LECTURE #25: Mega Disasters - Mass Extinction Events

Date: 21 April 2025

I. Course Information

- Final Exam reminder: **Wednesday, April 30th @ 8:00am**
  - *please be on time, bring a pencil, eraser, your PeopleSoft #, and a photo ID*
  - *covers everything from hurricanes up to and including today's final material*

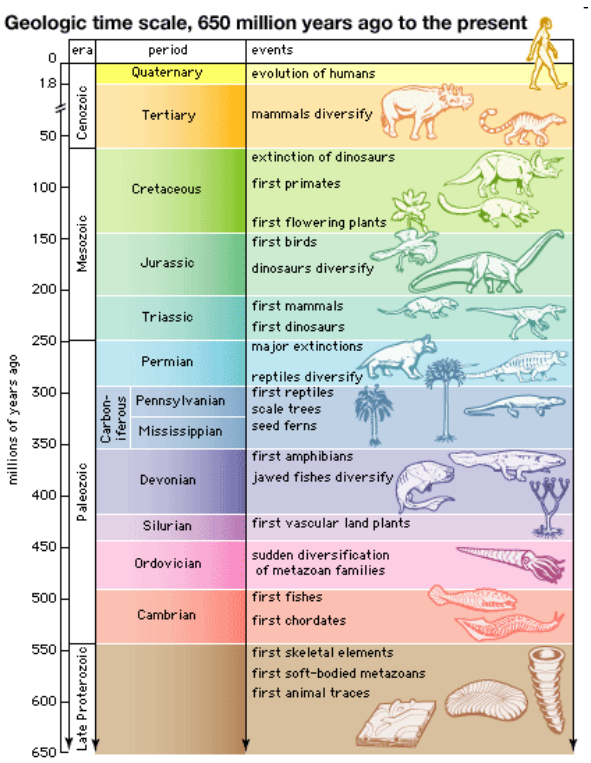
- reminder: the class evaluations (the OMETs) are open and available now to all students if you would like to review the class, myself, and/or your TA

II. Time & Life on Earth

- geologic time scale
  - divided into named eons, eras, periods, …

  - concept of "deep time"
    - sometimes hard to visualize
    - one way to do that is to compress the entire history of the Earth into a 24 hour clock:

      - oldest rocks formed at 10:27am
      - first fish not until 11:53pm
      - first land plants at 11:54pm
      - first dinosaur at 11:57pm
      - ice ages at 11:59.2 pm
      - **modern man at 11:59.9 pm**



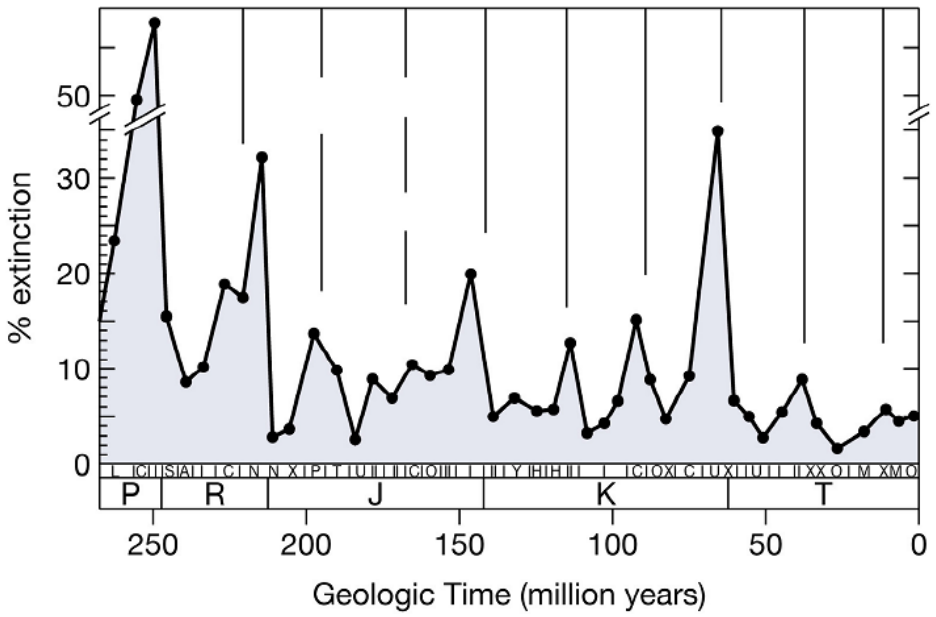
- taxonomy
  - the process of grouping of a species into higher and higher divisions based on similar characteristics
  - **kingdom → phylum → class → order → family → genus → species**
    - important to understand:
      - if a fossil is discovered that belongs to a known *order*, then everything <u>above</u> that *(class, phylum, kingdom)* must exist
      - conversely, if an extinction wipes out up to a known *order,* then everything <u>below</u> that *(family, genus, species)* must also be extinct
      - *the higher up in the taxonomy the more resistant to large disturbances*
      - *most diversity and least stability at the species level*

III. Biodiversity

- has changed markedly over geologic time
- <u>example:</u> Cambrian Period
  - name given to a particular time in geologic history
  - 545 million years ago
  - an "explosion" of diversity in marine **phyla**
    - from almost none to near today's amount
    - in less than 100 million years!
    - ***why?***
      - ➢ unknown exactly, but likely some large geologic event that disrupted the environments in which the species were adapted
      - ➢ if there was a sudden increase in ecological niches, these would be rapidly filled by the evolution of new species
      - ➢ many of these species flourished, but many also quickly died out

IV. Mass Extinctions

- *if there's a loss of more than 25% of the families in a kingdom, that could lead to mass extinction*
  - mass extinction events have removed 60-90% of the species that have ever existed on Earth
    - example: mass extinction of the dinosaurs *(65 million years ago)*
    - example: a much larger mass extinction at the end of the Permian Period *(245 million years ago):*
      - ➢ 95% of the species, 85% of the genera, 50% of the families, and 15% of the orders all disappeared

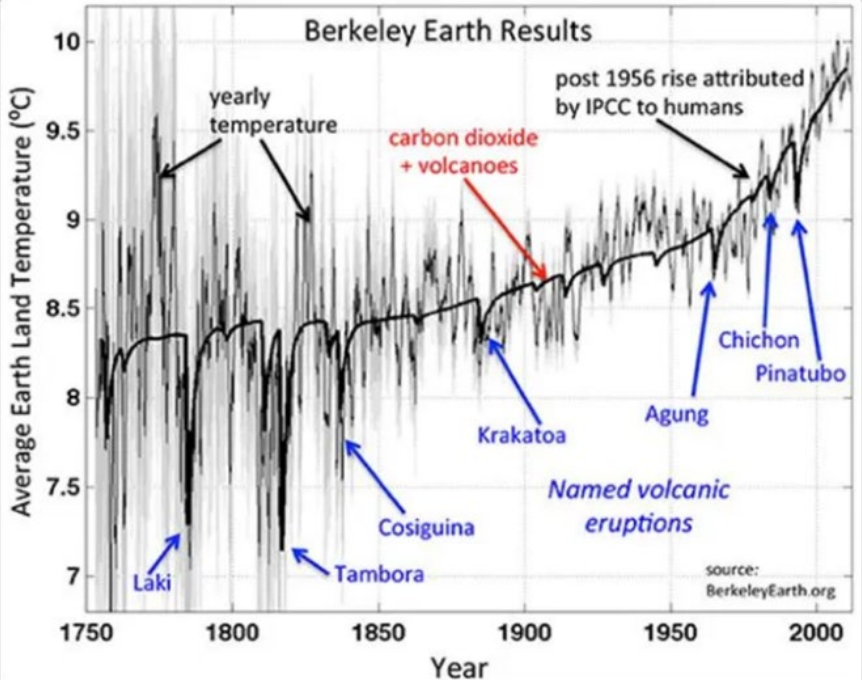


- many possible hypotheses for mass extinction events:
  - **changes in plate tectonics**
    - number of continents
    - rate of sea floor spreading
    - size and position of the poles
    - ***all lead to dramatic climate changes***

- **changes in ecosystems *(related to plate tectonics or climate)***
  - example: decreased sea floor spreading → less rocks produced at the divergent plate boundaries → more volume in the ocean basins → sea levels fall → draining of shallow/warm seas → species die off

- **volcanic causes**
  - most modern eruptions (effusive or explosive) influence local → regional **weather**
  - most large explosive (calderas) and large-volume mafic effusive eruptions also effect **climate**
  - very largest volume eruptions (flood basalts) linked to mass extinctions

  - gas/particulates (aerosols) from an eruption have four main effects on the atmosphere and climate:
    - ozone reduction → reactions with Cl
    - global warming *(less impact)* → production of CO_2 and H_2O
    - global cooling *(more impact)* → blocking sun light
    - acid rain → production of SO_2



  - flood basalt eruptions
    - linked to Permian extinction (250 million years ago)
      - 85% of all marine species
      - 70% of all terrestrial species
      - same time as the eruption of Siberian Traps flood basalts

    - Cretaceous extinction (65 million years ago)
      - eruption of Deccan Traps flood basalts in India
      - same time as the large impact crater
      - both likely contributed to end of the dinosaurs

- **meteorite impacts**
  - throughout history
  - most in the first ½ billion years
  - largest risk now from near-Earth objects (NEOs)
  - craters are well preserved on some planets (like Mercury, the moon)
    - no erosion/plate tectonics
  - seen on Earth in only a few locations
  - mostly younger events
  - only ~20% of what has hit land
  - recall the energy source:
    - transfer of potential energy into kinetic energy
    - **KE = ½ m v^2**
    - higher the mass, the higher the velocity, the greater the heating!
  - example: "near miss" in 1989
    - diameter = 500 m (1/3 mile)
    - v = 30,000 mph
    - calculated volume = 6.5 x 10^7 m^3
    - calculated mass = 1.7 x 10^5 kg
    - **KE = 2.2 x 10^{14} Joules**
    - *that energy would melt = 1.1 x 10^8 kg rock*

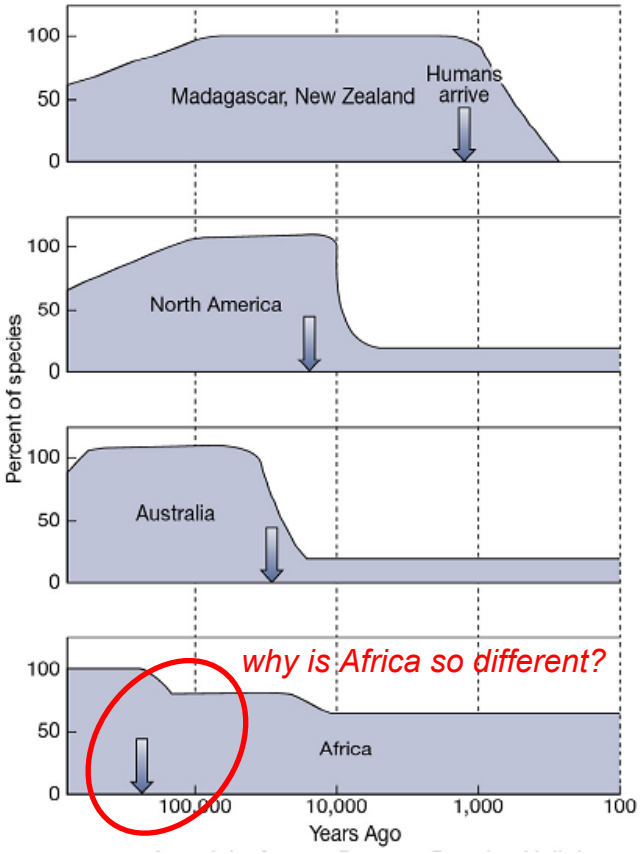
- what are the risks of a large impact today?
  - > 34,000 NEOs identified *(number is a lot higher!)*
    - ~ 2,400 are classified as potentially hazardous asteroids
    - ~ 50% of the NEOs could eventually hit the Earth
    - ~ 100,000 years between hits
  - chance of dying by an impact of 1km meteor is 1 in 20,000
    - high risk because of the large number of deaths that would occur
    - 1.5 billion people could be killed
    - this is 3x greater risk than dying in tornado!
    - about the same odds as dying in a plane crash

V. Modern Extinctions

- known to have been initiated by humans
  - migration patterns, industry, hunting, etc.
    - extinction over the past 10,000 years
      - 73% of the large mammals
      - 66% of the large birds
      - some of that is climate change related at the end of the last Ice Age
      - but also, much is from human migration and hunting

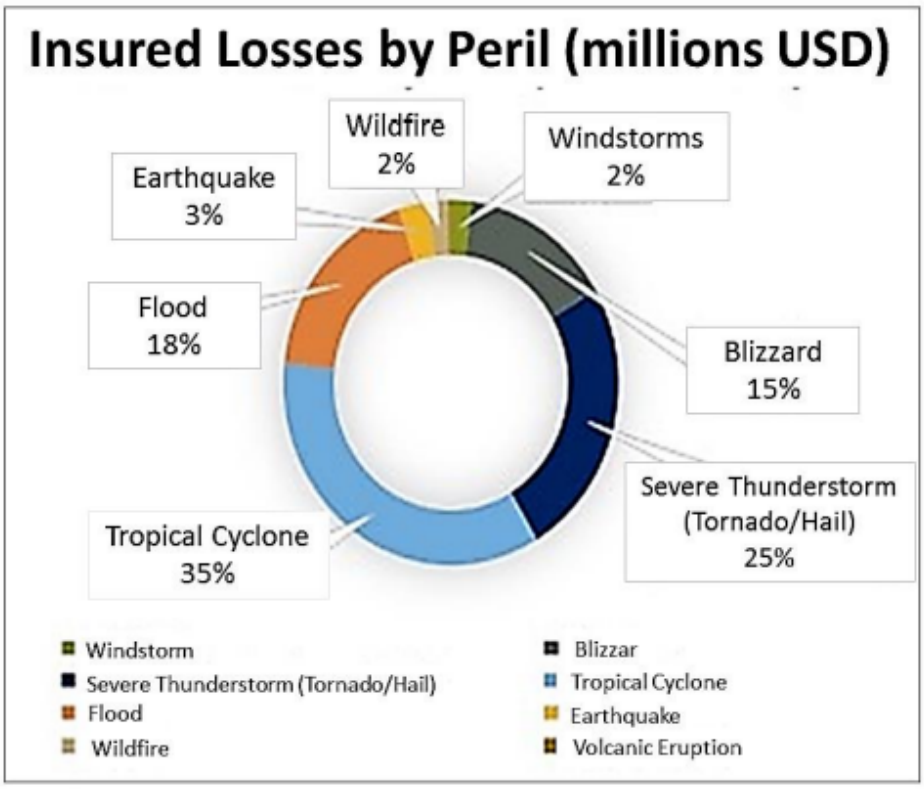
- example: New Zealand
  - ➢ isolated for a very long time (due to Plate Tectonics)
  - ➢ large, flightless birds evolved (kiwi, dodo, moa)
  - ➢ humans arrived in 1000 AD
    - 20 species quickly disappeared

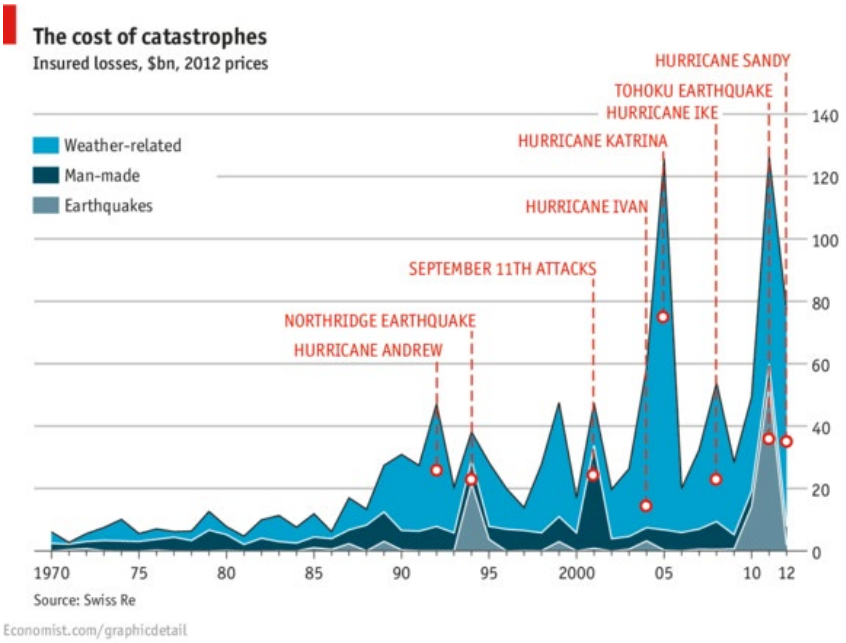
the dodo



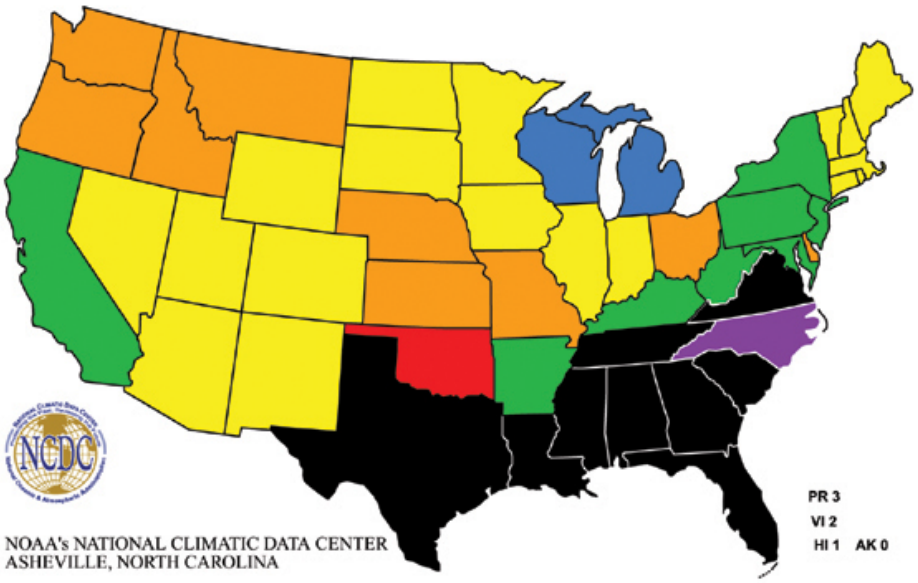
VI. Summary: the Course in Graph and Map Forms

- Insured Losses in 2023





Billion Dollar Climate and Weather Disasters



NOAA's NATIONAL CLIMATIC DATA CENTER
ASHEVILLE, NORTH CAROLINA

NUMBER OF EVENTS	DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	NORMALIZED DAMAGES (Billions of Dollars)	PERCENT DAMAGE
1 - 3	Tropical Storms/Hurricanes	20	32.3%	144	36.8%
4 - 6	Non-Tropical Floods	12	19.4%	55	14.1%
7 - 9	Heatwaves/Droughts	10	16.2%	144	36.8%
10 - 12	Severe Weather	7	11.3%	13	3.3%
13 - 15	Fires	6	9.6%	13	3.3%
16 - 20	Freezes	2	3.2%	6	1.6%
21 - 25	Blizzards	2	3.2%	9	2.3%
	Ice Storms	2	3.2%	5	1.3%
	Noreaster	1	1.6%	2	0.5%
		62		391	

Please note that the national map color-coded by state reflects a summation of billion dollar events, for each state affected--ie, it does not mean that each state shown suffered at least $1 billion in losses for each event.