Climate Time Series: Study Packet

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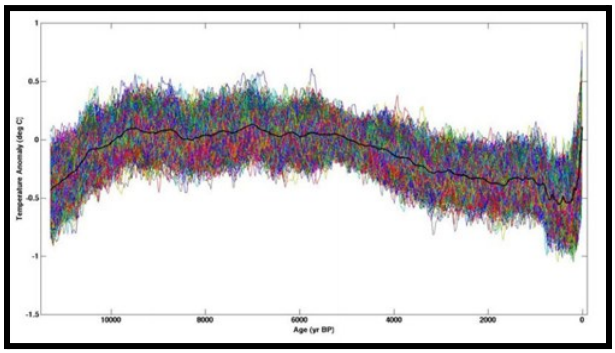
Introduction:

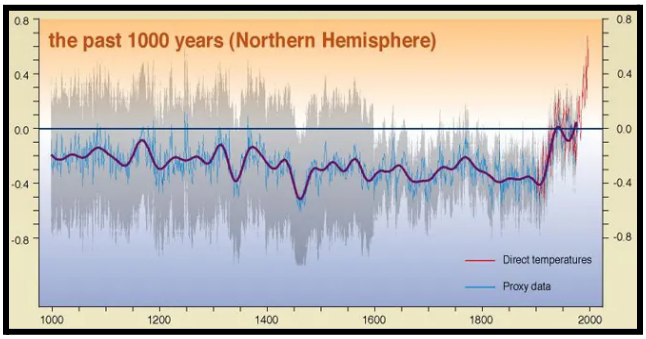
- Climate Change - long-term change in the average weather patterns that have come to define Earth's local, regional and global climates
- The rate of warming of the earth's temperature is the most concerning aspect of climate change. With rising temperatures, some adverse effects include
    - More frequent and stronger storms
    - Rising sea levels
    - More intense droughts
    - Harm food production
- In 1998, Michael Mann published data about earth's rising temperature. He obtained new data that extended temperature measurements going back thousands of years. He is known for his 'Hockey Stick' graph (Pictured below)



- This graph shows a steady rise and fall in temperature over the last 10000 years, but a very sharp and unexpected rise occurs in the last couple hundred of years. This is thought to be due to the man-made contributions to climate change. Some causes include,
    - Burning of fossil fuels
    - Deforestation
    - Overpopulation
- Data collection of Temperatures
    - Historic
        - Tree Rings
        - Ice
        - Lake Sentiment Data
        - Fossils
    - Current
        - Thermometers
        - Weather Stations

Findings:

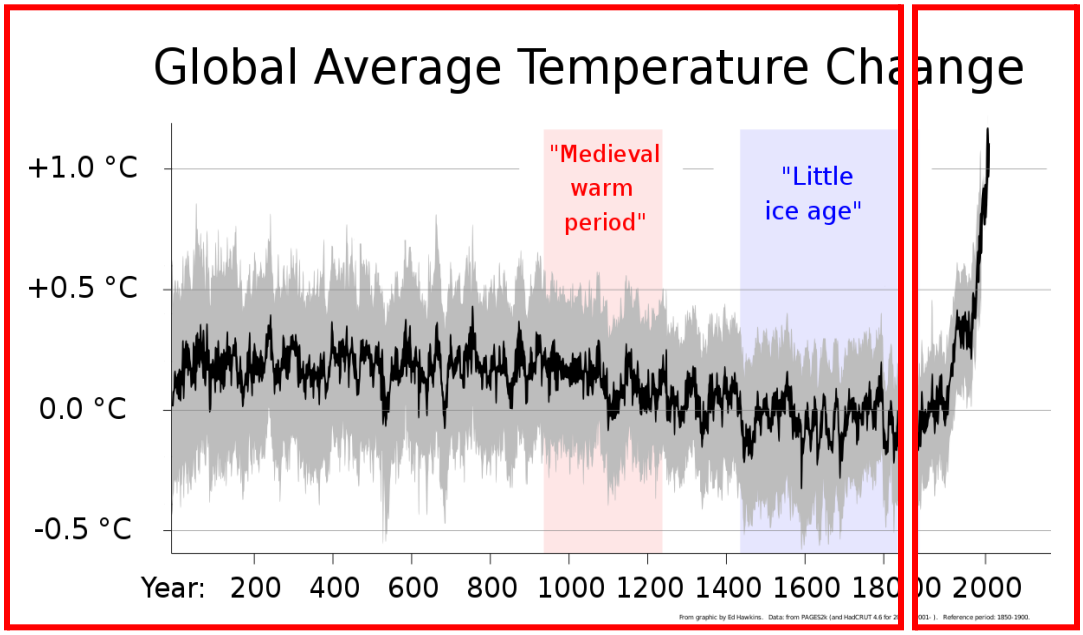
- All graphs measuring temperature over time are time series.
- Divergence in Tree-Ring Data
    - Recent tree-ring data has diverged from direct temperature data.
        - Different trends in northern vs. southern forests
        - CO2 concentration can affect tree growth
    - Mann decided to rely on direct temperature data for recent estimates.
- Revised Time-Series Graph



- Hockey-Stick Graph Controversy
    - Emails were leaked that cast doubt on the authenticity of Mann's data and his findings.
    - This controversy has been a political tool to attack climate change science and scientists.
    - There is still an ongoing conversation regarding the validity of Mann's data.
- Hockey-Stick Graph Benefits
    - The graph provides a clear narrative to the public. The easy to read time series allows people to have concrete evidence to argue for changes in our society.
    - The graph demonstrates a significant increase in the rate of temperature change.
    - The large spike at the end of the graph conveys urgency of government response. Activism in the forms of marches or strikes has also become more popular as concerns have grown.
    - Mann's graph is based on multiple sources of robust data.
- Relation to our time series studies
    - All temperature graphs are time series graphs
    - Climate time series are best modeled using the equation:

$$X(i) = X_{\text{trend}}(i) + S(i) \times X_{\text{noise}}(i).$$

- In this model, X(trend) is the center, X(noise) is white noise variable, but it is autocorrelated, and S(i) is a scaling factor that adds to the natural variance
- Trying to make a connection between climate time series and what we've learned in time series modeling, I found this model in research that can somewhat accurately predict temperature over time.
- Similar to an AR ts where previous measurements are correlated with predictions, but different in the sense that there is a scaling factor added onto the noise variable and the noise variable is found to be autocorrelated
- The handle part of the hockey stick graph is stationary and can be relatively well-modeled with the time series models we have learned in this class
- The blade of the hockey stick graph is nearly impossible to be modeled using at least what we have learned in our course - it is seemingly non-stationary and there would be no way to predict such a significant increase in the temperature using the models from the handle part of the graph



Conclusions:

- Climate time series are the main use of climatologists for temperature analysis
- Man-made effects on global temperatures are real and can be seen through hockey stick graph (there is a clear impact resulting from the start of the industrial revolution)
- Time series models aren't reliable for prediction of temperature
  - Linear regression would be better because you would better be able to account for the man-made impacts on climate
- Academic writing won't be supported unless you agree with the hockey stick graph claim
- Climate change will cause higher temperatures, more storms of higher severity, and a higher number of droughts

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