

## What drives emissions of isoprene in the tropics?

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**Project summary** Isoprene is the main non-methane volatile organic compound (VOC) emitted by terrestrial vegetation. It strongly affects climate by influencing tropospheric ozone production and the formation of organic aerosol. Models currently estimate that 75% of isoprene is emitted from tropical terrestrial ecosystems. In a broad sense, emissions of VOCs from terrestrial vegetation affect the forest carbon budget because they represent a loss of photosynthetically fixed carbon to the atmosphere, but the significance of this loss in the carbon cycle at regional and global scales requires clarification and quantification. Detailed bottom-up emission models, which describe the magnitude and variability of biogenic VOC fluxes, are derived largely from sparse *in situ* measurements, and are highly uncertain on continental scales. Temporal variability in model emission rates is driven by a series of empirical relationships relating biogenic emissions to weather and climate (e.g., surface temperature and photosynthetic active radiation, PAR). This approach has worked well for deciduous mid-latitude forests, but it has not been tested extensively on tropical ecosystems where other external factors play a role in modulating the seasonal cycle of biogenic emissions, e.g. the hydrological cycle. Recent research has also suggested that there may be a circadian influence on emission fluxes in some species, which also needs further investigation. Measurements of isoprene concentration show an unexpectedly large annual cycle over tropical ecosystems, such as the Amazon basin with values during the wet season (January to May) 30% lower than during the dry season (July to December), and the lowest values occurring during the wet to dry transition period (June). This annual cycle is also apparent in space-based observations of formaldehyde over the Amazon. Leaf senescence towards the end of the wet season followed by rapid leaf flushing, hotter temperatures, and increased PAR during the dry season could explain the observed annual cycle but ecological models fail to predict observed greening of vegetation in the dry season. To better understand these exciting discoveries a comprehensive set of measurements throughout an annual cycle is urgently needed.

The student will design and help execute an experiment to test current understanding of the factors that drive isoprene emissions at the established Daintree Rainforest Observatory (<http://www.jcu.edu.au/canopycrane/>) in coastal northern Australia. The Daintree rainforest has the highest biodiversity anywhere in Australia and has a unique Gondwanan flora. The rainforests where the research station is situated are part of the Wet Tropics World Heritage Area, and the only place where two World Heritage Areas sit side by side. The station is well equipped and flux measurements of major greenhouse gases are already in progress. The student will also be responsible for developing an existing isoprene emission model to reproduce the measurements taken.

**Techniques** The student will make, and subsequently interpret, enclosure and concentration measurements of isoprene, leaf area index (LAI), and PAR, and interpret these data using satellite observations of vegetation index (VI) and formaldehyde, and models of isoprene emission and atmospheric chemistry and transport. The student will:

- 1) run the instruments at the measurement site throughout the study period;
- 2) interpret observed changes in enclosure and concentration measurements of isoprene using measurements of LAI, PAR, temperature, rainfall, soil moisture, VI and formaldehyde;
- 3) develop an existing model of isoprene flux to accurately describe the variability in flux observations;
- 4) scale up results from the measurement site, using the developed isoprene flux model, to assess the importance of competing meteorological and hydrological factors in determining isoprene; and
- 5) test the consistency of the model and basin-wide space-based measurements of formaldehyde.

**Training** This project offers the candidate an exceptional opportunity to gain experience in making measurements of trace gases in a tropical rainforest, modelling these measurements, and subsequently assessing the regional and continental importance of the measurements. The scientific training includes:

- 1) Instrumental techniques to measure trace gases and canopy properties in the field;
- 2) the use of computer models for interpreting measurements of trace gases and canopy models;
- 3) Remote sensing techniques and subsequent interpretation of retrieved quantities; and
- 4) scientific collaboration with leading UK and Australian institutions (Macquarie and James Cook Universities).

**Existing facilities** The measurement facilities for the collection of micro-meteorological data exist at Macquarie and at the research station. A dedicated fast response isoprene analyser will be purchased for this project. There are also pre-existing flux chambers for the collection of samples within the Macquarie group. The research station has existing facilities including a canopy crane covering about one hectare of rainforest, laboratory space and accommodation. Computing resources, models codes and satellite data are available within the School of GeoSciences.

**Summary statement:** The successful candidate will gain experience in ecosystem-climate interactions by making measurements of isoprene concentration at an established rain forest site in tropical Australia and interpret data using a model of isoprene flux and atmospheric chemistry and transport.