CO_2 ATMOSPHERIC MEASUREMENTS AND LAND USE AND COVER CHANGE IN THE BRAZILIAN AMAZON

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1. Introduction

Global increase of CO_2 concentration in the atmosphere have reach levels never seen before (BARRIE; BRAATHEN, 2017). Among the main causes of these emissions are the burning of fossil fuels and the land use and cover change related emissions (IPCC, 2014). In the Amazon region, the main CO_2 emissions are related to deforestation (MCT, 2016). Although climate change and the extremes involved such as drought and floods have also affected the carbon balance of Amazonian forests (GATTI et al., 2014; ALDEN et al., 2016).

The lower-troposphere greenhouse gas (GHG) monitoring program “Carbam project” over Brazilian Amazon Basin, has been collecting biweekly GHGs vertical profiles in four sites of the Brazilian Amazon since 2010 (GATTI et al., 2014; BASSO et al., 2016). These novel measurements will help to understand the role of forest in the carbon balance under climate change (ALDEN et al., 2016).

Brazil has been monitoring deforestation in the Amazon (INPE, 2015) since the 80’s and land use and cover change (LUCC) for the whole country since 2000 (IBGE, 2016, 2018), this data was fundamental for the Brazilian national communications on GHGs and Reducing Emissions from Degradation and Deforestation under the United Nations Convention on Climate Change (UNFCCC). But the challenge is to link LUCC data with CO_2 local aircraft measurements.

Here we present the land use and cover change data from 2010 to 2016 in each mean influence area of Carbam[1] flight sites. Also, we try to show the relationship between local CO_2 emissions from 2010 to 2016 and the forest loss. Looking at the potentialities and limitations of this relationship, it will be possible to improve the methodology to better understand the interaction of human activities and CO_2 emissions on the carbon balance in the Amazon.

Key-words: carbon dioxide, Amazon, deforestation, greenhouse gases

[1] http://www.ccst.inpe.br/projetos/lagee/

2. Methods and materials

The CO_2 data is from the Carbam project which uses biweekly air sample profiles collected by a small aircraft descending in spiral (from 4,420 m to 300 m.a.s.l.) in four sites of the Brazilian Amazon. The sites are Santarem (SAN), Rio Branco (RBA), Alta Floresta (ALF), Tabatinga (TAB) and Tefé (TEF) (Fig. 1). Detailed methods to obtained CO_2 fluxes are described in Gatti, et. al (2014).

The influence areas are from Domingues (personal communication), these areas refer to the air trajectory and the number of flights (total of 515 profiles), the scale is in logarithm and we are considering a minimum density of trajectories of 30%. We are using the mean influence area per site (SAN, RBA, ALF, TAB and TEB) from 2010 to 2017. The influence areas of each site are bigger than the Brazilian Amazon, but as the IBGE data only is for Brazil, we are considering the Brazilian Amazon biome as the study area.

Figure 1 – Study area and Carbam flight sites

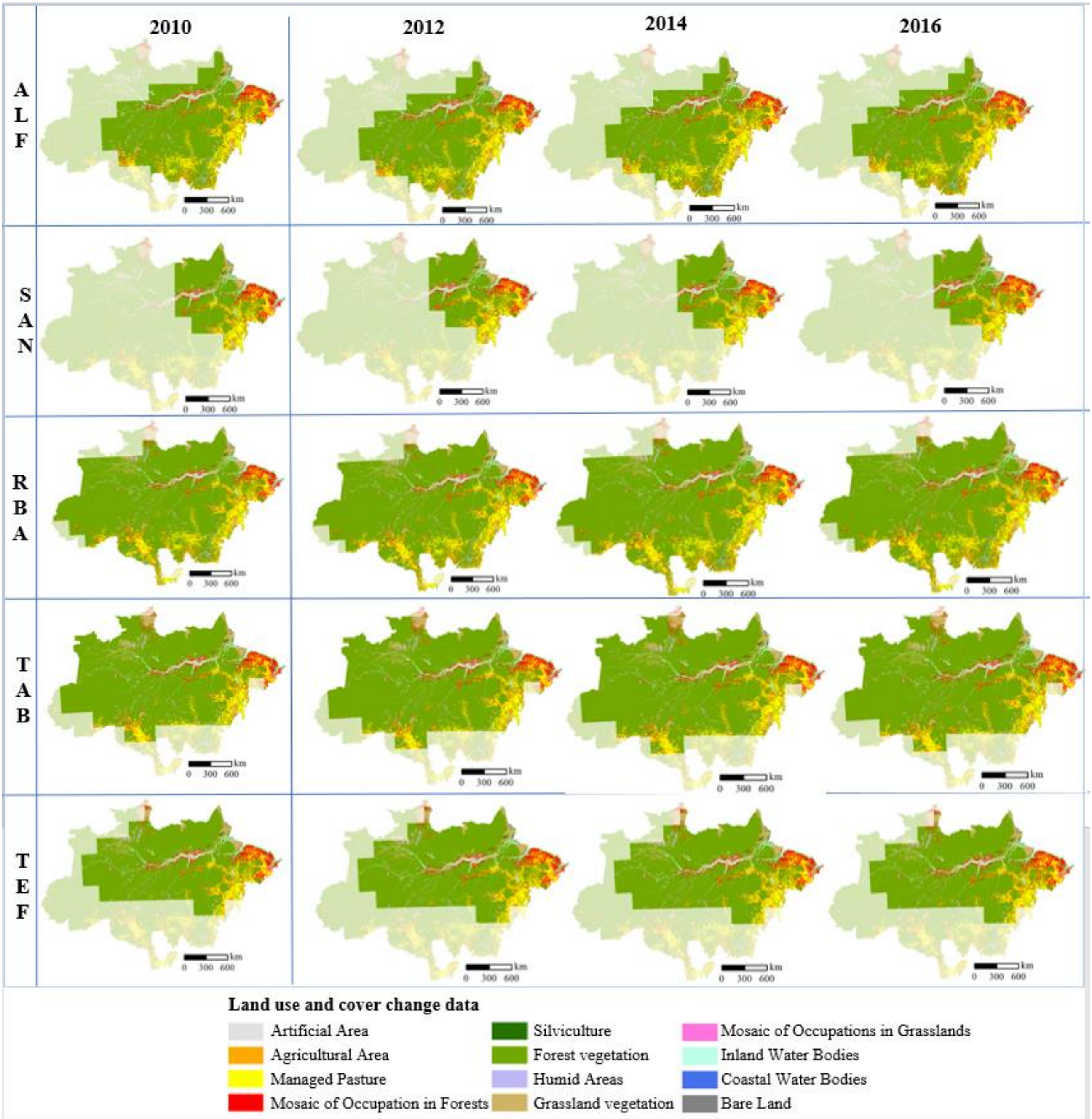
Source: The authors with data Google Earth data.

The LUCC data used, is from the Brazilian Institute of Geography and Statistics (IBGE) (IBGE, 2016, 2018). The CO_2 data is from 2010 to 2017, but the IBGE LUCC data is only for the years 2010, 2012, 2014 and 2016, so we compared the total carbon flux, fire carbon flux and net biome exchange carbon flux in these 4 years. We analyzed the mean annual CO_2 influence area (based on the back-air trajectories) to calculated the LUCC that occurred in each of the four years and correlated it with the mean annual CO_2 fluxes (detailed explanation of fluxes calculation is in Gatti et. al 2014).

3. Results and Discussion

The LCC data from the Carbam influence areas for the years 2010, 2012, 2014 and 2016 are in Figure 2. We can see that each site covers different area in the Brazilian Amazon, RBA (92%) and TAB (83%) are the most extensive areas, followed by TEF (59%) and TAB (58%), Santarem covers a smaller area (28%) in the northeast (Table 1).

Figure 2 – Land use and cover change data for each influence area: Alta Floresta (ALF), Santarem (SAN), Rio Branco (RBA), Alta Floresta (ALF), Tabatinga (TAB) and Tefé (TEF).



Source: The authors with data from (IBGE, 2018) and from Carbam Project.

The classes related to forest loss that are increasing are: managed pasture, mosaic of occupation in forests and agriculture, this can be seen in Figure 2 mostly in RBA site that covers all the deforestation arc.

Table 1 – Areas of the Land use and cover change data for each influence area: Alta Floresta (ALF), Santarem (SAN), Rio Branco (RBA), Alta Floresta (ALF), Tabatinga (TAB) and Tefé (TEF).

Carbam Flight sites	Total area (km2)	% of each site area respect to the Brazilian Amazon (km2)	Forest loss (km2) 2010-2016	% of forest loss respect to each site area
Alta Floresta (ALF)	2441614	58	52587	2.2
Rio Branco (RBA)	3883986	92	64905	1.7
Santarém (SAN)	1158577	28	25716	2.2
Tabatinga (TAB)	3489110	83	49212	1.4
Tefé (TEF)	2485095	59	35330	1.4
Brazilian Amazon Biome	4199070			

Source: The authors with data from (IBGE, 2018) and from Carbam Project.

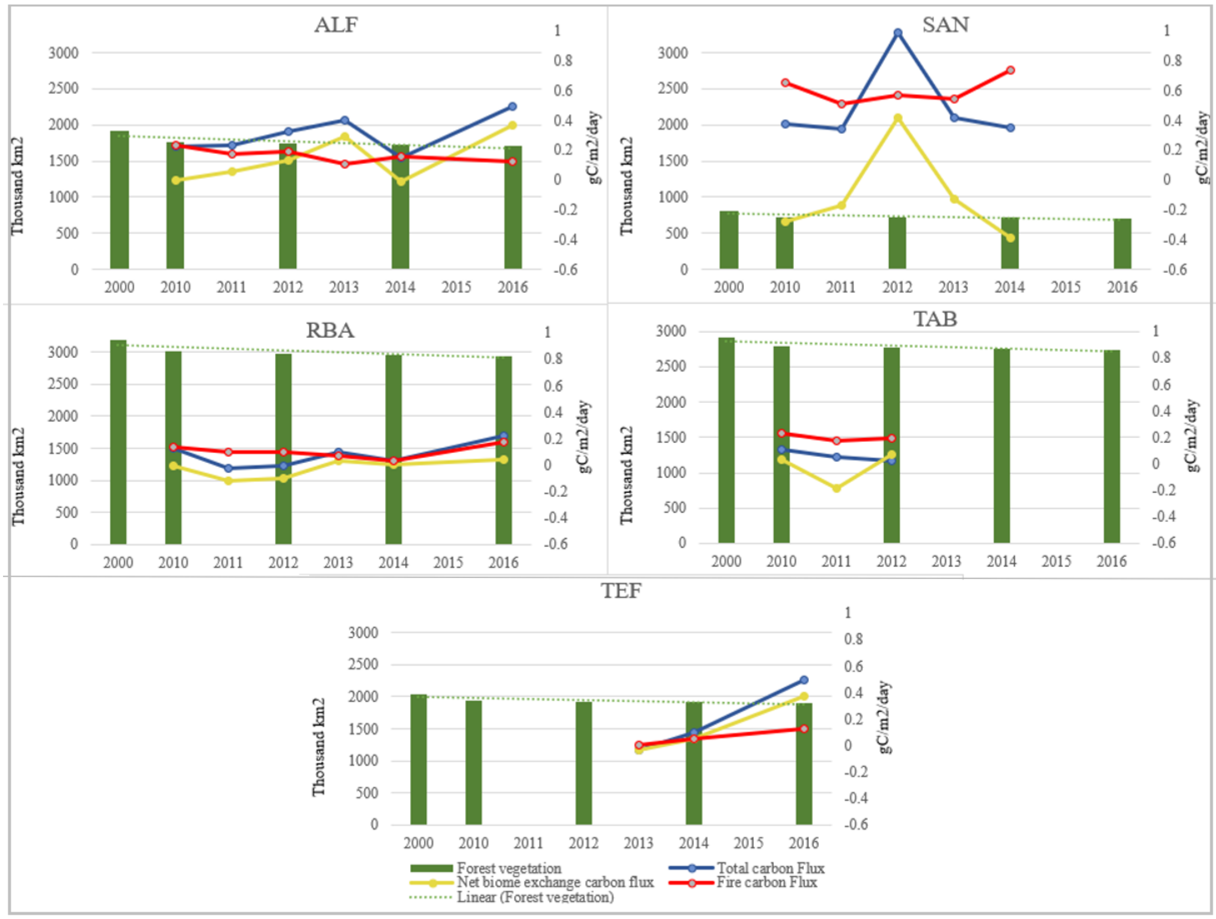
The loss of forest area of each site is in Figure 3 and Table 1. The sites with more total forest loss from 2010 to 2016 are RBA with 64,905 km^2, ALF with 52,587 km^2 and TAB with 49,212 km^2 due to they cover great part of the deforestation arc. TEF loss 35,330 km^2 and SAN 25,716 km^2 of forest, with a small area not covering the south and west of the deforestation arc. But if we look at the forest loss respect to each influence area, SAN and ALF loss 2.2 % while RBA 1.7 % and TAB and TEF 1.4% respectively.

Looking at the carbon fluxes and LUCC in Figure 3 we can see that the fire carbon flux of ALF has the same tendency as the forest loss, also in RBA without considering 2016. In this year an anomalous drought happened in Amazon region, so this increase in RBA fire flux can be related with an increase in biomass burning. In the rest of the sites, there is no a direct relationship between the carbon fluxes and the forest loss, the reason could be that the temporal scale is different, influence areas of these three sites (TAB, TEF and SAN) show more influence of North Hemisphere regions, the carbon fluxes are measure biweekly (we are using the mean annual flux), and the LUCC IBGE data is biannual. Another important factor is that the CO_2 fluxes have different influence annual years, but to compare the same areas we used the mean of 2010 to 2017, for further studies we can make the analyses yearly. The CO_2 influence areas also extrapolated the Brazilian Amazon to the rest of the Amazon Basin countries, using a global data of deforestation (e.g. HANSEN et al., 2013) could help to see the influence of the rest of the forest cover change in Carbam CO_2 fluxes.

The carbon fluxes are not only related to deforestation, climate variables as temperature and precipitation have strong influence in the carbon fluxes in the Amazon (GATTI et al., 2014).

Fluxes interannual variability could be partially related with the several droughts in Amazon (e.g. 2010, 2015 and 2016) or with wet years (e.g. 2011), that influence the photosynthesis/respiration rate and will not be captured by the land use and cover change data. Also, other variables related to land use and cover change as fire emissions mainly during the several drought years (ARAGÃO et al., 2018). This is a first attempt to see the relationship between LUCC data and local flight CO_2 measurements with different temporal and spatial scales. This study gave us relevant elements as to considered other LUCC data bases with different temporal and spatial scale, the annual influence areas of each site and other variables related to LUCC.

Figure 3 – Forest loss, total carbon flux, fire carbon flux and Net biome exchange carbon flux.



Source: The authors with data from (IBGE, 2018) and from Carbam Project.

4. Conclusions

The land use and cover change data of the carbon fluxes influence areas of the 4 flight Carbam sites in the Brazilian Amazon were calculated for 2010, 2012, 2014 and 2016. Showing that the influence areas with more total forest loss are those in the deforestation arc (ALF, RBA and TAB). But when looking at the percentage of forest loss in each area SAN has loss more forests. The LUCC classes which increases with forest loss are managed pasture, mosaic of occupation in forests and agriculture.

Carbon fluxes are influenced not only by LUCC, so the relationship between forest loss and fire carbon flux was direct only for ALF in all the analyzed years and RBA excepting 2016. As there were anomalous drought and wet years between 2010 and 2016 the rest of relationships were not direct. Using other spatial and temporal data bases and considering other variables related to LUCC on further studies will help to better understand the CO_2 local measurements related to anthropogenic activities.

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