different INPA research groups. The oldest plots were established by the MAUA research group from INPA in 2011 and have been monitoring stem increment with manual dendrometers. At the main plots, soil water is collected every two weeks to study nutrient cycling and its links to soil, plant and microbial activity. Recent plots established in 2021 have are located to cover the breadth of topographic and vegetation in the area. These plots have monthly monitoring of stem increment and continuous soil humidity conditions.

Campina Cloud Observatory

Additional new observations installed at the Campina site in 2021 detail the vertical structure and dynamics of the atmosphere above ATTO, as well as the distribution of aerosols and clouds (Figure 5). This unique observatory provides the opportunity to link aerosols to cloud life cycles over the Amazon forest and will deliver detailed information about the processes that mix forest-influenced air with the overlying free atmosphere under different conditions (day-night cycles, or during storms).

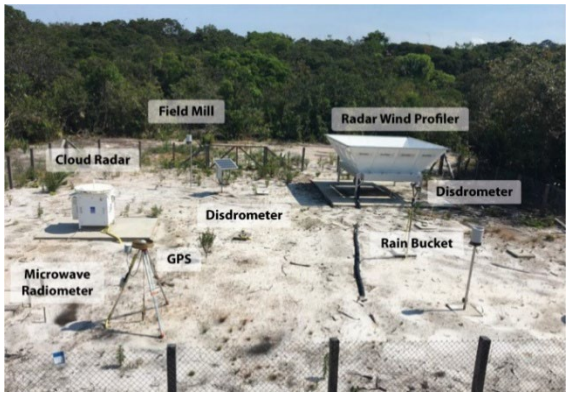

Figure 5. The Campina Cloud Observatory includes several state-of-the-art instruments for the study of cloud formation.

Automatic Air Sampling

In 2021, an automatic air sampler developed by the Integrated Carbon Observation System (ICOS), a large European research infrastructure for monitoring GHGs, was installed for the weekly collection of air for multiple analyses of gas concentrations and isotopic signals. Measurements of the collected gases are calibrated with international observation networks, as are other greenhouse gas tower observations. This intercalibration allows inferences about the role of Amazon forests upwind of ATTO in the global carbon dioxide and methane budgets, and acts as an additional independent quality control for other measurements in the region[3].

Education and Outreach

Sharing our science with the next generation is a major goal of our communication strategy. Over the past several years, we have developed various tools and materials to bring ATTO research into local classrooms and to students worldwide (Figures 6 and 7).

In 2018, an educational project was launched in partnership with schools in the Uatumã Reserve. As part of this partnership, regular training sessions have been offered at the ATTO site, and educational materials have been prepared based on the ATTO project's research topics.

Figure 6. ATTO researchers visit local schools in collaboration with teachers and present research topics in an easy-to-understand and fun way.

To learn more about ATTO, to see its educational materials (in German, English and Portuguese), please visit our website (www.attoproject.org). You can find the latest news and see what the weather is like from the top of the tall tower.

Figure 7. The educational platform ATTO escola was designed to offer training to school teachers about research topics from ATTO. Once a year, an in-person training is offered at the station.

References

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Contact

ATTO Project Science Coordination
Max Planck Institute for Biogeochemistry,
Dept. Biogeochemical Processes
Hans-Knöll-Str. 10, 07745 Jena, Germany
atto_project@bgc-jena.mpg.de
ATTO Project Outreach Coordination
INPA ATTO office
aline.radaelli@inpa.gov.br