One, Two, Three, Breathe

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ONE, TWO, THREE, BREATHE

Air pollution has been a growing world problem, amplified by the ever increasing number of people and their consumption patterns. Now, technological progress and big data have merged to enable environmental scientists and engineers at BreezoMeter to address the problems caused by this silent killer in a radical new way.

Battling Urban Air Pollution

A person can survive three weeks without food, three to five days without water, and only a few minutes without air. Despite the fact that each of us breathes almost 11,500 litres – or approximately 3,000 gallons – of air every day, it is often treated as less important than other resources. Yet ambient air pollution can trigger many illnesses and significantly shorten the life span of individuals, even in the absence of a fatal disease.

In 2012, air pollution caused 3.7 million deaths, corresponding to 6.7% of the planet's population and in 2015 that number climbed to 5.5 million people. In fact, ambient air pollution accounts for more than 20% of ischaemic stroke and heart disease cases, roughly 16% of lung cancer cases, about 13% of respiratory infection deaths, and an estimated 11% of chronic obstructive pulmonary disease (COPD) – a lingering disease decreasing the sufferers' quality of life and known to have caused the death of the celebrated actor Leonard Nimoy. On a daily basis 92% of all people inhabiting urban areas are exposed to levels of air pollution higher than those recommended by the World Health Organisation.
Although airborne particles and noxious gases decrease the air quality worldwide, the problem is disproportionately larger in poorer countries. However, pollution levels continue to rise even in developed countries. But what if technology would enable us to forecast pollution just like we can forecast the weather? Smart cities are currently under development, while smart buildings are already a part of our daily lives. So what if this infrastructure could be used so that people worldwide would receive high air pollution alerts in order to avoid areas of foul air?

With these problems in mind, a group of scientists and engineers at BreezoMeter started to search for a solution that would enable people to decrease their total exposure to polluted air. Making predictions and issuing actionable alerts is not easy because air quality in the same region changes several times a day and is governed by complex dynamics. Therefore, the team at BreezoMeter realised that this objective is not impossible. Knowing in advance what is to come, urban inhabitants could plan better alternative routes to or from work and home, use indoor air purifiers, and even move their regular jogging route to a safer location. At the same time, alerts from a main computer framework could be accompanied by suggestions for smart city dwellers regarding the best course of action when a pollution wave moves in. Additionally, several industries could work towards creating better air and a better standard of life by incorporating the knowledge regarding air pollution in their products.
For example, automotive manufacturers could create better air filters, and heating and cooling installations could be better equipped to handle the rising air pollution levels. In this vein, a smart home could activate supplementary filters upon receiving pollution wave alerts, whereas real estate brokers would be able to provide their clients with detailed heat maps showing the safest and healthiest places to live. To incorporate all these functions and more, Dr Benmoshe in collaboration with a handful of researchers and engineers at BreezoMeter develop a proprietary algorithm capable of offering never before seen accuracy and certainty.

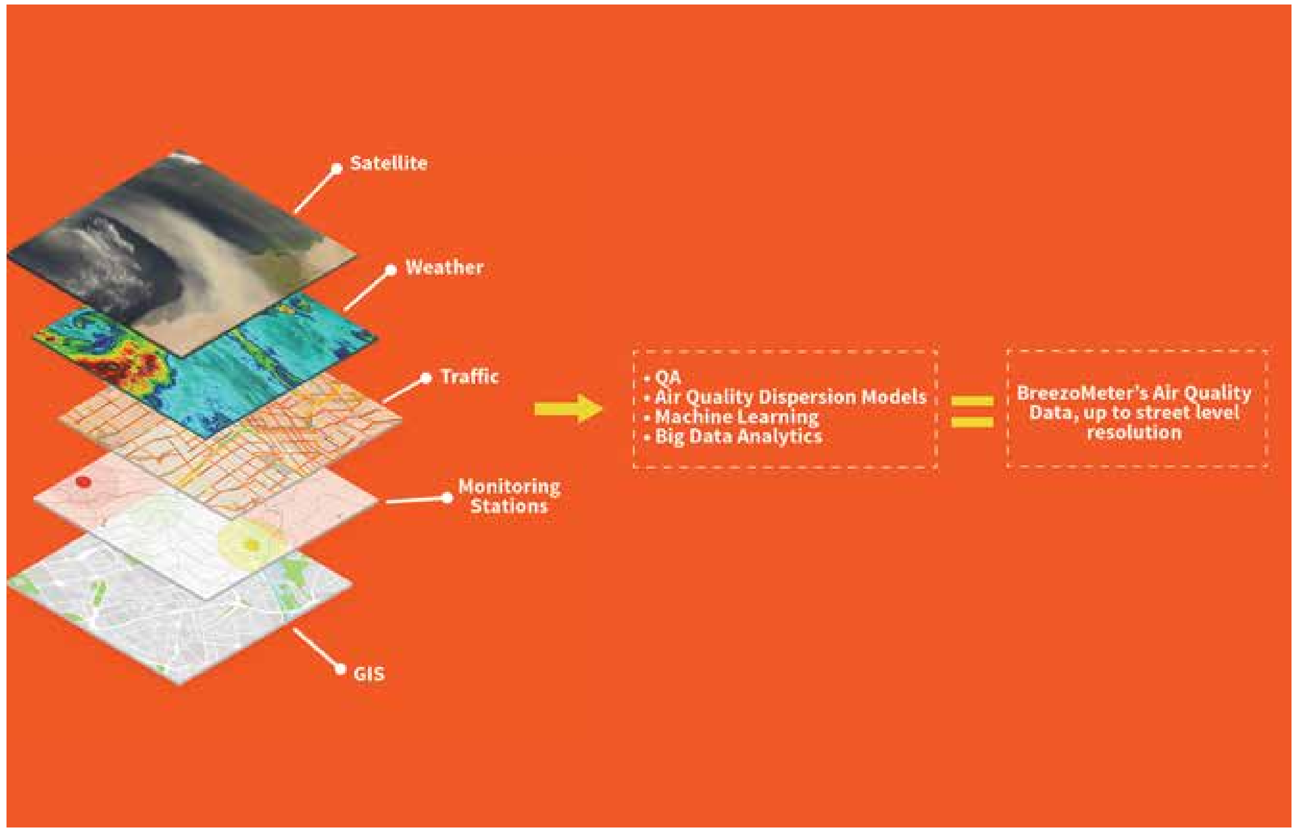
Forecasting Air Quality

Similar to climate and weather forecasting models, BreezoMeter is a big data platform that uses physical equations, statistical analysis and data collected in the field to predict and track the evolution of air pollution waves through inhabited areas. 'BreezoMeter maps the world's air pollution, delivering dynamic, real time, and up-to-city-block-level air quality data worldwide,' Ziv Lautman, BreezoMeter's Co-founder and Chief Marketing Officer explains. 'Our mission is to help cities and businesses improve the health and quality of life of millions of people worldwide, by providing the most accurate air quality data in a format as simple, intuitive, and actionable as weather data. BreezoMeter's big data analytics determine the dispersion and flow of air pollution from a combination of layered data sets derived from governmental sensors, satellites, weather patterns, transportation dynamics, and other environmental sources. Tied together with proprietary algorithms, this combination provides users with accurate air quality data that is up to the city block.'

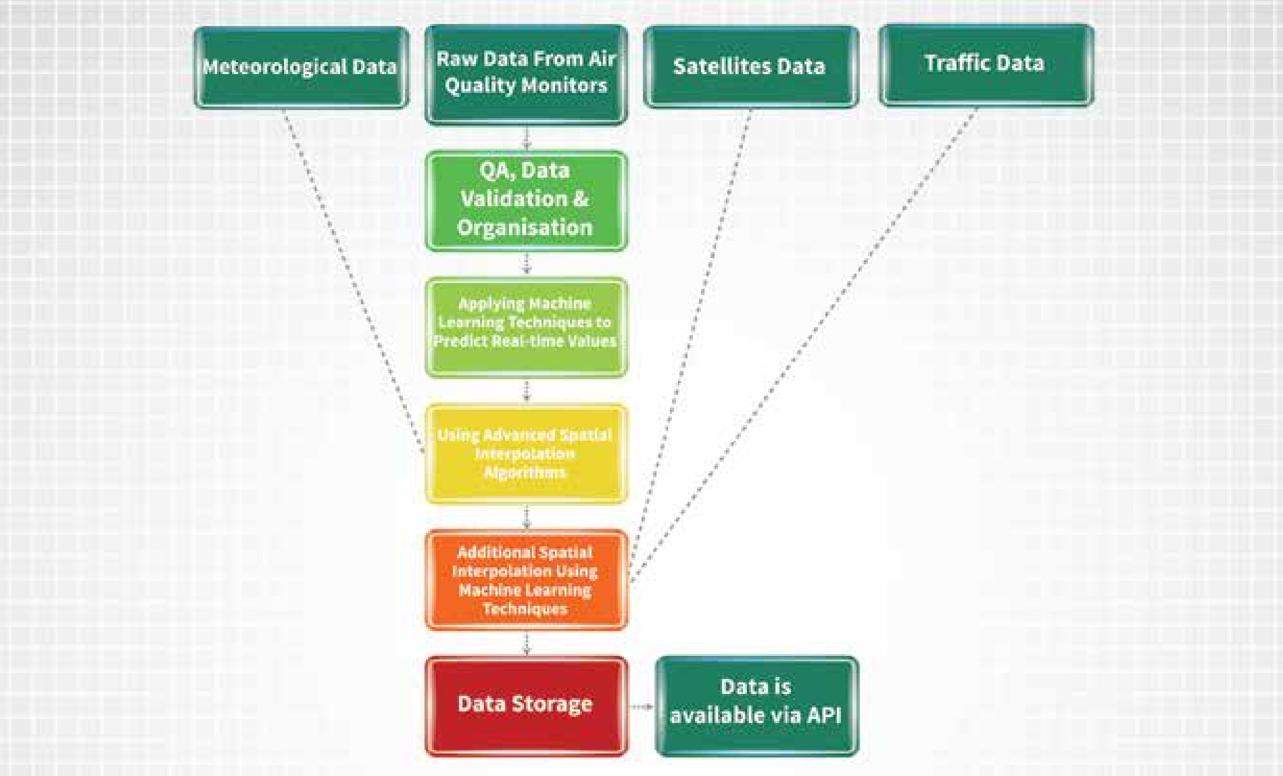
Dr Benmoshe together with the algorithm team at BreezoMeter were in charge of finding a way to accurately measure, forecast, and verify real time air pollution information. This is a challenge for several reasons. One of these reasons is the provenance of data incorporated in the analysis. Whereas other applications for air quality analysis take data from unverified sources, such as smartphones, individual reports, and off the ground report sources such as satellites, the researchers at BreezoMeter needed to find a way to also verify the data in real time and make sure the information is completely reliable. Another problem is that atmospheric circulation requires extreme computational power for accurate predictions, especially in models with high spatial resolution such as those currently incorporated in the platform.

The answer to the problem of forecasting the wave motion of pollution is inspired by global and regional weather models, which are used by meteorologists to track the progress of weather and make predictions.
The background BreezoMeter's research and development team has in atmospheric science, turbulent flow, and convection, helped BreezoMeter use the scientific principles and mathematical modelling tools with the decision on how the algorithm should behave for optimal results. These models divide the studied map or space in a grid, whose size is equal to the resolution of the model. In the BreezoMeter's case, the calculations use a grid resolution finer than 500 metres – the size of a block. As Dr Benmoshe points out: 'we are the first company in the world to provide spatially interpolated data at the resolution level of a city block.'

In its final form, the algorithm uses data from many sources to determine air quality levels. The main sources are governmental monitoring stations, which feed the platform with hourly concentration readings for air pollution. At the same time, supplementary data from satellite measurements, meteorological and traffic data, and data regarding types of land cover are added to increase the accuracy of the prediction, together with air quality models such as the European programme Copernicus Atmosphere Monitoring Service (CAMS). Air quality models track changes in pollution levels due to dispersion and chemical reactions; the CAMS offers no less than seven circulation models, which are validated every three months. Additionally, insufficient data will never be a problem for the platform, as Dr Benmoshe explains: 'Since we validate our data on every spot of the grid, we can know in real time if our algorithm's results are not accurate enough. We want to make sure we provide the most accurate data, so in cases of extremely thin coverage or inaccurate input data we might decide not to produce a map for a specific area.'



‘Our story began in 2012 when we were looking for pollution-free areas to settle in and buy a house – our families have health sensitivities, including asthma. As environmental engineers, we are too much aware of the correlation between environment and health, and refused to compromise on air quality’

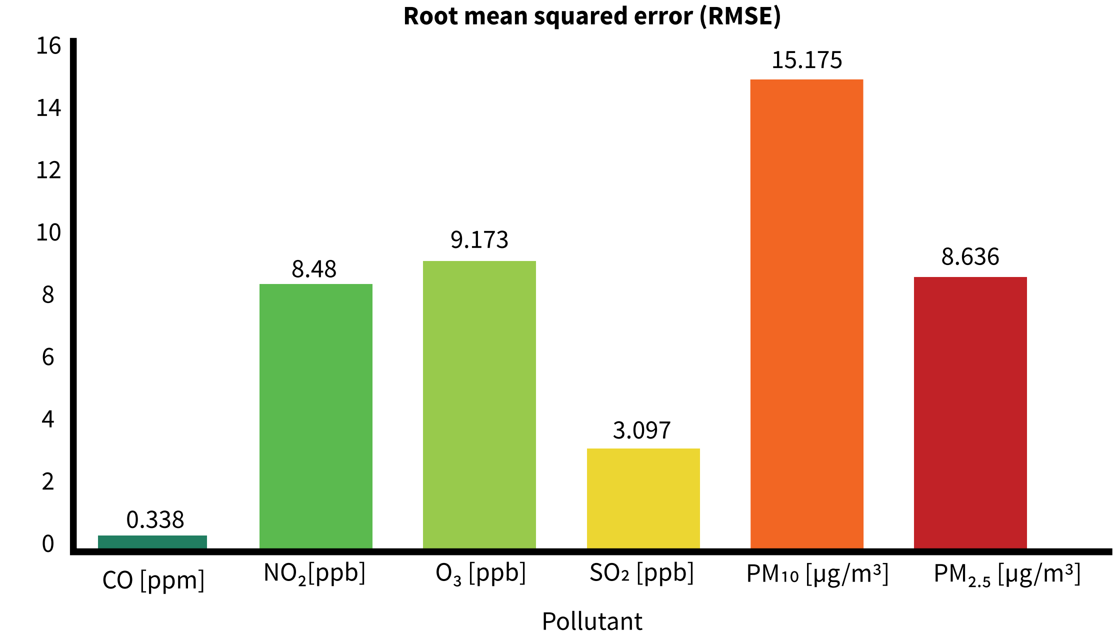


Precision and Dynamics in Real Time

Although important for country- and city-level air quality planning, public communication, and regulatory compliance, ground-level measurements alone are not sufficient to provide global coverage to estimate exposure because of the spatial biases in the availability of ground level measurements, the differences in measurement approaches among jurisdictions, and the absence of details about measurement data in some instances. Ground-level measurements of air pollution, particularly PM2.5, are unavailable in much of the world, and especially in many of the low- and middle-income countries. In addition to the inadequate and highly uneven coverage of ground-level measurements, measurement protocols and techniques are not standardised globally, with different quality control programs and different numbers of samples to arrive at annual averages. Even for measurements made by (similar) filter-based approaches, filters are equilibrated at different relative humidity conditions prior to weighing (for example, 35%, 40% and 50% relative humidity in the United States, Canada and European Union, respectively) and therefore are not completely equivalent. In addition, PM10 measurements and PM2.5/PM10 ratios are commonly used to infer PM2.5 concentrations for ground-level estimates. Therefore, surface measurements, although a key component of any global assessment approach, cannot be used solely to derive global exposure estimates.

Satellite-based measurements can help provide estimates for areas with no ground-level monitoring networks. But even in North America, where monitor density is high in populated areas, studies have indicated that satellite-based estimates do provide additional useful information on spatial and temporal patterns of air pollution (Kloog et al. 2011, 2013; Lee et al. 2012). Furthermore, in a large population-based study in Canada the magnitudes of estimated mortality effects of PM2.5 derived from ground measurements and satellite-based estimates were identical (Crouse et al. 2012). Satellite-based estimates nonetheless must be used cautiously, as discussed shortly (World Bank and Institute for Health Metrics and Evaluation. 2016. The Cost of Air Pollution: Strengthening the Economic Case for Action. Washington, DC: World Bank).

To make sure the raw data is reliable, the team constantly monitors its behaviour. Each new registered value is tested by several methods to confirm it falls within the normal trend and range, and is not a false data point. In fact, the data is normalised by eliminating invalid outliers, which may arise from sources such as uncalibrated or faulty monitoring stations. The platform uses the values measured at stations to interpolate the values between the stations, and then cross verifies it against the layer of data from other sources, at the same time taking meteorological aspects into account. Because the results are calculated in advance for billions of points worldwide, they are available for users instantaneously. Naturally, this process generates big data, and according to Emil Fisher, BreezoMeter’s Co-founder and Chief Technology Officer: ‘every hour we process more than 680 GB of data while calculating the air quality for more than 271 Million grid points worldwide. In this process we produce new 29 GB of data every hour. In order to succeed in this mission, we use Google Cloud services to manage our data, and run hundreds of CPUs every second. Currently, we store a total amount of more than 300,000 GB of data in the cloud.’



Results of 5000 random ‘leave-one-out’ tests, performed with data from June and July 2016. 100 hours of data were chosen randomly, for each of them 50 monitoring stations were chosen randomly. For each of the time-station pairs we calculated our algorithm’s result at the station coordinates, then compared the result with the measurement from the relevant hour. The RMSE results are satisfactory.

Accuracy Above All

The algorithm’s accuracy is regularly validated by several statistical methods. For instance, the leave-one-out cross validation method compares a prediction map with a real set of data. By eliminating the real input data set from the calculation and letting it make an interpolation to find the prediction, scientists can verify the accuracy of the algorithm by comparing the result at the end with data from the field. These tests are being run thousands of times, so that the team can understand whether they predict the right correlations. And above all that, BreezoMeter’s algorithm is one of the fewest currently capable of analysing pollution dispersion in real time, which means that the data is dynamic, relevant and based on the location of the individual using the platform – not just the location of the pollution monitoring stations, like other applications. As stated before, air pollution changes several times a day and is governed by complex flow dynamics. Therefore, in order to provide individuals accurate air quality levels, pollution data most be analysed as BreezoMeter does. Since the algorithm incorporates machine learning and is capable to adapt based on previous experience, the platform will function in real time even if the source data is not available in real time.

Although several other air quality monitoring applications exist, a major challenge for users is that reading scales are not standardised between continents, or even between countries. To address this issue, the BreezoMeter team created a standard Air Quality Index scale ranging from 0 (worst) to 100 (best) and divided it into five levels, each of which is associated with health recommendations for the general population and at-risk groups such as children and cardiovascular patients. There are six main pollutants tracked by BreezoMeter, namely carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide, and two size thresholds of particulate matter – with diameters below 10 and 2.5 micrometres. Given its ability to track particulate matter, BreezoMeter can also show pollution due to fires.

At this point, BreezoMeter’s air quality data is available in more than 7000 cities in 29 countries, and the goal is to map the entire world by 2017. When asked about their future plans, Ran Korber, BreezoMeter’s Co-founder and Chief Executive Officer tells us: ‘We are constantly improving our algorithms, adding data layers and aiming to a higher resolution of data. This is our main area of focus as our mission it to provide the most accurate air quality data’

About BreezoMeter

With over 50M daily users in 29 countries, BreezoMeter is the world’s leading real-time air quality analytics provider.
The company offers its air quality data as a service via a simple API integration to various products and services. BreezoMeter also offers a set of advanced solutions for Smart Cities such as: Air Quality Command and Control Platform, SMS-Sensor Management System and Optimization, Data analysis and more.

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