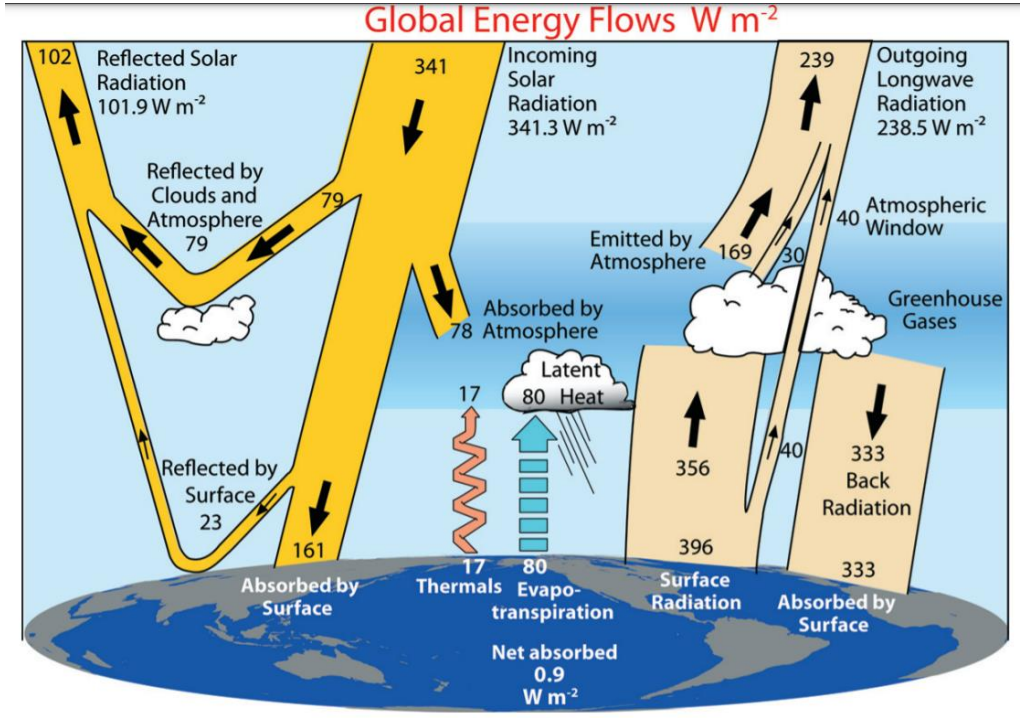
Meteorology Division B – Climate

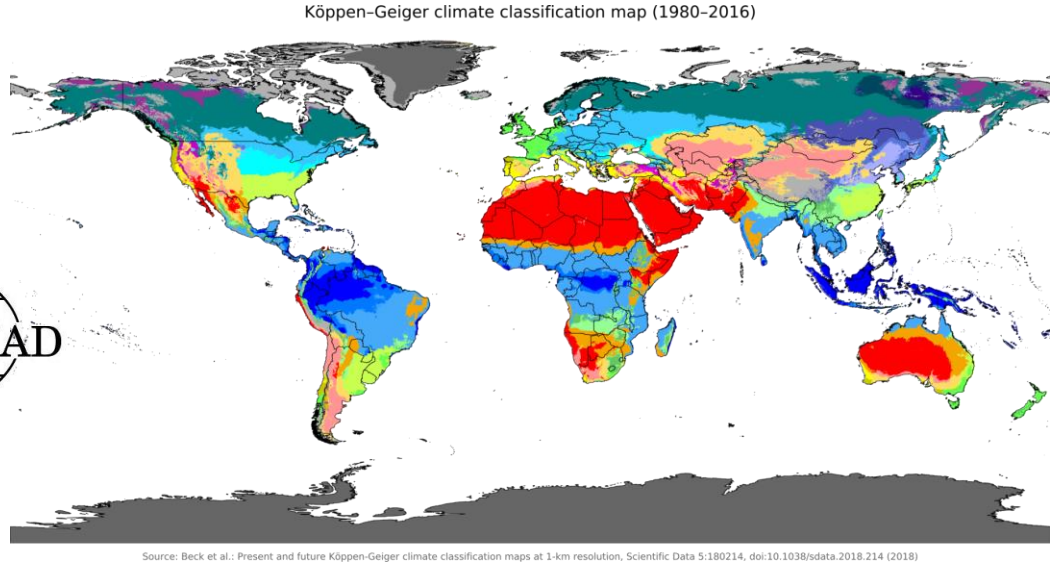
Michigan Science Olympiad Coaches Workshop



Radiation Balance: Trenberth et al.

SCIENCE OLYMPIAD

Exploring the World of Science



Köppen–Geiger Climate Zones: Beck et al.

Nathan Kelly – Event Supervisor

3-year Meteorology Competitor

Ph.D. Candidate in Atmospheric Science at Colorado State University

a) Understanding Weather vs Climate

- How is climate defined? How is weather defined?
- Why can we only predict weather for ~10 days but climate for decades?
- What process does the United States NWS use to define climate "normal"

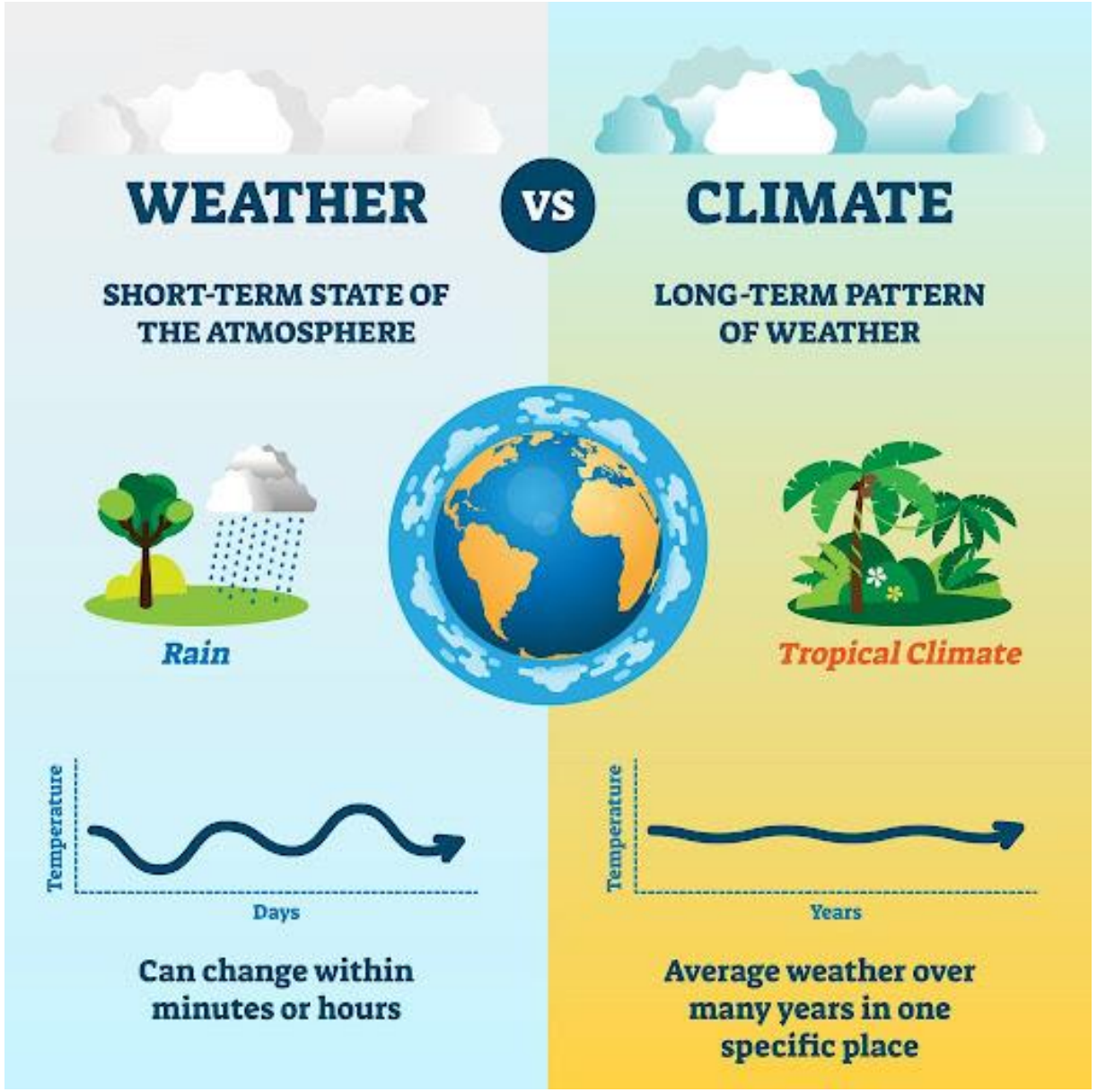


Figure from Australian Environmental Education website

Questions are NOT exhaustive and are meant as general starting points for learning.

b) Composition and Evolution of Earth's Atmosphere

- What are the most important greenhouse gases?
- What is the greenhouse effect and why is it important to life on Earth?
- What are the major pathways by which these gases enter the atmosphere?
- How do aerosols and particulates in the atmosphere impact climate?
- What is the ozone layer, and why is it important?
- What role does the ozone layer play in climate?
- Where and when during the year does the ozone hole form?
- What processes cause the ozone hole to occur?

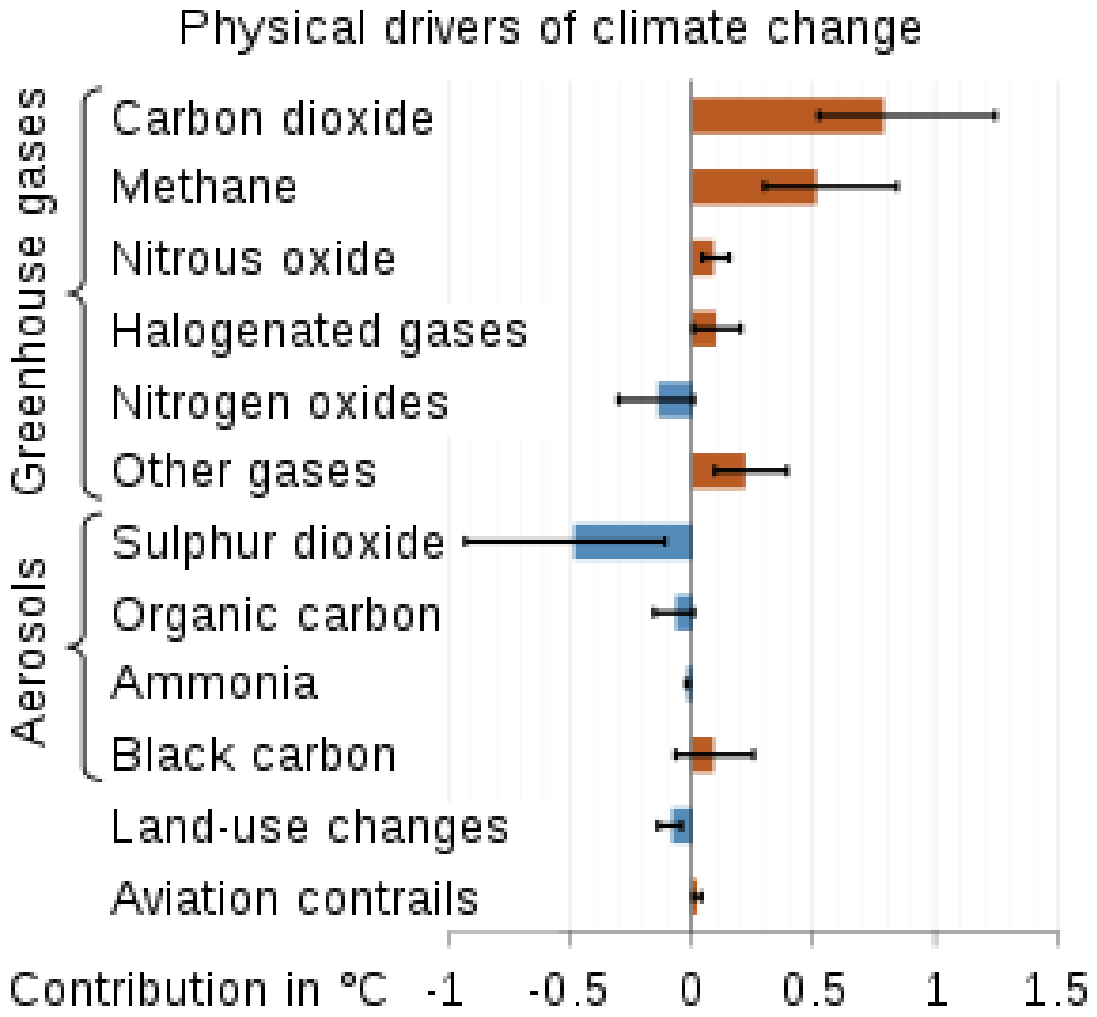


Figure from sixth IPCC Assessment

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c) Earth's radiative Energy Balance

- What is the difference between shortwave and longwave radiation, and the source(s) of each?
- How do albedo and emissivity of the Earth surface impact the climate of a region?
- How does shortwave and longwave radiation interact with "anthropogenic sulfate and black carbon aerosols and volcanic particulates" (rules b. ii), and high and low clouds of different compositions?
- Definition of positive vs negative feedbacks and examples of these, especially the water vapor feedback and the sea-ice albedo feedback (both positive feedbacks)
- What do changes in greenhouse gas concentration and aerosol scenarios do to the radiative balance?
- Why does the radiative balance change with these changes to greenhouse gas concentration and aerosols?
- Playing with the RRTM model is a good way to learn and understand the feedbacks caused by clouds, water vapor, aerosols

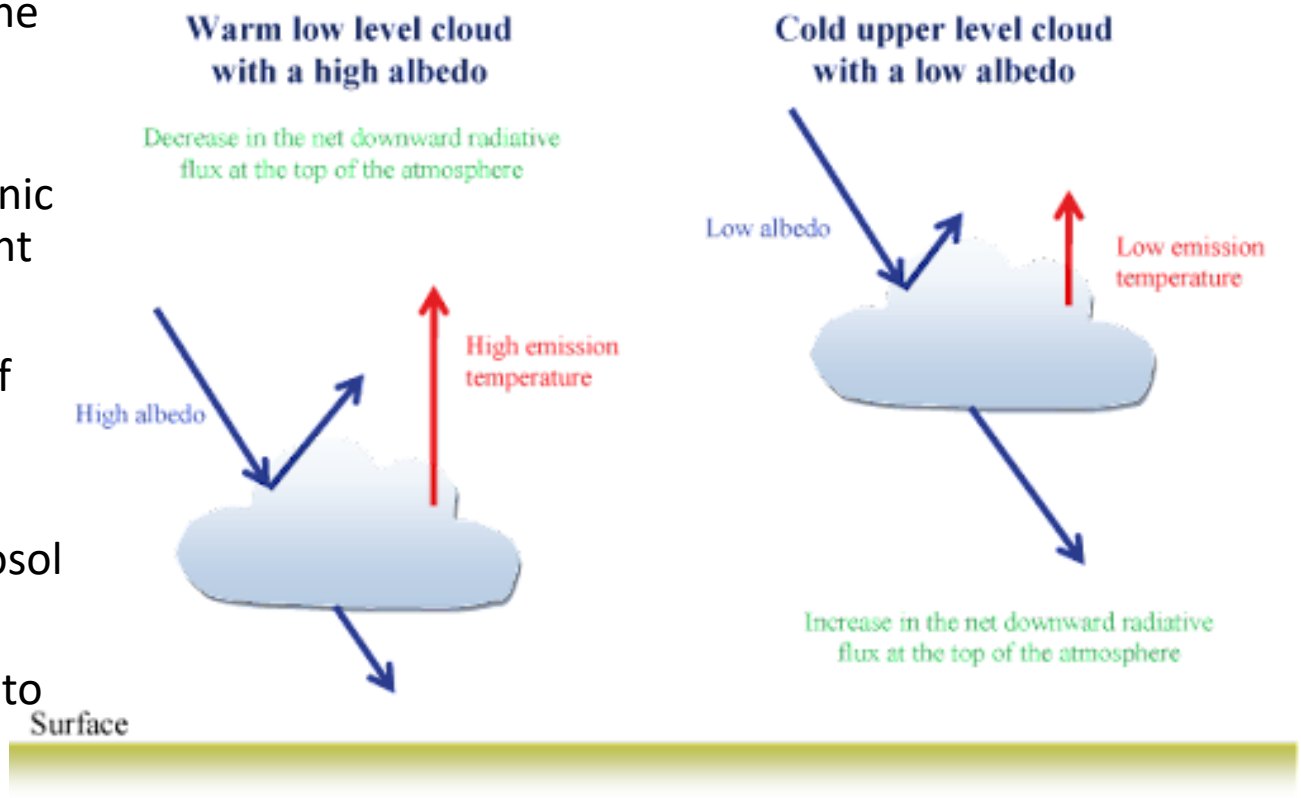
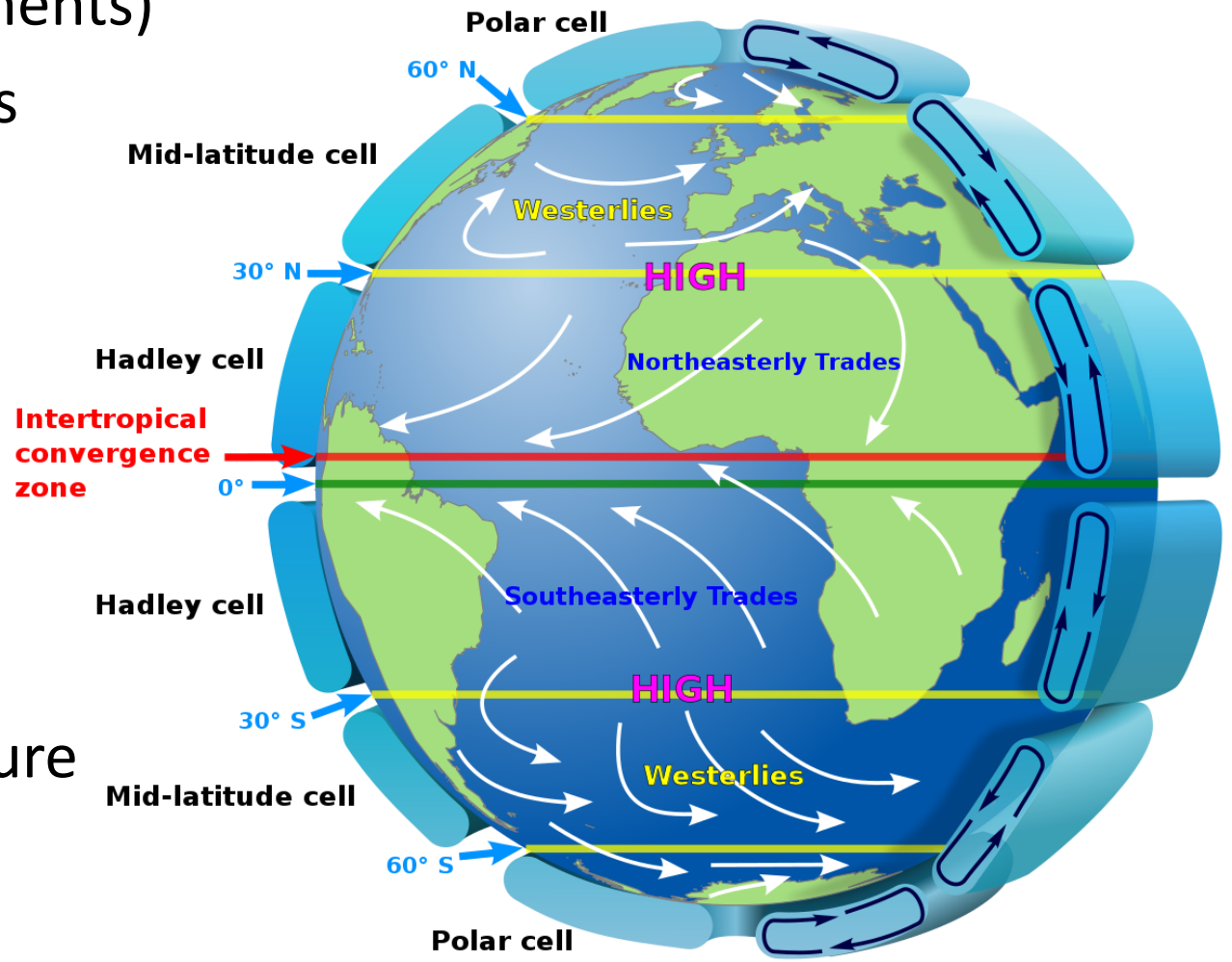


Figure from:
http://www.climate.be/textbook/chapter4_node8.html#image4x05

d) Oceanic and atmospheric circulation mechanisms that affect climate

- What is the three cell model, and how does it explain general climate trends? (for example, warm currents on the west side of continents)
- Walker Circulation/Cell: What causes this circulation and how does this circulation affect the climate in the region where it occurs (ENSO)?
- What physical reasons are behind the existence of the three cell model?
- What drives ocean currents and the thermohaline circulation?
- What impact does sea surface temperature have on local climate?

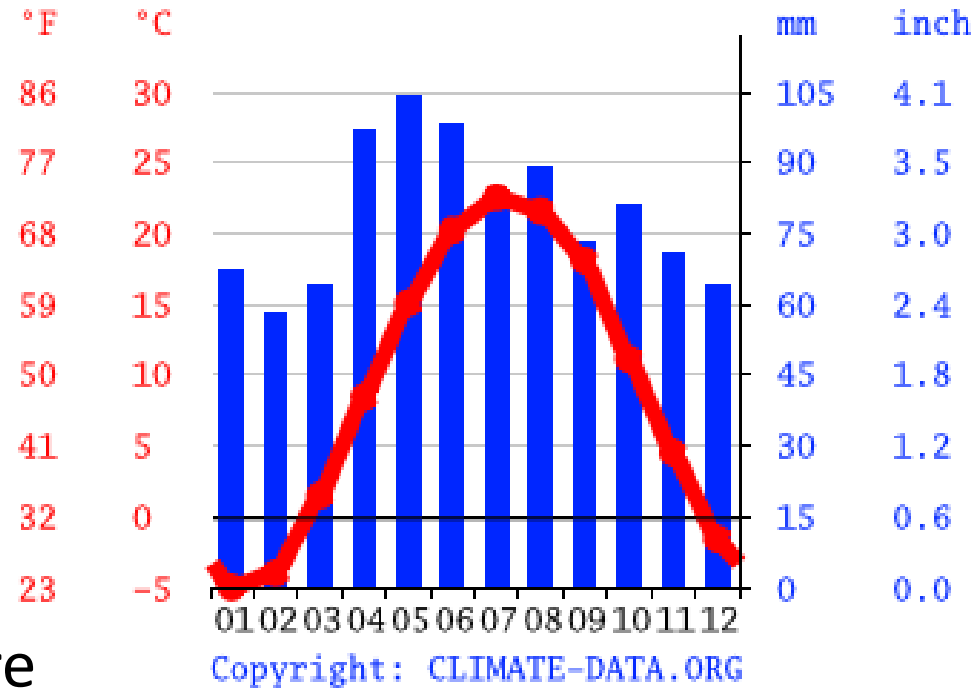
Figure from Wikimedia Commons; based on a NASA figure



Questions are NOT exhaustive, and are meant as general starting points for learning.

e) Climatic Zones and their causes

- Why do climate classification systems often include a vegetation component?
- How is climatic information displayed on a climatograph? How can different climate types be identified from looking at a climatograph, as well as basic statistics like wettest or warmest month?
- All other things being equal, how is a change of position on Earth's surface (latitude, elevation, level of urbanization) affect average temperature and precipitation (i.e. colder towards the poles)
- Why do the above factors influence climate?
- How does the heat capacity of various types of surfaces moderate (or not) the climate of a region?

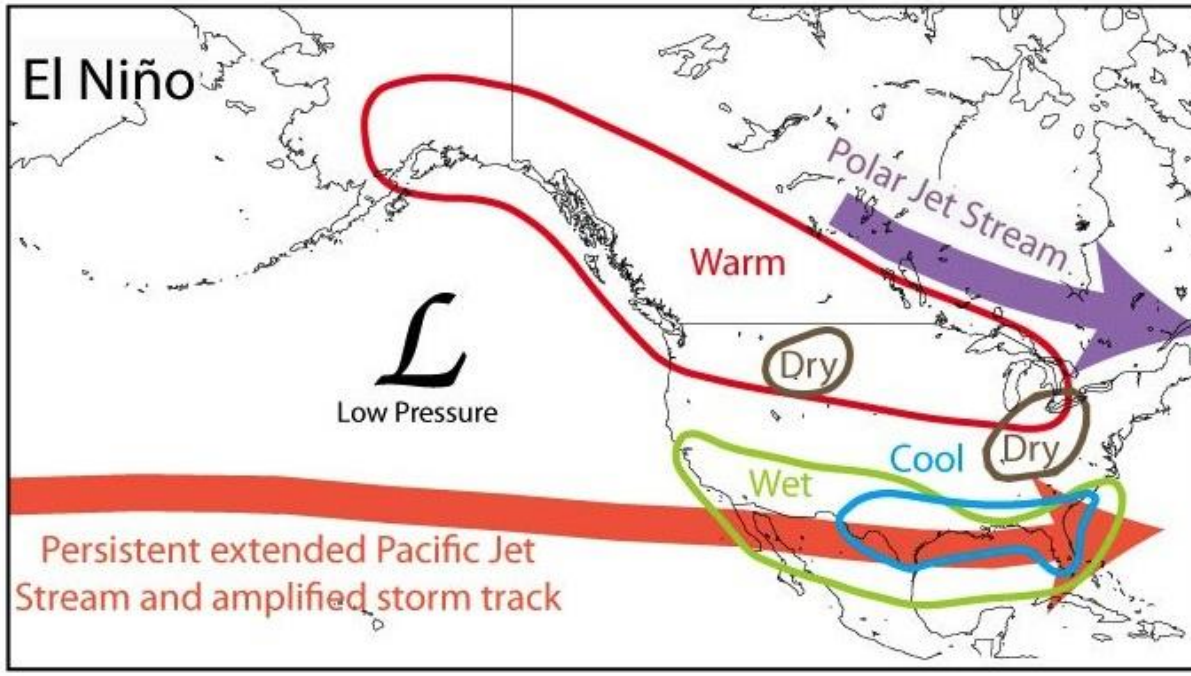


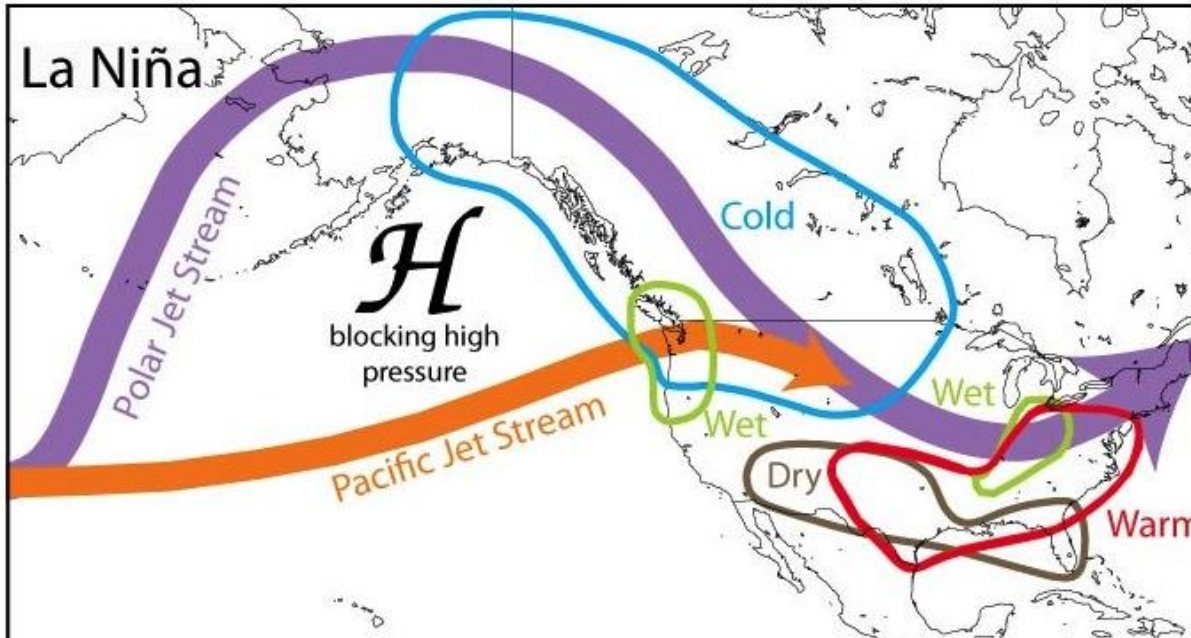
Lansing, MI Climatograph
Figure from Climate-data.org

Questions are NOT exhaustive, and are meant as general starting points for learning.

f) Recent Climate Trends:

- What was the temperature trend between years x and y?
- How is climate data for these temperature trends collected?
- How does the state of ENSO influence the global average temperature of the year, and why does it have this influence?
- Where and what type are anomalies associated with ENSO likely to be experienced? (for example, El Nino winters often (but not always!) wetter in California
- What are the major causes of sea level rise in a warming climate?
- How does a warming climate influence the likelihood of drought and heat waves, and through what meteorological processes does this occur?
- How is drought defined and forecasted?

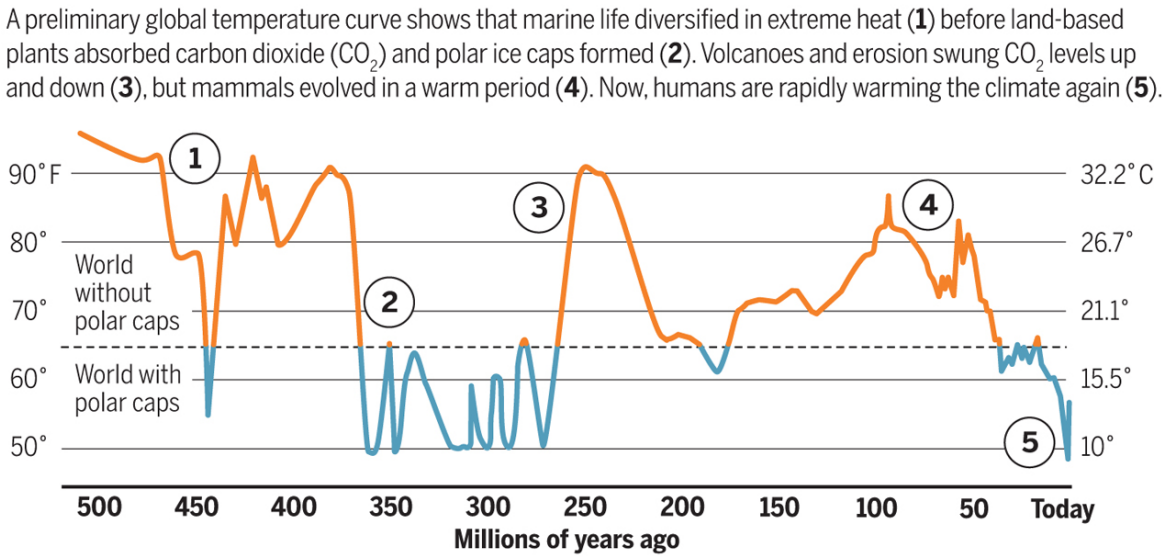


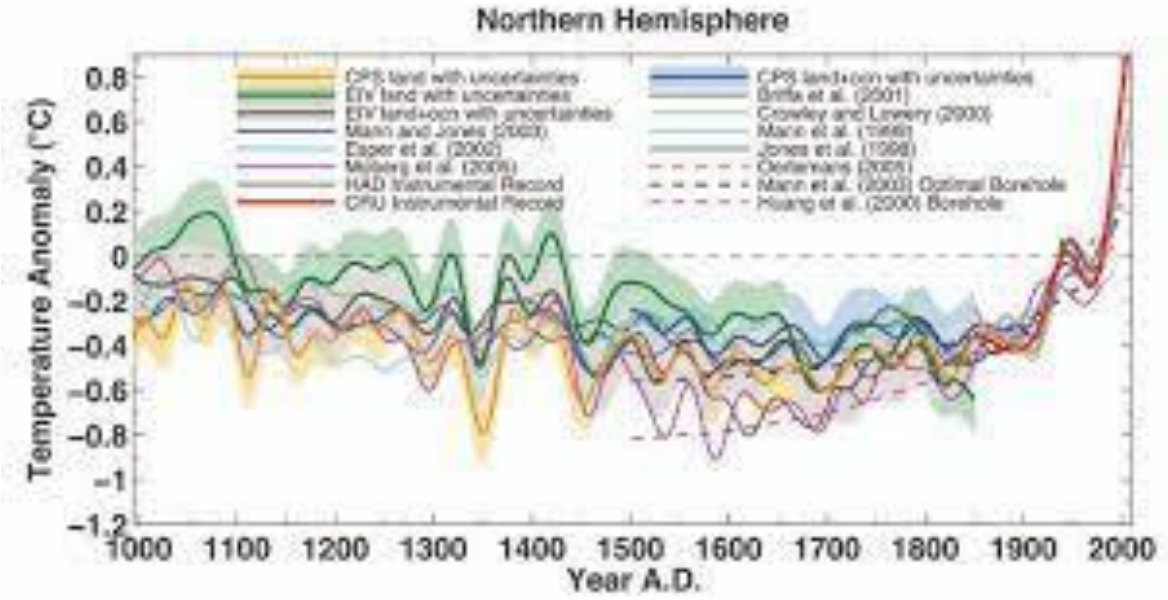


Questions are NOT exhaustive, and are meant as general starting points for learning.

g) Understand climate reconstructions from different methods

- How far back in time do they allow for climate estimation?
- How do scientists use them to estimate past climate?
- What uncertainties exist with the different methods?
- Focus will be on the methods listed, but a big one not listed is fossils, including insects and pollen

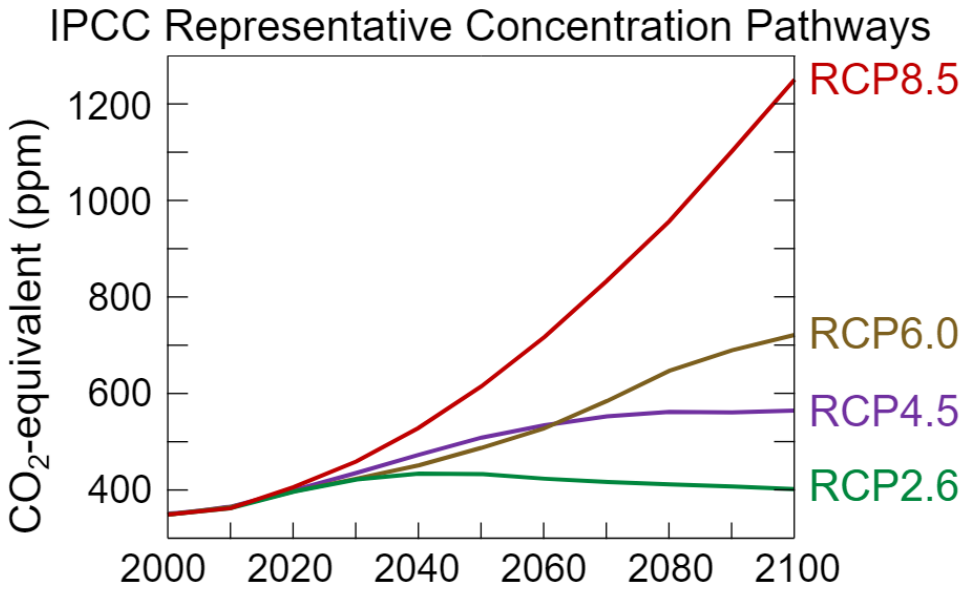


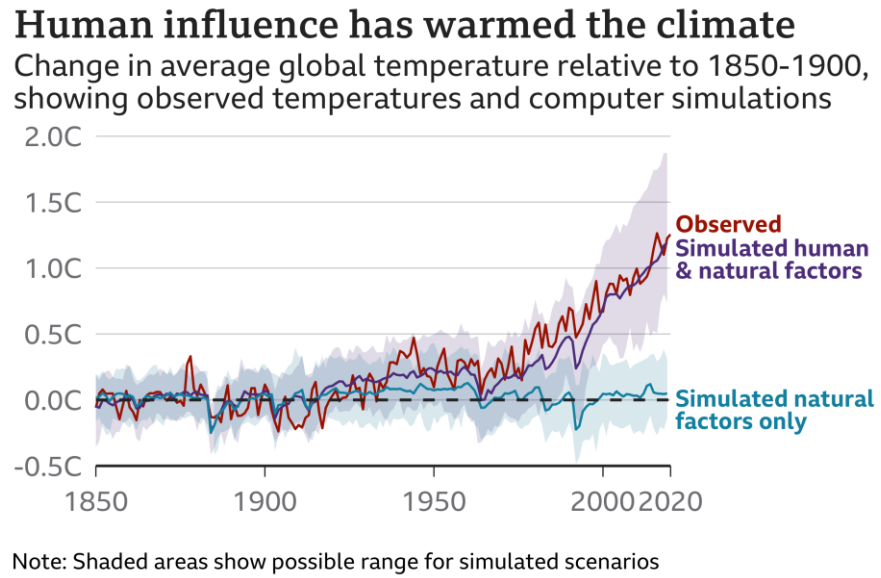


Questions are NOT exhaustive, and are meant as general starting points for learning.

h) Projected Changes in climate:

- What is climate sensitivity, how is it estimated, and why is it important?
- What are the Representative Concentration Pathways and how are they used?
- What do the numbers that describe the RCP pathways mean?
- How do climate models work?
- How can we predict climate over a hundred years when we can only predict weather ~10 days?
- Why are ensembles important?
- What uncertainties exist within climate models (why are all ensemble members not the same)?





Questions are NOT exhaustive, and are meant as general starting points for learning.

Resources: Wikipedia

- Don’t be scared of Wikipedia! A great place to get lots of information collected in one place that you would otherwise spend time searching for
- On the Climate Sensitivity page, 78 of 106 references are from peer reviewed journals or the IPCC reports, which are themselves based on peer reviewed research
- The other references are mostly journalism about climate change topics that highlight this research/interview scientists, and the balance is government websites
- Some material (especially the more complicated equations that many of these pages have) is beyond this event, but overall this is still a great resource both to have students read and/or generate lesson plans from

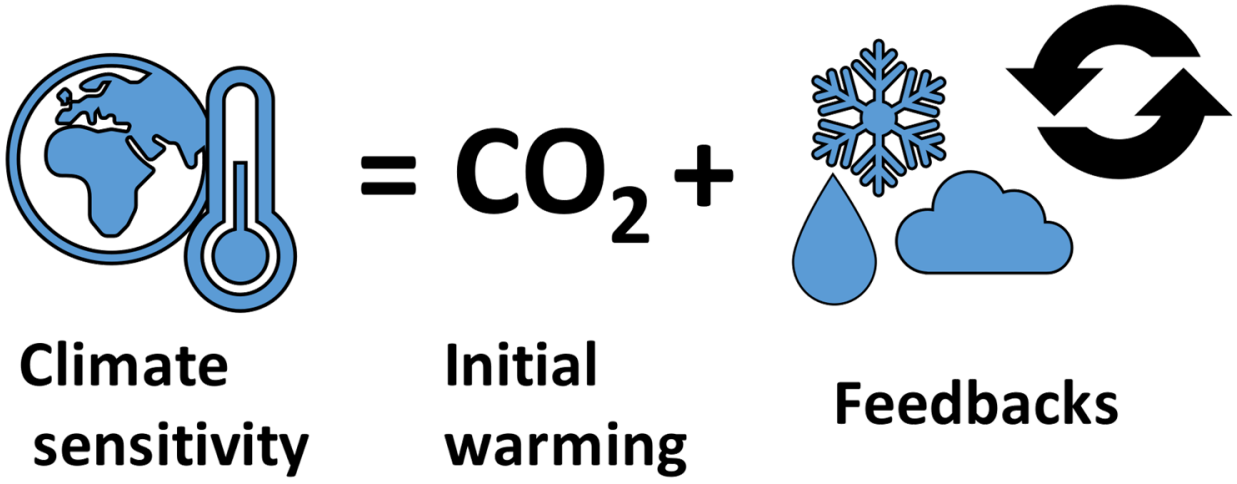
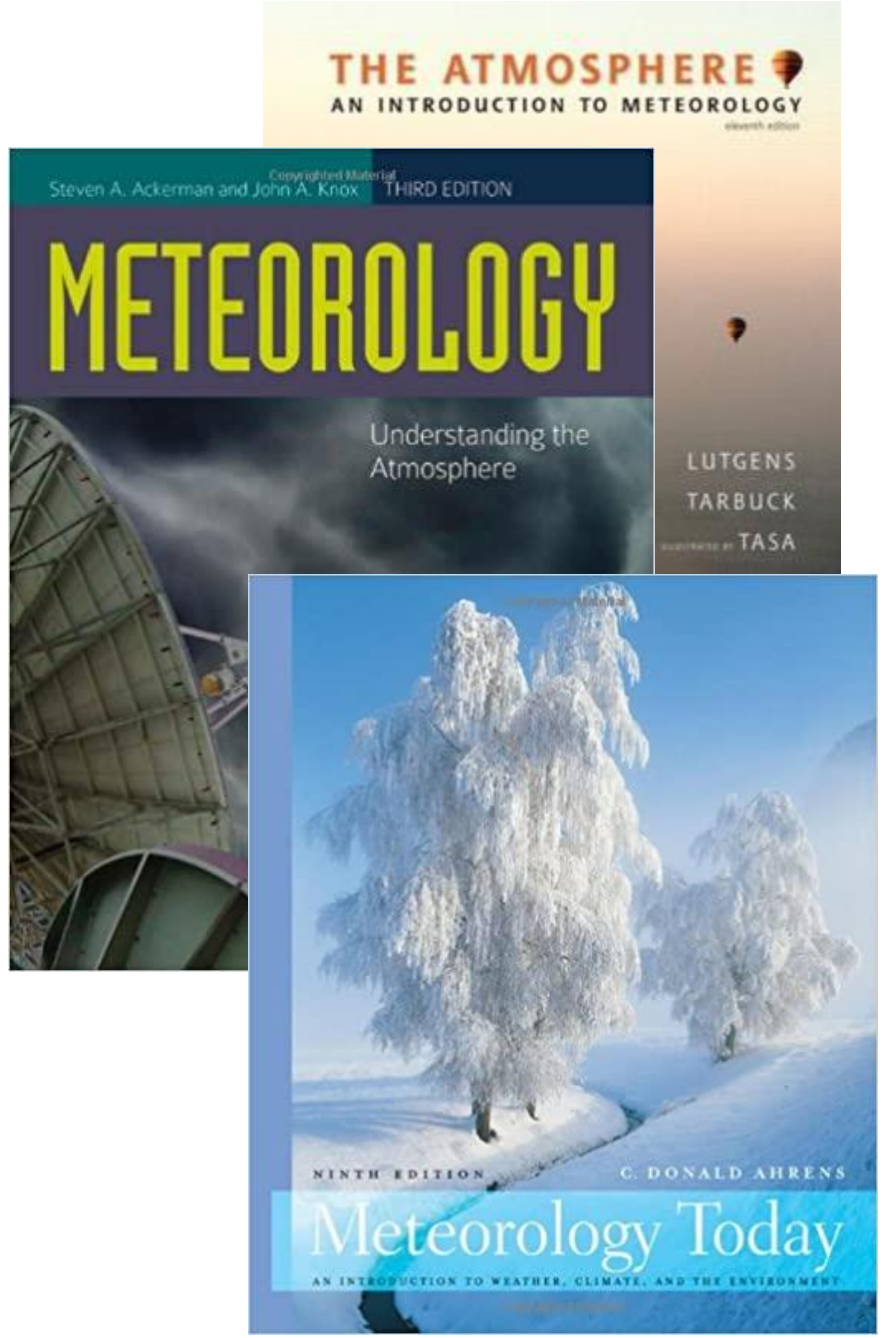


Figure from Climate Sensitivity Wiki page

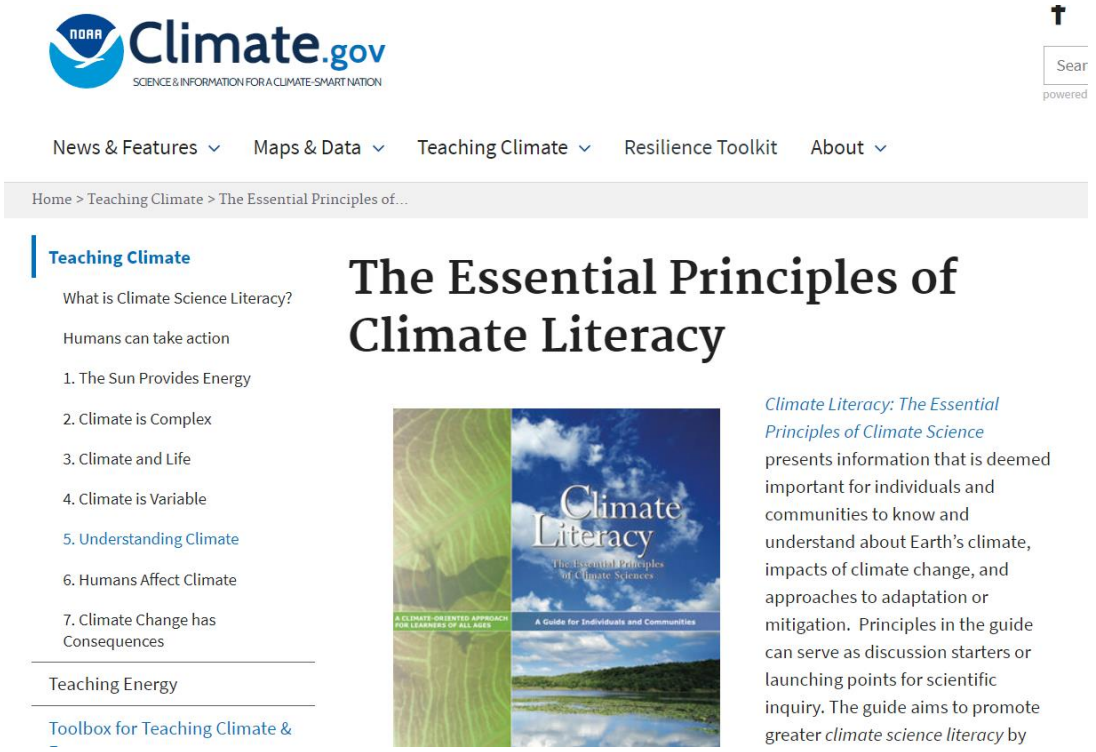
Resources: Textbooks

- Used older editions of many introductory meteorological textbooks can be had for <$50 online, and some down to ~$5
- Older editions will still be plenty up to date for this event. The only material that could be dated is information on the latest advancements in climate modeling
- While meant for Met 101 classes for undergrads, I think for motivated students most of the material in these books will be accessible, since while they are meant for undergrads, they are meant for undergrads who have never studied meteorology

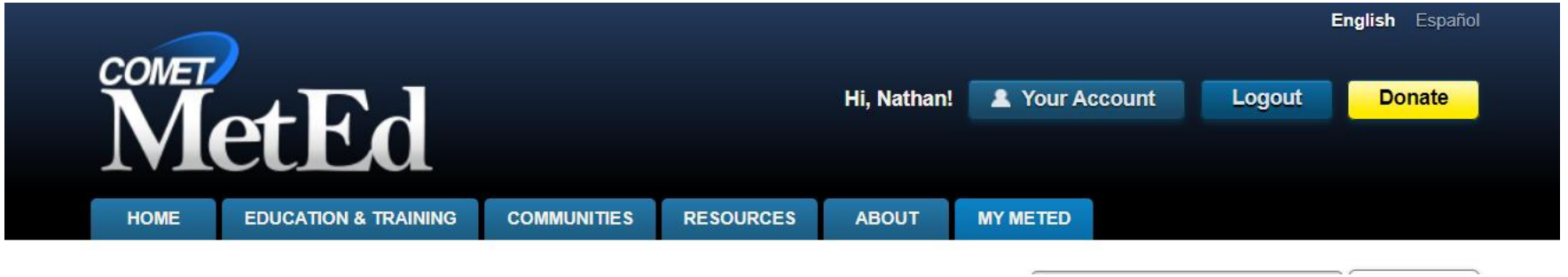


Resources: climate.gov

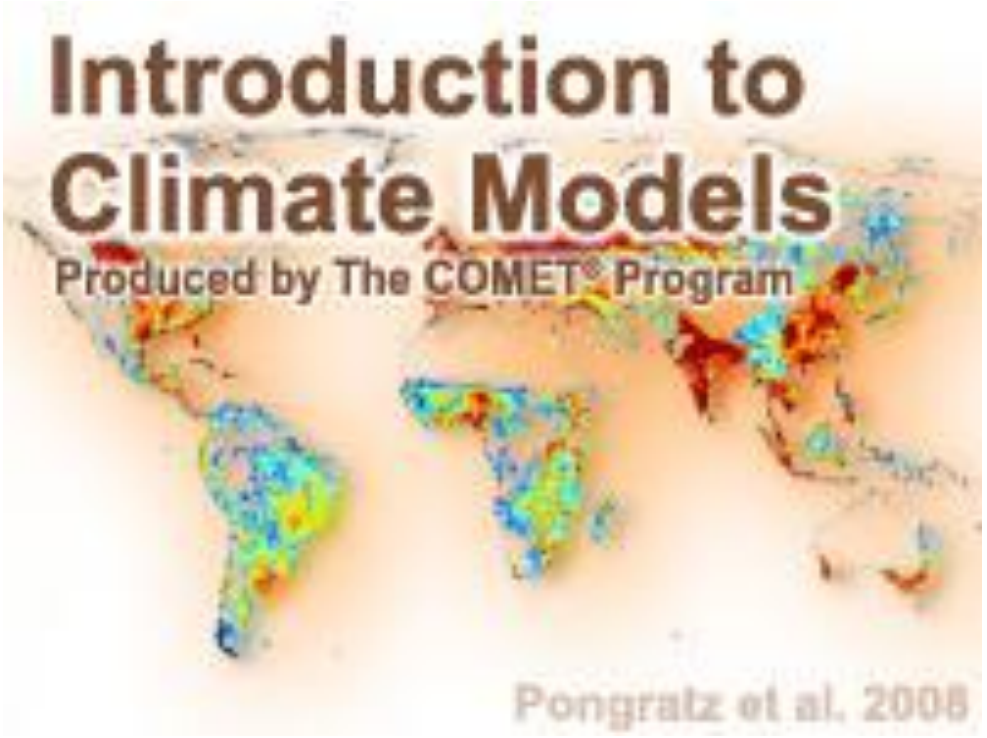
- Many resources here under the “teaching climate” tab
- Many videos covering most areas of the rules
- Elsewhere on the site is real time and historical climate and ENSO data
- Also many hands on experiments, a few of which are directly relevant to the rules (especially thermal expansion of water)
- Think of this as NWS Jetstream, for climate



Resources: MetEd



- Requires a (free!) account that is well worth it
- Unfortunately, there is more severe weather content on here than climate but there are a few good modules
- A few modules of interest (non-exhaustive, I might have missed some!):
  - “Climate Change and Sea Level Rise”, “Climate Change and Regional Impacts” and “Climate change and extreme weather”
  - Climate sections of “Volcanic Ash: Impacts to Aviation, Climate, Maritime Operations, and Society”
  - “Introduction to Climate Models”



Resources: Conclusion

- The resources I've listed here are just the places with the most concentrated information on the topics in the rules
- The questions in the line-by-line through the rules section are meant to be broad, and good questions to begin a google odyssey for more good resources which can often be found on university and government websites
- In my experience as a competitor and a former coach for a year here in Colorado, one of the best things a coach can do is find or create good practice tests/quizzes
- A community produced test bank is available at: https://scioly.org/tests/ Note that the quality of these can vary widely, so make sure to look through them yourself first!
- National Science Olympiad sells past nationals tests every event for $10; note that you would want 2018 since that's the last time climate was the topic!
- As a former competitor, thank you all so much for your dedication to your students and your countless volunteer hours!
- Questions?