



Photo credits: LAS ([www.scintec.com](http://www.scintec.com)), EC System ([www.licor.com](http://www.licor.com)), ICOS system and graphical output ([lginc.com](http://lginc.com)), blue mote computer board ([www.moteiv.com](http://www.moteiv.com)).

# Evapotranspiration Instrument Suite

Nodes PIs: H. Loescher, Oregon State University; J. Jacobs, University of New Hampshire

Characterizing evaporative fluxes is a key to closing the water budget closure, predicting short time scale water transformation at large spatial scales, and partitioning of sources to predict water dynamics, surface energy fluxes, and their relationship to system productivity. Measuring the magnitude and water source of evapotranspiration (ET) at different spatial scales is extremely difficult. Turbulent transport measurements represent a significant advance, but still cannot fully address the dynamic and spatially heterogeneous nature of ET fluxes, capture very stable atmospheric conditions during the nighttime, or reliably characterize large, heterogeneous areas.

Due to complex, non-linear, deterministic, and often stochastic processes that control ET, cases of mismatched measurement scales are profuse. The evapotranspiration suite node seeks to support instrumentation necessary to make measurements that i) directly establish process-oriented, functional relationships between biotic and abiotic controls on ET across discrete temporal and spatial scales, ii) characterize and reduce overall uncertainty in estimates, iii) establish and maintain the long-term comparability of results among research studies and iv) have the ability to explore new approaches that can extend measurements to larger scales.

The **ET Instrument Suite** includes:

## Two Eddy Covariance (EC) Towers

The flux towers include a high speed sonic anemometer, an open path CO<sub>2</sub>/H<sub>2</sub>O gas analyzer, and ancillary climate instruments to measure incoming and outgoing solar and longwave radiation, air temperature, relative humidity, wind speed and direction, and atmospheric pressure, and all supporting data loggers and power supplies. The flux instruments provide 10 Hz measurements of wind speed, water vapor, temperature, and CO<sub>2</sub> and integrated measurements of the energy balance components including net radiation, evapotranspiration, and sensible heat flux at a temporal resolution on the order of 30-minute on spatial scales of 100s of m. A deployable tower system capable of making measurements above most canopies is part of this system.

## Integrated Cavity Output Spectroscopy (ICOS)

ICOS systems measure fast response (e.g., ~10 Hz) water vapour isotopes, O<sub>18</sub>/O<sub>16</sub>. The isotope measurement can be used to partition the sources of evapotranspiration in real time, i.e., from free evaporation, and can differentiate

transpired water from subsurface flows or from deeper aquifers. The instrument uses an inexpensive, robust communication lasers that requires no calibration or standards. This instrument is very stable, can be driven, flown, or operated in a stationary environment. Measurements of O<sub>18</sub>/O<sub>16</sub> can be made with high precision, better than 0.5‰, and are able to dovetail with existing EC systems. Fluxes would be measured at the sub-basin (250-2,500km<sup>2</sup>), watershed (80-250km<sup>2</sup>), or sub-watershed (1-80km<sup>2</sup>) scales.

## LAS - Large Aperture Scintillometer (LAS)

A LAS system measures the sensible heat flux, turbulence statistics including the refractive index of fluctuations C<sub>n</sub><sup>2</sup> and the Fried parameter, and cross wind speeds. Estimates made by the LAS are average values along a line of sight. The scintillation technique is one of the few techniques that can provide fluxes at scales of several kilometers, ~10 km. These direct measurement of surface fluxes for larger landscapes (i.e., comparable to the grid box size of numerical models or satellite remote sensed pixels) are extremely valuable as they integrate the inherently patchy and heterogeneous land surface at these scales. LAS may be also used across a small watershed to capture the down slope transport of admixtures akin to an atmospheric weir.

## Distributed Soil Water Network

The network includes an array of networked, low cost, low power, small wireless data acquisition systems (e.g., motes) equipped instruments to measure soil water, soil temperature, and ground heat flux. Each mote can measure up to 6 independent sensors at rates to 10 Hz. Motes have a distributed, multi-hop, self healing network via a line of site.

The substantive technical support required for the maintaining, calibrating, and deploying instruments as well as data post-processing is included in the suite. The site research teams using the equipment would NOT be expected to have knowledge of the ET equipment.

The ET suite of instruments could be deployed with all or a subset of the sensors. In any given year, it might be practical to support 3-4 science teams, depending on their particular experimental needs. The sensor suite has broad applications in watershed hydrology and is envisioned as being complementary to existing watershed studies.