

Lesson Plan: Aerosols and Climate

Teacher- contributed lesson plan by Dr. Shefali Shukla, Assistant Professor, Sri Venkateswara College (University of Delhi), India.

As a **high School Chemistry** or **Environmental Sciences** teacher, you can use this set of computer-based tools to teach about **aerosols**, their **sources**, and their **direct and indirect impact on climate**.

This lesson plan will help students understand what aerosols are and what are the major sources of atmospheric aerosols. Students will learn the importance of atmospheric aerosols by evaluating their direct and indirect role in affecting climate. They will also learn how aerosol nanoparticles formation impacts Earth's climate by cloud seeding and precipitation. Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Chemistry or Environmental Sciences.

Use this lesson plan to help your students find answers to:

- What are aerosols and what are the sources of atmospheric aerosols?
- How do atmospheric aerosols aid in the formation of clouds and precipitation?
- Explain how atmospheric aerosols can have a cooling or warming effect on the planet?
- What kind of atmospheric aerosols are emitted during volcanic eruptions?
- Which are the main atmospheric aerosols produced by anthropogenic activities and how can they affect climate?

About the Lesson Plan

Grade Level: High school

Discipline: Chemistry, Environmental Sciences

Topic(s) in Discipline: Aerosols, Sources of Aerosols, Aerosol Nanoparticles, Radiative Energy Balance, Role of Aerosols in Cloud Formation, Sulphate Aerosols

Climate Topic: Climate and the Atmosphere, The Greenhouse Gas Effect

Location: Global

Access: Online

Language(s): English

Approximate Time Required: [40-50 min]

1 Contents

1. Reading (~10 min)

A reading that explains what aerosols are and describes the different sources of atmospheric aerosols. This reading includes a section on volcanic eruptions as one of the largest natural contributors to atmospheric aerosols.

<https://www.nasa.gov/centers/langley/news/factsheets/Aerosols.html>

2. Video (~6 min)

A video to visualize the effect of aerosols on climate specifically in their role in cloud formation. This video explains how the interaction of aerosols with gas molecules in the atmosphere helps in cloud formation.

https://www.youtube.com/watch?time_continue=342&v=uNqf5vbJf8

3. Classroom/ Laboratory activity (25 min)

A classroom activity about the different atmospheric aerosols and gases released during volcanic eruptions and how they affect climate.

<https://ag.purdue.edu/climate/wp-content/uploads/2018/06/Volcano-ActivityR2014.pdf>

4. Suggested questions/assignments for learning evaluation

- What are aerosols and what are the sources of atmospheric aerosols?
- How do atmospheric aerosols aid in the formation of clouds and precipitation?
- Explain how atmospheric aerosols can have a cooling or warming effect on the planet?
- What kind of atmospheric aerosols are emitted during volcanic eruptions?
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2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

1. Topic introduction and discussion

Use a reading, "[Atmospheric Aerosols: What Are They, and Why Are They So Important?](#)" by the Langley Research Centre, NASA, to discuss in detail what atmospheric aerosols are and what are their main sources. Use the reading to explain in detail how aerosols can affect climate and can cause both heating and cooling on the Earth's surface. Emphasize that volcanic eruptions are amongst the largest sources of atmospheric aerosols. Using examples discussed in text, explain how volcanic eruptions have affected Earth's climate in the past, due to the large-scale dispersal of particulate matter and the release of greenhouse gases into the atmosphere. Further, describe how the other main sources of aerosols- dust and anthropogenic sources like smoke particles and sulfate aerosols from the burning of fossil fuels- can also affect climate.

Describe how sulphate aerosols are formed in the atmosphere when sulphur dioxide reacts with water to form fine liquid droplets of sulphuric acid and solid particles of salts of sulphuric acid. Discuss how the concentration of human contributed sulfate aerosols have increased in the industrial age and how they could possibly affect Earth's climate. Finally, explain how aerosols are used as tracers to study global atmospheric patterns.

This reading can be accessed at <https://www.nasa.gov/centers/langley/news/factsheets/Aerosols.html>

2. Use a visualization tool to explain

Next, use an animated video, "[Aerosol Nanoparticle Formation](#)" by Aerosol Physics and Environmental Physics- Winkler Group, University of Vienna, to help students to visualize the interactions of aerosol particles and gas molecules in the atmosphere. Use this video to explain how some of these interactions result in molecular aggregates in the atmosphere, on which water condenses to form water droplets resulting in cloud formation. Clouds both absorb light from the sun and form a barrier for heat loss from the Earth's surface thereby affecting the Earth's radiation energy balance. Therefore, discuss how aerosols have an indirect effect on climate due to their role in aiding cloud formation.

This video can be accessed at https://www.youtube.com/watch?time_continue=342&v=uNqf5vbjf8

3. Conduct a classroom activity

Conduct this enquiry-based classroom activity, "[Volcanoes and Global Warming](#)" by Purdue University to enable students to study data of emissions from volcanic eruptions. Firstly, engage the students in a discussion of what kind of material is ejected into the atmosphere as a result of volcanic activity i.e. ash (fine dust) and several gases. Use the text to specify that water vapour, carbon dioxide (CO₂) and sulphur dioxide (SO₂) are the main gases released. Of these, water vapour and carbon dioxide are greenhouse gases and can directly contribute towards warming of the Earth's surface. Sulphur dioxide, on the other hand, has an indirect effect on climate by forming sulfate aerosols. Emphasize on the role of these sulfate aerosols on climate as they directly absorb or reflect light energy or indirectly, through cloud formation, cause heating or cooling on the Earth's surface. Using the data provided, instruct students to draw bar graphs to compare the percentages of the types of gases released from volcanic eruptions in disparate geographic locations. Use the 'Extend Your Thinking' section to analyse two cases of volcanic eruptions in the past and engage the students in a discussion about the impact of sulfate aerosols on the global climate.

This can be accessed at <https://ag.purdue.edu/climate/wp-content/uploads/2018/06/Volcano-ActivityR2014.pdf>

5. Questions/Assignments

- What are aerosols and what are the sources of atmospheric aerosols?
- How do atmospheric aerosols aid in the formation of clouds and precipitation?

- Explain how atmospheric aerosols can have a cooling or warming effect on the planet?
- What kind of atmospheric aerosols are emitted during volcanic eruptions?
- Which are the main atmospheric aerosols produced by anthropogenic activities and how can they affect climate?

3 Learning Outcomes

The tools in this lesson plan will enable students to understand:

- what aerosols are and what are their main sources
- the importance of the presence of aerosols in the atmosphere
- the role of aerosols in cloud formation and precipitation
- the mechanisms of the cooling or heating effects of atmospheric aerosols on the Earth's surface
- the possible effect of various types of atmospheric aerosols on climate

4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

1. **Quiz: "What are aerosols?"** by NASA's EARTH RIGHT NOW initiative.

A quiz that questions the students' knowledge and understanding of atmospheric aerosols and through such enquiry introduces their basic characteristics. This quiz can be used as an additional introduction to the topic of aerosols by testing the students' prior knowledge of aerosols.

This can be accessed at <https://climate.nasa.gov/quizzes/clouds-aerosols-quiz/>

2. **Reading: “Climate Change and the Impact of Aerosol- A Literature Review”** by B. Verheggen and E.P. Weijers, Energy Research Centre of the Netherlands (ECN)

This reading provides a literature review to assess the role of aerosols in affecting global climate.

This can be accessed at <https://www.ecn.nl/publications/PdfFetch.aspx?nr=ECN-E--09-095>

3. **Visualisation: “Exploring Aerosol Optical Thickness Using MODIS Satellite Imagery in NEO”** by Science Education Resource Centre (SERC).

This lesson plan provides a dataset from NASA Earth Observations for students to explore and use various ways to analyse and represent the data by changing the parameters for observations.

This can be accessed at <https://serc.carleton.edu/usingdata/datasheets/aeroslopticalthick.html>

5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and ownership details for each tool by following the individual links provided.

We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

1. **Reading: “Atmospheric Aerosols: What Are They, and Why Are They So Important?”**

Factsheet published by the [Langley Research Centre, NASA](#)

2. Video; “Aerosol Nanoparticle Formation”

Published by the [Aerosol Physics and Environmental Physics- Winkler Group](#), Faculty of Physics, University of Vienna

3. Classroom/Lab activity; “Volcanoes and Global Warming”

An activity for ‘conceptualizing climate and climate change’ by [Purdue University](#)

4. Additional Resources

NASA’s EARTH *RIGHT* NOW initiative, [NASA- Global Climate Change](#);

B. Verheggen and E.P. Weijers, [Energy Research Centre of the Netherlands \(ECN\)](#);

[Science Education Resource Centre \(SERC\)](#), Carleton College