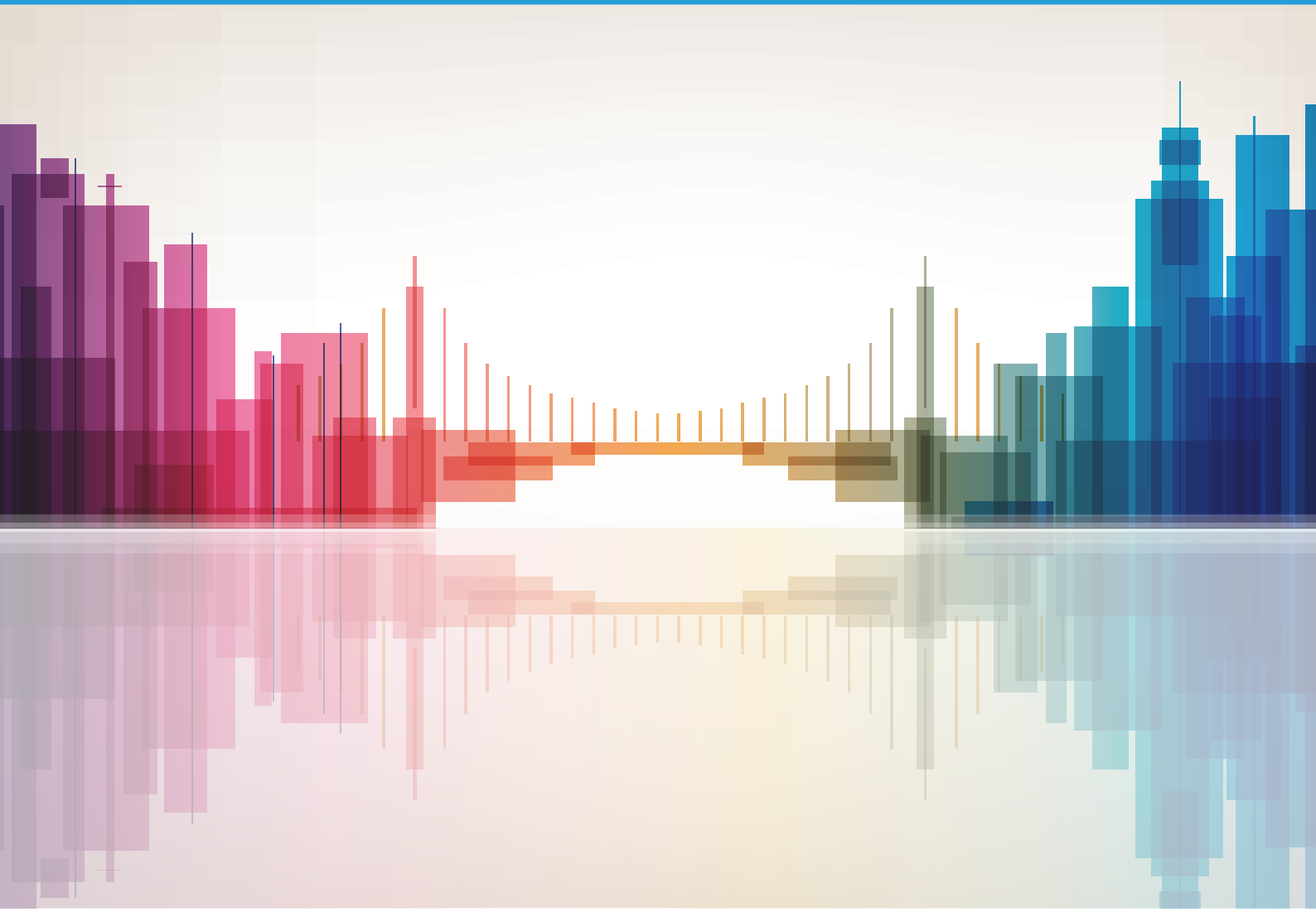
United 4 Smart Sustainable Cities

Air quality management in Southern California, USA

Case study of the U4SSC City Science Application Framework



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United 4 Smart Sustainable Cities

Case study: Air quality management in Southern California

California, USA

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Foreword

This publication has been developed within the framework of the United for Smart Sustainable Cities (U4SSC) initiative.

Acknowledgements

The development of the Case study: Air quality management in Southern California has been written by Alex Mateo (Envirosuite) and has been edited and revised by Okan Geray (Smart Dubai Office).

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1. Introduction

1.1. Background

San Francisco Bay Area population has been intensely growing during the last decades, with a census of around 5 million people in 1980, and an estimation of 7,756,158 inhabitants in 2017.

Source: Bay Area Air Quality Management District.

South Coast Air Quality Management District (SCAQMD) is composed of four counties (Los Angeles, Orange, Riverside and San Bernardino), with an estimated population of around 17 million people.

Source: South Coast Air Quality Management District.

The impact on the air quality coming from human and economic activities is very high and public authorities are becoming aware of the seriousness of air pollution and the negative effects have had on population health.

In California air pollution is managed at the regional level across 35 regional pollution districts. Two of these districts are the Bay Area Air Quality Management District (BAAQMD) and the South Coast Air Quality Management District (SCAQMD), which are responsible for regulating and managing the air quality in those areas.

Both districts currently use Envirosuite to provide a more rapid and effective response to air quality incidents. Presently, sensor data must go through a significant and time-consuming processing before it is available to be analysed for managing air quality incidents that have occurred. By the time issues are understood, the opportunity to solve those problems may have already passed. Envirosuite provides insights based on real-time information so that anyone can quickly understand the issue at hand and employs the unique tools in the Envirosuite platform to instantly identify the source of the issue.

There are current Smart and Resilient Cities trends that are promoting these types of Internet of Things projects all around the world, collecting real-time data from sensors and transforming them into valuable information through software, allowing decision makers to react immediately.

For instance, the US Department of Transportation awarded in 2016 the US City of Columbus with 50M$ after being selected showcasing a holistic and comprehensive vision of “how technology can help all residents move better and access opportunity”. The City has grown its initial funding of 50M$ to nearly 500M$ by the end of 2017.

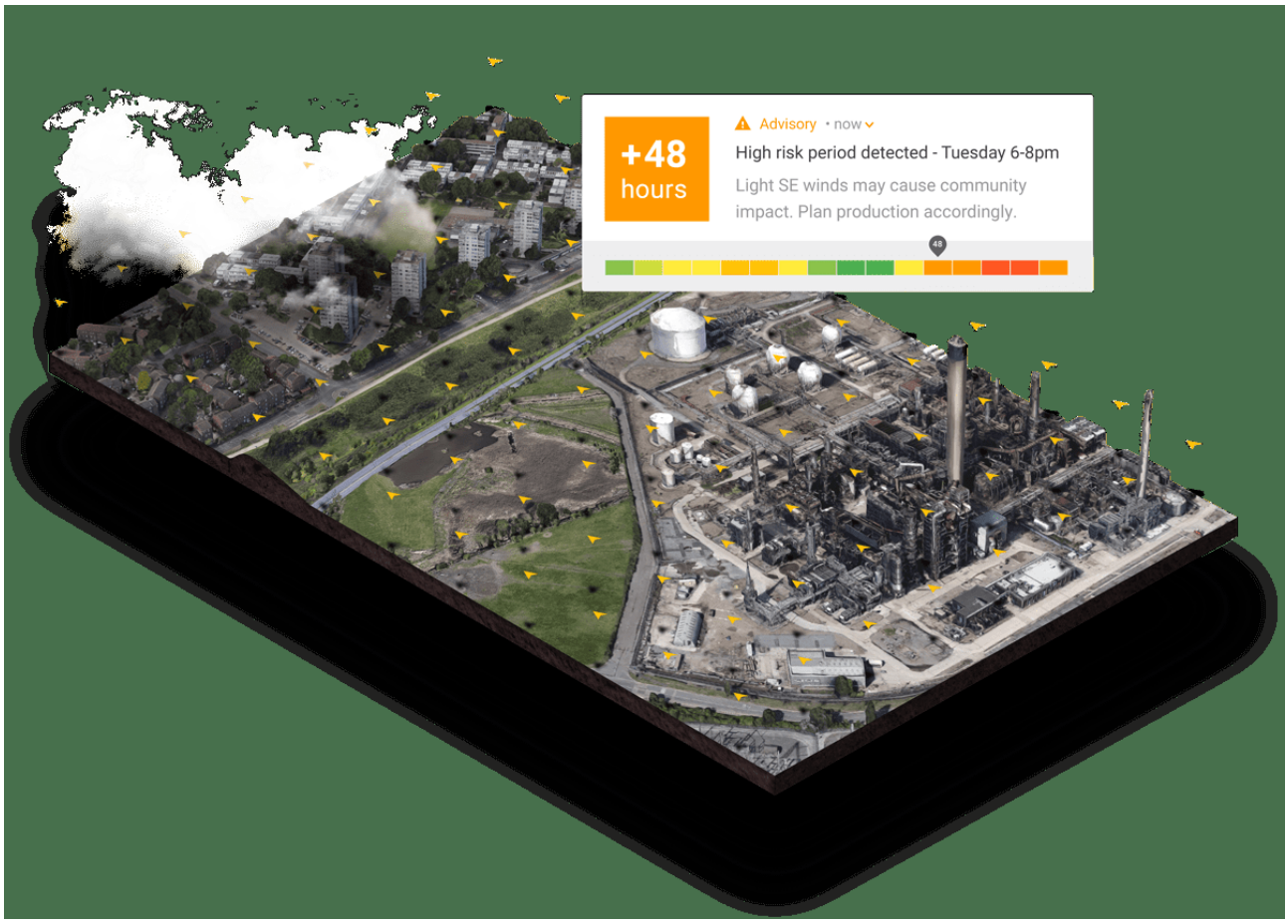
1.2. Challenge and response

Some regions in California experience high air pollution levels every day. This can be attributed to different factors such as traffic, industry or wildfires. This high level of pollution is affecting the population's health and life expectancy.

The Californian legislation has considered to use advanced sensing monitoring technologies to reduce air pollution but it also stipulates that air districts are to 'identify the contributing sources, and provide a catalyst and a platform for community engagement towards eliminating emissions hotspots'.

The solution discussed in this case study visualizes air quality data using an easy to understand color-coding system — this allows regulators to see the issues at hand clearly, identify who's responsible, assess the impacts it has had on the community in real-time and how to fix the problem. Moreover, the system helps to identify the origins of the pollution by drawing back trajectories and pinpointing potential sources within seconds of incidents occurring, a novel capability not previously available.

Figure 1: Illustration of the Solution[1]



2. The smart project(s)

2.1. Vision and content

The air quality approach discussed in this case study integrates air quality sensor data with measured and modelled meteorology and presents the information in a way that facilitates rapid understanding and response. Sophisticated analytical methods are used but re-engineered and presented in a way that non-subject matter experts can use.

The Southern California districts' target is very clear: to clean the air and protect the health of all residents through practical and innovative strategies, adopting policies and regulations, considering also ideas and comments from the public. A Governing Board comprised of several members discusses the way to improve the air quality and establish effective clean air programs. It has concluded that a digital platform that is capable of analyzing a wide-ranged of real-time data is an essential component to improve air quality in the districts.

The key feature is the ability to use proprietary algorithms based on mathematical atmospheric dispersion models such as WRF (Weather Research and Forecasting)[2], CALMET[3] (Computer Aided Learning in Meteorology) and CALPUFF (California Puff Model)[4].

These models are preferred by the US Environmental Protection Agency for assessing long range transport of pollutants and their impacts on a case-by-case basis for certain near-field applications involving complex meteorological conditions.

Many cities and regions all around the world have implemented online sites, dashboards and platforms that show and graph air quality information so citizens can check the air pollution and make decisions according to that.

Moreover, it is also typical that these Smart City platforms allow to check other vertical applications data such as water quality, weather data, waste management, car park availability, etc. but it is relatively rare to see that the intelligence behind these platforms correlate different siloed data.

Envirosuite´s platform combine multiple data sources data such as air quality data, weather data, emission rates, weather forecasts and altitude to provide a very accurate baseline about air pollution. Significant innovation in design makes complex data sets simple for non-subject matter experts to understand and use in real-time decision making and response to incidents.

And the solution has been implemented on a very large scale, covering several counties with the technical challenges this implies.

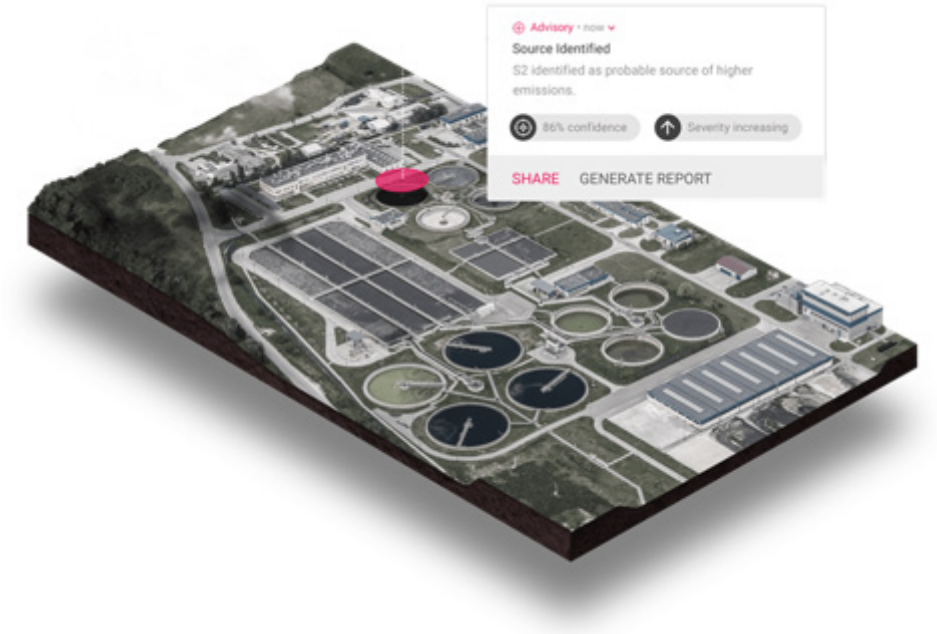
Information and Communications Technologies are crucial for this project as real-time data is needed in order to feed Envirosuite´s proprietary algorithms. Real-time air quality data from these Districts' air quality monitoring network is collected and aggregated as a dataset. It is then augmented with real-time actual weather data and sent to Envirosuite´s platform for processing (Envirosuite platform is running on Amazon Web Services).

On this platform, cloud computing techniques are applied in order to transform the data into usable and actionable information that facilitates pollution mitigation actions.

2.2. Implementation

Two unique approaches are used during the implementation phase. 1) Sensor data are integrated with real-time information on wind speed, wind direction and the variability in wind direction to provide a real-time designation of the likely area that a measured value has originated from. With clever design, users of the system can immediately see which industry or other source is the likely cause of air quality incident. 2) Three-dimensional, non-steady state meteorological modelling techniques (commonly used in advanced dispersion modelling) are re-engineered and reprocessed and displayed in a way to provide an immediate reverse trajectory display of the likely source of elevated sensor value or complaint in the community.

Figure 2: Illustration of Source Identification[5]



In response to Assembly Bill (AB) 617[6], the California Air Resources Board (CARB) established the Community Air Protection Program which focuses on reducing exposure in the communities most impacted by air pollution. The BAAQMD was the first district to roll out a Community Health Protection Program under AB617.

The following entities have been involved during the implementation: California Air Resources Board (CARB), South Coast Air Quality Management District (SCAQMD), Bay Area Air Quality Management District (BAAQMD).

It was quite innovative and important to provide a tool at the regional level that allows regulators to identify and assess environmental issues in real-time and to determine their impact on the communities.

The air quality and weather stations already have wireless connectivity technologies installed in them, so the key factor was to connect them to the Envirosuite´s platform in order to allow for data to be sent.

The aforementioned real-time air quality and actual weather data is then processed in the cloud using machine learning techniques and converted into an easy-to-understand output.

The Envirosuite platform resides in Amazon Web Services infrastructure which is replicated in several parts of the world, so it provides high availability and reliability due to service guarantees. The key limiting factor in a solution of this type is the reliability of the devices in the field, which are managed carefully by the agencies in this case.

2.3. Results

The system allows air quality control agencies in California to respond promptly to incidents and complaints. The outputs of these intelligent systems are used by the authorities to detect pollution sources and adopt immediate actions and elaborate plans in order to reduce air pollution and move towards a more sustainable model. Time and labour related to complaints management are also reduced as manual and expensive analysis of data are no longer required to support investigations.

The project directly contributes to air quality management at the region level including the cities in it.

The project is still in its implementation phase, so the results will come in the following years. The projected impacts are indicated below:

- **Social Impact**: Better air quality will have positive impacts on citizens´ health and wellbeing, increasing life expectancy. Air quality may also play a role in determining housing prices as locations with cleaner and better air quality are often more marketable than areas that have been heavily polluted.

- **Economic Impact:** It is expected that the sanitary costs related to illnesses coming from air pollution will decrease as mitigation policies are implemented and improved. Manual analyses of air quality incidents and complaints are significantly reduced resulting in operational efficiencies in the form of cost savings. Companies will also be more involved in formulating Corporate Social Responsibility policies, taking care of their employees, which also means keeping an eye on the environmental conditions they live in. Clean air can also be a determining factor for a company to decide whether it should settle in a more polluted area or move to a cleaner area.

- **Environmental Impact:** The positive environmental impact is very clear in terms of having cleaner air, not only for the inhabitants but also for vegetation in the region. Vegetation is the

basis for functioning of most terrestrial and aquatic ecosystems. The air pollutants penetrate vegetation through their leaves and cause complex and varied adverse effects on different ecosystems (e.g. eutrophication of ecosystems, mineral deficiencies, reduction of biodiversity). The only negative environmental impact is related to providing energy to the air quality stations -which there were already installed- and to the servers where the platform is hosted. These impacts are considered acceptable.

3. Conclusions

As demonstrated above, operating the Envirosuite platform at the regional scale has many hurdles to overcome. Noticeably, there More processing capabilities are needed when working with huge amount of data.

Understanding the high degree of interdependence that bordering cities have between each other is quite important. High-accuracy data sources and validated scientific models combined with the proper software processing capability can help fighting complex problems such as regional air quality.

The willingness to cooperate among public authorities, and the adaptability of the cloud platform in order to process huge amount of data coming from different data sources existing on a large area is important.

Looking forward, the project is looking to the following points in order to continue to improve and adapt to the dynamic environments that it is in:

- understanding the feedback from the public authorities,
- assessing the policies implemented,
- being able to compare the initial situation about air quality against the current air situation, and
- measuring the impacts on population health improvement will be challenging and also highly beneficial.

The platform has been designed to be configured very easily and replicable in other cities and regions. The Envirosuite platform is a scalable solution that flexible in its implementation. It is usually implemented on a local scale, covering facilities such as a port or a refinery, or a small city. The platform has also been adapted at the regional scale such as the case of the Californian authorities in this case study. In the case of needing a denser network, or the project managers decide to increase the extension of the project, more air quality and weather stations can be flexibly added to the platform without any problem. Therefore, the project can be scaled up to more Air Quality Management Districts if necessary.

A. References

Bay Area Air Quality Management District: http://www.baaqmd.gov/

South Coast Air Quality Management District: http://yourstory.aqmd.gov/

Envirosuite:

https://envirosuite.com/

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B. List of discussion partners/interviews

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Endnotes

1 Source: Envirosuite.com

2 WRF is a numerical weather prediction (NWP) system designed to serve both atmospheric research and operational forecasting needs. NWP refers to the simulation and prediction of the atmosphere with a computer model, and WRF is a set of software for this – Source: Wikipedia

3 CALMET (currently developed by Exponent, Inc.) is a diagnostic meteorological model which reconstructs the 3D wind and temperature fields starting from meteorological measurements, orography and land use data – Source: https://www.enviroware.com/calmet/

4 CALPUFF is an advanced, integrated Lagrangian puff modelling system for the simulation of atmospheric pollution dispersion – Source: Wikipedia

5 Source: Envirosuite.com

6 Assembly Bill (AB) 617 is a California state bill that encompasses new stipulations on nonvehicular air pollution: criteria on air pollutants and toxic air contaminants.


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