Reconstructing Cloud Cover from Tree Rings and Its Relationship with Tree Growth, Northeast United States

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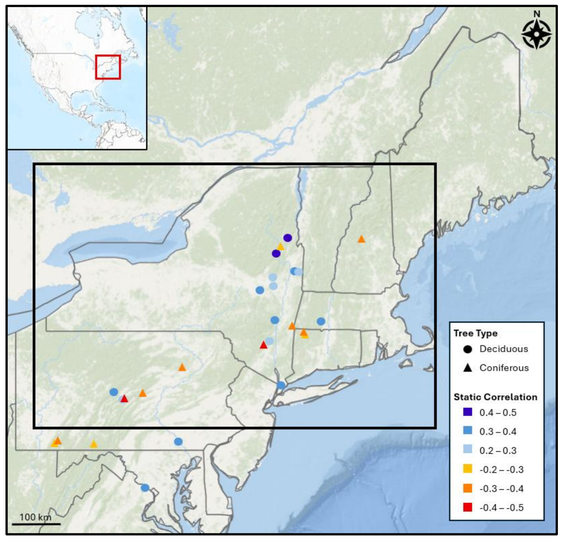
Introduction

The climate of the Northeast United States has been rapidly changing since the 1970s, and the suitable habitats for different tree species are predicted to shift (Iverson et al., 2008). There is a lack of research regarding cloud cover in relation to tree growth despite the importance of clouds to various climate feedbacks.

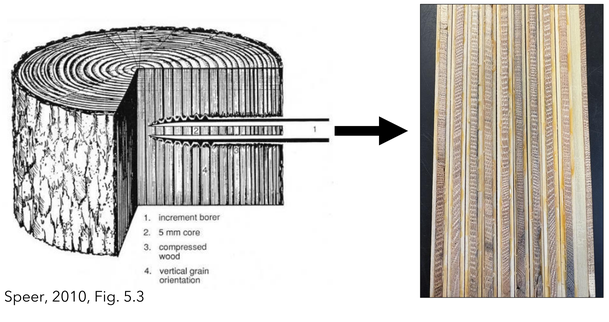
This study explores the following research questions:

- How has cloud cover in the Northeast United States changed over time?
- What biological, natural, or anthropogenic factors forced the changes in cloud cover?
- How do cloud cover changes influence tree growth?



Dendroclimatology

Trees grow annual rings that record the ways in which trees are responding to their environment. Climate reconstructions can be built by comparing annual tree ring data with monthly climate data.

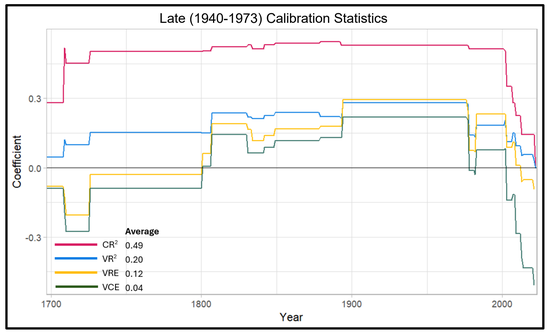


Speer, 2010, Fig. 5.3

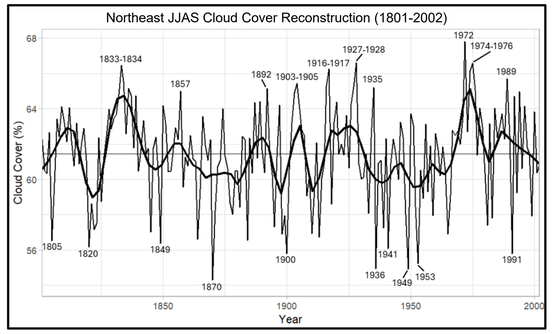
Materials and Methods

- Ring width data from 16 oak sites and latewood blue intensity data from 14 eastern hemlock (*Tsuga canadensis*) (Harley et al., 2024) sites were standardized and compiled into site-level chronologies
- Nested principal component regression analysis was utilized to reconstruct 1801 to 2002 Northeast June through September (JJAS) cloud cover from the tree ring data
- Static and partial correlations comparing the tree ring data with cloud cover, temperature, and precipitation were calculated

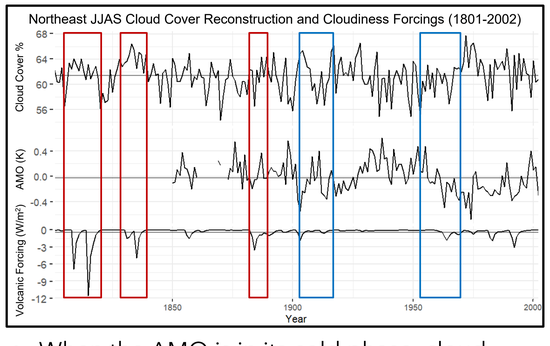
Results and Discussion



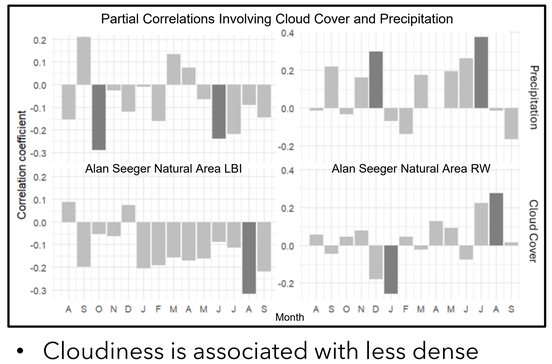
- 40 total nests were built, originally spanning 1697 to 2022
- Calibration and verification statistics suggest that the model has predictive power from 1801 to 2002
- Bias correcting ensures estimates are as reliable as possible



- Rising sulfate aerosol emissions in the 1950s led to increased cloudiness, whereas greenhouse gases have the opposite effect
- Deforestation caused cloud cover lows in the late 1800s from slower evapotranspiration rates and lower biogenic volatile organic compound atmospheric concentrations



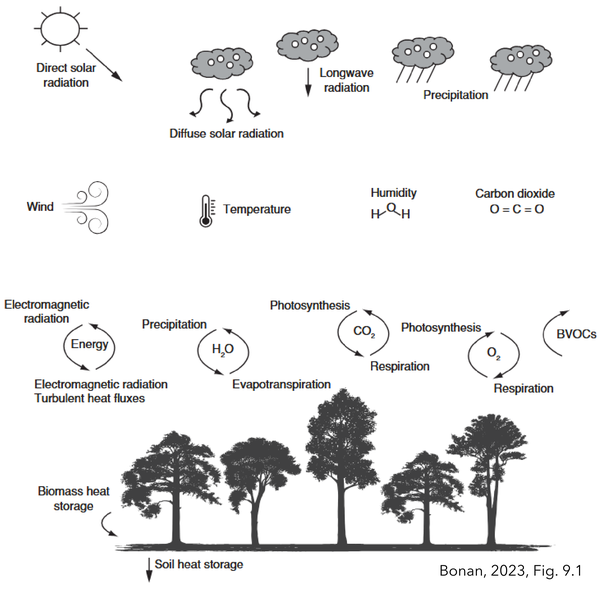
- When the AMO is in its cold phase, cloud cover tends to increase in the Northeast because the AMO can cause changes in the North Atlantic Subtropical High
- Volcanic eruptions release sulfate aerosols, which contributed to cloudiness in the early 1800s



- Cloudiness is associated with less dense hemlock latewood and wider oak annual rings
- Partial correlations indicate that precipitation has a more direct effect on tree growth, especially for oak ring width
- Warmer temperatures lead to more dense hemlock latewood

Conclusions

- Clouds are an integrative component of climate that indirectly influences tree growth by reducing light availability, producing rain, and altering temperatures
- Hemlock latewood density is more strongly influenced by temperature and light availability, whereas the oak ring width tends to be limited by moisture



Bonan, 2023, Fig. 9.1

Acknowledgements

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