Amazon Forests and Global Change – Summer school
Sep 28 – Oct 10, 2023

1. **Objective:**

To offer scientific theory and methods to investigate forest functioning, biodiversity, and forest-atmosphere interactions in the context of global change.

2. **Background:**

The summer school is part of the Amazon Tall Tower Observatory (ATTO) project (www.attoproject.org), which investigates forest functioning, biodiversity, forest-atmosphere interactions, and atmospheric chemistry and physics, funded by the Brazilian Ministry of Science, Technology, and Innovation and the German Federal Ministry of Education and Research.

Tropical forests are key components of global carbon and biogeochemical cycles; however, how they will respond to global change - such as increased atmospheric carbon dioxide (CO_2) and other greenhouse gases, increased temperatures, and changes in precipitation regimes - is still highly uncertain. In this light, the ATTO project has an interdisciplinary approach, including meteorology, atmospheric chemistry and physics, biogeochemistry, and forest ecology, among others, to develop observations and model-data integration to improve our understanding of the Amazon Forest in a global change context.

The summer school activities will be divided into two sections - one focused primarily on observations and the other on modeling. The observational part will be developed at the ATTO experimental site at the Uatumã Reserve (~150 km from Manaus), with activities focused on measurement techniques (see topics I-III, section 6) integrated with data analysis approaches. The modeling part will occur at the National Institute for Amazonian Research (INPA), Manaus, and will be connected to the activities performed in the field.

3. **Target public:**

The course will host about 15 outstanding master's or Ph.D. students, with 50% of them preferably from Latin American countries. The course is free, but students must cover travel costs and accommodation in Manaus. Students from low- and low-middle-income countries can apply for travel support (see item 9).

4. **Teaching Scholars:**

Susan Trumbore – Max Planck Institute for Biogeochemistry (MPI-BGC), Germany; Jürgen Kesselmeier – Max Planck Institute for Chemistry (MPIC), Germany; Eliane Gomes Alves – MPI-BGC, Germany, and INPA, Brazil; Christopher Pöhlker - MPIC, Germany; Cybelli Barbosa - UniGraz, Austria; MPIC, Germany and INPA, Brazil; Hella van Asperen – MPI-BGC, Germany; Santiago Botía – MPI-BGC, Germany; Flávia Durgante – Karlsruher Insitute for Technology (KIT), and INPA, Brazil; Ingrid Chanca – MPI-BGC, Germany; Cléo Quaresma Júnior – Federal Institute of Pará State (IFPA), Brazil; Paulo Artaxo – University of São Paulo (USP); Jonathan Williams – MPIC, Germany; Achim Edtbauer – MPIC, Germany; among others.

5. **Procedure:**

Students will follow a common agenda, including lectures, measurements, data analysis, model-based analysis, and model simulations. After two introductory days with talks from keynote speakers at INPA (Days 1 and 2), they will learn the principal measurements performed in the ATTO site on the

three main topics (see below) (Days 3-6); then, they will develop field measurement projects (Days 7-8), for which students will work in three separate groups (one for each topic). Theoretical assessments, including data analysis, will be conducted for each field measurement project. Students will be mentored during measurements and provided with independent pre- and post-analysis tasks. The last day in the field (Day 8) will be used to present the results of each measurement project as a final group-based presentation. At INPA (Day 9-10), students will learn model-based analysis and model simulations.

6. Topics:

I. Greenhouse gases and Biogenic Volatile Organic Compounds

The global atmosphere contains less than 1% of Greenhouse Gases (GHG), but nevertheless, it is largely affected by small changes in their concentration. The accumulation of GHGs since the pre-industrial period (~1750) due to human activities has led to global warming and yet unknown consequences for ecosystems and societies. Two main GHGs are CO_2 and CH_4, and the Amazon rainforest plays a crucial role in cycling these two gases regionally and globally. CO_2 uptake via photosynthesis and carbon storage by vegetation counteract anthropogenic emissions, but, at the same time, the Amazon represents a large source of CH_4, contributing to about a third of the global wetland emissions. The context of the ATTO summer school is embedded in understanding the future of these processes under global change.

Biogenic Volatile Organic Compounds (BVOCs) are gases emitted by soil, microorganisms, animals, and, mostly, plants. In plants, they have functional roles of defense against biotic and abiotic stressors. In the atmosphere, they are very reactive and participate in processes such as GHG formation/degradation and the formation of particles, which contribute to cloud formation and affect the Earth's radiative budget, thereby, the climate. The Amazon forest is the largest source of BVOCs to the global atmosphere, which makes it a unique region to study their emissions and interactions with the climate. BVOC emission measurements at different scales (soil, leaf, and canopy) and manipulated experiments can provide an important mechanistic understanding to model emissions and forest-atmosphere interactions in the Amazon.

II. Aerosols

Aerosols (airborne suspended particles) have nice properties in the atmosphere, like sunlight scattering, nucleation, or chemical reaction component. Primary biological aerosols and secondary organic aerosols are important to the nucleation processes that start cloud formation, influencing the hydrological cycle. In the Amazonian atmosphere, the natural aerosol composition is very diverse and complex, placing together a variable mixture of biological particles emitted from the forest ecosystem, long-range transported dust, marine aerosols from the Atlantic Ocean, and smoke particles from deforestation fires. For the rainforest, those particles are of significance with respect to biogeochemical and hydrological cycling, climate, and atmospheric chemistry.

III. Biodiversity and Forest Functioning

The Amazon Forest is home to a high diversity of tropical tree species that occur in different forest ecosystems, ranging from flooded forests (Varzea and Igapó), forests with sandy soils (Campinas and Campinaranas), and upland forests as “terra-fime”. Forest ecosystems’ role in the carbon and water cycles depends on the functional characteristics of the species that inhabit them. Functional characteristics such as tree growth rate, wood density, and specific leaf area are related to a more acquisitive or conservative behavior in using carbon in the ecosystem. Meanwhile, anatomical characteristics of vessels and other hydraulic traits are related to water use efficiency and solute transport from the roots to the crown. Recognizing the functional characteristics of different forest ecosystems allows us to understand how ecosystem dynamics can respond to different climatic events and affect biogeochemical cycles.

In ATTO, we assess forest functioning with a variety of tools, and one of these tools is the measurement of Radiocarbon (14C). Radiocarbon is a natural radioactive isotope of carbon and produced continuously in the upper atmosphere by the reaction of neutrons from cosmic rays with 14N and can be used for radiocarbon dating. During nuclear weapons tests in the late 1950s and early 1960s, neutrons were produced, creating excess 14C (bomb 14C) that, after oxidation, is assimilated by the biosphere and oceans and can be used to trace biogeochemical processes in the terrestrial biosphere. Measuring 14C in different plant materials and soil fractions can be used to estimate the carbon age in different C pools. Additionally, the 14C in autotrophic and heterotrophic respiration might give us insights into carbon pool homogeneity, allowing us to benchmark carbon models. Through measurements of 14C in plant materials, soils, and respiration in Amazonia, we can understand the fate of carbon in different ecosystems (e.g., Campinarana, terra-fime). Moreover, relating 14C observations with plant traits allows us to correlate turnover rates of C pools with plant functions.

7. Schedule:

Day 1 – Thursday, Sep 28 (INPA, Manaus)
General lectures on the Amazon forest and global change;
Day 2 – Friday, Sep 29 (INPA)
Explanation of the projects (observation+modeling);
Day 3 – Saturday, Sep 30
Travel from INPA, Manaus, to the ATTO site
Day 4 – Sunday, Oct 1 (ATTO)
Fieldwork and data analysis
Day 5 – Monday, Oct 2 (ATTO)
Fieldwork and data analysis
Day 6 – Tuesday, Oct 3 (ATTO)
Fieldwork and data analysis
Day 7 – Wednesday, Oct 4 (ATTO)
Group-specific work - fieldwork and data analysis
Day 8 – Thursday, Oct 5 (ATTO)
Group-specific work:
Morning - Data analysis, interpretation of the results, preparation of the presentations; Afternoon – Summary presentations of results of four days of group work and discussion of the scientific activities
Evening – Barbecue
Day 9 – Friday, Oct 6 (ATTO) –
Travel to Manaus
Weekend off
Day 10 – Monday, Oct 9 (INPA)
Group-specific work: model-based analysis and model simulations
Day 11 – Tuesday, Oct 10 (INPA)
Presentation and discussion of model-based analysis and model simulations.
Final discussion on Amazon Forests and Global Change, overall feedback on the summer school, farewell words

Please be aware that most of the summer school will occur at the field site, in the middle of the central Amazon forest, under high humidity and temperature conditions, and with a basic lodging infrastructure (sleeping in a hammock). See more information on the website (www.attoproject.org).

The summer school will be in English. Therefore a basic communication level in English is expected.

8. Selection Process:

Applications should be written in English and combined in one .pdf file with the CV, a motivation letter (max. two pages), one recommendation letter, and the indication of first and second choices on the topics of this summer school (section 6).
Applications must be emailed to egomes@bgc-jena.mpg.de
Candidates should apply by July 7, 2023.

9. Travel support

We have limited funding to support the participants financially, but candidates from low- and low-middle-income countries are welcome to apply for our travel grant. For that, please add to your motivation letter why you need travel support (max. 1 page). Please note that the travel grant is only for transport (e.g., flight tickets) and not for accommodation in Manaus.