Abstract:

In this report we present an interdisciplinary research and development work carried out by the students of the ETec, located in the province of Mendoza, Argentina. From the geography classes we carry out practical activities. Accompanied with the observation and detection of a local problem. Due to its infrequency, the intense hailstorms that affect the Benegas urban area are not noticed with anticipation by the citizens, generating considerable damage. Because our school is technically oriented, we propose the following solution:

"It is possible to develop a system composed by open source software and hardware technologies for meteorological data acquisition. This system will use atmospheric data like temperature, humidity, atmospheric pressure and cloudiness in order to emit hail storm alerts to the citizens of Benegas area mitigating the damage produced in the community of the area."

Once the solution to the problem is established, we set the objectives of the work:

- Take reliable weather variables from our school.
- Store and process data collected with open source technologies.
- Make data acquisition automatically using open source technologies.
- Create an app that reports the atmospheric state of the school zone and in the presence of possible hail storms, issue alerts.

Disseminate the project and make the software as well as the hardware available to the community. We divided the tasks and formed two work teams: A team was responsible for the observation and collection of meteorological variables. For this we work with the **GLOBE atmosphere protocols.**

The other team was dedicated to developing devices to perform data acquisition and software tools to store and process them.

During 2018 we were able to carry out part of the objectives set, currently we continue working on the creation and diffusion of the app.

Keywords: Meteorology, Hail, Arduino, Open Source Technologies.

STORM SEEKER: "An open source meteorological data acquisition system for local hail storm prediction"

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27/03/2018

Table of contents:

Research questions & hypothesis and Introduction

The current project is the result of an interdisciplinary work done by the ETEC's students.

From geography class, we performed many activities that allow us to observe closely the climatic characteristics from our hometown.

How did we do it?

- We built homemade meteorological instruments, which we use to take data of temperature, atmospheric pressure, wind presence and direction, level of water from precipitation, you can see some of the instruments made in the images 1, 2y 3.

Image1: Barometer made by students

Image 2: Vane built in class.

Image 3: Rain gauge located in school yard

Image 4: GLOBE protocols, used by students.

To complete our data gathering:

We started working with ***GLOBE atmospheric protocols***; in this stage we used printed clouds protocols. In picture number 4a[1], there are some of these protocols shown. As we did not have a specific atmospheric point of study, we took measure in several points at the school.

As we obtained data with the use of the protocols, we were registering them in the atmospheric research worksheets for periods, the image 4b shows one of the worksheets worked.

[1] To see all the protocols, go to: https://drive.google.com/file/d/1EyvUHI0e-KrDRuE1kvpDyb2zSfdpoznD/view?usp=sharing

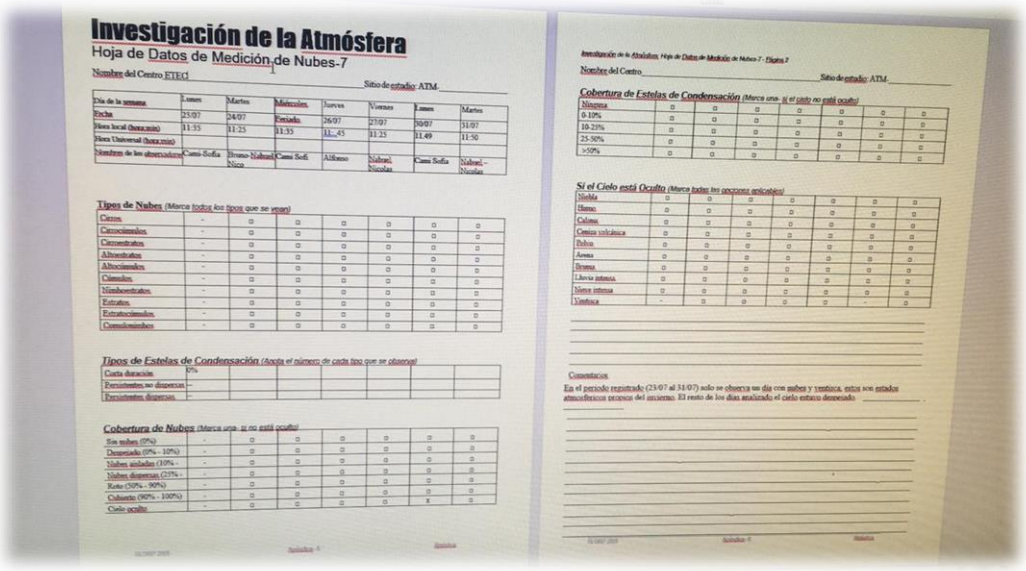
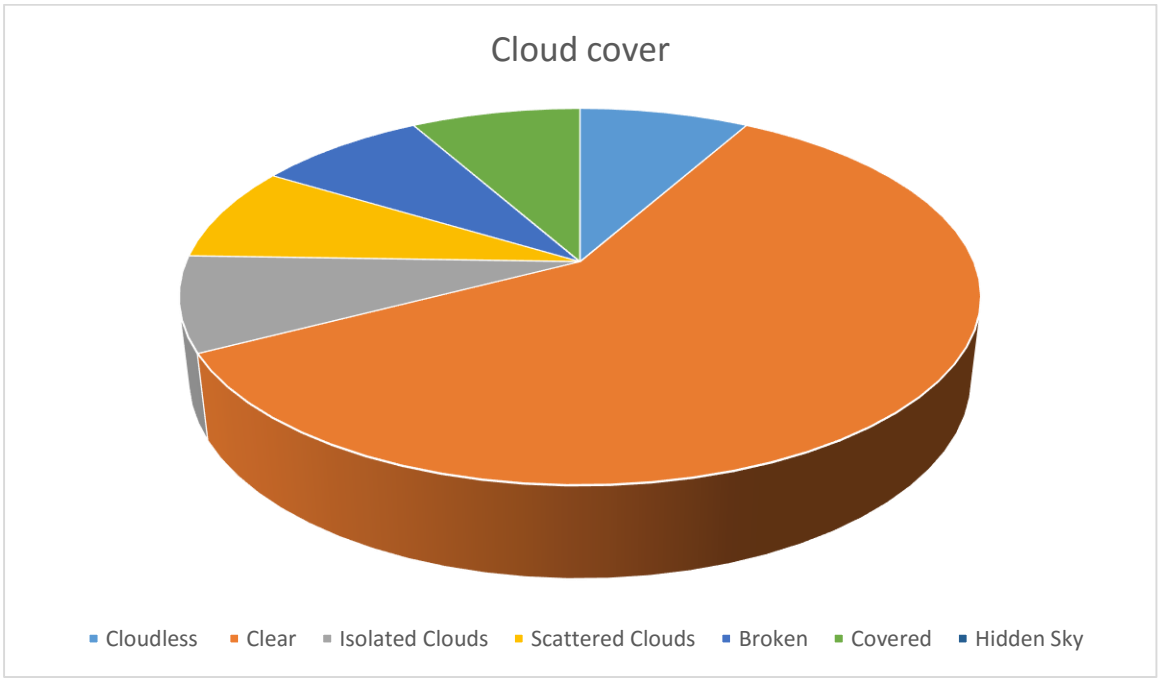


Image 4b : 7-day cloud study data register.

The following are the results for that measures:

Graphic 1



As it´s possible to appreciate in the graph 1, the majority of the days registered are clear, a very small percentage of days' presents cloudiness.

All along July, we registered the data these instruments gave us, along the data delivered by a Climate App and the "Servicio Meteorológico Nacional" (National Meteorological Service). In picture number 5, the data register schemes are shown glued to the wall.

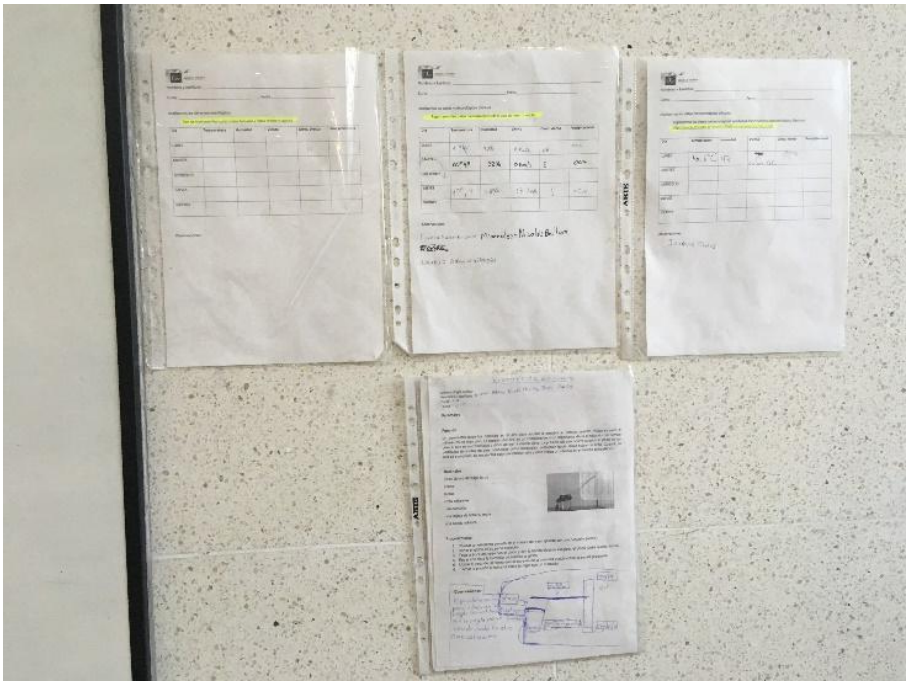


Image 5: Tables of data records pasted on the walls of the course.

Table 1 shows the observations made regarding the reliability of the data provided by each source of information.

Table 1

Source of data	**Observations**
Instruments made by the students	Data could be taken, but the lack of accuracy and little stability of the same did not allow us to build monthly average data.
Servicio Meteorológico Nacional (SMN)	Both give us the same value
Mobile App	

The analysis of the data is translated in Table 2:

Table 2

Average values for July 2018	
Monthly Average Temp.	11°C
Max. Temperature	26°C
Min. Temperature	-1°C
Average Precipitation	--------
Average Pressure	1018.4 hPa
Average wind speed	8.1 Km/h

The results of these observations was accompanied with an investigation of diverse biologic sources; as a result of this recollection stage of data we managed to build a characterization of the main weather traits of our zone, which we detail in the following paragraph:

Because of its latitudinal location, Mendoza presents tempered characteristics, but for being at the bottom of the Cordillera de los Andes (image nº6) arid characteristics can be appreciated

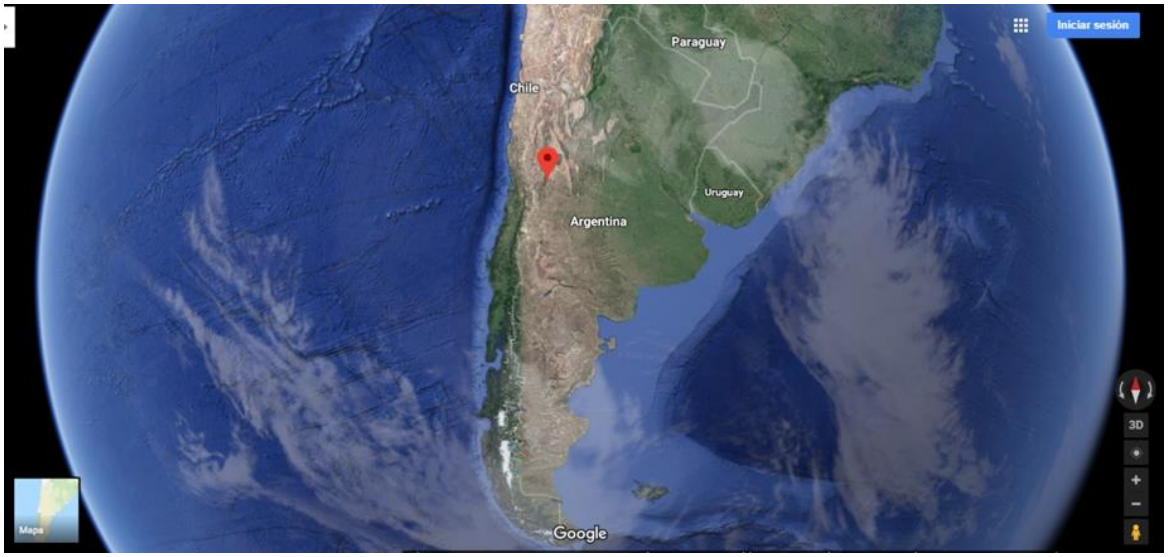


Image 6 . https://www.google.com.ar/maps/place/Mendoza,+Capital,+Mendoza/@-29.8916855,-67.1237083,7687867m/data=!3m1!1e3!4m5!3m4!1s0x967e093ec45179bf:0x205a78f6d20efa3a!8m2!3d-32.8894587!4d-68.8458386. Accessed 26/03/2019

The average temperature in the plain is 15º C, with maximums that climb up to 42º C and minimum temperatures that drop to -5º C while rainfall does not exceed 200 mm per year. In the months of

autumn and winter and, at the beginning of spring, one of the most characteristic winds of the province is the Zonda wind[2].

The days in Mendoza are mostly clear, skies that lack cloudiness and mists that occur only exceptionally. According to recent studies, these climatic characteristics could have undergone some modifications due to climate change[3], detecting summers with higher than average temperatures and winters with temperatures lower than historical averages. The Province of Mendoza is one of the main zones of occurrence of hail storms in the Argentine Republic[4]. The aridity described above was mitigated by the society with the construction of a system of distribution and administration of water, through a network of dams, reservoirs, channels and ditches[5], creating a true artificial oasis.

As we can see on Image 7, our school is on an urban zone (Benegas) with abundant public trees.
The observations made and the data obtained generated in us several questions that surpassed the characterization of our climate, worked until the moment, some of these questions are posed next:
how does the storms form?
in what conditions does the hail form?
Is there a connection between the zonda wind and the hail?
Is there a risk of hail storms for the whole province?
Is society prepared to mitigate the impact of a hail storm?

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2 It´s a hot and dry wind that blows in the west of Argentina, to leeward of the Cordillera of Los Andes, between the 38 degrees' south latitude and the south of Bolivia. It belongs to the group of winds that descend from the crest of the mountain to the valley or the plain.
It´s similar to the fohen of the European Alps, to the Chinook of the Cordillera Rocallosa in the United States and Canada; to the berg-wind of South Africa; to the norwesterly of New Zealand.
The climatology of the phenomenon shows an annual distribution with a maximum in winter.

The Zonda wind is produced by the rise of humid air from the Pacific Ocean to the windward side of the Andes Mountain and by the subsequent orographic descent of a prefrontal air mass that at the top of the Cordillera is presented as a cold wind but it becomes warmer when descending.
The Zonda wind in the plain drags a lot of dust especially in August, at the end of the dry season, which in central-western Argentina is in winter. North, F. A. 1988. Climatic characteristics of the Zonda wind in the Cuyo region. Doctoral thesis. Faculty of Exact and Natural Sciences. Buenos Aires' University.

[3]See Impact of climate change in Mendoza Volume 47 • N ° 1 • 2015 Rev. FCA UNCUYO. 2015. 47 (1): 67-92. ISSN printed 0370-4661. ISSN (online) 1853-8665. Impact of climate change in Mendoza. Climatic variation in the last 50 years. Look from the physiology of the grapevine Climate change impact in Mendoza. Climate variation on the last 50 years. A view to grapevine physiology Leonor Deis 1, María Inés de Rosas 1, 2, Emiliano Malovini 1, 2, Martín Cavagnaro 3, Juan Bruno Cavagnaro 2 Originals: Reception: 09/17/2014 - Acceptance: 04/16/2015

[4] Mezher, R. N., Doyle, M., & Barros, V. (2012). Climatology of hail in Argentina. Atmospheric Research, 114(115), 70-82.

[5] Mendoza's water system of canals and canals has its origin in the Huarpe culture that existed before the arrival of the Spanish conquerors in the mid-sixteenth century. It also has a cultural and historical link with the Inca Empire that had, precisely in the current Mendoza its southernmost point. Edition U 13 - Roots / by Jorge Ricardo Ponte, researcher of the Conicet CCT Mendoza (08-14-2016)

In order to correct our doubts, Dr. Ing. Lucas Iacono, our Director of Studies of ETec, called Dr. Jorge Rubén Santos, who has a PhD in the Atmospheric and Oceanics Sciences Department of McGill University to give us a chat.

Image 7: screenshot Google maps, Artigas street (entrance of the school)
https://www.google.com.ar/maps/@-32.9516274,-vist68.8523678,3a,75y,94.94h,87.74t/data=!3m7!1e1!3m5!1sqlXrnsqcFEa-ZCW_JLBy6A!2e0!6s%2F%2Fgeo2.ggpht.com%2Fcbk%3Fpanoid%3DqlXrnsqcFEa-ZCW_JLBy6A%26output%3Dthumbnail%26cb_client%3Dmaps_sv.tactile.gps%26thumb%3D2%26w%3D203%26h%3D100%26yaw%3D137.03777%26pitch%3D0%26thumbfov%3D100!7i13312!8i6656
Accessed 28/03/2019.

After the dissertation our interest continued to grow, responding to our concerns the Meteorology Workshop is created, which is a research space open to students of all years.
In the first meetings of the workshop we return to our previous investigations and detect a problem:

Because of it's low frecuency, the intense hail storms that affect the Urban Area of Benegas are not warned with anticipation by citizens, generating a lot of damage.

Due to the fact that our school grants degrees in Electronic Technician or Computer Technician, we follow this orientation to propose the following solution:

"It is possible to develop a system composed by open source software and hardware technologies for meteorological data acquisition. This system will use atmospheric data like temperature, humidity, atmospheric pressure and cloudiness in order to emit hail storm alerts to the citizens of Benegas area mitigating the damage produced in the community of the area."

Methods and Materials:

In order to carry out our project and verify its viability, we divided the tasks and formed two work teams:

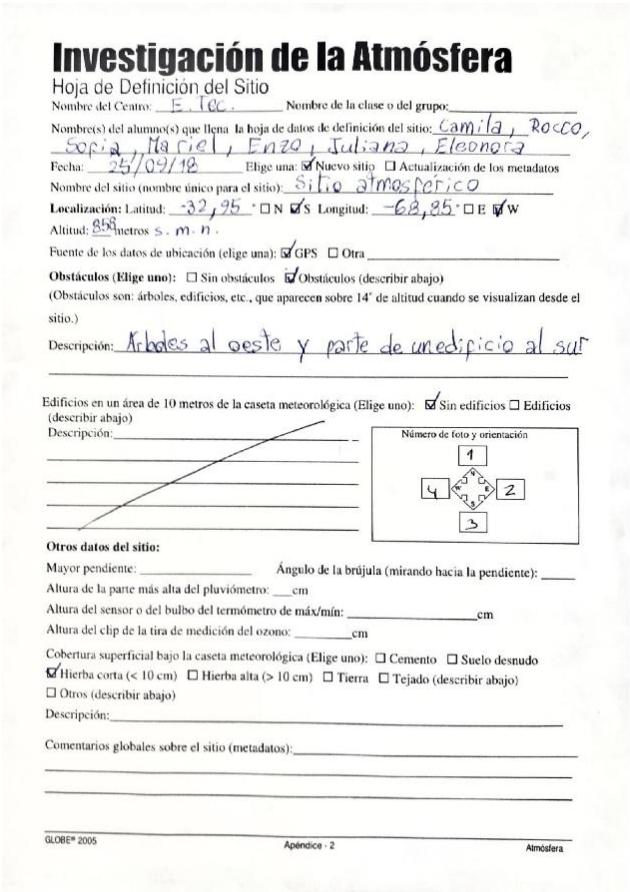
First, a team was responsible for the observation and collection of meteorological variables. The other team was dedicated to developing devices to perform data acquisition and software tools to store and process them.

In the first group we developed the following activities:

The first step for data collection was to establish an ***Atmosphere site*** using the site selection protocols (images 8, 9 , 10 and 11) ***provided by GLOBE.***

Image 8: Building a clinometer for site selection.

Image 9 and 10: Students choosing site selection.



Investigación de la Atmósfera

Hoja de Definición del Sitio

Nombre del Centro: E. Tec. Nombre de la clase o del grupo:

Nombre(s) del alumno(s) que llena la hoja de datos de definición del sitio: Camila, Rocco, Sofía, Maricel, Enzo, Juliana, Eleonora

Fecha: 25/09/18 Elige una: ☑ Nuevo sitio ☐ Actualización de los metadatos

Nombre del sitio (nombre único para el sitio): Sitio atmosférico

Localización: Latitud: -32,95 ° ☐ N ☑ S Longitud: -68,85 ° ☐ E ☑ W

Altitud: 858 metros s. m. n.

Fuente de los datos de ubicación (elige una): ☑ GPS ☐ Otra

Obstáculos (Elige uno): ☐ Sin obstáculos ☑ Obstáculos (describir abajo)

(Obstáculos son: árboles, edificios, etc., que aparecen sobre 14° de altitud cuando se visualizan desde el sitio.)

Descripción: Árboles al oeste y parte de un edificio al sur

Edificios en un área de 10 metros de la caseta meteorológica (Elige uno): ☑ Sin edificios ☐ Edificios (describir abajo)

Descripción:

Número de foto y orientación

1 2 3 4

Otros datos del sitio:

Mayor pendiente: Ángulo de la brújula (mirando hacia la pendiente):

Altura de la parte más alta del pluviómetro: cm

Altura del sensor o del bulbo del termómetro de máx/mín: cm

Altura del clip de la tira de medición del ozono: cm

Cobertura superficial bajo la caseta meteorológica (Elige uno): ☐ Cemento ☐ Suelo desnudo ☑ Hierba corta (< 10 cm) ☐ Hierba alta (> 10 cm) ☐ Tierra ☐ Tejado (describir abajo) ☐ Otros (describir abajo)

Descripción:

Comentarios globales sobre el sitio (metadatos):

GLOBE® 2005 Apéndice - 2 Atmósfera

Image 11: Atmosphere site selection sheet

- We download App GLOBE OBSERVER AND GLOBE DATA ENTRY. Once installed, we started uploading data to the GLOBE platform. The data collection dates and times were made in the afternoon and at the times when the satellites passed through our location (image 11).

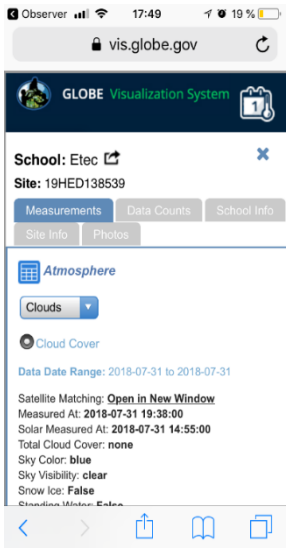


Image 11: Screenshot of data uploaded to GLOBE

- We installed the GLOBE account of our teacher in the PC of the Teachers' Room and started loading the data from the desktop computer along with those of the APP.

The first visualization of data taken by us was very incredible.

Image 12: Screenshot of data uploaded in GLOBE

- Parallel to these actions we began the construction of our weather house, following the instructions of the GLOBE program. Images 13 and 14 illustrate the work of teachers and students.

Image 13: Teacher Marianetti working on the construction of the shed.

Image 14 Giving the final details.

Dr. Rubén Santos continued working with us as a direct collaborator, image 14 shows the work in the workshop.

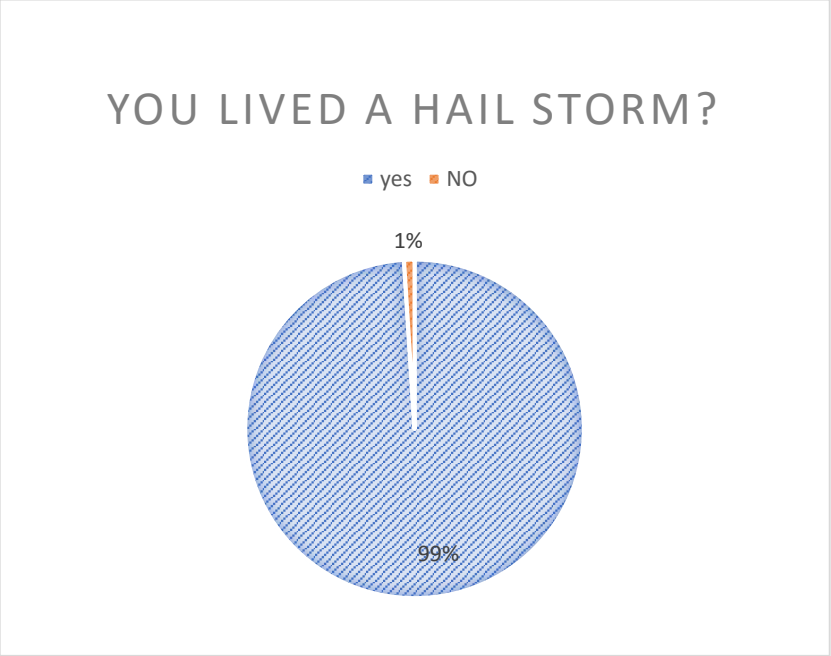
Image 15: data collection team with Dr. Santos and Teachr Morelli.

In one of the meetings we discovered that Godoy Cruz, according to the data of the Directorate of Agriculture and Climatic Contingencies of the Province of Mendoza (DACC), does not constitute a department with great risks of hail. However, we note that Luján de Cuyo (department next to Godoy Cruz) does have a high probability of storms[6]. We understand that this point is one of the causes of the lack of prevention against hail storms, being a phenomenon that develops with greater intensity in other locations, the citizens of Godoy Cruz are not prepared to face the phenomenon.

The DACC has developed an app that issues alerts about hail storms. After analyzing the application we reached the conclusion that it did not solve the problem detected since the alerts issued are for a region and not for a particular town. That is why we continue with the creation of our own APP.
In order to know the opinion of the neighbors we conducted a survey, which allowed the following graphics to be elaborated:

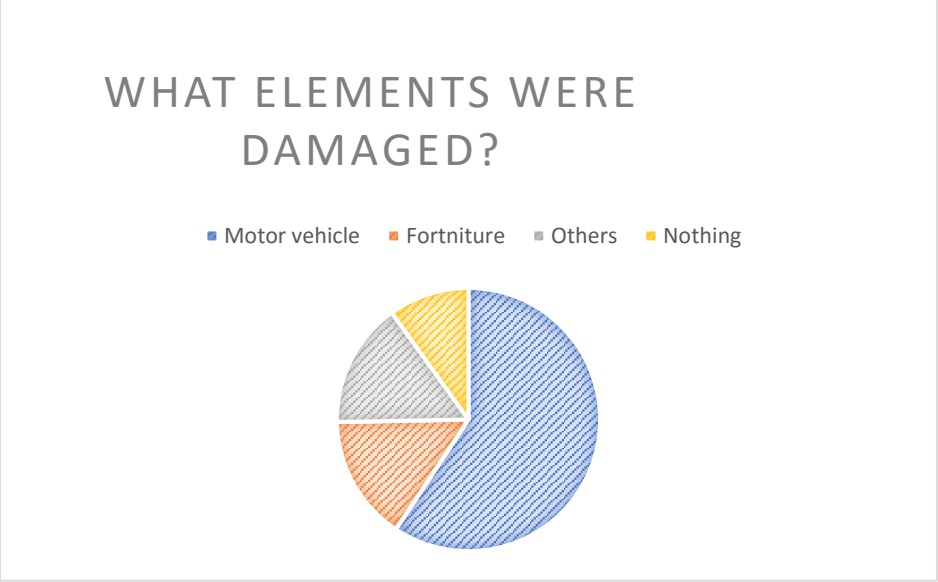
[6] To see the damage history of hail storms by area and most affected departments, consult : http://www.contingencias.mendoza.gov.ar/web1/agrometeorologia/danos_zona_norte.php. (spanish)

Graphic 2



To this point we conclude that, despite being few, 99% of the people interviewed lived a hail storm.

Graphic 3



To this point we conclude that more than 50% of the received damage is in vehicles, we consider that these damage could decrease with the use of our app.

We consulted about the interest in downloading and using an application that emits alerts about hail storms, we obtained the following results:

Although it is a first approximation, the data regarding the interest were encouraging.

Graphic 4

Continuing with the work of data collection, we began to receive reports from the satellites, in order to analyze them we counted on the advice of Prof. of English Leticia Savoy to be able to translate the information and Dr. Santos who helped us analyze the data and add them to our collection of weather variables that will then be disseminated in the App that our technical team is currently developing.

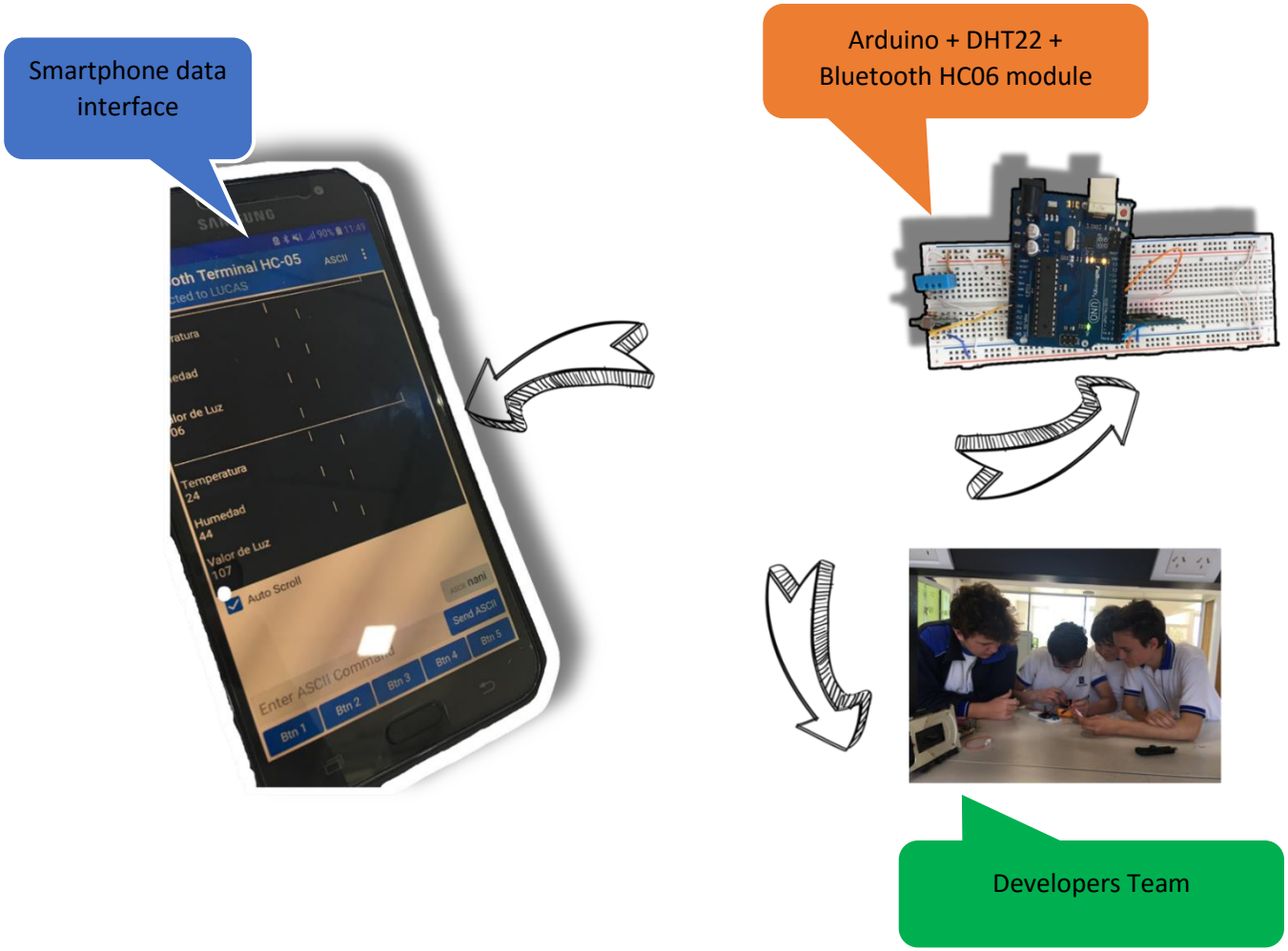
On the other hand, the technical team is working on the following actions:

-Arm of meteorological house with sensors and embedded system (Arduino embedded system).

What we did was a meteorological booth which included a prototype device to acquire data and transmit it to a user via bluetooth and issue alarms via emails. This was done with DHT22 digital temperature and humidity sensors, an Arduino board, a computer with an application developed in Python and a spreadsheet. This application reflects the data obtained from the Arduino in a graphic interface made with the TKINTER library. Then, the same data is stored in a spreadsheet. In addition, we started working on data analysis automatically using another application developed in Python, this allowed us to send an email to the user in case a certain temperature and humidity limit was exceeded.

In the following figure, the first prototype of the data acquisition device can be observed:

Data Acquisition System and Developer Team



The school and some of the members of the team had several of the materials to develop the system (Arduino, sensors and other components). We assembled the necessary materials. Then, we investigated about the programming of the sensors, arduino and bluetooth module. Then, the prototype was assembled in a test plate, we programmed them in Arduino language and after several attempts we managed to work correctly. We went through a process of analysis and solution of errors, because the result was not the sought after, and once these errors were solved, we made a graphical interface pleasant to the eye.

This project was diffused through different means:

- Diffusion in the official Facebook of the school, in picture 16 a screenshot is shown with the presentation of the GLOBE program made on September 06th, 2018.

Image 16: Communication of participation in the GLOBE Program.

- Webinar Argentina 2018

On November 06 we had the pleasure of presenting our work in Webinar Argentina 2018.
In images 17 and 18 the team is presenting the work:

Image 17: students next to teacher Morelli about to start the video call.

Image 18: Our team after the Webinar.

- **Institutional science fair**

In this opportunity we presented our work to the educational community, we talked about our work to the guests and we invited the parents to participate in the observations of clouds. In image 19 the presentation stand is shown.

Image 19: Camila and Sofia in a dissertation about our project

All dissemination activities allow us to get closer to the community for which we are working on this project.

Conclusions

The main conclusions of the work carried out are the following. In the first place, the prototype of our system for data acquisition, storage and representation fulfilled the proposed objectives. These objectives are (i) obtain the necessary data to make statistics and (ii) perform "alerts" for the local community using Internet. Secondly, a team of students could be formed to implement the data collection according to GLOBE protocols. The work carried out by our teams allowed to validate the hypothesis of work proposed at the beginning of this work. This will continue through the activities detailed in the "Discussion" section that will be developed throughout the currently school year.

Discussion

As a starting point, a survey of local hail storm prediction applications was made in Mendoza. While there is an application that makes hail forecasts in the province, this one not provides local alerts for particular towns. This is an incentive for the development of our own application. Another aspect to note is that we found open source technologies to develop the project. These can be used by other institutions to contribute with data to the community.

As future work, the following activities are planned:

In order to visualize the data of the booth via the web or through an application for smartphones (Android), a server must be implemented to receive the data from the Arduino. In addition, this server will allow to provide data throught http, so that they can be consumed by the different devices. Then two types of client applications will be developed (the client is the one who consults the server to obtain the data, which is then formatted and presented to the user). One for Android OS and the other one for PC Web browsers. With these tools the people of our community can get a warning about the occurrence of hail storms in our city. Finally, it must be noted that all software and hardware developments performed in our work will be documented and uploaded to an Internet public repository in order that they can be accessed by different institutions.

Acknowledgments

We appreciate the opportunity that the school gave us to carry out this project, to the professors who brought us this idea and who were helping us and accompanying us along the way we have traveled and in which we still have to go, thanks to them we obtained the necessary means and knowledge to to be able to carry out our research activity, enriched with the contribution of Dr. Rubén Santos. We thank the management team of the ETEC and the University of Mendoza for giving us all their support.

We cannot fail to thank the GLOBE program, especially the team from Argentina that allowed us, through the protocols, to take reliable data for our research, as well as share them with the GLOBE community. Each of the instances of participation, including this opportunity, has been a great growth for us.

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• Atmosphere: Site Selection and Configuration

• Cloud protocols

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