# BLACK CARBON AND $PM_{2.5}$ TRANSPORT BETWEEN SANTIAGO DE CHILE AND THE ANDES MOUNTAINS


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Near Santiago de Chile, and towards the Andes Mountains there are several areas sensitive to contamination, such as the Farellones sky resort, the Natural Sanctuary Yerba Loca and several glaciers. To study the influence of Santiago´s contamination on the glaciers continuous black carbon and PM2.5 monitors as well as meteorological stations have been placed in the city, near the glaciers and in an intermediate point. The results indicate that during the afternoon there is an increase in black carbon that is coming from the city, however, at night there is a second peak which is most likely due to local emissions. The fraction of black carbon in La Parva is 11.8% of black carbon in Las Condes

## Introduction

Santiago de Chile has about 6 million inhabitants and it is located in a valley surrounded by the Andes mountains on the east side and several high hills on the west and north side. Like most cities surrounded by mountains, pollutions levels in Santiago are very high in winter because low wind speeds and strong temperature inversions[1]. The climate is semi-arid with an annual precipitation of only 300 mm and the city relies strongly on water from the Andes coming from snow thaw and dams[2]. There are several mountain glaciers that also provide water for the city and agriculture. Thus, near Santiago there are areas sensitive to contamination such as Natural Sanctuary Yerba Loca and glaciers La Paloma, Olivares Alpha, Olivares Beta and Esmeralda. Very close to the glaciers, there are two copper mines which are also large sources of pollution.

## Measurements and methods

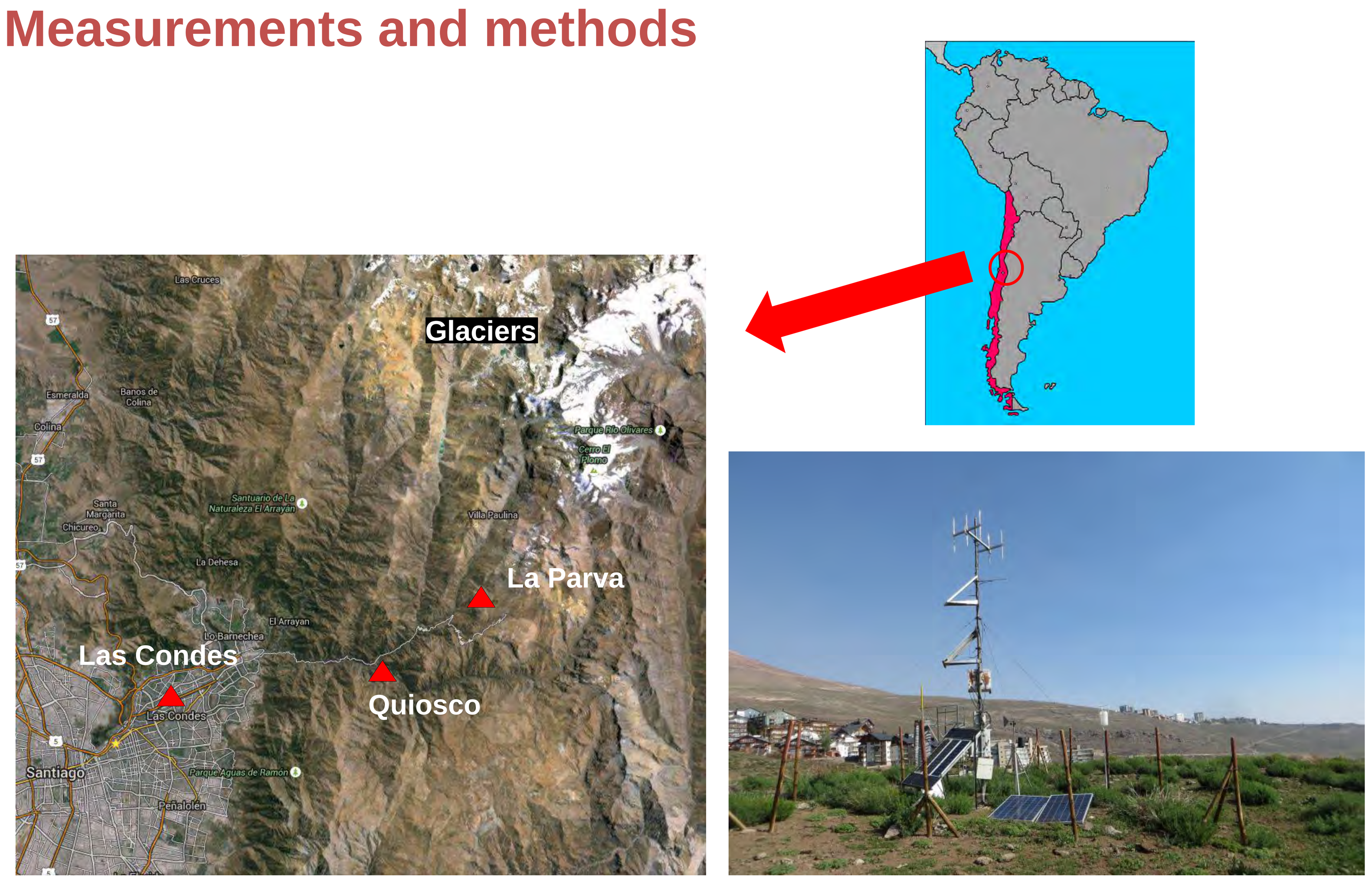



*Figure 1. Measurement sites*

In this work the transport of black carbon and PM2.5 has been studied using instruments located in a place near the glacier (La Parva, 2200 m), in the city (Las Condes, 800 m) and an intermediate site (Quiosco, 1200 m). Near the glacier, an optical instrument[3] was used to measure BC, a DustTrak from TSI was used to measure $PM_{2.5}$ and a meteorological station was used to measure wind speed and direction. Similar instruments were used in the other sites.

The optical instrument was developed at the University of Santiago, and uses a variation of the integrating plate method to measure the light absorption coefficient[4]. With our method, a volume of air is drawn through a filter, where particles with sizes bigger than the pore size are collected. We used a 25 mm diameter Nuclepore filter with 0.2 µm pore size. A 880 nm Led is placed on one side of the filter, a photodetector on the other side and the intensity of light passing through the filter is measured. Measurements are made before and after the particles are collected. After a predetermined period of time, a new volume of air is drawn through the filter, and new measurements are made. This process allows us to obtain the absorption coefficient for an extended period of time without changing the filter.

## Results

Measurements took place between December 2014 and May 2015 in La Parva and Las Condes. Mesurements in Quiosco were done from February to May 2015. The daily average for the whole period for La Parva is shown in figure 2.

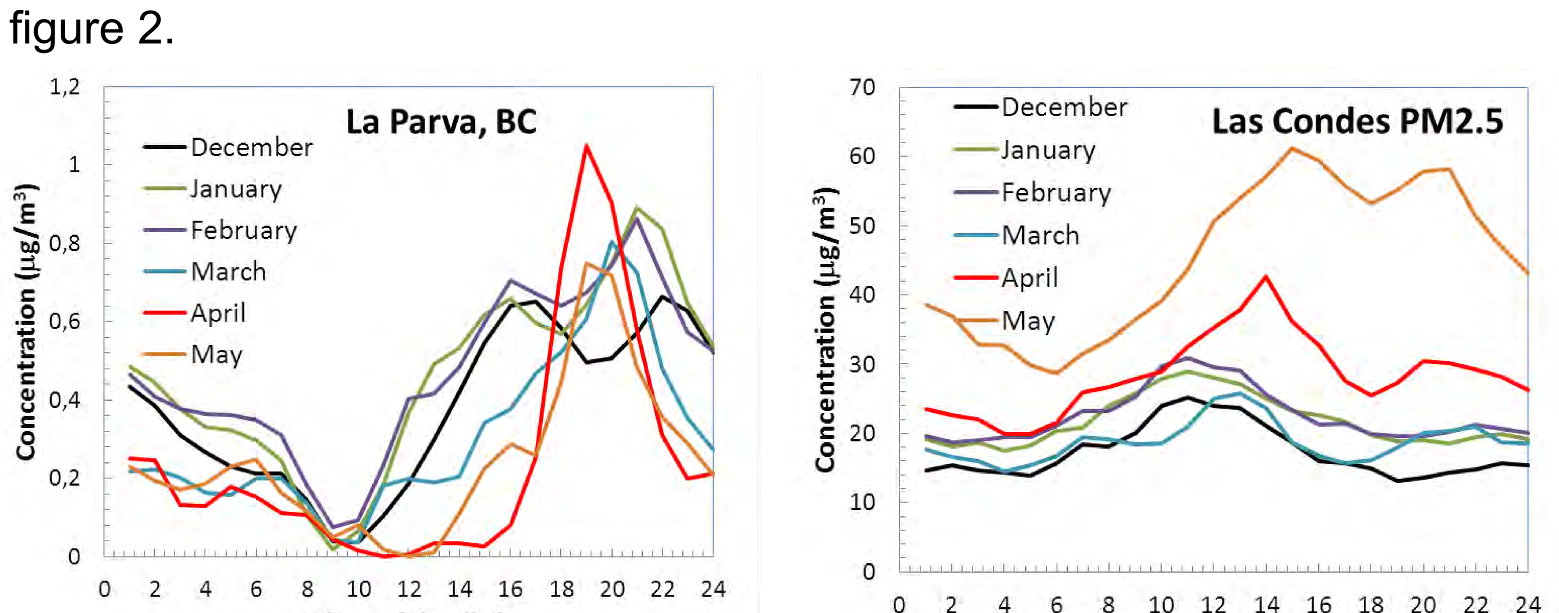



*Figure 2. Black Carbon and PM2.5 in Las Condes and La Parva for the whole measuring period (Dec. 2014 – May 2015)*

In figure 2, it can be seen that the maximum of the concentration in Las Condes occurs before the maximum in La Parva. These data indicates that movement of pollution occurs from Las Condes to La Parva. The wind rose in figure 3, shows the direction of the wind in both sites.

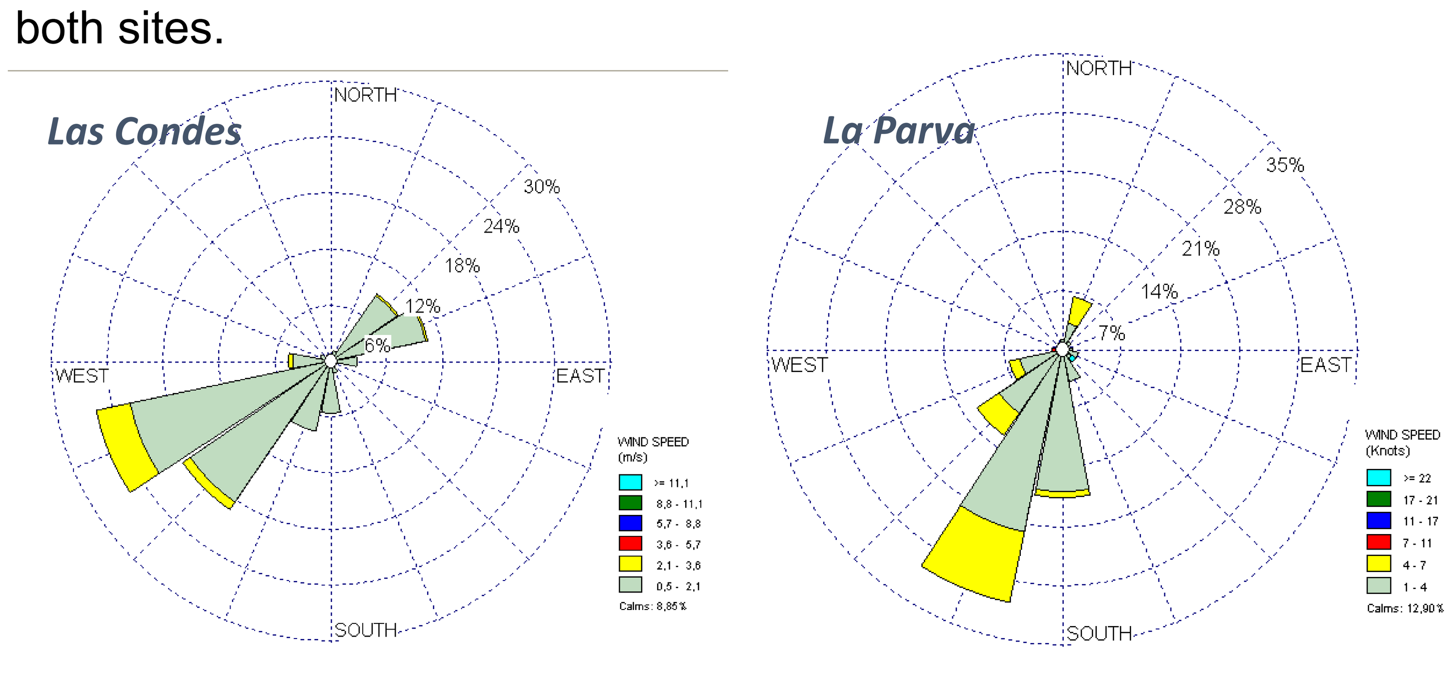



*Figure 3. Wind roses in Las Condes and La Parva from from 2 – 8 pm in the months of January to May 2015.*

The wind roses in figure 3 show that during the afternoon, the wind direction is north-east, that is from Las Condes towards La Parva. It also indicates that any influence from the city in La Parva should be seen during the afternoon.

An indication that transport of contaminants can be seen from Las Condes to La Parva is shown in figure 4.

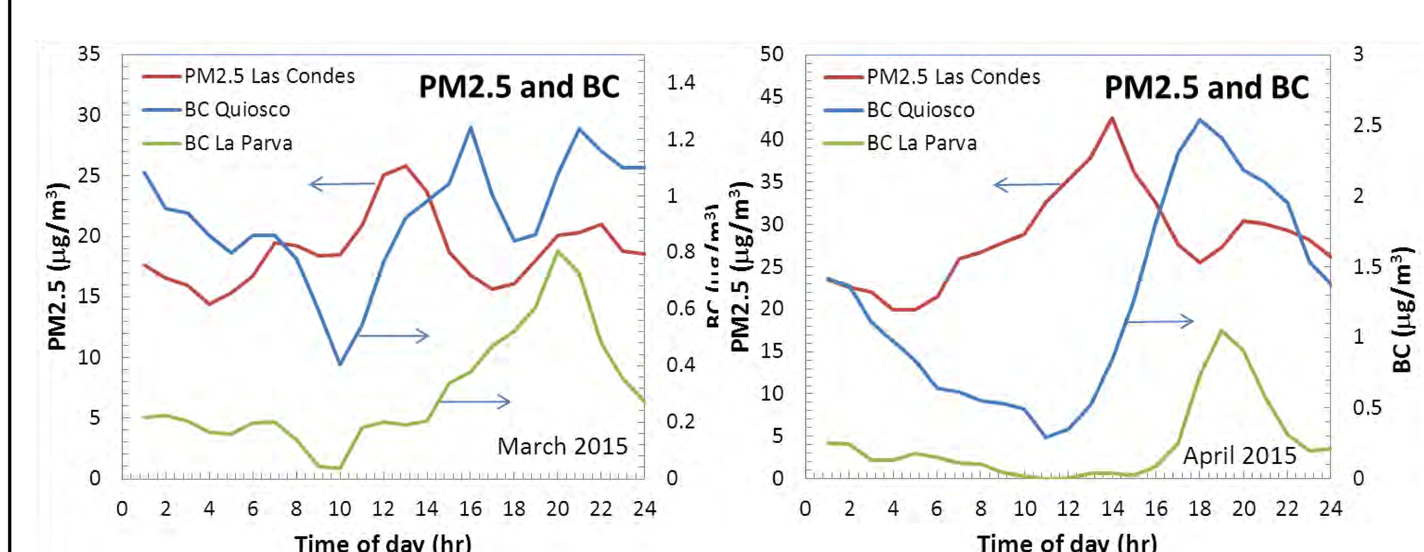
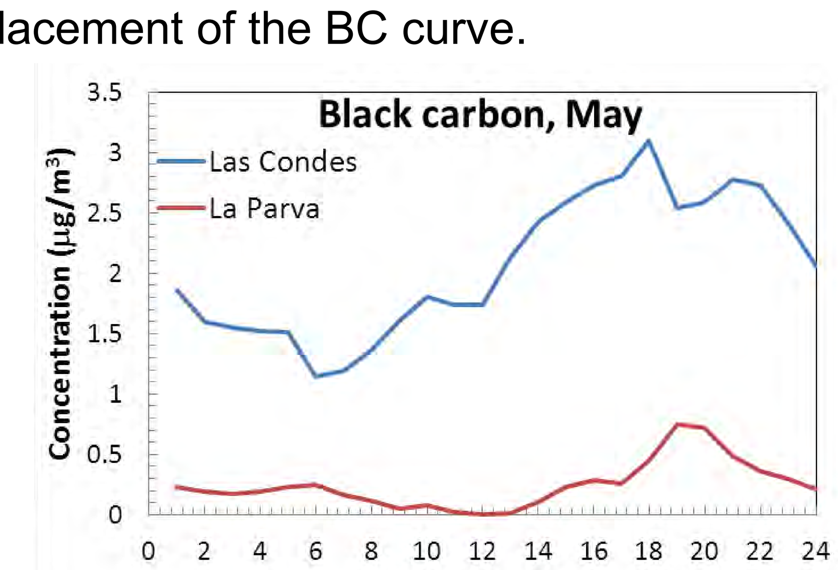



*Figure 4. Black carbon and PM2.5 in the three measurement sites. The maximum in each site is displaced.*

The maximum for PM2.5 in Las Condes is reached at ~ 2 pm in March and April. In the intermediate site (Quiosco) the maximum of BC is reached at 4 pm in March and 6 pm in April. In la Parva, the maximum of BC is reached at 8 pm in March and 7 pm in April. That In the stations downwind from the city the maximum is reached at a later time, indicating that BC is transported from the city towards the mountains during the afternoon. For the other months, there is a similar displacement of the BC curve.




The fraction of BC that is transported from the city to La Parva can be inferred from a comparison of the average during the month of May in Las Condes and La Parva. Due to a failure in the equipment, BC could not be measured in Las Condes the other months. The fraction of BC in La Parva is 11.8% of BC in Las Condes.

## Conclusions

Black carbon concentration in La Parva has a maximum in the afternoon or at night (depending on the season) and very low concentration in the morning, indicating that there is no influence from traffic. A station located in between La Parva and Las Condes shows an increase in concentration after Las Condes, but before La Parva. The displacement in the maximum of BC concentration in the three stations is related to transport from the city.

## REFERENCES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