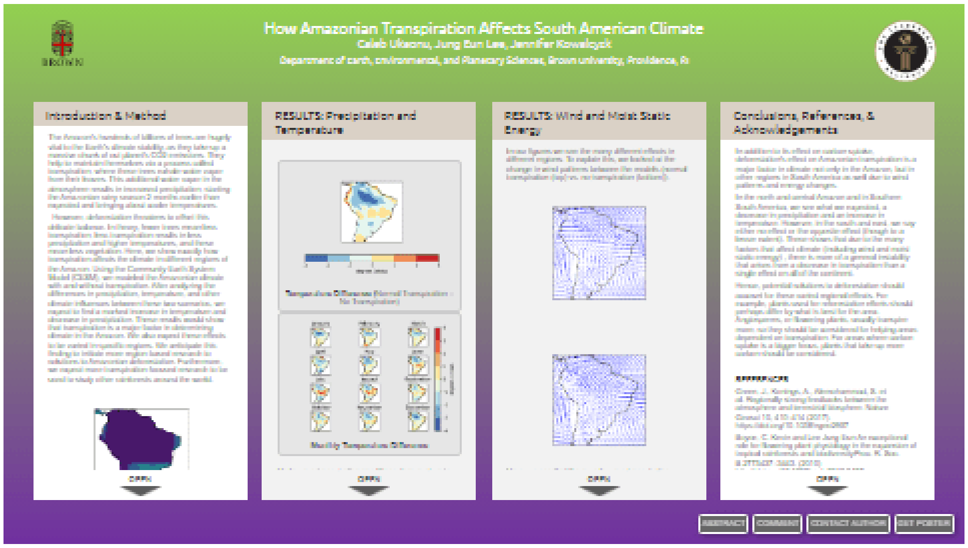
How Amazonian Transpiration Affects South American Climate



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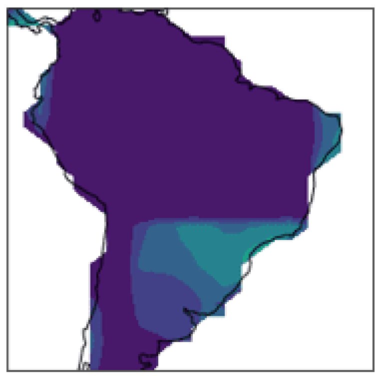
INTRODUCTION & METHOD

The Amazon's hundreds of billions of trees are hugely vital to the Earth's climate stability, as they take up a massive chunk of out planet's CO2 emissions. They help to maintain themselves via a process called transpiration, where these trees exhale water vapor from their leaves. This additional water vapor in the atmosphere results in increased precipitation, starting the Amazonian rainy season 2 months earlier than expected and bringing about cooler temperatures.

However, deforestation threatens to offset this delicate balance. In theory, fewer trees mean less transpiration, less transpiration results in less precipitation and higher temperatures, and these mean less vegetation. Here, we show exactly how transpiration affects the climate in different regions of the Amazon. Using the Community Earth System Model (CESM), we modeled the Amazonian climate with and without transpiration. After analyzing the differences in precipitation, temperature, and other climate influences between these two scenarios, we expect to find a marked increase in temperature and decrease in precipitation. These results would show that transpiration is a major factor in determining climate in the Amazon. We also expect these effects to be varied in specific regions. We anticipate this finding to initiate more region-based research to solutions to Amazonian deforestation. Furthermore, we expect more transpiration-focused research to be used to study other rainforests around the world.



METHOD

•Run the Community Earth Science Model (CESM) under normal conditions for 30 years.

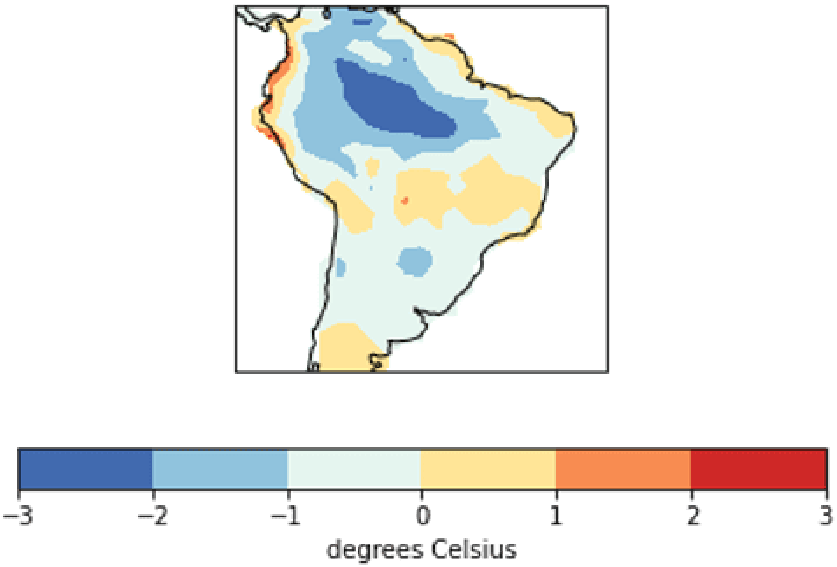
•CO2 will be set to pre-industrial conditions, and vegetation will be constant, so that it doesn't affect any of the values we intend to measure.

•Run the CESM with zero transpiration in the Amazon for 30 years.

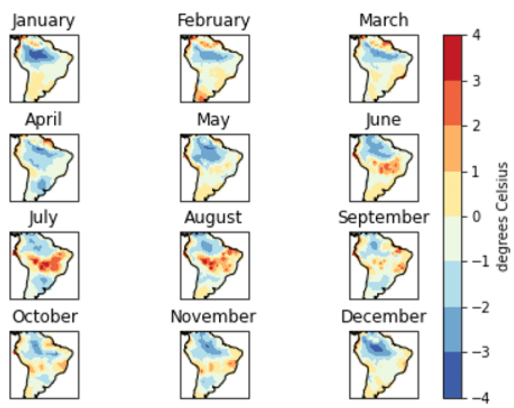
•Plot the average temperature and precipitation for the last 10 years of 30-year run.

•Analyze the difference between the plots, looking at the regional and temporal intricacies.

RESULTS: PRECIPITATION AND TEMPERATURE



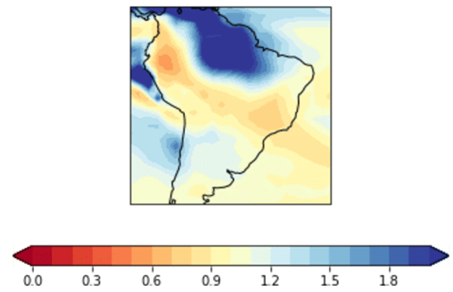
Temperature Difference (Normal Transpiration – No Transpiration)



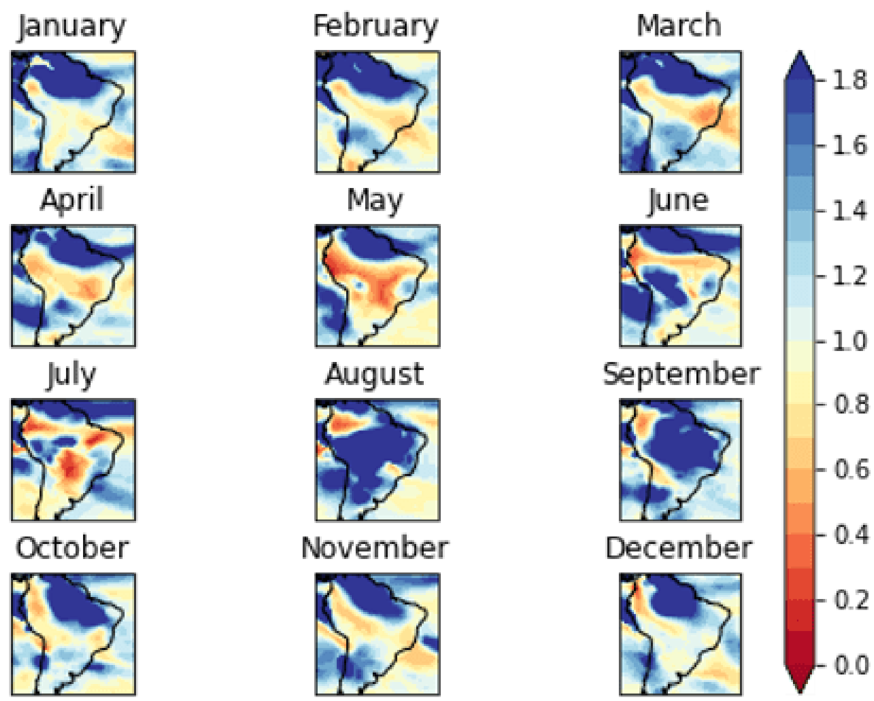
Monthly Temperature Difference

Under zero transpiration conditions, temperature in the North and Central Amazon increases by up to 3 degrees, while it decreases slightly or stays constant in the south and eastern parts. We also see a larger increase in southern South America.

The monthly plots show that there are many more regions affected by a large temperature decrease throughout the year.



Precipitation Ratio (Normal Transpiration/No Transpiration)



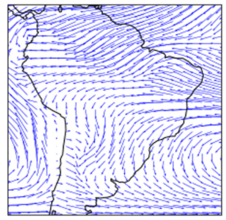
Monthly Precipitation Ratio

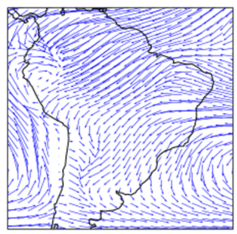
Here, the north Amazon is again affected as expected, with many areas seeing more than a twofold decrease in precipitation under no transpiration conditions. We also see a slighter effect in the opposite direction in the south and west Amazon. In southern South America, we see a 20%-30% decrease.

The monthly differences show that this differences are most extreme during the rainy season. Also, southern South America is affected the most in the late summer and fall.

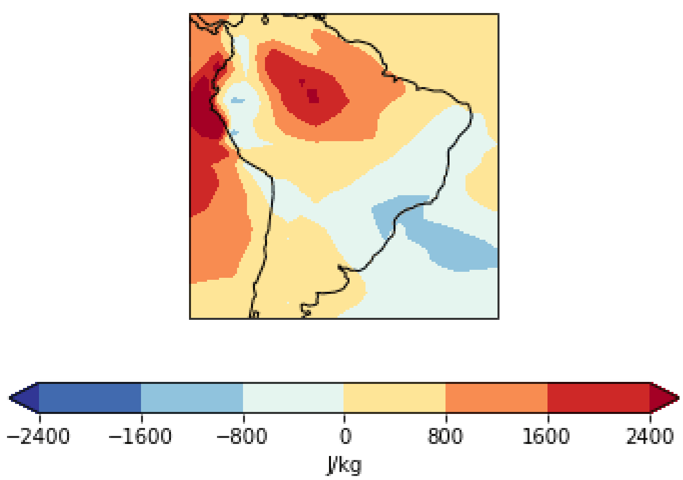
RESULTS: WIND AND MOIST STATIC ENERGY

In our figures we see the many different effects in different regions. To explain this, we looked at the change in wind patterns between the models (normal transpiration (top) vs. no transpiration (bottom)).





Here, we see that there under zero transpiration conditions, there is more of a net south and western movement of the wind. This partially explains the change in precipitation patterns, since more of the rain in the rainforest regions are being moved to drier areas southwards. This also explains why the effects of no transpiration in the Amazon are echoed in the southeast.



Moist Static Energy (MSE) difference (Normal transpiration - no transpiration)

As a product of wind and advection we see that the moist static energy has dropped in regions received that less precipitation under zero transpiration and increased in regions where there is more precipitation under zero transpiration conditions. These factors also help to explain the interesting changes in precipitation and temperature.

CONCLUSIONS, REFERENCES, & ACKNOWLEDGEMENTS

In addition to its effect on carbon uptake, deforestation's effect on Amazonian transpiration is a major factor in climate not only in the Amazon, but in other regions in South America as well due to wind patterns and energy changes.

In the north and central Amazon and in Southern South America, we see what we expected, a decrease in precipitation and an increase in temperature. However, in the south and east, we say either no effect or the opposite effect (though to a lesser extent). These shows that due to the many factors that affect climate (including wind and moist static energy) , there is more of a general instability that arises from a decrease in transpiration than a single effect on all of the continent.

Hence, potential solutions to deforestation should account for these varied regional effects. For example, plants used for reforestation efforts should perhaps differ by what is best for the area. Angiosperms, or flowering plants, usually transpire more, so they should be considered for helping areas dependent on transpiration. For areas where carbon uptake is a bigger focus, plants that take up more carbon should be considered.

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ACKNOWLEDGEMENTS

This research was conducted through Dynamic Earth in the 21st Century, an NSF Earth Sciences REU Site at Brown University run by the Dept. of Earth, Environmental and Planetary Sciences and the Leadership Alliance (EAR-1852273)

ABSTRACT

The Amazon's hundreds of billions of trees are hugely vital to the Earth's climate stability, as they take up a massive chunk of out planet's CO2 emissions. They help to maintain themselves via a process called transpiration, where these trees exhale water vapor from their leaves. This additional water vapor in the atmosphere results in increased precipitation, starting the Amazonian rainy season 2 months earlier than expected and bringing about cooler temperatures.

However, deforestation threatens to offset this delicate balance. In theory, fewer trees mean less transpiration, less transpiration results in less precipitation and higher temperatures, and these result in less vegetation. **Hence, in this project, we showed exactly how transpiration affects the climate in different regions of the Amazon.** Using the Community Earth System Model (CESM), we modeled the climate with and without Amazonian transpiration. After analyzing the runs of two scenarios, we found marked differences in temperature, precipitation, wind patterns, and static energy not only in the Amazon, but across the South American continent. These results showed that transpiration is a major factor in determining climate in the Amazon. Also, these effects were much more varied than expected, with some regions experiencing the opposite effect of what was expected. We anticipate this finding to initiate more region-specific solutions to Amazonian deforestation. Furthermore, we expect more region-based research to be used to study other rainforests around the world.