METR 3613: Meteorological Measurements

Fall 2004 **Dr. Petra Klein**
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Overview of the Thunderbird Micronet

Introduction

The Lake Thunderbird Micronet is a micrometeorological measurement network intended to obtain data on fine-scale spatial and temporal variability of temperature, relative humidity, and liquid precipitation fields under conditions typical for Central Oklahoma. The Micronet, located on a private piece of land near Lake Thunderbird 9 miles east of Norman (see a view of Micronet site in Fig. 1), includes 28 stations equipped with temperature and humidity sensors, and three rain gauges. The average spacing between sensors is approximately 30m.

Fig. 1: View of the Lake Thunderbird Micronet site

The main task of the Micronet is the establishment of an outdoor micrometeorological laboratory (Microlab) which will serve as a comprehensive training facility for undergraduate students in the atmospheric and environmental sciences. We want to bring micrometeorology and hydrology out of the classroom and into the field, and to integrate inquiry-driven learning throughout the undergraduate curriculum.

Micronet Location

As stated in the introduction, the Micronet is located on a private piece of land near Lake Thunderbird. The address is**:** 1000 110 Ave. NE, Norman, OK. It is highlighted in the map shown in Fig. 2. More detailed driving directions will be provided to you shortly before your studies at the Micronet are scheduled.

Since the Micronet is located on a private piece of land it is absolutely mandatory that you coordinate all activities with the instructors (Dr. Petra Klein or Sean Arms) before you visit the site. You also must assure that you will leave the Mirconet site in the same state as you found it (i.e. no trash should be left, no plants or anything else should be destroyed etc.)

Fig. 2 Location of the Lake Thunderbird Micronet

Measurement Posts of Micronet

The location of the 28 monitoring stations is shown in Fig. 3. The coordinates for each station are also listed below.

Post	X (m)	Y (m)	Z (m)
2	57.1	246.5	23.7
14	73.4	140.5	6.4
10	32.2	172.9	14.8
5	74.5	224.0	18.8
7	37.8	209.2	18.6
22	100.4	47.2	4.0
26	1.5	23.3	9.7
12	102.3	172.0	14.8
17	73.4	103.2	7.4
27	0.0	0.0	0.0
23	69.3	61.5	4.8
20	65.6	79.6	5.0
24	31.9	43.9	7.6
9	99.7	201.6	18.8
15	32.1	139.7	9.9
1	84.5	247.1	24.1
4	44.1	227.7	19.9
18	31.5	102.6	9.5
16	115.3	105.4	6.0
8	70.0	199.8	14.5
28	47.3	196.9	16.3
11	70.8	164.1	14.0
21	106.4	78.4	4.5
19	36.3	71.1	8.2
13	109.0	145.0	23.3
3	29.3	244.6	8.9
25	43.4	42.4	6.6
6	90.8	230.7	23.1

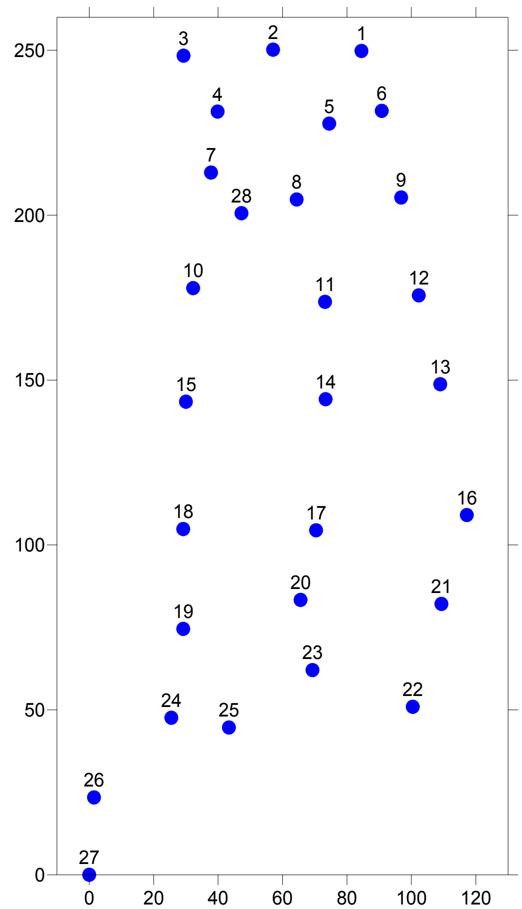

Fig. 3: Sketch of post locations on the Micronet site.

Sensors

Air temperature and humidity:
HOBO® H8 Pro RH/Temperature Logger (see Fig. 4).

Features and specifications

- Weatherproof (RH sensor requires protection from rain or direct splashing)
- High accuracy: ±0.3°F and ±3% RH; ±4% in condensing environments

- Capacity: 65,291 standard resolution measurements or 32,645 high resolution measurements
- 0-100% RH range including intermittent condensing environments up to 30°C (86°F) and non-condensing environments above 30°C (86°F)
- User-selectable resolution on temperature measurements (8 or 12 bit)
- User-selectable sampling intervals: 0.5 seconds to 9 hours, recording times up to 3 years

Fig. 4: Photo of the Onset Hobo Temp/RH sensor and logger.

- Readout and re-launch in the field with optional HOBO Shuttle (new H09-002-08 version required)
- High speed data readout: full 64K in about 1 minute to either PC or HOBO Shuttle
- Precision components eliminate the need for temperature calibration
- Drop-proof to 5 feet
- Mounting tabs, self tapping screws and hook/loop tape included
- Programmable start time/date
- Memory mode: stop when full
- Automatic data archiving of 7 previous deployments
- Nonvolatile EEPROM memory retains data
- Blinking LED light confirms operation (visible through communication jack)
- User-replaceable battery lasts 3 years
- Battery check at launch
- Operating range: -22°F to +122°F (-30°C to +50°C)
- Time accuracy: ±1 minute per week at +68°F (+20°C)
- Size/Weight: 4 x 3.2 x 2" (102 x 81 x 51 mm)/ approx. 3.7 oz. (104 gms)
- Intrinsically Safe (IS) model available for use in monitoring conditions in hazardous locations where combustible dust or gas may be a concern.

Measurement specifications

Temperature (internal sensor)

- Range: -22°F to +122°F (-30°C to +50°C)
- Accuracy: ±0.33°F (±0.2°C) at +70°F in high resolution mode and ±0.7°F (±0.4°C) in standard resolution mode, see plot below
- Resolution: 0.04°F (0.02°C) at +70°F in high resolution mode and 0.68°F (0.38°C) in standard resolution mode, see plot below
- Response time in still air: 34 minutes typical

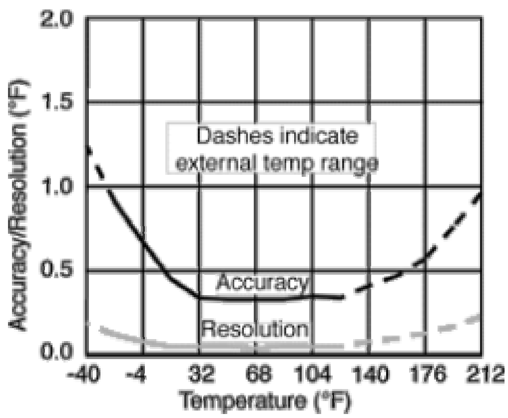

Fig. 5a: Temperature accuracy and resolution in high resolution mode

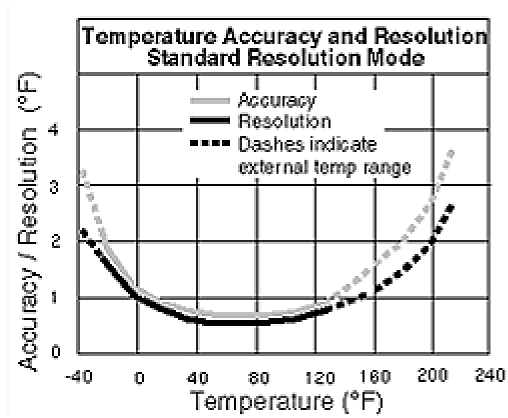

Fig. 5b: Temperature accuracy and resolution in standard resolution mode

Relative humidity

- Range: 0% to 100% RH
- Accuracy: ±3% (up to ±4% in condensing environments) (requires BoxCar 3.7.3 or BoxCar Pro 4.3 or higher)
- Response time: 5 minutes typical to 90%
- Sensor operating environment: +32°F to +122°F (0°C to +50°C)
- Intermittent condensing environments up to 30°C (86°F); non-condensing environments above 30°C (86°F).

Drift: 1% per year typical, an additional temporary drift of up to 3% can occur when average humidity is above 70%; factory tune-up available.

Liquid precipitation:

Onset’s Data Logging Rain Gauge RG2 or RG2-M

Onset’s Data Logging Rain Gauge (RG2, imperial version and RG2-M, metric version) are fully self-contained, battery-powered rainfall data collection and recording systems. They include a data logger integrated into a tipping-bucket rain gauge. The RG2 automatically records up to 80" (160 cm for the RG2-M) of rainfall data that can be used to determine rainfall rates, times and duration. A time and date stamp is stored for each 0.01" (0.2 mm for the RG2-M) tip event for detailed analysis.

Fig. 6: Photo of the Onset’s Data Logging Rain Gauge

Rain gauge features

- Fully integrated HOBO Event data logger
- Removable top with a single thumbscrew for easy data offload
- Self-emptying for continuous rainfall logging
- Three mounting feet for use on flat level surfaces (3 screws included)
- Side bracket for mast mounting (hose clamps included)
- 6" (154 mm) collector ring
- Size: 6.5" diameter x 10" high (165 mm x 254 mm)
- Weight: 2.2 pounds (1.0 kg)

Other features and specifications

- 8000-tip memory capacity: RG2 records up to 80" of rainfall data and RG2-M records up to 160 cm
- Readout and relaunch in the field with optional HOBO Shuttle
- Programmable start time/date

- Memory modes: stop when full or wrap-around when full
- Nonvolatile EEPROM memory retains data even if battery fails
- Blinking LED light inside logger case confirms operation
- User-replaceable battery lasts 1 year
- Battery check at launch
- Resolution: 0.01" for the RG2 and 0.2 mm for the RG2-M
- Calibration accuracy: 1.0% (up to 1" per hour for RG2 and 20 mm per hour for RG2-M; field accuracy depends on environmental conditions)
- Timestamp resolution: 0.5 seconds
- Operating temperature: +32°F to +122°F (0°C to +50°C)
- Storage temperature: -4°F to +158°F (-20°C to +70°C)
- Relative humidity range: (when logger case is closed) 0 to 100% RH, weatherproof
- Time accuracy: ±1 minute per week at +68°F (+20°C)

Rain gauge construction

The RG2 and RG2-M Data Logging Rain Gauges are constructed from field proven, corrosion-resistant mechanical components.

- Housing: Aluminum with a baked white enamel finish
- Collector ring, screen, mounting bracket and feet: black anodized aluminum
- Shafts, bearings and hardware: stainless steel and brass
- Tipping bucket: high precision, injection molded, high-impact polystyrene plastic

Micronet Tower

The Micronet was recently extended by 15m-tower (see Fig. 7) that is equipped with 5 RM Young 81000 sonic anemometers that are connected to a Campbell Scientific CR5000 datalogger. Presently, the tower is not yet fully operational but it is planned to finalize its installation during Fall 2004.

Fig. 7: Photos of the Micronet tower with 5 levels of sonic anemometer measurements.

Some Ideas about the Analysis of Spatial Variability of Micronet Data

Instantaneous or time-averaged values of meteorological variables measured on the Micronet posts are spread in space over the whole Micronet site (see Fig. 3). Measurements at individual posts are affected by many factors, of which the main is the geographical location (type of the underlying surface, vegetation surrounding the post, closeness to the lake, elevation, exposure, etc.) of the post. Spatial variations of meteorological quantities over the Micronet site can be characterized in many different ways.
For instance, one can consider the measured air temperature as function of height above some reference level. In this case, we will have a discrete one-dimensional (1D) function $F_z = \{T(z_i)\}$, with i = 1…N, where N is the number of posts. Analysis of such function could be useful for understanding how the elevation of measurement location affects temperature values on the site.

One can also consider a discrete 2D function of temperature values as a function of two horizontal coordinates, x and y: $F_{xy} = \{T(x_i, y_i)\}$, with i = 1…N, where (x_i, y_i) are the horizontal coordinates of individual posts. In this case, analysis of the spatial distribution of temperature can be indicative of local disturbances of the temperature field associated with inhomogeneity of the underlying surface of the Micronet site.

In addition to the function F_{xy}, it might be useful to analyze the absolute difference $\Delta T_{ik} = |T_i - T_k|$ between the temperature values measured at individual posts i and k as a function of distance $r_{ik} = \sqrt{(x_i - x_k)^2 + (y_i - y_k)^2}$ between the posts.

Another possible way to characterize the temperature variability is to consider a discrete 1D distribution (histogram) $D_T = \{n_j(T_j)\}$ at the different posts, where the number n_j characterizes how often a temperature value from your sample i (i = 1…N), falls in the j-th interval between $T_j - \Delta T / 2$ and $T_j + \Delta T / 2$. The total number of intervals N_j and size ΔT of the temperature intervals depends on the total range of temperature variations over the Micronet site.

In order to provide some simple description of a distribution such as D_T, we need measures of the value, at which the distribution is centered and how wide the distribution is. The center of the distribution (mean value) is estimated as $\overline{T} = \frac{1}{N}\sum_{i=1}^{N} T_i$, and the standard deviation $\sigma_T = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(T_i - \overline{T}\right)^2}$ is a measure of the distribution width.

Reference

Lyons, L., 1991: *A practical guide to data analysis for physical science students*. Cambridge University Press, 95 pp.