The nature of NESAF

Gregory S. Poulos, Steve Semmer, John Militzer, Steve Oncley, Steve Cohn

In-situ Sensing Facility
Earth Observing Laboratory
National Center for Atmospheric Research
nesaf@eol.ucar.edu

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SUMMARY

The Networked Environmental Surface Array Facility (NESAF) is anticipated to be the next-generation near-surface (ISFF-like) facility. NESAF would wirelessly network a multi-disciplinary array of off-the-grid sensors on a large-suite of highly portable, readily deployable towers. The sensor suite is envisioned to expand on the current ISFF to enable enhanced multi-disciplinary work (adding to the soil/ecology/chemistry suite and volume of atmospheric/chemical flux sensors) and simultaneously addressing the geoscientific need to cover large geographic areas in detail for long periods. The current ISFF cannot meet this need because the towers, sensors and cabling are too cumbersome. The proposed system would enable the rapid (< 1 month) deployment of 100s of towers rather than ~10. Ground-based, airborne and satellite remote sensing methods are unable to fill this need because they do not yet provide continuous high-rate correlated measurements or high-quality fluxes. Over complex orography the value of the proposed system is accentuated. A prototyping project is underway at NCAR at the current time

Further information

Experience: The ISFF team within ISF has significant experience with wireless data transfer in real-field applications, including activities utilizing 'sensor array' techniques and similar alternatives over relatively long distances. Recent field examples include CuPIDO, T-REX, METCRAX, HVAMS and CME-04. The sensor array community has tested certain array configurations with 10-100 sensors at a local scale (e.g. SenSys, 2006). Few of these applications have been repeated and none have achieved routine or facility/campaign-style application. These tests have not included the detailed large-scale observations anticipated for NESAF.

Scientific Need: Various geoscientific communities have delineated the scientific need for many-tower (O[100]) or many sensor (O[1000]) sensor arrays to advance knowledge of crucial scientific areas into currently unachievable spatiotemporal parameter space (Arzberger et al. 2005, Guenther et al. 2007, iLEAPS 2005, Jacobs et al. 2006, Loescher et al. 2007, NEON, 2006, Wakimoto, 2006, BASC, 2005). Current EOL tower-based deployment methods are not able to efficiently meet such requirements. The BASC report specifically states (p. 4-24): "However, many problems related to weather and climate – for example, the

interactions between the atmosphere and Earth's surface in the context of heat, moisture, or biogeochemical cycles – require sustained, specially designed, and focused measurements … Operational weather- and climate-monitoring networks provide observation over the longer term, but often not at the intensive level needed for process studies." Ground and satellite based remote sensing systems are unable to provide the type of measurements available from large-scale sensor arrays.

Sensor Array technology: Numerous sensor array industry entities have developed or are developing robust methods for sensor array communications. ISF team members have tested some of these and while easy to use in the laboratory and for certain pre-determined sensors, they have not been developed for specific geoscientific or atmospheric science use (that is, modifications are needed to fulfill the above referenced scientific needs).

ISF, through NESAF, would realize significant logistical benefit if a more nearly or fully wireless tower-based deployment technique could be developed (e.g. the elimination of wired data acquisition). This benefit derives from the fact that current deployment techniques require time-consuming tower climbing, fastening and wiring and wires are subject to chafing, chewing and other means of disturbance that negatively influence reliability of data acquisition. On the other hand, it has not yet been demonstrated that the suite of NESAF sensors can be made usefully wireless, and be modified therefore to meet the observational specifications sought by the geoscientific community.

NESAF vision (see Figures): NESAF has been brainstormed at NCAR as depicted in the attached figures. It could utilize crank-up telescoping tower technology and would operate using arrayed wireless communication between itself and a second standard tower over different ranges depending on deployment requirements. In general there would be minimized up-tower wiring, data transfer would be wireless to the local data acquisition system on each tower, and the tower sensor suite would be expanded so as to sample the microscale heterogeneity of local soil and radiation variables (embedded networked sensors using 'Motes' and sensor array software).

At full scale NESAF is envisioned to enable the deployment of hundreds of towers with 1000s of sensors in seeking to meet the above referenced geoscientific need. NESAF is anticipated to expand the suite of wireless sensors to all of those in the current ISFF suite, and to a broader suite of geoscientific sensors (see survey). NESAF development requires thorough paper study, technology evaluation and field deployment tests, including, at least, the following areas.

- maximum system and sensor energy usage
- maximum sensor and node mass for efficient deployment
- maximum sensor and node deploy time
- telescoping boom load and viability of modular miniature scale instrument booms
- wireless data communication metrics (local and long distance data rates)
- current state of sensor technology for sensors of relevance (low power, broad geoscientific scope)

References

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