Ozone: Good Up High, Bad Nearby

17th Annual GLOBE Partner Meeting
Surface Ozone Training
August 13 & 15, 2013

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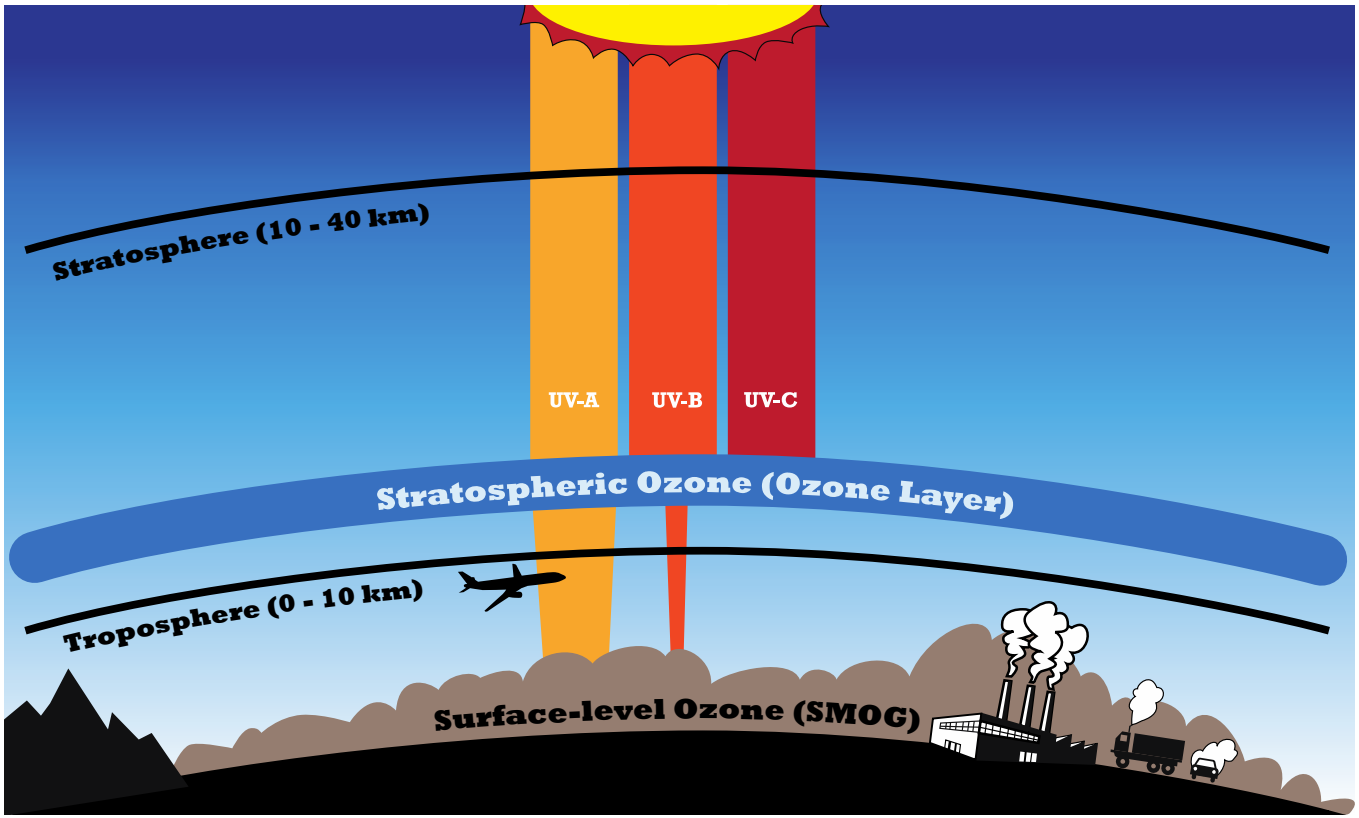
Ozone: the good and the bad

Ozone is a reactive molecule made up of three atoms of oxygen (O)

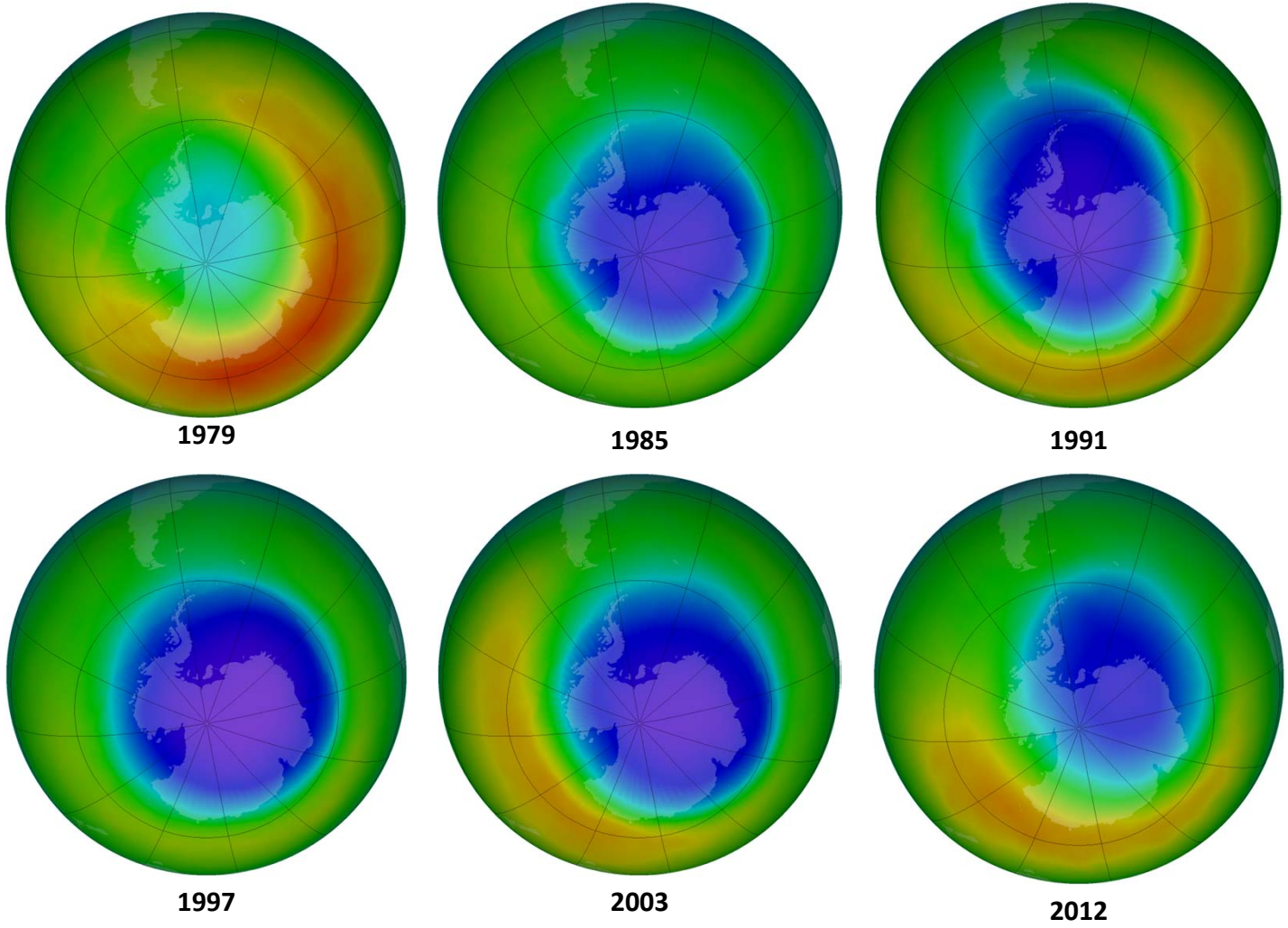


GOOD – protective layer in the stratosphere

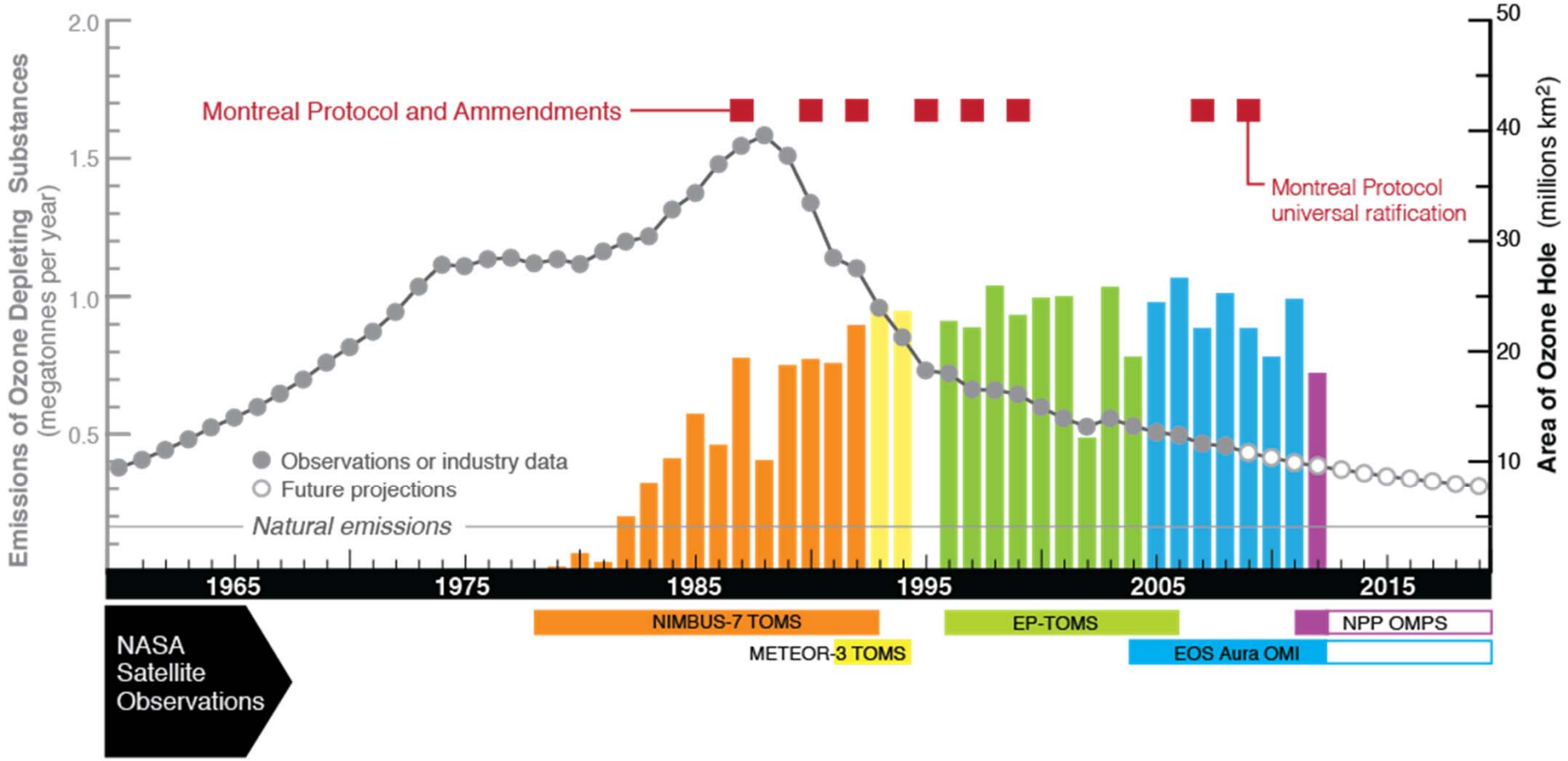
BAD – at the surface "nose-level" ozone is a pollutant

The “Good” Ozone

A layer of stratospheric ozone protects life on Earth from harmful Ultraviolet radiation.
A thinning in this ozone layer was first observed in the late 1970s by NASA.



Ozone Hole & Satellite Observations



What is **“bad”** ozone?

Ozone at ground level, or tropospheric ozone, is a pollutant.

Ozone can damage plants and when breathed, can damage lung tissue.

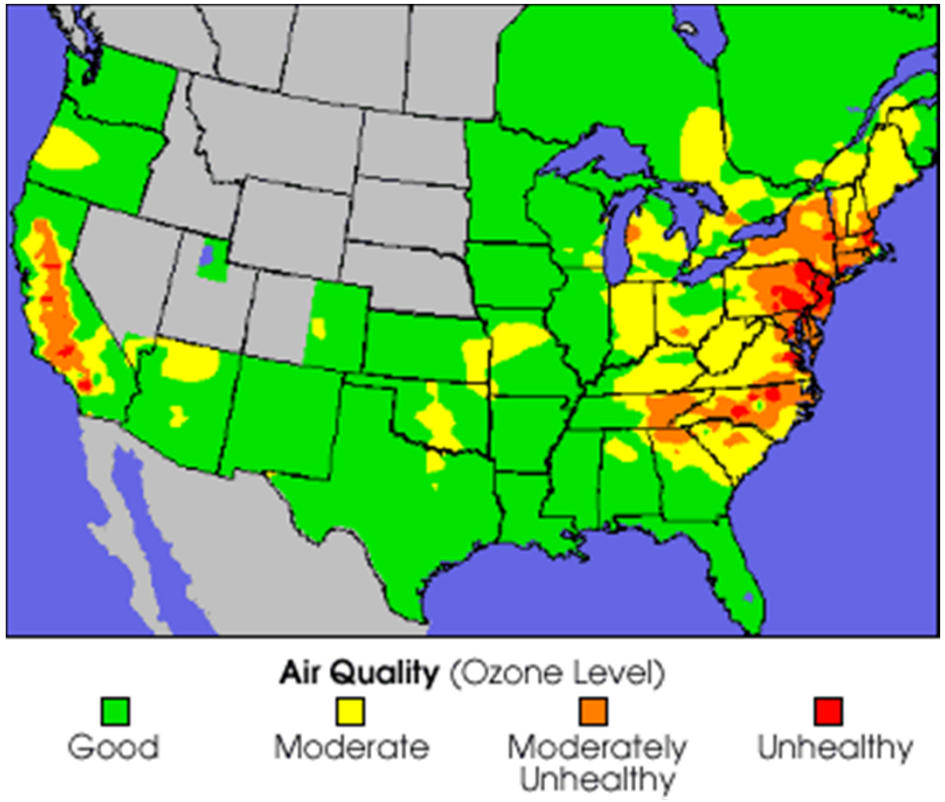
EPA Air Quality Index (AQI) for Ozone Levels

Ozone Concentration (ppm) (8-hour average, unless noted)	Air Quality Index Values	Air Quality Descriptor
0.0 to 0.064	0 to 50	Good
0.065 to 0.084	51 to 100	Moderate
0.085 to 0.104	101 to 150	Unhealthy for Sensitive Groups
0.105 to 0.124	151 to 200	Unhealthy
0.125 (8-hr.) to 0.404 (1-hr.)	201 to 300	Very Unhealthy

US EPA

Ground-level ozone is formed by a series of chemical reactions involving pollutants released during the burning of fossil fuel (such as gasoline or coal).

Surface-level Ozone

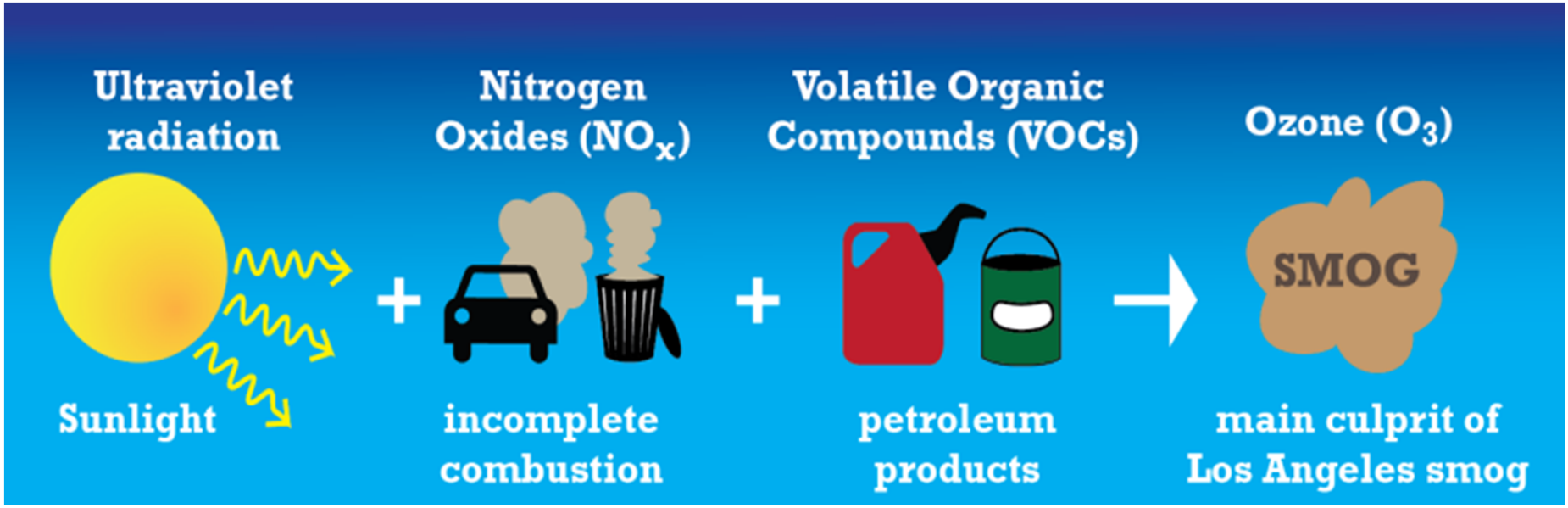


EPA map of Air Quality on August 12, 2002 shows the air in many parts of the U.S. with unhealthy concentrations of ozone.

Ozone contributes to smog, seen here in Los Angeles

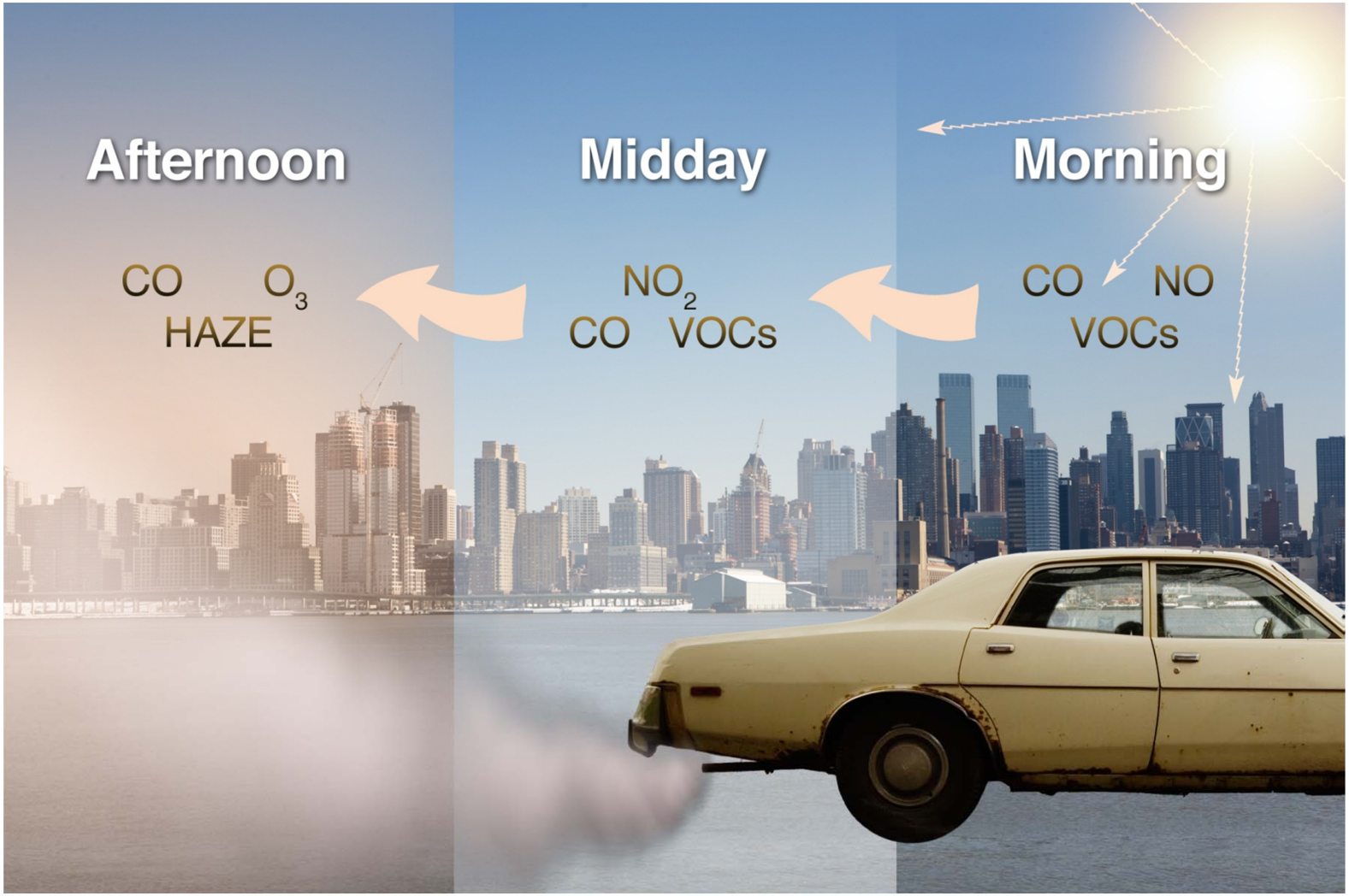
SMOG = “smoke” + “fog”

Unlike “London smog” (consisting mostly of particulate matter from burning fuels like coal), ozone is photochemical.

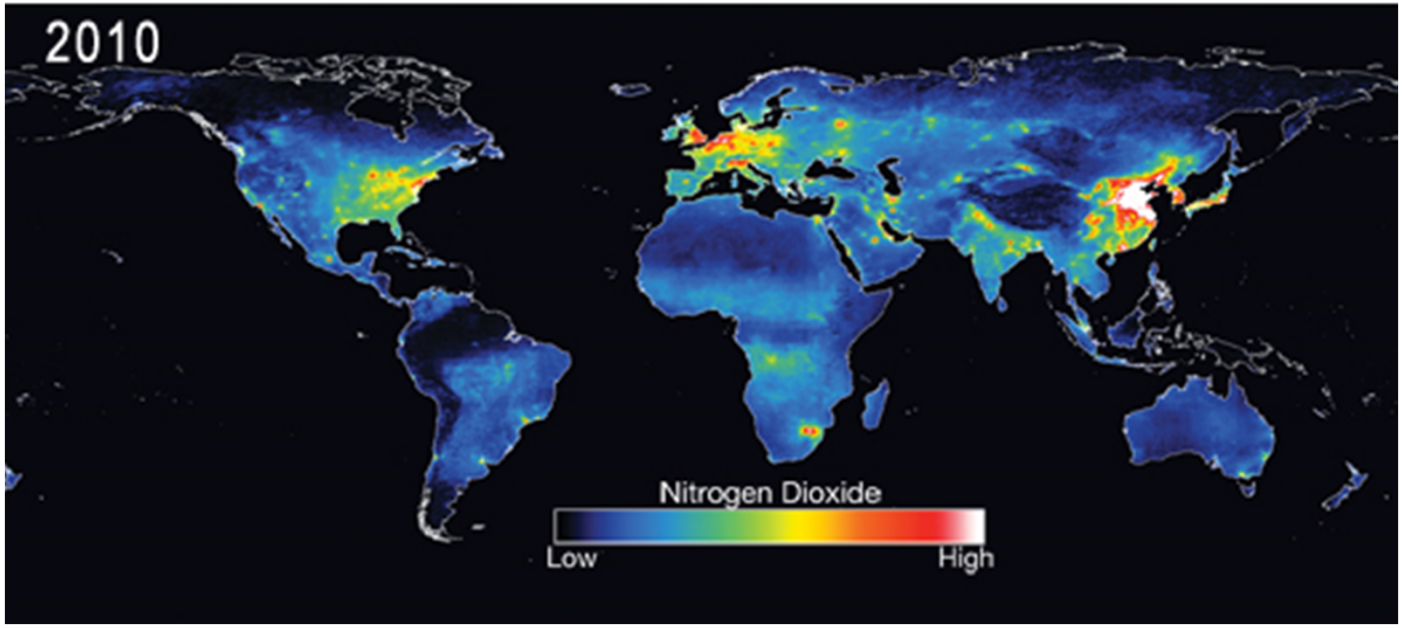


Surface level ozone is formed by a series of chemical reactions involving primary pollutants (NO_x and VOCs) plus sunlight.

When is surface ozone harmful?



Satellite observations of NO_2



Nitrogen dioxide (NO_2) is a short-lived pollutant and thus is shown close to the source (e.g., cities, industrial regions). It is also a good indicator for location of surface ozone.

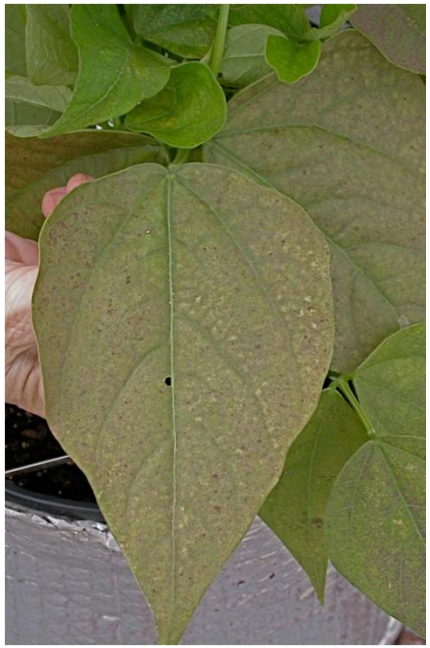
Credit: NASA Aura

Plants can be sensitive to tropospheric ozone

Healthy plant,

0% Injury

25 to 50% Injury



Sick plant,

50 to 75% Injury

Dying plant, 80 to 100% Injury

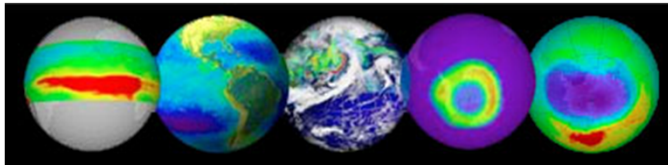
Example: Soybeans

NASA uses satellites, ground sites, and agency-wide partnerships to monitor and study ozone

- SAGE
- EPA
- NOAA
- AirNOW
- OMI on Aura
- DISCOVER-AQ

AIRNOW

DISCOVER-AQ

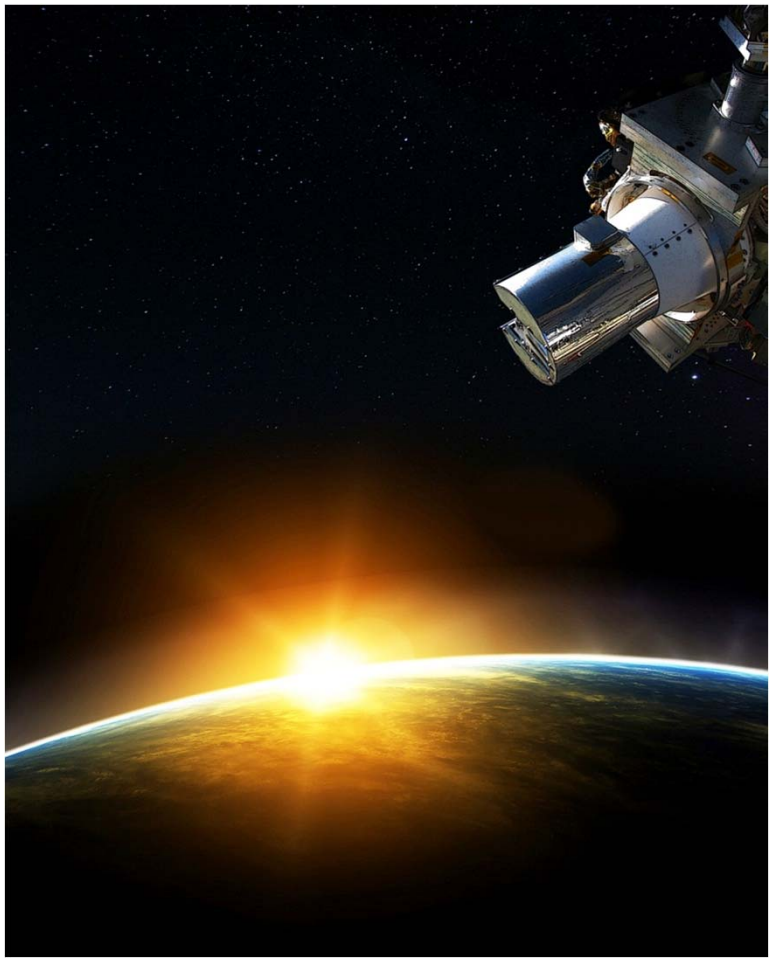


Aura
atmospheric chemistry

SAGE III on ISS

http://sage.nasa.gov/SAGE3ISS/

- **The Stratospheric Aerosol and Gas Experiment, or SAGE III on ISS, is one of NASA's ozone monitoring instruments**
  - measures stratospheric ozone, aerosols and other traces gases from the International Space Station
  - makes measurements by locking on to the sun and scanning the limb, or thin profile of the atmosphere
  - Launches on SpaceX in 2015



Continuing a legacy of measurements that help humans understand and protect Earth's atmosphere

DISCOVER-AQ

Deriving Information on Surface Conditions from Column and VERtically Resolved Observations Relevant to Air Quality

A NASA campaign intended to improve the interpretation of current and future satellite observations to diagnose near-surface conditions relating to air quality

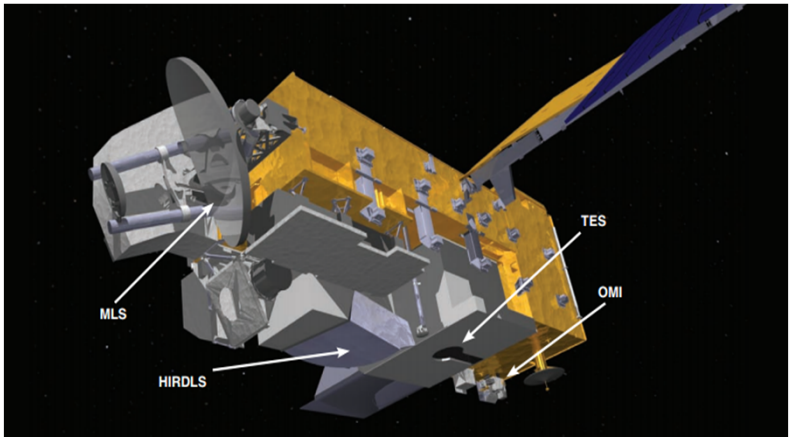
Deployments and key collaborators

- *Maryland, July 2011 (EPA, MDE, UMd, UMBC, Howard U.)*
- *California, January 2013 (EPA, CARB, UC-Davis&Irvine)*
- *Texas, September 2013 (EPA, TCEQ, U. of Houston)*
- *Colorado, Summer 2014 (EPA, NSF, NOAA, CDPHE)*

Learn More about Campaign and how students can be involved:
http://discover-aq.larc.nasa.gov/
Click on "Education" Tab

Aura Is Designed To Answer Questions About Changes In Our Life-Sustaining Atmosphere

- Aura's four instruments study the atmosphere's chemistry and dynamics. Aura's measurements will enable us to investigate questions about ozone trends, air quality changes and their linkage to climate change.
- Aura's measurements will provide accurate data for predictive models and provide useful information for local and national agency decision support systems.



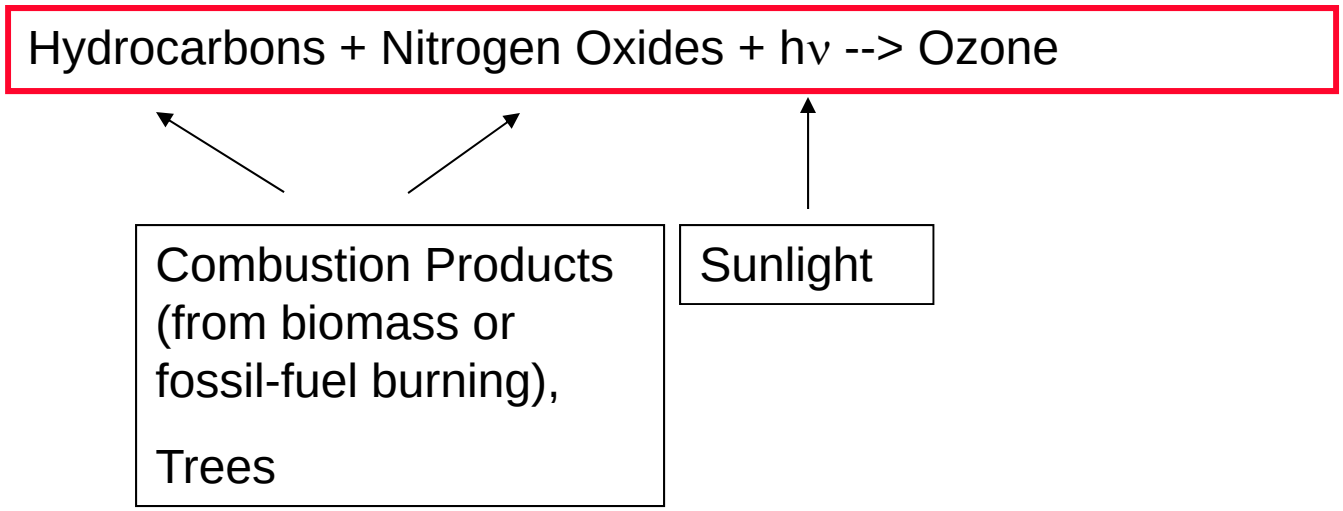
http://aura.gsfc.nasa.gov

GLOBE Measuring Tropospheric Ozone

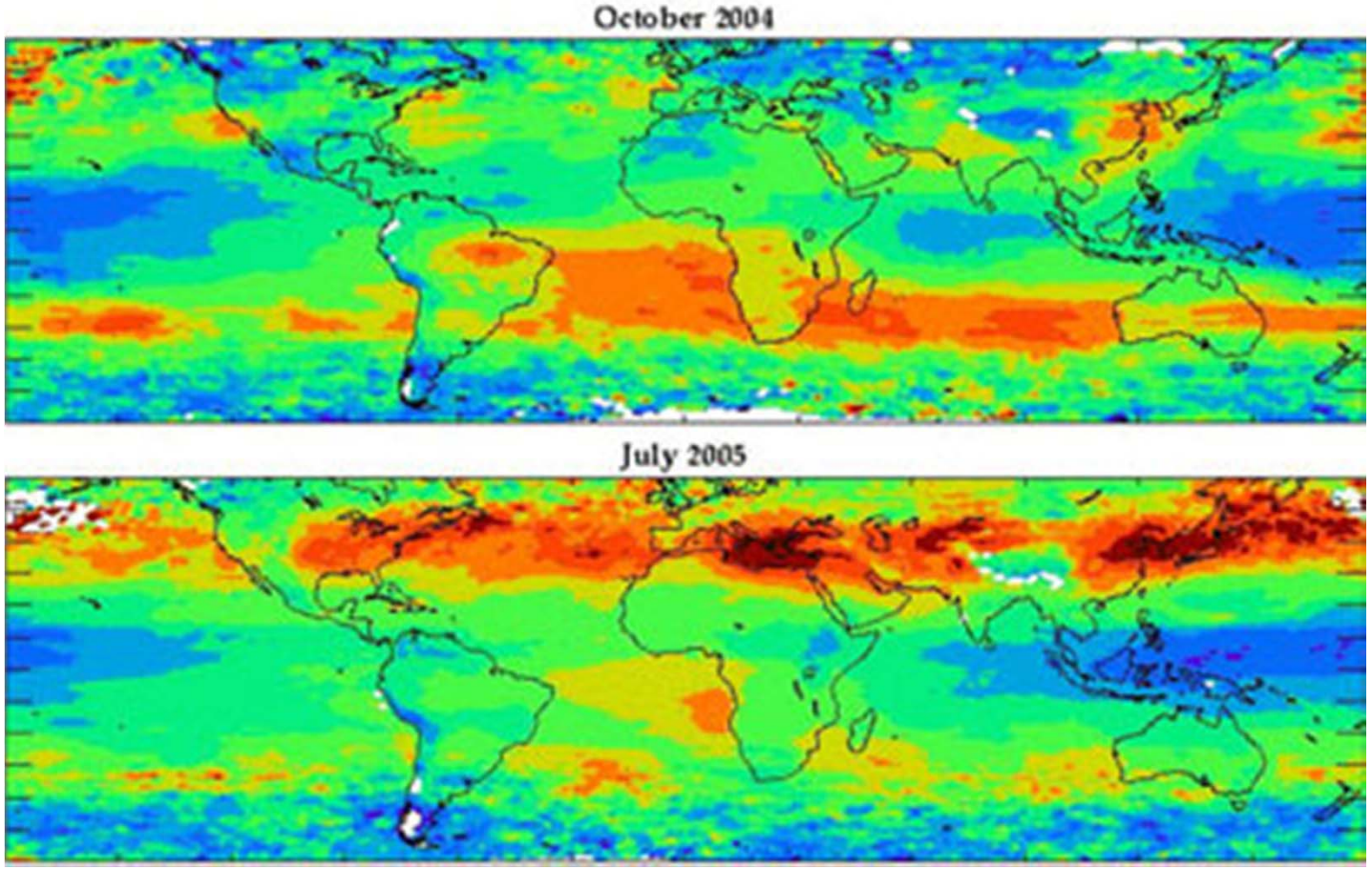
Surface Ozone Protocol

Science Content:
Where does surface ozone come from?

It is the primary component of **photochemical** smog



Ozone can circulate about the globe.



Ozone is not just at the surface, this image shows total amount of ozone in the troposphere (e.g., about up to 10 km)

AURA

Why do GLOBE scientists research surface ozone?

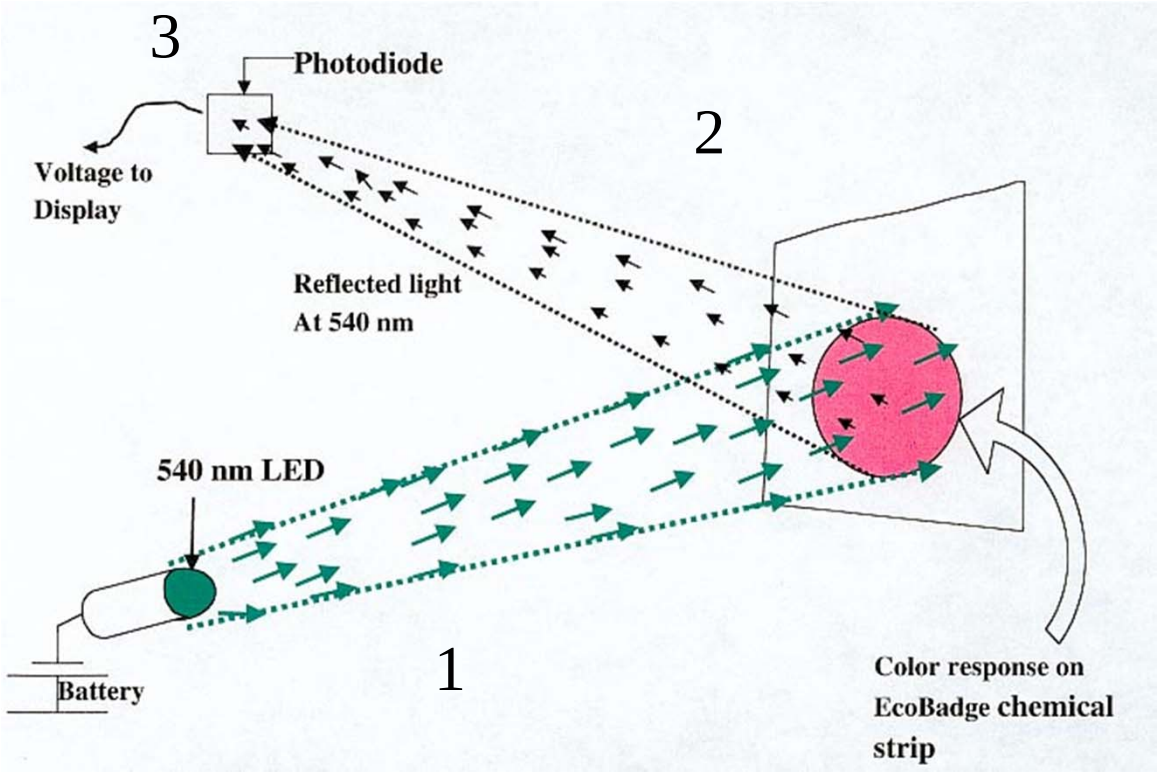
- Considered a pollutant
- Globally its abundance is unknown
- Amount present in the air affects many other trace gases
- Helps assess the degree to which it is an environmental problem

Inquiry Context

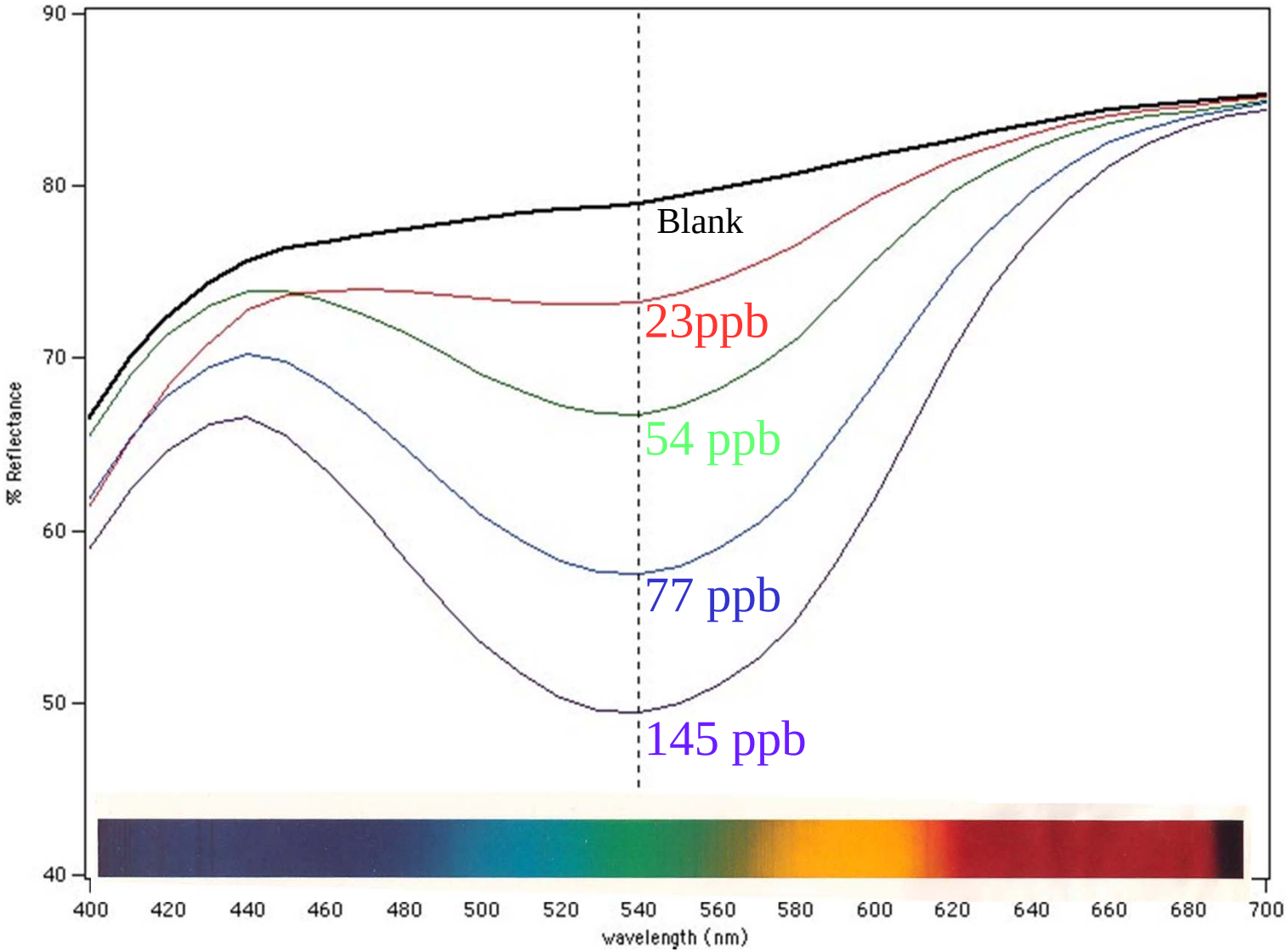
- Is the amount of surface ozone related to other atmospheric phenomena?
- What is the variability of ozone in the atmosphere daily? Seasonally? Annually?
- How can you use your data collected over a period of time to predict future changes in the atmosphere?
- How do local values of ozone compare globally?

Instruments: Zikua™ Optical Scanner

Exposed test strip placed in slot of scanner



Spectral Reflectance as a Function of Ozone Concentration



Placing Chemical Strip

- Chemically sensitive strips change color in presence of ozone
- Keep strip in closed pouch until monitoring station
- Don’t touch the chemical circle on the strip
- Strip can not get wet

The Measurements

Time=0

Ozone Test Strip *Exposure*

- Current temperature
- Cloud Protocols
- Wind direction
- Relative humidity
- Within 1 hr local solar noon

Time=1 hour later

Ozone Test Strip *Reading*

- Current temperature
- Cloud Protocols
- Wind direction
- Relative humidity
- Surface Ozone

Collecting Data: Protocol

Exposing the ozone test strip

- Place scanner on shaded and level surface, wait 5 minutes
- Record cloud protocols, current temperature, wind direction and relative humidity
- Turn on scanner, wait 1 minute (the scanner will automatically turn off)
- Turn scanner back on
- Calibrate scanner with unexposed ozone test strip
- Place this ozone test strip on monitoring station

Collecting Data: Protocol

Reading the ozone test strip

- Place scanner on shaded, level surface; Wait 5 minutes
- While waiting, record cloud protocols, current temperature, wind direction and relative humidity
- Turn on scanner; Wait 1 minute (the scanner will automatically turn off)
- Turn scanner back on
- Measure exposed ozone test strip in scanner
- Record the surface ozone reading

Pre-requisite Measurements

- Clouds
- Current Temperature
- Relative Humidity
- Wind Direction (not a “protocol”)

Collecting Data: Protocol

Clouds

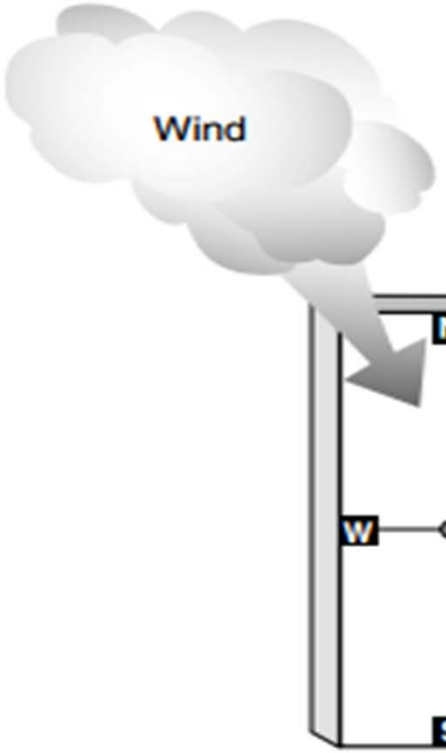
Collecting Data: Protocol

Measuring Wind Direction

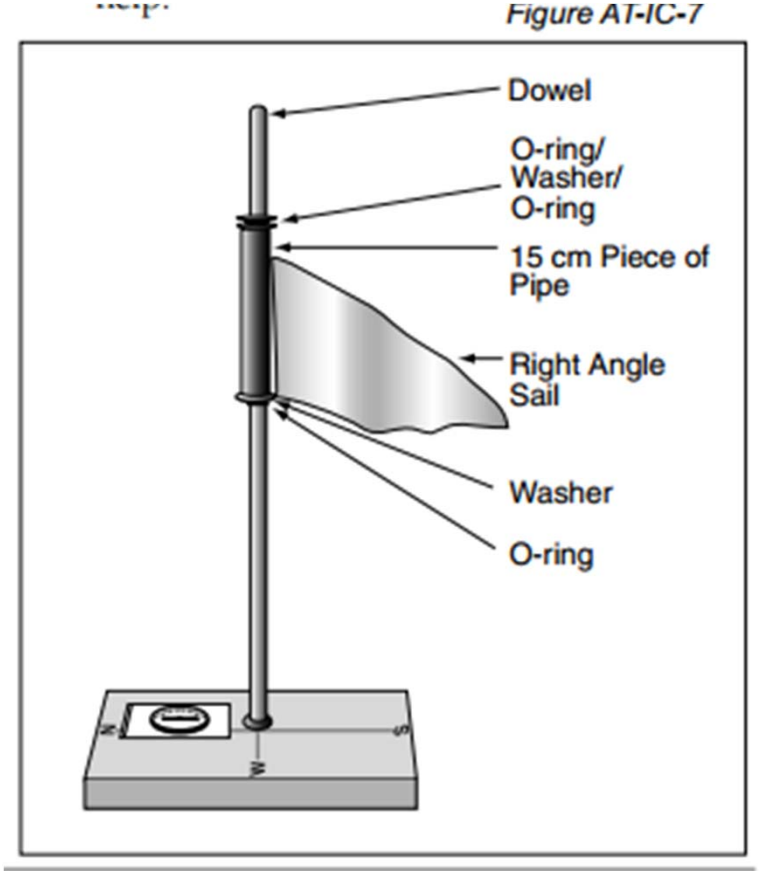
- Place wind direction instrument 1 meter above ground
- Align base with magnetic north
- Place right hand on hip, left arm out straight
- Turn your body in line with wind sail so that your left arm is pointing in the same direction as the sail
- Record the direction your right elbow is pointing

Winds are identified by the direction from which they are coming

Wind is coming from the **northwest**



Wind sail is being blown towards **southeast.**

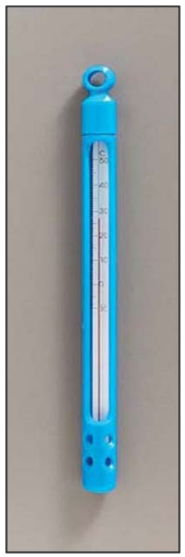


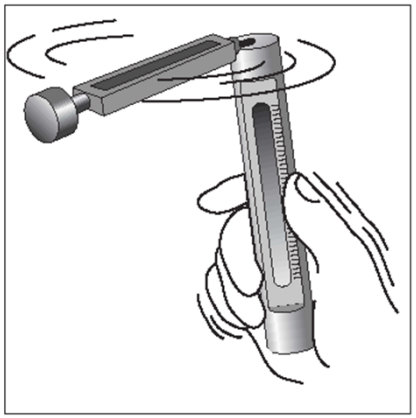
Constructing Wind Direction Instrument

- In *Atmosphere Site Selection, Set-Up, and Construction*

Collecting Data: Protocol

Current Temperature



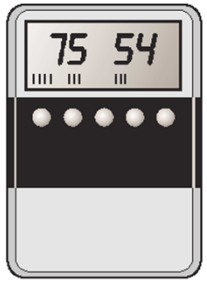


Protocol

Relative Humidity

Digital Hygrometer

- Relative humidity reading
- Current air temperature



Sling Psychrometer

- Dry bulb temperature
- Wet bulb temperature
- *Calculate RH*
- Current air temperature

Science Content: What is Relative Humidity?

$$RH = \frac{\text{amount of water vapor in the air}}{\text{amount of water vapor in the air at saturation}}$$

When Air is Saturated:

- It contains the maximum amount of water vapor at the current air temperature and pressure.
- Water droplets or ice particles begin to form.
- RH = 100%

Relationship to Air Temperature

Air Temperature (°C)	Water Vapor Present in air (g/m^3)	Water Vapor Present at Saturation (g/m^3)	Relative Humidity
30	9	30	9 ÷30 * 100 = 30%
20	9	17	9 ÷ 17 * 100 = 53%
10	9	9	9 ÷ 9 * 100 = 100%

Dew Point

- Dew point is a measure of the actual water vapor content.
- *The dew point temperature is the temperature to which air must be cooled to achieve saturation (relative humidity = 100%) given its current water content.*

Science Content

Relative humidity is important because it…

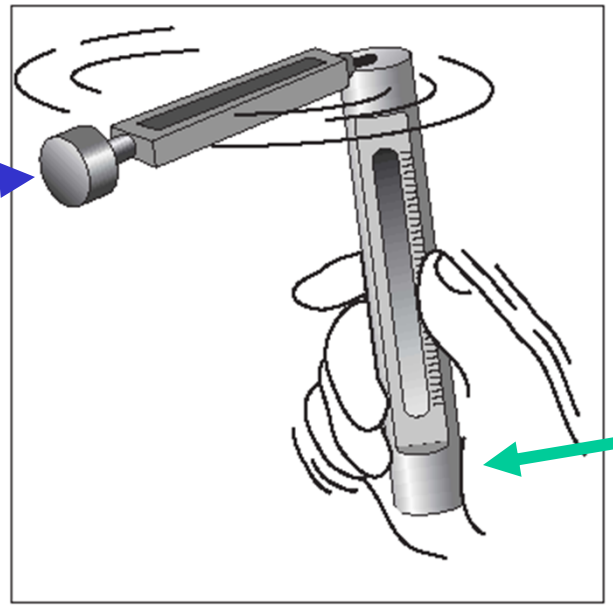
- Influences rates of evaporation and evapotranspiration
- Influences the height of cumulus clouds
- Determines how cool it will get before dew forms (and the temperature at which dew forms is often the minimum temperature)
- Is a key element of local climate.

Instruments: Digital Hygrometer

- Ceramic and metallic compounds measure electrical resistance
- Directly reads relative humidity
- Works below freezing
- Needs 30 minutes outside before reading
- Must be kept indoors and/or in a dry container
- Ruined by condensation

Instruments: Sling Psychrometer

Wet bulb thermometer has a wet wick that measures air cooled by evaporation



Dry bulb thermometer measures air temperature

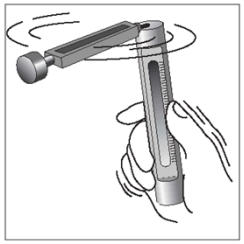
Relative humidity is calculated using the temperatures of the wet bulb and dry bulb thermometers.

Collecting Data: Protocol

Relative Humidity

Digital Hydrometer

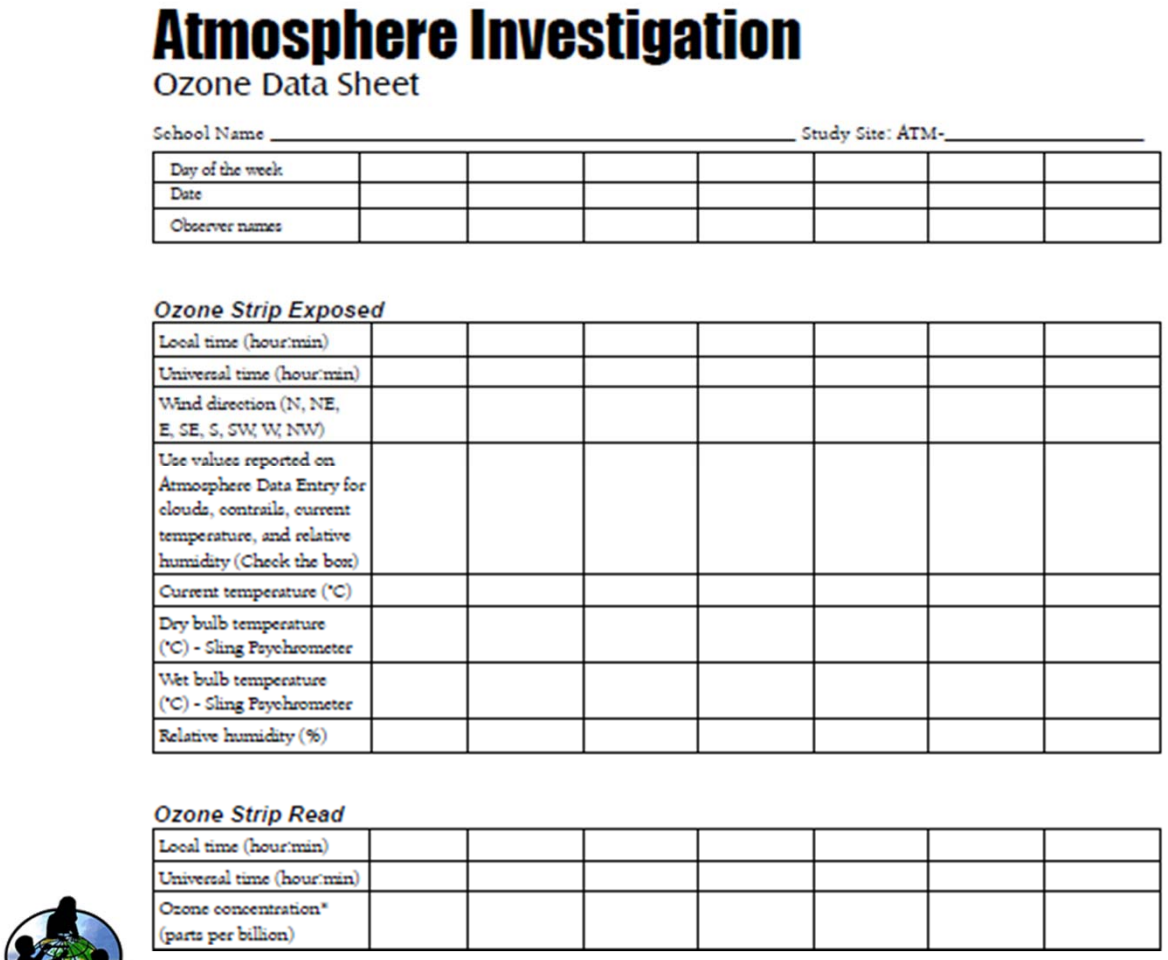
- Place outside in instrument shelter for 30 minutes
- Take relative humidity reading
- When there is rain or fog 100% is reported without taking measurement



Sling Psychrometer

- Stand in shade near instrument shelter
- Keep away from body
- Wait 3 minutes, take dry bulb reading
- Whirl sling psychrometer for 3 minutes, take wet bulb reading

Collect Data



Atmosphere Investigation

Ozone Data Sheet

School Name _____ Study Site: ATM-_____

Day of the week							
Date							
Observer names							

Ozone Strip Exposed

Local time (hour:min)							
Universal time (hour:min)							
Wind direction (N, NE, E, SE, S, SW, W, NW)							
Use values reported on Atmosphere Data Entry for clouds, contrails, current temperature, and relative humidity (Check the box)							
Current temperature (°C)							
Dry bulb temperature (°C) - Sling Psychrometer							
Wet bulb temperature (°C) - Sling Psychrometer							
Relative humidity (%)							

Ozone Strip Read

Local time (hour:min)							
Universal time (hour:min)							
Ozone concentration* (parts per billion)							

Resources:

- Field Guide
- Troubleshooting Guide

GLOBE Learning Activity

Constructing a Model of Surface Ozone

Other Resources

- Ozone Garden Field Guide

  http://science-edu.larc.nasa.gov/ozonegarden/pdf/Bio-guide-final-3_15_11.pdf

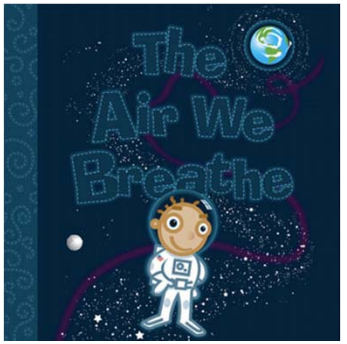
- ChemMatters Article

  http://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/past-issues/archive-2012-2013/in-the-fog-about-smog.html

- Ozone Hole Poster

  http://aura.gsfc.nasa.gov/ozoneholeposter/

- Air We Breathe Storybook



http://nasawavelength.org/resource/nw-000-000-002-547/

Upcoming Plans

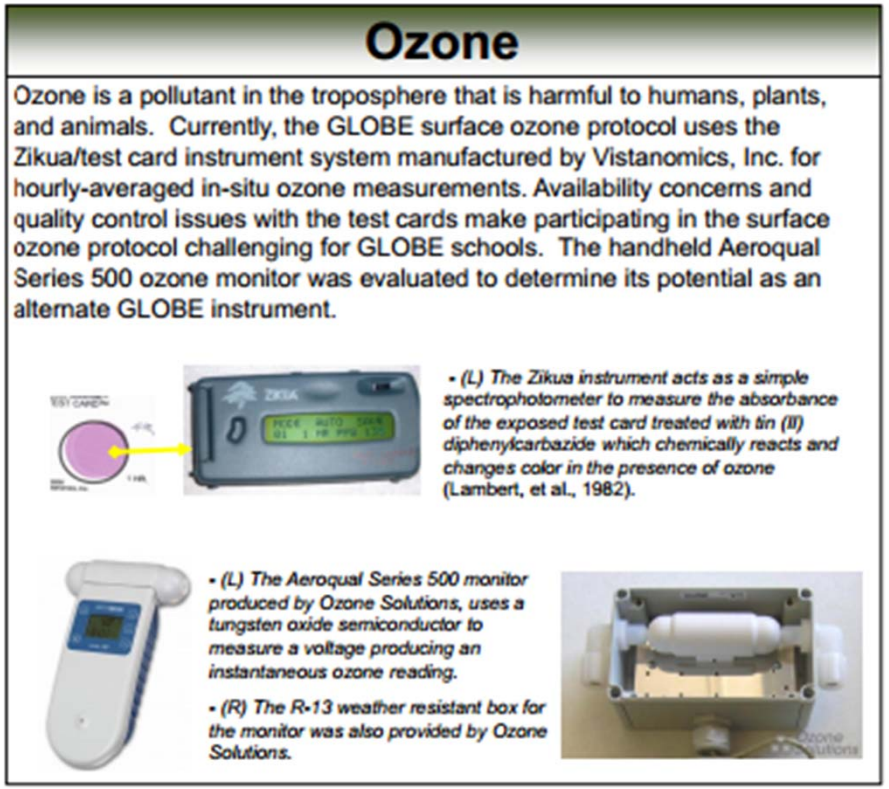
- Testing additional surface ozone instruments
- Sharing “recipe” to make chemical strips for use in the Zikua

Instruments Being Tested

- AeroQual
- CairClip
- Geotech AQMesh-5

Recent Student Research

- View full posters online: http://science-edu.larc.nasa.gov/GLOBE/resources-studentResearch.php



Ozone

Ozone is a pollutant in the troposphere that is harmful to humans, plants, and animals. Currently, the GLOBE surface ozone protocol uses the Zikua/test card instrument system manufactured by Vistanomics, Inc. for hourly-averaged in-situ ozone measurements. Availability concerns and quality control issues with the test cards make participating in the surface ozone protocol challenging for GLOBE schools. The handheld Aeroqual Series 500 ozone monitor was evaluated to determine its potential as an alternate GLOBE instrument.

• (L) The Zikua instrument acts as a simple spectrophotometer to measure the absorbance of the exposed test card treated with tin (II) diphenylcarbazide which chemically reacts and changes color in the presence of ozone (Lambert, et al., 1982).

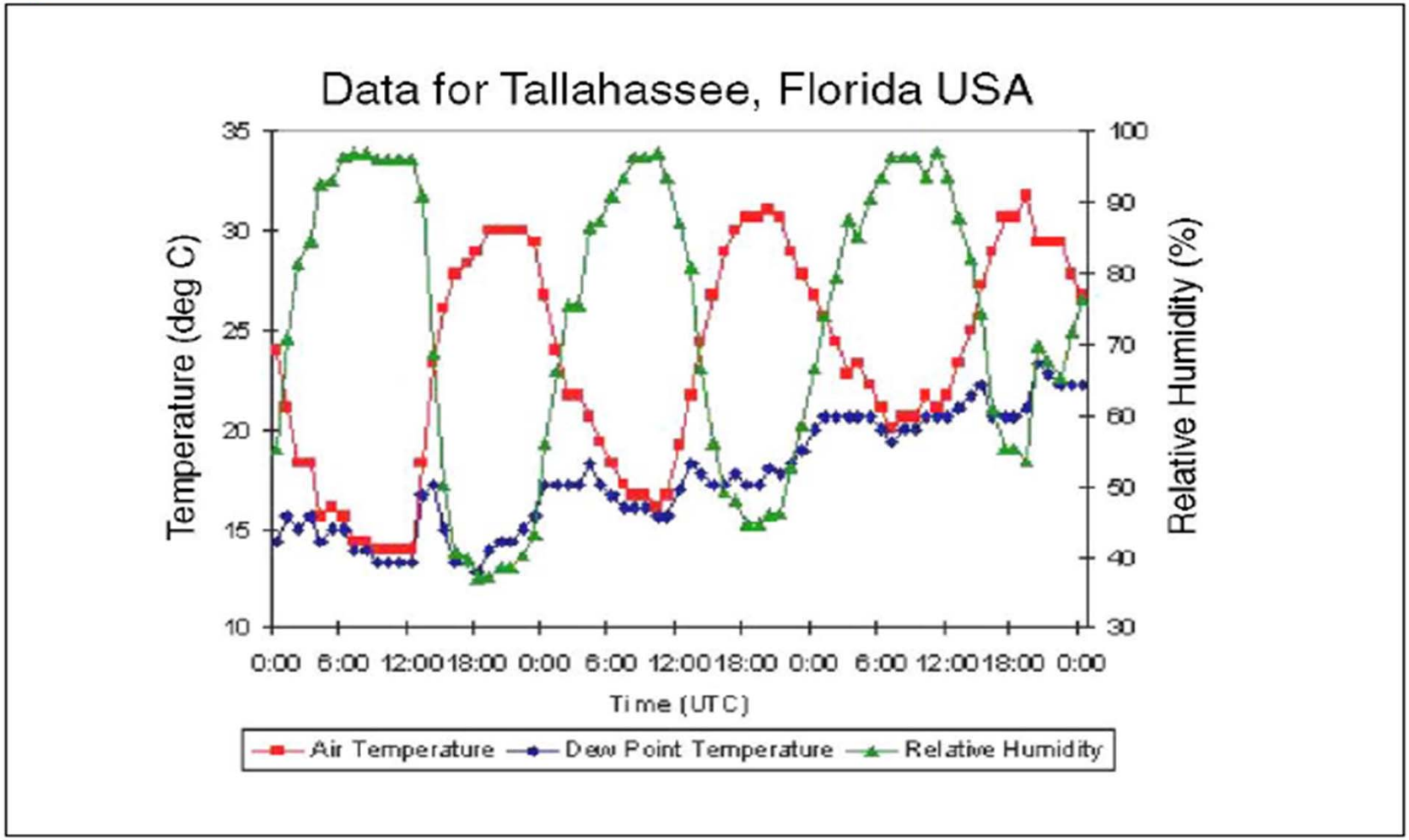
• (L) The Aeroqual Series 500 monitor produced by Ozone Solutions, uses a tungsten oxide semiconductor to measure a voltage producing an instantaneous ozone reading.

• (R) The R-13 weather resistant box for the monitor was also provided by Ozone Solutions.

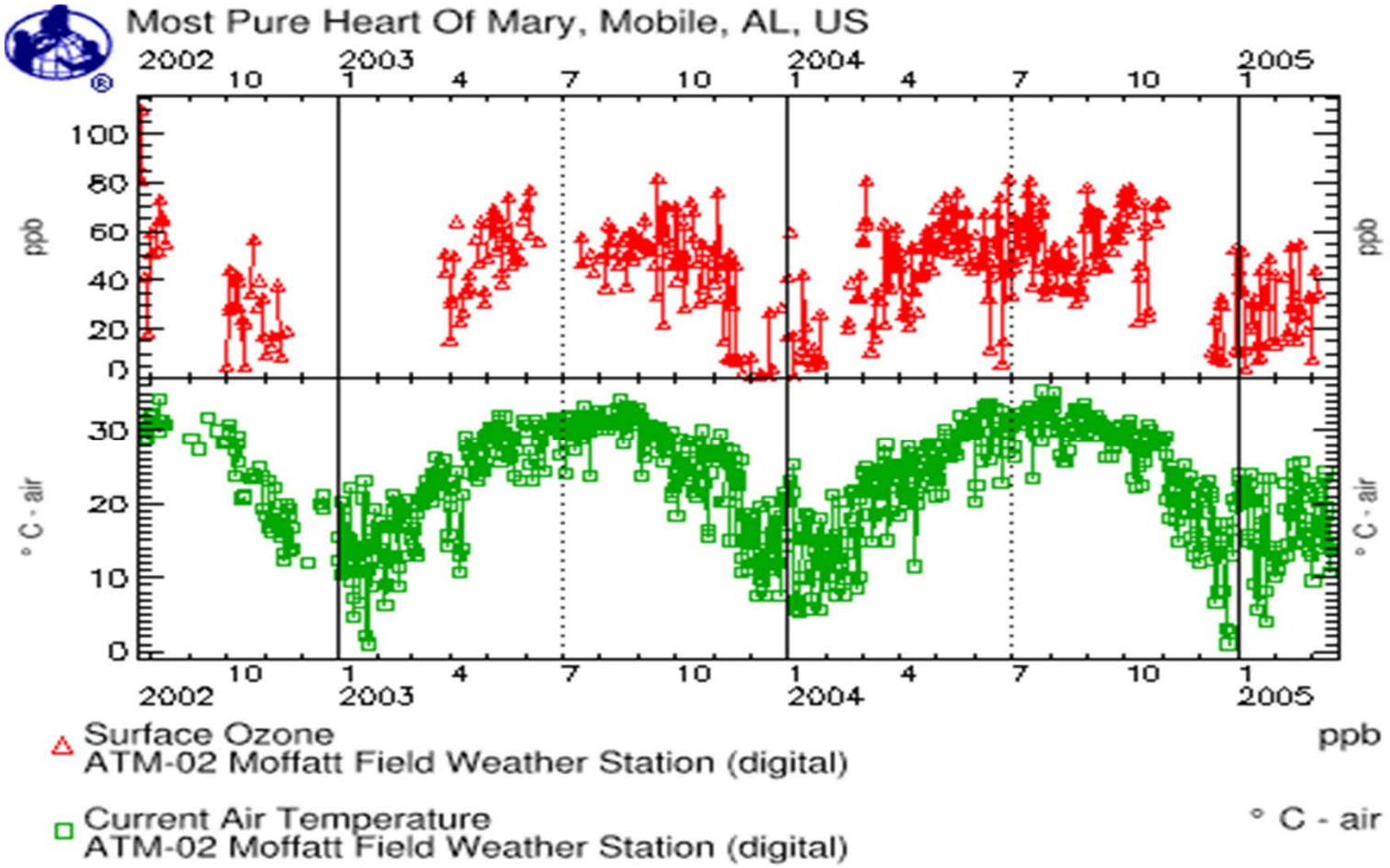
Extras

Looking at the Data – Relative Humidity

Figure AT-RH-4



Looking at the Data = Surface Ozone



Air Quality improving Globally