A window on the environment from Tahoe to the ocean

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If there is a big idea in environmental science, it is interconnectedness. Air, water, land and the living things on or in them are connected in ways obvious and subtle. But actually seeing and understanding all those connections in context is very hard. That is why environmental and computer scientists at UC Davis are working together to get a "God's-eye view" of a chunk of California, from the ocean off Bodega Bay to Lake Tahoe.

The Coast to Mountain Environmental Transect, or COMET, project was recently funded with a $2.1 million, three-year grant from the National Science Foundation. The project is part of the agency's "Cyberinfrastructure for Environmental Observatories" program.

Covering coasts, forests, farmland, urban and suburban areas, COMET will represent a slice of California's environmental issues, including a forecast of how climate change will affect the state.

"How is climate change going to change precipitation patterns, summer droughts or snowfall" Will there be more wildfires, and how will that affect climate change" If we're going to understand what's happening with the environment, we need better networks of sensors," said Susan Ustin, professor and director of the Center for Spatial Technologies and Remote Sensing at UC Davis, and of the Western Regional Center of the National Institute for Global Environmental Change.

Based on existing networks funded by the National Science Foundation,

COMET will integrate data from hundreds of environmental sensors and put it into a "virtual library" for geosciences, said Michael Gertz, associate professor of computer science at UC Davis and principal investigator on the project. It will include data ranging from climate to chemistry to animal counts, over distances from hundreds of miles to a few feet, spanning timescales from minutes to decades.

Gertz and co-principal Bertram Ludäscher, associate professor at the Department of Computer Science and at the UC Davis Genome Center, will build the tools that allow users to collect, combine, review and analyze data through a single Web-based portal.

Ludäscher is also co-investigator on a related, complementary project led by UC Santa Barbara, to use a scientific workflow system called Kepler for environmental and sensor network applications.

"The goal of scientific workflow systems is to allow scientists to spend less time managing data and more time studying it -- and Kepler is an excellent starting point for us in COMET," Ludäscher said. At the Genome Center, Ludäscher and his colleagues are working on similar tools to automate analysis of genomics data.

COMET is an ambitious attempt to understand how ocean and land are linked together.

"The ocean influences the climate from tide line to Tahoe," said Susan Williams, director of the Bodega Marine Laboratory and one of the investigators in the project. With COMET, researchers will be able to look at that swath of land and ocean in great detail.

Consider springtime off the California coast. Cold water wells up from the deep ocean, drawing to the surface carbon dioxide and nutrients that create some of the world's most productive waters and trigger climate

changes hundreds of miles inland.

The upwelling is seasonal and affected by other climate phenomena, such as El Nino events. In years when the upwelling is weak or ends early, ocean production dives, affecting fish and birds. Animals that move back and forth between the sea and land, such as migrating birds or salmon running upriver, may change in numbers or behavior -- changing how nutrients move around.

Cold upwelling water generates clouds and fog that move inland, carrying water and trapping carbon dioxide and tiny particles in the air. Researchers want to understand more about how fluctuations in upwelling influence the weather over time periods from a few weeks to months, said Ian Faloona, assistant professor in the Department of Land, Air and Water Resources and at the Bodega Marine Lab.

Faloona, John Largier, also an assistant professor in the same department, and their students will be among those feeding data into COMET from the Bodega lab. They are measuring how carbon dioxide moves between the ocean and the air, at suspended nutrients, at fluorescence and temperature in the ocean, and at the currents off the coast. The Bodega lab uses a sophisticated radar system to track ocean surface currents over a grid of two-kilometer (one and a quarter-mile) squares stretching 25 miles off the coast.

Largier's group is also looking at the marine boundary layer, cause of the coastal fog that can roll inland from the ocean. When that cold, damp air moves over land, it limits carbon exchange between plants and the rest of the atmosphere, trapping carbon dioxide within it.

At the other end of the slice at Lake Tahoe, researchers have instruments out recording water clarity, particles in the air and the movement of water in the lake. They plan to add moisture probes in the forest to

measure fire risk around the lake, said Geoffrey Schladow, professor and director of the Tahoe Environmental Research Center. And there are observations of birds, fish and other wildlife.

Currently, some of that data is collected through cable and wireless links, some by actually visiting instruments and collecting the data, and some by researchers in the field. But it all goes into different places and in different formats. COMET will change that, Schladow said.

"What it enables us to do is connect sensors in the environment, for example of lake temperature and forest health, and bring the data into central repository in real time," he said. "Instead of spending months and months collecting data, we would do it automatically.

"We know we can get an unprecedented amount of information," Schladow added. "The aim is to use it and make it available."

UC Davis' Gertz, the principal investigator, agreed. Cyberinfrastructure, or "e-infrastructure," he said, is meant to allow scientists to do their work in a better way.

"Up to 80 percent of time is spent on data management. We want to reduce this drastically," Gertz said. Researchers would be able to sit at their desks and call up data, some of it updated live every few minutes, and combine, compare and analyze it to find patterns and connections, for example between dissolved carbon dioxide leaving the ocean and rainfall at Tahoe.

Indeed, federal agencies and environmental scientists around the country are building up networks of sensors to monitor the environment, especially the ocean. These include IOOS, the Integrated Ocean Observing System, and BOON, the Bodega Ocean Observing Node. IOOS, which is coordinated between 10 federal agencies, is intended to

provide information on the status of the oceans and the Great Lakes. BOON is a coastal observing system centered at UC Davis' Bodega lab, which provides information on the state of the ocean to other networks, including IOOS. Efforts are under way to build up such networks worldwide.

"This is the era of wiring the ocean," Largier said.

On land, a similar project, the National Environmental Observatory Network or NEON, has been proposed by the NSF. It would collect environmental data and address issues such as climate change, biodiversity and infectious diseases. The tools developed for COMET will potentially be prototypes for NEON, and the area covered by COMET will also be California's primary contribution to the national network, Ustin said.

Congress expects the various federally funded networks on land and in the ocean to link up, Williams said. Pulling different kinds of measurements into a single compatible format is no small challenge, however.

Researchers will also be able to build models of environmental change and turn them loose within the system, to see if they can recreate real-world events, Gertz said.

Technological advances mean that researchers in many different fields are now generating very large amounts of data. That makes this a great time for developing collaborations between computer science and other fields, Gertz said, and the computer scientists value those multidisciplinary efforts.

"It's currently still a social experience for scientists to work with people not in one's own discipline," Ludäscher said, "but the barriers are slowly

coming down, and cyberinfrastructure and e-Science projects like COMET are accelerating that trend."

It is not necessarily easy to work across disciplines -- for example, it can be difficult to publish in journals that are both read by computer scientists and comprehensible to ecologists, or vice versa. The opportunity, though, is to create a dramatic shift in how science is done.

"I think we're going to see a giant leap forward in our ability to see changes across long timescales and wide distances," Williams said.

Source: University of California - Davis