Data Assimilation Schemes in Colombian Geodynamics - Cooperative Research Plan for 2017 - 2020 Between Universidad EAFIT and TUDelft, With the Help of Universidad de Antioquia and universidad Nacional de Colombia Sede Medellin

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Procedure Report- Implementation of LOTOS-EUROS between the days April 2015- March 1 2016 RP-05

Medellin Air qUality Initiative MAUI

MAUI-RP-05

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ABSTRACT

In the present work is presented the analysis of the LOTOS-EUROS model over Tropical Andes domain, between Abril 1-2015 and March 1-2016. The volume mixing ratio of PM2.5 and PM10 was selected for the analysis. This variables are part of the most important pollutants in the atmosphere. The selected model outputs are showed foe the complete domain but the analysis is make only in the closest point to the Aburrá Valley.

INTRODUCTION

Air pollution is defined as the presence of solid, liquid or gaseous components in the atmosphere. Above all, in the troposphere (lower atmosphere layer in contact with the land) the pollutants are a risk and trouble for living beings or goods in general. In fact, air pollution is the major environmental problem in modern human history (Green & Sánchez, 2012). Nowadays environmental pollution can be produced by natural or human actions; as evidence of natural sources are mainly forest fires, volcanic emissions, dust, sand, vegetation and wildlife; and main human sources of air pollution for instance are industry, power generation, transportation, deforestation and cattle raising (Borrego et al., 2015).

The city of Medellin is located in the center of Aburra Valley, and has been one of the most polluted cities in Latin America, where its geographic qualities, the plenty industry and the growing car fleet provide the poor air quality (Green & Sánchez, 2012). A proof of this is given around March of 2016 when the environmental pollution ratings were the highest registered in the city and several factors that influenced these ratings were the ENSO (commonly called 'El Nino'), little rains, weak winds and increased temperatures, generating accumulation of pollutants from fuel combustion, Sahara sand and smoke from forest fires in Colombia and Venezuela, that joined with kept off the scattering of pollutants and raised up the concentration levels of pollutants like PM2.5 and PM10 (Alsema, 2016). Therefore the measures registered were PM2.5 higher than 160 µg/m3 24-hour, when the guideline of WHO is 25 µg/m3 24-hour mean (Gustavo, 2016).

Due to the magnitude of the problem that air pollution has become, vague efforts have been made to monitor, reduce and prevent the spread of pollutants in the air. As a first containment action is greatly important to know the pollution concentrations and the air quality in an area and the time given. For this, nowadays, an advanced system of measure and mathematical models exist, which represent the air pollution dynamics. These mathematical models known as Air Quality Models (AQM), allow a permanent monitoring and in many cases predictions of the air quality behavior.

In view of the problem that air pollution represents to the city of Medellin, is necessary looking for mechanisms that allow contain and reduce levels of pollutants in the environment. The first step to decrease these pollutants is to know their behavior and the air state of the city. Having measures of the main air pollutants and knowing their behaviors in the Aburra Valley atmosphere could be proposed actions that help to improve air quality levels and reduce impacts of pollution on the population. Without these factors in advance is impossible to think of responses or preventives actions. One of the most used and studied Air Quality Models at present is the

LOTOS-EUROS (Mues et al., 2014). The LOTOS-EUROS (LOng Term Ozone Simulation- EURopean Operational Smog model) is a chemical transport model that models in three dimensions the air pollution in the lower troposphere. This model was developed in 2004 by TNO and RIVM/MNP organizations, in Netherlands, unifying the previous developed LOTOS and EUROS models. At the beginning it was developed like a model focused on ozone, but actually, the LOTOS-EUROS (versión 1.8) allows calculate concentrations of ozone, particulate matter, nitrogen dioxide, heavy metals and organic pollutants with a standard model resolution of approximately 36x28 km. (Sauter et al., 2012).

LOTOS-EUROS OUTPUTS ANALYSIS

The LOTOS-EUROS model has the next outputs:

1. Volume mixing ratio of O_3 in humid air
2. Volume mixing ratio of NO_2 in humid air
3. Volume mixing ratio of NH_3 in humid air
4. Volume mixing ratio of SO_2 in humid air
5. Volume mixing ratio of HNO_3 in humid air
6. Volume mixing ratio of CO in humid air
7. Volume mixing ratio of N_2O_5 in humid air
8. Volume mixing ratio of CH_2O in humid air
9. Volume mixing ratio of isoprene in humid air
10. Volume mixing ratio of PAN in humid air
11. Mass concentration of NO_3 in humid air
12. Mass concentration of SO_4 in humid air
13. Mass concentration of ammonium dry aerosol in humid air
14. Mass concentration of TPM25 in humid air
15. Mass concentration of TPM10 in humid air
16. Tendency of atmosphere mass content of ozone due to dry deposition
17. Tendency of atmosphere mass content of sulfur dioxide due to dry deposition
18. Tendency of atmosphere mass content of sulfate dry aerosol due to dry deposition
19. Tendency of atmosphere mass content of nitrogen monoxide due to dry deposition
20. Tendency of atmosphere mass content of nitrogen dioxide due to dry deposition
21. Tendency of atmosphere mass content of nitric acid due to dry deposition
22. Tendency of atmosphere mass content of nitrate dry aerosol due to dry deposition
23. Tendency of atmosphere mass content of ammonia due to dry deposition
24. Tendency of atmosphere mass content of ammonium dry aerosol due to dry deposition
25. Tendency of atmosphere mass content of carbon monoxide due to dry deposition
26. Tendency of atmosphere mass content of formaldehyde due to dry deposition
27. Tendency of atmosphere mass content of sulfur dioxide due to wet deposition
28. Tendency of atmosphere mass content of sulfate dry aerosol due to wet deposition
29. Tendency of atmosphere mass content of nitric acid due to wet deposition
30. Tendency of atmosphere mass content of nitrogen monoxide due to wet deposition
31. Tendency of atmosphere mass content of nitrogen dioxide due to wet deposition
32. Tendency OF atmosphere mass content of nitrate dry aerosol due to wet deposition
33. Tendency of atmosphere mass content of ammonia due to wet deposition
34. Precipitation

The output concentration for each pollutant is calculated through five vertical layer. The height of this vertical layer depend of the mixing layer. In the Figure 1 is shown an example of the layers height.

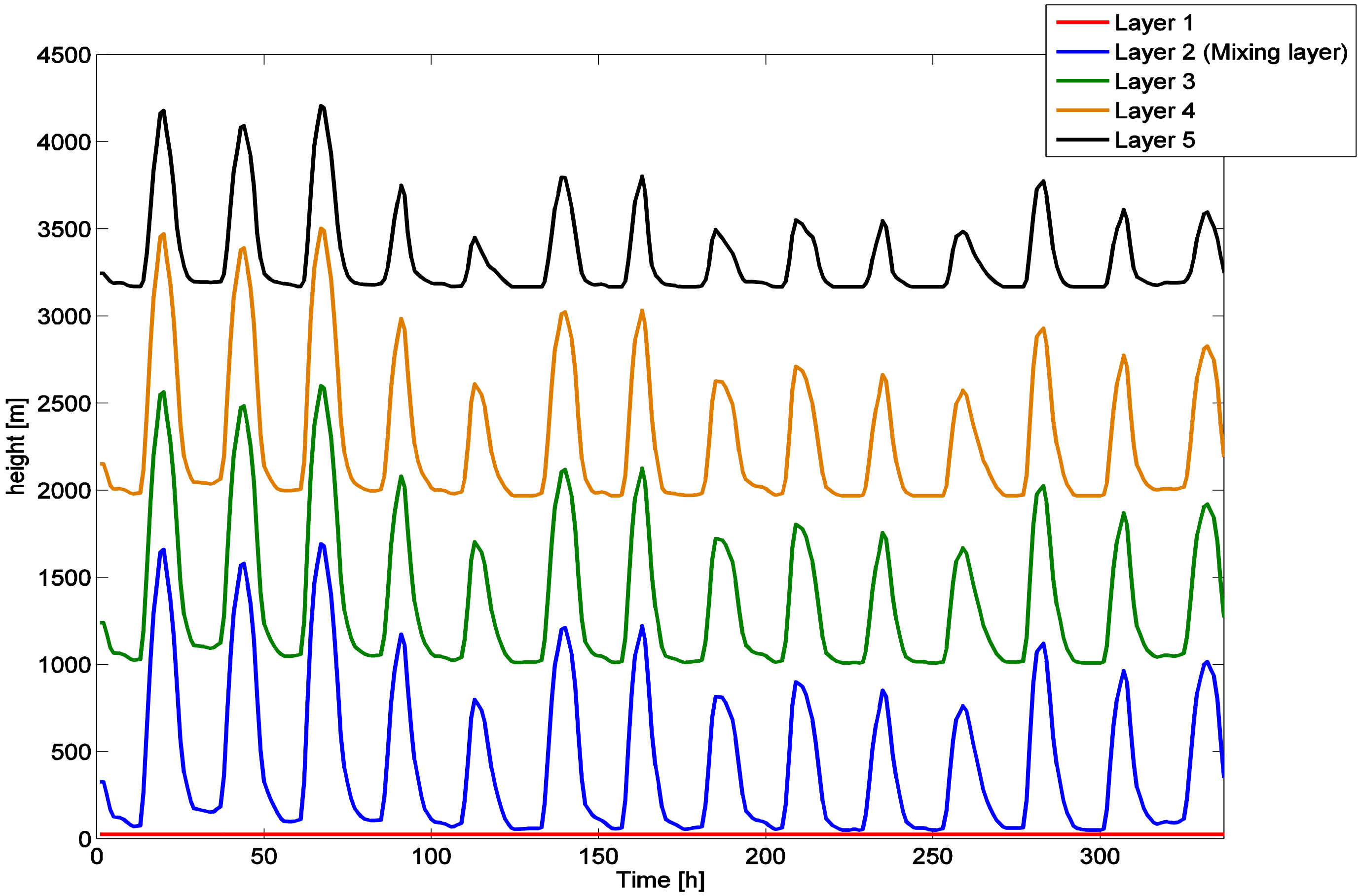

Figure 1. Vertical layers of LOTOS-EUROS.

Below are shown the result of the LOTOS-EUROS implementation over the Tropical Andes Domain. The Tropical Andes domain is between 80 to -65 west degrees, and 25 to-10 north degrees. The model was implemented in a standard resolution of 0.25°x 0.25° in the region between. The simulation experiment was set between the days April 1-2015 and March 1-2016.

Below is presented the three selected points for the analysis. This points are the closest to the Aburra Valley.

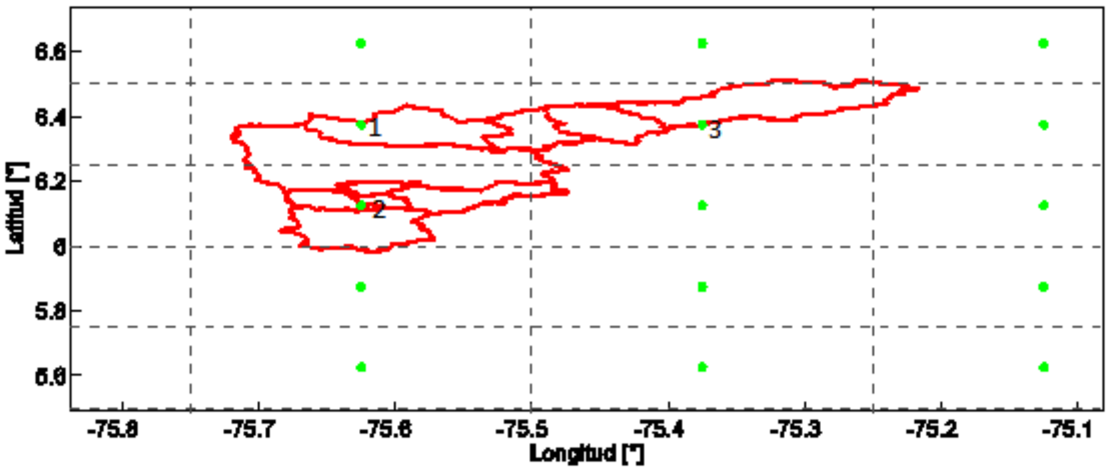

Figure 2. Current resolution and selected points for LOTOS-EUROS over Aburrá Valley.

SPECTRAL ANALYSIS

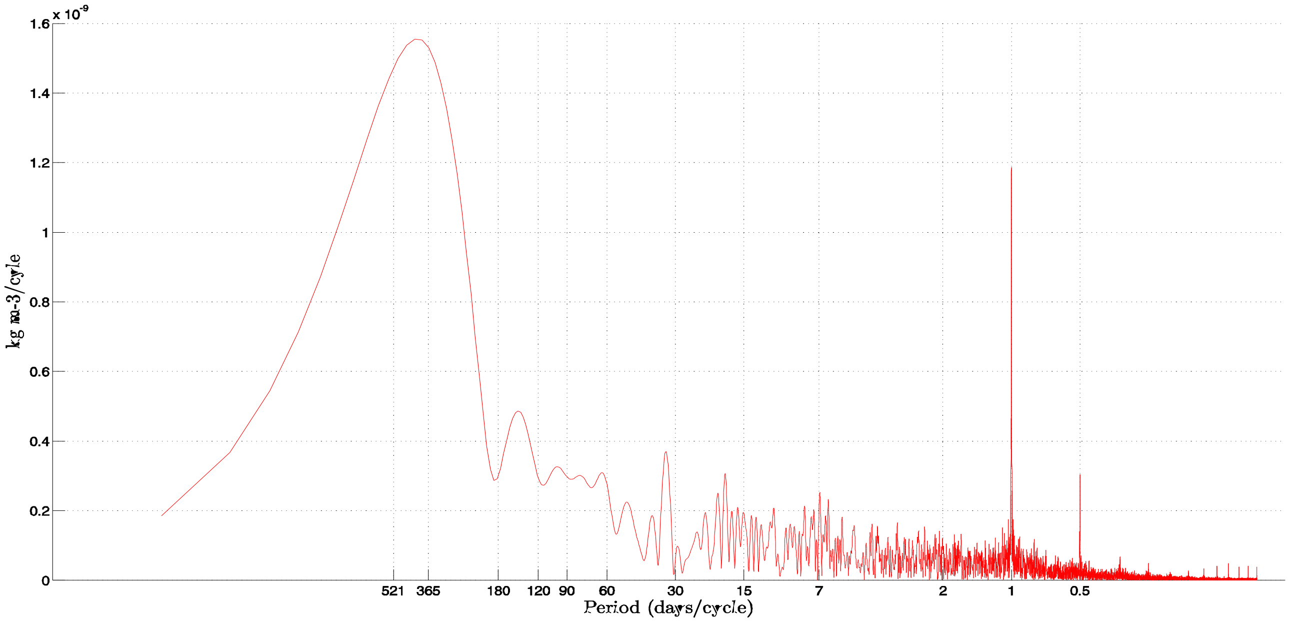

Figure 3. Frequency spectrum of PM2.5 by LOTOS-EUROS for Point1.

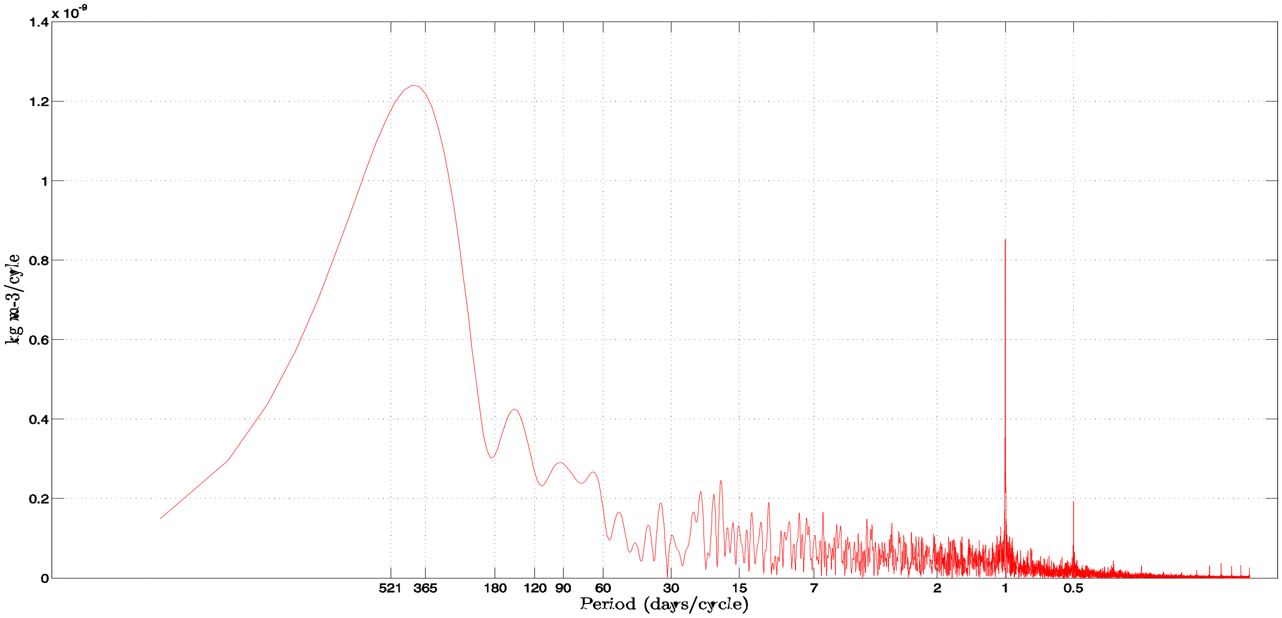

Figure 4. Frequency spectrum of PM2.5 by LOTOS-EUROS for Point2.

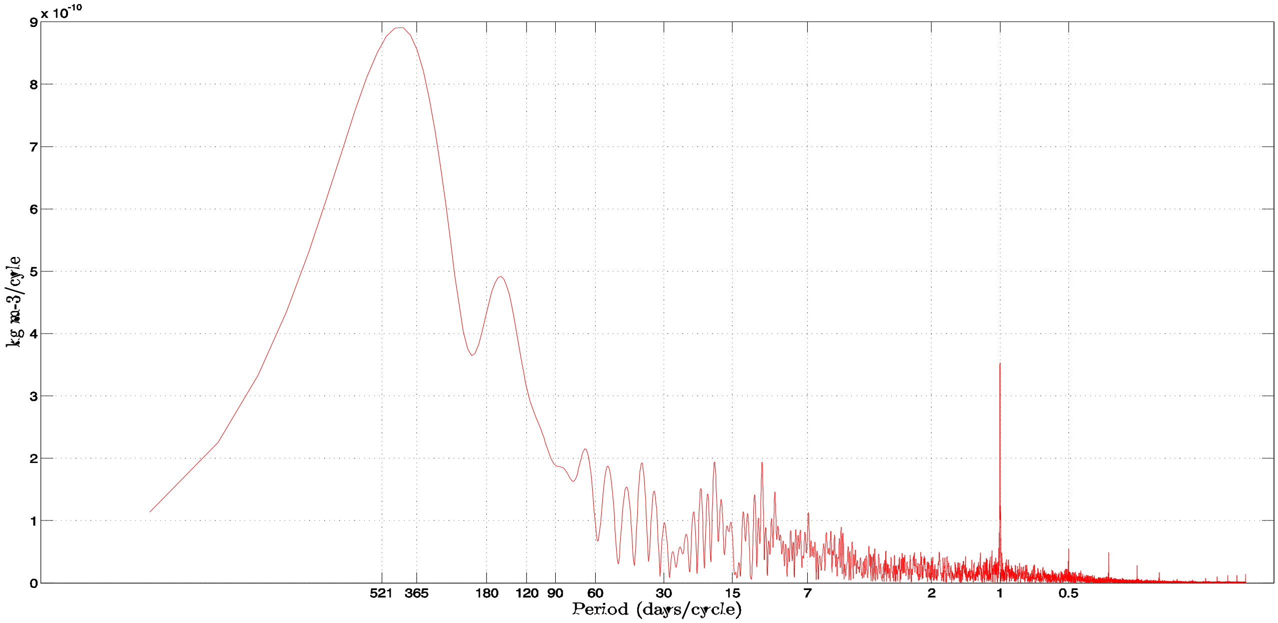

Figure 5. Frequency spectrum of PM2.5 by LOTOS-EUROS for Point3.

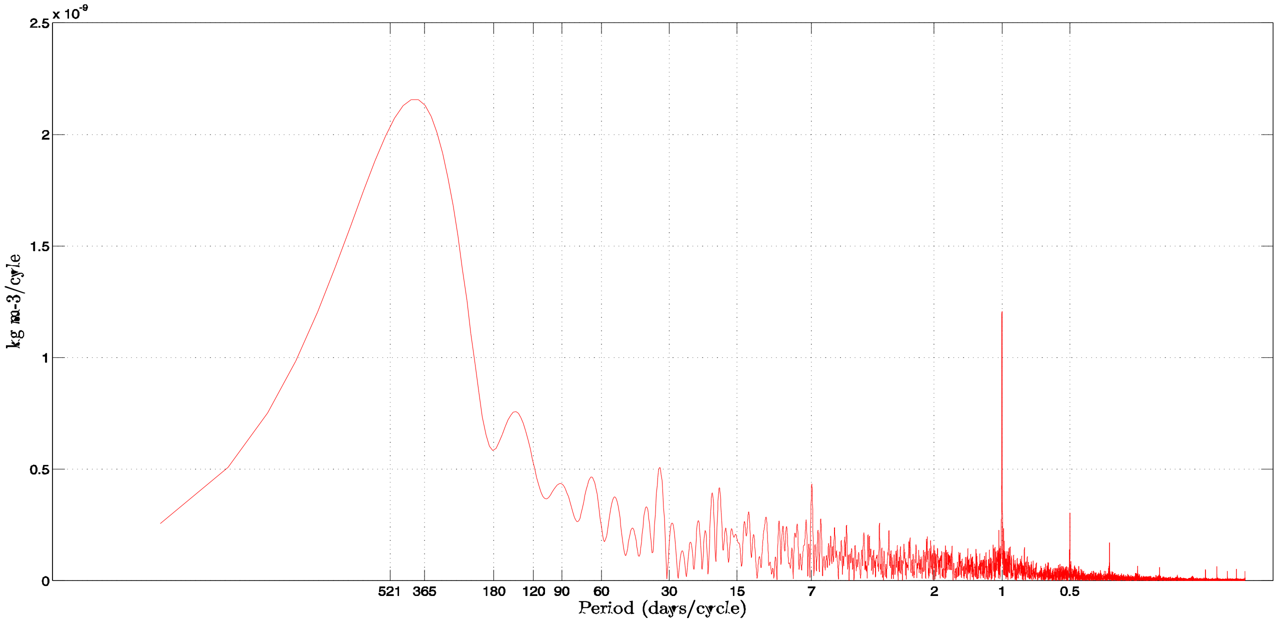

Figure 6. Frequency spectrum of PM10 by LOTOS-EUROS for Point1.

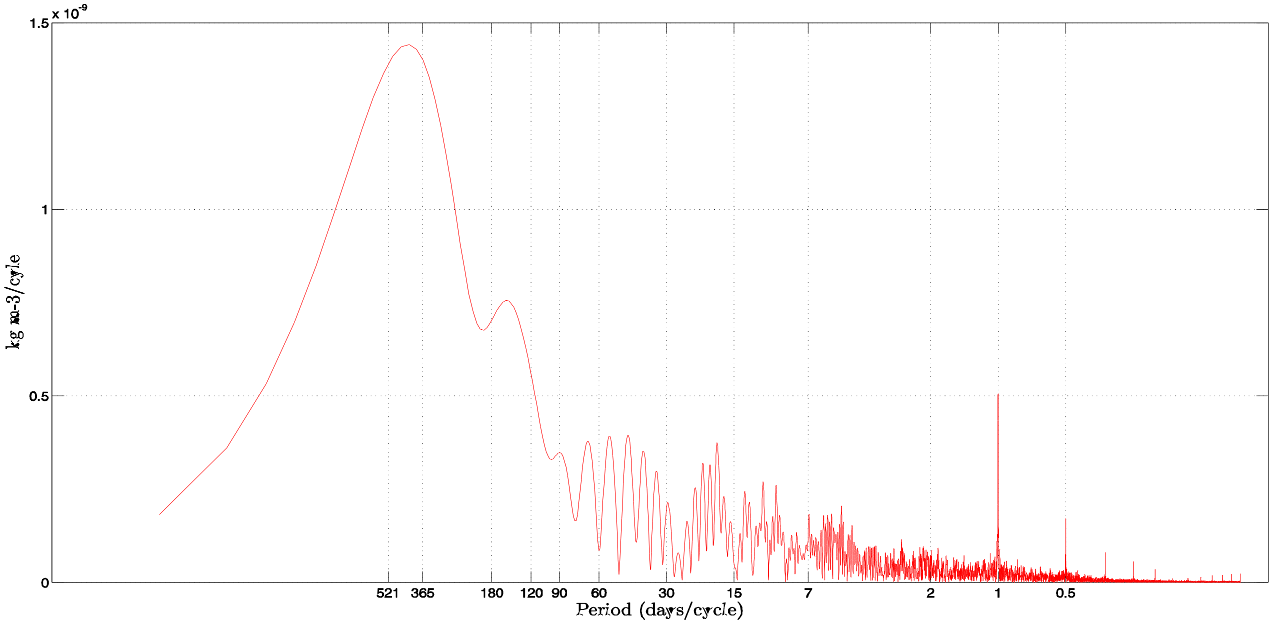

Figure 7. Frequency spectrum of PM10 by LOTOS-EUROS for Point2.

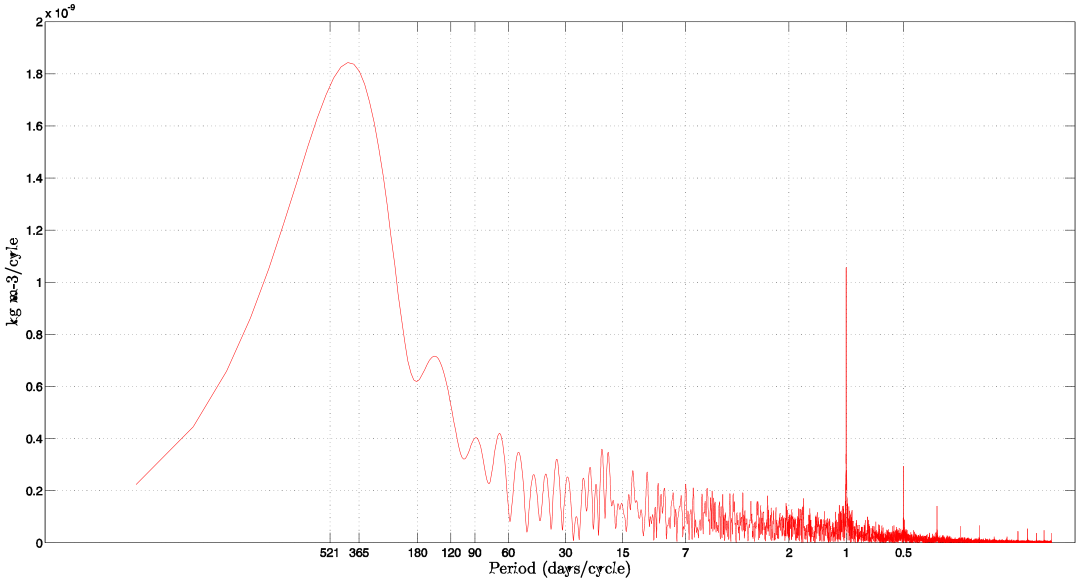

Figure 8. . Frequency spectrum of PM10 by LOTOS-EUROS for Point3.

DAILY CYCLE

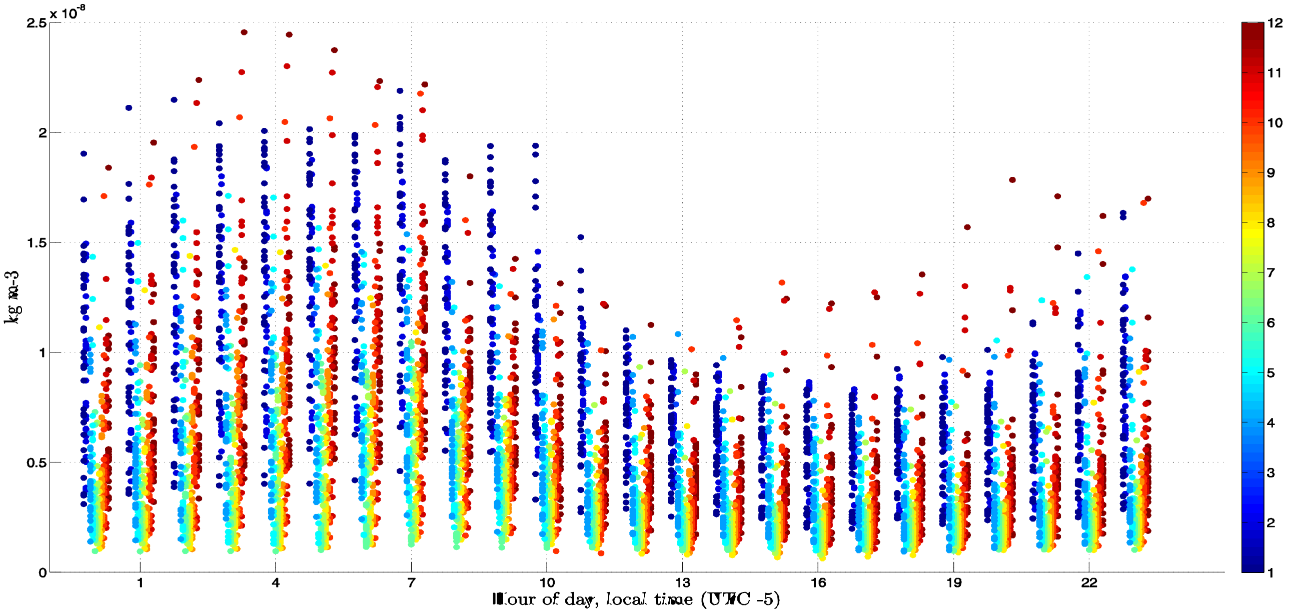

Figure 9. Daily cycle for PM2.5 by LOTOS-EUROS for Point1.

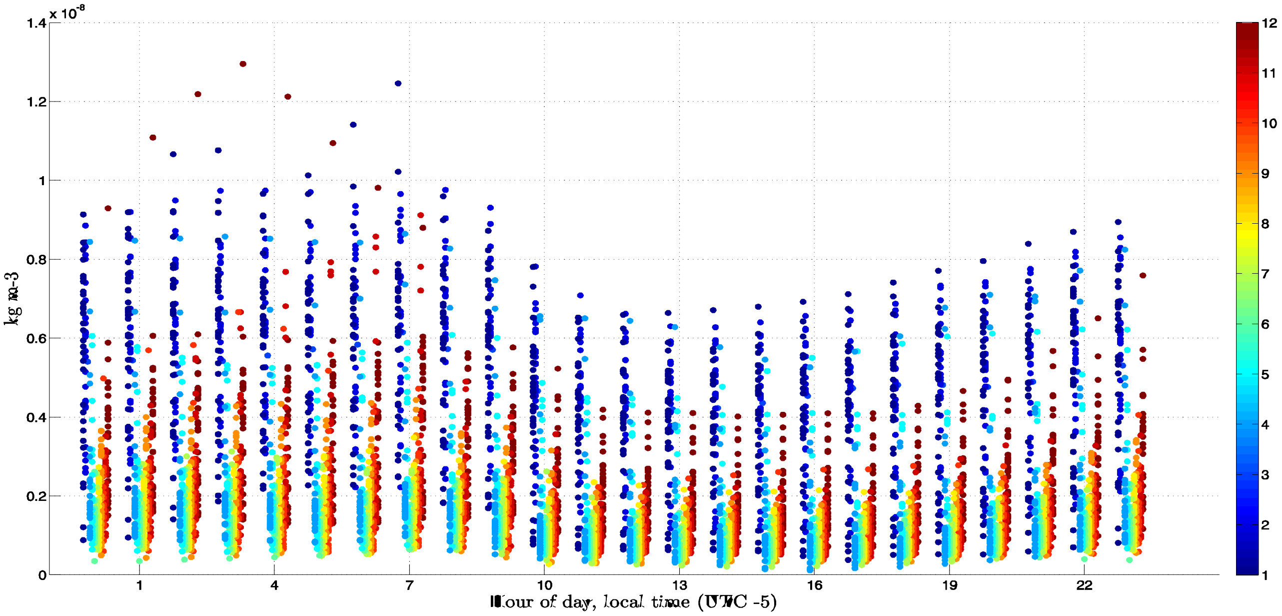

Figure 10. Daily cycle for PM2.5 by LOTOS-EUROS for Point2.

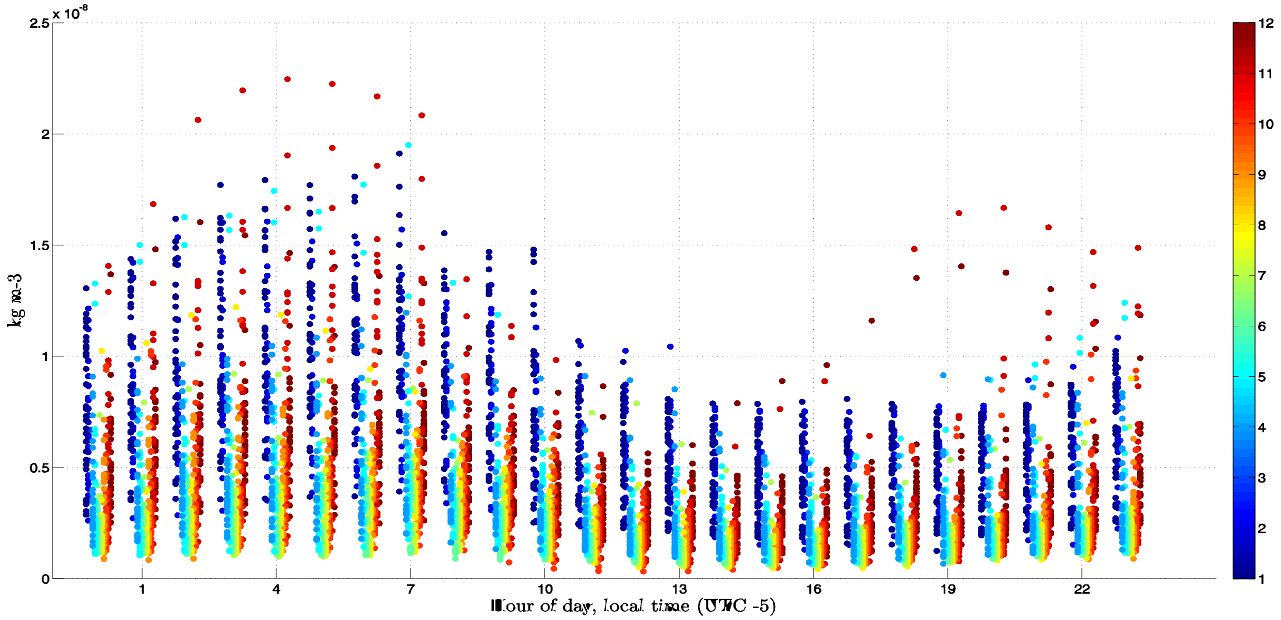

Figure 11. Daily cycle for PM2.5 by LOTOS-EUROS for Point3.

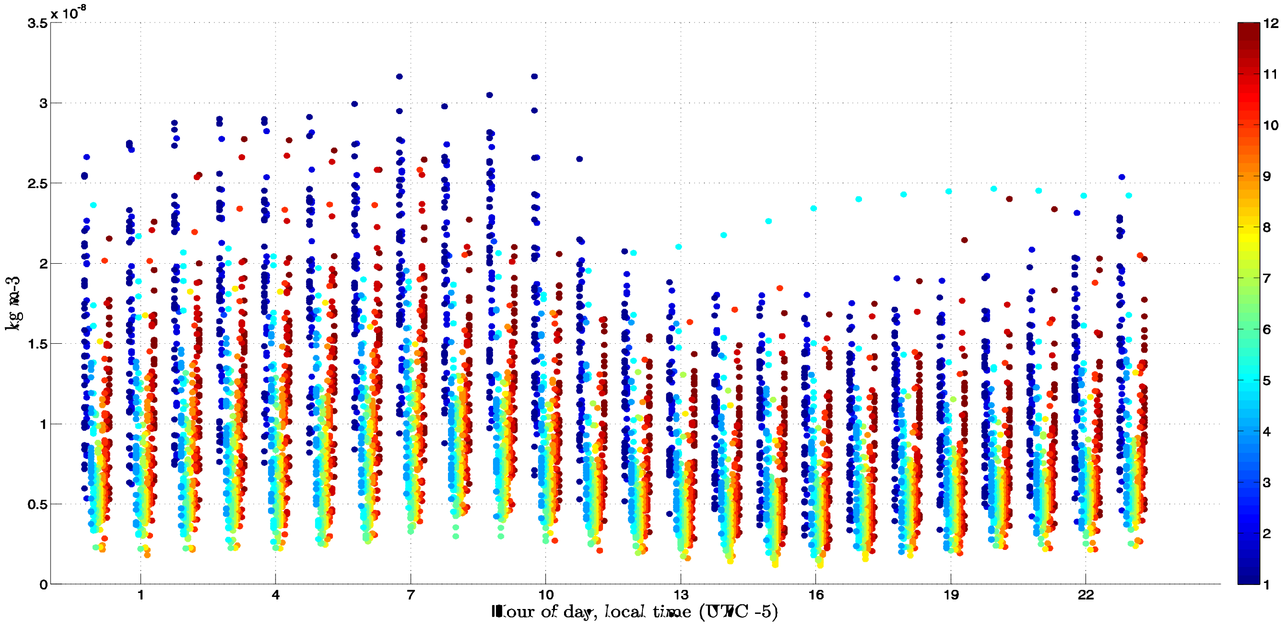

Figure 12. Daily cycle for PM10 by LOTOS-EUROS for Point1.

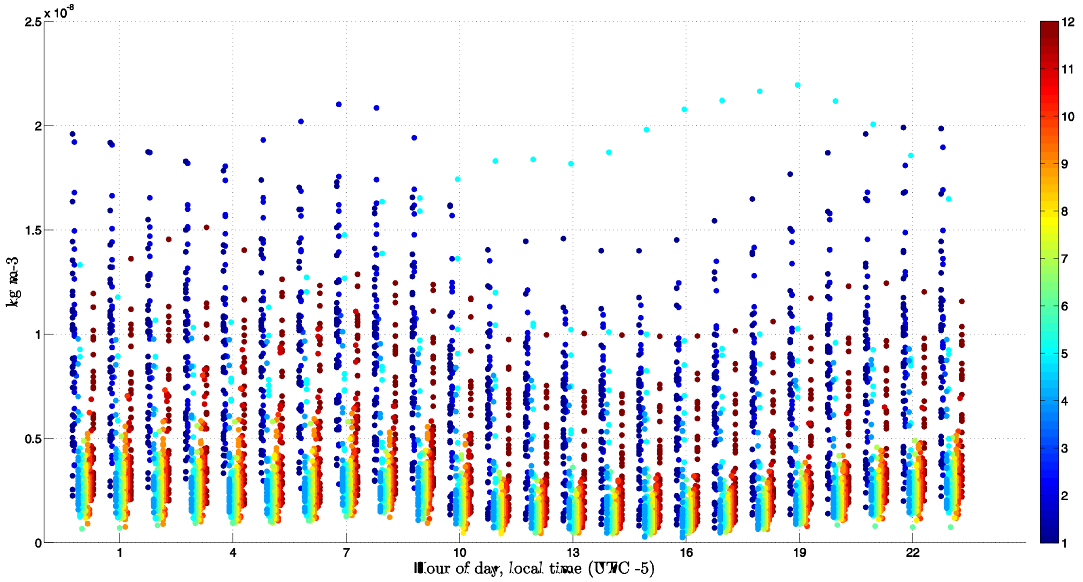

Figure 13. Daily cycle for PM10 by LOTOS-EUROS for Point2.

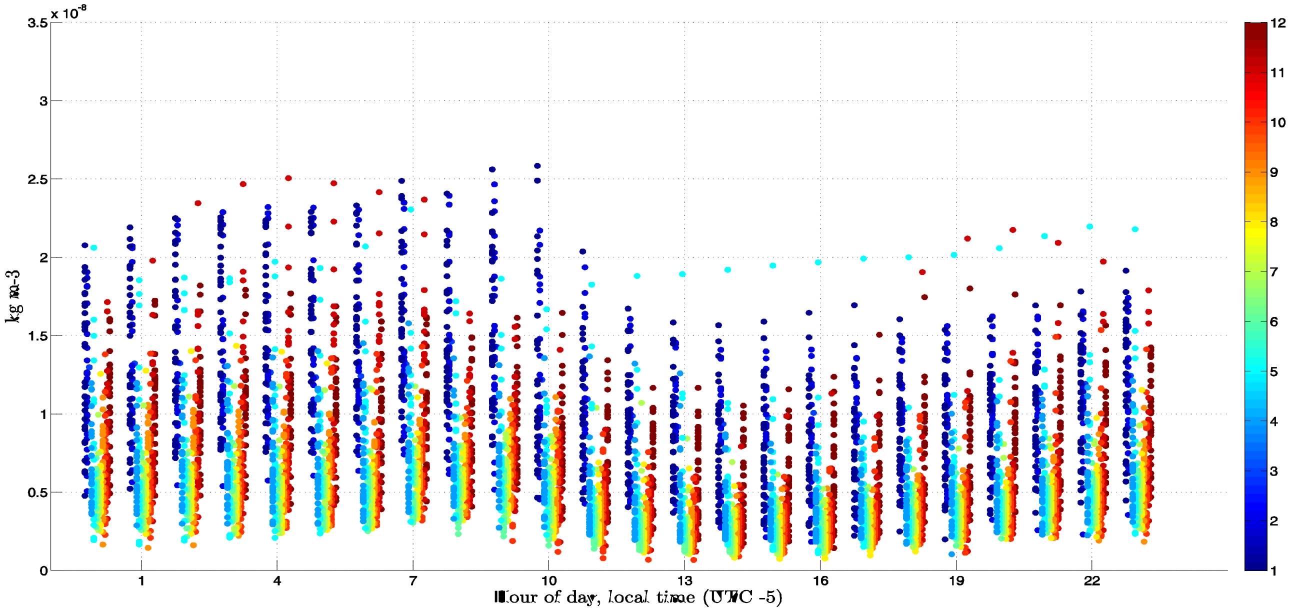

Figure 14. Daily cycle for PM10 by LOTOS-EUROS for Point3.

TEMPORAL DISTRIBUTION ANALYSIS

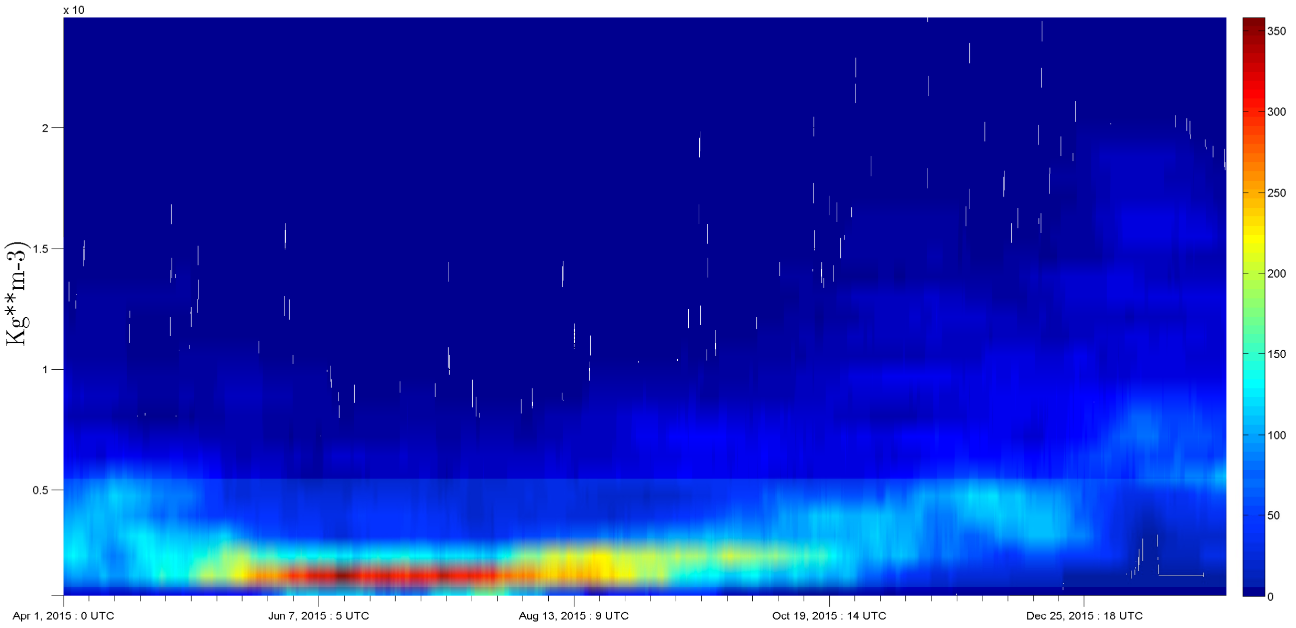

Figure 15. Temporal distribution of PM2.5 by LOTOS-EUROS for Point1.

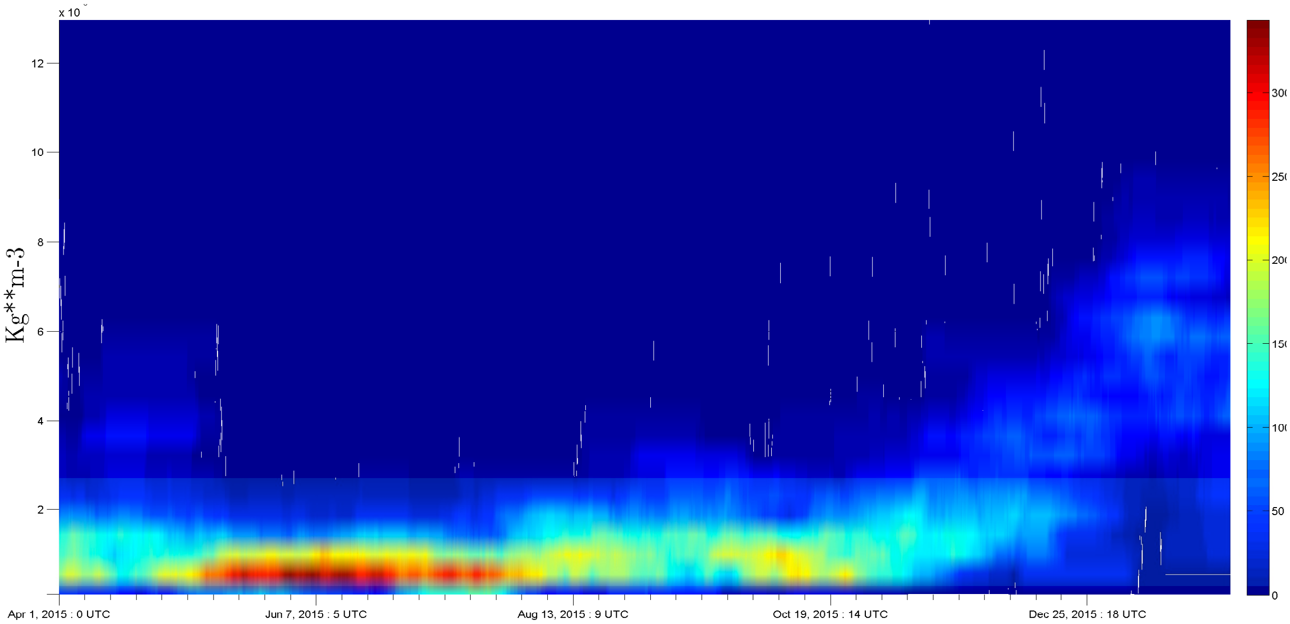

Figure 16. Temporal distribution of PM2.5 by LOTOS-EUROS for Point2.

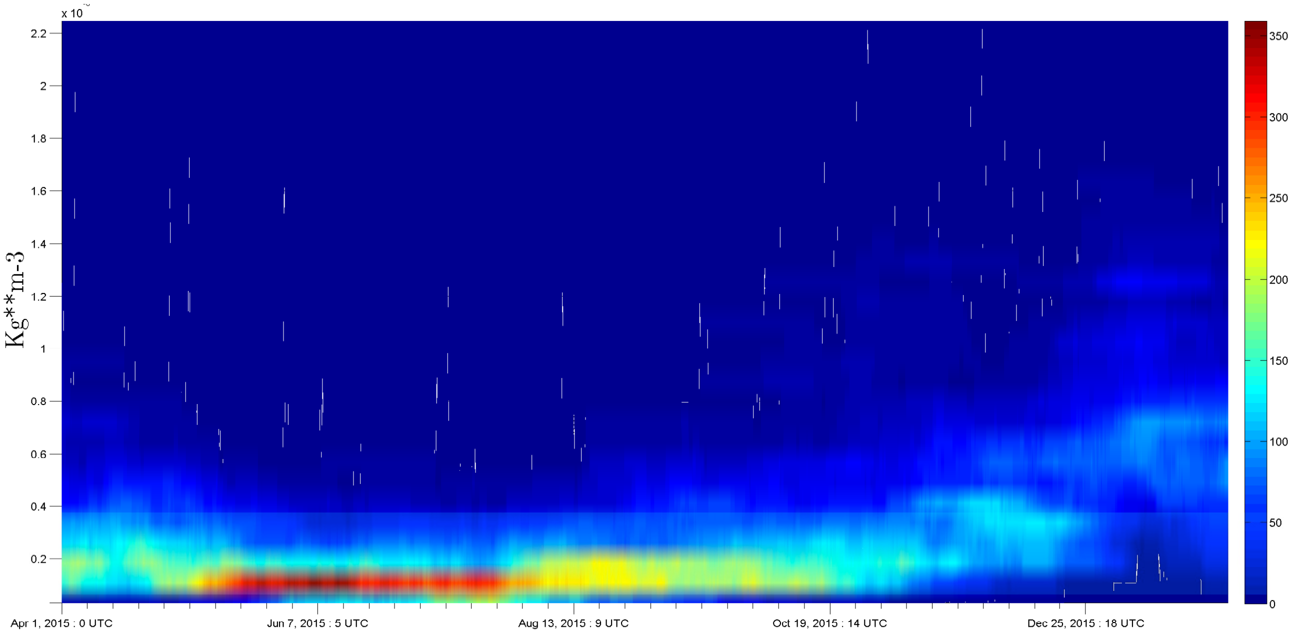

Figure 17. Temporal distribution of PM2.5 by LOTOS-EUROS for Point3.

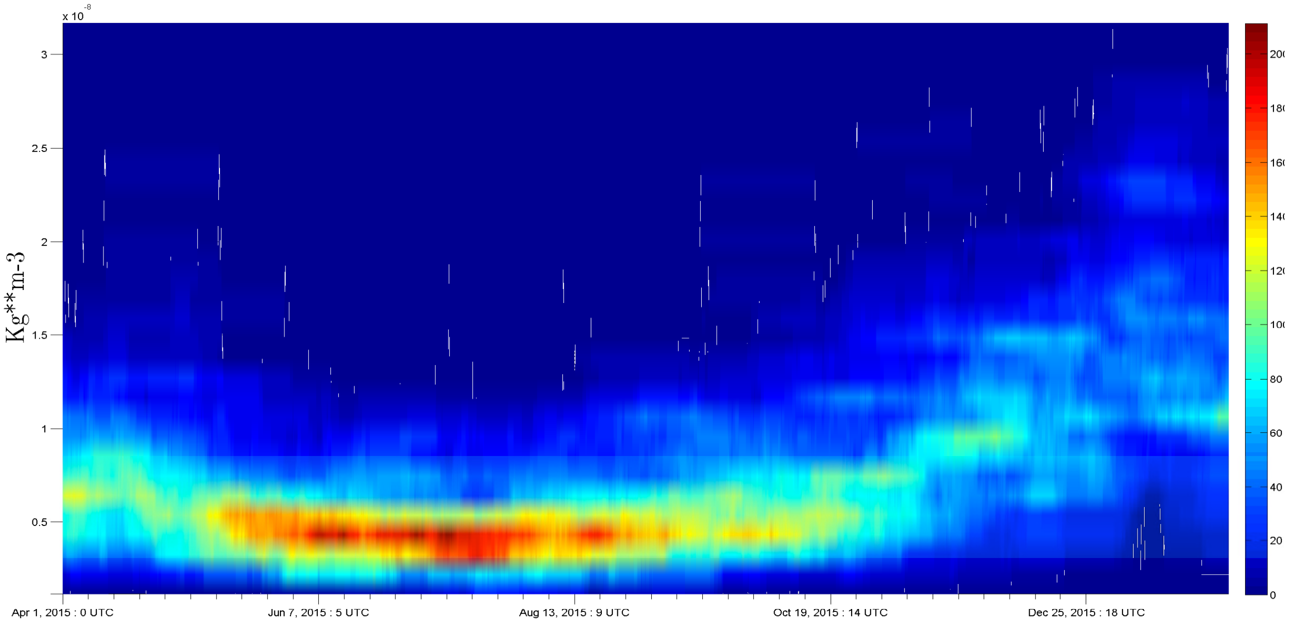

Figure 18. Temporal distribution of PM10 by LOTOS-EUROS for Point1.

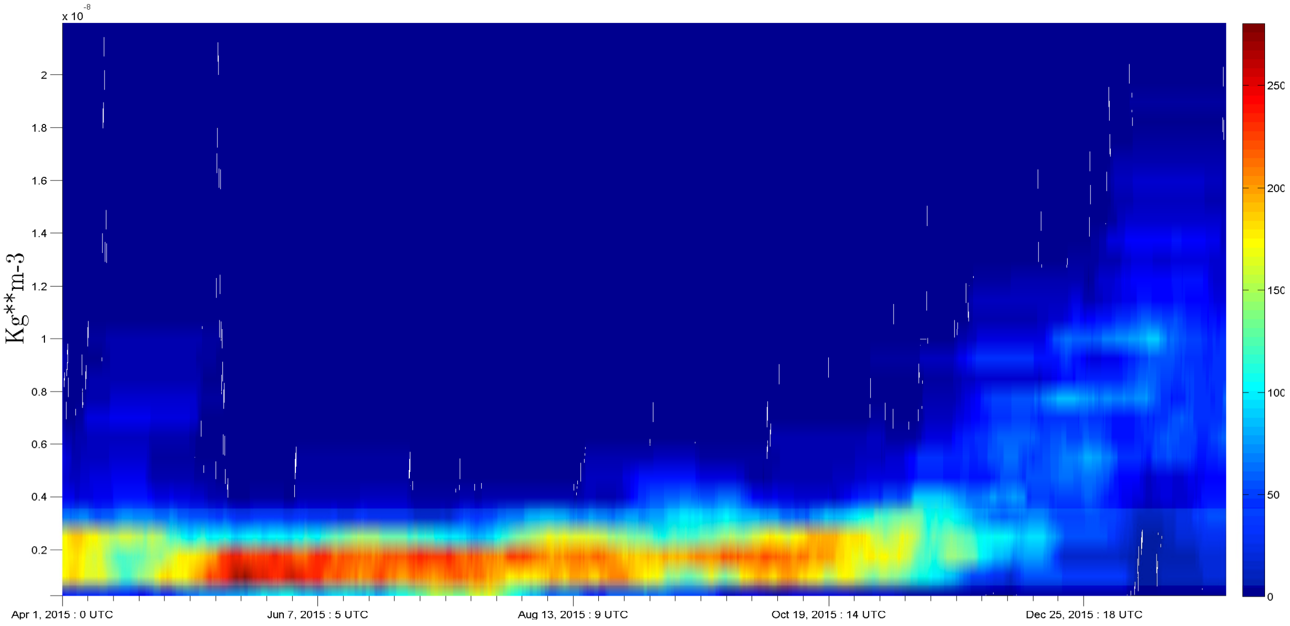

Figure 19. Temporal distribution of PM10 by LOTOS-EUROS for Point2.

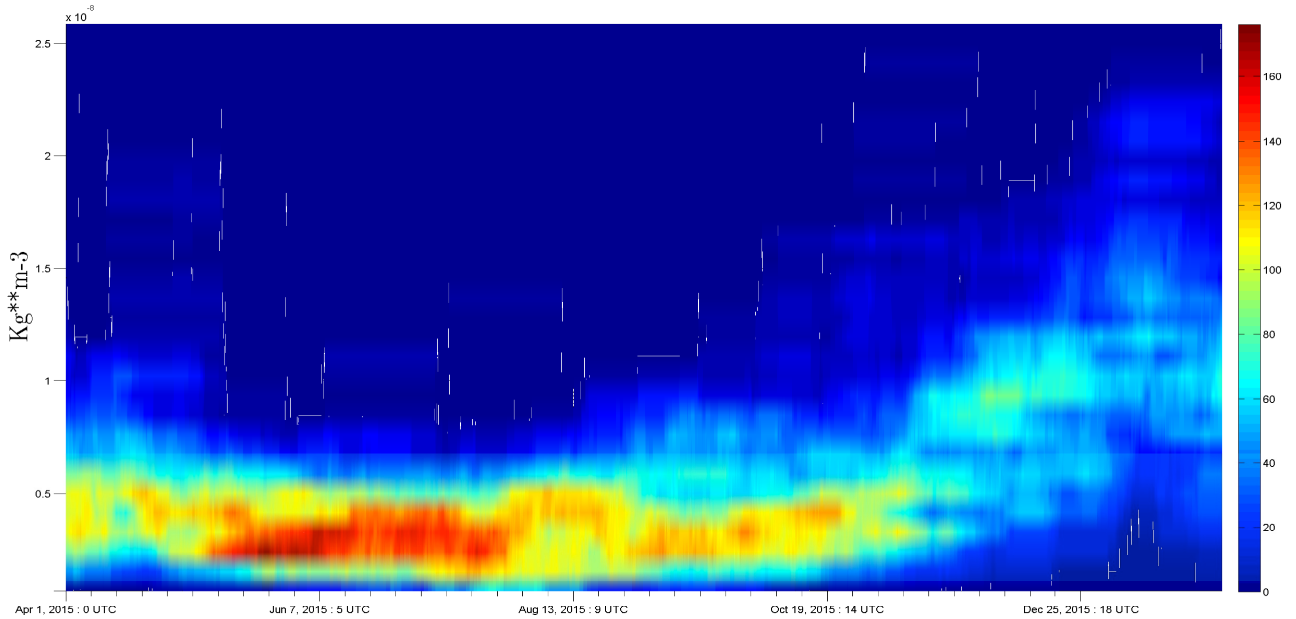

Figure 20. Temporal distribution of PM10 by LOTOS-EUROS for Point3.

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