**Group Term Project**

**EARS 06: Environmental Change**

**Fall 2020**

**Pre-project Questionnaire**

This term, we will learn how to assess measurements of environmental change. We will gain a better understanding of how the scientific process works by performing experiments to measure solar irradiation.

Before we delve into the term-long project, I would like you to think back on what you already know about the environment. Please complete the following pre-project questionnaire. Each question should be answered with a brief paragraph.

1. Why do seasons occur?
2. What determines climate?
3. How does the scientific method work?
4. How would you design an experiment to measure solar irradiation?

**Group Term Project**

**EARS 06: Environmental Change**

**Fall 2019**

**Preliminary data and hypotheses due:**

**Final Project report due:**

**Video Abstract due:**

**Objectives**: By completing this term project, you will:

1. Make actual measurements of current environmental change
2. Estimate the uncertainty associated with your measurements
3. Formulate a hypothesis as to the nature of the change
4. Test a hypothesis
5. Draw conclusions
6. Collaborate with fellow students to share data, work, and ideas
7. Communicate your findings in both written and oral form

**Group Work:** As stated above, you will be undertaking this assignment in your Active Learning groups. This means many things, in particular that collecting lots of data will be much easier with a group. We expect each group to determine, before the preliminary data are due, how the work will be divided. We want, in particular, to differentiate between the concepts of **collaboration** and **cooperation**. In collaborative work, each member of a group is working to understand the whole project, and each contributes to each aspect. In contrast, cooperation often refers to work in which the project is divided into parts, and each participant becomes a specialist in completing that one part. In this setting, we favor collaboration over cooperation for your work mode, since this allows all group members to share in learning each aspect.

Note that **your whole group will turn in a single product for each deliverable,** but we expect that the whole group will have contributed. For example, if you divide the final paper sections amongst group members, it makes sense to gather together once all sections are written and revise the whole document together, to keep everything in a single voice.

Given the group nature of the deliverables, **each group will receive a single grade** – *provided* each group member contributed to the project. You will have an opportunity to confidentially evaluate the relative contributions of each group member, including yourself, and based on the entire group’s ratings, if a single group member either really carried the group or conversely contributed very little, individual grades may be adjusted accordingly. Thus, it is in your interest to **work together** and if this poses a difficulty, come see the professor, one of the TAs, or one of the Learning Fellows as early as possible.

**Background:** Latitude is extremely important in determining the climate of any particular location on Earth. The most important reason for this is the angle at which the sun’s rays strike the Earth. This affects the amount of incoming solar radiation, or *insolation* (measured in Watts per square meter), that arrives at the surface at a given point on the globe. The amount of energy coming from the sun to any particular part of the globe is relatively constant, but at the lower latitudes where the sun’s rays strike the earth perpendicular to the surface, there is a greater *flux* of energy into the surface. At higher-latitude locations, where the sun’s rays strike more obliquely, the energy of the sun must spread out over a larger surface area, and so the flux entering the surface at higher latitudes must therefore be lower.

One way of thinking about this is the concept is by looking at the two-dimensional example in the diagram below. Imagine the amount of energy coming from the sun to be equivalent to the number of rays in the drawing. When the surface is exactly perpendicular to the rays, it collects the most energy. When it is angled obliquely to the rays, as in the center example, it does not collect as much energy. If one keeps the same angle, yet enlarges the surface (as in the right-hand example), it once again collects the same number of rays as in the first case, but now since they are spread across a larger surface, the number of rays *per unit surface area* is still lower than in the first case.

A close up of a device

Description automatically generated

Now take this concept and apply it to the surface of the globe, which for our purposes can be approximated by a sphere (it’s actually an oblate spheroid). The measurement of latitude on Earth comes from the Earth’s relation to the sun, and the angles involved. Thus, the equator is defined as the latitude on the Earth where the sun’s rays, at midday on the *equinox*, strikes the earth at an *incidence angle* of zero. This angle increases as you travel North along a longitudinal line, until at the pole, the sun’s rays, again at midday on the equinox, strike the earth at an angle of 90°. Thus, if you want to determine where you are on the Earth, you can measure the incidence angle of the sun at noon on the equinox, and this will tell you your latitude.

Note that in the preceding discussion we have been referring to the equinox, and this only happens twice a year. During the other times of the season, the *incidence angle* of solar radiation will be different from the latitude. What kind of effect will this have on local climate and weather? Through the rest of the term, we will be taking **frequent observations** of this solar incidence angle and observing the changes in weather that accompany it.

**Project Summary:** You will be making frequent (ideally daily) measurements of the incidence angle of the sun. You will be analyzing this data, combined with climate data, to examine and explain the effect of incidence angle of solar radiation on local climate and weather. Additionally, you will be evaluating insolation data to assess the association between latitude and insolation.

**Directions:**

*How do we measure the incidence angle of the sun?*

In order to measure the incidence angle of the sun here in Hanover, we need some instruments. One method would be to use a *sextant* or *theodolite*, used for precision measurement of angles. Not having one of these instruments, what might we do?

An expedient way to measure the angle of the sun is to use the shadow of a building of known height. At high noon, the top of the building, the bottom of the building, and the end of the shadow cast by the building form a *right triangle,* as long as the building is on flat ground. Measure the two legs of the triangle, and you can determine the angle using trigonometry. We are looking for the angle θ in the diagram below. Knowing the height of the building *H* and measuring the length of the shadow *S*, you can find the angle θ by the equation

,

Which solves to

,

since arctan is the inverse of tan. To calculate the angle θ, you can use the arctan function in Excel or Google Sheets.

A close up of a logo

Description automatically generated

Now all we need is a suitable building to measure! There are many possibilities on campus, but the one we will be using for this project is the Wheeler dorm. Wheeler is just across the way from the Fairchild Physical Sciences Center and offers a convenient grassy area on which to make our measurements.

A close up of a map

Description automatically generated

The height of the Easternmost “chimney” (closest to Wilder hall, small circle to the right in the photo) is 15.7 meters. Next, we need to measure the other leg of the triangle. We will need to make this measurement as often as possible, ideally daily.

*How can we make the measurement we need?*

Since we need to make this measurement daily, we need a tool that will always be available. We could use a laser or a measuring tape, but for the purpose of this project, we will use our *feet*. We always have them with us! So, our methods boil down to:

1. **Determine** the length of your foot with a given shoe using the calibration stations in the classroom (don’t just measure one shoe with a ruler).
2. At or close to solar noon, every day if possible, but at least 2-3 times per week, use your feet to **measure** the length of the shadow cast by Wheeler’s Easternmost chimney. The measurements should be recorded in a single, shared Google Sheet.
3. Use the height of the building along with the formula above to **calculate** the solar incidence angle. Use the arctan function (atan) available on Google Sheet to calculate the solar incidence angle. Please make sure that your results are converted to degrees as the arctan function will produce results in radians.

For reproducibility of data analysis, each calculation done on the cells should **include** a short description of what was done on the cell or column. It can be done by right clicking the cell and selecting *insert note*. These notes will be useful when writing the methods section of your final report.

1. **Plot** your calculated incidence angle versus time as it changes; we will use these plots to come up with hypotheses about continuing change, and then see if we are right!

*Where can we keep track of our data?*

To ensure collaborative efforts from all group members, we will be keeping track of all data used in this project in a single Google Sheet file. It should be created at the start of the project and shared with all group members. Please make sure all data are clearly labeled as the final version of the Google Sheet containing your data will be submitted as part of the final report.

It is important to keep a record of the data analysis steps so that your work may be reproduced by someone else. **Explain** each step you have taken to reach the final result so that someone else may be able to follow it exactly in your final report methods section.

*How do we access and analyze the additional data that we need?*

In addition to your measurements, we will be using publicly available datasets to observe associations between temperature and solar incidence angle as well as changes in insolation over time.

**Download** actual temperature data of the days you measured the shadow length from the NOAA national climate data center at <https://www.ncdc.noaa.gov/cdo-web/>. Add this data in your Google Sheets file in the column next to your data. Look at the maximum temperature on each day you observe the incidence angle.

1. Do you see any correlations? Try finding historical average temperature or historical high temperature data on the days of your observations.
2. Do you see any correlations? Why or why not?

**Access** the insolation data from the MacLean building at Dartmouth at <http://s40418.mini.alsoenergy.com/Dashboard/2a566973496647334243554b772b716f3d>. The Elkor Production Meter is representative of the insolation. Explore the daily, monthly, and yearly insolation data. Different days, months and years can be accessed by clicking the arrows on the top bar.

* 1. What do you expect the insolation data to look like over the course of the year?
  2. Select a day that is representative of a day for a nice hike.
  3. Select also a day that would not be pleasant for a hike.
  4. What conclusions can you make from the two days?
  5. View the insolation data over a five-day period. What conclusions can you draw from the data over span of five days?
  6. Compared to the five-day period, what is the weekly, monthly, or yearly data plotting? Include screenshots of the days you selected and the five-day period data you explored in your final report.

**Download** the yearly data from 2018 to present by using the button with three lines on the bottom right of the plot. Export into either Excel or CSV format and load onto a new sheet of the Google Sheets file containing your data.

For reference, following is what the data for January 2018 to June 2018 should look like:

A picture containing object

Description automatically generated

With this in mind, plot graphs from 2018 to the present.

* 1. What conclusions can you draw from this graph?
  2. What conclusions can you draw from plotting all the years stacked onto each other in one graph?
  3. In this same graph, please also include a graph of the averages over the months.

**Explore** the insolation data from the UQ PACE building in Australia as well. It can be found at <https://monitoring.solaredge.com/solaredge-web/p/home>. Click the demo account and **UQ Pace Building – 226.46I** to access the data. **Download** the yearly data from 2018 onwards by clicking the csv button next to the *Power and Energy* section header. This dataset should also be in a new sheet of the same Google Sheets file you’ve been working with. Do the same analysis as you did for the data from the MacLean building.

* 1. Do you observe any relationships between the insolation over the year between the MacLean building and Australia? When comparing the two datasets, make sure they have the same unit of measurement (i.e. kilowatts/hour). If converted into a different unit of measurement, it should be recorded as a note on the column. Please explain any relationship you see.

Each screenshot and plot created should be included in the results section of your final report. Additionally, each numbered question in this section should be addressed in the discussion section of the final report.

**Deliverables:**

**Preliminary data and hypotheses:**

**Format:** One page, two-sided

**Requirements:**

1. A brief (1 paragraph) description of your **experimental model**, how often you made measurements, how you calibrated your “instrument” (your feet), what difficulties you encountered. This only needs to be a paragraph. Note that you should be calibrating your shoes by walking a set length heel-to-toe, rather than measuring the shoe directly.
2. Your **data.** This should be your calculated solar incidence angle, plotted against time, created with chart functions in Google Sheets. Note that if your samples are irregular in time (i.e. every day for 5 days, then missing 3 days, then 2 days in a row, then missing a day…), you need to account for that in your plot; email or come see us, the TAs, or the learning fellow if you have questions about this aspect; we may arrange an x-hour to cover methods of plotting for those who are unsure.
3. Your **working hypothesis**, (1 paragraph) based on the data you have collected, on the nature of solar incidence angle change through a full year. This is essentially your prediction for what your plot would look like if we were able to continue it out through the winter solstice and towards the spring equinox. This can also be just a paragraph. Be sure to state how you see things changing and paying particular attention to the *rate* of change.
4. Your group’s **work plan** – describing how your group has determined to share the work of conducting the experiment, analyzing the results, and writing up the report. How you choose to divide this is up to you, but we want to know your plan. See **Group Work** above.

**Final Project report:**

**Format:** Manuscript

**Requirements:**

Your final project report should be in the format of a manuscript (scientific article), such as would be submitted for publication in a peer-reviewed journal. Specific sections in such a manuscript should include:

1. **Abstract**, a concise statement of the questions to be answered, why it is important, how you went about answering the question, the answer to the question, and what it means. This needs to be direct, and to the point. Many journals limit this section to *no more than 200 words*, and we will obey this length restriction.
2. **Introduction and/or background**, in which the reason for the study is made clear and the background information to place the current study in context is presented.
3. **Methods,** in which you discuss your field location, the choice of field location and what factors may influence the result, talk about how you went about measuring the solar incidence angle, what difficulties you had, how someone in the future might do things differently (i.e. what you learned about actually making the measurements). As part of this section, you need to be sure to state something about the *accuracy and precision* of your measurements.
4. **Results**, which are your data you collected through the term. These are your observations, and it is important that no *inferences* come into this section – this is simply your description of the data you collected, and any interesting features you’d like to point out to the reader. At least one plotfrom your data should be part of this section. Plots of the insolation data from the MacLean building and Australia you explored should also be included.
5. **Discussion**, in which you can draw inferences based on the data. This is your chance to say what you think the data means; this section is generally the heart of any scientific paper. Please be sure to include what **your** insolation data would look like in different seasons of the year as well discussion of the results from the public datasets.
6. **Conclusions,** stating explicitly the conclusions reached in the study (which may also have been discussed in the discussion section above).
7. **Citations** – be sure to cite your sources, including this handout. It is important to note that copying text directly from any source, without proper quotation form, is plagiarism. The exact format for your citations can be up to you, it is merely important to us that you indeed cite your sources.
8. In addition to the above needed elements, multi-author documents (which yours will be) are often required by journals to include a **Contribution Statement** which outlines the individual contributions of each other. We expect this to be a fair and honest account of each author’s contributions to the paper, written and approved by all group members.
9. To promote reproducibility in science, many journals require data analyzed in the manuscript to be stored in a public repository. For this project, please include a **Data availability** section with a link to the shared Google Sheets with your data. Each sheet should be clearly labeled so anyone can easily find specific datasets used.

**Video Abstract:**

**Format:** 1 – 3 min video (mpg, mpeg, Youtube/Vimeo links all fine)

**Requirements:**

After you have finished your final report, your group will create a **Video Abstract** of your report. In this video, which must be less than 3 minutes long, you will briefly summarize (1) the question you set out to answer and why it is important, (2) the methods you used to answer the question, (3) the answer you found to the question, and (4) how this is meaningful. You can be creative (we want you to be) with this video but remember to keep the content meaningful. You may choose to edit your video (you can get help from the Jones Media Center – if you choose this, get in touch with them early), or shoot directly on your phone. How you produce the video is up to you – remember that we will evaluate your video on your group’s ability to communicate the science, not necessarily the production values.

**Reflections:**

**Format**: One-paragraph summary

**Requirements:**

After submitting your **final report** and **video abstract**, each of you will write a one-paragraph summary of what you have learned about seasons and climate through this project. Looking back at your responses to the pre-project questionnaire, would your responses be different after having completed this project? Briefly answer the first two questions again: Why do seasons occur? What determines climate?