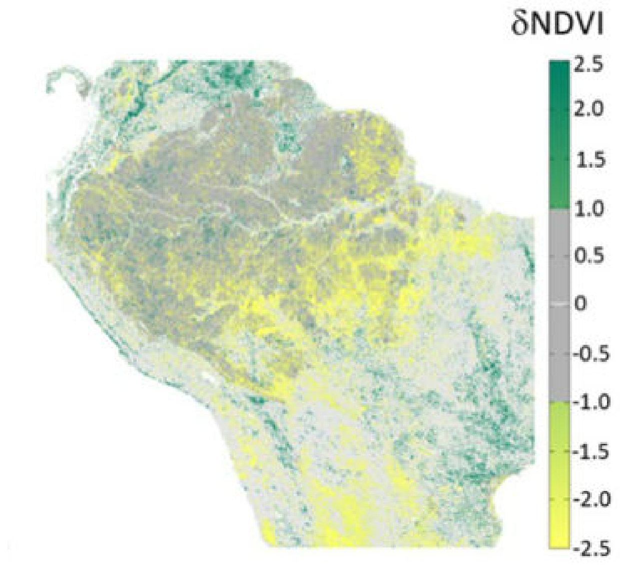
NASA study shows 13-year record of drying Amazon caused vegetation declines

10 December 2014, by Ellen Gray



This image shows change in Amazon greenness from 2000 to 2012, measured as Normalized Difference Vegetation Index. Greener colors represent increased greenness, gray is no change, and yellow represents decreased greenness over the 13-year record. Credit: Hilker et al.

A 13-year decline in vegetation in the eastern and southeastern Amazon has been linked to a decade-long rainfall decline in the region, a new NASA-funded study finds.

With global climate models projecting further drying over the Amazon in the future, the potential loss of vegetation and the associated loss of carbon storage may speed up global climate change.

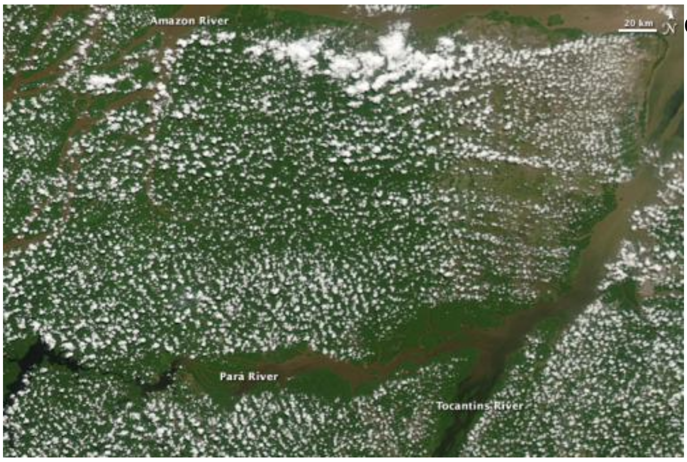
The study was based on a new way to measure the "greenness" of plants and trees using satellites. While one NASA satellite measured up to 25 percent decline in rainfall across two thirds of the Amazon from 2000 to 2012, a set of different satellite instruments observed a 0.8 percent decline in greenness over the Amazon. The study was published on Nov. 11 in *Proceedings of the National Academy of Sciences*.

While the decline of green vegetation was small, the area affected was not: 2.1 million square miles (5.4 million square kilometers), equivalent to over half the area of the continental United States. The Amazon's tropical forests are one of the largest sinks for atmospheric carbon dioxide on the planet.

"In other words, if greenness declines, this is an indication that less carbon will be removed from the atmosphere. The carbon storage of the Amazon basin is huge, and losing the ability to take up as much carbon could have global implications for climate change," said lead author Thomas Hilker, remote sensing specialist at Oregon State University in Corvallis, Oregon.

Plants absorb carbon dioxide as part of photosynthesis, the process by which green plants harvest sunlight. The healthier the plants, the greener the forest.

The Amazon basin stores an estimated 120 billion tons of Earth's carbon - that's about 3 times more carbon than humans release into the atmosphere each year. If vegetation becomes less green, it would absorb less of that carbon dioxide. As a result, more of human emissions would remain in the atmosphere, increasing the greenhouse effect that contributes to global warming and alters Earth's climate.



Popcorn clouds above the Amazon rainforest, August 19, 2009. This type of cloud forms during the dry season, likely from water vapor released by plants during transpiration. Credit: NASA's Earth Observatory

Can't See the Forest for the Clouds

Teasing out changes in vegetation greenness over the Amazon is one of the most challenging problems for satellite remote sensors because there's no tougher place on Earth to observe the surface.

"The wet season has typically 85 to over 95 percent cloudiness from late morning to early afternoon, when NASA satellites make measurements," said co-author and remote sensing specialist Alexei Lyapustin of NASA's Goddard Space Flight Center in Greenbelt, Maryland. "Even during the dry season the average cloudiness can be on the order of 50 to 70 percent." Add other atmospheric effects, soot and other particles released from fires during the dryer months, and it's very difficult for the satellite to pick up a clear signal of the surface, Lyapustin added.

Using the Moderate Resolution Imaging Spectroradiometer, or MODIS, instruments aboard NASA's Terra and Aqua satellites, Hilker, Lyapustin and their colleagues developed a new method to detect and remove clouds and other sources of error in the data. It looks at the same location on Earth's surface day after day over time and analysts pick out a pattern that is stable in contrast to the ever-changing clouds and aerosols. This knowledge of what the surface should look like from earlier observations is used later to detect and remove the atmospheric noise caused by clouds and aerosols. It's as if the signal from the ground were a song on a static-y radio station, and by listening to it over and over again for long enough, the new method detects and removes the static. By reducing those errors, they increased the accuracy of the greenness measurements over the Amazon.

"We're much more confident that this is a gap between clouds where we can measure greenness, but standard algorithms would call it a cloud," said Lyapustin. "We can get more data about the surface, and we can start seeing more subtle changes."

One of the subtle changes visible in the new data-set is how the Amazon's greenness corresponds to one of the long-known causes of rainfall or drought to the Amazon basin: changes in sea surface temperatures in the eastern Pacific Ocean, called the El Nino Southern Oscillation. During warmer and dryer El Nino years, the Amazon appears browner. During cooler La Nina wet years, the Amazon appears greener.

In the past, with greenness data, "it's been hard to tell an El Nino year from a non-El Nino year," said Lyapustin.

The effects of large and more frequent droughts may have lasting impacts that contribute to the long-term decline in vegetation, especially in an increasingly water stressed ecosystem. Many climate models project that in the future, El Nino and La Nina events will become more intense. They also project a northward shift of the main rain belt that provides moisture to the Amazon rainforest, which could further reduce rainfall to the region.

"Our observations are too short to link drying to human causes," Hilker said. "But if, as global circulation models suggest, drying continues, our results provide evidence that this could degrade the Amazonian forest canopies, which would have cascading effects on global carbon and climate dynamics."

Limits of Light vs. Water

The researchers found another subtlety in the Amazon's response to rainfall, which has led to new insights on a question under debate: Are seasonal changes in plant growth more limited by lack of sunlight or lack of water?

The Amazon basin, which consists of grasslands, evergreen forest, and deciduous forest where trees lose their leaves annually, has a wet season and a dry season. Past measurements from satellites have shown either no changes in greening between seasons or increased greening through the end of the dry season, attributed to fewer clouds blocking sunlight from reaching the ground. Measurements from a handful of field stations across the basin, however, indicated the vegetation greenness due to increased sunlight in the dry season would decline once the water in the soils was used up - especially in drought years.

"Our study has helped confirm field-based results across large areas from space," Hilker said. "With our work, we have shown that there is a dry season greening but that under extended drought we get a decline in vegetation greenness."

During the dry season of an average year, the evergreen plants tap into groundwater, bask in the sunlight, and become greener.

"They're deeply rooted so they have plenty of water and they have lots of leaves," said Compton Tucker, a senior research scientist at Goddard who also contributed to the paper. "However, when you come up to one of these really dry periods, [like the drought of 2005 or 2010], then there isn't enough water to take advantage of all the light during the dry season." Water becomes the limiting factor whose effects can carry over from one year into the next if trees and vegetation die off.

More information: *Proceedings of the National Academy of Sciences*, www.pnas.org/content/111/45/16041.abstract

Provided by NASA's Goddard Space Flight Center

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