Research carried out in the Microclimate Lab in the Department of Geography & Environment focuses on biophysical interactions that occur at the interface between Earth’s surface and atmosphere. This includes the role of ecosystems as well as human activities, which provide sources and sinks of atmospheric constituents such as CO₂, water vapor and heat energy at the surface. Until recently, the lab focused on observing natural ecosystems and their interaction with the atmosphere, especially exchanges of greenhouse gases. More recently, our focus has shifted toward urban ecosystems, which include both the biophysical processes of vegetation in cities and the role of the built environment and anthropogenic activities such as fossil fuel combustion. The mechanism for transport of heat and trace gasses between the surface and atmosphere is via vertical motions in turbulent winds that occur due to the frictional drag of the surface. In the Microclimate Lab, we use eddy transport theory and high frequency anemometers and gas analyzers mounted on towers above the surface to calculate the fluxes of heat and gasses between the surface and atmosphere.

One of our current projects is to determine the climatic benefits of living roofs in urban areas. These roofs have the potential to mitigate carbon emissions through photosynthesis, reduce heat loading in buildings due to the thermal insulation of soil and to limit the urban heat island effect through enhanced evapotranspiration. An undergraduate student and Climate Scholars grant recipient Ryan Thorp and a graduate student Siobhan Lavender are leading experimental work on the living roof of the California Academy of Sciences building. There they have deployed an eddy flux monitoring station that is continuously measuring the rates of CO₂, water vapor, radiation and heat energy exchanges between the rooftop ecosystem and the atmosphere. To date, this work has shown that the roof is a net sink of carbon, on the order of 1.5 grams per square meter per day. Although this is quite small compared with many natural ecosystems (~25%), it contrasts strongly with the large source of CO₂ from most urban surfaces. For example, the daily CO₂ emission from Black Rock City during the Burning Man event (see page 4) was 25 grams per square meter.

The living roof also acts to increase the evaporative heat flux compared with traditional ‘dry’ roofs. This amounts to the absorption of several million joules of heat energy from the atmosphere per day for every square meter of rooftop, helping to offset the enhancement of sensible heat fluxes over urban surfaces. In another project lead by graduate student Stephanie May we have found this evaporative cooling produces a 2-4 degree Celsius decrease in temperature in Golden Gate Park relative to the surrounding neighborhoods. It is hoped that improved understanding of unique urban climates and carbon cycles as well as the role of vegetation, can lead to urban planning and management decisions that will improve future climates from the local to global scale.

Top photo: Micrometeorological station on the California Academy of Sciences (CAS) rooftop. Photo Ryan Thorp

Left Three dimensional sonic anemometer and high frequency gas analyser deployer on the CAS rooftop. Photo by Dr. Oliphant.

Right Closer view of the micrometeorological station on the CAS rooftop. Photo by Dr. Oliphant.