STANDARDIZED METEOROLOGICAL MEASUREMENTS

for

LONG TERM ECOLOGICAL RESEARCH SITES

Prepared by

The Long Term Ecological Research Climate Committee

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PREFACE

Following the initial establishment of the Long Term Ecological Program (LTER) a Meteorological Committee was organized under the cochairpersonship of Dr. Harvey L. Ragsdale and Dr. Lloyd W. Swift of the Coweeta LTER site. The other committee members were Drs D. Bark (Konza), D. Greenland (Niwot), B.J. Kjerfve (North Inlet), and A. McKee (Andrews). 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 the committee, the first part of a document outlining the standardization of LTER meteorological measurements was completed. The majority of the work was performed by Drs. Ragsdale and Swift and the first three sections of the present document is largely due to their efforts. Drs. Swift and Ragsdale subsequently described the status of meteorology within LTER in an overview document (Swift and Ragsdale, 1985). In 1985, the committee was reestablished by the central coordinating committee of LTER as a climate committee whose tasks are to complete the present document and to prepare a climatic description of the LTER sites. This manual has been reviewed by all members of the LTER Climate Committee and represents the approved procedures for the operation of the the LTER climatology program at the time of writing. Changes and additions to the contents of this manual will be supplied to site principal investigators when appropriate. It should be noted that the reference USDC 1970 supplied with hardbound versions of the manual is currently under revision by the National Weather Service and a new version of this will be available from the NWS within the next two years.

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1.0 INTRODUCTION

Each LongTerm Ecological Research (LTER) site assumes an obligation to collect and make available data to characterize the ecosystem which the site represents. This document is the LTER guide for assembling meteorological data. Preliminary statements of standard meteorological measurements for LTER sites were published in 1979 before LTER sites were selected (TIE, 1979). The present document defines, for the LTER program, the measurement and reporting standards for meteorological data. Standards are based on LTER documents, the needs at existing LTER sites, other standards existing in the literature, and the substantial experience of current LTER scientists.

1.1 Objectives

The objectives of standardized meteorological measurements are:

1) establish baseline meteorological measurements to characterize each LTER site and enable intersite comparisons,

2) document for LTER objectives both cyclic and longterm changes in the physical environment,

3) provide a detailed climatic history for each 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.

1.2 Levels of Participation

The diversity of sites and their core research programs argue against a single inclusive set of standard measurements. Consequently, LTER meteorological measurements are grouped into four levels of standardized measurements, a plan which establishes degrees of uniformity for intersite comparative data yet allows flexibility for the site specific requirements of each core research program. The four levels are:

Level 0: The entry level meteorological measurements of maximum and minimum temperature and precipitation amounts over 24 hour periods.

Level 1: A basic climatic station using standard measurements and instruments to measure temperature and precipitation on a continuous basis throughout the day. Data will be extracted for specific times or intervals to serve the climatological goals of objectives 1 and 2. All LTER sites will achieve Level 1.

Level 2: A research meteorological station having more intensive measurements in order to characterize in detail both long and shortterm meteorological events affecting biological systems. These stations sense temperature, precipitation, and other parameters on a continuous basis, may record observations digitally, and may have the capability to extract instantaneous observations, or do integrations on a real time basis. Most LTER sites will seek to meet Level 2 standards for some or all measurements.

Level 3: At various times, the research program at each LTER site may require additional specialized meteorological measurements directly related to local research needs. Researchers should seek, at the conceptual stage of a study, to coordinate plans for special Level 3 meteorological measurements in order to develop standardized techniques, identify mutual interests, and facilitate short term data collection and potential intersite comparisons.

The entry level Level 0 is available for new sites to the LTER program or, under exceptional circumstances, to other sites. The Climate Committee regards the existence of this level as an interim measure only and sites are urged to proceed to the next levels as soon as possible and certainly within one year.

1.3 Station Site Selection

The LTER meteorological station should be located where surface measurements will record representative conditions for the LTER site. A level area is more desirable than an unusual topographic setting. The station should not be on a slope, a ridge, or in a sheltered area unless such extreme positions are representative of the LTER site. Substations may be located to establish the range of conditions at a site.

The station should be located where surroundings are uniform. For example on a sod base at least 30 meters from hard surface areas such as asphalt or concrete and stations should be no closer to vertical obstructions (trees, buildings, etc.) than four times the height of the obstructions (USDC, 1970 a copy of which accompanies original versions of the present standardization document). At LTER sites with very tall trees this instruction may not be practical.Instead, the measurement site should be selected so that it has at least a 35 degree horizon i.e. no obstacles should be above 35 degrees on the local horizon. Similarly for lake and other aquatic sites it may be more expedient to record wind at a low level on or near the lake. In the case of the wind variable important local considerations will be permitted to take precedence over intersite standardization.

1.4 The Observation Record

The original record of meteorological data for an LTER site will be retained. Entries in an Observation Record or log made when instruments are read, original chart recordings and printouts of electronic records are examples of original records. Retention is important for verification of derived data because the Observation Record usually contains the comments necessary to establish the station history. Intersite reports are climatological summaries, and thus detailed data for onsite and intersite studies will be made only in the original record. Wherepossible, the original record will be available onsite to researchers from other sites for research activities requiring the primary record of meteorological data.

The accuracy levels of certain measurements are specified below. Explicit statements on accuracy and precision are given in section 5.1.

1.5 Intersite Exchange of Data

Not all meteorological data collected at a site must be in the LTER files. Information collected as part of a specific study at a single site may be reserved by the scientist until the results are analyzed and reported. Each site must make available data from at least one station as described in this document. The suggested data formats are described later. In addition to paper reports, sites will maintain equivalent summarized data files in computer accessible form. Sites with Level 2 participation will also maintain computer accessible files of calculated and summarized hourly values. Data in all reports and prepared files will be in the metric units suggested below. Although data will be processed and available for exchange between LTER sites, sharing of data will not be automatic but will depend upon individual requests to fill specific research projects. Requests may come from scientists at other LTER sites, the National Science Foundation, or from scientists with cooperative research arrangements with one or more sites. In some cases, data will be provided, as requested, or as necessary, in a format and medium convenient to both the provider and requester, for a fee to cover out of usual expenses for the preparation of the data.

2.0 LEVEL 0 METEOROLOGY

A site may choose to initiate meteorological measurements with Level 0 as a temporary expedient. An existing Cooperative Observer station for the National Weather Service might be used until the site can establish its own station.

2.1 Instrumentation

Temperature instrumentation (Table 2 1) will consist of maximum and minimum thermometers mounted in a National Weather Service type instrument shelter. The installation of the instrument shelter and thermometers will follow the guidelines of the National Weather Service for Cooperative Observer Stations (USDC, 1970). When NWS standards for electronic temperature measurements at cooperative observer stations are established, these will also be acceptable guidelines for LTER sites.

The nonrecording precipitation gage (Table 2 1) should be located no nearer the instrument shelter than twice the height of the instrument shelter. At exposed windswept sites a windshield may be required for the precipitation gage. The gage must be elevated above maximum snow depth, and, if possible, operation should continue during freezing weather. These considerations are covered in the Observing Handbook No. 2 (USDC ,1970) which is the guideline document for the precipitation gage.

2.2 Measurements

Daily observation of precipitation and temperature is necessary at level 0 (Table 2 2). All daily meteorological measurements and comments on station operation will be entered into a Permanent Observation Record or log which is the official data source for calculated values appearing in LTER intersite reports. Observations made early in the morning are interpreted as representing conditions on the previous day. We suggest observations be made between 0500 and 0900 hours. The observation time should be as consistent as possible from day to day and should be noted in the observation log. This specification of observation time is important since daily, monthly or longer mean temperatures, calculated from daily maximum and minimum values, may be biased by the time of observation by as much as 2 or 3 $_{o}$C compared to the midnight to midnight reading (Baker, 1975).

2.3 Reporting

A monthly intersite report for Level 0 meteorology (Table 2 3) will consist of daily values for maximum, minimum and average daily temperature and total precipitation. Monthly means for maximum, minimum and average daily temperature will be calculated along with total monthly precipitation. Maximum and minimum temperatures will be reported in degrees Celsius. The daily mean air temperature will be the average of the maximum and minimum temperatures. Daily precipitation will be reported as mm of water and the water equivalent depth of snow will be recorded (USDC,1970).

TABLE 2 1

Level 0 Meteorological Station Equipment

Equipment	Specifications
Maximum and Minimum Thermometers	National Weather Service type maximum and minimum thermometers mounted on a support in the shelter.
Shelter	"Cotton Region" type, medium size (20x30x32 inch box).
Precipitation Gage	Capacity of measuring tube is 2" of rainfall with overflow capacity of 7". Funnel to measuring tube area ratio is 10:1 so that 1 mm of rain produces a 10 mm depth for measurement to the nearest 0.10 cm. Where data are taken from NWS Coop stations measurement may be to the nearest 0.25cm.

TABLE 2 2

LEVEL 0 Meteorological Measurements

Variable	Frequency of Observation	Observation Record Entry
MaxMin Temperature	Daily	Daily
Precipitation	Daily	Daily

TABLE 2 3

LEVEL 0 Meteorological Summaries For InterSite Reports

Variable	Determination	Units	Values
Temperature	Observation	Celsius	Daily Maximum Daily Minimum
	Daily sum of the two MaxMin values divided by two	Celsius	Daily Mean
	Monthly sum of the MaxMin values per day divided by two divided by the number of days in the month	Celsius	Monthly Mean
Extreme Temperature	Extracted from the Observation Record of the MaxMin Thermometers	Celsius	Monthly Maximum Monthly Minimum
Precipitation	Daily total preci pitation	mm	Daily total
	Summation of daily Record per month	mm	Monthly Total

3.0 LEVEL 1 METEOROLOGY

3.1 Instrumentation

All LTER sites should eventually maintain a Level 1 meteorological station for standardized measurement of four variables:

Air Temperature

Atmospheric Moisture

Precipitation

Wind Travel

Two additional variables, required at level 2, namely Wind Direction and Solar Radiation, are optional but recommended for Level 1.

The Level 1 meteorological station is conceived to be economically achievable by each LTER Site and utilizes field proven instrumentation of minimum complexity and maximum reliability. A Level 1 station may be an enhanced National Weather Service Cooperative Observer Station. It will consist of: a NWS type instrument shelter, maximum and minimum thermometers, a hygrothermograph, a standard (8 inch non recording) precipitation gage, a recording precipitation gage, and a totalizing anemometer (table 3 1). This is the minimum instrumentation. An alternate sensor for atmospheric moisture, a recording wind vane, and a recording pyranometer are optional. A portable psychrometer will be used as a calibration check device for the hygrothermograph.

The instrument shelter and the maxmin thermometers will be installed following the guidelines of the National Weather Service for Cooperative Observer Stations (USDC, 1970). The hygrothermograph will be in the instrument shelter.

The hygrothermograph will provide a continuous record of temperature and relative humidity using a weekly time scale. The hygrothermograph record should be adjusted to read within 1oC of the maxmin thermometers. The accuracy of the hygrograph response to relative humidity will be verified using a portable psychrometer which draws a constant air stream over wet and dry bulb thermometers. The relative humidity reading of hygrograph and psychrometer will be compared at high and low relative humidities. The use and adjustment of the hygrothermograph are discussed in Field Manual for Research in Agricultural Hydrology Chapter 3 (Brakensiek, Osborn and Rawls, 1979) which serves as the guideline document for the hygrothermograph.

Both precipitation gages should not be closer to trees, buildings or the instrument shelter than twice the height of the obstruction. Standards for precipitation measurement given in section 2.1 will apply.

The recording precipitation gage may be either a weighing or tipping type gage. Gages should record to at least 0.5 mm (0.02 inch) unless a NWSrecommended FisherPorter gage is used. Both standard and recording precipitation gages will be maintained at the same site. Recording gages will be impractical for some LTER sites in winter unless exposure and servicing can be provided in deep snow and the gage heated. The water equivalent depth of snow will be recorded (USDC, 1970).

The anemometer should be located away from obstructions which would interfere with wind flow over the instrument. The anemometer will be mounted with the cups at 3 meters. Maintenance on the bearings and spindle will be performed twice yearly as recommended in the Observer Handbook No. 2 (USDC, 1970) or the instrument manufacturers manual. Wind travel may be accumulated by an internal counter or at a separate recorder. The optional wind direction variable will require a recording system. Level 1 stations require increased reliance upon recording instruments. The individual LTER site may elect to install a data logging system rather than separate recorders.

Total global incoming solar radiation is listed as an optional variable because of the cost and effort required to obtain a valid record. Some sites may be able to copy global solar radiation data from another location having approximately the same elevation and average cloud cover. Otherwise, an LTER site may install a sensor at the meteorological station or at any nearby point with similar exposure that has power to operate a recorder. The sensor must be fully exposed to the sky in all directions (not shaded by vegetation, buildings, or topography). An exception may be made if all of an LTER site is similarly shaded by topographic obstacles. A fully exposed sensor is preferable because the data have wider application and the effect of shading can be subtracted from fullsky data. The sensor should be inspected daily, the glass kept clean, and the sensor and recorder recalibrated every 18 months.

3.2 Measurements

Daily observations are required (Table 3 2). Instruments that are read manually should be observed at some consistent time between 0500 and 0900 hours as for Level 0 observations. Where recording instruments are not available for all parameters the LTER site may be able to use an enhanced NWS Cooperative Observer or special worktime scheduling to obtain weekend and holiday observations.

Recording instruments such as the hygrothermograph should be inspected daily to assure continuous recording. The accuracy of the temperature and relative humidity record should be verified at least weekly by comparing hygrothermograph chart readings to the thermometers and the portable psychrometer. All daily measurements and comments on station operation will be entered into a permanent Observation Record or Log which is part of the official data source for calculated values appearing in LTER intersite reports. Values taken from recorder charts may be entered in the observation record. Recorder charts will be retained as part of the log record. A day (24 hour period) is defined as midnight to midnight.

At Level 1 stations, two temperatures will be extracted from the hygrothermograph chart the maximum and minimum temperatures for the day. The two observations for each 24 hour period will be recorded in the observation record. The daily mean temperature is the average of the two temperatures. Relative humidity (or dew point) is read from the chart at the same time points as minimum and maximum temperatures are read.

Because the standard precipitation gage is considered the more accurate, the recording gage values are adjusted to equal the standard gage total.

Wind direction may be recorded as an instantaneous observation once an hour (or as the most common direction in a five minute interval at times when the direction is highly variable) or summarized as the mean direction for each hour. As a minimum, direction will be listed for eight points plus the calm condition.

Global solar radiation may be recorded on a stripchart and hand integrated to get daily totals. With a ball and disc or electronic integrator installed on the chart recorder, both instantaneous radiation intensity and the accumulated solar energy can be displayed. As an alternative, separate electronic integrators can accumulate the energy input and display daily or hourly period totals or provide input to a data logger.

3.3 Reporting

The monthly intersite report for Level 1 (Table 3 3) will consist of daily values of each variable and monthly totals or means. The monthly mean temperature for LTER intersite reports is the average of the daily mean temperatures expressed in degrees Celsius (^{o}C). The intersite report will list the maximum and minimum temperatures (2 values per day) and the absolute maximum and minimum for each month. Actual vapor pressure in millibars may be calculated for each of the two daily observation points as:

```
                                Relative Humidity    {saturation vapor
_____________________     {pressure at air
                actual vp =                          {temperature
                                       100

     or

               actual vp =  saturation vapor pressure at dewpoint
temperature,


    where saturation vapor pressure in millibars:

                   e =    6.1121 exp (17.368 T / (238.88 + T))
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and T = air temperature in ^{o}C. This equation is the simplest of several given by Buck (1981). Errors in estimates of saturation vapor pressure over water for the range 10^{o}C to +50^{o}C are less than deviations caused by temperature measurement errors of 0.01^{o}C. Factors for atmospheric pressure adjustment are given in the same reference. Monthly mean vapor pressure for LTER intersite reports is the average of the daily mean vapor pressures.

Daily precipitation will be reported in millimeters for the LTER site reports. Hourly precipitation totals will be tabulated and available at each site but not included in intersite reports. Total wind travel, observed for a 24 hour period, will be converted to mean daily wind speed in meters per second. At sites experiencing diurnal wind shifts, the report may list day and night means rather than a single 24 hour mean. Where measured, wind direction will be reported as the number of hourly observations in each of 8 directions, plus calm, for each 24 hour period, for example:

Date	N	NE	E	SE	S	SW	W	NW	Calm
1	2	2	1	3	5	6	2	3	0
2	1	1	2	4	5	7	2	1	1
3	0	2	1	3	6	2	3	2	2

Total global incoming solar radiation will be reported in Joules/square cm./day (WMO,1971:pp.IX.1 and IX.51).

TABLE 3 1

LEVEL 1 Meteorological Station Equipment

Equipment	Specifications
Shelter	"Cotton Region" type, medium size (20x30x32 inch box).
Maximum and Minimum thermometer and the spirit	National Weather Service type maxmin Thermometersthermometers utilizing a support for the mercury maximum minimum thermometer.
Hygrothermograph	Air temperature measured with bimetallic strip. Relative humidity measured by human hair bundle. Continuous record on a sevenday drum rotation.
Portable Psychrometer	Electric fandriven drywet bulb psychrometer to be used as calibration check device for the recording hygrothermograph.
Precipitation Gage	Receiver capacity is 2" of rainfall with overflow capacity of 7". Receiver to rainfall ratio is 10:1 so that 1 inch of rain produces a 10 inch collection.
Recording Precipitation	NADP Station, weighing pan or tipping Gage bucket gage
Totalizing Anemometer	Activated at wind speeds 1 m/sec (2 mph)
Recording Vane	Wind direction divided into 8 (45o sectors
Recording Pyranometer	Capable of recording total global (direct and diffuse) radiation on a daily basis.

TABLE 3 2

LEVEL 1 Meteorological Measurements

Variable	Frequency of Observation	Observation Record Entry
MaxMin Temperature	Daily	Daily
Recorded Temperature	2 times/day	Daily
Relative Humidity or Dew Point	2 times/day	Daily
Precipitation	Daily	Daily
Recorded Precipitation	Hourly	Daily
Wind Travel/Wind Speed	Daily	Daily
Wind Direction	Hourly	Daily
Radiation	Daily	Daily

The temperature and relative humidity are extracted from the chart recording 2 times per day by determining the maximum and minimum temperature and the associated relative humidities.

TABLE 3 3

LEVEL 1 Meteorological Summaries For InterSite Reports

Variable	Determination	Units	Reported Values

Mean Temperature	Daily sum of the MaxMin values divided by two	oC	Daily Mean
	Monthly sum of the Max and Min values per day divided by two, divided by the number of days in the month	oC	Monthly Mean
Extreme Temperature	Largest and smallest absolute values from the observation record of the MaxMin Thermometers	oC	Monthly Max Monthly Min Daily Max Daily Min
Actual Vapor Pressure (AVP)	Mean of 2 calculated AVPs	mb	Daily mean
	Monthly sum calculated AVP values (2 values/day taken at maximum and minimum temperatures) per month divided by two divided by the number of days in the month	mb	Mon Mean
Precipitation	Daily total precipitation	mm	Daily Totals
	Summation of daily Record per month	mm	Monthly Totals
Wind Speed	Summation of wind travel per day divided by the number of seconds per day	m/ sec	Daily Mean
	Summation of daily means per month divided by the number of days in the month	m/ sec	Monthly Mean

Table 3.03 Continued

Wind Direction	Instantaneous direction taken each hour (or most common dir in a five min interval when dir is variable)	45o sectors	Most frequent daily
	Most frequent daily	45o sectors	Most frequent monthly
Global Radiation	Daily Total	J/sq.cm	Daily Totals
	Mean of daily totals	MJ/sq.m	Monthly Means

4.0 LEVEL 2 METEOROLOGY

The Level 2 station obtains the more detailed meteorological data appropriate for a research site in addition to basic climatic parameters obtained at a Level 1 station. The same variables will be measured, with wind direction and solar radiation required, and all variables reported on hourly intervals. The relatively low cost of electronic data loggers and sensors makes this an especially attractive method for handling the additional recording requirements of a Level 2 station. The state of the art for data loggers changes rapidly and equipment selection depends on the individual site's present and future needs, electronic technician capability, adaptability of sensors on hand, and funds available.

4.1 Instrumentation

With electronic data logging, analog signals (usually of varying voltage or resistance) from sensors are sequentially sampled and converted to a digital form by a digital voltmeter. Sampling may be done at a rapid rate of one or more times a minute to obtain integrated sums or means. Some signals, for example those of wind velocity, come in pulse form and an integration is made as the digital output is produced. The output can be channeled to a visual monitor, paper strip chart or paper tape, but more often is recorded on magnetic tape (usually a cassette) or a silicon chip. Some recording systems may be interrogated remotely by telemetering.

No specific sensing and recording system is recommended by the committee since each site should be free to select its own system. However, the minimum requirements are that the selected system:

1) be able to record the Level 1 variables at hourly intervals,

2) be able to provide data in a form compatible with LTER data archiving requirements which are very flexible,

3) include sensors to record: air temperature, relative humidity or dew point, precipitation, wind speed and direction, global solar radiation,

4) include recorder(s) to collect and process the data,

5) have available translator(s) to convert the data from the recorder into computer accessible form.

Although the sensors in electronic data logging systems sense the same variables as Level 1 equipment they often are more sensitive and need to be exposed in a different manner. Some package systems come with masts and shelters that obviate the need for the standard shelters and other equipment mentioned in sections 2 and 3.

The following are some criteria that LTER sites may use for selecting data logging systems:

1) Components of a system must be physically and electrically compatible. Response speed and signal level of sensor and recorder must match to avoid degrading raw data. Recorder and translator must match to avoid losing data. Unless the user is prepared to assume system design responsibility, components should be bought from a single supplier who guarantees system compatibility.

2) The recorded data should be accessible in the field for checks and calibration as well as being easily translatable to a record which can be read and processed by computer for summary reporting, and further analysis.

3) The system should be able to operate during expected environmental conditions. Estimate climatic extremes at your site and specify that the equipment will operate within these limits. Components that seem particularly susceptible to cold (<10 deg.C) and moist (RH>90%) conditions include hard copy paper printers andcassette recorders. Modems are more reliable if a phone line can reach a station.

4) Be sure that the manufacturer can provide fast service and backup for your equipment or have two or more compatible systems to interchange components. If components are interchanged make sure intercalibration factors are available. Budget for repairs and recalibrations.

The components of an example data logging system are listed in appendix 2.

4.2 Measurements

Except for reporting frequency, measurements for Level 2 are those made at Level 1 as listed in Table 3 2. Additional resources will be required to record and process both hourly data and summaries for intersite reports. Some data logging systems have built in microprocessors that can be programmed to provide a portion of the data summarization.

Intersite reports will not list hourly data but hourly measurements will be necessary for future comparisons of detailed meteorological phenomena between studies on sites. Assuming hourly data are summaries of short timeinterval observations, air temperature and vapor pressure data should include the instantaneous maximum and minimum and 60 minute average for each parameter. Where calm wind conditions are the rule, listing of minimum wind speed may be omitted. Wind direction may be reported by the prevailing direction or as the mean wind vector. Precipitation and solar radiation should be hourly totals. These hourly measurements are a minimum and additional parameters may need to be recorded at some sites.

4.3 Reporting

All original data records (tapes, charts, etc) should be kept, where practical, for at least ten years and the earliest listing of raw electronic data should become part of the permanent record for the site. Summaries for intersite reports for Level 2 stations would be similar to Level 1 (Table 3.3) with the exception that daily means will be based on hourly data.

Data formats for intersite reporting will vary according to the purposes for which the data are required and will be specified on an ad hoc basis for particular projects.

5.0 LEVEL 3 METEOROLOGY

Level 3 meteorology concerns additional specialized measurements directly related to local site specific research needs. Because a wide variety of such needs exist, the topic can be treated in only a general manner here. To give some guidance, Appendix 3 presents a specialized bibliography of literature on this subject, and Appendix 4 lists examples of bioclimatology studies that have been performed or are in progress at LTER sites. Persons interested undertaking similar studies should contact the investigators listed to obtain advice and coordinate methodology.

5.1 Standardization of Specialized Measurements.

Owing to the large variety of specialized measurements that might be undertaken at LTER sites the Climatology Committee does not specify procedures but does make two recommendations:

First, where any specific future intersite study is anticipated the investigators are strongly urged to plan the experiment in such a way that instrumentation and methods are identical at the sites involved. The climate committee would be able to give advice on experimental design.

Second, investigators using specialized meteorological measurements must pay special attention to reporting the accuracy and precision of their observations. This will enable future studies to determine whether intersite comparisons fall within or outside of measurement error. Statements of accuracy and precision should address all parts of the following definitions which have been provided by the National Atmospheric Deposition Program (NADP, 1984. p38):

Accuracy: A measure of the degree of conformity of the mean value, obtained by using a specific method or procedure, with the true value. The concept of accuracy includes both bias (systematic error) and precision (random error).

Precision: The degree of agreement of repeated measurements of a homogeneous sample by a specific procedure, expressed in terms of dispersion of the individual values about the mean value.

The LTER Climate Committee endorses the precision and accuracy values suggested by the North Central Region of the Agricultural Climate Committee and advises LTER sites to attempt to meet these standards. They are as follows:

o

Measurement	Precision	Accuracy
Temperature	0.oC	0.25oC
Radiation	1%/100 KJ	5%

Wind Speed	0.1 m/sec	5%
Wind Direction	1 degree	2 degrees
Precipitation	1 mm	5%
Relative Humidity	1%	5%

5.2 The National Atmospheric Deposition Program (NADP)

The National Atmospheric Deposition Program is a cooperative research program of the state agricultural experiment stations and other federal, state, and private research organizations. Its aim is "to determine both the composition and amount of atmospheric deposition and its distribution on a national scale in order to assess the magnitude of the effects..." (NADP, 1984).

Some LTER sites already participate in the NADP. The LTER climate committee endorses all the practices already in place for the standardization of NADP measurements. These practices are reported in the documents NADP Site Selection and Installation Manual, NADP Instruction Manual On Site Operations, and Field Operations Manual.

The NADP is now closed to the establishment of any new sites. Any LTER sites that are interested in making atmospheric deposition measurements should use the same sample collectors (Aerochemetrics Model 201) used in the NADP program. These are available from Aerochemetrics Ltd. 6832 SW 81 Street, Miami, Florida 33143. Investigators should also follow, as closely as possible, the same laboratory analytical methods used in the NADP program. Details of these may be obtained from the NADP documents NADP Quality Assurance Plan : Deposition Monitoring and CAL Analytical Methods Manual. Copies are available from Dr. Gary Stensland, Illinois Water Survey, 2204 Griffith Drive, Champaign, IL 61820 which is the location of the Central Analytical Laboratory (CAL) of the NADP.

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