



by Rachel Hauser
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Human-related carbon emissions add approximately one billion tons of carbon dioxide to the atmosphere per year, primarily from deforestation and fossil fuel combustion, according to the International Panel on Climate Change (IPCC). To reduce the amount of atmospheric carbon dioxide, the principal greenhouse gas linked to global warming trends, signers of the Kyoto Protocol have agreed, by 2008, to reduce greenhouse gas emissions to five percent below 1990 levels.

Because IPCC and other studies have shown that up to 25 percent of human-made carbon emissions may be taken up and stored by plants for use in respiration and growth, the Kyoto agreement allows nations to take credits towards their emission goals if they maintain or augment forest extent. However, scientists consulting on the Kyoto agreement were reluctant to sanction such credits because no one thoroughly understands the complexities of carbon exchange between the atmosphere and the biosphere. Consequently, scientists do not know if the creation of carbon sinks in the form of increased forests will do anything more than provide a temporary solution to the greenhouse gas problem.

In an effort to better understand carbon fluxes both on regional and worldwide scales, international scientists have created a mechanism to coordinate FLUXNET, a global network of research sites that measure regional carbon, energy and water vapor exchange between terrestrial vegetation and the atmosphere.

The idea of coordinating the worldwide network of carbon flux study sites originated in 1995 in La Thuile, Italy at a meeting of researchers interested in modeling and monitoring carbon dioxide. With group consensus on the viability of creating a network from existing research sites, Dennis Baldocchi, acting associate professor at University of California Berkeley, and his co-investigators Steve Running, Riccardo Valentini, David Hollinger and Richard Olson, secured funding from NASA to initiate the FLUXNET project.

The flux community members contributing information to FLUXNET seek to better understand the mechanisms controlling the exchanges of carbon dioxide, water vapor and energy across a spectrum of time and space scales and to provide ground truth for NASA's Terra satellite sensors. Additional funding for regional studies came from national organizations such as the U.S. Department of Energy for the AmeriFlux network covering North and Central America and the European Commission, in support of equivalent programs, Euroflux and CarboEurope, in Europe.

"To integrate these global carbon flux studies, FLUXNET provides a consistent data format, making it



A typical FLUXNET tower dominates the skyline of a deciduous forest.

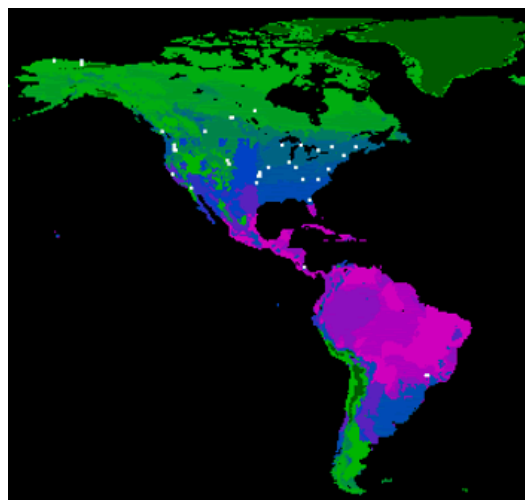
(Image courtesy of [AmeriFlux](#). A new browser window will open.)

"Carbon cycling is by its nature very interdisciplinary and the more interdisciplinary that the research gets, the more complex it becomes."

For more information, visit the [Oak Ridge National Laboratory DAAC](#). The [FLUXNET](#) Web site provides flux data as well as information about FLUXNET community activities. (A new browser window will open for each.)

easier to manipulate and compare data from different instruments and between regions," Baldocchi said. "The project supports data exchange by holding annual and semiannual meetings and workshops for participating scientists and providing a repository for information archival and distribution. The FLUXNET program has grown into an active data archive and now includes scientists in Asia and Oceania as well as some independent sites in Africa."

Over 150 sites presently acquire long-term, regional flux measurements over the grasslands and forests of Europe, Asia, Australia, and the Americas. FLUXNET promotes regional ecosystem comparisons and is expected to yield information about what drives the differences between them.



White dots indicate participating sites in the AmeriFlux network, part of the global FLUXNET program. (Image courtesy of [AmeriFlux](#). A new browser window will open.)

"The ongoing collection of flux and other biological measurements that drive ecosystem process models will increase the depth and breadth of the research," said Beverly Law, chair of the AmeriFlux Science Team. "The agencies funding us hope that we will learn enough to say something about carbon dioxide fluxes across regions and continents and will better understand what goes on seasonally across different vegetation types."

Scientists have installed flux towers at regional sites that span up to or, in anticipation of tree growth, above the tree canopy. Towers in forests may be as high as 70 meters compared to grassland tower heights of 4.5 meters. The AmeriFlux network also includes one 400-meter TV tower, which enables scientists to sample air in the planetary boundary layer.

Field personnel rig instruments along the height of the towers and at the soil surface to record a variety of parameters including carbon dioxide exchange, air temperature, wind speed and direction and water vapor exchange. After collecting the recorded data, researchers send the information from their research site to their regional network, such as the AmeriFlux network.

"Information collected from individual flux tower sites is routinely 'cleaned' and submitted to a regional network," said Richard Olson, staff scientist at the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). "The regional network then sends the data to us for additional quality checks and to interpolate any gaps that might occur due to things like instrument failure. Finally, we put all of the data into a common format and make it accessible to researchers."

"Collecting FLUXNET data is a complex, time consuming activity," said Law. "Carbon cycling is by its nature complex, requiring interdisciplinary study. Large spatial-scale questions involve the contributions of many variously skilled researchers, including atmospheric scientists, ecophysiologicalists and climate modelers, to work together in understanding the role of vegetation in the global carbon cycle."

"We have soil-plant-atmosphere gas exchange (SVAT) models to predict an ecosystem's net carbon uptake based on our understanding of carbon uptake from the leaf level on up to plant level. However, prior to FLUXNET we were never able to get an integrated measure in addition to all of the little pieces required for the models, so we didn't know whether models were giving us realistic answers for the various outputs. The real value of the flux data is that they give us that integrated measure and allow us to explore general principals of ecosystem functioning across vegetation types and climate zones," said Law.

"Currently, FLUXNET data are used to compare flux measurements with output from both models and values derived from the Moderate Resolution Imaging Spectroradiometer (MODIS), one of the sensor's on NASA's Terra satellite," Olson said. "Twenty sites post micrometeorology measurements for modeling groups to use in running SVAT models. In addition, ORNL DAAC staff work with the MODIS Data Processing System and the Earth Resources Observation Systems (EROS) DAAC staff to extract, reformat, and post MODIS-derived products for the area immediately surrounding flux towers. The comparisons with flux data provide a unique measurement to improve models and satellite products."

"With access to global data, processes emerge that we hadn't recognized using regional data alone," said Baldocchi. "Because the network is still relatively sparse, it's not possible for us to sum up the carbon balance. But we can identify the biosphere/atmosphere interactions required for gas exchange models. Combined with remote sensing information, these models might eventually be better able to identify where carbon is sequestered, versus where it is released."

"It's important to collect ecosystem carbon dioxide flux data as a first priority. But we also need to collect weather and soil data, as well as information on the structure and function of the underlying plant community, to better interpret the flux data," said Baldocchi.

"In the past people made very localized carbon flux measurements to determine how green plants use atmospheric carbon," said Baldocchi. "However, after the initial collection, data were often simply filed away. FLUXNET takes all of this information and makes it accessible to scientists via a global information network. FLUXNET will likely increase the number of scientific discoveries as more and more scientists begin looking at data and results."