LECTURE #14: Extreme Heat & Desertification

Date: 10 March 2025

I. This is the Start of "Second Half" of the Course

- transitioning into the weather- and climate-related disasters
- although this lecture also contains geological information about deserts

II. Dry Weather and Heat Waves

- critically important for loss of life and impact on the environment
  - these occur on short to long time scales
  - short: heat wave *(lasting days to weeks)*
  - medium: drought *(months to years)*
  - longer: desertification *(years to decades)*

- News/History
  - Riyadh, Saudi Arabia (2009)
    - on March 10 2009, a dust cloud engulfs entire city of 4 million
      - visibility reduced to only 0-3 meters
      - caused traffic jams and stopped airport operations
      - storms may last only hours up to several days
      - becoming more frequent

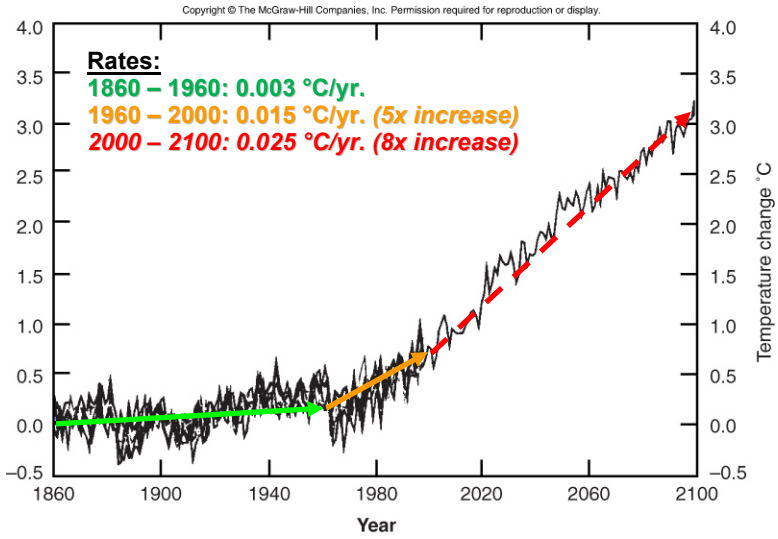
  - Europe (2003)
    - a record heatwave in August
    - claimed an estimated 35,000 lives
      - in France alone, 14,802 people died from the searing temperatures

  - Italy (2023)
    - Italian cities need to plan for longer and more frequent heatwaves
    - analysis reveals predicted heatwave trends with and without climate change mitigation efforts
    - 659 mainly elderly people died between 8 July and 17 July due to heat
    - between 21 June and 8 July 309 excess deaths were recorded, bringing the total to 968

  - Chicago, IL (1995)
    - strong upper-level ridge of high pressure in the northern Plain states
    - 13-15 July: numerous heat records
      - high humidity also

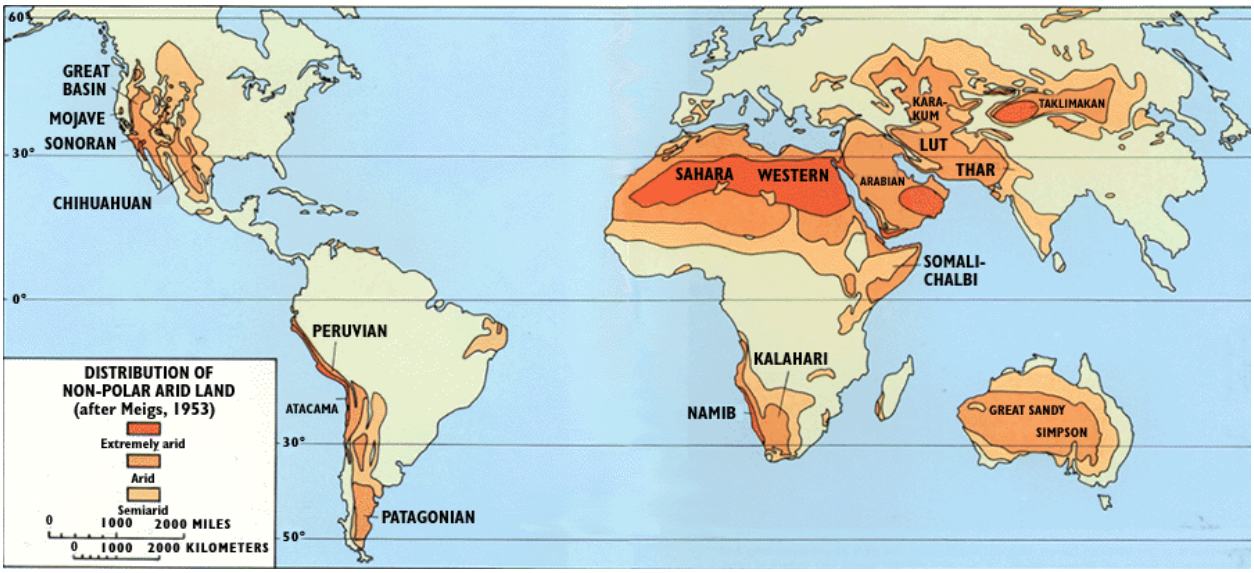
    - 13-17 July
      - 465 people died in Chicago
      - most affected: poor and elderly
      - over ½ died on the upper floors and the first floor of apartment buildings
      - ***why??***

- longer term climate change *(more on this at the end of the course)*
  - over the last 25 years the average global temperature rose by 1°F or 0.6°C
  - this rate of increase is 5 times more than the previous century
  - projected to increase to 8 times more over the next 100 years *(or sooner)*



III. Deserts & Desertification

- what is a desert??
  - a region with a mean annual precipitation < 25 cm (~ 10 inches) per year
    - very little vegetation and support for life
    - ~ 1/3 of the Earth's land surface is classified as a desert



- numerous classifications of deserts
  - rely on some combination of:
    - the number of days of rainfall
    - the total amount of annual rainfall
    - the average temperature

- deserts are <u>not</u> restricted by latitude, longitude, or elevation
  - <u>example:</u> China has both the highest desert (the Qaidam @ 2,600 ASL) & one of the lowest (the Turpan @ 150 meters BSL)

- *only about 20% of deserts are covered by sand*

- in the US, we have 4 named deserts:
  - Sonoran, Mojave, Chihuahuan, and Great Basin

- how do they form?
  - in regions where there is very high evaporation compared to the amount of precipitation
  - to meet this condition, there must be warm, dry air masses
  - ***why??***
    1.
    2.
    3.
    4.

  - definition of a high-pressure system

- four primary classes of deserts:
  - polar
    - an area of intense cold but very little snow/precipitation
    - <u>example:</u> parts of Antarctica

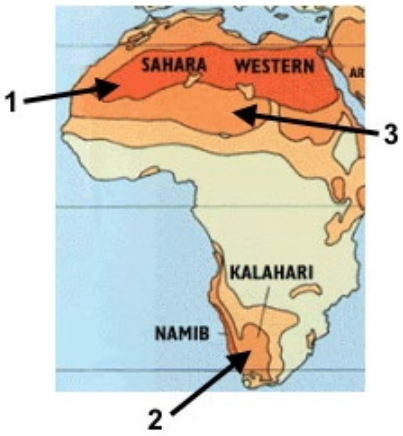
  - mid-latitude *(a.k.a., "continental")*
    - typically, in basins of large continental land masses far from oceans
    - typified by low rainfall and sparse vegetation
    - <u>examples:</u> Gobi Desert, China, Great Basin Desert, US

  - trade-wind
    - located at 30 degrees N and S latitude
    - controlled by persistent areas of sinking air masses
    - typified by very arid conditions
    - <u>example:</u> Sahara Desert

  - coastal
    - generally, on the western edges of continents
    - bounded by cold ocean currents
    - these cool the air above starting the cycle of increased evaporation
    - <u>examples:</u> coastal Peru and the Namibian Desert

IV. Climate Regimes:

- hyper-arid:
  - receives < 2.5 cm of precipitation/year
  - marked by little to no vegetation
  - form the central areas of larger desert systems
  - dunes and sand seas are common
  - example: central Saharan Desert



Africa Deserts:
(1) hyper-arid *(Sahara)*

(2) arid *(Kalahari)*

(3) semi-arid *(Sahel region)*

- arid:
  - receives 2.5 - 25 cm of precipitation/year
  - marked by some drought-resistant vegetation
  - have playas (dry lake beds) and saline lakes in areas
  - dunes are less common
  - example: Kalahari Desert, Africa

- semi-arid:
  - receives 25 - 50 cm of precipitation/year
  - marked by semi-stable vegetation and sparse agriculture
  - flash-flooding and alluvial fans are common
  - able to sustain moderate human development
  - situated at the margins of larger deserts systems
  - *no longer a desert by precipitation definition*
    - *most at-risk regions for desertification!*

V. What is Desertification?

- slowly advancing spread of desert conditions/sand along a desert edge due to:
  - prolonged drought
  - climate change
  - anthropogenic *(human)* land degradation and/or expansion

- some desert fringes form a gradual transition from a dry to a more humid environment
  - example: Sahel region of West Africa
    - 1968-1973 drought combined with poor land-use practices
    - caused the deaths of more than 100,000 people and 12 million cattle

- causes?
  - climate change: shorter-term climate change causing years of drought
    - important to remember that drought ≠ desert
    - but it can lead to desertification and famine

  - land degradation/soil erosion: human land use patterns that lead to conditions favoring eventual desertification

        - over-cultivation
        - over-grazing
        - deforestation
        - bad irrigation practices

    - can lead to extreme dust conditions, dust storms, and poor respiratory health

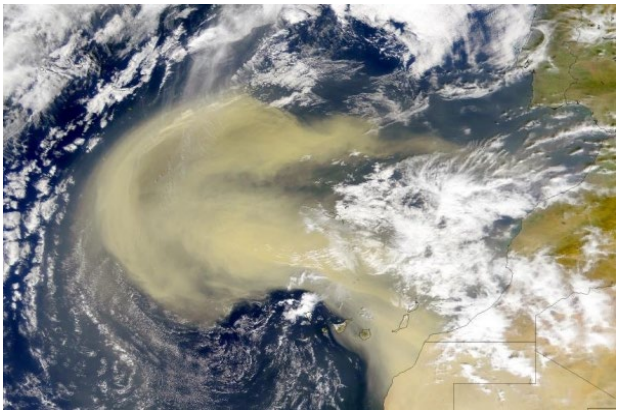
VI. Monitoring and Mitigation

- monitoring
    - weather and soil moisture conditions using ground- and satellite-based instruments
    - human land use practices

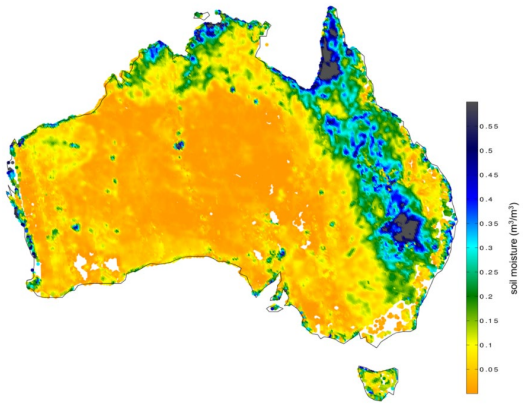
Kansas: dust storm advancing

China: post dust storm

- mitigation
    - little that can be done once a long-term drought transitions to desertification with sand encroachment into towns and farmland



Africa (2002): large dust storm seen from space



Australia: satellite-based soil moisture