

**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 In The Week Of The Contingency

**Medellin Air qUality Initiative MAUI**

MAUI-RP-04

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Executing agency

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Grupo reconocido por COLCIENCIAS Categoría A  
  
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**ABSTRACT**

In the present work is presented the analysis of the LOTOS-EUROS model over Tropical Andes domain, between March 24 and April 4 in 2015. The volume mixing ratio of Ozone (O<sub>3</sub>), Nitrogen Dioxide (NO<sub>2</sub>) and PM<sub>2.5</sub> was selected for the analysis. This variables are part of the most important pollutants in the atmosphere. The selected model outputs are showed for 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 Niño'), 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 PM<sub>2.5</sub> and PM<sub>10</sub> (Alsema, 2016). Therefore the measures registered were PM<sub>2.5</sub> higher than 160 µg/m<sup>3</sup> 24-hour, when the guideline of WHO is 25 µg/m<sup>3</sup> 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- EURocean 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<sub>3</sub> in humid air
- 2 Volume mixing ratio of NO<sub>2</sub> in humid air
- 3 Volume mixing ratio of NH<sub>3</sub> in humid air
- 4 Volume mixing ratio of SO<sub>2</sub> in humid air
- 5 Volume mixing ratio of HNO<sub>3</sub> in humid air
- 6 Volume mixing ratio of CO in humid air
- 7 Volume mixing ratio of N<sub>2</sub>O<sub>5</sub> in humid air
- 8 Volume mixing ratio of CH<sub>2</sub>O 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<sub>3</sub> in humid air
- 12 Mass concentration of SO<sub>4</sub> 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.



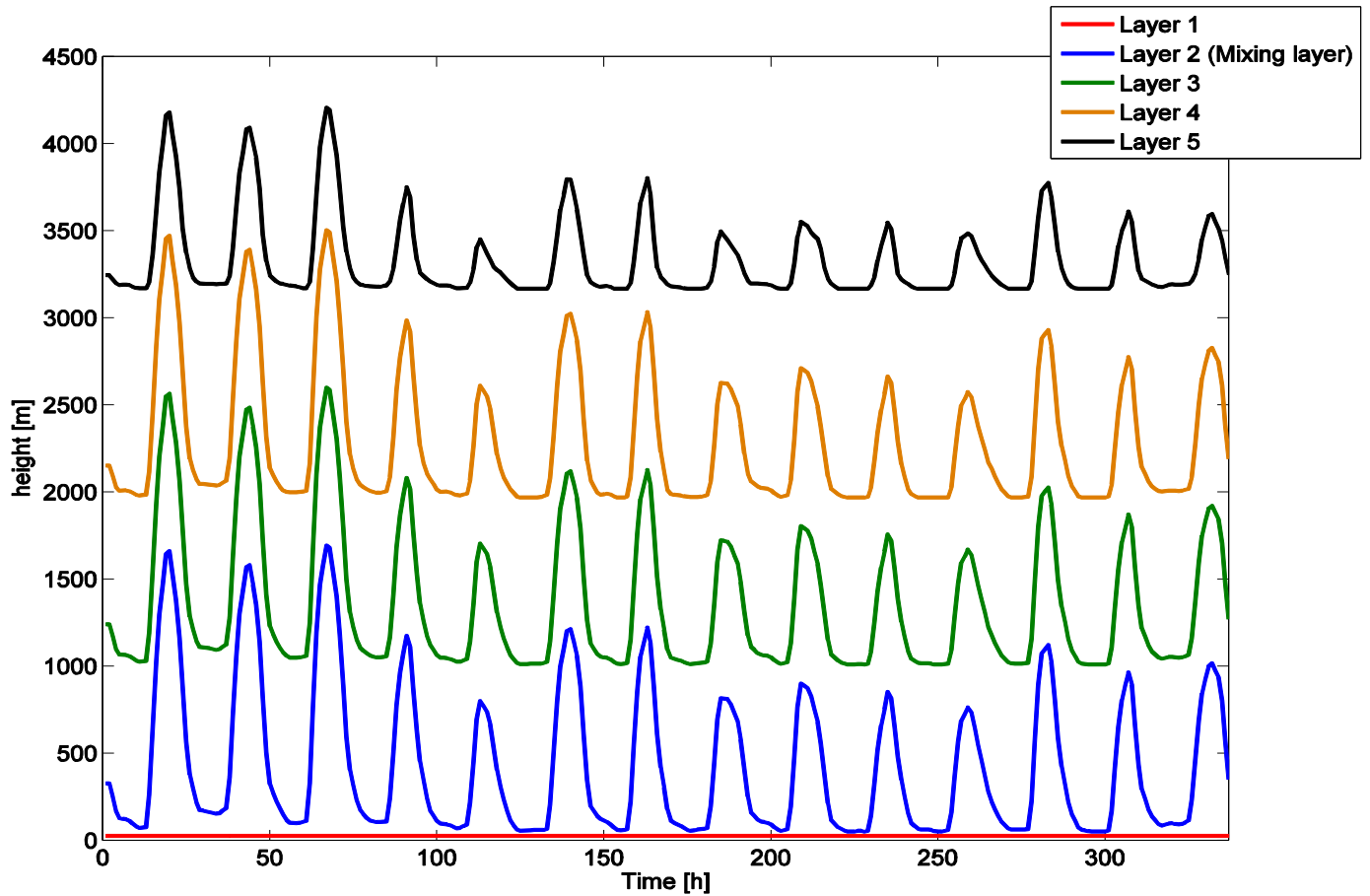


Figure 7. Vertical layers of LOTOS-EUROS.

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  $0.25^{\circ} \times 0.25^{\circ}$  in the region between. The simulation experiment was set between the days March 24 and April 6, 2015. This period correspond with the contingency in the region owing to the high concentration of pollutants in the atmosphere.

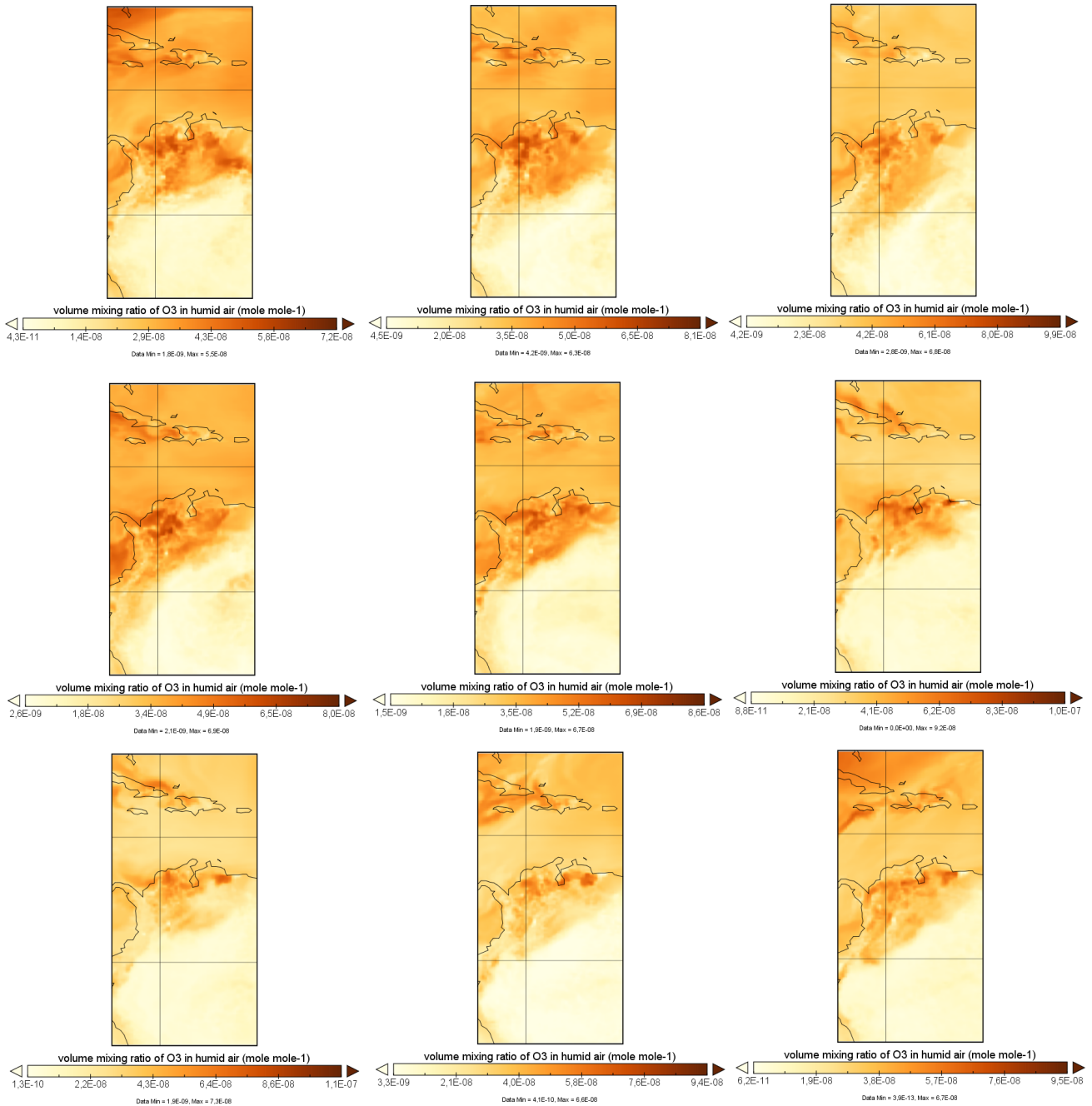


Figure 8. Volume mixing ratio of O<sub>3</sub> in the layer 2 (mixing layer), for the days (in order from left to right, top to bottom): March 24, March 25, March 26, March 28, March 30, April 1, April 3, April 5 and April 6.

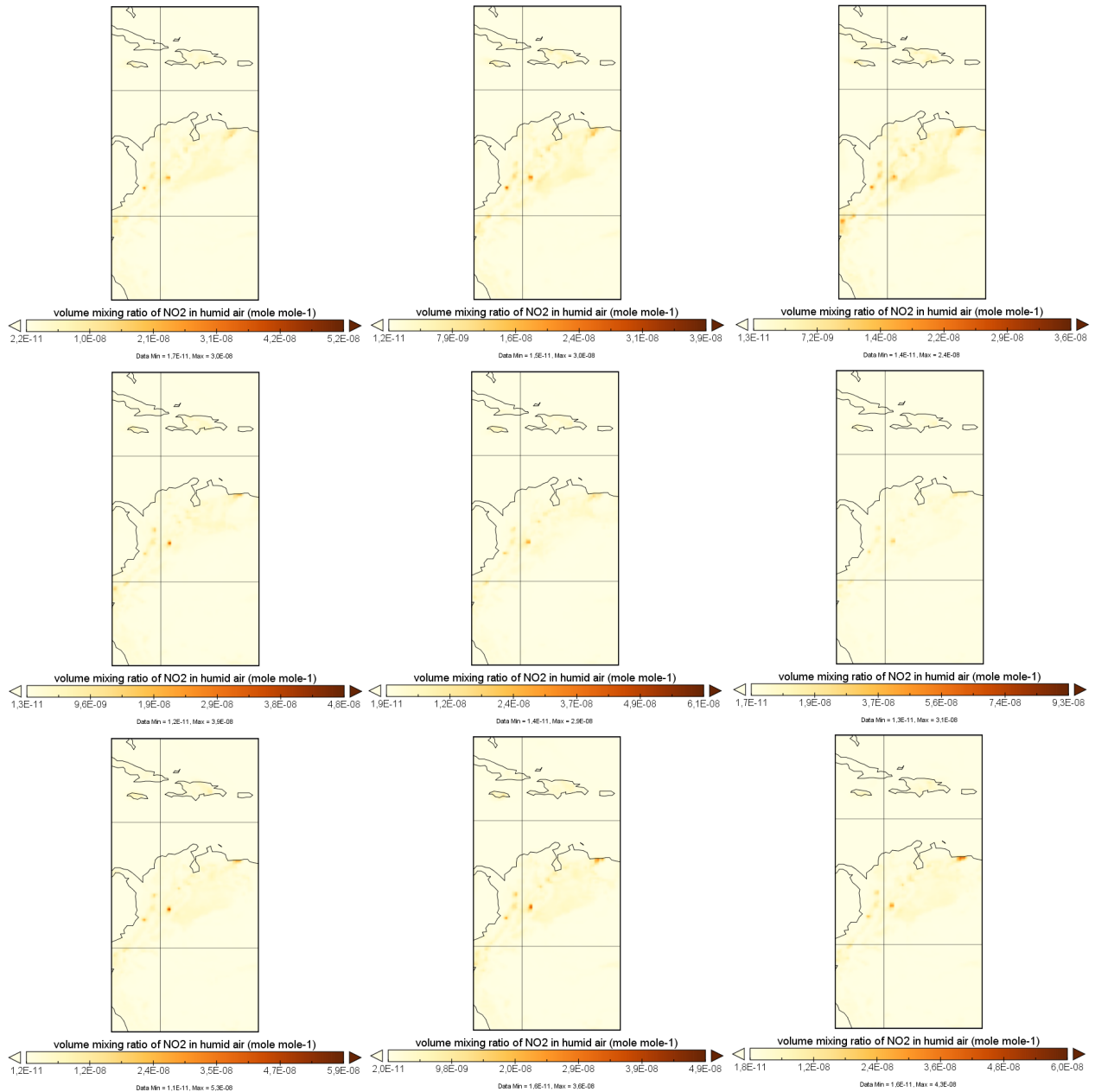


Figure 3. Volume mixing ratio of NO<sub>2</sub> in the layer 2 (mixing layer), for the days (in order from left to right, top to bottom): March 24, March 25, March 26, March 28, March 30, April 1, April 3, April 5 and April 6.

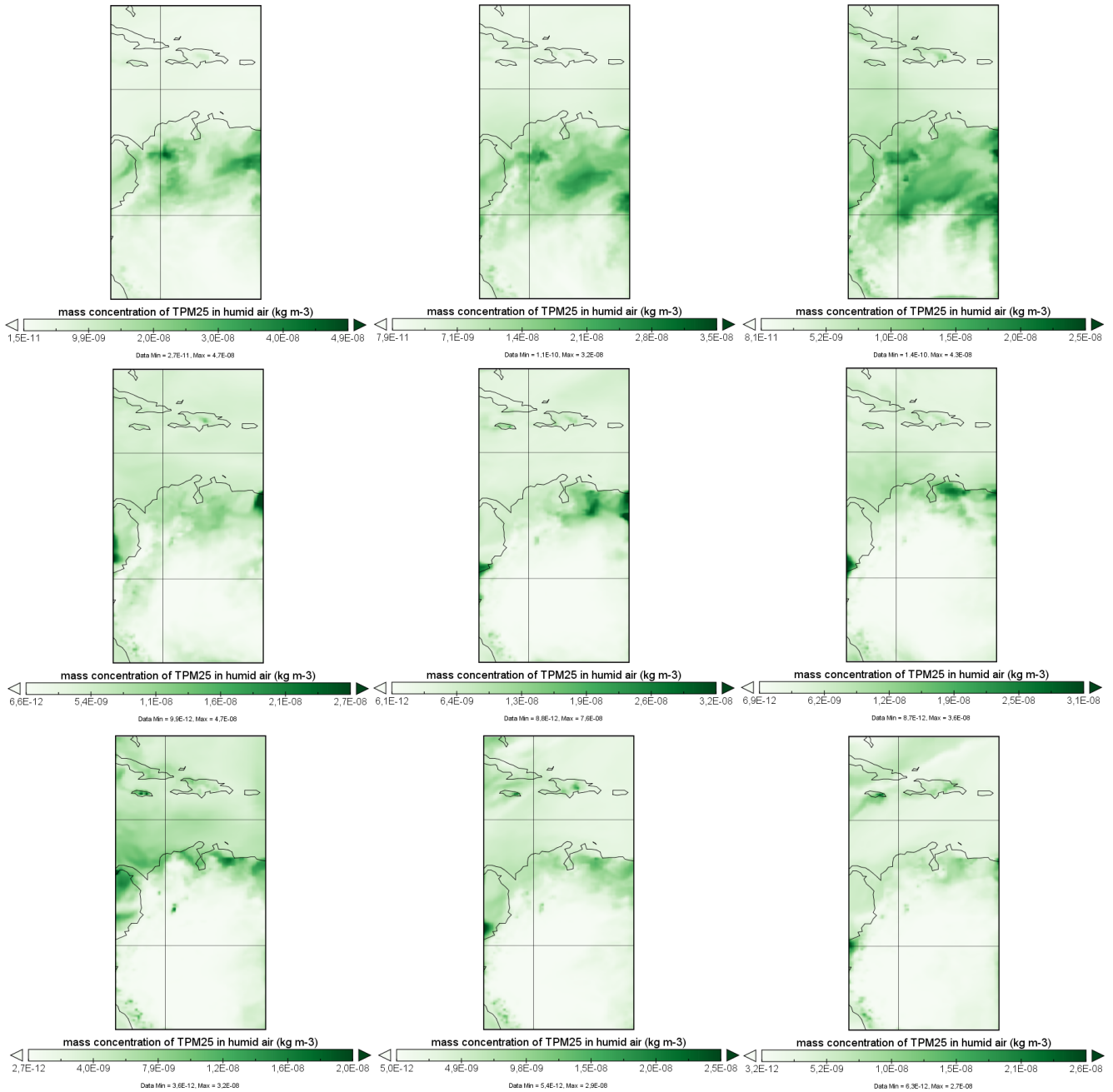


Figure 4. Volume mixing ratio of PM<sub>2.5</sub> in the layer 2 (mixing layer), for the days (in order from left to right, top to bottom): March 24, March 25, March 26, March 28, March 30, April 1, April 3, April 5 and April 6.

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

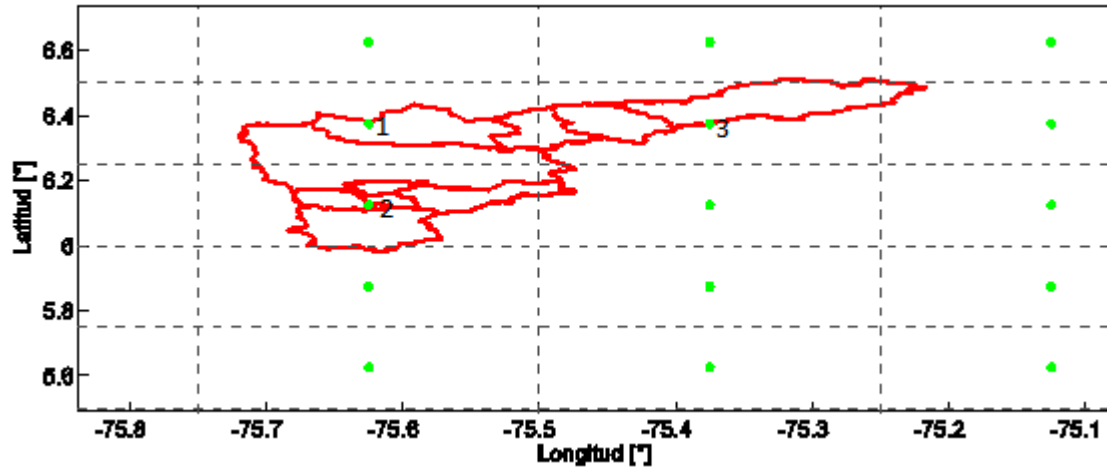


Figure 9. Current resolution and selected points for LOTOS-EUROS over Aburrá Valley.

For the contingency period, was analyzed the volume mixing ratio of Ozone, Pm2.5 and PM10. For each selected substance are shown the LOTOS-EUROS outputs values in the three points.

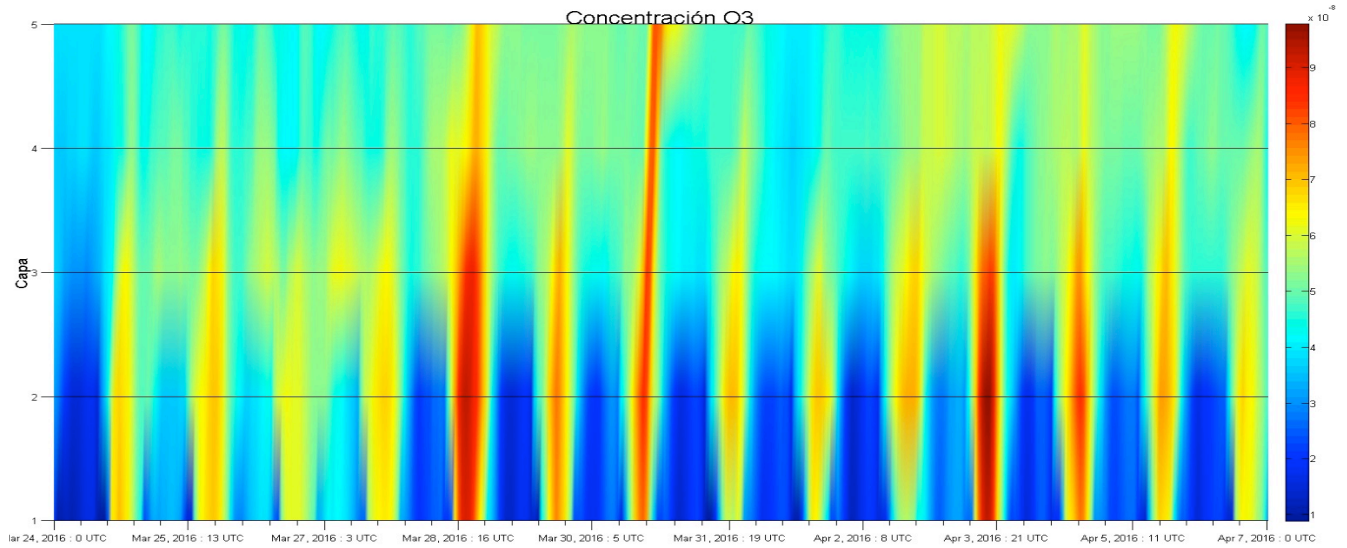


Figure 10. Volume mixing ratio of O<sub>3</sub> in the Point1.

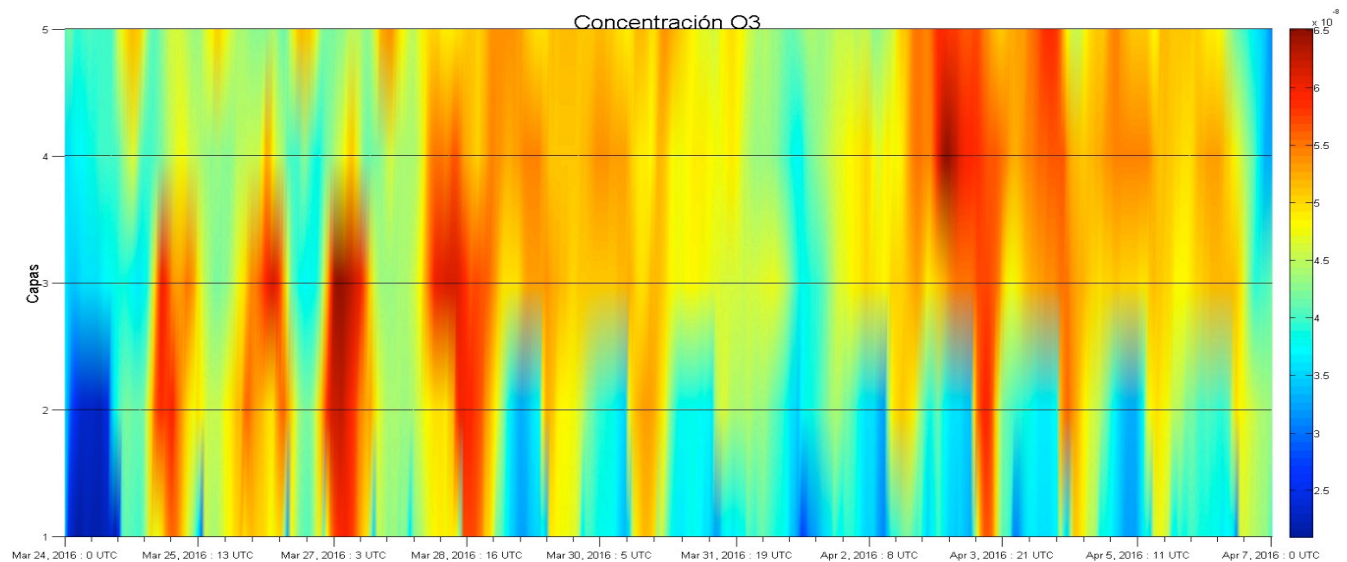


Figure 11. Volume mixing ratio of O<sub>3</sub> in the Point2.



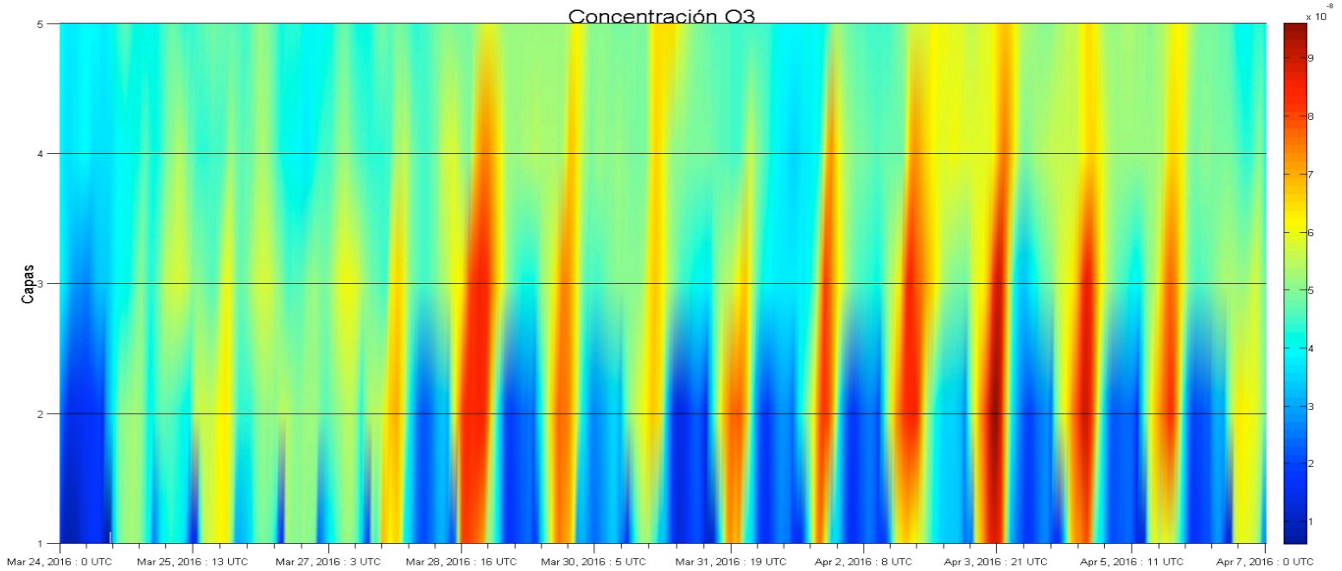


Figure 12. Volume mixing ratio of O<sub>3</sub> in the Point3.

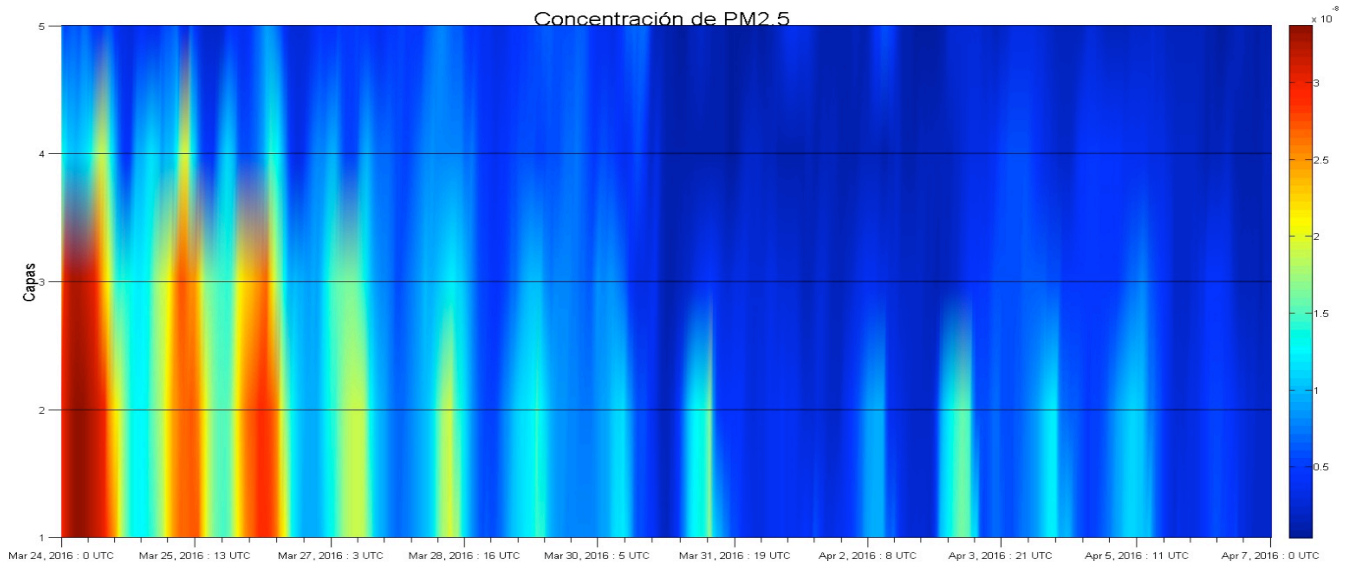


Figure 13. Volume mixing ratio of PM<sub>2.5</sub> in the Point1.

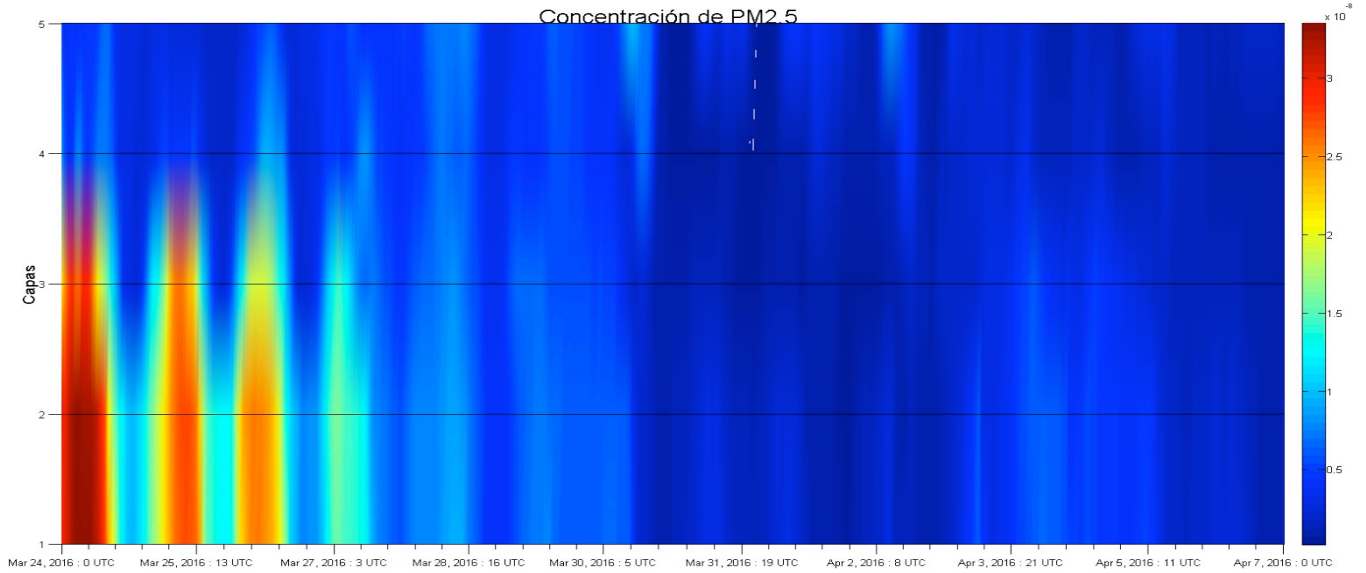


Figure 14. Volume mixing ratio of PM2.5 in the Point2.

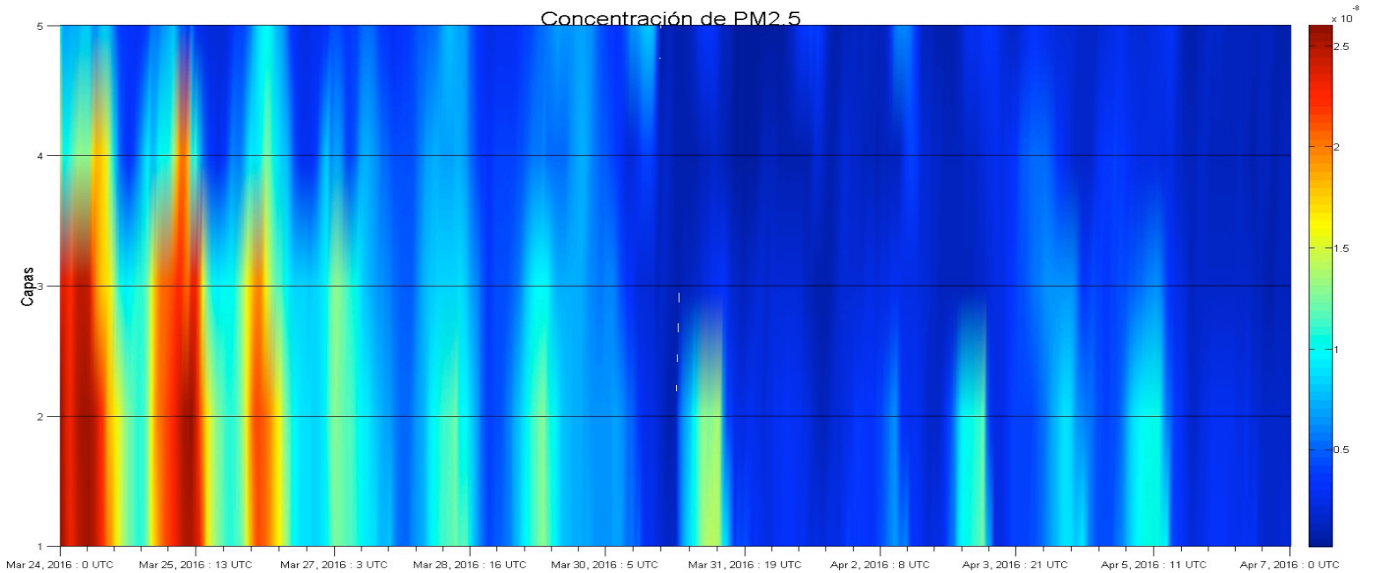


Figure 15. Volume mixing ratio of PM2.5 in the Point3.



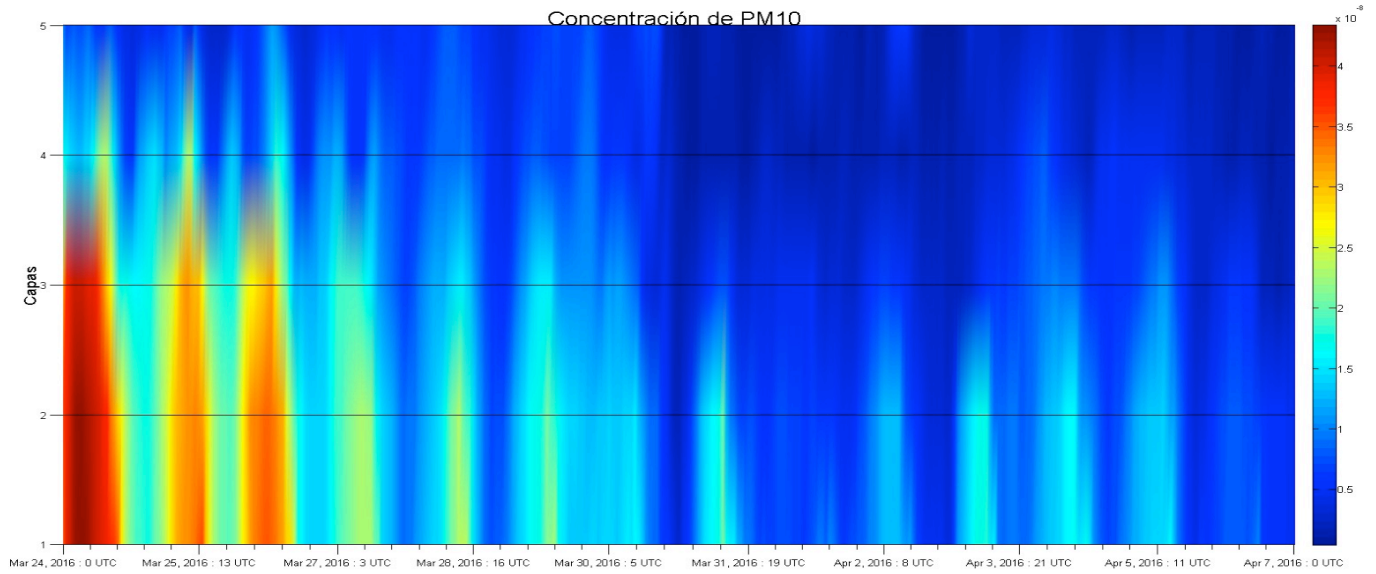


Figure 16. Volume mixing ratio of PM10 in the Point1.

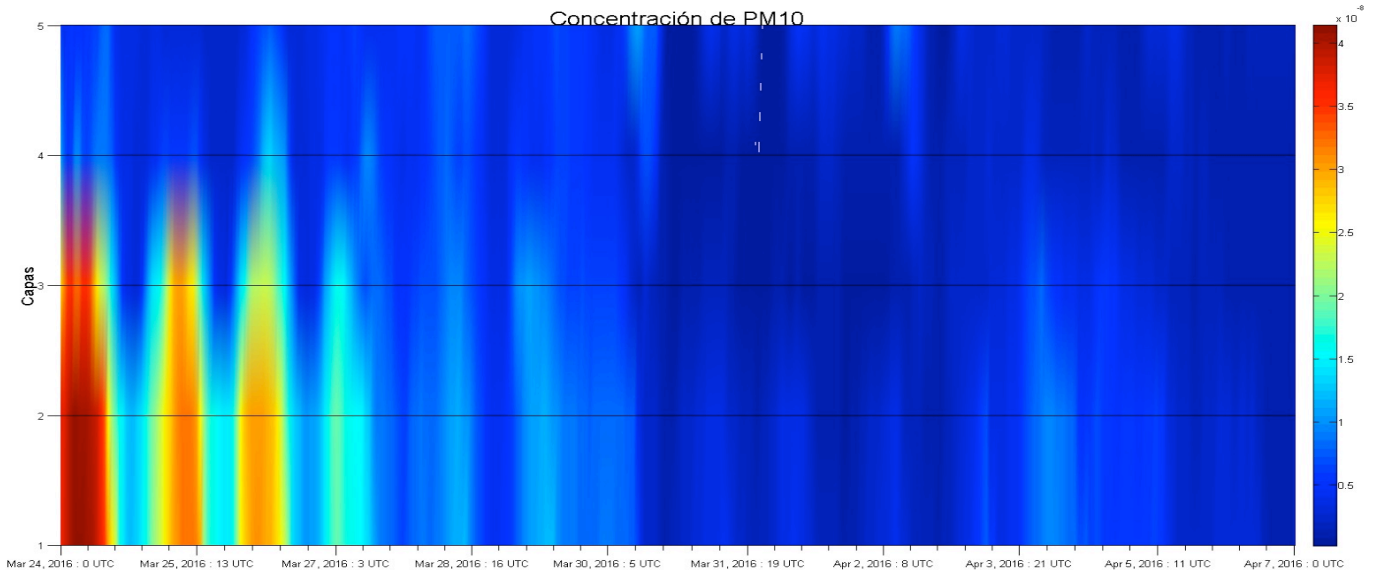


Figure 17. Volume mixing ratio of PM10 in the Point2.

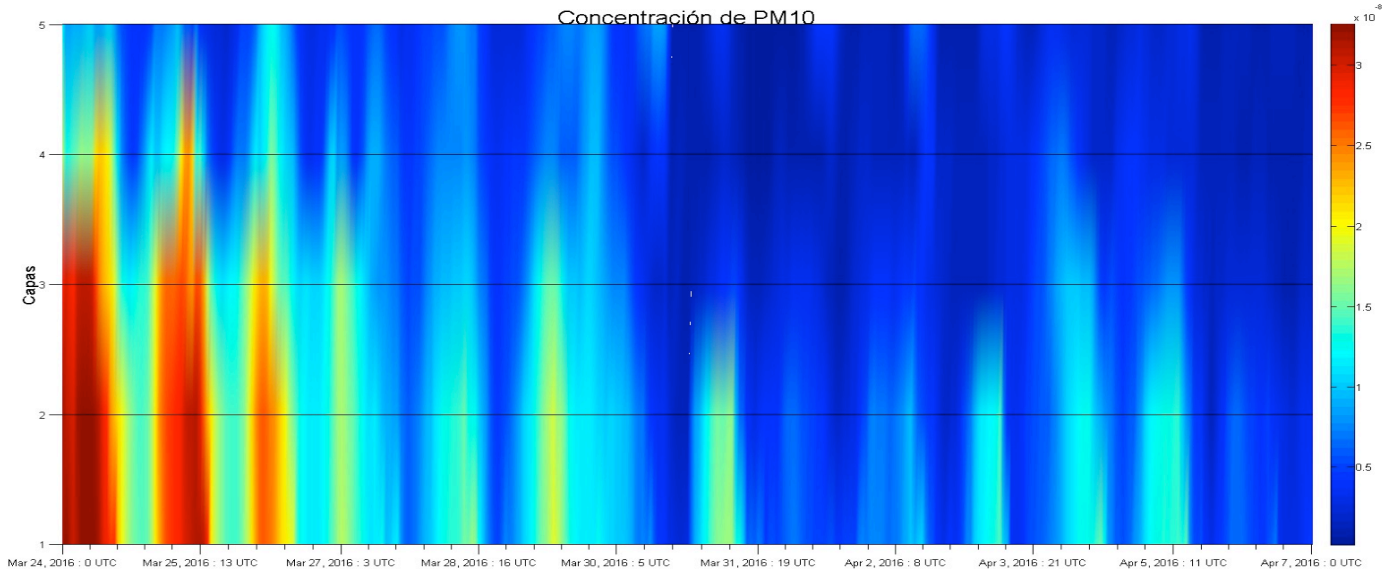


Figure 18. Volume mixing ratio of PM10 in the Point3.