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Identification of natural and anthropogenic pollutants in the transboundary area of Saint-Georges de l'Oyapock for a modeling and monitoring of these pollutants by GIS in the future



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Abstract

Like other communes in French Guiana, the commune of Saint-Georges de l'Oyapock is subjected each year to natural pollutants (e.g. Saharan dust, Prospero et al. 1981) and to anthropogenic pollutants (e.g. benzene). Given that the measuring stations of PM10, PM2.5, nitrogen oxide and benzene belonging to ATMO GUYANE currently exist only on Cayenne, Matoury and Kourou, a preliminary study had to be carried out here for desert aerosols at first, then for benzene. In the case of desert aerosols, a first work on the search for correlation between ground data collected by Thermo Scientific Tapered Element Oscillating Microbalance (TEOM) and optical thickness data (AOT) from satellite VIIRS images was carried out. In the case of benzene, the very first measurement campaign was carried out at the end of June 2021 just before the closing of schools. For the OHM Oyapock, establishing a recurrent benzene measurement campaign over the medium term would be a tool to evaluate internal mobilities in Saint-Georges and Oiapoque as well as cross-border mobilities inherent to the opening of the bridge. The results will be presented here but it will be necessary to repeat this campaign in full school period. The goal in the short or medium term is to evaluate the impacts on health. For this, according to WHO recommendations for population health, we have chosen a threshold of $50 \mu\text{g m}^{-3}$. In fact, values greater than $50 \mu\text{g m}^{-3}$ are harmful to populations.

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Method and Results for aerosol desert dust

Figures 5 and 6 are VIIRS images for two different dates. Below these figures we have in the legend the range of PM10 detected by the TEOM of ATMO GUYANE for the same dates on Cayenne. As we do not have TEOM at Saint-Georges de l'Oyapock for these dates it is necessary to look for correlation between TEOM measurements and AOT of these VIIRS images.

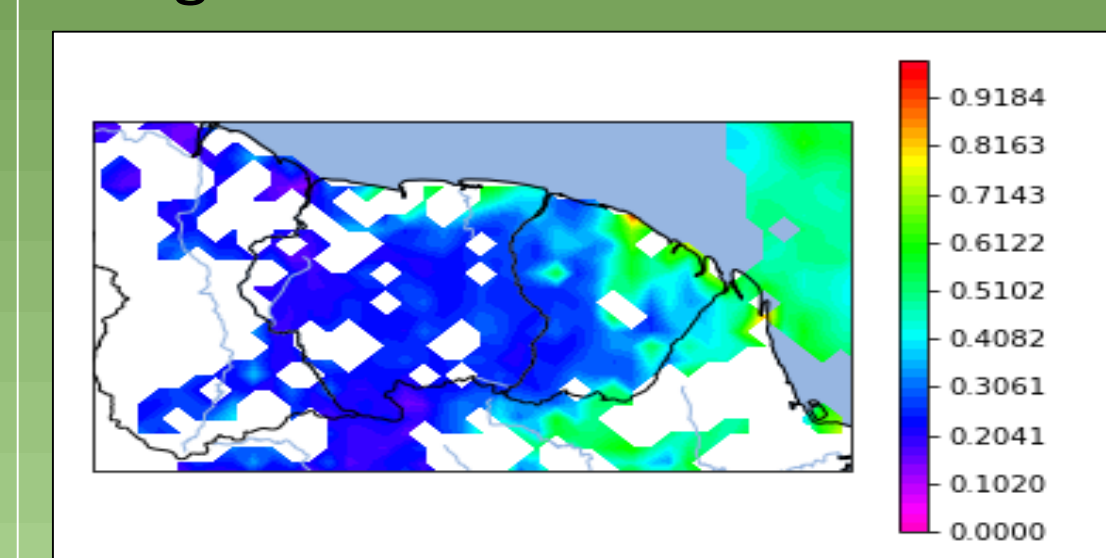


Figure 5 : VIIRS image in March 27, 2018, Atmo Guyane's TEOM measures on ground these values : $100 \mu\text{g m}^{-3} < \text{PM}_{10} < 150 \mu\text{g m}^{-3}$

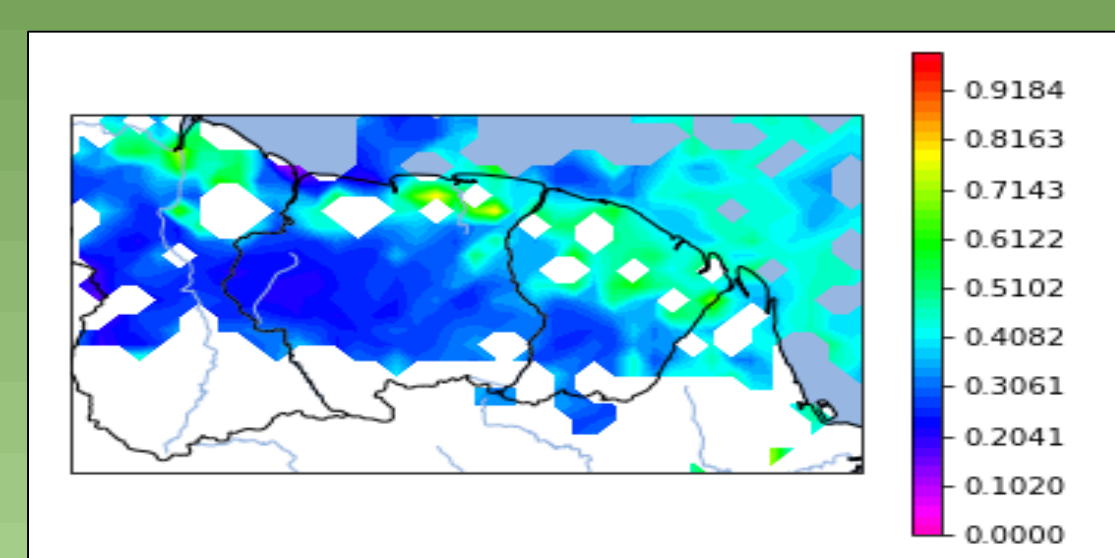


Figure 6 : VIIRS image in April 11, 2018, Atmo Guyane's TEOM's measures on ground these values : $50 \mu\text{g m}^{-3} < \text{PM}_{10} < 100 \mu\text{g m}^{-3}$

A software is being developed within the PROGYSAT project to compare the ground data with all available VIIRS images.

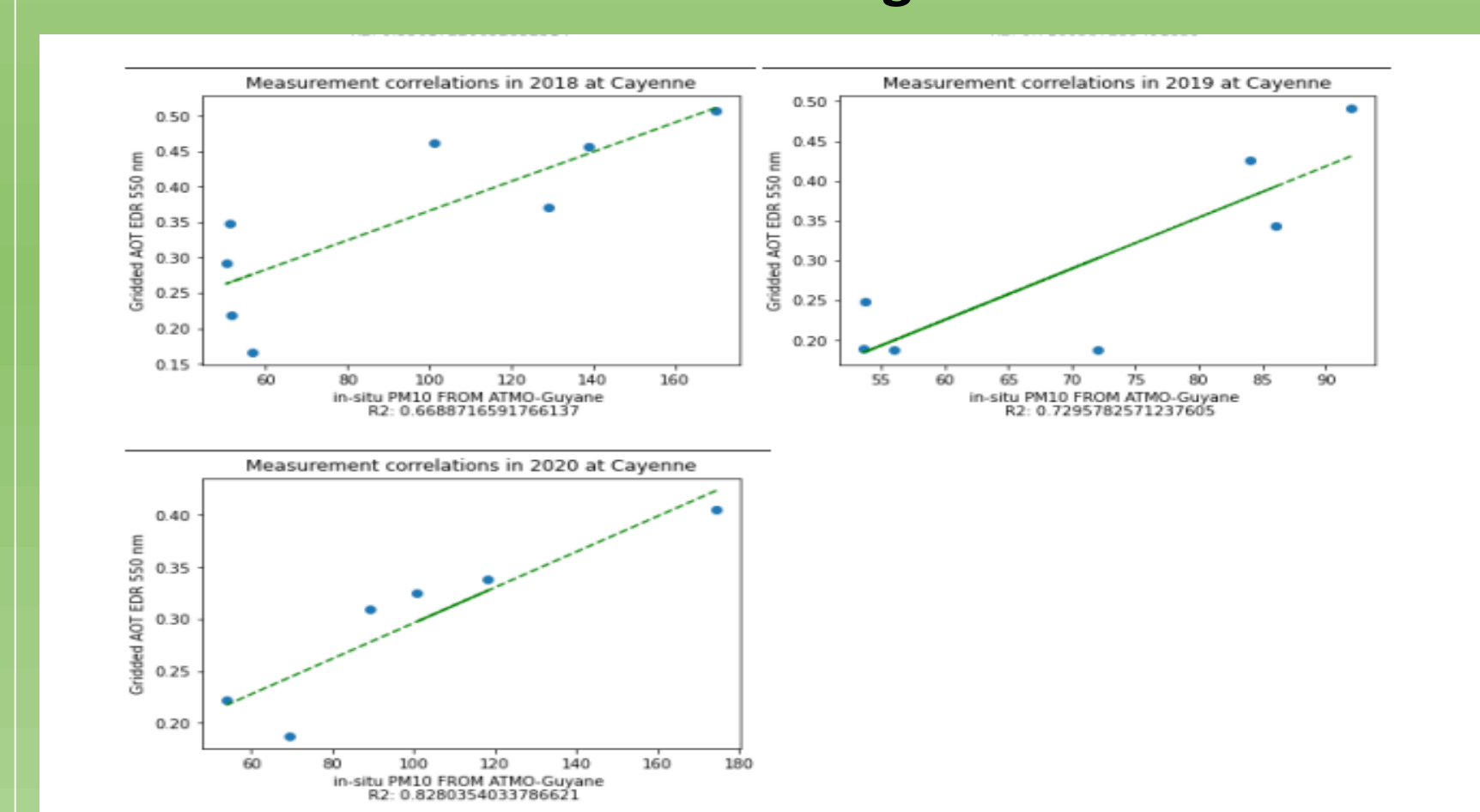


Figure 7 : Correlation between TEOM measures and VIIR AOT values for Cayenne city

For Cayenne city we have observed a correlation around 0.7 for the intense dust events but not for the weak ones.

These results can allow the implementation of an air pollution warning in the future for other cities of French Guiana in absence of ground measurements in other cities.

Data Set

Two pollutants have been studied here in Saint-Georges de l'Oyapock, a natural pollutant and an anthropogenic pollutant :

- **The natural pollutant** : Desert dust (Gobinddass et al. 2020) Characterized by Atmo Guyane during measurements of PM10, PM2.5 and by satellite images from Visible-Infrared Imager/Radiometer Suite sensor (VIIRS) with optical Thickness extraction (Gridded AOT EDR 550 nm).

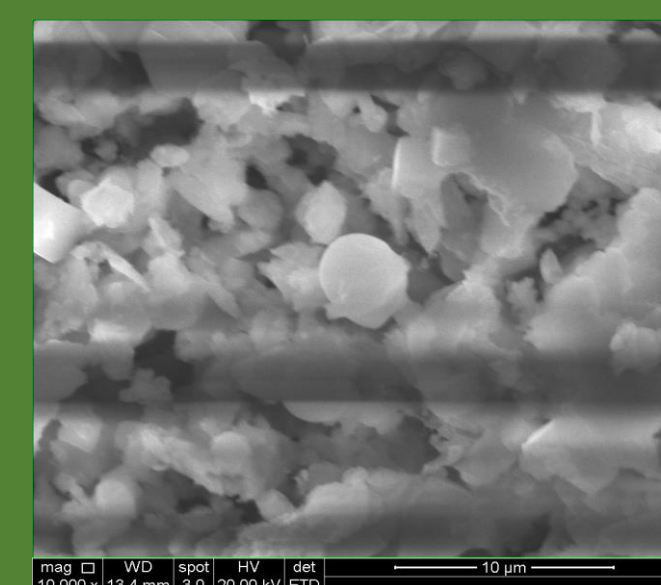


Figure 1 : Aerosol desert dust Al Si by scanning electron microscope

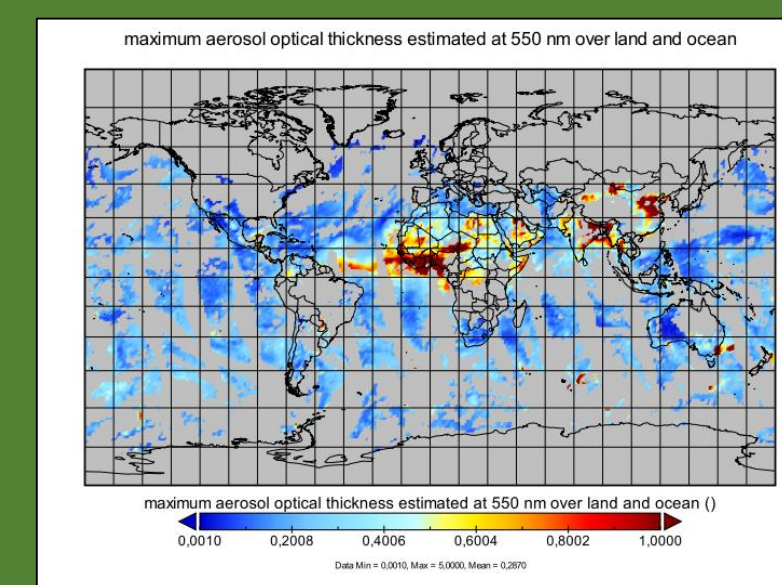


Figure 2 : Example of VIIRS image

- **The anthropogenic pollutant** : benzene

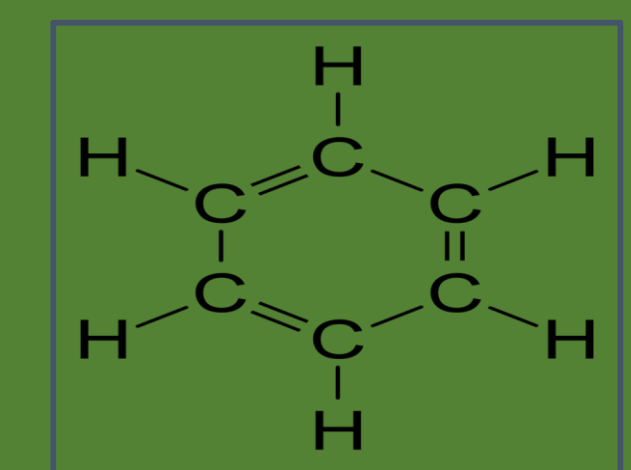


Figure 3 : Structural formula of the benzene molecule



Figure 4 : Example of a passive tube device installed to measure benzene. Source : Atmo Grand Est

Method and Results for benzene

We decided to establish 4-week sampling at three sites and 2-week sampling at two other sites. The passive tubes collected on the five sites were studied by the Laboratoire d'Analyse Micropolluants Technologie and by the GC-MS method.

Passives tubes site					Concentration
First week : from June 23 to June 30 2021					
1 - Ecole :	15h09	15h16	BW598		0.77 $\mu\text{g m}^{-3}$
2 - Piste cyclable :	15h26	17h27	BW600		0.42 $\mu\text{g m}^{-3}$
3 - Pont :	16h55	16h11	BW596		0.26 $\mu\text{g m}^{-3}$
Second week : from June 30 to July 7 2021					
1 - Ecole :	15h16	17h22	BW595		0.41 $\mu\text{g m}^{-3}$
2 - Piste cyclable :	15h40	15h26	BW597		0.42 $\mu\text{g m}^{-3}$
3 - Pont :	16h11	17h40	BW599		0.21 $\mu\text{g m}^{-3}$
4 - Debarcadere	15h03	/	CB438	tube lost	
5 - Nouveau lycée	16h01	17h30	CB436		0.27 $\mu\text{g m}^{-3}$

Table 1 : First and second week benzene sampling

Passives tube site					Concentration
Third week : From July 7 to July 14					
1 - Ecole :	17h22	17h19	CB443		0.54 $\mu\text{g m}^{-3}$
2 - Piste cyclable :	17h27	17h23	CB444		0.58 $\mu\text{g m}^{-3}$
3 - Pont :	17h40	17h36	CB437		0.22 $\mu\text{g m}^{-3}$
4 - Debarcadere	/	/	??		
5 - Nouveau lycée	17h30	17h29	CB440		0.25 $\mu\text{g m}^{-3}$
Fourth week : du 14 au 21 juillet 2021					
1 - Ecole :	17h19	17h19	CB439		0.45 $\mu\text{g m}^{-3}$
2 - Piste cyclable :	17h23	17h23	CB441		0.52 $\mu\text{g m}^{-3}$
3 - Pont :	17h36	17h36	CB433		0.24 $\mu\text{g m}^{-3}$
4 - Debarcadere					
5 - Nouveau lycée					

Table 2 : Third and fourth week benzene sampling

With its 4000 inhabitants, Saint-Georges de l'Oyapock during the COVID period had benzene values higher than $0.57 \mu\text{g m}^{-3}$ at some sites. Even if this value remains lower than the limited value of $2 \mu\text{g m}^{-3}$ fixed in local this value approaches all the same $0.7 \mu\text{g m}^{-3}$ for cities like Cayenne which have more than 57 000 inhabitants. Further studies must be carried out in Saint-Georges de l'Oyapock.

The value of benzene decreased by almost half for the school site when we entered the school vacation period. The value of benzene measured at the level of the bridge is a natural background noise because for COVID this one was closed. It will be necessary to redo these measurements between October and December.

Conclusions

Remote sensing is a particularly interesting tool for French Guiana which is a vast, sparsely populated area. Indeed, set up pollutant measurement stations on the entire territory, mainly covered with equatorial forest, is not a viable solution. Satellite images from the VIIRS sensor provide valuable air quality information on a daily basis. However, before to be used in a model which makes it possible to estimate the daily concentration of aerosols desert, it is necessary to validate the satellite products. This means that the satellite data must be well correlated with the ground data. We have found here a correlation of 0.7 between PM10 in-situ data and AOT satellite data for Cayenne city. We need to investigate whether there are correlations between the results of the sensors that will be installed in Saint-Georges in the PROGYSAT project and the satellite images. For the OHM Oyapock, establishing a recurrent benzene measurement campaign over the medium term would be a tool to evaluate internal mobilities in Saint-Georges and Oiapoque as well as cross-border mobilities inherent to the opening of the bridge. The value of benzene measured at the level of the bridge is a natural background noise because for COVID this one was closed. It will be necessary to redo these measurements between October 2022 and December 2022.

Bibliographie

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