



**HELEN
PARKHURST**
Daltonschool mavo havo vwo



INFLUENCE OF FIREWORKS ON THE AMOUNT OF AEROSOLS

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1. Abstract

a. Concise

Our main research question is about the subject aerosols. Aerosols are little pieces dust or parcels, for example soot and water droplets. They are present at all the levels of the air up to the ozone layer. If they are in the bottom layer of the atmosphere, they can cause breathing problems. In that context, they are also known as particulate matter content. The number of aerosols is phrased in AOT. We will measure the AOT with a device called Calitoo, it is a sun photometer. We will compare our measurements with data from satellites.

he health effects of aerosols consist of short-term acute symptoms, such as asthma and bronchitis, and long-term chronic irritation and inflammation of the respiratory tract.

It is known that particulate matter content is increased by the fireworks during New Year's Eve. We don't know if this influences the AOT. When fireworks explode, a lot of particulate matter is released. The size of the air pollution from the fireworks particles in the air depends on the weather conditions. The high number of particles in the air will disappear rather quickly, they mostly do not last long.

b. Context of research

There is a lot of attention for the environment nowadays. There are many research projects about the subject and there are a lot of conventions to reduce pollution. Aerosols are a problem for the environment. Aerosols can, if they are in the bottom layer of the atmosphere, cause breathing problems. Particulate matter is a part of aerosols and it is known that the amount particulate matter increases during New Year's Eve. The influence of fireworks on the aerosol optical thickness has not been investigated yet. That is why we are going to research this subject, so we can answer an unanswered question.

c. Research questions

Our main research question is:

Do the fireworks during New Year's Eve affect the amount of aerosols?

The sub-questions are:

- What are Aerosols?
 - What is the influence of aerosols on the climate?
 - How do aerosols affect health?
 - How can you measure the amount of aerosols?
- How reliable are our sources?
 - The Calitoo (sun photometer)
 - The satellite
- What is the connection between aerosols and fireworks?
 - What do fireworks consist of?
 - How do the fireworks particles react in the atmosphere?

d. Objectives set

The objective of this research is to give some information about if the fireworks during New Year's Eve affect the amount of aerosols. We will do this by do measurements in the Netherlands a while before and a while after New Year's Eve. The exact moment is in each country different because of the lag. That is why also researched the direction of the wind, that stipulates how fast and in which direction the particulate matter flows. This way we want to declare a prospective random high AOT.

e. Brief methods description

We have used the following methods:

- Satellite data
- Calitoo measuring instrument
- We compared our measurements with measurements of a school in Croatia.

f. Results

We have three different kind of results:

- We have our own measurements. (measured with a sun photometer)
- We have satellite data
- We have measurements from Croatia.

g. Conclusions

We could not conclude if the fireworks during New Year's Eve affected the amount of aerosols. The sub-conclusions were too different.

h. Recommendations for a way forward

Overall, the research project went relatively well. We have had some struggles, such as the bad weather, which was unfortunate, but we pulled through. We are very satisfied with our end result.

We have learned a few things from this project:

- Always have a backup plan for when things go wrong.
- Don't be afraid to ask for help if you are stuck.
- Never give in immediately if someone disagrees with you.

As for our next project, we are probably going to collect money for the trip to Ireland.

Next time we would like to do research to a different measuring instrument. One that can measure the AOT on all days, so also days with clouds.

i. Key words that emphasize key ideas in the paper

AOT, particulate matter, fireworks pollution.

2. Research Questions

- a. Include why they are important and are of scientific interest.

It's important to get to know if the amount of aerosols increases after New Year's Eve, because aerosols are bad for your health. If the amount of aerosols after New Year's Eve is so high that it becomes too dangerous for your health, measures must be taken.

We also research the reliability of our sources. We do this because we want reliable results.

- b. Concern some aspect of Earth's environment (local or global issue)

Aerosols are a global issue. If the amount of aerosols is high the environment is not very good.

- c. Include a well-written description of background information.

You can find the description below where we answered our research questions.

Our main research question is: Do the fireworks during New Year's Eve affect the amount of aerosols?

What are Aerosols?

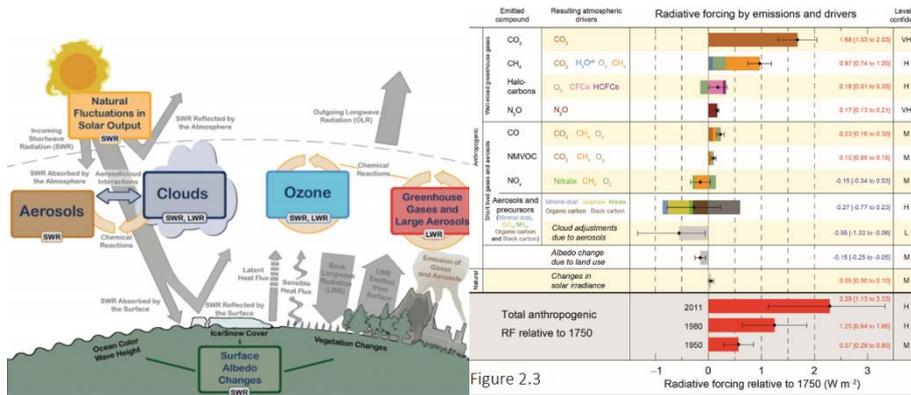
Aerosols are little pieces of dust or particles, for example soot and water droplets. These float in the air. Aerosols scatter and absorb sunlight, with the result that they affect the climate. How they do that depends on several factors, such as the concentration and the kind of aerosols. Aerosols are present at all the levels of the air up to the ozone layer. If they are in the bottom layer of the atmosphere, they can cause breathing problems. In that context they are also known as particulate matter. One measure of the number of aerosols in the atmosphere is the aerosol optical thickness (AOT).

"Optical" means: in relation to light, and in this case, with respect to sunlight. Solar radiation becomes weaker because of the aerosols in the air. To measure AOT, you measure the amount of solar radiation at the surface of the Earth and compare that to what you would expect outside the Earth's atmosphere. The decrease in solar radiation is converted to AOT.

What is the influence of aerosols on the climate?

The role of aerosols is still a bit unclear. What we know for sure is this. Aerosols have a cooling effect on the climate. The reason for this is that aerosols send back a part of the incoming solar radiation. How big those climate effects are depends on:

- The optical properties (is material properties that determine how the material influences light rays)
- The chemical compositions (is the identity and the relative number of the elements that make up a certain connection)
- The atmospheric distribution (how the ideal gas properties of an atmosphere change)
- The hygroscopicity (attracting and retaining water molecules from the surrounding environment)
- The ability to serve CCN (cloud condensation nuclei, the size of a cloud droplet)



You can see that the Aerosols send back the sunlight.

You can see that the temperature decreases because of the aerosols.

How do aerosols effect health?

The health effects of aerosols consist of short-term acute symptoms, such as asthma and bronchitis, and long-term chronic irritation and inflammation of the respiratory tract. PM2.5 and narrow UFP penetrate deep into the lung and are therefore more likely to have adverse health effects. Since PAHs, a class of organic matter found in the aerosol particles, are known to be carcinogenic. According to the World Health Organization (WHO), particulate matter (PM) is on 13th place as a cause of death.

How can you measure the amount of aerosols?

There are different ways you can measure the amount of aerosols. You can for example use a radiometer. Radiometers measure the amount of electromagnetic radiation. (e.g., light) ¹ Terra, a satellite also measures the optical thickness, with a sensor called: MODIS. This is a radiometer. You can also measure the amount of aerosols with ground-based instruments, such as a sun photometer. (Calitoo) The Calitoo measures not only the optical thickness, but also other things such as: the temperature, the pressure and it determines an Alpha coefficient. The alpha coefficient expresses the difference in AOT at two different wavelengths of light. The higher the exponent, the smaller the particles. The average value of the Alpha coefficient is 1,3. The typical value range is 0,5 to 2,5.

- **How reliable are our sources?**
 - Sun photometer (Calitoo)

We use the Calitoo to measure the AOT. This is a sun photometer. The Calitoo measures at three wavelengths. (red, blue and green). The results are only reliable when the sun shines and when there are no clouds. Clouds scatter a lot of solar radiation, so if there are clouds, the sun photometer will give a very high optical thickness.

According to the KNMI ², the best time to do your measurements is between 10h and 16h. During this time the sun is high in the sky. This gives a better reliability of the measurement. Also, at this time the satellites fly over, so it's more reliable to compare the data from satellites with the Calitoo, if you measure between these times.

¹ <https://www.earthobservatory.nasa.gov/Features/Aerosols/page5.php>
² <http://projects.knmi.nl/globe/meetinstructies.html>

- Terra (satellite)

Satellites can, of course, be wrong sometimes. For that reason, scientists often compare data from the satellite with data from ground-based instruments. 'Globe Nederland'³ also compares data from the Aura satellite with measurements from the Calitoo. (sun photometer)

We use measurements from the MODIS sensor from the Terra satellite. MODIS can view aerosols at many different angles and wavelengths. This gives more accurate results.

A satellite is no longer used when the fuel runs out or when the systems fail. Solar panels are a very important energy source of a satellite. When the solar panel panels fail, the satellite will fail too. One unofficial survey puts solar panel failure as the cause for 40% of satellite failures. (10) Solar panels fail sometimes, because the temperatures rapidly change from very cold to very hot. (From the hot sunlight to the cold and dark space) This can damage the solar panels. The solar panels must meet certain requirements before they can go to the space. Scientist also do research into better solar panels. If the solar panels are well tested before they go to the space, satellites are a pretty reliable source.

- **What is the connection between aerosols and fireworks?**

- What do fireworks consist of?

Fireworks generate a lot of particulate matter. Particulate matter is another word for a blend of solid particles and liquid droplets in the air. Some are visible and others are too small for that.

A lot of fireworks contain potassium nitrate. Also, gunpowder is often used. When you light that up, there will take place a chemical reaction whereby a lot of carbon dioxide and nitrogen will be released. This comes together with a bang. One adds other substances in fireworks for the different colors. Depending on the required color, you can use: sulphur oxide-, titan-, iron-, charcoal-, aluminum-, copper-, antimony-, strontium-, barium- and magnesium compounds. In addition, silicon and boron are often used as fuels in the wicks.

According to the RIVM⁴, fireworks results into particles in the air. These are: soot, sulfur dioxide, nitrogen oxides and dust particles. This is detrimental for asthma patients. Sulfur dioxide and nitrogen oxides are gas-phase products, but can be converted into particle-phase sulfate and nitrate through chemical reactions

Product	Normal total pollution (kg x 1000)	Extra pollution by fireworks (Kg x 1000)	Share fireworks (%)
Dust	100.000	500	0,5
Sulphur dioxide	207.000	300	0,02
Mg-, and Al-oxides	3000	20	0,07
Barium	3	10	>300
Strontium	0,03	10	>30000

Source table.⁵ Normal total pollution and fireworks pollution for some products over a year. As you can see some products are heavily influenced by fireworks while other products are less influenced by fireworks.

³ <http://globenederland.nl/onderzoeksproject/aerosolen/>

⁴ http://www.rivm.nl/Documenten_en_publicaties/Algemeen_Actueel/Nieuwsberichten/2017/Vuurwerk_zorgt_voor_smog_door_fijnstof

⁵ <http://www.chemischefeitelijkheden.nl/Uploads/Magazines/CF-194-vuurwerk.pdf>

- How do the fireworks particles react in the atmosphere?

Most of the substances will end up in the ground and cause pollution, because of the high melting points. Examples are: magnesium-, titanium-, boron-, copper- and strontium.

Other substances will remain in the air, as particulate matter. How much air pollution is caused by fireworks particles in the air depends on the state of the weather. When there is no wind and a high humidity, the fireworks smog will linger longer. The high amount of particles in the air mostly does not last long, because they are larger than typical air pollution and fall out of the air faster.

The RIVM⁶ measured the amount of particles in big Dutch cities during New Year's Eve 2002. The amount of particles in the night was so high, that the average particulate matter concentration the next day rose to 150 µg/m³, with peaks of 1000-1700 µg/m³. In the course of the next day this amount decreased. (Compare this with the average of a day with 'serious smog' is 200 µg/m³.)

- d. Provide significant insight into both the topic of investigation and the research process

Do the fireworks during New Year's Eve affect the amount of aerosols?

The sub-questions are:

- What are Aerosols?

- What is the influence of aerosols on the climate?

To answer this question, we used research reports from scientists. We also got information about this from an aerosol scientist, we had mail contact with.

- How do aerosols affect health?

We used research reports from scientist.

- How can you measure the amount of aerosols?

We already had instructions about how to use the sun photometer, but we did not understand it all the way, so we also watched YouTube videos about how to use the sun photometer. To find out what other measuring instruments there are to measure the amount of aerosols we did literature review.

- How reliable are our sources?

- The Calitoo (sun photometer)

To answer this question we did literature review. We used different sites, but it was hard to find useful information. We also asked question to our experts and to people who did this project before. With this we found enough information to answer our question.

- The satellite

To answer this question we did literature review, using different kind of sites. We also approached a professor who should know more about satellites. However, he did not have enough time to help us with our questions.

- What is the connection between aerosols and fireworks?

- What do fireworks consist of?

We did literature review, using different kind of sites. We also used knowledge ready available to us.

- How do the fireworks particles react in the atmosphere?

We did literature review, using different kind of sites. We also asked our teacher, because she knew more about this topic.

⁶http://www.rivm.nl/Documenten_en_publicaties/Algemeen_Actueel/Nieuwsberichten/2017/Vuurwerk_zorgt_voor_smog_door_fijnstof

e. Answering them requires an advanced understanding of the subject matter
Answering the research questions requires an advanced understanding of the subject matter.
Basically, anyone can look up that aerosols are tiny particles in the air, but you are going to need to go deeper to find out exactly what properties these particles have and how they affect the air.

f. Require a thoughtful research plan

A thoughtful research plan is essential. We decided to just measure whenever there was clear weather. When we were able to measure, we tracked the following things:

- The temperature.
- We will take photos of the sky
- We will write down the wind velocity and the wind direction
- We will write down the sun intensity.

If the weather is bad for measuring, we have a backup plan. Satellites are in orbit around the earth, some of these measure the AOT. We could use the satellite data to draw a conclusion.

g. Are answerable through scientific research appropriate to the scope of the report.

The scope of the report is relatively small, because it is a high school research project and not something students from college would make. The scientific research that is needed to answer the research questions is appropriate to the scope of the report, because we only need to learn to use a measurement system and we can use satellite data if it goes wrong. Some of the questions are also easily answerable through using Google.

3. Introduction and review of the literature

a. Thorough

For our literature research we used Dutch and English sources. We have a good premium if they were reliable. We have, for example, noticed who wrote it and when it was published. A few important Dutch sources are: the KMNI and the RIVM. These are two government organizations. From this we can conclude that they can be trusted. We have also used Universities that have researched this. These universities have conducted research into aerosols more often. We also use papers from Google Scholar. Sometimes we were not sure if we could use a source. We have then looked for more sources with about the same information and so we could conclude that the source and information were trust worthy. The last step to be sure of the information was correct, we consulted professors. They have checked our research to see if it all worked out. These professors are at badges B3.

See 3c for our literature research.

b. Description of the problem

Many accidents happen during the new year eve with regard to fireworks. It is also said that fireworks have a lot of effect on your health and on the aerosols content. With the literature research we have looked at the effect of aerosols on your health, the climate and what do fireworks consist of and so on. Based on results, we checked whether the aerosol content changed before and after the new year.

c. State of the science

The state of science is good. They can already do a lot of research about aerosols. Not everything is known, but a lot is. what this research is good is that there are measuring instruments.

d. Importance

It is important that research is done on aerosols. Aerosols affect health (see 2C.) So the more we know about it, the more we can do about it.

e. Community relevance

Because aerosols have an effect on health and climate (see 2C) It is important to reduce it. For example, in Eindhoven (the Netherlands), they placed large quantities of fine dust filters in the inner city to reduce the aerosol content.

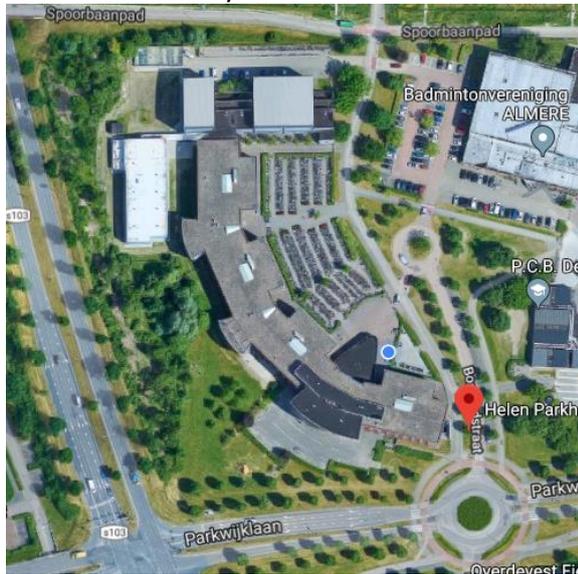
4. Research Methods

- a. There is a direct link provided between the datasets and the research questions.

We did research about aerosols, so in our graphics you can see the AOT. This is a direct link between the datasets and the research questions.

- b. Study site

The study site is located in Almere, the Netherlands. The land is made out of clay and it is relatively flat. The climate of the Netherlands is affected by the Atlantic Ocean and the North Sea, so it is cool, cloudy and humid for most of the year.



- c. Data collection

When the sun was shining we immediately took measurements. We measured with a sun photometer. Each time we took measurements we did at least four of them. Sometimes we measured more times a day, because the sun shone the whole day.

A globe protocol we used is the cloud protocols. We carefully looked at the clouds, if there were clouds, to check if our results were reliable.

- d. Print screen of data entry in the Web page of GLOBE.

THE GLOBE PROGRAM SCIENCE Data invoer

Welcome Student 1 of Maaïke Vollebregt

aanpassen Home / Helen Parkhurst / Parkwijk Rvriër-ATM-01 / Aerosols

2018-01-14 14:23 UTC Local [Krijg huidige UTC tijd](#) Yes Nee calltoo x

Je UTC tijd omgezet naar lokale tijd is (N/A) 2018-01-14 15:23

Serienummer van de fotometer 0103

Aerosols * geeft de benodigde secties of velden aan - Expand / Collapse

Was er een satelliet overvliegen op datum van de meting ? * Yes Nee

Trial 1* UTC-tijd (24) 14:23:13

Channel Golfengte	465	nm	AOT Reading	0,251
Channel Golfengte	540	nm	AOT Reading	0,230
Channel Golfengte	619	nm	AOT Reading	0,186

e. Data analysis

We calculated the average amount of aerosols per day, before and after New Year's Eve. There are measurements you can use to calculate the alpha coefficient. However, we used a sun photometer who immediately gives the alpha coefficient, so we did not need to use the calculations.

f. The data presented are sufficient to answer the research question(s)

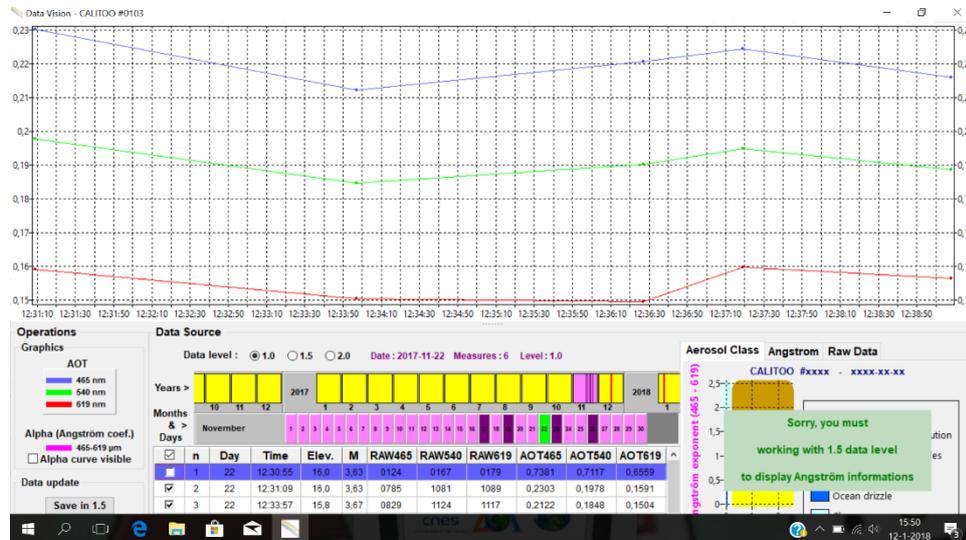
Yes, with the average AOT before and after New Year's Eve we can conclude if the AOT is higher after New Year's Eve or not. The reason for a higher AOT after New Year's Eve can be the fireworks.

5. Results

a. Tables and graphics

Our measurements:

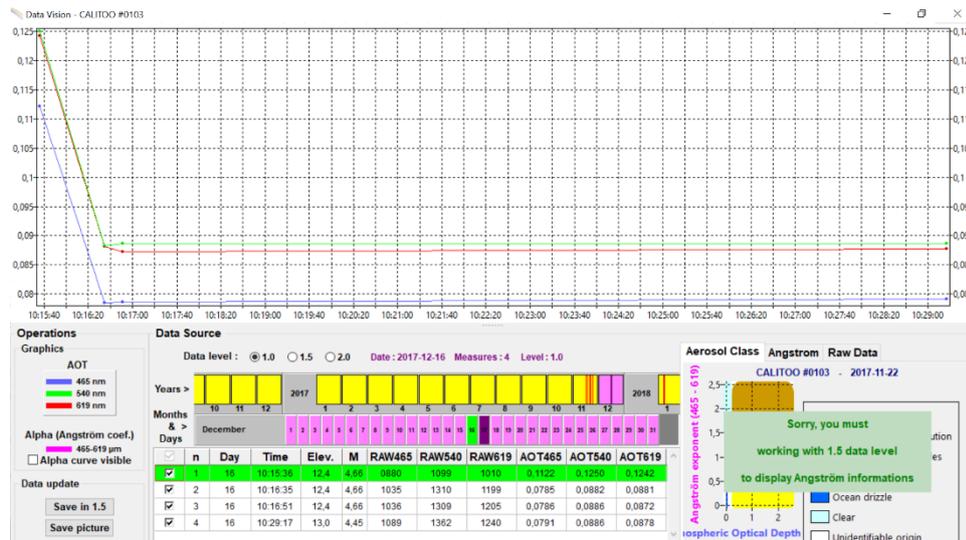
22-11-2017



Average AOT:

- AOT 465 (blue): 0,2208
- AOT 540 (green) : 0,1913
- AOT 619 (red) : 0,1551

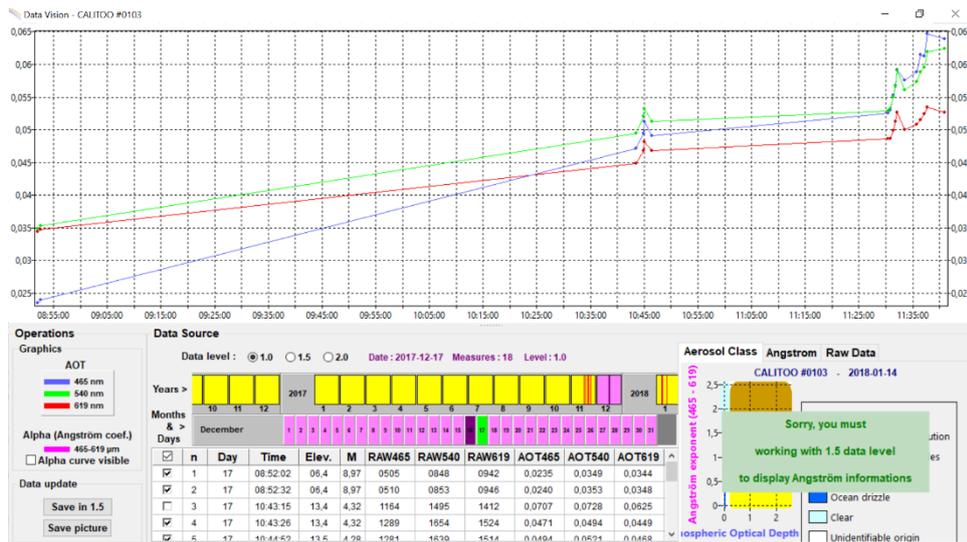
16-12-2017



Average AOT:

- AOT 465: 0,0896
- AOT 540: 0,0976
- AOT 619: 0,0968

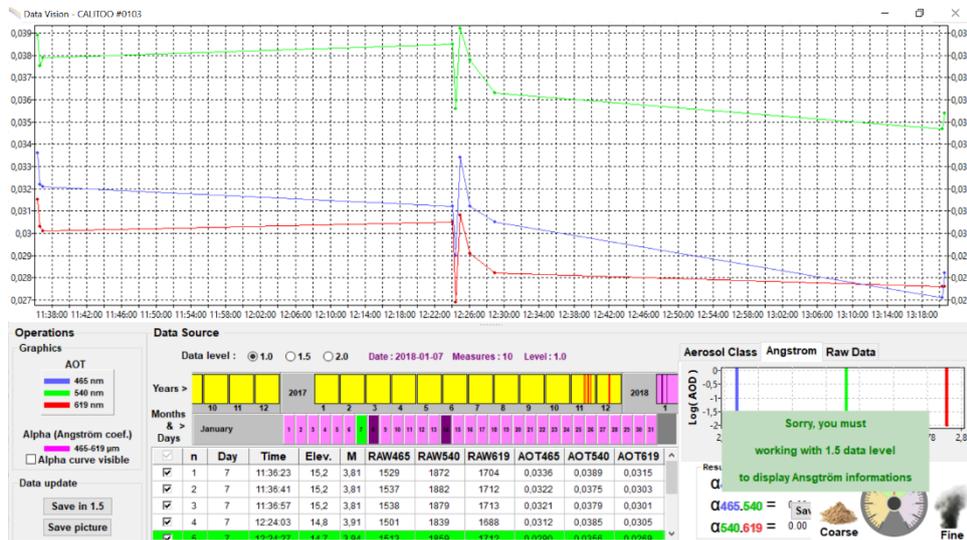
17-12-2017



Average AOT:

- AOT 465: 0,0523
- AOT 540: 0,0535
- AOT 618: 0,0481

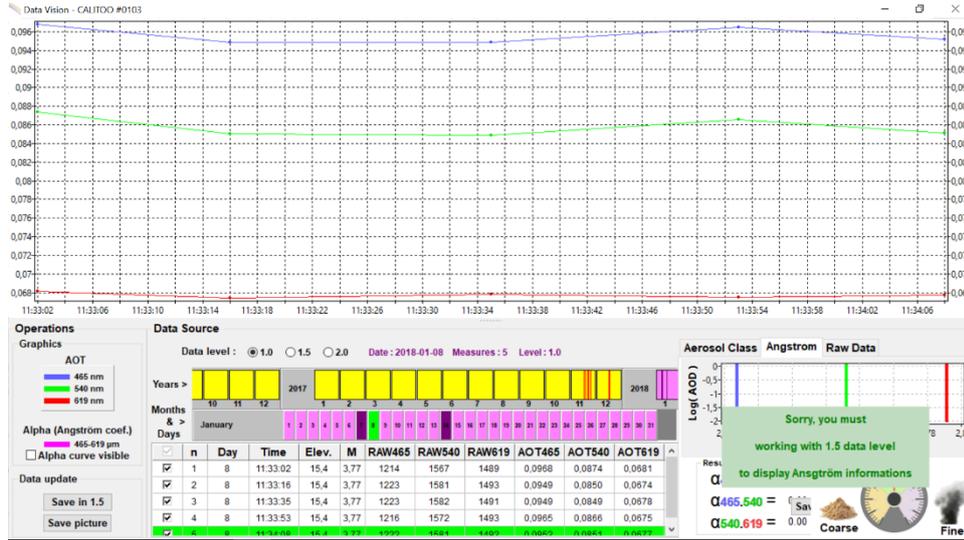
7-01-2018



Average AOT:

- AOT 465: 0,0309
- AOT 540: 0,0372
- AOT 618: 0,0293

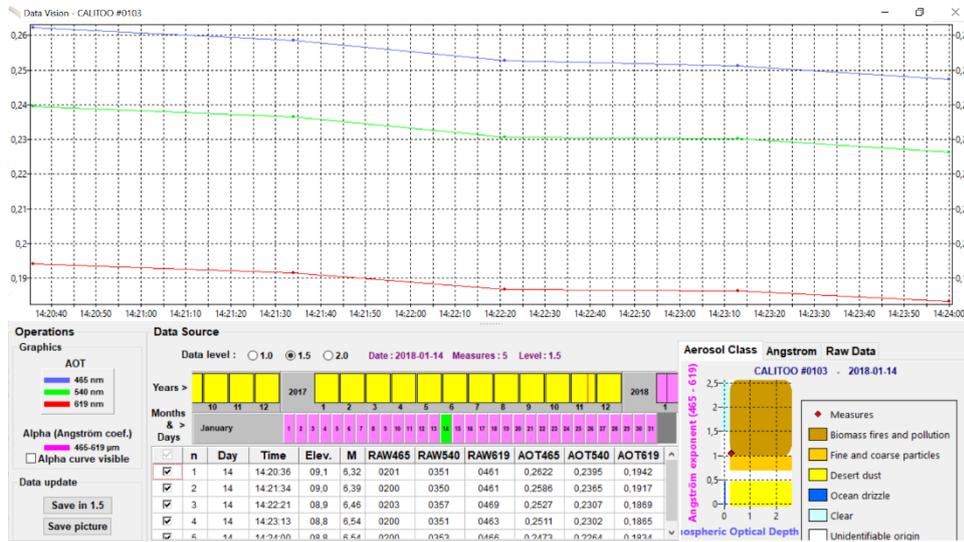
8-01-2018



Average AOT:

- AOT 465: 0,0955
- AOT 540: 0,0858
- AOT 618: 0,0677

14-01-2018



Average AOT:

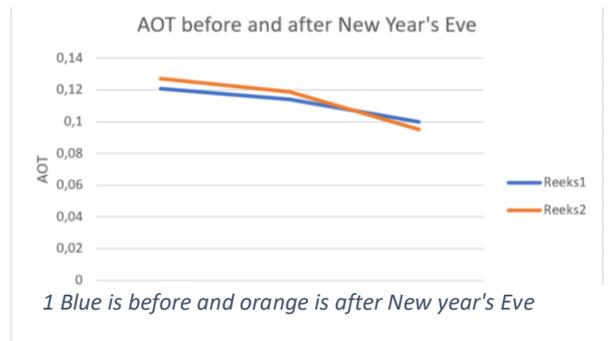
- AOT 465: 0,2544
- AOT 540: 0,2327
- AOT 618: 0,1885

Average amount of aerosols before New Year's Eve:

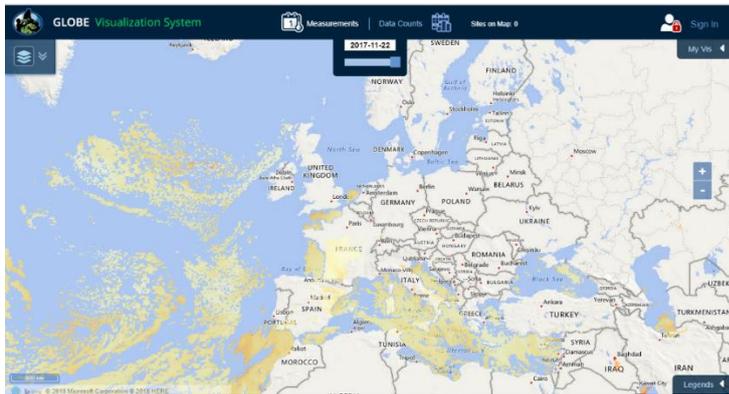
- AOT 465: 0,1209
- AOT 540: 0,1141
- AOT 618: 0,1000

Average amount of aerosols after New Year's Eve:

- AOT 465: 0,1269
- AOT 540: 0,1186
- AOT 618 : 0,0952

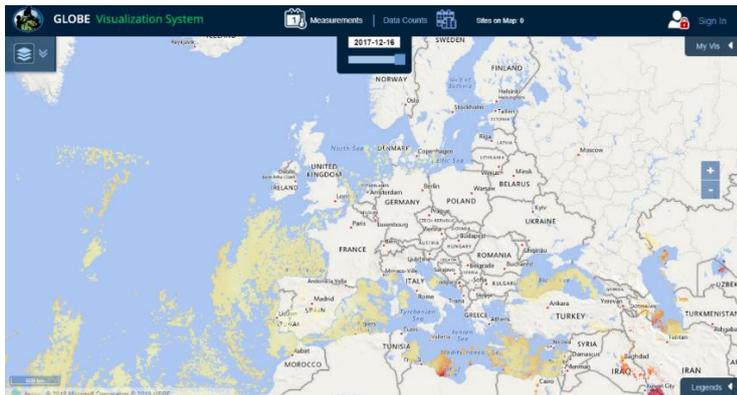


Data from the satellite:
22-11-2017



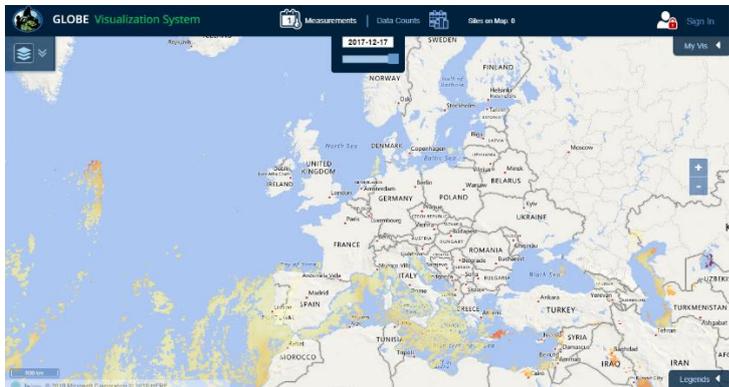
Wind velocity: 6,3 m/s from south west

16-12-2017



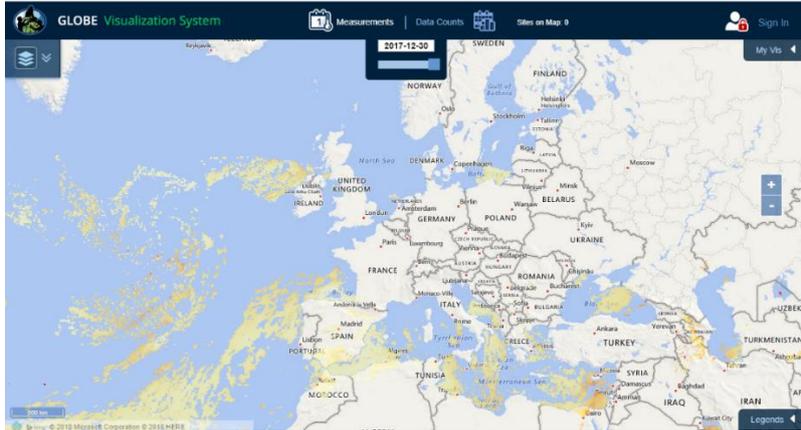
Wind velocity: 2,2 m/s from the West

17-12-2017



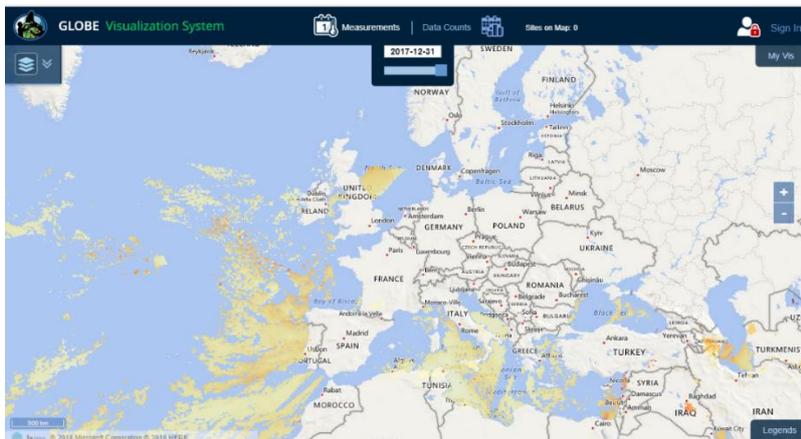
Wind velocity: 3.0 m/s from South-West

30-12-2017



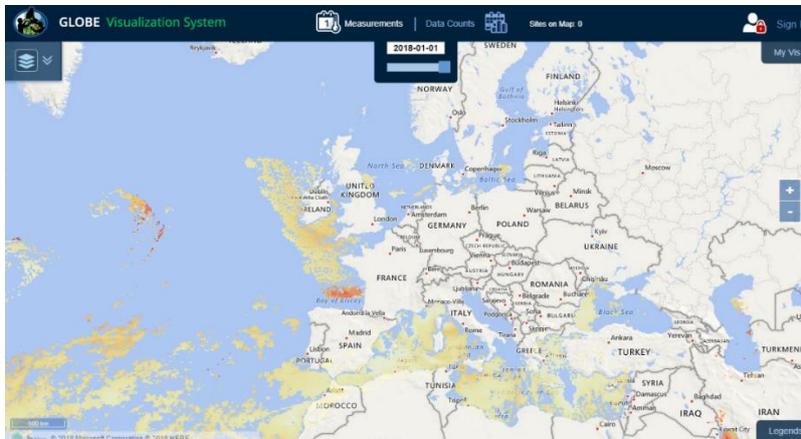
Wind velocity: 6.2 m/s from South West

31-12-2017



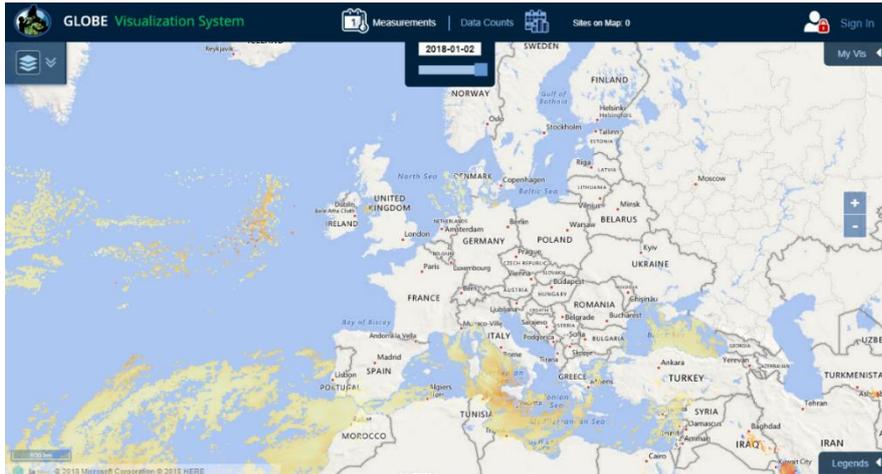
Wind velocity: 5.0 m/s from South West

01-01-2018



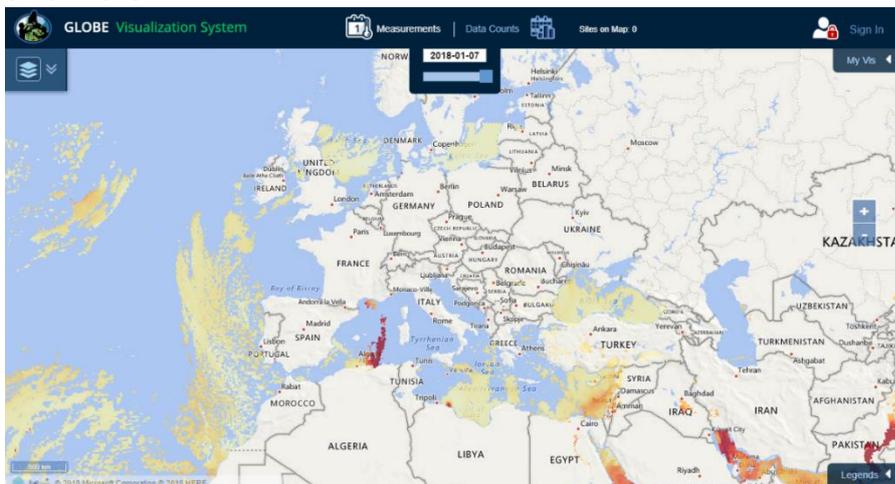
Wind velocity: 5 m/s from South West

02-01-2018



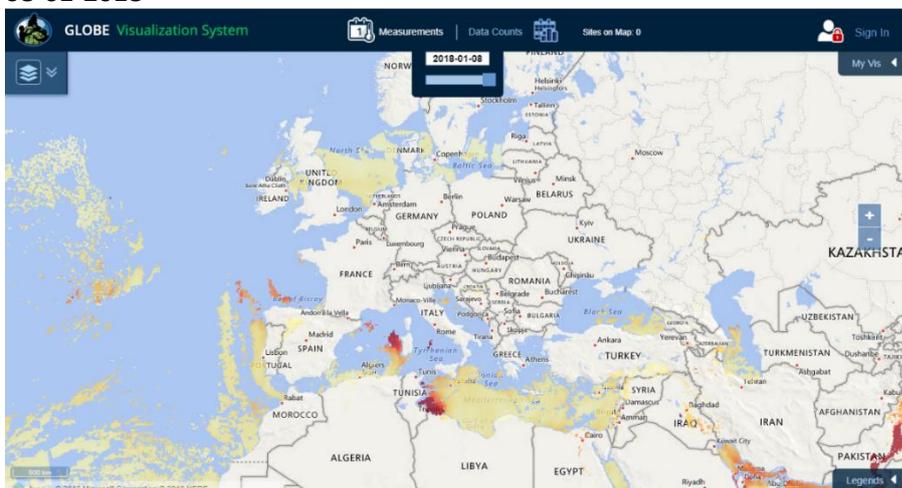
Wind velocity: 4,5 m/s from South West

07-01-2018



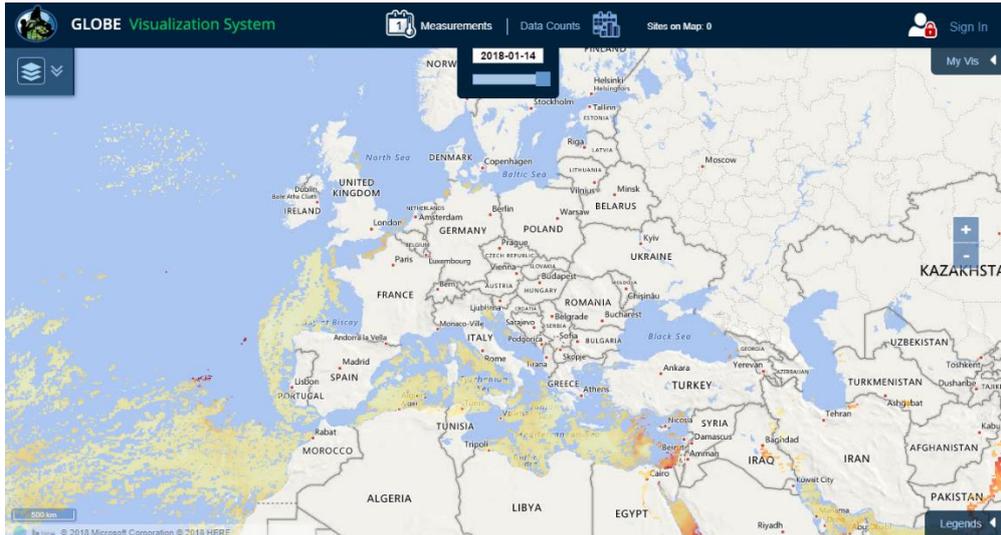
Wind velocity: 5,9 m/s from North East

08-01-2018



Wind velocity: 5,5 m/s from East

14-01-2018



Velocity: 5,5 m/s from East.

- *Data from Skola Za Medicinske Sestre Vrapce (School in Croatia)*

Day	Average AOT
19-12-2017	0,0965
22-12-2017	0,3294
31-12-2017	0,0493
3-1-2018	0,2826
5-1-2018	0,2277
6-1-2018	0,2289

Average AOT before New Year's Eve: 0,1584

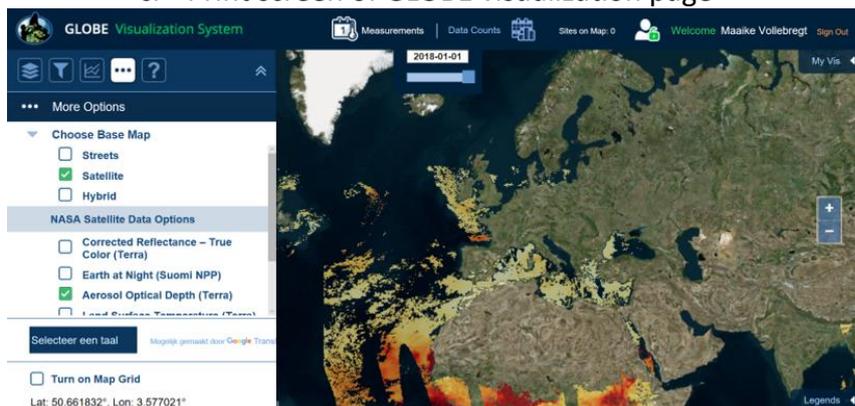
Average AOT after New Year's Eve: 0,2464

b. Data support the conclusions

We only use good data for our conclusion. We did more measurements, but some of them were not reliable. We have determined the reliability by looking to various factors. If the results were higher than 0,5 we didn't use them. (The manual says that results above 0,5 are not reliable) After every measurement, we made photos of the sky too. With this, we could explain the divergent results. When we had a very high AOT and we saw clouds on our photos of that day, the high AOT was probably because of the clouds.

We also tracked the wind strength and wind direction after every measurement.

c. Print screen of GLOBE visualization page



6. Discussion

a. interpretation of results

According to our literature study, we can explain our results. Particulate matter is a part of the aerosols. During New Year's Eve, the amount of particulate matter is higher than normal, because of the fireworks. Because of this you might expect that the AOT also is higher than normal. However, the aerosols are the particles from the ground to the ozone layer and particulate matter is only the bottom layer of the atmosphere. It is possible that most of the aerosols are in another layer than the bottom layer and that the amount of aerosols in the bottom layer does not really affect the AOT.

b. possible sources of error

We could not measure the day after New Year's Eve, because it was cloudy. The days after these days, there was a storm. Our first measurement after New Year's Eve was after one week. It is conceivable that a high number of aerosols flew away before we could measure them. It was also very cloudy during this period of the year (autumn/winter), so we could only measure eight times. Six of these measurements were reliable. If we could do more measurements, our results would be more reliable.

We could not check the reliability of the Croatian measurements. However, we assume that their measurements were reliable. We also didn't have the wind velocity from Croatia, so we could not take this into account. In the Globe visualization system, we could not select different wavelengths. We took the average of the aerosol optical thickness. Also, they measured the aerosols in the wavelength green and red and did not measure the blue wavelength.

c. comparison with similar studies

- The RIVM did a similar study. They measured the amount of particulate matter during New Year's Eve. Their conclusion was that the particulate matter content became higher because of the fireworks during New Year's Eve.
- SATLINK did an expletory research about the connection between the AOT and particulate matter content.
- Chemical Engineering & Technology also did a research about the AOT during New Year's Eve. They detected aerosols from 30 to 450 nm.
- There also was a research ⁷ about the effect of fireworks display perchlorate in air aerosols during the spring festival. Their conclusion was that the fireworks display can result into the levels of perchlorate increase.

d. discuss whether results support the hypothesis or not, and why

Our hypothesis was that the fireworks during New Year's Eve would increase the AOT, because the particulate matter content increases too. Our results do not support this.

⁷ <https://www.sciencedirect.com/science/article/pii/S1352231010010277>

7. Conclusion

- a. Gives a thorough and insightful explanation as to how the conclusion was reached

Based on our measurements we can draw the following sub-conclusions:

- If you look at our measurement results, you can see that the average amount of aerosols one week after New Year's Eve, was not higher than before New Year's Eve. With these results, we can conclude that one week after New Year's Eve, the fireworks do not affect the amount of aerosols.
- When we looked at the satellite data from Terra, we could see that the amount of aerosols do not change very much before and after New Year's Eve. Most of the time, there were no aerosols above the Netherlands according to the satellite data. Because of this, we took the wind directions into account. If, for example, the wind came from the South, we looked to the aerosols in the South, who were the closest to the Netherlands. With this, we can conclude that the fireworks during New Year's Eve do not affect the amount of aerosols according to the satellite data.
- According to the measurements from Skola Za Medicinske Sestre Vrapce, the average AOT before New Year's Eve and after New Year's Eve is higher. You can also see a big difference between the AOT on 31-12-2017 and on 3-01-2018.

Conclusion:

Our sub(-)conclusions were very different. With our sub(-)conclusions we cannot conclude if the fireworks during New Year's Eve affect the amount of aerosols.

- b. Put findings in context, why it's important/relevant, impact, with regard to the science

Due to the increasing focus on the climate changing and the improvement of the climate.

- c. What improvements in methods.

Next time, we would like to do research to a different measuring instrument. One that can measure the AOT on all days, so also days with clouds.

- d. What follow-on research/actions to be taken, future protocols that could be added

- A next research which can be done, is measuring the AOT before and after New Year's Eve three years in a row. With this you have a more reliable conclusion. It is also better to take the measurements in a country where it is always sunny, so we can measure for sure on New Year's Day. This gives a better conclusion.
- Another possible next research is doing research to the effect of fireworks in the summer. You can light fireworks on a special place and then immediately take measurements. With this you can say something about the amount of aerosols immediately after lighting fireworks.

- e. Impact of working with a project mentor

Our project mentor helped us with various things. For example, with how you send a good e-mail to an expert and with the basics of doing good research. This gave us a good base for our further research. Our project mentor also helped us with making a good research question, because we had some trouble with that.

8. Bibliography/citations

All Globe sources are marked with *.

Source satellite data: <https://vis.globe.gov/GLOBE/> *

What is the influence of aerosols on the climate:

https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=5041&context=open_access_etds

Written by: Xijing Zhu (from the Portland State University). Consulted at 10 January 2018

https://icp.giss.nasa.gov/research/ppa/2001/2001_cross_etal.pdf

Written by: Rashele Cross, Autumn Anderson, Kashida Davidson, Jawad Cipriani, DeVoya Stewart, Alana Hamlett (students from Howard University, Bronx High School of Science and Frederick Douglass Academy) Consulted at 10 January 2018.

How do aerosols affect health?

https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=5041&context=open_access_etds

Written by: Xijing Zhu (from the Portland State University). Consulted at 10 January 2018

<https://lucris.lub.lu.se/ws/files/6068538/8572429.pdf>

Written by: Johan Friberg (from the Lund University). Consulted at 10 January 2018

<https://www.knmi.nl/kennis-en-datacentrum/uitleg/aerosolen>

Organization: KNMI. Consulted at 10 January.

How can you measure the amount of aerosols?

<https://www.earthobservatory.nasa.gov/Features/Aerosols/page5.php>

Written by: Paul Przyborski. Consulted at 16 December 2017.

<https://terra.nasa.gov/about/terra-instruments/modis>

Written by: Tasia Owen. Consulted at 16 December 2017

<http://www.calitoo.fr/index.php?page=aerosols-measurement>

Organization: Calitoo. Consulted at 16 December 2017.

How reliable are our sources?

Sun photometer (calitoo)

<http://projects.knmi.nl/globe/meetinstructies.html>

Organization: KNMI. Consulted at 20 December 2017.

Terra (satellite)

<https://terra.nasa.gov/about/terra-instruments/modis>

Written by: Tasia Owen. Consulted at 16 December 2017

<http://www.calitoo.fr/index.php?page=aerosols-measurement>

Organization: Calitoo. Consulted at 16 December 2017.

https://www.nts.com/resourcecenter/articles/testing_reliability_of_satellite_power_systems

Organization: National Technical Systems. Consulted at 20 December 2017.

<http://globenederland.nl/onderzoeksproject/aerosolen/> *

Organization: Globe Nederland. Consulted at 20 December 2017.

What is the connection between aerosols and fireworks

What do fireworks consist of?

<https://www.nemokennislink.nl/publicaties/vuurwerk-knallen-en-kleuren/>

Written by: Harm Iking, Jos van den Broek en Danièle Gibney. Consulted at 16 December 2017.

<http://www.chemischefeitelijkheden.nl/Uploads/Magazines/CF-194-vuurwerk.pdf>

Written by: Arthur van Zuylen. Consulted at 16 December 2017.

How do the firework particles react in the atmosphere?

<http://www.chemischefeitelijkheden.nl/Uploads/Magazines/CF-194-vuurwerk.pdf>

Written by: Arthur van Zuylen. Consulted at 16 December 2017.

<http://www.chemischefeitelijkheden.nl/Uploads/Magazines/CF-Barium-11.pdf>

Written by: dr J.H.O.J Wijenberg. Consulted at 17 December 2017

<https://www.milieucentraal.nl/bewust-winkelen/spullen-en-diensten/vuurwerk/>

Written by: milieu centraal. Consulted at 17 December 2017

http://www.rivm.nl/Documenten_en_publicaties/Algemeen_Actueel/Nieuwsberichten/2017/Vuurwerk_zorgt_voor_smog_door_fijnstof

Written by: RIVM. Consulted at 17 December 2017

Discussion

<http://www.pbl.nl/publicaties/2008/De-relatie-tussen-aerosol-optische-dikte-en-PM2.5-in-Nederland---SATLINK-eindrapport>

Organization: RIVM. Consulted at 27 January 2018

<http://onlinelibrary.wiley.com/doi/10.1002/ceat.201100080/abstract?systemMessage=Please+be+advised+that+we+experienced+an+unexpected+issue+that+occurred+on+Saturday+and+Sunday+January+20th+and+21st+that+caused+the+site+to+be+down+for+an+extended+period+of+time+and+affected+the+ability+of+users+to+access+content+on+Wiley+Online+Library.+This+issue+has+now+been+fully+resolved.+We+apologize+for+any+inconvenience+this+may+have+caused+and+are+working+to+ensure+that+we+can+alert+you+immediately+of+any+unplanned+periods+of+downtime+or+disruption+in+the+future.>

By A.Dutschke, C.Lohrer, L.Kurth, S.Seeger, M. Barthel and U.Panne. Consulted at 27 January 2018.

<https://www.sciencedirect.com/science/article/pii/S1352231010010277>

By Yali Shi, Ning Zhang, Jianmin Gao, Xin Li and Jaqi Cai. Consulted at 27 January 2018.

Wind directions:

<https://earth.nullschool.net/#current/wind/isobaric/1000hPa/orthographic=-6.30,39.94,431>

<http://projects.knmi.nl/klimatologie/daggegevens/index.cgi>

We consulted these sources every day we took measurements and on the days we used satellite data.

Badges:

B1: Collaboration

All team members are listed, along with clearly defined roles, how these roles support one another, and descriptions of each student's contribution. The descriptions clearly indicate the advantages of the collaboration. We were all responsible for the research we did on the internet.



Eva Janssen



My name is Eva. My task was to search for professionals and schools. My job was to find professionals and schools who could help us with our research. My other task was to maintain contact with the schools and professionals, together with Rozemarijn.

Rozemarijn van den Born



My name is Rozemarijn. I am the planner of the group. My job is to set deadlines for the group and adjust the planning, if necessary. I discuss the planning frequently with the group, so everyone knows what they have to do and when it needs to be done. My other task is to do research on the Calitoo and to help with keeping contact with the professionals.

Sander de Beet



My name is Sander. I am the group 'translator'. I translate from English to Dutch and vice versa. When other people in the team don't know some of the more difficult words in English, I help them with translating. My other task is to help Rozemarijn with the research on the Calitoo.

Sanne Streekstra



Hello, my name is Sanne. This project, I did several things. I had contact with two of the three professionals. Because I checked my mail so frequently, we were able to respond quickly. The information which the professors sent us through mail was very helpful. Besides, I made the poster. I also worked on the research report.

B3: Connecting to a STEM Professional

The report clearly describes collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results.

We would like to thank our professors. We had three STEM professionals that helped us during the project. We also had contact with Globe Nederland. Two teachers of our school helped us with the research, this was not related to the content but to the way of researching.

Our three STEM professionals are:

- Joost Wesseling, from the RIVM (in the Netherlands)

He helped us to draw up our research question. He also helped us with the things we did not understand about aerosols. Besides that, he helped us partially with understanding the Calitoo (our measure device).

- Hester Volten, from the RIVM (in the Netherlands)

She is a colleague of Joost Wesseling. She helped us to find satellites, so we could compare our results with it. Besides that, she read our research report (3c) and gave a reaction. Finally, she helped us with understanding the Calitoo.

- Leah Williams, from the Aerodyne Research Inc. Center for Aerosol & Cloud Chemistry (America)

Leah Williams is an aerosol expert. She answered our questions and she gave comments on the information we wrote at 3c (Include a well-written description of background information). She also gave tips about information we could add to our research and corrected our English.

Other professionals

- Our teachers, from Helen Parkhurst (the Netherlands)

We have two teachers who helped us with this project. Those are Maaïke Vollebregt and Joris ten Barge. They helped us to draw up our research question. Besides, we conferred with them about the research plan. They did not help us with the content of our report.

- Professional, from Globe Nederland (the Netherlands)

During the project, we had some questions about the commission. Globe Nederland answered those questions.

- Koen Michels, a Calitoo professional (the Netherlands)

He helped us with the questions about the Calitoo, that the other professionals could not answer.

B4: Interscholastic connection

The report describes a carefully planned interscholastic or international collaboration that describes rationales for data collection in different regions and the advantages of comparing results.

We compared our data with a school in Croatia. (Skola Za Medicinske Sestre Vrapce)

The advantages of comparing results for our research:

- We have more data for our conclusion. With more results you get a more reliable conclusion.
- In Croatia, the sun shines more than in the Netherlands. This is an advantage for our research, because we measure the AOT with a sun photometer, which you can only use when the sun shines and when there are no clouds in front of the sun.

We wanted to compare our data with another country. First we searched on the Globe site to schools who measure the AOT. We send an email to a lot of schools. Skola Za Medicinske Sestre Vrapce answered to our mail. They also measured the AOT, so we could exchange results. We also told each other about our schools and what we already did with Globe. We both plan to go to the Globe Learning Expedition in Ireland, so it would be fun to meet each other there.

GLE theme:

Environmental problems and solutions.

We choose this theme, because we did research about aerosols, which is an environmental problem.

Photo release forms



NASA Media Release for Parent and Minor

I, Peter de Beet, am the parent/guardian/legal representative of
(Please print your name)
Sander de Beet and do hereby give permission
(Please print name of child)

for the above-named minor child (hereinafter "Minor") to be interviewed, photographed and/or videotaped by NASA or its representatives. I understand and agree that the text, photographs, and/or videotapes containing the words, image and/or voice of the Minor may be used in the production of instructional and/or promotional materials produced by or on behalf of NASA (hereinafter the "Program") and that such materials may be distributed or broadcast to the public and displayed publicly. I also understand that my permission to use the text, photographs and videotapes is for an unlimited duration and that neither I nor the Minor will receive any compensation for granting this permission or for the use, if any, by NASA of the Minor's words, image and/or voice.

I acknowledge that NASA has no obligation to use the Minor's words, image or voice in connection with the Program.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am at least 18 years of age and am the parent/guardian/legal representative of the above-named Minor. I have read the foregoing agreement and am familiar with all of the terms and conditions thereof and I consent to its execution by the Minor. I agree that neither I nor the Minor will revoke or disaffirm this agreement at any time.

Signature of Parent/Guardian/Legal Representative of Minor: [Signature]
 Relationship to Minor: Parent Date: 14-02-2018
 Signature of Minor: [Signature]
 Name and Location of Event: Almere, the Netherlands
 Address: Bongerdsgracht 1 1326 AA
 Telephone: ~~06 406 457 66~~ + 31 6 406 457 66
 Email: Sander447debeet@gmail.com



NASA Media Release for Parent and Minor

I, Sanne Tjeerd Streekstra, am the parent/guardian/legal representative of
(Please print your name)
Sanne Streekstra and do hereby give permission
(Please print name of child)

for the above-named minor child (hereinafter "Minor") to be interviewed, photographed and/or videotaped by NASA or its representatives. I understand and agree that the text, photographs, and/or videotapes containing the words, image and/or voice of the Minor may be used in the production of instructional and/or promotional materials produced by or on behalf of NASA (hereinafter the "Program") and that such materials may be distributed or broadcast to the public and displayed publicly. I also understand that my permission to use the text, photographs and videotapes is for an unlimited duration and that neither I nor the Minor will receive any compensation for granting this permission or for the use, if any, by NASA of the Minor's words, image and/or voice.

I acknowledge that NASA has no obligation to use the Minor's words, image or voice in connection with the Program.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am at least 18 years of age and am the parent/guardian/legal representative of the above-named Minor. I have read the foregoing agreement and am familiar with all of the terms and conditions thereof and I consent to its execution by the Minor. I agree that neither I nor the Minor will revoke or disaffirm this agreement at any time.

Signature of Parent/Guardian/Legal Representative of Minor: [Signature]
 Relationship to Minor: Father Date: 14-2-2018
 Signature of Minor: [Signature]
 Name and Location of Event: Almere, the Netherlands
 Address: Bongerdsstraat 1
 Telephone: +316 139 72974
 Email: 420365@hp.osgleerling.nl



NASA Media Release for Parent and Minor

I, Heidi van de Kolk, am the parent/guardian/legal representative of Rozemarijn van den Boven and do hereby give permission

for the above-named minor child (hereinafter "Minor") to be interviewed, photographed and/or videotaped by NASA or its representatives. I understand and agree that the text, photographs, and/or videotapes containing the words, image and/or voice of the Minor may be used in the production of instructional and/or promotional materials produced by or on behalf of NASA (hereinafter the "Program") and that such materials may be distributed or broadcast to the public and displayed publicly.

I acknowledge that NASA has no obligation to use the Minor's words, image or voice in connection with the Program.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am at least 18 years of age and am the parent/guardian/legal representative of the above-named Minor. I have read the foregoing agreement and am familiar with all of the terms and conditions thereof and I consent to its execution by the Minor. I agree that neither I nor the Minor will revoke or disaffirm this agreement at any time.

Signature of Parent/Guardian/Legal Representative of Minor: [Signature]
Relationship to Minor: Mother (parents) Date: 14-2-2018
Signature of Minor: [Signature]
Name and Location of Event: Almere, the Netherlands
Address: Bongerd street 1
Telephone: +316 53854989
Email: 420568@hp.asglearning.nl



NASA Media Release for Parent and Minor

I, Liesbeth Alexandra van Galen, am the parent/guardian/legal representative of EVA Laureline Janssen and do hereby give permission

for the above-named minor child (hereinafter "Minor") to be interviewed, photographed and/or videotaped by NASA or its representatives. I understand and agree that the text, photographs, and/or videotapes containing the words, image and/or voice of the Minor may be used in the production of instructional and/or promotional materials produced by or on behalf of NASA (hereinafter the "Program") and that such materials may be distributed or broadcast to the public and displayed publicly.

I acknowledge that NASA has no obligation to use the Minor's words, image or voice in connection with the Program.

I hereby unconditionally release NASA and its representatives from any and all claims and demands arising out of the activities authorized under the terms of this agreement.

By signing below, I represent that I am at least 18 years of age and am the parent/guardian/legal representative of the above-named Minor. I have read the foregoing agreement and am familiar with all of the terms and conditions thereof and I consent to its execution by the Minor. I agree that neither I nor the Minor will revoke or disaffirm this agreement at any time.

Signature of Parent/Guardian/Legal Representative of Minor: [Signature]
Relationship to Minor: Mother Date: 14-02-2018
Signature of Minor: [Signature]
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Email: Liesbeth@demov.nl