

STANDARDIZED METEOROLOGICAL MEASUREMENTS FOR LONG-TERM ECOLOGICAL RESEARCH SITES

The purpose of this note is to bring to the attention of the ecological community the existence of newly prepared standards for meteorological measurements at Long-Term Ecological Research Sites. Following a brief description of the Long-Term Ecological Research (LTER) program, we will address the need for meteorological standards, some problems in establishing them, and the solution to the problems, as well as the format and substance of these standards.

The Division of Biotic Systems and Resources of the National Science Foundation created the LTER program in response to the realization that most funding situations cannot allow for coherence in research over the long term, yet many parts of ecosystems operate over a long time scale and show directionality and periodicity in ecosystems (Callahan 1984). Studies that have recognized this (e.g., Hubbard Brook) have made fundamental contributions to ecology. Consequently, in 1980 and 1981, 11 LTER sites were established in varying biomes throughout the conterminous U.S.

Within these sites it was recognized that human-derived (as well as natural) perturbations also act over a long time period, e.g., air pollution, acidification, CO₂. Studies at the sites are organized around five core themes which are: pattern and control of primary production, spatial and temporal distribution of populations selected to represent trophic structure, pattern and control of organic matter accumulation in surface layers and sediments, patterns of inorganic input and movement through soils, groundwater and surface waters, and patterns and frequency of disturbance to the research site. The LTER sites (Table 1) are funded in 5-year renewable funding periods and overseen by a Central Coordinating Committee consisting of all site principal investigators, and normal NSF peer review procedures.

There is obviously a need for comparability between LTER sites. Furthermore, climatological information is essential, either directly or indirectly, to investigations of the five core themes and the LTER program as a whole. At an LTER "All-Scientist" meeting at Lake

Itasca, Minnesota, in 1984 all of the keynote speakers, in one way or another, related their long-term research to climatic variables. In many cases records of climatic variables are the only truly "long-term" records yet available at individual LTER sites. Although there are clearly other possibilities, climatological analyses present an obvious method of comparison across all LTER sites.

Using some of the original planning documents of the LTER program (TIE 1979), site-specific material (e.g., Waring et al. 1978), National Weather Service and World Meteorological Organization documentation (WMO 1970, 1971, USDC 1970), and the experience of an early committee, the first part of a document outlining the standardization of LTER meteorological measurements was completed in 1983. The majority of the work was performed by Drs. Ragsdale and Swift, and the first three sections of the new document are largely due to their efforts. Drs. Swift and Ragsdale subsequently described the status of meteorology within LTER in an overview paper (Swift and Ragsdale 1985). In 1985, the committee was re-established by the central coordinating committee of LTER as a climate committee whose tasks were to complete the document being reported here and later and to prepare a climatic description of the LTER sites.

There were numerous problems in setting standards for meteorological measurement in the LTER program. These included the wide variety of ecosystems encompassed, the varying level of meteorological expertise at each site, and the fact that whereas some sites were long established and had continuing meteorological observation programs, other sites were completely new and thus had no climatological data base. More practical specific problems included the fact that different meteorological variables were of widely disparate importance at different sites. Wind, for example, has little or no importance at some sites, but at others such as North Inlet it is a fundamental forcing function of the ecosystem. At the Trout Lake site, wind measured at the meteorologically standard 10-m level is surpassed in importance by a

Table 1. The LTER sites—ecosystem and climate.

Site	Ecosystem	Climate
H. J. Andrews Expt. Forest (Oregon)	Coniferous Forest	Marine West Coast
Cedar Creek Nat. History Area (Minnesota)	Hardwood Forest/Tallgrass Prairie	Humid Continental
Central Plains Expt. Range (Colorado)	High Plains Grassland	Mid-latitude Steppe
Coweeta Hydrol. Lab. (North Carolina)	Deciduous Forest	Humid Subtropical
Illinois and Mississippi Rivers (Illinois)	Temperate Freshwater	Humid Continental
Jornada (New Mexico)	Desert	Subtropical Desert
Konza Prairie (Kansas)	Tallgrass Prairie	Mid-latitude Steppe
Niwot Ridge/Green Lakes Valley (Colorado)	Alpine Tundra	Highland
North Inlet (South Carolina)	Coastal Marine	Humid Subtropical
Northern Lakes (Wisconsin)	N Temperate Lake Mixed Forest	Humid Continental
Okefenokee Nat. Wildlife Refuge (Georgia)	Freshwater Wetland	Humid Subtropical

measurement at 1 m above the water surface.

These problems were generally overcome by adopting three strategies. First, it was important to specify carefully the objectives of the measurement program. Second, the concept of varying levels of sophistication of measurement was adopted. Third, some site-specific exceptions had to be permitted as long as the committee was clear about the physical or biological reason why the exceptions were being made.

The objectives of the program of standardized meteorological measurements were defined as follows:

- 1) establish baseline meteorological measurements that both characterize and allow comparison among LTER sites,
- 2) document both cyclic and long-term changes in the physical environment,
- 3) provide a record of the physical environment to support each LTER site's core research program to correlate with bioecological phenomena and to provide data for modeling,
- 4) provide a basis for coordinating specialized or short-term meteorological measurements at two or more sites when such measurements are required for specific research problems.

The levels of participation conceived were as follows:

Level 0: The entry level meteorological measurements consisting of temperature and precipitation. All sites will achieve Level 0 and move to Level 1 as quickly as possible and within 12 months.

Level 1: Relatively simple measurements using standard instruments with a data format to serve the climatological goals of objectives 1 and 2. All LTER sites will achieve Level 1.

Level 2: More intensive measurement and data reporting using electronic instrumentation with on-line data loggers and computers in order to characterize short-term and detailed meteorological events affecting biological systems. Most LTER sites will seek to meet Level 2 standards for some or all measurements.

Level 3: Each LTER core site research program may require at various times additional specialized meteorological measurements directly related to local research needs. Researchers will seek, at the earliest time, to coordinate plans for such Level 3 meteorological measurements so that long-term data resources at a site may be improved and special intersite comparisons accomplished.

The LTER Climate Committee has produced a 32-page document outlining, for each of these levels, the instrumentation required, the measurements to be made, and the method of reporting. We also address the standardization of specialized measurements at Level 3 and the relationship with the National Atmospheric Deposition Program. Appendices list observation record formats and give sample components of data logging systems, a short bibliography concerning bioclimatological measurements, and a list of specialized meteorological studies within the LTER program. Each site has a limited number of copies of the document which is in a loose leaf format to allow for updates. Fur-

ther information on the standardization document may be obtained from the author.

The existence of the standards will give rise to the establishment of valuable baseline data on the atmospheric environment of the various ecosystems. It will permit intersite comparisons and form the basis for both descriptive, and later, more sophisticated studies. The first descriptive study outlining the basic climate of all eleven sites is forthcoming. The exercise of establishing these standards has been an interesting one and will go some way to help achieve the overall goals of the LTER program.

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