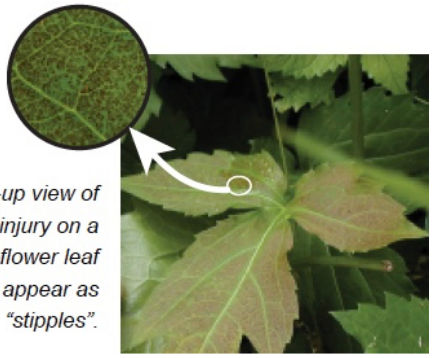
Lesson 3 – Bad Ozone

Summary:
Students will analyze real NASA data about ground-level ozone and nitrogen dioxide. They will determine where ozone concentrations are highest, why ozone concentrations are highest, and how ozone concentrations have changed over time. Students will also learn about the effects of ground-level ozone on plants and people.



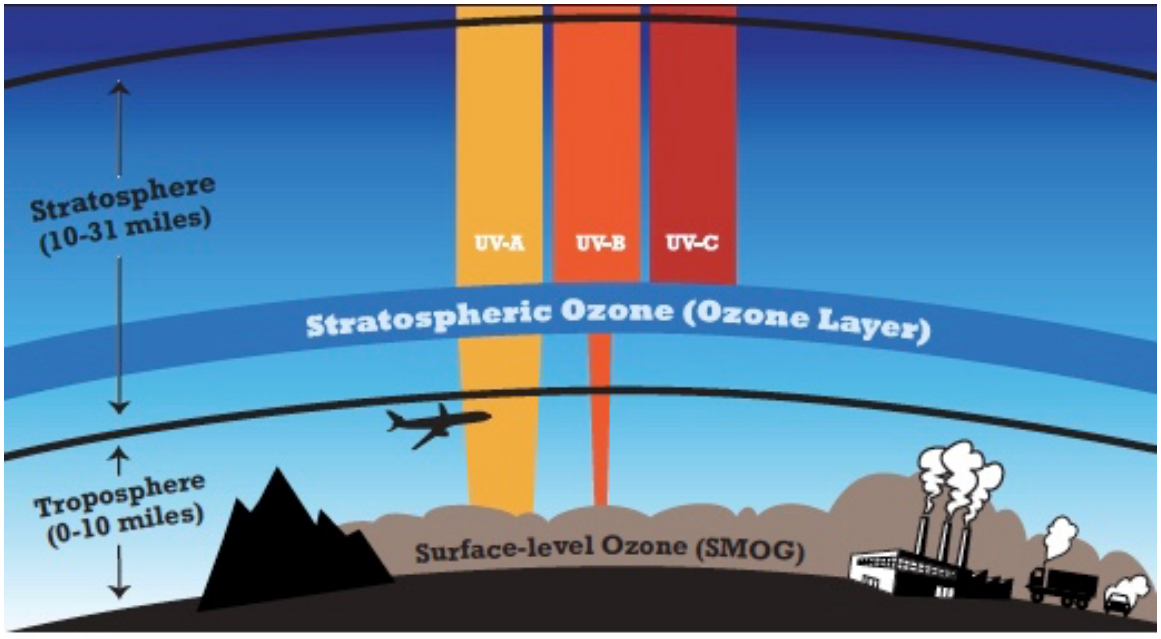
Close-up view of ozone injury on a coneflower leaf that appear as "stipples".

Time: This lesson plan should be conducted over two 45-minute class periods.

Science standards addressed:

MS - Human Impacts

MS-ESS3-2.	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
MS-ESS3-3.	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4.	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.



Ozone in our atmosphere is "good" up high and "bad" nearby, at the surface where we live and breathe.

Engagement
Discussion with class, comparing images (5 minutes)

Students are shown images of Los Angeles and Atlanta that show a dark haze in the air. Ask students, "What do these cities have in common?" (Common answers may include: pollution, smog, dark clouds, buildings, cars, etc.)

> Teacher Note: The discussion can be guided by asking students what they notice about the atmosphere in each of the images and asking them to identify the source of the haze in the air.
>
> or
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> Have students write ideas on small pieces of paper, like post-its, that can be tacked up on the board or students can share ideas and a scribe can write them on the board.

Bad Ozone: 4 Activities
Identifying the Causes of Ground-Level Ozone

Exploration
Complete Bad Ozone Handouts:

- Activity 1: L3A Bad Ozone Handout: Identifying the Causes of Ground-Level Ozone
  - Students watch the video, **Breathable – A Story about Air Quality** (https://www.youtube.com/watch?v=2yd2s5vdQeQ&feature=youtu.be), from the beginning through 4:25 and answer guided questions provided in the handout.
- Activity 2: L3B Bad Ozone Handout: Understanding NO_2 Pollution Data Visualizations
  - Students analyze a map of the United States that shows nitrogen dioxide concentrations over city centers, using the guided questions on the handout.
- Activity 3: L3C Bad Ozone Handout: Comparing NO_2 Pollution and Population Density
  - Students analyze the relationship between population density and nitrogen dioxide concentrations, comparing two maps produced with satellite data.
- Activity 4: L3D Bad Ozone Handout: Comparing NO_2 Concentrations Over Time
  - Students analyze two maps of nitrogen dioxide concentrations, one from 2005 and the other from 2010. Students will observe a decrease in nitrogen dioxide concentrations in the United States.

Explanation
Students read the article *In the Fog About Smog*, published by the American Chemical Society and available at the following link http://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/archive/smog-chemmatters-april2013.pdf (10 minutes)

Teacher note:
Suggested types of group reading:

- **popcorn reading**, where students read until they want to stop or where a paragraph ends and they name another student to continue reading at that point.
- **Independent reading**, where students are allowed to

The reading explains the relationship between ozone and smog. It covers the human causes of ground-level ozone and the hazards of high ozone concentrations on Earth's surface. It also tells the good news story that ground-level nitrogen dioxide concentrations are decreasing, an improvement in air quality.

Elaboration
Watch Air Quality TED talk (Bryan Duncan) Tale of 3 Cities http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11812 (14 minutes). In this video Bryan Duncan explains air quality in Los Angeles, Beijing, and Atlanta from the perspective of space. He uses compelling satellite imagery to explain what is smog, where smog concentrations are highest, what ozone's relationship is to smog, and what measures have lead to the reduction of smog and the improvement of air quality.

Extension
For students that want more information or sources for potential research assignments, direct students to the following resources.

Check our daily Air Quality Index at https://www.airnow.gov/
Learn about how plants are impacted by ground-level ozone http://aura.gsfc.nasa.gov/outreach/ozonegarden.html

Evaluation
Students answer the questions on the L3DOzone: Reflection handout referencing information they learned from "In the Fog about Smog" article and the "Tale of 3 Cities" video. They will submit all the completed handouts (Activities 1 – 4 and the completed reflection) for credit.