Competing Hypotheses

This plan was developed by Alan Journet and SOCAN's Climate in the Classroom Project for SOREEL's August Institute 2016. (25min for the workshop). Can be adapted for Middle School and High School teachers.

Overview: Participants (in groups) examine one of the 5 competing hypotheses for global warming and build arguments for and against it.

Objectives: To analyze images to understand the principle arguments used to explain global warming and to evaluate the relative strengths of each hypothesis.

Grade Level: Teacher education, could be adapted for MS and HS.

Standards:

Science and Engineering Practices
- Engaging in Argument from Evidence
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions

Crosscutting Concepts
- Patterns
- Stability and Change

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

HS-ESS3-5 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Materials: (For each group) One image or set of images for one of the competing hypotheses. One copy of the basic temperature graph. (see supplemental information)

Science Terms

- Hypothesis = A proposed answer (untested) to a scientific question (explanation for an observed phenomenon) based on observation, logic, or prior experience.
- Sunspot = a dark patch on the surface of the sun where less energy is being released than in the area around it. However, surrounding bright spots or faculae emit more radiation so paradoxically, the more sunspots, the greater the solar radiation.
- Milankovitch cycles = periodic variation in aspects of the Earth's orbit and orientation as it circles the sun. Eccentricity of the orbit refers to the shape of the orbit, Obliquity of the ecliptic refers to the tilt, and precession of the equinoxes refers to the rotation of that tilt. A Great video explaining at: http://channel.nationalgeographic.com/videos/ice-age-cycles/
- El Niño Southern Oscillation (ENSO) = El Niño is a somewhat cyclic ocean pattern involving ocean currents resulting in the tropical eastern Pacific Ocean becoming warmer than usual. The Southern Oscillation is a somewhat cyclic see-saw in the atmospheric pressure between the tropical west pacific and the tropical east pacific that affects the trade winds and ocean currents. El Niño leads to slight global warming while its opposite condition, La Niña, leads to very slight global cooling.

Activity:

- Introduction (4min) What are Competing Hypotheses?
  (Instructor dialog in italics.)
  Scientific progress is made through testing 'competing hypotheses.' This means that we generate as many possible explanation for an observed phenomenon as we can summon, and test each of these, eliminating those that are falsified. If we find one is supported by experimental / test results, and is not falsified, this is the explanation which we conclude is the most likely explanation for the phenomenon. This is no more complicated a process than we employ in everyday life -
  Example: Suppose you walk into the living room pick up the remote and try to turn on the TV– but it doesn't work. You decide instead to read a book, but if you really want to watch TV you try to overcome the problem. Rather than engaging in random acts of hope and desperation (like polishing the screen and trying again – or maybe praying for Divine intervention, you will probably propose and start testing a series of competing hypotheses to explain the problem and which will allow you to remedy the problem:

  What might these hypotheses be? (These could be collected from the participants.)
  Possible ideas
  1 - The remote is not switched to TV – so you check the settings.
  2 – The TV is not plugged in - so you check the socket and confirm the plug is in.
  3 – The power connection to the TV is broken – so you check that.
  4 – The power strip into which the TV is plugged is turned off – so you check the strip.
  5 – The circuit breaker for the TV line is off – so you check the breaker box.
  Only after all these competing hypotheses have been falsified do you start to suspect that maybe the TV itself is faulty.

  When it comes to explaining the phenomenon of global warming, climate scientists have explored an array of competing hypotheses to determine if they are likely to be the cause for the

temperature pattern the data exhibit. Show global temperature pattern and provide copy for each group.

What are these competing hypotheses?

- The exercise

  The five competing hypotheses included are:

  1) Solar Radiation
     a. Global Temperature trends 1880 to 2015
     b. Graph of temperature and solar radiation
  2) Milankovitch Cycle
     a. Global Temperature trends 1880 to 2015
     b. Sub-cycle 1 Eccentricity of orbit
     c. Sub-cycle 2 Obliquity of the ecliptic
     d. Sub-cycle 3 Precession of equinoxes
     e. Overall trend for the three sub-cycles
  3) Volcanoes
     a. Global Temperature trends 1880 to 2015
     b. Global temperature and volcanic episodes
     c. Global atmospheric carbon dioxide trend and volcanic episodes
     d. Stratospheric volcanic aerosol trends and volcanic epsodes
     e. Stratospheric volcanic aerosol concentration, temperature, and volcanic episodes
  4) El Niño Southern Oscillation (ENSO)
     a. Global Temperature trends 1880 to 2015
     b. ENSO and Global Atmospheric Temperature Trends
  5) Greenhouse gases
     a. Global Temperature trends 1880 to 2015
     b. Greenhouse gas concentration trends

  Figure Analysis (6min) The participants work in mixed grade groups of four or five (no more). Each group gets one image (or set of images) to use to evaluate their assigned hypothesis. They have five minutes to determine what the images are telling them, and develop a report to the participants.

  Discussion (10min) Each group explains their hypothesis and discusses how well it explains global warming. Figures are projected during this discussion so everyone can see.