Student Exercise
SEASONAL SURFACE TEMPERATURES

Purpose: To introduce students to the use of a hand-held infrared thermometer, collection of thermal data of varied natural and man-made surfaces over the course of several weeks, to capture, and analyze sequential variations in the temperatures and rates of changes in temperatures of different surfaces.

References:
http://www.globe.gov/web/atmosphere-
https://www.youtube.com/watch?v=Rz7EXNAMsyg
http://satellitesk12.org/?page_id=1269
http://americaview.org/earth-observation-day

Materials: (1) Handheld infrared thermometers with capability to change emissivity settings. (There are numerous infrared thermometers available for $120 or less (e.g. Fluke, Omega, Extech) that are compact, accurate, and practical for student use); (2) Hand-held GPS receivers (such as the Garmin Etrex, Magellan Triton, or DeLorme EarthMate); (3) Students should access to Microsoft Excel, or comparable software. (4) Maps and or images of local areas on or near your school's campus.

Instructor Preparation: Prior to the first data collection day, organize the class into several groups of the two to three students each, such that the number of groups matches to the availability of thermometers and GPS units. All students should be proficient in each of the skills required, and rotate duties as they conduct the exercise. For this exercise, use of the GPS, at a minimum, includes recording waypoints to match locations of temperature observations. Among skills required for use the thermometers are setting emissivity's to match the surfaces to be observed, awareness of the instrument's field of view, effects of nearby thermal sources and reflection from nearby surfaces objects, and knowledge that the thermometer itself must be shielded from heating from direct sunlight, and from other thermal sources.

Instructions presented here are based upon experience with our class of 60 undergraduate and undergraduate students, with separate lecture and lab sessions. We divide the class into separate sections such that they can alternate activities on successive lab class, swapping lab activities, so the entire class can participate. Individual instructors should modify details of these instructions to match their own circumstances. Days with wind, rain, snow, or other weather that will prevent observation of differential heating or cooling of surfaces are not satisfactory for this exercise, so the activity should be rescheduled.

DATA COLLECTION

Organize groups with designated people to record GPS locations, local climate conditions, and surface temperatures, each designed to capture a variety of different surfaces within your campus. Each group should plan to revisit the same sites during the semester. Students collect approximately 12 to 15 observations representing different surface types under different atmospheric conditions, distributed throughout their designated area as marked on a campus map. Try to represent each of the following categories:

- Pavement (concrete)
- Pavement (asphalt- black)
    - (Collect several examples of the pavement/concrete category)
- Grass
- Water (feasible only for some areas)

- Soil
- Under tree-(describe surface)
- Steel
- Limestone

Students will be required to set the emissivity on their thermometers to match the surface to be observed, and to record the emissivity together with the corresponding temperature. Students record a GPS location for each point they visit. (For future data collection dates, each group will revisit the same locations, so will record the coordinates only once.) We assign each group leader responsibility of posting data to a shared spreadsheet such as GoogleDocs template that will preserve the record over the course of the semester, and to provide access for all students in preparing their reports.

DATA ANALYSIS

Objectives: To collect, record, and analyze thermal properties of different surfaces at varied location and dates.

Assignment: This assignment is to prepare a set of maps and diagrams to summarize spatial and temporal variations in surface temperatures.

Materials: Each group's shared spreadsheet recording the temperature observations.
Maps and images of campus that show locations of observations.
These are for your use in responding to the items presented below.

Methods: Download a copy of the spreadsheet for this exercise. Additionally, the spreadsheets from all groups can be utilized for a more extensive analysis.

1. Use the utilities in the spreadsheet to prepare a graph or chart that shows changes in observed temperatures at each point, for the dates in the exercise (or, use a selection of these data).

2. Briefly summarize patterns of temperature changes during the semester. How does the air temperature differ from the surface temperature readings that you obtained? The data will likely show the usual seasonal decline in temperatures during the autumn, or increases during the spring. However, you may find that the amount of change will differ from one surface or location to another, so discuss why some surfaces display differing rates of change. Remember: the goal is not only to observe the changes in temperatures during the semester, but also the *differences in the rates of change* for different surfaces over time.

3. The thermometers have collected point observations. Discuss your thoughts concerning the impact of the local context upon the temperature observations (i.e., the surroundings within approximately 10 meters or so of each observation).

4. Discuss briefly how this information helps understand: (a) analysis of thermal imagery (compare with Figure 1 below), (b) phenomena such as the urban heat island, and (c) interrelationships between local temperatures and land use patterns (consider for example, impervious surfaces, shadowing, exposure to winds and nearby sources of moisture).

Submit for this assignment: Prepare a short lab report to show your maps and diagrams, and to discuss the results of your analysis. Spreadsheet, diagrams and graphs mentioned in (1), and short written responses to questions 2-4 above, using no more than two pages.

Figure 1

Example of a Thermal Image