My NASA Data

Air Quality

Grade Band

- 3-5
- 6-8
- 9-12

Image Credit: NOAA

What is Air Quality?

Air quality is a measure of the pollution level in the air. Monitoring air quality is important because polluted air can be bad for human health and the environment.

Sources of Air Pollution

Pollutants are formed from both natural and human (anthropogenic) sources. Some examples of natural and anthropogenic sources are listed below.

Anthropogenic Sources

- Fuel combustion sources (such as electric utilities and boilers)
- Industrial processes (such as metal smelters, petroleum refineries, cement kilns and dry cleaners)
- Highway vehicles
- Other mobile sources (such as recreational and construction equipment, marine vessels, aircraft and locomotives)

Natural Sources

- Pollen
- Volcanoes (release of sulfates)
- Fires (release of organic/black carbon)
- Desert dust
- Sea salt

Monitoring Air Quality

NASA’s PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) Mission launched February 8, 2024, has a multi-angle polarimeter that is monitoring how the oscillation of sunlight is changed by passing through clouds and aerosols in our atmosphere. PACE will collect systematic records of key atmospheric variables associated with air quality and Earth's climate enhancing 20+ years of data that have been collected by previous NASA Earth observing satellites. My NASA Data’s Air Quality resources provide multi-year time plots of air quality data and activities designed to allow users to draw conclusions about the relationship between particulate pollution and human health. You can also access My NASA Data’s Earth System Data Explorer to find your own datasets for aerosol and cloud data by accessing monthly aerosol optical depth and monthly total cloud coverage under atmosphere.”

Worldwide, air quality is also monitored by a network of environmental agencies. The major air pollutants that are regulated by the Clean Air Act and are monitored to see if they meet the national air quality standards set by the EPA include:

- Particulate Matter, or Aerosols
- Ground Level Ozone, or Tropospheric Ozone
- Carbon Monoxide
- Sulfur Dioxide
- Nitrogen Dioxide
- Lead

Air Quality Index

Video: Air Sensors: Measurements and Your Health

Air Sensors: Measurements and Your Health | https://www.youtube.com/watch?v=pztai6z6fO0 | Source: US Environmental Protection Agency

The overall air quality in an area is measured using the U.S. Environmental Protection Agency's **Air Quality Index**, or AQI. AQI is a unitless number, from 0 to 500, that communicates the health risk caused by the amount of pollution in the air. Higher AQI values relate to increased health risk.

Air Quality Index		
AQI Category and Color	**Index Value**	**Description of Air Quality**
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

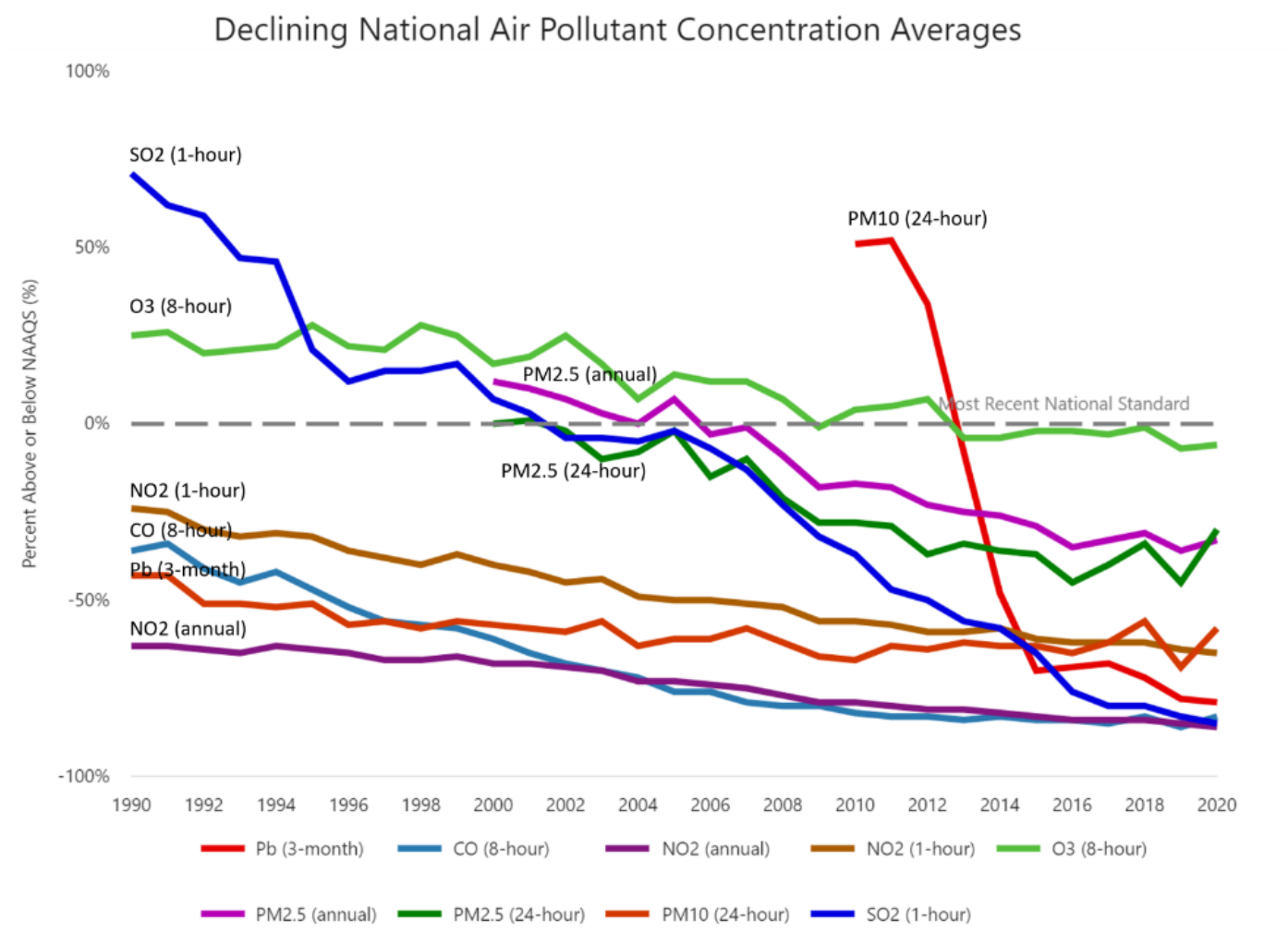
U.S. Environmental Protection Agency Air Quality Index

Air Quality Standards

For each pollutant, there is a **standard concentration** for meeting the standard determined by the National Ambient Air Quality Standards (NAAQS) set by the Clean Air Act. A location is evaluated by computing a series of average concentrations for a pollutant over hours, days, and years. If the average concentrations do not meet the air quality standard, then that location is considered a **Nonattainment Area** for that pollutant. This doesn't mean that Nonattainment Areas always have high pollution. They just have high pollution frequently enough that their average does not meet the standard. Likewise, areas that meet the standard and "pass" could still have days where the air quality is poor.

Trends in Air Quality

While air quality can exceed standards in specific locations on specific days, the overall air quality in the U.S. has improved since 1990.



Criteria Pollutants

The list below identifies the common sources of each criteria pollutant. In addition, primary and secondary sources are identified. Primary sources are directly emitted. Secondary sources are produced due to chemical reactions in the atmosphere. Due to chemical reactions in the atmosphere and winds, air pollution can be experienced in locations far from the original sources.

- **Particulate Matter, or Aerosols**

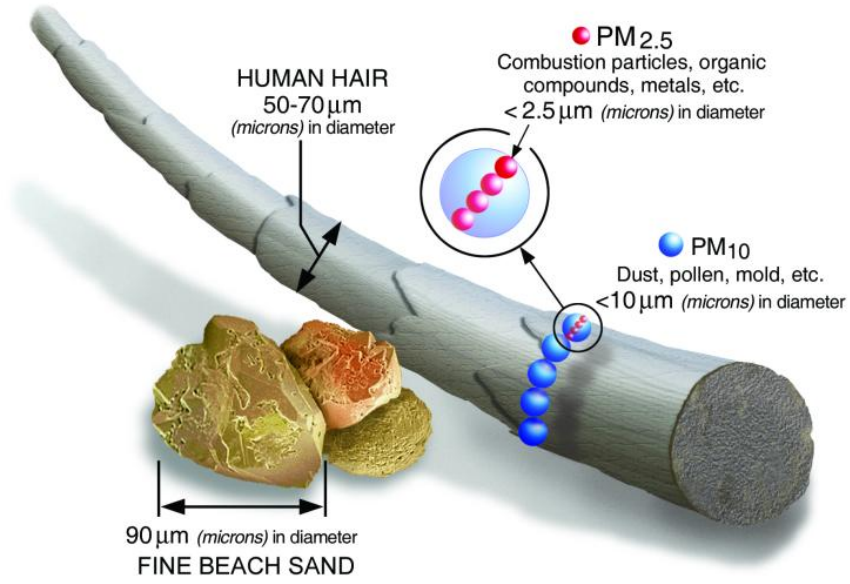


Diagram comparing the sizes of different particulate matter particles to a human hair.
Source: EPA

- Can be both primary and secondary pollutants
- Mixture of solid particles and liquid droplets suspended in the air
- Particulate matter, or PM, are in a range of sizes.
  - Examples of larger particles (10 microns or smaller) include dust, pollen and mold
  - Smaller particles (2.5 microns or smaller) come from combustion or organic compounds
- Some particulate matter is emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires
- Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries and automobiles.

- **Ground Level Ozone, or Tropospheric Ozone**
  - Secondary pollutant
  - Tropospheric ozone is created by chemical reactions between oxides of nitrogen (NOx), such as (NO_2), and volatile organic compounds (VOC)
  - Happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight
- **Carbon Monoxide**
  - Primary pollutant
  - Carbon Monoxide (CO) is a colorless, odorless gas that is released when something is burned
  - Greatest sources of CO to outdoor air are cars, trucks and other vehicles or machinery that burn fossil fuels
- **Sulfur Dioxide**
  - Primary pollutant
  - Largest source of sulfur dioxide (SO_2) in the atmosphere is the burning of fossil fuels by power plants and other industrial facilities
  - Smaller sources of SO_2 emissions include: industrial processes such as extracting metal from ore; natural sources such as volcanoes; and locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulfur content

- **Nitrogen Dioxide**
    - Primary pollutant
    - Primarily gets in the air from the burning of fuel.
    - NO_2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment
- **Lead**
    - Primary pollutant
    - Major sources of lead in the air are ore and metals processing and piston-engine aircraft operating on leaded aviation fuel
    - Other sources are waste incinerators, utilities, and lead-acid battery manufacturers
    - Highest air concentrations of lead are usually found near lead smelters
    - This pollutant is monitored but is **not** part of the Air Quality Index because the effects of lead are cumulative

Health Effects of Air Pollution

Short and long-term exposure to air pollution has been associated with a wide range of human health effects including increased respiratory symptoms, and heart or lung diseases. Hazardous (or toxic) air pollutants may cause cancer or other serious health effects.

Environmental Effects of Air Pollution

Harm to Animals and Plants

Air pollution can affect many parts of the environment. It can cause damage to plants and the respiratory systems of animals. It can also cause damage to entire habitats, water, or food sources that plants and animals need to survive.

Acid Rain

Acid rain forms when sulfur dioxide and nitrogen dioxide mix with water droplets in the atmosphere to make sulfuric acid and nitric acid. When the pollutants fall to the surface as acid rain, they can acidify the water and soil environments, damage vegetation, and even damage buildings and outdoor structures.

Haze

Haze is caused when sunlight encounters tiny pollution particles in the air. Haze obscures the clarity, color, texture, and form of what we see.

Ozone Depletion

Depending on where ozone resides, it can protect or harm life on Earth. Most ozone resides in the stratosphere (a layer of the atmosphere between 10 and 31 miles above us), where it acts as a shield to protect Earth's surface from the sun's harmful ultraviolet radiation. This portion of ozone is ofter referred to as "good ozone." In the troposphere (the atmospheric layer from the surface up to about 10 miles), ozone is a harmful pollutant that causes damage to lung tissue and plants. This type of ozone is often referred to as "bad ozone". Scientists have found that the "bad" tropospheric ozone is increasing in the air we breathe, and the "good" stratospheric ozone is decreasing in our protective ozone layer.

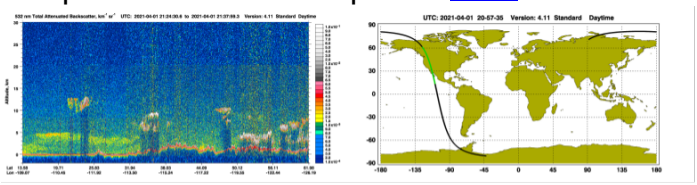
Air Quality & NASA Science Missions

NASA has several missions that make observations and measurements related to air quality. Some of these are included below.

Current Missions

- AERONET: The AErosol RObotic NETwork is a global network of ground-based sun photometers that measure the amount of sunlight transmitted through the atmosphere. These measurements can then be used to determine Aerosol Optical Depth (AOD), and can also provide information about the size and type of aerosols in the atmospheric column.

- CALIPSO: The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation satellite, launched in 2006, makes measurements of clouds and aerosols, and helps provide information on their effect on the Earth's weather and climate. CALIPSO includes a lidar instrument that provides high-resolution vertical profiles of the atmosphere. Data visualizations from CALIPSO are available.



The image on the left is a "curtain" showing Total Attenuated Backscatter (the amount of light "scattered" back to the lidar instrument by the atmosphere) over the western United States, April 2021. The black line on the map to the right shows the track of the CALIPSO satellite. The green section (of the black line) shows the location of the "curtain". Image source: NASA.

- MAIA: The Multi-Angle Imager for Aerosols instrument, a partnership between NASA and the Italian Space Agency. MAIA studies the effects of particulate matter on human health in both the short term and the long term, and will also collect data on naturally occurring and anthropogenic air quality events. Data collected by the MAIA instrument, orbiting the Earth at 740 kilometers overhead, needs to be able to tell a group of tiny sulfate particles from a group of equally tiny dust particles. This is certainly a challenge, but MAIA will be able to distinguish types of PM based on how the particles reflect or absorb sunlight. MAIA contains a specialized digital camera that peers at how the Sun's light reflects off the Earth and its atmosphere. This is no ordinary camera, however. It uses a combination of observing techniques to capture information about a layer of air pollution.

- MODIS: The Moderate Resolution Imaging Spectroradiometer is an instrument that flies aboard the Terra and Aqua satellites. MODIS instruments are able to "see" the entire Earth every 1 - 2 days, collecting data across 36 different wavelengths. Data from MODIS provides insight into how clouds and aerosols affect the Earth's energy budget, as well as the

properties of atmospheric aerosols. MODIS data can be added as a base layer in the GLOBE Visualization tool and viewed with GLOBE observations. The base layer name is Corrected Reflectance - True Color (Terra).

- PACE: The Plankton, Aerosol, Cloud ocean Ecosystem satellite continues NASA's efforts of observing the Earth's oceans. PACE carries two primary instruments. The first, an ocean color instrument, that is collecting data on global ocean biology. The second, multi-angle polarimeters, that are measuring how sunlight changes as it passes through clouds, aerosols and the ocean, providing detailed information about the Earth's atmosphere and oceans.

- TEMPO: The Tropospheric Emissions: Monitoring of Pollution instrument, NASA's first Earth Venture Instrument mission measures pollution of North America, from Mexico City to the Canadian oil sands, and from the Atlantic to the Pacific hourly and at high spatial resolution. TEMPO observations are from the geostationary vantage point, flying on the telecommunication spacecraft Intelsat-40e (IS-40e). The TEMPO instrument is a UV-visible spectrometer, and is the first ever space-based instrument to monitor air pollutants hourly across the North American continent during daytime. It collects high-resolution measurements of ozone, nitrogen dioxide and other pollutants, which revolutionize air quality forecasts.

- VIIRS: The Visible Infrared Imaging Radiometer Suite is an instrument that flies on the Suomi-NPP and NOAA-20 satellites. Both satellites are polar-orbiting, circling the Earth about 14 times a day. VIIRS collects data across 22 wavelengths, providing information about clouds and aerosols, and helping to detect wildfires. VIIRS satellite images are available on the AerosolWatch website.

Video: NASA | Human Fingerprint on Global Air Quality

NASA | Human Fingerprint on Global Air Quality | https://www.youtube.com/watch?v=aMnDoXuTGS4 | Source: NASA Goddard