

# Pedagogy of working with [climate] ‘big’ data

## using RStudio

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# Welcome to today's workshop!

We are getting set up and oriented before we start.  
Use Chat for questions.

You should . . .

Complete the instructions for getting setup on the Handout, which is available on the Whova agenda page for this session.

Might be helpful to have a pen and paper handy too.

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# What we are going to do:

- Introduction
  - Project EDDIE
  - Why teaching with large datasets is important
  - What do we mean by quantitative reasoning
- Work through a module
  - experience what a student would!
- Discussion of the module experience and structure (metacognition)

# What is Project EDDIE?

Environmental Data-Driven Inquiry & Exploration

- provides an effective pedagogical framework for teaching with large datasets.
- a community of STEM disciplinary and educational researchers
- develops effective, flexible inquiry-based teaching modules using large, publicly available datasets to improve quantitative reasoning
- span topics such as ecology, limnology, geology, hydrology, and environmental sciences
- provides professional development for effective use of the modules

# Why is teaching with ‘big’ data important?

Jam Board:

- <https://tinyurl.com/4ypv9vtu>

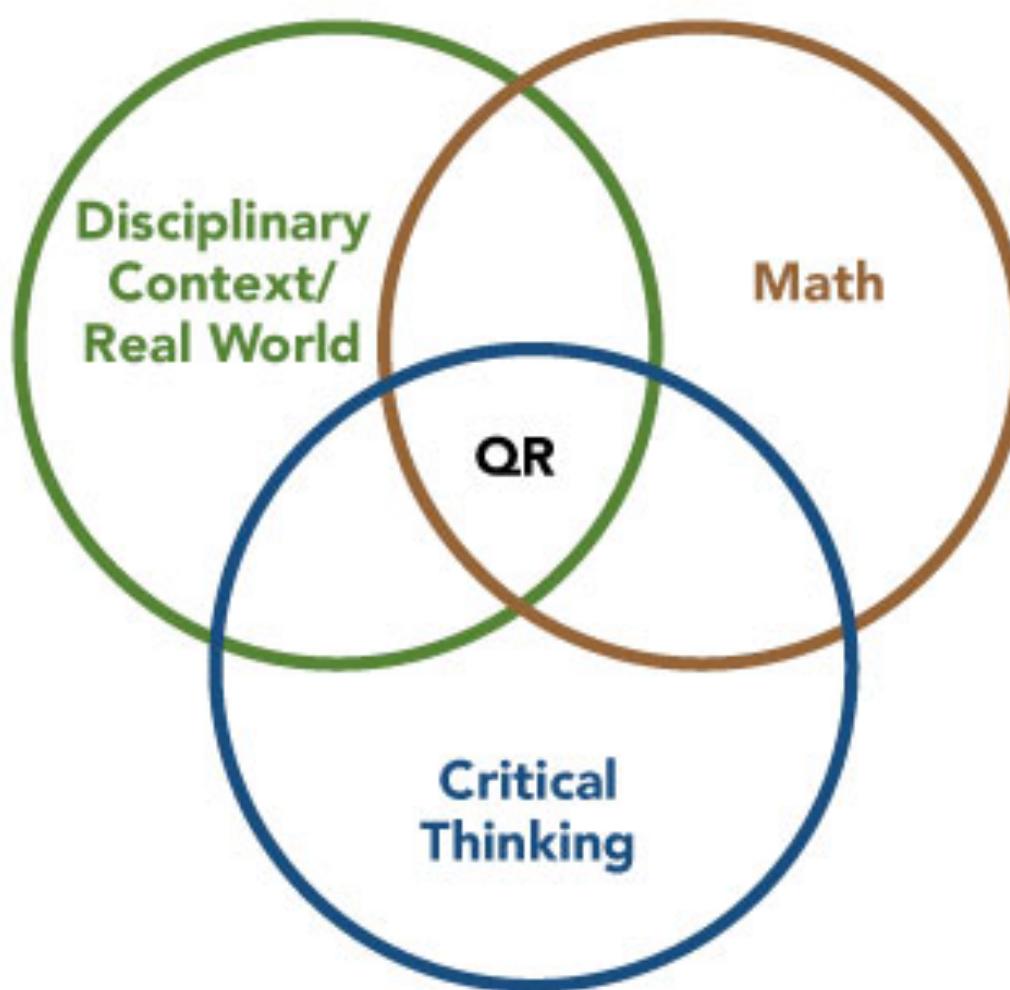
# Why is teaching with ‘big’ data important?

- Mirrors what we do as scientists
- Allows students to develop quantitative skills
- Uses publicly accessible data – democratizes science
- Provide opportunities for application of scientific concepts
- Students can’t disregard what they find
  - ‘more data is needed’ does not work!
- Unexpected results can help students resolve their misconceptions

# Workshop Objectives

- Learn how to structure data-based activities for students to develop quantitative reasoning
- Experience what it is like to learn in the context of a Project EDDIE module
- Increase your confidence in developing students' quantitative reasoning

# What is quantitative reasoning?



Elrod 2014

# What is quantitative reasoning?

1. Students use tools to create a visualization, conduct an analyses, generate quantitative output. (Q skills)
2. Students are compelled to make a claim/statement/conclusion, supporting it with quantitative evidence and explaining the connection. (Q literacy)
3. Students learn about a concept within a disciplinary context. (disciplinary knowledge)

# Project EDDIE: Climate Change module

O'Reilly, C.M., D.C. Richardson, and R. Darner. 15 March 2017. Project EDDIE: Climate Change. Project EDDIE Module 8, Version 1.

NSF 1245707, 1821567, 1821564



CENTER FOR  
MATHEMATICS, SCIENCE,  
AND TECHNOLOGY  
*Illinois State University*

Questions we will address:

How do we know that human activity is contributing to current atmospheric CO<sub>2</sub> concentrations?

How do current changes in CO<sub>2</sub> compare to past, pre-historic, natural changes in CO<sub>2</sub>?

# How fast is CO<sub>2</sub> changing?

We will compare

- current rate of change in CO<sub>2</sub> over the last 50 or so years

to

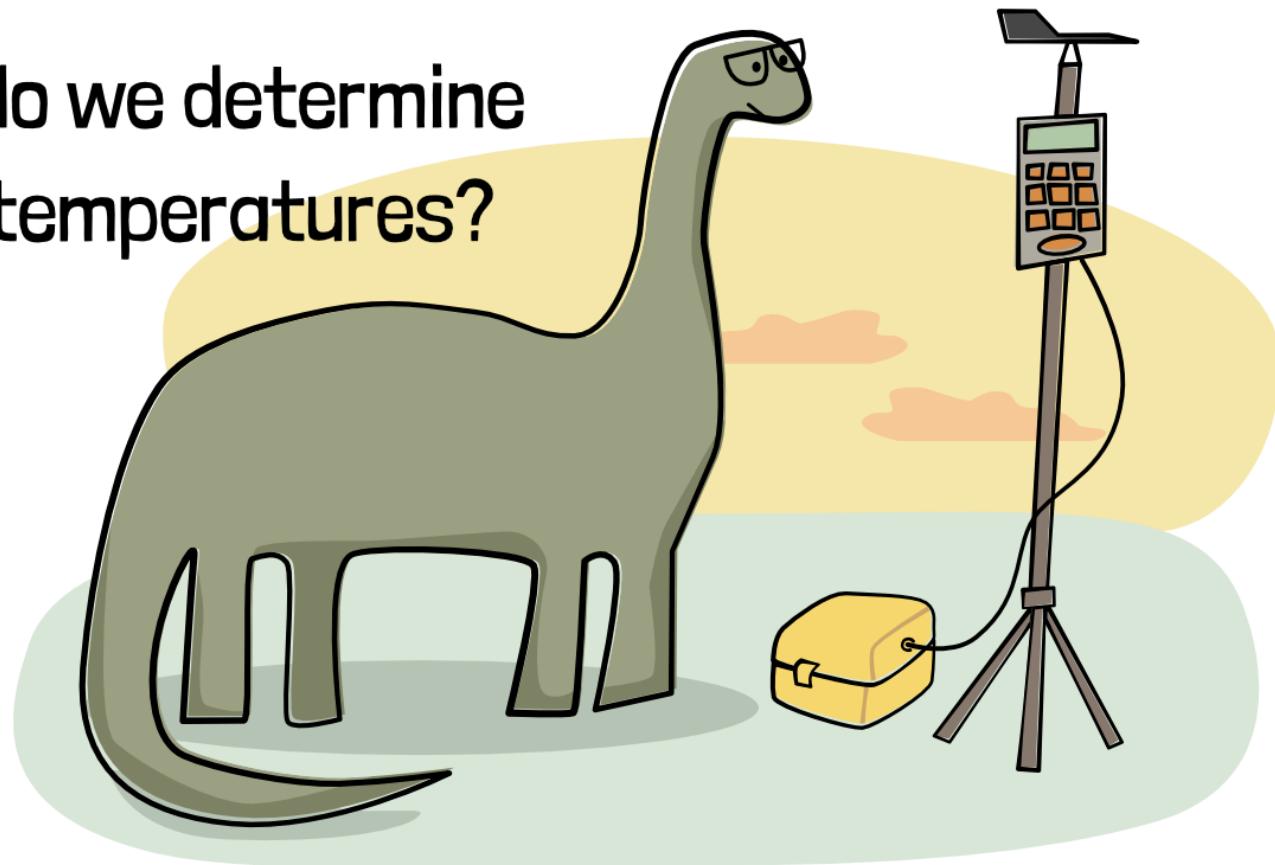
- fastest natural change over the past 450,000 years:

Modern datasets come from monitoring stations like the [one](#) in Mauna Loa, Hawaii



# Comparing current climate to past conditions

How do we determine  
past temperatures?

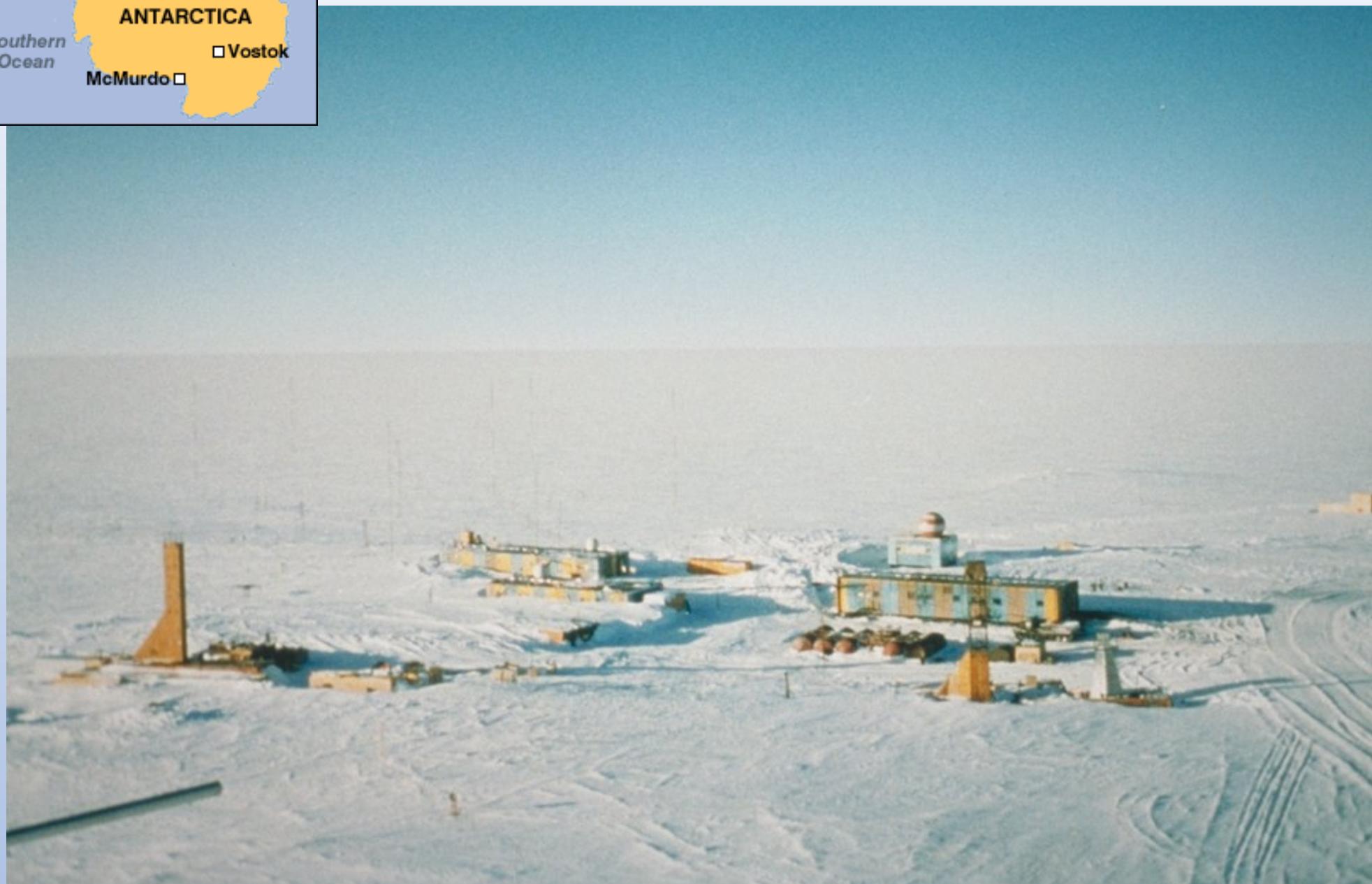


# You're off on a trip . . .





# Vostok, Antarctica



www.rollingstone.com/music/videos/watch-metallicas-blistering-antarctica-show-20131223

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## Watch Metallica's Blistering Antarctica Show

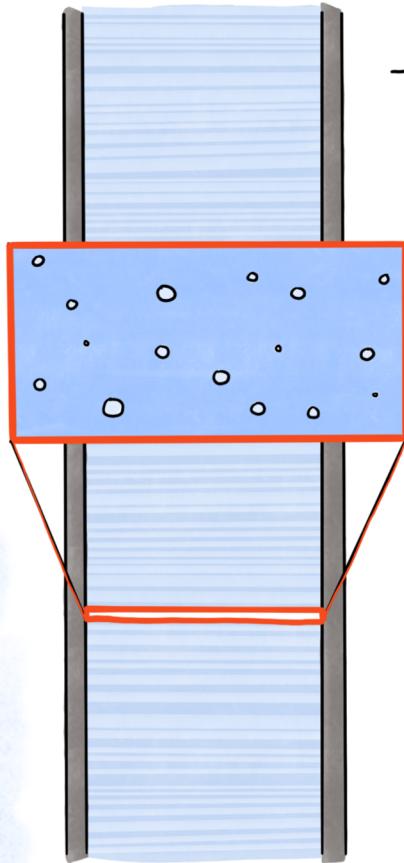
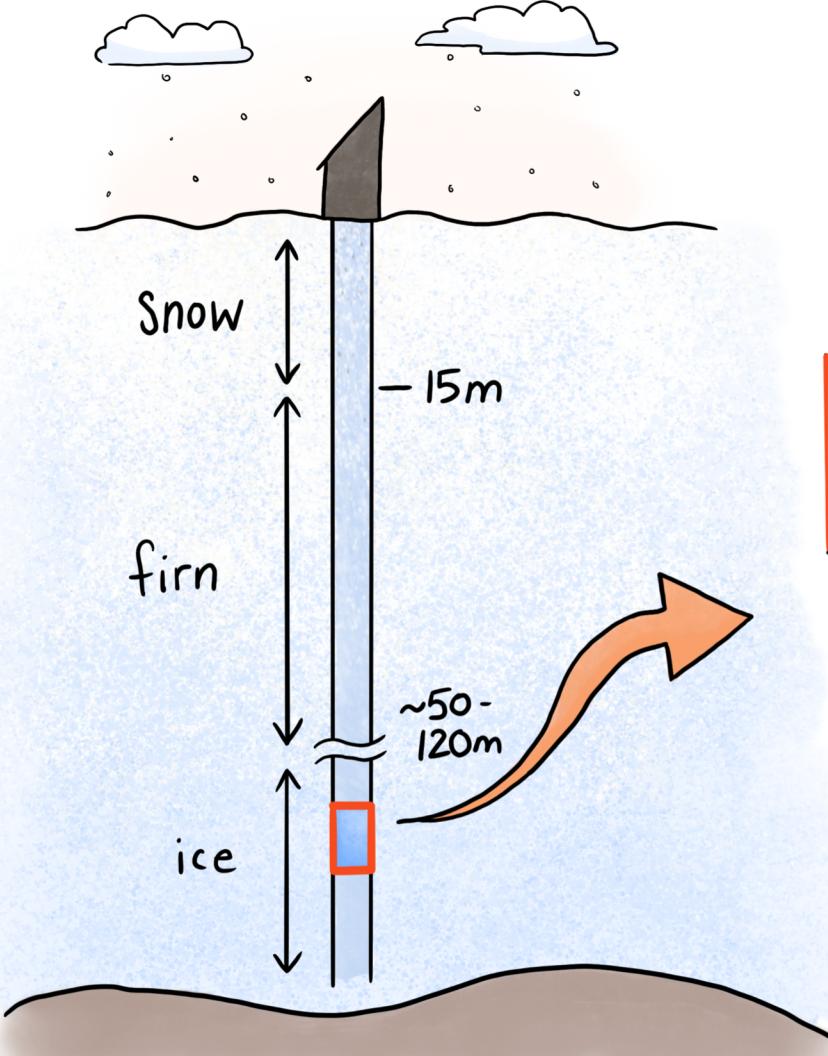
Check out the 10-song set from earlier this month

Like 4.8k Tweet 547 G+ 35 Pin It 5 Comment 25

Metallica - Freeze 'Em All: Live in Antarctica ...

A circular video thumbnail showing a snowy, icy landscape with the word 'ANTARCTICA' written in large, jagged, ice-like letters. A play button icon is in the center of the circle.





Layers tell us the number of years present

Air trapped in the bubbles tells us about the atmospheric composition at that point in time.



Many other climate datasets come are available online, like the [CDIAC](#)



Carbon Dioxide Information Analysis Center



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## Carbon Dioxide Information Analysis Center

### ESS-DIVE CDIAC Data Transition

The CDIAC data archive ceases operation at the end of September 2017. The data collected over 30 years of operation are transitioning to new archives. The [U.S. Department of Energy's \(DOE\)](#) Environmental System Science Data Infrastructure for a Virtual Ecosystem ([ESS-DIVE](#)) archive is managing the transition. During the transition, this version of the CDIAC website provides access to the CDIAC data. ESS-DIVE is maintained by the [Lawrence Berkeley National Laboratory](#) and supported by the DOE's Office of Science [Biological and Environmental Research program \(BER\)](#). If you have any questions about ESS-DIVE or the data transition, please contact [ess-dive-support@lbl.gov](mailto:ess-dive-support@lbl.gov) or see <http://ess-dive.lbl.gov>.

The new archive for the CDIAC data will be ESS-DIVE except in the specific cases mentioned below. The Oceanic Trace Gas data have been transitioned to the new [Ocean Carbon Data System \(OCADS\)](#) operated by NOAA's National Centers for Environmental Information (NCEI) at <https://www.nodc.noaa.gov/ocads/>. The Total Carbon Column Observing Network (TCCON) data are being transitioned to [Cal Tech \(http://www.tccon.caltech.edu/\)](http://www.tccon.caltech.edu/). HIAPER Pole-to-Pole Observations (HIPPO) data are transitioning to the [NCAR Earth Observing Laboratory \(https://www.eol.ucar.edu/data-software\)](https://www.eol.ucar.edu/data-software).

### Data Access



[Search CDIAC Data](#)



[Frequently Used Data Products](#)



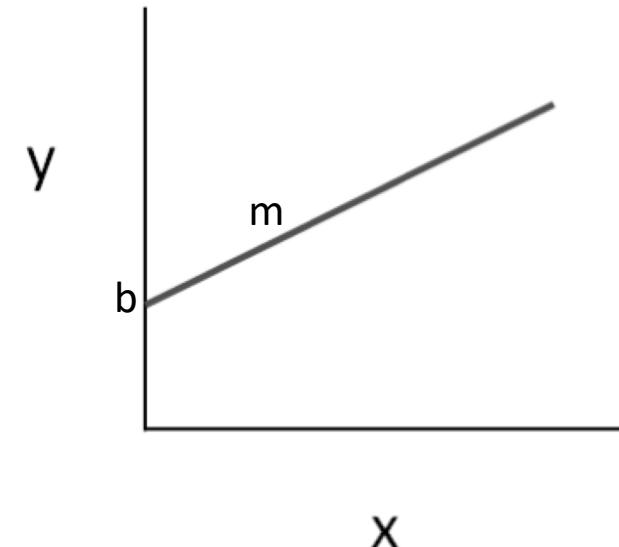
[View Entire CDIAC Catalog](#)

# How do we determine rates of change?

- Answer in the chat.

# How do we determine rates of change?

## Linear regression



$$y = m*x + b$$

$m$  is the slope of the line, or the change in temperature (y) over time (x)

# So let's get started!

- You will use RStudio to make graphs of the data and determine the rates of change

## Part A

How much are current CO<sub>2</sub> concentrations changing?

- We will work through this analysis together
- Post your answer on the Jam board

## Part B

### How much are current CO<sub>2</sub> concentrations changing?

- So maybe you don't want to use the whole time period?
- Now let's try adjusting the time period that you run. You pick the years you want to use.

## Part C

What is the fastest pre-historic rate of CO<sub>2</sub> change?

1. Make a graph of the ice core CO<sub>2</sub> data
2. Identify a period of rapid change.
  - Feel free to go into a breakout room to talk about what you're doing with other people if you want to.
3. Determine the rate of change
4. Post your result on the Jam board
5. Write an answer to the overarching question:

How do current changes in CO<sub>2</sub> compare to past, pre-historic, natural changes in CO<sub>2</sub>?

## Overarching questions:

1. How different are current rates of change from what we have seen happen in the last 500,000 years?
2. What does this suggest about whether human activity is contributing to current climate change?

# Discussion for Metacognitive Reflection

- The Handout sheet has a set of questions that relate to how this activity was structured and why we did what we did.
- Post responses on the Jam boards.

Ok, so what did we do here?

Followed the 5E Model for teaching science

1. Engagement
2. Exploration
3. Explanation
4. Elaboration
5. Evaluation

# Critical components of teaching with data

- Exploration of a relevant scientific question
- Authentic, publicly accessible data
- Scaffolding as students learn and practice skills
- Opportunities to make increasingly sophisticated choices
- Communication of reasoning and results

# Flexible with modifications

Additional things that could be done:

- Examine the correlation between CO<sub>2</sub> and temperature
- Calculate pre-historic temperatures directly from the deuterium data
- Incorporate statistical analyses/linear regression
- Do the comparison of rates of change only for temperature or only for CO<sub>2</sub>
- Do a simplified version with the graphs pre-made and printed out

# Get involved in Project EDDIE

- projecteddie.org and sign up for email updates
- Professional development:
  - webinars
  - faculty mentoring networks
  - workshops on module development and module adoption
- Find us at conferences

Have fun working with  
your students!