

## MEASUREMENT PROGRAM OF GHG VERTICAL PROFILES AT AMAZON

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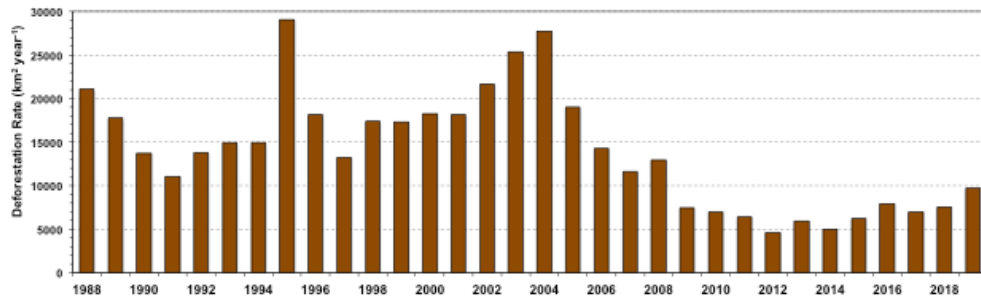
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Amazon is the major tropical land regions and is still been poorly comprehend, with only very few regular greenhouse gas measurements available in the tropics, and mostly not of a suitable nature for estimating carbon balances. Amongst the land regions in the tropics of particular importance for the global carbon cycle is the Amazon, by far the largest region hosting the largest carbon pool in vegetation and soils (~200 PgC). Net carbon exchange between tropical land and the atmosphere is potentially important because it holds large amounts of carbon in forests and soils which can be released on short time-scales e.g. via deforestation or changes in growing conditions, like increased heat and the extension of dry season. Such changes may thus cause feedbacks on global climate.



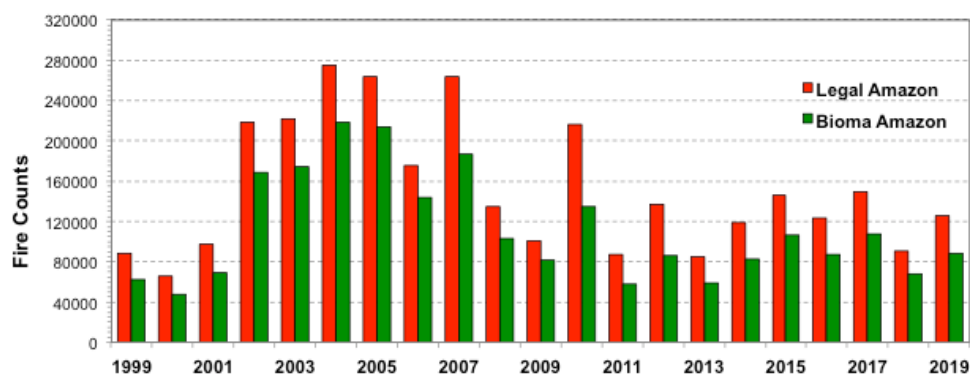
**Figure 1. Since 2000 SAN aircraft site, 2010 added more 3 sites TAB, RBA, ALF (0.3 to 4.4km) and more 2 sites until 7.3km RBA and SAL with 3 coast sites SAL (10-17), CAM (14 to now) and NAT (2010 to now). TEF is the substitute of TAB site (TAB was substituted by TAB at 2013)**

Actually there are strong pressures over Amazon for agriculture, livestock, mining, logging, etc. The estimated deforestation for Brazilian Legal Amazon is 9,762 km<sup>2</sup> for the period August 2018 to July 2019. The area of Brazilian Legal Amazon is 5,217,423 km<sup>2</sup> and represents 9 states, where 40% of deforestation happens at Para state. The deforestation this year represents an increase of 29.5% compared to deforestation rate determined by PRODES 2018, which was 7,536 km<sup>2</sup>. Since 2012 the deforestation is growing, after a very successful programme in reduction. In 2004 the deforested area was 27,772 km<sup>2</sup> and at 2012 was 4,571 km<sup>2</sup>, representing a reduction of 65.5% (Figure 1).



**Figure 2. Annual rate of deforestation in the Brazilian Amazon since 1988. In blue the estimate for 2019.**

The fires in August 2019 were very abundant and surpassed historical averages since 1998. The Figure 3 shows Fire counts at Amazon, where around 70% of the fire is inside Biome Amazon. The international political pressure was very helpful in make the government take action to control fires. Understand the roles of Amazon in the Global Carbon Balance and the impact of Climate change is promoting it is very important. Also what the impact of Amazon in the climate change?



**Figure 3. Annual Fire counts in Amazon. Red represents fire counts inside Legal Amazon (9 states: Acre, Amapá, Amazonas, Mato Grosso, Pará, Rondonia, Roraima, Tocantins and partially Maranhão) and Green represents Fires inside the Bioma Amazon.**

To understand the role of the Amazon in the global carbon balance, we developed a scientific strategy of GHG measures, using small aircraft to perform vertical profiles. The aircraft measurement programme was started in 2000 with monthly/biweekly vertical profile sampling at SAN (2.86S 54.95W). From December 2004 to December 2007 we performed vertical profiles at MAN (Dec 2004 / Dec 2007). In 2010, a new step in our programme was started. We added three more aircraft sites: TAB (5.96S 70.06W), RBA (9.38S 67.62W) and ALF (8.80S 56.75W). In 2013 TAB site was moved to TEF (3.39S 65.6W) and we add two more aircraft sites with vertical profiles from 300m to 7300 m, at Salinópolis (SAH 0.60S; 47.37W) near the Atlantic coast and RBH at the same place then RBA, in the western Amazon to compare with GOSAT. In 2017 we started a new place at Pantanal, the biggest flooded area in Brazil. During this time, until now, it was performed 910 vertical profiles (Table 1).

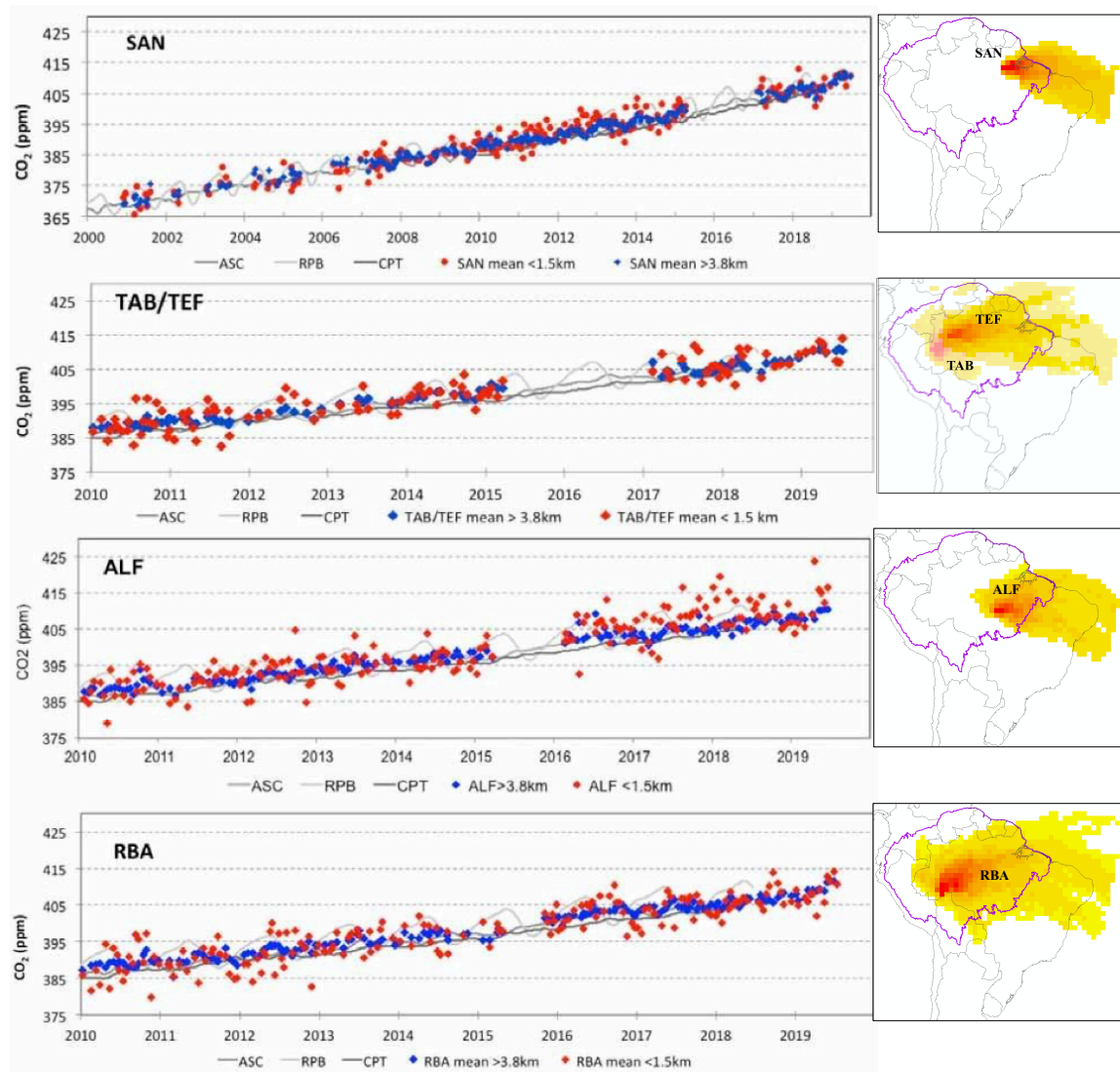
	2000/09	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
<b>SAN</b>	108	19	23	24	23	16	6		17	21	18	<b>275</b>
<b>ALF</b>		20	19	24	22	19	5	20	24	23	22	<b>198</b>
<b>RBA</b>	1	20	18	22	19	15	12	21	24	20	22	<b>194</b>
<b>TAB/TEF</b>	20	14	9	9	15	16	4		14	13	17	<b>131</b>
<b>SAH</b>					10	9	4					<b>23</b>
<b>FOR</b>	11											<b>11</b>
<b>PAN</b>									11	8	8	<b>19</b>
<b>MAN</b>	35						1		9	2	12	<b>59</b>
<b>Total</b>	<b>140</b>	<b>73</b>	<b>69</b>	<b>79</b>	<b>89</b>	<b>75</b>	<b>31</b>	<b>41</b>	<b>90</b>	<b>85</b>	<b>87</b>	<b>910</b>

According the Brazil's Third Biennial Update Report to UNFCCC (2019), related to 2015 from the Ministry of Science, Technology and Innovation. The total anthropogenic emissions in 2015 were 2,133,180 Gg CO<sub>2</sub> eq, and according the MCTIC the removals was 774,724 Gg CO<sub>2</sub>, considering the regrowth of vegetation, in areas considered managed (2019). Changing the LULUCF participation from 52% to 23%, Agriculture from 20 to 34% and Energy from 21% to 31%, industry is 7%.

Air sample was collected with portable flask sampling systems consisting of separate compressor and flask (PFP and PCP) units (Tans et al., 1996). GPS, temperature and relative humidity sensors have also been attached to the compressor unit. We used two kinds of flask units: one contains 17 (SAN) flasks and other 12 (RBA, TAB and ALF) with each 700 mL and pressurized to about 40psi. The flights consisted of one descending profile from 4500 m to 300 m. Profiles were usually taken between 12-13h local time, because this is the time when the boundary layer is close to being fully developed and stable. The profiles are made 2 times per month in the four places and in the two coast stations the sample is weekly.

The consistent trade winds that enter Amazonia from the Atlantic coast, permit us use a column integration technique to calculate fluxes for all gases (Miller et al., 2007; D'Amelio et al., 2009, Gatti et al., 2010 and 2014 and Basso et al., 2016). This technique implicitly accounts for emissions resulting from all biosphere-atmosphere exchange processes between the site and the coast, excepting some "leakage" (via convection) above 4.5 km asl. Usually at the 4 aircraft sites, during the wet season (generally December to June), it is observed uptake by the forest, because the profile mean below PBL (<1.5km) is lower than ASC and RPB mole fractions or near neutral due to mean profile being similar to the background. During the dry season, the profile mean below PBL is higher than ASC and RPB. This period correspond to biomass burning season at Amazon, where it is more intense between Augusts to October. The time series are showed in Figure 4.

The efforts to construct a Brazilian network are very important, considering actual Amazon degradation, the changes in temperature and precipitation are great and have an important impact in the Amazon Carbon Balance, that are presenting a strong impact in the left side of Amazon that are showing a consistent source of carbon to the atmosphere. Also it is an important tool to verify the inventories and compare the emissions and the supposed uptake from the forest.



**Figure 5. Vertical Profiles Time Series at RBA, ALF, SAN e TAB/TEF. Blue mean above 3.8km height and red mean below 1.5km height.**

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