Eddy Covariance Flux Towers

The flux towers measure the interaction between the earth's surface and the lowest layers of the atmosphere. These interactions are described as fluxes by atmospheric scientists, and they play a large role in climate and air quality. Measuring them over the city enables us to understand the climate and air quality conditions in the city. What are these fluxes? One is the flux of momentum and a second set of fluxes describe energy exchange.

When winds blow across the surface of the earth, "roughness elements" (think of trees and buildings) block the wind, creating drag forces that slow the winds near the ground. Atmospheric scientists describe this as a flux of momentum from the atmosphere to the earth. The earth slows the winds and the winds (imperceptibly) add momentum to the earth. These are the same forces that propel a sail boat on the water. These drag forces, or "momentum fluxes" are one major source of turbulent mixing in the earth's atmosphere.

Energy is also exchanged between the earth's surface and the atmosphere. The sun heats the ground during the day, the hot ground heats the air, water evaporates into the air, and the ground reflects some sunlight and emits infrared radiation into the atmosphere. Lastly, greenhouse gases in the atmosphere emit infrared radiation towards the earth's surface. These are all components of the surface energy balance. At night the ground cools by releasing infrared radiation to space and tends to cool the atmosphere. The heating and cooling of the air by the earth's surface is the second major source of turbulent mixing in the earth's atmosphere.

The flux towers measure these exchanges with a suite of three instruments. First, **radiation sensors** (think, for example, of an infrared thermometer) measure infrared radiation and solar radiation traveling towards and away from the earth. Second, a sound-based instrument called a **sonic anemometer** measures winds in three directions (up-down, east-west, north-south) simultaneously and, using a technique known as eddy covariance, these data can be used to compute the momentum flux. The sonic anemometer also measures air temperature and, when combined with a **water vapor sensor,** these data can be used to compute the rate of heating or cooling of air by the ground, and the rate of evaporation of water vapor into the atmosphere.

Energy and momentum fluxes play a huge role in determining urban climate and air quality. Many climate mitigation strategies such as urban greening and white roofing are designed to manipulate the surface energy balance to provide a cooler microclimate. Air quality is strongly influenced by how much turbulent mixing exists to disperse pollutants away from the earth's surface. Our measurements enable us to test our numerical models of climate, weather and air quality that simulate these fluxes and improve our understanding of urban climate and climate management strategies, and urban air quality.