

Request for LTER Connectivity Upgrade Support LTER-Plum Island Estuary (PIE) Effects of changing land cover, climate, and sea level on estuarine trophic dynamics

Summary

We are applying for LTER Connectivity Upgrade Supplemental funding to provide a high speed T1 connection, a network server and remote data acquisition for monitoring stations at our LTER Plum Island Estuary field station in Rowley, Ma. The high speed (1.54 Mb/s) T1 connection at the field station will be used to facilitate transfer of data over the Internet and data collection from on line equipment while at the site. The network server and Ethernet hub will allow storage and processing of data from remote monitoring stations, posting of the data near real-time to the world wide web, and accessibility of other field house computers to the internet. Remote data acquisition will allow near real-time access to data collected at our meteorological station, tidal water quality stations and watershed stream stations.

Near real-time access to field monitoring station data will provide valuable information for coordination of field experiments designed around associated events such as phytoplankton blooms, storms and salinity distributions. Estuarine biogeochemical and watershed hydrological data will also be readily accessible. Frequent evaluation of the proper functioning of the monitoring equipment will be possible including potential software remedies from remote locations which will help eliminate lost data collection. Computationally intense simulation models will be able to be evaluated from the field station to coordinate with associated field experiments. The PIE Schoolyard program will gain connectivity to the LTER database and on-line data from field equipment providing a benefit to students, teachers and the community at large.

Background

In much of scientific research, the investigator is usually in close proximity to the laboratory where experimental work is conducted. However, for field-based research, the physical separation between field site and home research institute often can delay, limit or even prevent the ability of the investigator(s) to conduct event driven field experiments.

Many ecosystem processes occurring in watersheds and estuaries are tightly coupled with hydraulic cycles that in turn are driven by weather and climate. In many systems it has been observed that annual biogeochemical cycles can often be dominated by sporadic events, such as those associated with storms. Consequently, to accurately characterize biogeochemical cycles in ecosystems, it is necessary to monitor sites at high temporal (and sometimes spatial) resolution in order to capture events. High temporal resolution of ecosystem processes can be obtained by deployment of monitoring instruments and associated data loggers. Yet, if the data collected by field instruments can not be readily examined, important events can pass unnoticed, or noticed too late to initiate field experiments and/or observations that are necessary to characterize the event. This lag in information between field data acquisition and investigator analysis is made more acute in remote field sites where field instruments cannot be readily accessed due to long travel times between field station and an investigator's home institution.

Because of the dynamic nature of aquatic ecosystems, initiation of field experiments are often keyed to critical changes in ecosystem state variables, such as phytoplankton concentration associated with a bloom, benthic ammonium release associated with salinity intrusion, and changes in water residence time associated with freshwater discharge. In this case, it is not the event that is to be characterized, but rather it is the event that marks a fundamental change in operation of the ecosystem. It is this transition of the ecosystem to a new operation condition that is often the focus of a particular field campaign. However, without the ability to monitor field instruments remotely, critical events necessary for the start of a field experiment can often be missed. Some of these events, such as salinity intrusion into the freshwater end-member of an estuary, occur only seasonally so that field experiments can be significantly delayed if the critical triggering event is missed.

Another difficulty associated with research conducted at remote field stations is the loss of computational infrastructure that is often available at the home institute. With the increase in our understanding of ecosystem processes and the development of complex, computationally intense, computer models to describe these systems, it is becoming more common to develop field experiments in association with spatially resolved ecosystem models. As a result, model-based field experiments may require access to these models while the experiment is in progress at the field station. For instance, it may be necessary to process observational data to determine if an experiment is proceeding correctly, or the model may be necessary to predict the location of the samples to be taken at the next time point given the current observations. Without the ability to reliably communicate between the remote field station and a computing facility, model governed field experiments become impractical to execute if the computational requirements cannot be met at the field station.

In this supplement, we are asking for support to provide a T1 connection to the field station and communication between the field station and deployed instruments, so that the site can be monitored remotely. In addition, we would like to increase the connectivity of the PIE schoolyard LTERs so that they can take advantage of the real-time data that will be available on-line.

Field Station at Plum Island Estuary

The field station association with the Plum Island Estuary (PIE) LTER project is located within the Plum Island Estuary, in Rowley MA (see <http://www.mbl.edu/PIE>). This field station is equipped with a basic laboratory facility and residence quarters that are used to logistically support field experiments, prepare experimental equipment for deployment in the field and process field samples. In addition, we are in the process of deploying 2 to 3 YSI water quality probes within the estuary, 1 tidal monitoring station near the estuarine mouth, 5 ISCO+YSI water sampler/monitors within the watershed, and a weather station. Since the majority of experimental work conducted under the auspices of the PIE LTER project is conducted at Plum Island Estuary, the field station is an integral component of the project. Typically, investigators conduct experiments that last usually no less than one week and often extend into several months. Investigators usually reside at the field station for the duration of their experimental study.

Although the field station laboratory is well equipped to conduct complex experiments of significant duration, the station lacks all but the most rudimentary communication infrastructure. Currently, the station has a standard phone line and maintains a 386 PC equipped with a 2400 bps modem that is used to communicate with a investigator's home institution. This lack of connectivity has made it difficult for researchers to stay in touch with their home institution and has made it impossible for remote model development.

The lack of any type of server and network at the field station has made it difficult to post process field observations. After samples/observations have been collected in the field, they usually require some kind of manipulation and graphical display in order to be interpreted. Some of the deployed instruments generate tens of Mbytes of data that need to be processed by more than one individual. However, the size of the data files prevents their exchange between computers without the presence of a network. Consequently, this data must often be brought back to the home institute for post processing. This means that if the data collected is insufficient, or contains errors, the investigator will not know this until they have left the field site and have lost the ability to repeat the experiment or correct the problem.

Benefits of Field Station Connectivity

By providing a T1 connection to the PIE LTER field station, investigators residing at the field station will have access to their home institutions at sufficient bandwidth to continue work that is not possible with the current connectivity. The high bandwidth connection will also allow computationally intense models to be run remotely. In particular, we are currently developing a spatially and tidally explicit hydrodynamic model that is

coupled to an estuarine biogeochemistry model. This model is being developed under the NSF-LTER and NPACI sponsored workshop on modeling ecosystem processes at regional scales (see <http://www.npaci.edu/Research/ESS/workshops/BSPM1998/master.html>). Because the computation requirements of the model, it will be run at the San Diego Supercomputer Center. With the high bandwidth connection, we will be able to run this model to assist field experiments while at the field station.

The local field station network with T1 connectivity will allow researchers more efficient and faster access to the Internet improving existing exchange of data. Near real-time data acquisition from remote field instrumentation will be available to both our field station and our home institution. Weather, tidal and stream conditions throughout the estuary and watershed will be more readily accessible and available for planning field experiments. Remote monitoring equipment failures will also be recognized in a more timely manner minimizing down time and loss of data.

Plum Island Estuary (PIE) LTER Schoolyard Program

The PIE LTER project has been interacting with the local school communities and community associations for the past several years involving K-12 students and teachers with summer research projects ranging from whole estuarine fish population surveys and migrant fish home ranges to short term measurements of marsh sedimentation and tracing nitrogen through food webs. The PIE field station in Rowley, MA serves as the focal point for our interaction with students, teachers and community associations interested in long term ecological research.

We have also been active through the use of Research Experience for Teachers supplemental funding whereby we have established a broader line of communication between various interested K-12 parties in the region and have begun to involve local school participation in the operation of a meteorological and atmospheric deposition station. Several independent K-12 environmental programs and curricula exist throughout the LTER watershed boundaries. Local community organizations such as the Ipswich River Watershed Association, Massachusetts North Shore Audubon Society and the Parker River Clean Water Association have outreach programs with several K-12 schools in the region. These community organizations have expressed increasing interest in assisting with the collection of data through out the watershed.

We plan to use the connectivity supplement to allow for high speed and near real-time access of data from remote monitoring stations throughout the watershed. The remote stations consist of a meteorological and atmospheric deposition station, three (YSI) tidal multi-parameter water quality stations and five (ISCO) freshwater stream sampling stations. The meteorological station collects data on air temperature, precipitation, wind speed, wind direction, barometric pressure, relative humidity, photosynthetically active radiation and total solar radiation. The tidal water monitoring station collects data on temperature, salinity, oxygen, turbidity and water level. The stream monitoring station collects data on water level and discharge and can also collect water samples. Students, teachers, community associations and researchers will be able to get access to near real-time data from these monitoring stations. For example, it will be possible for students to observe the relationship between precipitation and run off events as measured in the streams, or the relationship between freshwater discharge and salinity profiles in the estuary, or tide heights as affected by storms or phases of the moon. Our schoolyard program will benefit from this increased connectivity by minimizing the time lag between data collection from the remote monitoring stations and the classroom. Students and teachers will be able to discuss environmental data resulting from a storm event while the event is either actively occurring or at least while it is still fresh in their minds thus minimizing the loss of students attention spans.

Implementation plan

To provide T1 internet access to the PIE-LTER field station, an internet service provider will be contracted.

The necessary lines connecting the field house to the network will be installed, and a router and CSU/DSU unit connected and placed in the station. The Windows NT network server will then be configured, providing shared network resources and real-time data acquisition storage. An ethernet hub connected to the field house server will provide network connectivity to multiple users at the field station. When the field station server is operational, the remote field-deployed monitoring equipment connections will be installed. The meteorological station communicates with the server through a cellular phone uplink, and the stream and tidal monitoring stations communicate via radio. Since the manufacturers of the field deployable equipment supply hardware and support remote communication with their devices, we do not foresee any difficulties in establishing communications between field station server and the field deployed instruments. The server will then be programmed to display certain aspects of the data in a real-time format to the PIE-LTER world wide web page (<http://www.mbl.edu/PIE>).

Budget Justification

Real-time graphical displays of meteorological, estuarine water column, and stream discharge conditions in the Plum Island Sound estuary and watershed will be available to researchers, students, and the public. Research and education in the Plum Island area will be enhanced through real-time and historical data accessible by students and researchers through the world wide web, general internet access from the field site, and remote access to the scientific field equipment.

This project includes funds for connecting the Plum Island Ecosystem LTER meteorological station, tidal monitoring stations, and stream monitoring stations to a server at the PIE field house for real-time web-based graphical display and remote access of the data. Researchers, students and the public will be able to access the real-time data through a fast, reliable dedicated T1 connection. Researchers on the PIE-LTER will further use the internet connection to transfer data between the field house and laboratory, and have access to the internet while based at the field house. A network server is needed at the field house to store and process incoming data, post the data in real-time to the world wide web, and provide access to other field house computers to the internet through a connected ethernet hub. A lap-top computer is required for editing the monitoring equipment and data acquisition software at each of the remote monitoring stations.

To transfer data from the meteorological station to the field house server, a cellular phone uplink will be installed with the meteorological station. Air temperature, wind speed and direction, barometric pressure, light and PAR, and precipitation measurements will be sent to the server, processed and posted on the world wide web. Three YSI tidal monitoring stations will be connected to the server through radio transmitters and a receiver, to post real-time water temperature, dissolved oxygen, conductivity, turbidity and depth measurements to the world wide web. Similarly, five ISCO stream monitoring stations will be connected to the server by radio communications, transmitting stream level and discharge data to the web.

Access to the real-time data of weather, estuarine and stream conditions will benefit PIE-LTER educational activities by providing students with direct access to data from the classroom as well as during field trips to the site. The data will also be available to other groups in the area, such as the Ipswich River Watershed Association and the Parker River Clean Water Association, who may be interested in conditions in Plum Island for their own research. Researchers, students, and the public will have access to both real-time conditions in Plum Island, as well as historical weather, estuary, and stream data through the PIE-LTER web site.