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Lessons from the 2021 Amazon flood (commentary)

Commentary by Philip M. Fearnside on 23 July 2021

- *In June 2021, the annual flood season in the western and central Amazon reached record levels, and dramatic scenes of inundated homes, crops and city streets captured attention beyond Amazonia. This event provides lessons that must be learned.*
- *The high flood waters are explained by climatological forces that are expected to strengthen with projected global warming. Damaging floods represent just one of the predicted impacts in Amazônia under a warming climate.*
- *The administration of Brazilian President Jair Bolsonaro must change its current denialist positions on global warming and its policies that encourage deforestation. The Amazon forest must be maintained for many reasons in addition to its role in avoiding climate change.*
- *This post is a commentary. The views expressed are those of the author, not necessarily Mongabay.*

This text is updated from a Portuguese-language version published by Amazônia Real.

The drama of the record flood in the Brazilian Amazon Basin reached on 30 June 2021 offers valuable lessons that need to be learned — even as this July the Paraná

River Basin south and east of the Amazon (where a third of Brazil's people live) sees record drought.

First, the flood height in Manaus that broke the record since measurements began in 1903 is consistent with predictions for climate change associated with global warming. In addition to the need to avoid the large emissions that deforestation causes, thus helping to mitigate global warming, the Amazon rainforest needs to be kept standing to maintain a variety of other essential environmental services, including water recycling.

The year 2021 is a La Niña year, which always leads to more rain in the Amazon. The "southern oscillation" between El Niño and La Niña has been more frequent since 1976, and the U.N. Intergovernmental Panel on Climate Change (IPCC) attributes this to global warming and projects that this trend is likely to continue. The variability and severity of El Niño and La Niña events are expected to increase. These phenomena, and others as well, modify the air currents around the planet, which causes extremes of drought and rain in different places.

On top of the impact of La Niña, an additional factor increased the 2021 flood: the combination of warmer water in the Atlantic Ocean and cold water in the Pacific (Figure 1). Cold water in the Pacific near the coast of Peru is normal in La Niña years, and this is increased by the current phase of the Pacific Decadal Oscillation (PDO). Warm water in the Atlantic is a phenomenon that is increasing in frequency. One explanation is the effect of global warming in causing the westerly wind belt around Antarctica to move away from the tip of Africa, allowing water from the Indian Ocean in the warm Agulhas current that descends from Mozambique to the Cape of Good Hope to leak into the South Atlantic (the "Agulhas leakage")(see here, here and here).

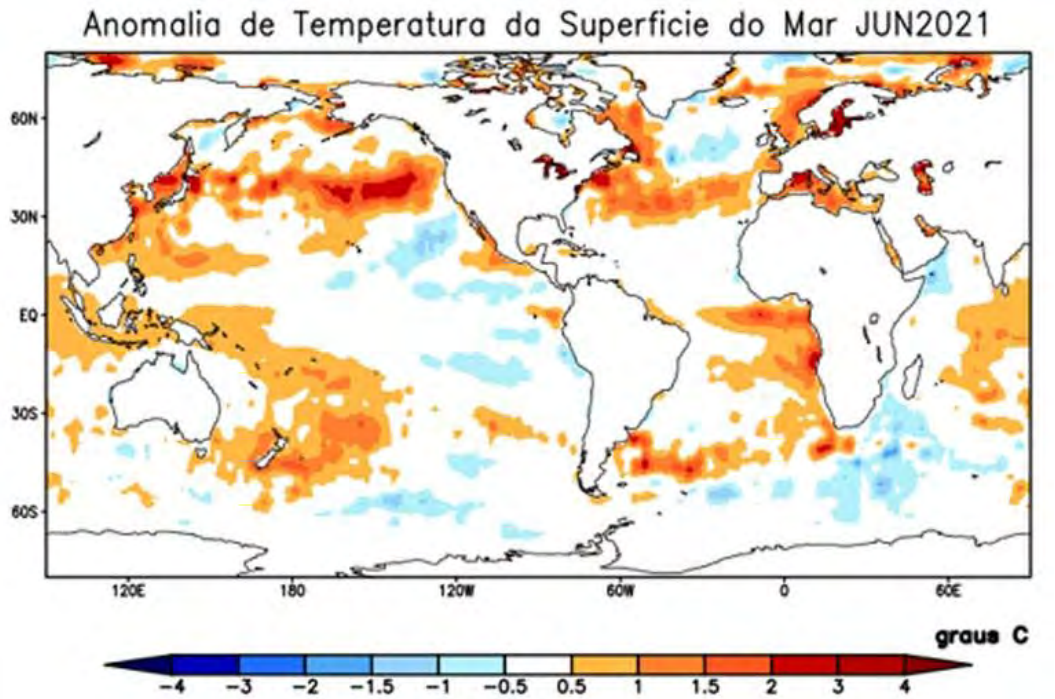

Figure 1. Sea surface water temperature anomaly (difference from the mean) in June 2021. Source: CPTEC.

The surface temperature of the South Atlantic has been increasing continuously since the 1960s. The dramatic temperature difference between the Atlantic and the Pacific increases the movement of air from east to west (the Walker circulation), complementing the effect that moves air in this direction due to the rotation of the Earth (which, unlike the Walker circulation, is constant one year to another), taking air with water that evaporated from the ocean into the Amazon, where the water falls as rain. Figure 2 shows these water vapor flows, while the length of the arrows indicates the quantity being transported. The arrows are short in the Atlantic off the coast of Africa, and they grow in length as they accumulate evaporated water on their way to the Amazon.

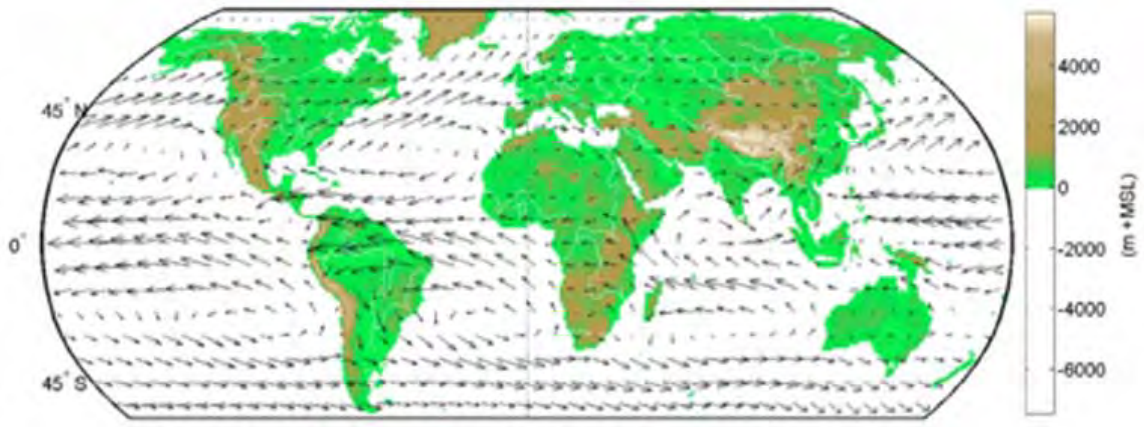

Figure 2. Global moisture transport –1999-2008 average (proportional to arrow length). Source: van der Ent et al.

The maximum annual flood levels in Manaus are positively correlated with the magnitude of the temperature difference between the warm Atlantic water and the cold Pacific water, reinforcing the importance of the Walker circulation on floods. The Pacific Ocean is currently in the “negative” phase of the Pacific Decadal Oscillation (PDO), with the average water temperature being cooler near the coast of Peru, thus widening the gap to the Atlantic temperature, strengthening the Walker circulation and leading to more rainfall in the Western Amazon. In 2021 the negative phase intensified, with more negative values of the Pacific Oscillation Index (POI)

Deforestation has various effects on rainfall and on the runoff from the landscape that gives rise to floods. In a clean pasture, the rainwater that runs off the surface and enters the streams is up to twenty times more than in an adjacent intact forest. This is because in the forest the water percolates into the ground, where about half is sucked up by tree roots and returned to the air through the leaves. The soil in the forest also retains part of the unrecycled water and releases it with a delay (the hysteresis phenomenon), thus minimizing local flooding. At the basin level, the effect can be seen in the Tocantins River Basin, which is already heavily deforested: a change in river flow has been documented, with higher rainy-season flows and lower dry-season flows.

There is little deforestation in the Upper Amazon River (Solimões) and Negro River catchments, which are the basins that affect the flooding in Manaus. The effects of deforestation at the local level, both the augmenting effect on the percentage of runoff and the negative effect of decreasing evapotranspiration, would therefore not yet be significant. However, simulations indicate that in the future the effect of deforestation may increase flooding in the western Amazon, especially in the Madeira River. Modeling studies also show that deforestation in eastern Amazonia can decrease precipitation in western Amazonia due to reduced water recycling in deforested areas, even in distant locations.

Flooding in Manaus, Amazonas state, Brazil in 2009. Such floods, like the record one occurring there in June 2021, provide visceral evidence that worsening climate change, along with increasing deforestation, are making extreme weather in the Amazon increasingly dangerous, Image by Jochen Schöngart / National Institute for Amazon Research.

The trend predicted by global climate models indicates less rain in eastern Amazonia and more rain in western Amazonia, and imply greater flooding. This is also the pattern observed in recent decades (see here and here). The hydrological cycle has been intensifying in the Amazon since the early 1990s, contributing to increased rainfall in the western Amazon. The average flow of rivers in western Amazonia has been increasing since 1980, and modeling studies indicate increased flow in the Marañón Basin in the Peruvian Amazon. It is clear that increases in average precipitation and river flow in western Amazonia imply increasing flooding when it occurs.

Again, the lessons are clear: Larger floods represent just one of the expected changes that make the Brazilian Amazon one of the places in the world with the most severe impacts of global warming that are expected to occur without major cuts in emissions (see here and here). The Brazilian government needs to wake up to this fact and change its positions both internally and in international negotiations, radically reducing national emissions and assuming a leading role in combating the greenhouse effect globally.

Banner image: *Flooding in the Brazilian Amazon in 2021. The region, with its large indigenous population, has been hit extremely hard by the pandemic, with the floods adding to people's challenges. Some riverine villages were completely submerged during the flooding. Image by Alexandre Noronha / Greenpeace.*