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What Does Wildfire Do to the Air

Introduction

With the development of modern industry, air pollution has become increasingly serious. Air quality issues have caused widespread concern. Air pollution is one of the top ten problems (Li et al., 2000) that threaten human survival in today's world. However, when people look into this problem. They usually ignore the natural factors which may increase more severe outcome than human factors such as traffic and industrial emissions. Therefore, this article will focus on wildfires which are also one of the factors contributing to air pollution.

In this article, I will evaluate the Woolsey Fire, happened on November 8th in Los Angeles and see how this fire worsen the air quality in LA areas. This fire started on November 8th and was contained on 21st. It is one of the most severe fire in California and burned 96,949 acres of land, destroyed 1,643 structures, killed three people, and prompted the evacuation of more than 295,000 people. After 13 days of burning, people can see the smoke rising from the mountains. Even if the fire was over, the air quality in the Los Angeles area is still very poor.

Background

Under normal circumstances, the composition of air mainly includes nitrogen, oxygen, argon, carbon dioxide and hydrogen, helium, ozone, strontium, barium and dust. The components of smoke generated by forest fires are mainly carbon dioxide and water vapor. The particulate matter accounts for 90% to 95% of all smog; there are also carbon

monoxide, hydrocarbons, sulfides, nitrogen oxides and particulate matter, which account for about 5% to 10% (Knorr et al.,2017). In this article I'm going to mainly talk about two kinds of emissions of wildfires, sulfur dioxide and particulate matter.

Sulfide mainly refers to toxic substances such as sulfur dioxide, sulfur trioxide, sulfuric acid and hydrogen sulfide, of which sulfur dioxide is the main sulfur compound. When the sulfur dioxide content in the air is 1 to 10 μg/g, it is irritating to humans (Knorr et al.,2017). When it exceeds 100 μg/g, human life is seriously threatened. The concentration of sulfur dioxide on plants is much lower than these figures. The presence of sulfides in the air is also the main cause of acid rain. The phenomenon of acid rain has become a public hazard in Europe, not only the death of large forests, but also the harm to human life and buildings. The sulfur dioxide content of forest combustibles is about 0.2%, and the amount released after combustion is enough to cause harm to animals and plants (Knorr et al.,2017). On June 2, 2010, the U.S. Environmental Protection Agency (EPA) sets the standard for sulfur dioxide of 0.075 ppm of hour max.

The particulate matter refers to a mixture of smoke, tar and volatile organic compounds. Particulate matter is the main emission of forest burning. The effect of particulate matter on air pollution depends mainly on the size of the particles (Knorr et al.,2017). The smaller the particles, the greater the damage. Particles can cause a significant drop in atmospheric visibility. Forest fires usually release large amounts of particles.

In this article, we will talk specifically about PM2.5 which refers to particulate matter up to an aerodynamic diameter of 2.5 μm. The United States Environmental Protection Agency (EPA) established National Ambient Air Quality Standards for PM2.5 in 1997 and revised them in 2006 and 2012.The short-term standard (24-hour or daily average) is 35 micrograms per cubic meter of air (μg/m3) and the long-term standard (annual average) is 12 μg/m3. In this article, I want use GIS to mainly talk about two question:

- How does the air quality change during or after the fire?
- How much does air quality take to return to normal?

- What is the role of wind when considering the range of the air pollution?

Data Source

The project uses the following shapefile:

- 2018 Simply Analytics, Population, Quantile (local), Los Angeles County
- 2018 Los Angeles County GIS Data Portal, Woolsey Fire Perimeter

The Project uses the following data:

- 2018 California Air Resources Board, Los Angeles County daily max 1-hour average PM2.5 data seven-day display ending 10/15/2018
- 2018 California Air Resources Board, Los Angeles County daily max 1-hour average PM2.5 data seven-day display ending 11/15/2018
- 2018 California Air Resources Board, Los Angeles County daily max 1-hour average Sulfur Dioxide data seven-day display ending 10/15/2018
- 2018 California Air Resources Board, Los Angeles County daily max 1-hour average Sulfur Dioxide data seven-day display ending 11/15/2018

Data

To acquire the air quality data, I use *California Resource Board* (https://www.arb.ca.gov/aqmis2). As the fire was first started at November 8th, I searched for the daily max 1-hour average PM2.5 data starting from 9th to 15th, as seen in table 1. To better understand the consequence Woolsey Fire brought to us, I also downloaded the exact same data from 1 mouth ago for comparison, as seen in Table 2.

Table 1. Los Angeles County Daily Max 1 Hr Avg PM2.5 Data Seven Day Display Ending 10/15/2018

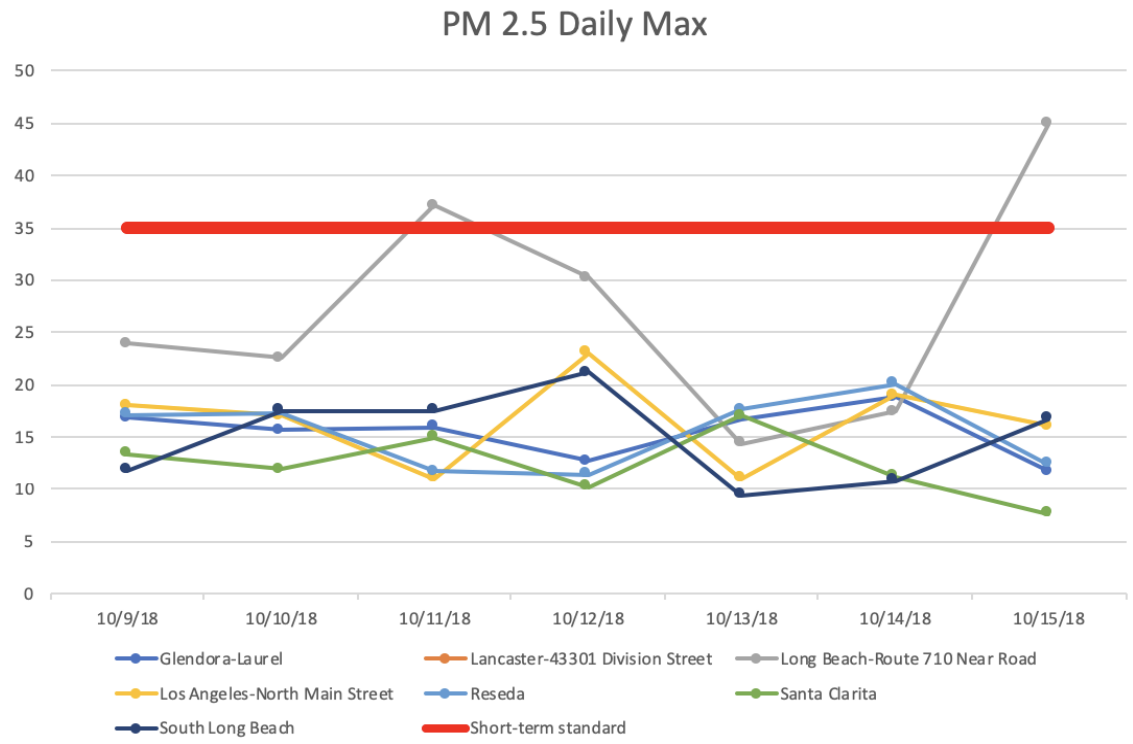
MAX 1 HR AVG							
PM 2.5	10/9/18	10/10/18	10/11/18	10/12/18	10/13/18	10/14/18	10/15/18
Glendora-Laurel	16.8	15.7	15.9	12.7	16.7	18.8	11.7
Lancaster-43301 Division Street							
Long Beach-Route 710 Near Road	23.9	22.6	37.1	30.2	14.4	17.4	44.9
Los Angeles-North Main Street	18	17	11	23	11	19	16
Reseda	17.1	17.3	11.7	11.4	17.6	20.1	12.4
Santa Clarita	13.4	11.9	15	10.2	17	11.2	7.7
South Long Beach	11.8	17.5	17.5	21.2	9.4	10.8	16.7
Short-term standard	35	35	35	35	35	35	35

Table 2. Los Angeles County Daily Max 1 Hr Avg PM2.5 Data Seven Day Display Ending 11/15/2018

MAX 1 HR AVG							
PM 2.5	11/9/18	11/10/18	11/11/18	11/12/18	11/13/18	11/14/18	11/15/18
Glendora-Laurel	10.7	46.3	74.2	13.1	11	11.7	9.8
Lancaster-43301 Division Street	11	45	26	10	9	12	985
Long Beach-Route 710 Near Road	39.3	75.7	85.3	54.1	29.4	24.6	23.2
Los Angeles-North Main Street	22	76	74	25	22	25	18
Reseda	10.2	148.3	63.7	8.3	7.3	11.4	13.9
Santa Clarita	6.7	34.6	27.3	4.3	5.2	5.2	6.2
South Long Beach	27.3	55.3	47.6	39.3	18.7	23.3	20.2
Short-term standard	35	35	35	35	35	35	35

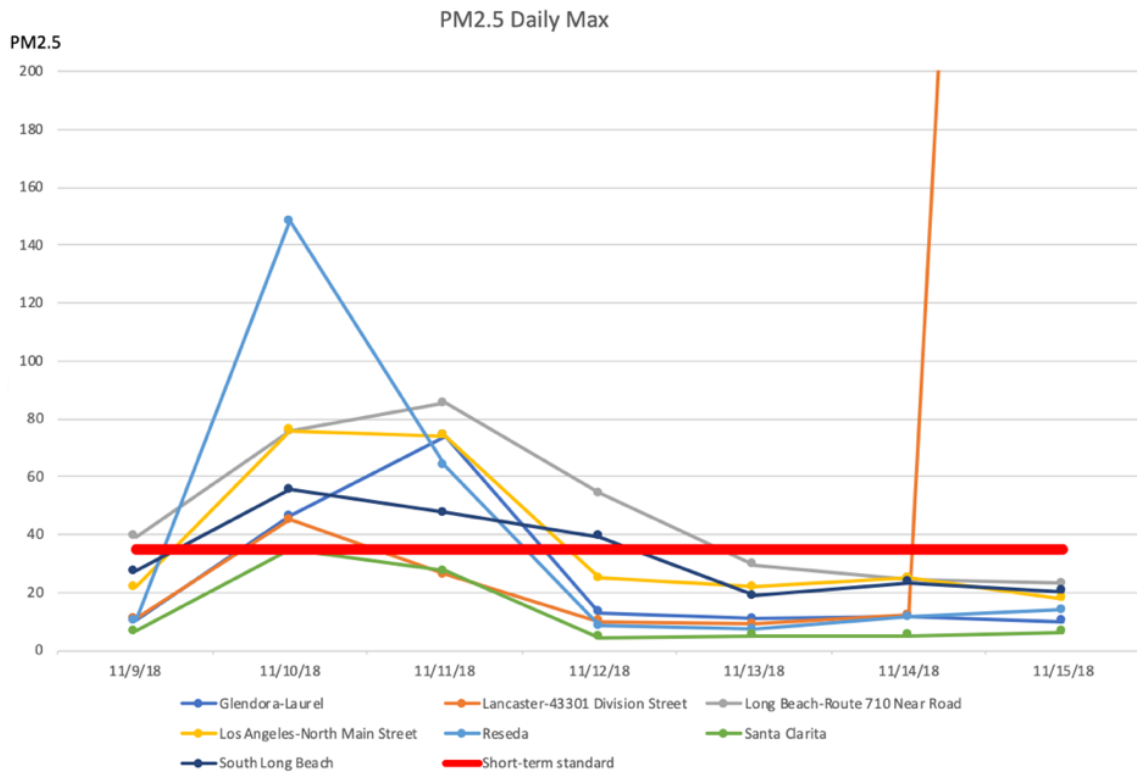
In October, there are only two days which PM2.5 exceeded the short-term standard (35µg/m3), as seen in Graph 1. Both of these two points were around freeway. Therefore, we can easily assume that car emission maybe the main reason for PM2.5 in normal days.

Graph 1. Los Angeles County Daily Max 1 Hr Avg PM2.5 Data Seven Day Display Ending 10/15/2018



Take a look at November PM2.5 rising trend which is seen more clearly at Graph 2. There was a sudden rise right after the beginning of the fire. Reseda, as the nearest in 7 locations, was the first to get affected. Also, from the graph, we can see Lancaster barely got affected in the first three days and got a sudden rise on 14th probably due to the change

Graph 2. Los Angeles County Daily Max 1 Hr Avg PM2.5 Data Seven Day Display Ending 11/15/2018



of wind direction. Long Beach is about 48 miles away from the fire but got influenced immediately probably because of the strong wind blew from north to south. And from the graph, the nature took about 4 days to recover from a severe pollution.

The second part of data in this project is sulfur dioxide. I downloaded the data of 1-hour daily max sulfur dioxide on *California Resource Board,* as seen in Table 3 and Table 4 below.

Table 3. Los Angeles County Daily Max 1 Hr Avg Sulfur Dioxide Data Seven Day Display Ending 10/15/2018

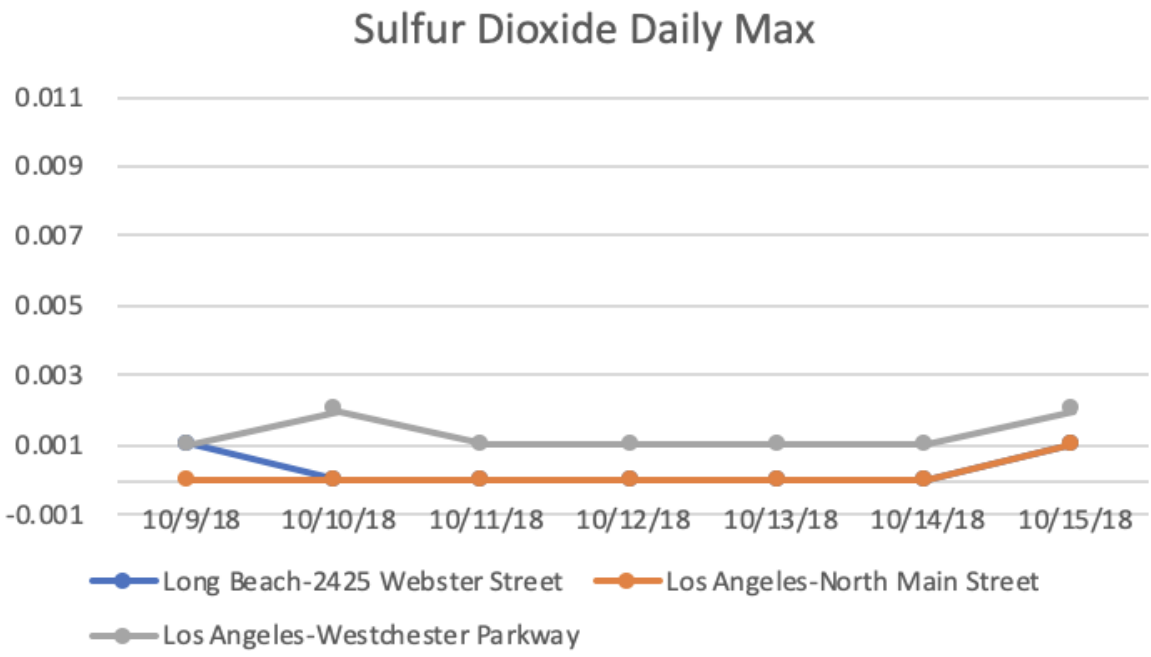
MAX 1 HR AVG							
Sulfur Dioxide	11/9/18	11/10/18	11/11/18	11/12/18	11/13/18	11/14/18	11/15/18
Long Beach-2425 Webster Street	0.001	0.002	0.001	0.001	0.001	0.001	0.001
Los Angeles-North Main Street	0.001	0.002	0.003	0.004	0.002	0.002	0.001
Los Angeles-Westchester Parkway	0.002	0.011	0.003	0.002	0.003	0.002	0.002

Table 4. Los Angeles County Daily Max 1 Hr Avg Sulfur Dioxide Data Seven Day Display Ending 11/15/2018

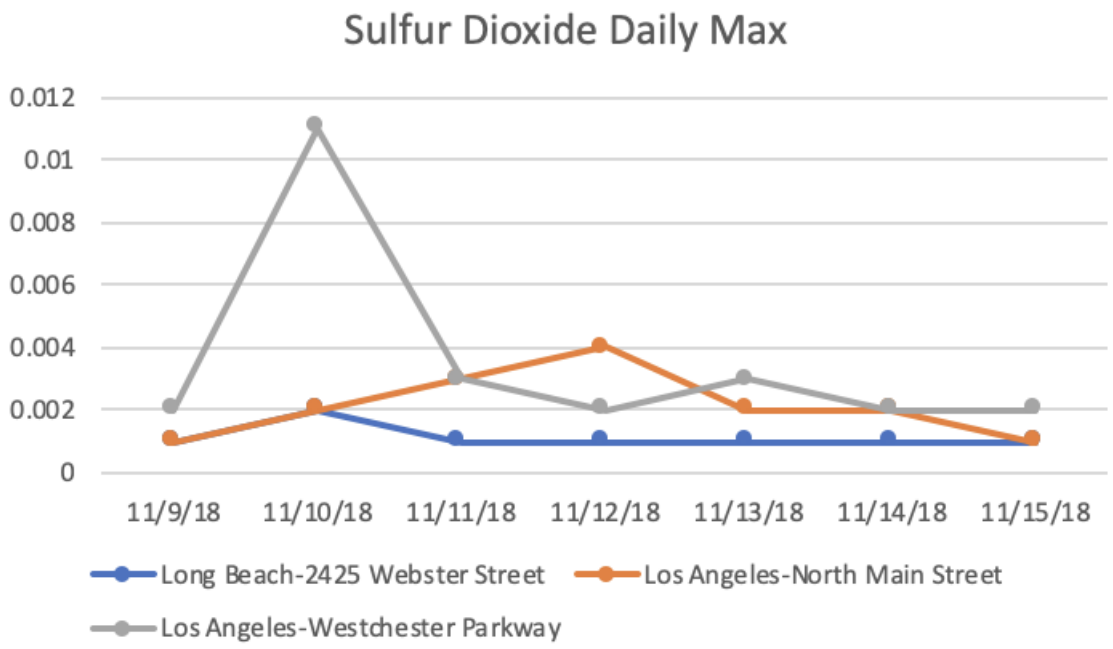
MAX 1 HR AVG							
Sulfur Dioxide	10/9/18	10/10/18	10/11/18	10/12/18	10/13/18	10/14/18	10/15/18
Long Beach-2425 Webster Street	0.001	0.000	0.000	0.000	0.000	0.000	0.001
Los Angeles-North Main Street	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Los Angeles-Westchester Parkway	0.001	0.002	0.001	0.001	0.001	0.001	0.002

Although the short-term standard for sulfur dioxide is 0.075 ppm which indicates that no area in either month exceed the standard line, there were still rapid increase in all three observation locations. The nearest location, Westchester Parkway had its sulfur dioxide increasing 5 times than one month ago. The other two locations had almost 0 emission in sulfur dioxide on October 10th. And on November 10th, the had 0.002 ppm. The number rose tremendously, and the pollution influenced a huge range in LA county. Compared to PM2.5, sulfur dioxide is harder for forest to cleanup. As seen in Graph 3 and 4, it took almost 6 days or even more to return to normal.

Graph 3. Los Angeles County Daily Max 1 Hr Avg Sulfur Dioxide Data Seven Day Display Ending 10/15/2018



Graph 4. Los Angeles County Daily Max 1 Hr Avg Sulfur Dioxide Data Seven Day Display Ending 11/15/2018



Data Processing

To analyze the data, I need to put these data on a map. However, all these data have a timeline which cannot be processed on a single map. Therefore, I came up with an idea to compare the 7-day max in November with October. I selected the biggest number in each column in two tables and put them into Table 5 and 6 below.

Table 5. Comparison between PM2.5 of October and November

7Day Max			
PM 2.5	October	November	Growth Ratio
Glendora-Laurel	18.8	74.2	294.7%
Lancaster-43301 Division Street		985	
Long Beach-Route 710 Near Road	44.9	85.3	90.0%
Los Angeles-North Main Street	23	76	230.4%
Reseda	20.1	148.3	637.8%
Santa Clarita	17	34.6	103.5%
South Long Beach	21.2	55.3	160.8%

Table 6. Comparison between Sulfur Dioxide of October and November

7 Day Max			
Sulfur Dioxide	October	November	Growth ratio
Long Beach-2425 Webster Street	0.001	0.002	100%
Los Angeles-North Main Street	0.001	0.004	300%
Los Angeles-Westchester Parkway	0.002	0.011	450%

In this way, all the data are processed and ready to be put on a map.

Limitation

I first thought about this topic when I walked on the street one morning and felt the air quality was really bad. Then I thought it would be interesting to match natural factor to air pollution, as most people would consider air pollution is largely done by human causes. However, to track down the latest data is very difficult.

First, there are so little information as I called to ask if they could offer me more data to analyze. They said they still need time to process and categorize the raw information coming from the observation locations. Therefore, some observation locations' information cannot be seen on website. Also, some observation locations sometimes change. As seen in Table 1 and 5, there are no data in "Lancaster" column in October.

Second, the addresses of these observation locations are ambiguous. Instead of testing the air quality in area, there is only one address shown of each location. I used "Find" tool to track them down each by each. But one thing still bothering is whether these points can represent a whole area's air quality.

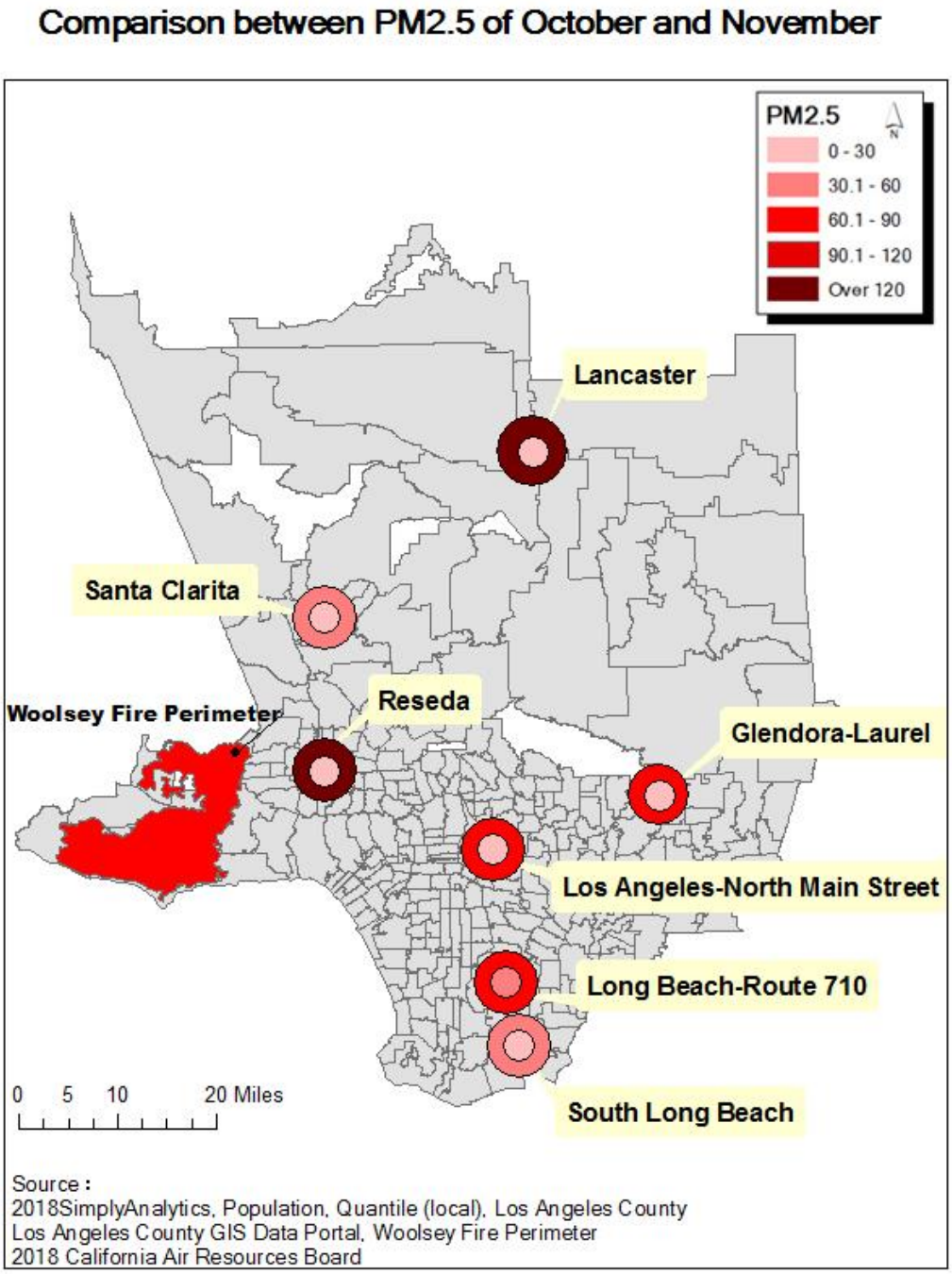
Third, observation locations are different when test PM2.5 and Sulfur Dioxide. At first, I wanted to use an air quality index to mix both PM2.5 and Sulfur Dioxide together. However, as the observation locations are different, I had to compare these pollutants one by one making this much less clear.

Forth, carbon-containing gas is the most important emission of forest fires. But to track down carbon is hard, because carbon dioxide is not harmful or easily trackable in a short run. But it will show its damage on global warming in a long run.

Last, wind direction and level are most difficult factor to put into this. It is hard to track

down how wind influence air pollution during a wildfire. This is where I originally want to conclude. But I cannot explain or calculate this into a deeper level.

Mapping

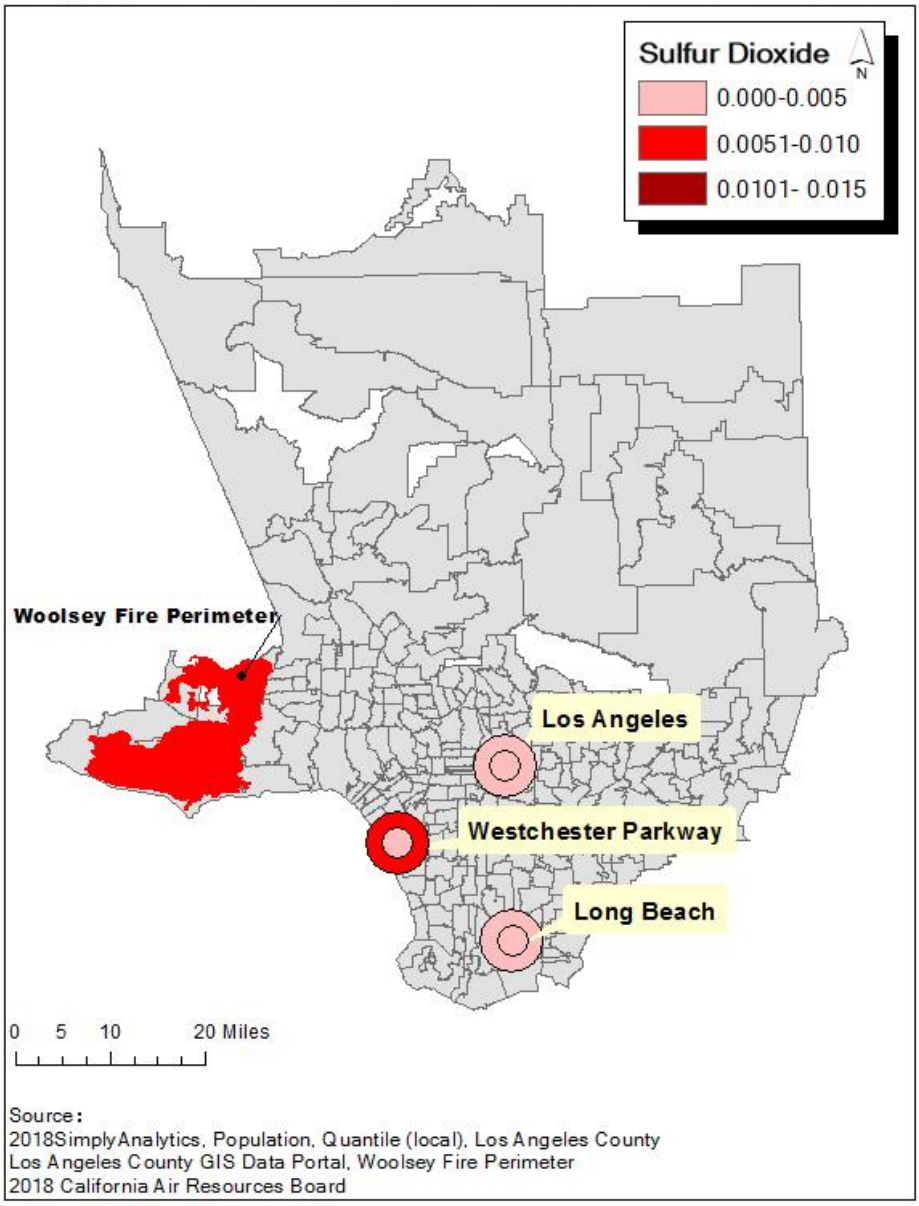


In the map, big circles represent the PM2.5 condition in November while small circles representing PM2.5 in October.

In October, air qualities in all locations are good and below the standard line except the one near freeway. Even in that situation, there was only one day the PM2.5 in Route 710, Long Beach exceeded the standard line.

During the fire, the number of PM2.5 rose quickly. And lots of area got affected. Surprisingly, Santa Clarita, though near the fire, just had a minor rise on PM2.5 possibly due to the wind direction and the forests near it.

Comparison between Sulfur Dioxide of October and November



In the map, big circles represent the sulfur dioxide condition in November while

small circles representing sulfur dioxide in October.

In California, sulfur dioxide is not a major pollutant. Though the number increases largely. But it is still way below the standard line.

Conclusion

It is certain that forest burning produces a large amount of smoke and toxic substances, which has released into the atmosphere and has a serious negative impact on global warming, biogeochemical cycles, air quality and human health. However, this is also the consequence of global warming (Liu & Wang, 2017). With the global warming and the impact of the El Niño phenomenon, the frequency and intensity of wildfires are increasing tremendously. Though one wildfire may emit huge amount of pollutants, it will recover in a week. However, what human did is affecting the earth every day in a long term. If we don't pick up the sense of global warming, there will only be more and more wildfires and we are then in a vicious cycle.

R E F E R E N C E

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