

# Cleaning Up Our Air

## Tracking Air Quality from Space

Imagine waking up to hear that school is closed because of a throat-burning cloud of pollution (smog). That happened in Los Angeles and other cities in the 1940s and 50s. Smog still forms today in some parts of the world, but mostly we can see from space that air quality has been improving.

Smog has been a problem in Los Angeles for decades. An astronaut on the first space station, Skylab, shot this photo of a thick blanket of smog over the city in 1973.



The term “smog” is a contraction of the words “smoke” and “fog.” It describes a mix of **pollutants** in the air over cities. One pollutant, nitrogen dioxide ( $\text{NO}_2$ ), is particularly harmful to breathe, especially for people with asthma.  $\text{NO}_2$  is released into the air from burning fuels such as coal or gasoline, so cars, trucks, factories, and power plants are the largest sources. The burning of fuels also releases **volatile** organic compounds (VOCs) — chemicals that easily evaporate. Thousands of VOCs are emitted from trees and everyday products like paint, cleaners, glues, and air fresheners. All of them can affect our air quality indoors and outdoors.

### Sunlight and Chemistry

Photochemical smog requires sunlight to form. When sunlight interacts with **nitrogen oxides** ( $\text{NO}_x$ ) and VOCs in the air, the chemical reactions produce another harmful pollutant called ozone. When found near the ground, ozone can cause damage to our lungs and lead to shortness of breath.



### Vocabulary



**pollutant** – A substance or chemical that makes the air, water, or soil harmful or damaging to the environment and its inhabitants.

**nitrogen oxides** – Chemical combinations of nitrogen and oxygen (such as nitrogen dioxide).

**volatile** – Evaporating or vaporizing under normal temperature and pressure; having a low boiling point.

## Sensing Smog from Space

Satellites measure the **concentration** of ozone from the edge of space to the ground. Since most ozone is found high in the atmosphere (in the stratospheric ozone layer), it can be difficult to figure out exactly how much ozone is near Earth's surface. However, satellites can measure a key ingredient of ground-level ozone – nitrogen dioxide ( $\text{NO}_2$ ) – which shows up near its sources in cities and industrial areas. Satellite observations of  $\text{NO}_2$  can help scientists predict where ozone and photochemical smog might form. These data also can show whether efforts to reduce pollution are working.

### Vocabulary



**concentration** – The relative amount of a given substance contained within a volume of space.

**emissions** – Gases released into the air.

### Where in the World is Nitrogen Dioxide?

Looking at a map of  $\text{NO}_2$  data from a satellite, it is easy to spot industrial regions and populated areas like large cities. These areas have many sources of  $\text{NO}_2$ , such as **emissions** from cars, trucks, power plants, and factories. As the world population continues to grow, so do cities and the need to generate electricity and transport people. The good news is that the air is getting cleaner in the U.S. and some other regions. Improved technology is helping to reduce emissions, and more countries are following environmental regulations.



### Pollution and Our Food

While we can't see ozone damaging our lungs, we can see evidence on plants that are sensitive to ozone. The La Chipper potato was harvested in the eastern U.S. for potato chips until the 1950s, when high levels of ozone reduced the plants' ability to produce enough potatoes.

### 2018 Global Concentrations of Nitrogen Dioxide

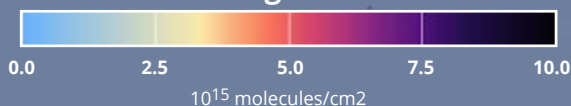


IMAGE: NASA/GSFC SCIENTIFIC VISUALIZATION STUDIO

Los Angeles

New York

### LA Smog Mystery Solved

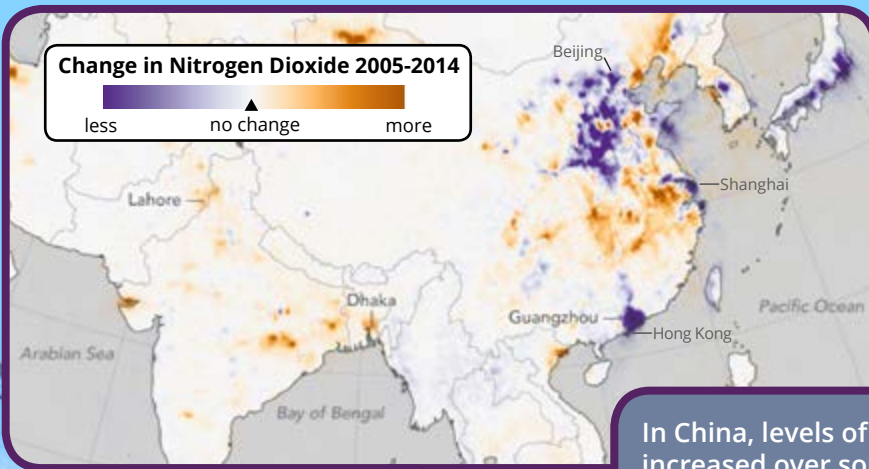
In the 1940s, a food chemist named Arie "Haagy" Haagensmit studied the chemicals that give various fruits their characteristic smells. One day he noticed that the smog in the Los Angeles air smelled similar to the ozone he was using in the lab. But how was ozone getting into the air? Haagy and other scientists eventually figured out that nitrogen oxides in the air were reacting with VOCs, with help from sunlight. It turned out that sunny Southern California was the perfect environment for the formation of photochemical smog.



COURTESY OF CALTECH ARCHIVES

In Europe, NO<sub>2</sub> is highest around industrial and manufacturing regions of northern Italy and Germany. However, satellite data have shown decreases around major cities such as Madrid, Paris, and London thanks to stricter emission regulations.

Change in Nitrogen Dioxide 2005-2014



In China, levels of NO<sub>2</sub> have increased over some cities and dropped over others. The North Central Plain had the largest increases, as manufacturing moved away from cities like Beijing. The good news is that NO<sub>2</sub> has been slowly decreasing in cities like Shanghai, Hong Kong, and Beijing due to public demand for cleaner air and pollution laws. In India, cities have increased NO<sub>2</sub> emissions because of economic growth and increased energy use. Traffic congestion has also been a major contributor to India's pollution.

Areas with fewer people or manufacturing sites — such as the Australian Outback — have lower amounts of NO<sub>2</sub>.

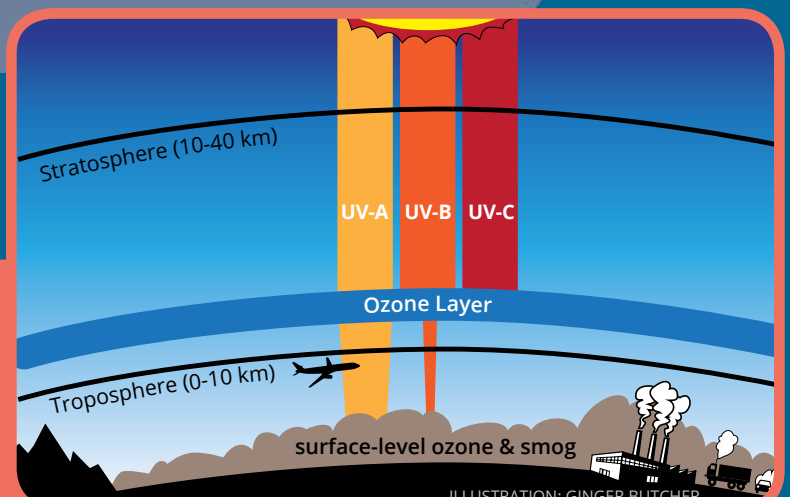
Australian Outback

In South Africa, coal-fired power plants, metal mining, and industrial activity are sources of NO<sub>2</sub> around some cities. But Cape Town has fewer NO<sub>2</sub> sources and their citizens also drive more fuel-efficient vehicles.

Cape Town

## Ozone: Good Up High, Bad Nearby

Ozone high in the atmosphere is good because it protects our planet from harmful ultraviolet (UV) rays. But ozone near Earth's surface, where people live and breathe, is a harmful pollutant.



# Data Detective

## Air Quality is Improving

There is good news. Our air quality in the United States is improving. Government regulations on power plants and cars have reduced emissions of  $\text{NO}_2$ . From 2005 and 2018, satellite data show that  $\text{NO}_2$  decreased between 20% to 50% in the United States. Reduced  $\text{NO}_2$  emissions from cars and power plants means less ozone and cleaner air to breathe. While air pollution has improved dramatically, it can still be unhealthy in many US cities.

### Questions

1. Can you find the following cities in the United States based on  $\text{NO}_2$  concentrations?  
A) Los Angeles, CA;  
B) Atlanta, GA; C) Minneapolis, MN; D) Denver, CO
2. Have  $\text{NO}_2$  concentrations increased or decreased from 2005 to 2018 in those cities?
3. Rank the cities in order of highest to lowest concentrations of  $\text{NO}_2$  for each area in 2005.
4. In 2005, in what region is there the most  $\text{NO}_2$  concentrations and why?

### What Can You Do?

Pump gas or mow lawns early or late in the day to reduce the amount of VOCs released into the air.

Ride a bike or walk, when possible, to reduce  $\text{NO}_2$  emissions.

Exercise early in the morning if you are in an area with a lot of traffic. By the afternoon, ozone formation will be in full swing.

