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TEOS: Terrestrial Ecology Observing Systems

Overview of Embedded Networked Systems and EMISSARY Tools for Instrument Management and Data Exploration

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Embedded Networked Sensors for Ecological Research at the James Reserve

Hardware, Software, Systems

- TEOS applications research group collaborates with many core CENS groups to design, develop, deploy, evaluate, and support Embedded Networked Sensors (ENS) and instrumented platforms for ecological research.
- Fixed and mobile arrays, instruments, and associated technologies for measurement are deployed, tested, and are being continually refined as the first wave of CENS systems at our James Reserve field site.



Figure 1. On the left is an original CMS weather station that is now being used as a reference to compare newer technology hardware and firmware developed for the new ESS systems.



Figure 2. Nest boxes with built-in cameras and micrometeorological sensors supply a constant data stream for analyzing nesting behavior and nesting location selection..



Figure 3. Fixed imagers, such as the Mosscam, provide high-throughput data streams. Years worth of daily (or more) images can now be analyzed for trends not sensed by other means.



Figure 4. At Deep Canyon, and at the James Reserve, energy-independent monitoring systems as well as towers supporting imagers and acoustic sensors are now adding to the TEOS data stream. Imagers located on these towers are publicly available for control and image capture from the internet.



Figure 5. NIMS mobile nodes are receiving upgrades to increase their reliability and sustainability for data collection and experiment-specific applications, such as the ongoing soil sensing project in collaboration with the AMARSS investigations.

EMISSARY enables a user to interact in real-time with sensors and data streams

Progress towards a new class of Biological Research Portal, EMISSARY is composed of the following tools:

1. **Deploy, troubleshoot, and control static and mobile sensor networks.** The two top figures are from (1) a NIMS control interface that allows a non-technical user control over node movement and camera position, and (2) DAS, a collection of tools accessible on the internet that helps users understand and deploy static sensor networks

2. **Visualize and graph sensor data collected by those networks.** The figure to the right represents a new class of web-based tools allowing the user more flexibility in zooming/panning through data and altering the details of graph formatting without reloading the page. Sensor measurement streams can also be stacked directly on top of image capture time series.

3. **Analyze image data collected by those networks.** Many tools have been developed for data analysis and interoperability is the key focus of EMISSARY. Most tools are web-based, like the image analyzer (first figure to the right) or are platform-independent code that can be compiled for any operating system (second figure to the right, Matlab-based analysis).

4. **Explore all these data sets in an integrated, visual, 3-D system.** Because Google Earth is designed for tight web-integration, tying it to our existing web-based graphing tools and sensor database has been relatively straightforward. Thus far, we have had great success using Google Earth as a top-level visual interface for TEOS systems.











