INFLUENCE OF MICROCLIMATE ON PARTICULATED MATTER DISTRIBUTION IN SANTIAGO-CHILE

COLLABORATIVE RESEARCH

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Region:	Region Metropolitana	Region Metropolitana
Country:	Chile	Chile

MARZO 2016

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ABSTRACT

This Project was done in a collaborative manner between two schools from the Regio**n Metrop**olitana (RM) of Chile: Villa Maria Academy (VMA) and Liceo Carmela Silva Donoso (LCSD), located in Las Condes and Ñuñoa respectively. A weather station was installed in both schools, which was equipped with two thermometers, a digital multi-day and a mercury thermometer. From each school, 8th grade students registered maximum and minimum air temperatures every six days for the 2015 fall-winter period. By comparing temperatures for both schools, it was determined a significant difference of 3.2°C in the maximum temperatures for the months May and June. It is worth mentioning that, historically, this period has been characterized by high levels of atmospheric pollution in the RM.

Based on that, our hypothesis was that locally significant differences in the temperatures are related to the distribution of particulate matter PM_{10}. To prove this hypothesis, we compared data from both schools.

The data of atmospheric pollution belongs to the closest MACAM monitoring stations to each school: "Las Condes" (VMA) and "Parque O'Higgins" (LCSD).

When both maximum temperatures and thermic amplitude were compared between both schools, they showed to be significantly different during the period May-June 2015. We concluded that these parameters affect the distribution of particulate matter PM_{10}, therefore, the higher PM_{10} concentrations was found to be related with a higher/lower temperature as seen in the comparison between LCSD with VMA values.

INTRODUCTION

In these days, critical peaks of atmospheric pollution in the Chilean Region Metropolitana (RM) are important and more prevalent in the winter season because of the characteristics of the Santiago Basin. It is located in a central valley surrounded by high structures such as the mountain ranges "de la Costa" and "Los Andes". Santiago has a population over six million inhabitants who suffer from poor conditions for air quality [1]. The main sources of pollution are industries, public and private urban transport (both in constant growth) among others, which have promoted the emission of atmospheric pollutants (gases and particulate matter) that affect the health of people [2]. In the 80's and 90's the highest levels of pollution were presented and Santiago was distinguished as one of the most contaminated capitals of the planet. This condition derived in the implementation of a Decontamination Plan for the RM which has reduced pollution levels progressively. However, during 2015 several warnings and some environmental pre-emergencies were declared.

The warning statement or pre-emergency are based on a predictive model which uses the monitoring network MACAM (from the Spanish translation for *Air Quality and Meteorological Variables Monitoring System*) which register the average emission of particulate matter. Nonetheless, it does not account for pollution episodes in a smaller observation scale.

Geographically, it has been shown that the Eastern and Western areas of Santiago have differences in the distribution and concentration of the particulate matter regarding on the temperature of each area [3]. The variation on temperatures have been originated in the growth dynamic of the RM, which has resulted in changes in land uses, substantially modifying the urban landscape.

This patterns of temperature increasing at a local level are called "heat islands" and they are influence the speed and direction of winds, causing the transfer of pollutants from one place to another [4].

Based on this data, our research examined the behavior of local temperature in two schools located in the districts of Ñuñoa (Liceo Carmela Silva Donoso) and Las Condes (Villa Maria Academy). By registering maximum and minimum temperatures

RESEARCH QUESTION

Do exist significant differences of local temperature between these both schools that could influence the distribution of particulate matter PM_{10} in the air?

HYPOTHESIS

The distribution of PM_{10} in SANTIAGO is influenced by the different temperatures found in the city.

OBJECTIVES

GENERAL OBJECTIVE

The purpose of studying minimum and maximum daily temperatures in the period from May to June, is to identify a potential effect on the distribution of particulate matter PM_{10}. in both schools: Colegio Villa Maria Academy (VMA) and Liceo Carmela Silva Donoso (LCSD).

SPECIFIC OBJECTIVES

1. To measure minimum and maximum daily temperatures in VMA and LCSD.
2. To analyze the temperature data recorded by graphical representations.
3. To compare the temperature profile to the pollution data of PM_{10} registered in two of the MACAM monitoring stations: Las Condes and Parque O'Higgins close to VMA and LCSD correspondingly.

RESEARCH METHODOLOGY

The proposed methodology was as follows:

Step 1: Atmospheric study, research site set up as described in the GLOBE protocol [5].

Step 2: Placement of the instrument shelter in each school as described in the GLOBE protocol [5].

Step 3: Calibration of mercury thermometer as described in the GLOBE protocol [5].

Step 4: Placement of Digital Dual Sensor Thermometer (Forestry Suppliers) inside the instrument shelter as described in the GLOBE protocol [5].

Step 5: Setting the Digital Multi-Day Thermometer to zero degrees. GLOBE [5]

Step 6: Calibration of Digital Dual Sensor Thermometer (Forestry Suppliers), as described in the GLOBE protocol for "Maximum/Minimum Thermometer Calibration" [5].

Step 7: To register, every six days, the minimum and maximum temperatures using the Digital Dual Sensor Thermometer (Forestry Suppliers) as described in the "Maximum-Minimum-Current Temperature Protocol Field Guide" [5].

All the measures were performed after the solar noon (13:40 hours), during the period May- June 2015.

Step 8: To enter the data to the GLOBE science database.

Step 9: To collect and read bibliographic material about atmospheric pollution in the RM, Chile.

Step 10: to analyze the daily data, maximum and minimum for each school.

Step 11: to analyze the thermal amplitude (difference between maximum and minimum temperature) in each school.

Step 12: To enter the data to an Excel workbook and create the corresponding charts.

Step 13: to discuss, compare and analyze the data from both schools.

Step 14: To obtain and analyze the data for PM_{10} emissions registered in the Parque O'Higgins and Las Condes MACAM stations during the period from May to June 2015.

Step 15: To identify peaks of PM_{10} pollution registered in Parque O'Higgins and Las Condes MACAM stations [6] during the period from May to June 2015 and determine their relation to the temperature profile for each school.

SUMMARY OF RESULTS

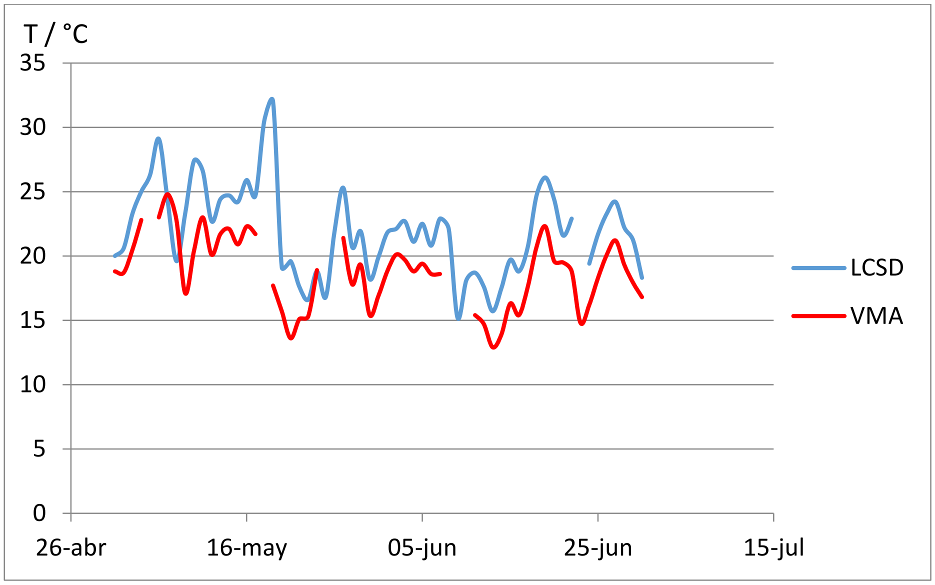


Figure 1: Comparison of maximum temperatures recorded on VMA and LCSD during the period May-June 2015. The temperatures were recorded every 6 days. The red line correspond to the data for VMA and the blue line to the LCSD data.

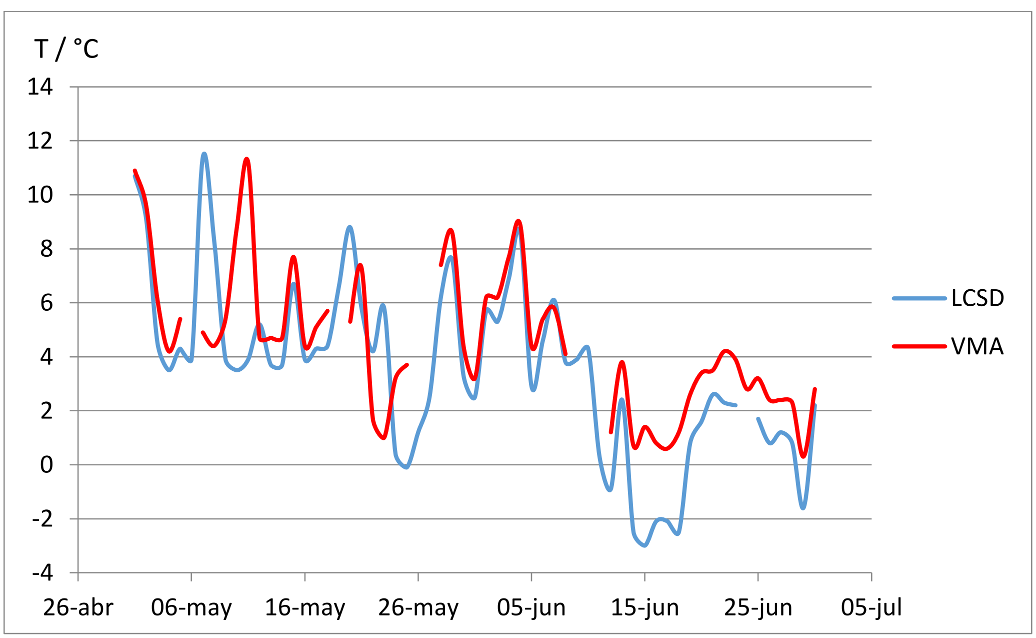


Figure 2: Comparison of minimum temperatures recorded on VMA and LCSD during the period May-June 2015. The red line correspond to the data for VMA and the blue line to the LCSD data.

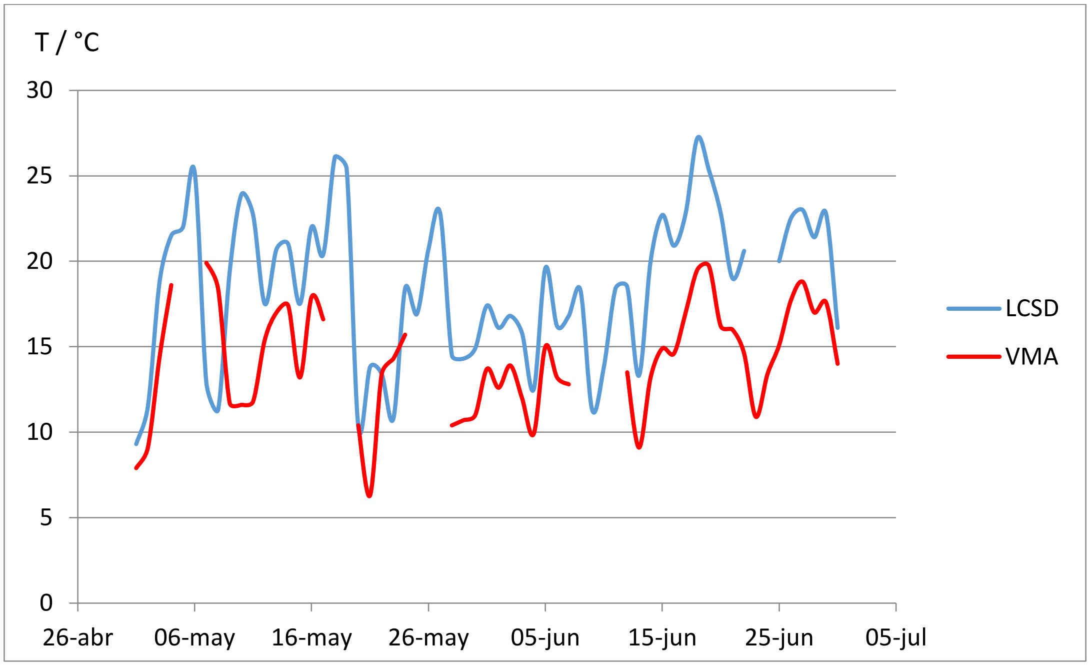


Figure 3: Comparison of the thermal amplitude for VMA and LCSD during the period May-June 2015. The red line correspond to the data for VMA and the blue line to the LCSD data.

	May		June	
Mean /°C	**LCSD**	**VMA**	**LCSD**	**VMA**
Maximum Temperature	22,9	19,5	21,0	18,0
Minimum Temperature	5,0	5,7	1,9	3,4
Thermal amplitude	18,0	13,6	19,1	14,7

Table 1: Monthly summary for the thermal parameters obtained in both schools. Each value correspond to the average temperature registered during May and June.

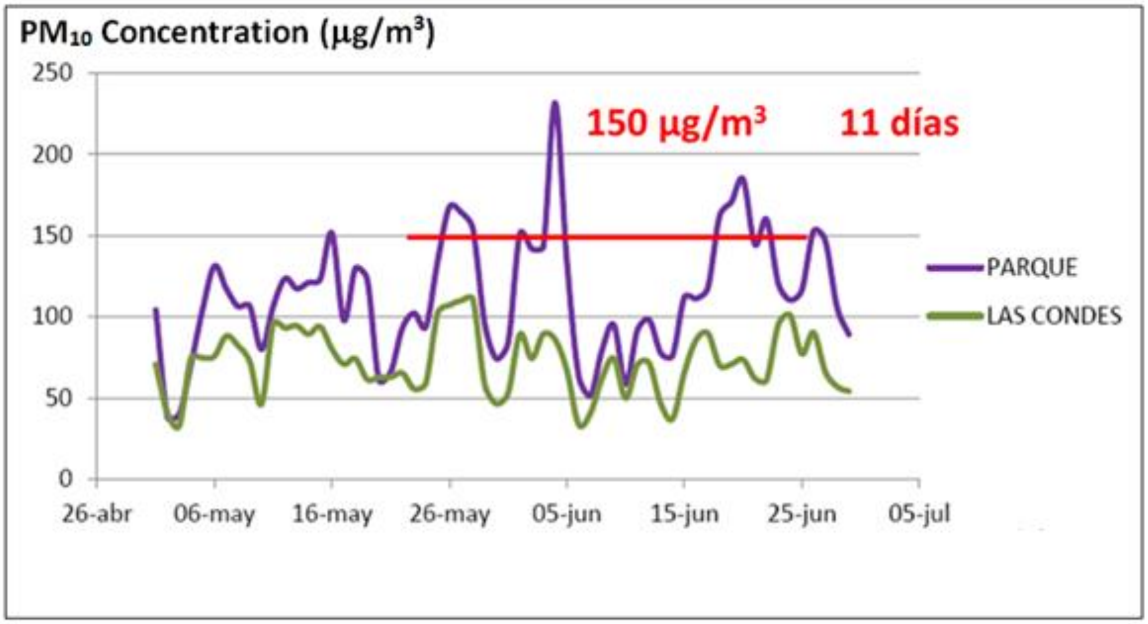


Figure 4: Comparison of the particulate matter PM_{10} level recorded at Parque O'Higgins and Las Condes monitoring stations between May and June 2015. The data showed in this figure was obtained from two stations belonging to the MACAM network, which are the closest station to each school. The green line correspond to the data registered in Las Condes station (the closest to VMA) the blue line to the Parque O'Higgins Station (the closest to LCSD). The red line correspond to the Primary Air Quality Standard for PM_{10} concentration: 150 $\mu g/m^3$. Source: Information System for Air Quality, Ministry of Environment, Chile.

DATA ANALYSIS

The Figure 1 shows that LCSD have higher temperatures than VMA during the period from May to June 2015. The difference for the average maximum temperature between both schools is 3.2°C. In the Figure 2 it is observed that the difference in the minimal temperatures is smaller in the same period of time, being of only 1.1°C. It is also noted that the days between June 12th and 19th are the coldest, registering the lowest temperatures in LCSD. For the thermal amplitudes, LCSD showed the highest values in the studied period. When the data for both schools were compared, the difference is of 3.4°C in average.

Based on these results, it is clear that between both schools there exists thermal differences which allows us to identify microclimates at a local level and LCSD can be recognized as a heat island. It is worth to mention that the identification of heat islands indicates unfavorable conditions for air quality in potentially critical situations of atmospheric pollution during the fall-winter season in the RM.

The microclimatic differences between VMA and LCSD are clearly established in the table 1, which shows a summary of the thermal parameters found in May and June 2015.

It is important to clarify that, in the present study, the atmospheric pollution variable was not measured by us, because we did not have the specific measurements instruments. However, these data was obtained from the database of particulate matter PM_{10} concentration recorded at the monitoring stations belonging to MACAM network. Specifically, we used the data from Las Condes station, in the eastern area, and Parque O'Higgins station in the western area; each one of them located in proximity to VMA or LCSD. The figure 4 shows the emission of particulate matter PM_{10} registered, at both stations, for the studied period. The concentration of PM_{10}, and therefore atmospheric pollution, is higher at Parque O'Higgins station; also, during 11 days it was higher than the Primary Air Quality Standard that correspond to 150 $\mu g/m^3$ [6]. In contrast, Las Condes station did not exceed the Primary Air Quality Standard throughout the study period.

CONCLUSION

The proposed hypothesis is accepted because significant differences were found when a comparison of VMA and LCSD temperature profiles were performed. Specifically, the maximum temperature and thermal amplitude for the period May-June 2015 might affect the distribution of atmospheric pollution levels.

DISCUSION

To determine if air temperature of our schools has a potential impact on atmospheric pollution by particulate matter, our research project was based in an earlier study that shows the distribution of particulate matter in accordance to microclimatic condition in the studied area [3]. This study compared the Western and Eastern areas of the RM during 2009. It concludes that the particulate matter PM_{10} concentration is increased in the Western area compared to the Eastern area of the RM during the more critical episodes of atmospheric pollution, which is explained by the local thermal differences.

Therefore, to observe what happens with the particulate matter in our schools, from May to June 2015, we used the PM_{10} emission data taken at the closest MACAM network monitoring station to each school: Las Condes and Parque O'Higgins stations [6]. However, to make this study more accurate it is necessary to have access to local atmospheric pollution data located in the same place of the studied microclimates.

Besides, the present study guide us to the following projection work:

- To study the relation between the hourly-variation temperature for each day and the urbanization characteristics present in the surrounding area to each school.
- To investigate the distribution and origin of atmospheric pollutants, specifically particulate matter PM_{10} or the aerosols emission during peaks of atmospheric pollution.
- To study the changes in thermal comfort and its effect on the anthropogenic activities that could influence in the increase of atmospheric pollution, for example, an increase on the consumption of thermal energy or the augmented use of vehicular transport in days with critical episodes of pollution.

Finally, it is important to mention some of the impacts that can be achieved through the realization of GLOBE scientific projects, referred to:

- Educational aspect: the students can develop abilities such as critical and creative thinking, effective communication, technological abilities and the sense of social responsibility. Also, the collaborative work between teachers and students from different schools, private and public institutions from the district a model for social integration.
- Political and social aspects: To give relevant information obtained by a local monitoring network to district authorities, allow them to use this information in taking measures and developing mechanisms that could promote to a better life quality for their inhabitants.
- Public Health aspect: To contribute with environmental information, at a smaller scale than a regional level, i.e. at a district level. Such as the relation between respiratory diseases and the increase of atmospheric pollutants throughout peaks of pollution, that might be useful in the implementation of palliative control measures among the high risk inhabitants in a determined district

ANNEXES

Annex 1. Maximum and minimum temperatures for VMA and LCSD corresponding to May and June 2015. The lacking data correspond to days when no data was measured.

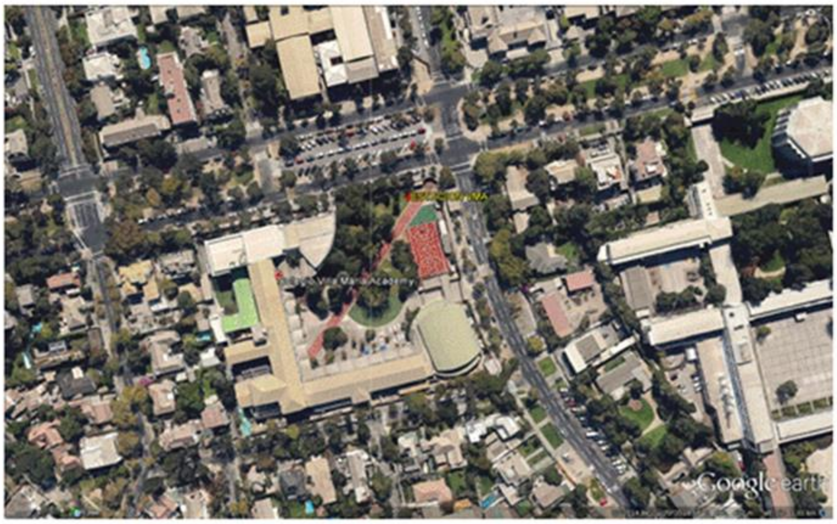
	LCSD			VMA		
Date	Current Temperature	Maximum Temperature	Minimum Temperature	Current Temperature	Maximum Temperature	Minimum Temperature
01-may	***17,4***	20,0	10,7	***17,0***	18,8	10,9
02-may	***17,4***	20,6	9,1	***17,5***	18,7	9,6
03-may	***18,0***	23,3	4,5	***18,2***	20,5	6,1
04-may	23,6	25,0	3,5	19,0	22,8	4,2
05-may	***20,1***	26,3	4,3	***19,0***	*	5,4
06-may	***22,0***	29,1	3,9	***20,0***	23,0	*
07-may	23,9	24,3	11,4	21,8	24,8	4,9
08-may	***16,4***	19,6	8,3	***18.6***	22,8	4,4
09-may	***17,9***	23,3	3,9	***16,0***	17,1	5,4
10-may	***20,7***	27,4	3,5	***19,0***	20,4	8,8
11-may	25,9	26,6	3,9	20,8	23,0	11,2
12-may	20,1	22,7	5,2	18,0	20,1	4,7
13-may	***18,6***	24,4	3,7	***19,6***	21,7	4,7
14-may	23,4	24,7	3,7	18,7	22,1	4,7
15-may	***19,3***	24,2	6,7	***19,1***	20,9	7,7
16-may	***19,7***	25,9	3,9	***19,9***	22,3	4,4
17-may	***19,0***	24,7	4,3	***19,0***	21,7	5,1
18-may	24,2	30,5	4,4	17,0	*	5,7
19-may	***24,9***	32,0	6,6	***16,0***	17,7	
20-may	***16,2***	19,1	8,8	***14,0***	15,7	5,3
21-may	***15,7***	19,6	5,8	***12,7***	13,6	7,3
22-may	***13,8***	17,6	4,2	***14,0***	15,1	1,7
23-may	***13,6***	16,6	5,8	***13,2***	15,3	1,0
24-may	***13,6***	18,8	0,4	***17,0***	18,9	3,2
25-may	14,6	16,8	-0,1	19,1	*	3,7
26-may	***16,1***	21,9	1,2	***18,0***	*	*
27-may	***18,9***	25,3	2,5	***17,0***	21,4	*
28-may	18,0	20,7	6,2	16,6	17,8	7,4
29-may	***17,9***	21,9	7,6	***17,9***	19,3	8,6
30-may	***14,0***	18,2	3,3	***13,7***	15,4	4,4
31-may	***15,0***	19,9	2,5	***14,7***	16,9	3,2
01-jun	15,3	21,8	5,7	***16,7***	18,8	6,2
02-jun	***17,4***	22,1	5,3	***19,2***	20,1	6,2
03-jun	***18,3***	22,7	6,9	***18,1***	19,7	7,7

04-jun	19,4	21,1	8,6	***17,9***	18,8	8,9
05-jun	***17,0***	22,5	2,9	***18,6***	19,4	4,4
06-jun	***16,3***	20,8	4,6	***17,1***	18,6	5,4
07-jun	***18,2***	22,9	6,1	***16,4***	18,6	5,8
08-jun	***17,0***	22,1	3,8	***18,6***	*	4,1
09-jun	***12,0***	15,2	3,9	*	*	*
10-jun	14,2	18,1	4,3	*	*	*
11-jun	***13,5***	18,7	0,3	*	15,4	*
12-jun	***12,4***	17,6	-0,9	12,9	14,7	1,2
13-jun	***12,0***	15,7	2,4	***11,0***	12,9	3,8
14-jun	***11,9***	17,5	-2,5	***11,8***	13,9	0,7
15-jun	***13,3***	19,7	-3,0	***14,0***	16,3	1,4
16-jun	16,8	18,8	-2,1	***14,4***	15,4	0,8
17-jun	***14,3***	20,7	-2,1	13,7	17,6	0,6
18-jun	21,2	24,7	-2,5	***18,0***	20,7	1,2
19-jun	***19,0***	26,1	0,8	***18,5***	22,3	2,6
20-jun	***18,0***	24,4	1,6	***17,9***	19,6	3,4
21-jun	***16,3***	21,6	2,6	***17,5***	19,5	3,5
22-jun	***17,1***	22,9	2,3	18,3	18,8	4,2
23-jun	16,8	*	2,2	***13,0***	14,8	3,9
24-jun	***14,0***	19,4	*	***14,3***	16,2	2,8
25-jun	***16,1***	21,7	1,7	***16,7***	18,3	3,2
26-jun	***17,0***	23,3	0,8	***17,8***	20,1	2,4
27-jun	***17,8***	24,2	1,2	***18,6***	21,2	2,4
28-jun	***16,2***	22,2	0,8	***17,1***	19,3	2,3
29-jun	***14,8***	21,2	-1,6	***16,1***	17,9	0,3
30-jun	16,8	*	2,2	15,7	16,8	2,8

1. * Temperature data not registered.
2. Data Current temperature in cursive and bold were estimated by interpolation according to the following formula:

$$T\ current\ = 0.72\ (T\max - T\min) + T\ min.$$

Annex 2. Location of instrument shelters in each school. The upper satellite map correspond to VMA and the lower to LCSD.



VMA: Villa María Academy

LCSD: Liceo Carmela Silva Donoso

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   Protocolos

   - Definición del sitio.
   - Instalación caseta metrológica en cada establecimiento.
   - Calibración del termómetro de mercurio.
   - Instalación de termómetro, Digital Dual Sensor Thermometer marca Forestry Suppliers en la caseta meteorológica
   - Puesta a Cero del Termómetro Digital Multi-Dia de Max/Min.
   - Calibración de instrumento de medición, Digital Dual Sensor Thermometer marca Forestry Suppliers.
   - Registro diario de las temperaturas máximas y mínimas realizado con un Digital Dual Sensor Thermometer.
   - Subir datos obtenidos al sitio GLOBE.
6. RED MACAM. Sistema de Información Nacional de Calidad del Aire. Ministerio del Medio Ambiente. Gobierno de Chile