

Wireless Technology to Enhance Research and Education Capabilities at the Yuan Yang Lake GLEON site in Taiwan

Existing Infrastructure and Needs. The Global Lake Ecological Observatory Network (GLEON, gleon.org) is a grassroots, international network of scientists, engineers and information technology experts who use near-real time, high-frequency data from in-situ sensors on lakes and reservoirs to advance our understanding of lake ecosystems. One of the first lakes to be instrumented in GLEON is Yuan Yang Lake, Taiwan, a small mountain lake in northern Taiwan. Yuan Yang Lake is also part of the Taiwan Ecological Research Network (TERN), a parallel organization to the US LTER network. In April 2004, an instrumented buoy was placed on the lake to record water temperature, dissolved oxygen, wind speed and direction, relative humidity and air temperature at roughly 10 minute intervals. In addition to the instrumented buoy moored centrally in the lake, there is a separate installation near shore to measure water level and a land-based meteorological station about 1 km from the lake. Yuan Yang Lake is located approximately 3 km from a rustic field station operated by Academia Sinica in Taiwan. One of the major challenges facing researchers is moving data in near real-time from the instrumented platforms on or near the lake to an internet point-of-presence.

Because of the mountainous topography, cell phone coverage is not available at any of the instrumented platforms, but there is marginal cell phone signal at the Academia Sinica field station (ASFS). Power lines were run to the field station in 2006, but there is no line power to any of the instrumented platforms. These platforms are powered by batteries recharged by solar panels. We currently use Freewave Serial radios operating in the 900-915MHz range to attempt to transmit data from the instrumented platforms, via a series of relays to the field station. At the field station the data is sent via GSM modem to an internet point of presence at the National Center for High-Performance Computing in Hsinchu, Taiwan. Both the Freewave connection from the instrumented platforms on or near the lake to the field station and the GSM modem signal from the field station to the internet point of presence are not robust and often the connections cannot be established. Having a robust and reliable signal from the instruments in the field to an internet point-of-presence is a major need that, if established, would greatly enhance the research and education capability at the field station and at the lake. As a proof-of-concept we used WiMAX to attempt to connect the instrumented platforms on YYL to the nearest internet point of presence (POP) in a nearby valley. Our test result shown the link between instrumented platforms at YYL and ASFS can be sustained at 4Mbps. But the connection between ASFS and the POP in the nearby valley was relatively unstable due to topographical complexity with limited hops. The link should be more robust if we add more hops, but this has not yet been tested due to budget limitations.

Proposed Infrastructure: We propose wireless advances in two areas. First we propose to bring a high-speed internet point-of-presence directly to the Academia Sinica field station. Because of the mountainous terrain, there are long, line-of-sight corridors from the field station to the valley below. With appropriate engineering and the possible construction of several relay towers we believe it will be possible to bring wireless internet access, with enough bandwidth to support vtc capabilities among researchers at the field station to any GLEON site, to the field station from the closest existing point-of-presence in Ilan City. Second, we propose a more robust wireless connection from the field station to the instrumented research platforms on and near Yuan Yang Lake. Building a more robust network will likely include re-engineering our existing wireless pathways and perhaps building one or more towers to allow quasi line-of-sight relays from the field station to the research sites.

Our Taiwanese colleagues, Dr. Fang-Pang Lin at the National Center for High-Performance Computing, Dr Chih-Yu Chiu at Academia Sinica, and Dr. Hen-Biau King at the Taiwan Forestry Research Institute are in support of this initiative.

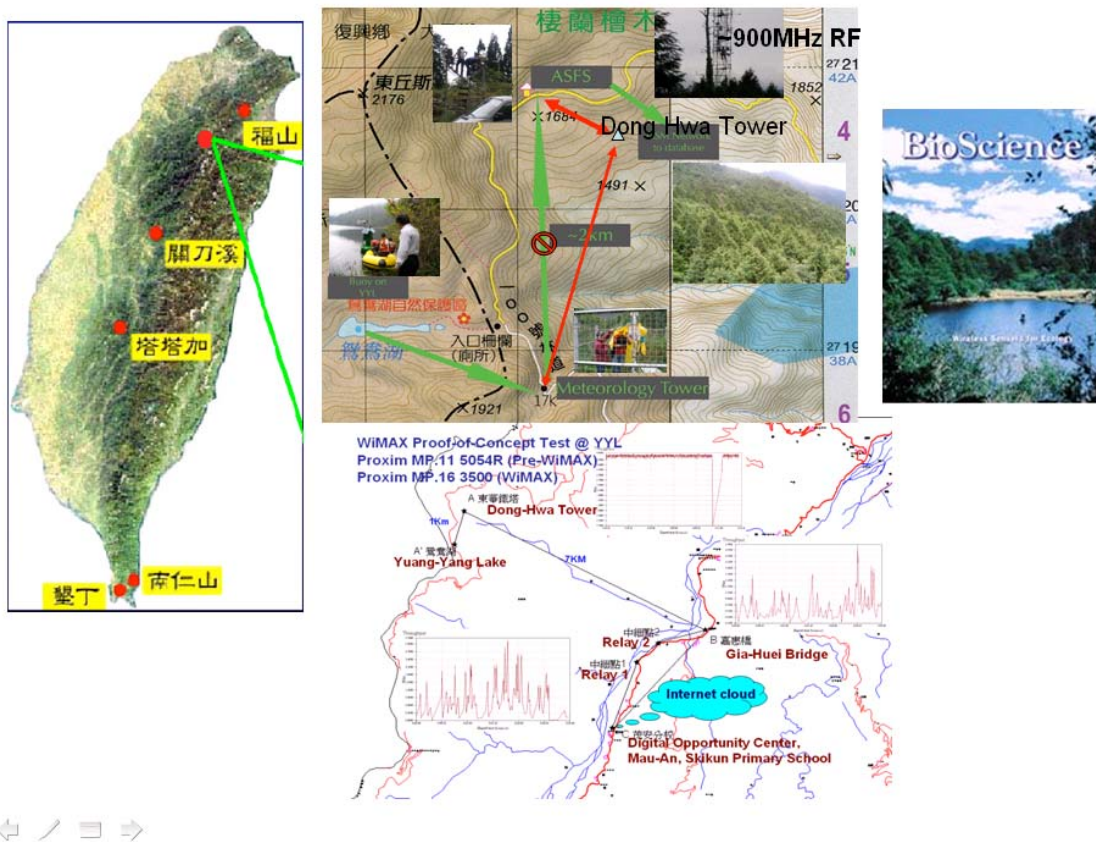


Figure 1. Yuan Yang Lake is a small, mountain lake in north-central Taiwan (a picture of the lake appeared on the cover of *Bioscience* in 2005, right). Wireless communication from the Academia Sinica Field Station (ASFS) to the instrumented buoy on YYL is attempted using Freewave Serial Radios at 900MHz through several relays, including the meteorology station and an eddy-flux tower operated by Dong Hwa University. This wireless link is not robust. In addition, we attempted to link ASFS (Dong-Hua Tower) to the closest internet POP (the Digital Opportunity Center at Skikun Primary School) using WiMAX solution, but the link used only two hops and was unstable (bottom)