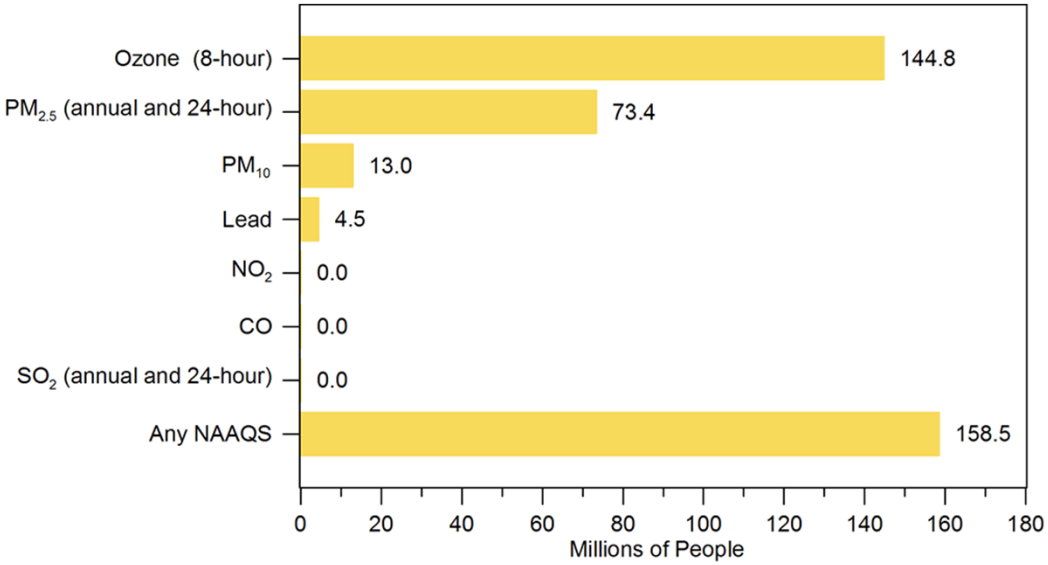
DISCOVER-Air Quality

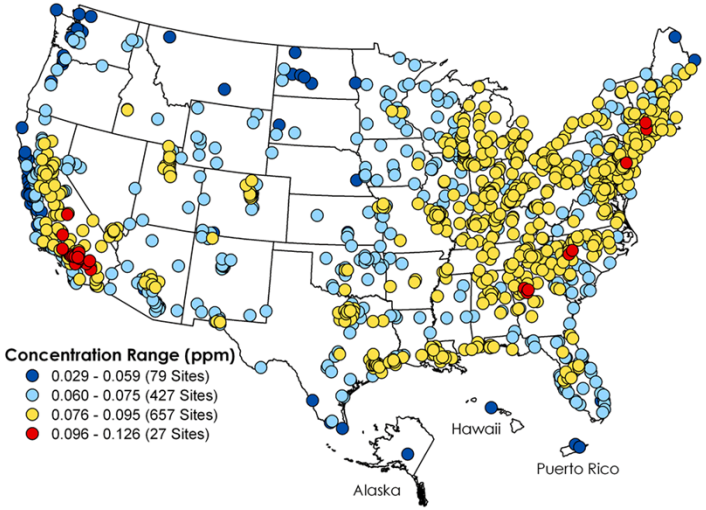
Improving the View of Air Quality from Space

Jim Crawford
Science Directorate
NASA Langley

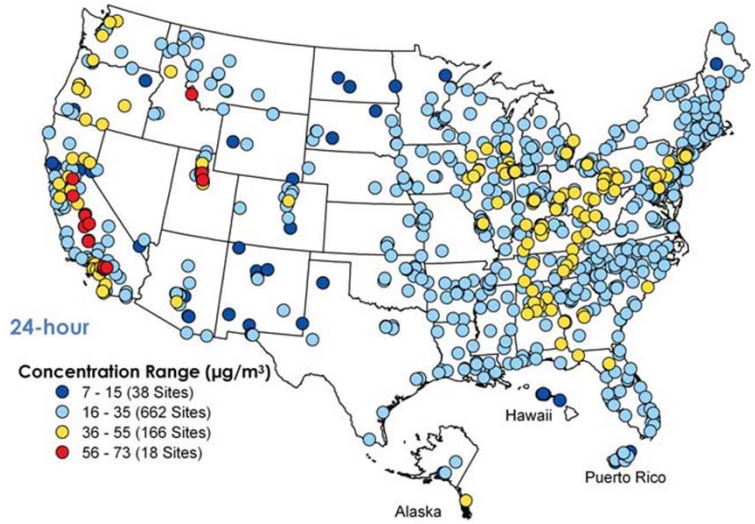
National Ambient Air Quality Standards (NAAQS): Violations are primarily related to ozone and fine particulate matter.



Ozone concentrations in ppm, 2007
(fourth highest daily max 8-hour concentration).

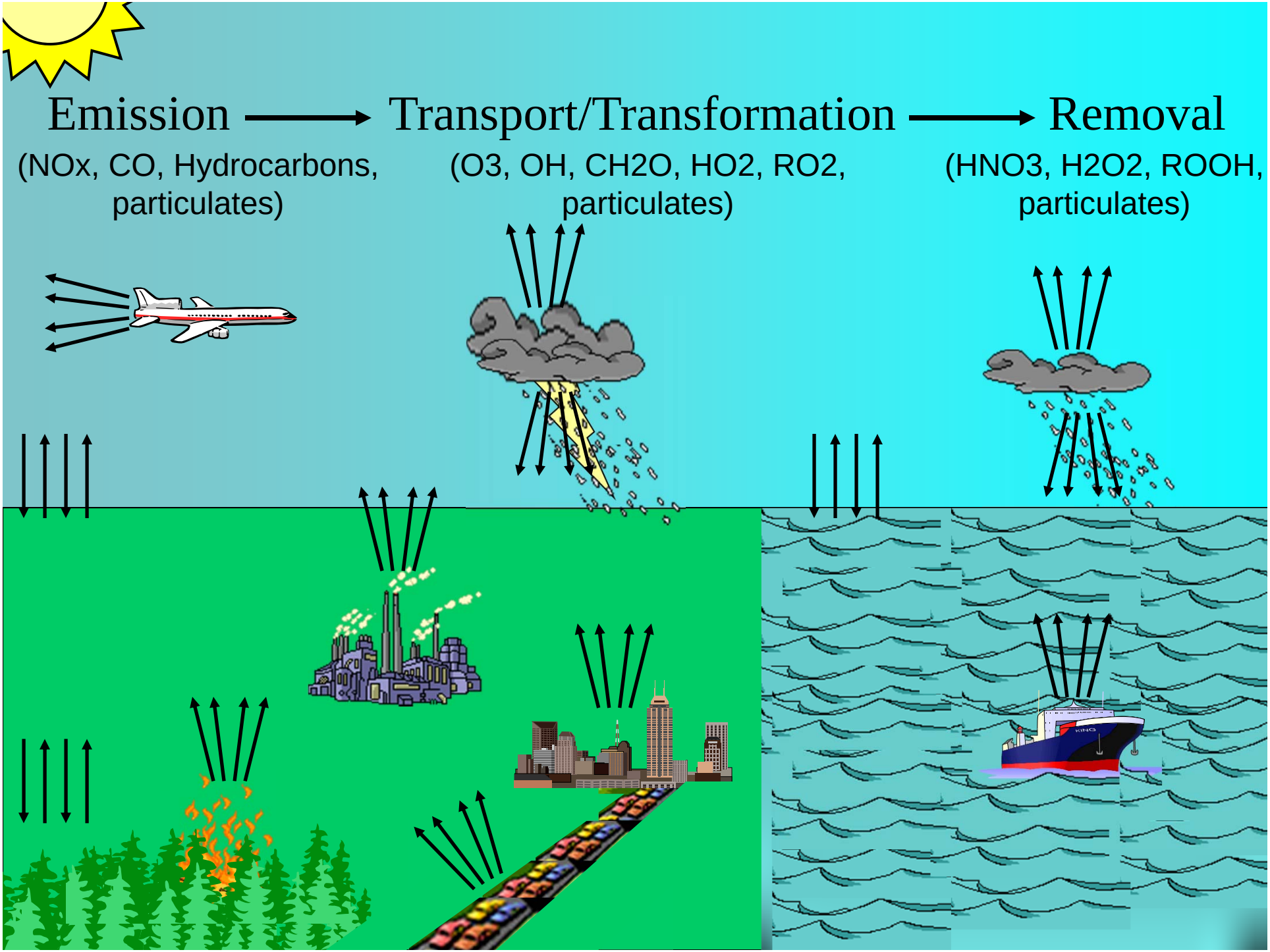


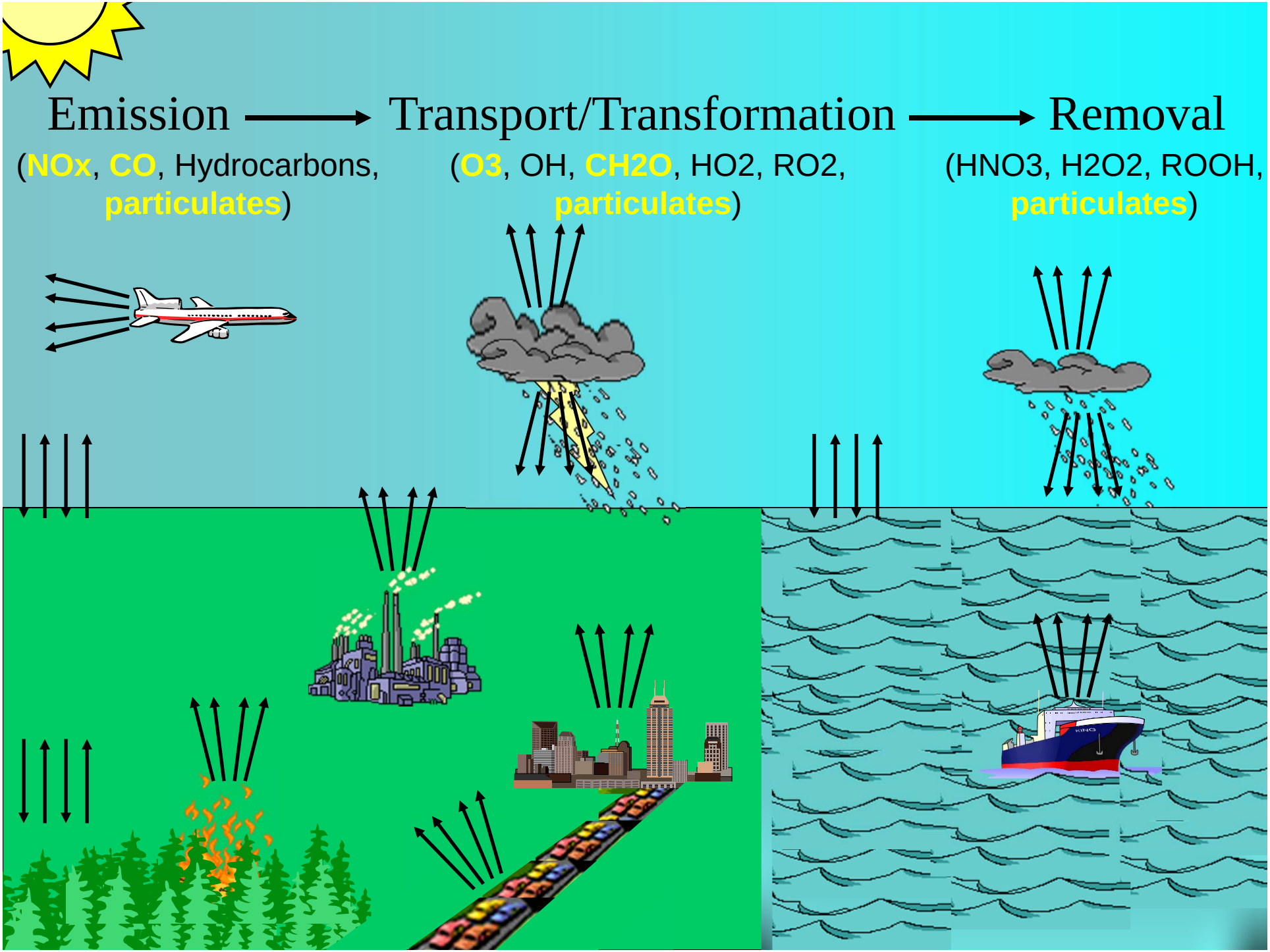
24-hour PM2.5 concentrations in µg/m3, 2007
(98th percentile 24-hour concentration)



**** Yellow and Red symbols represent levels in violation of NAAQS***

Taken from National Air Quality-Status and Trends through 2007 (http://www.epa.gov/airtrends/2008/)


Emission
(NOx, CO, Hydrocarbons, particulates)
Transport/Transformation
(O3, OH, CH2O, HO2, RO2, particulates)
Removal
(HNO3, H2O2, ROOH, particulates)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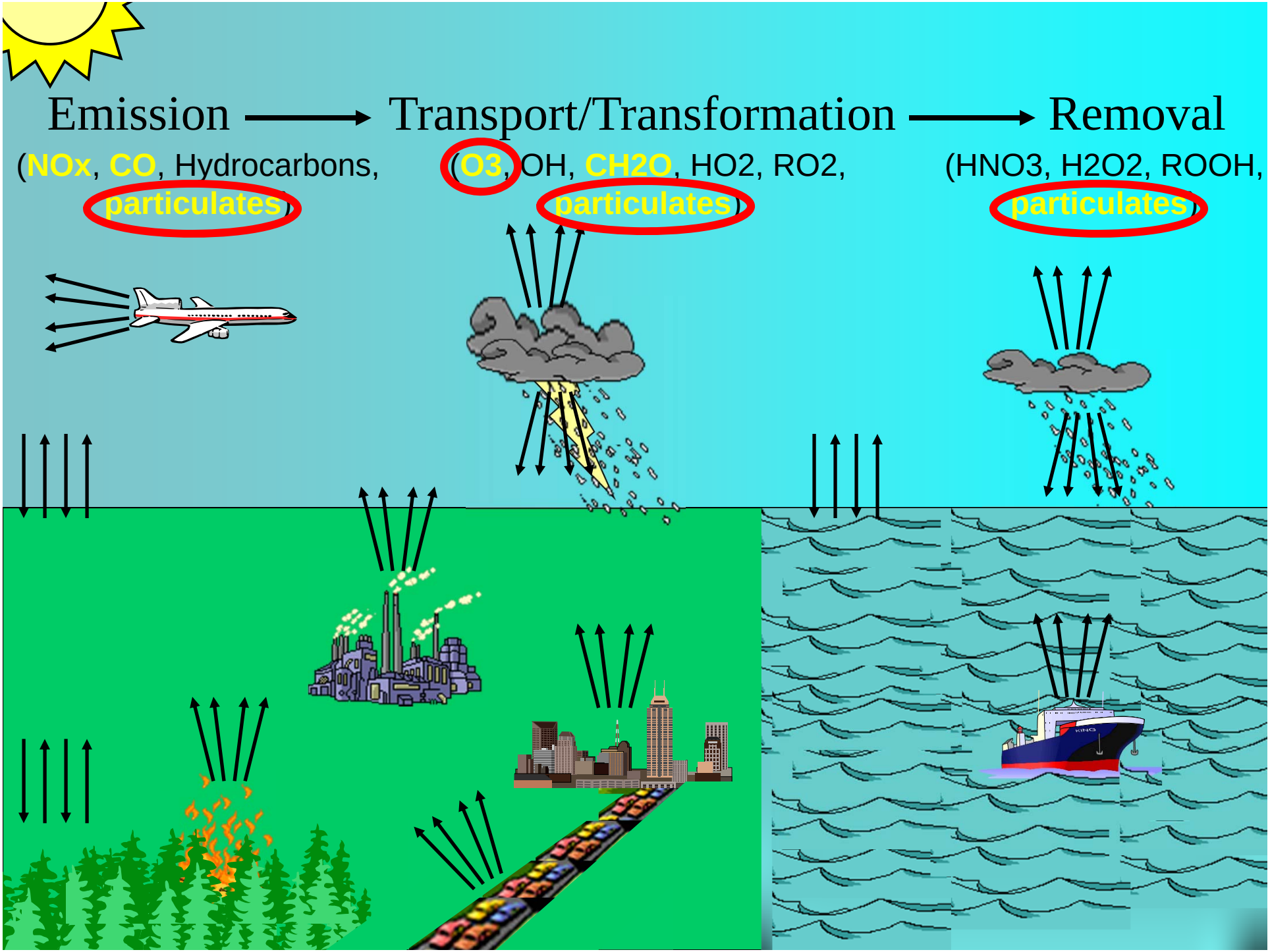
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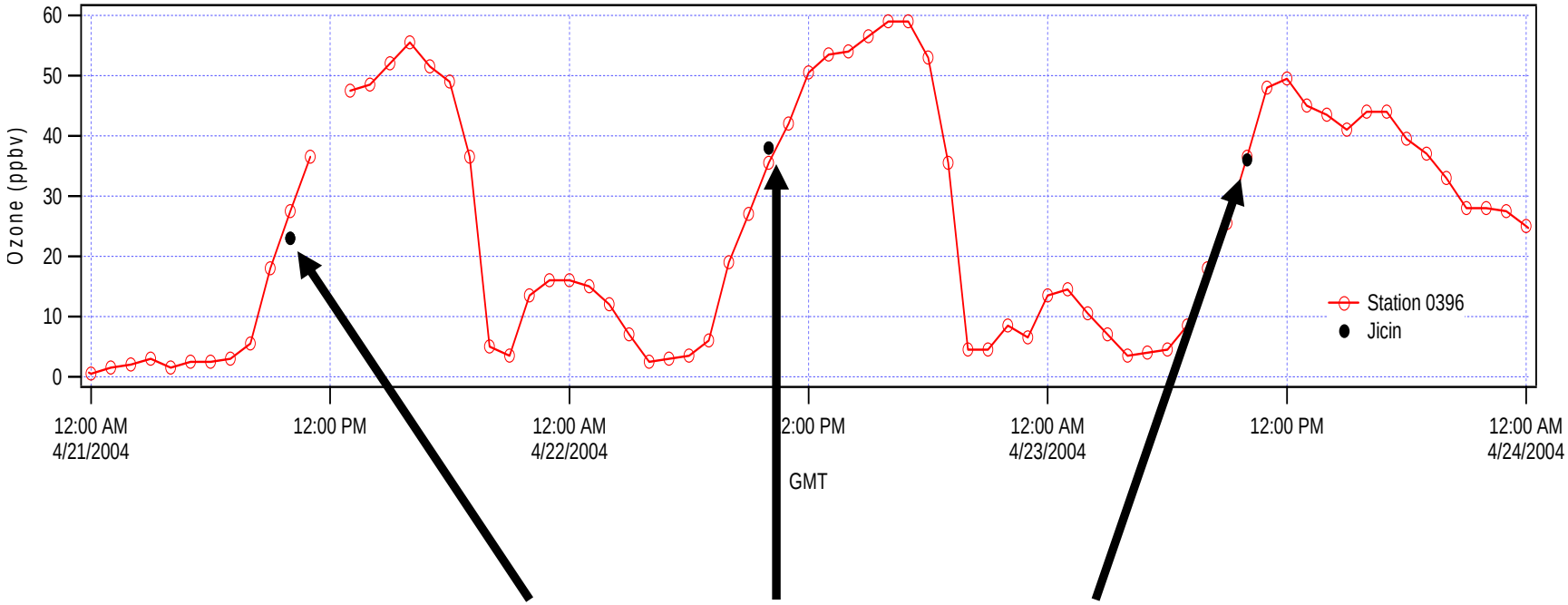
Ozone Data at Jicín, Czech Republic

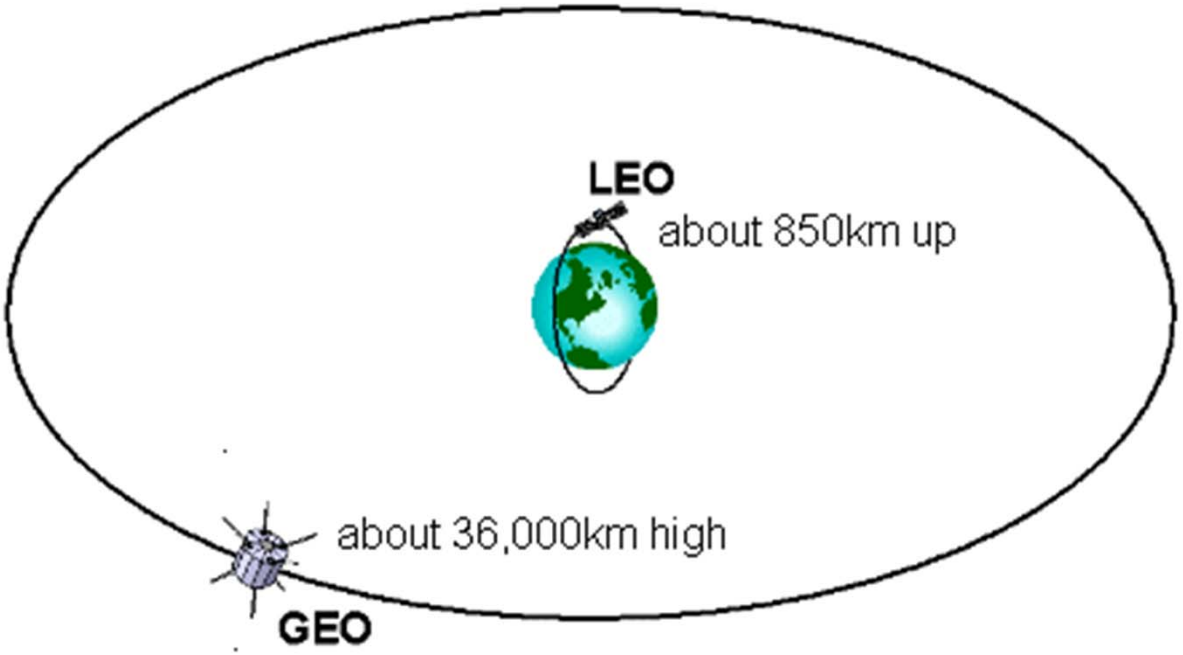


GLOBE measurements

- Air Quality observations require high temporal resolution
- Monitoring standard is hourly information
- Exposure is regulated based on 8-hour average values

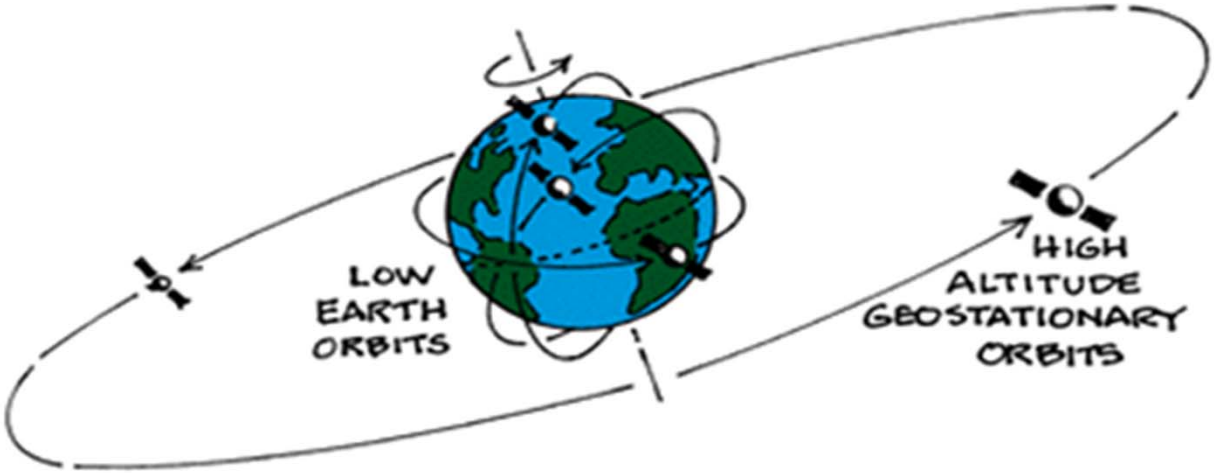
Data courtesy of M. Pippin, NASA LaRC

Satellite Orbits used for Earth Observations.



<u>Low Earth Orbit (LEO)</u>
Global Coverage
Brief viewing time
Relatively Close

<u>Geostationary (GEO)</u>
Hemispheric coverage
Continuous view
Far Away



Hourly atmospheric pollution from geostationary Earth orbit

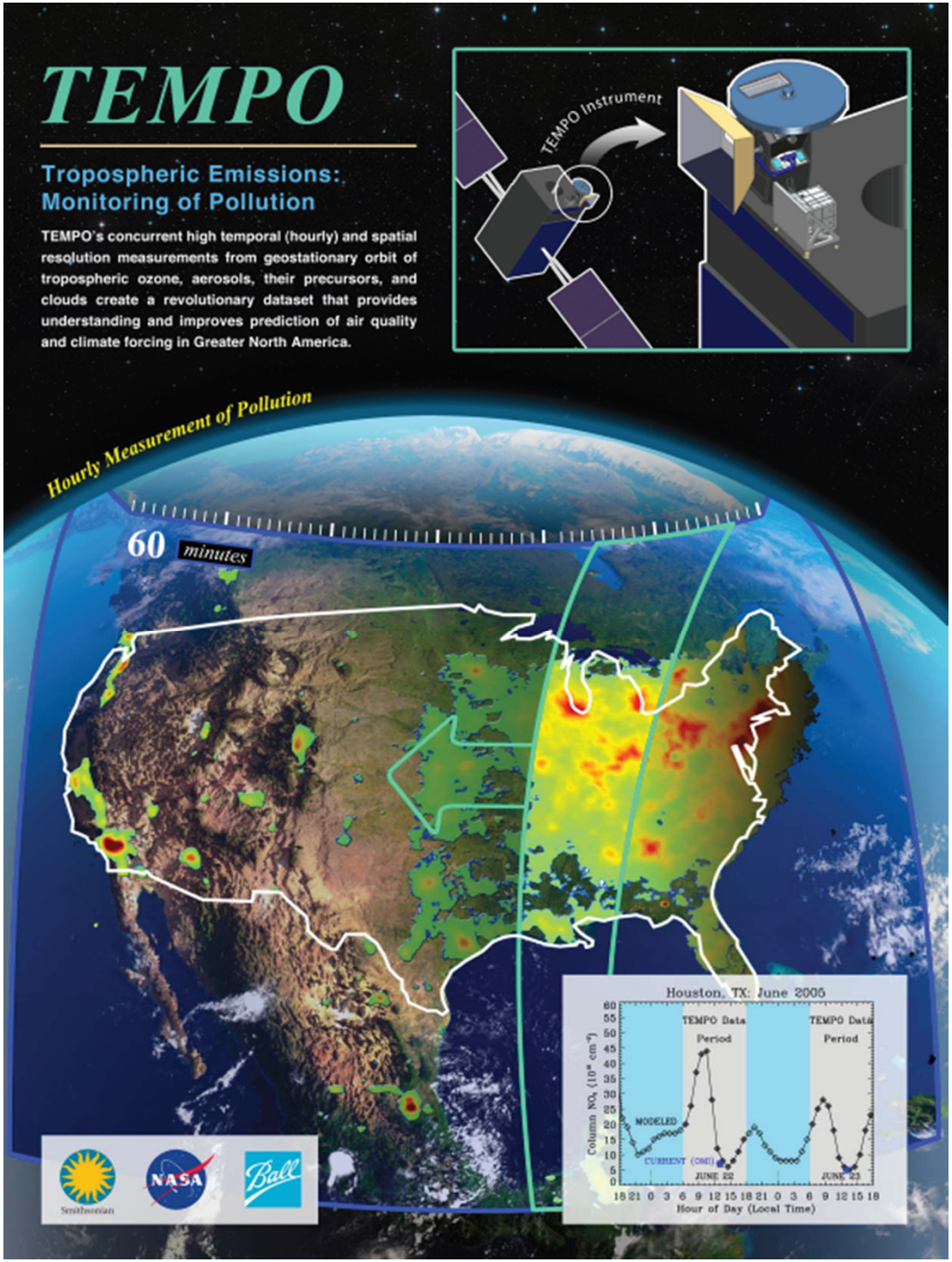
Selected Nov. 2012 as NASA's first Earth Venture Instrument

- Instrument delivery September 2017
- NASA will arrange hosting on commercial geostationary communications satellite with expected launch in 2018/2019

Provides hourly daylight observations to capture rapidly varying emissions & chemistry important for air quality

- UV/visible grating spectrometer to measure key elements in tropospheric ozone and aerosol pollution
- Exploits extensive measurement heritage from LEO missions
- Distinguishes boundary layer from free tropospheric & stratospheric ozone

PI: Kelly Chance, Smithsonian Astrophysical Obs.
Instrument Development: Ball Aerospace
Project Management: NASA LaRC
Other Institutions: NASA GSFC, NOAA, EPA, NCAR, Harvard, UC Berkeley, St. Louis U, U Alabama Huntsville, U Nebraska
International collaboration: Korea, Europe, Canada



GLOBE Aerosols Protocol

Current GLOBE aerosol instrument

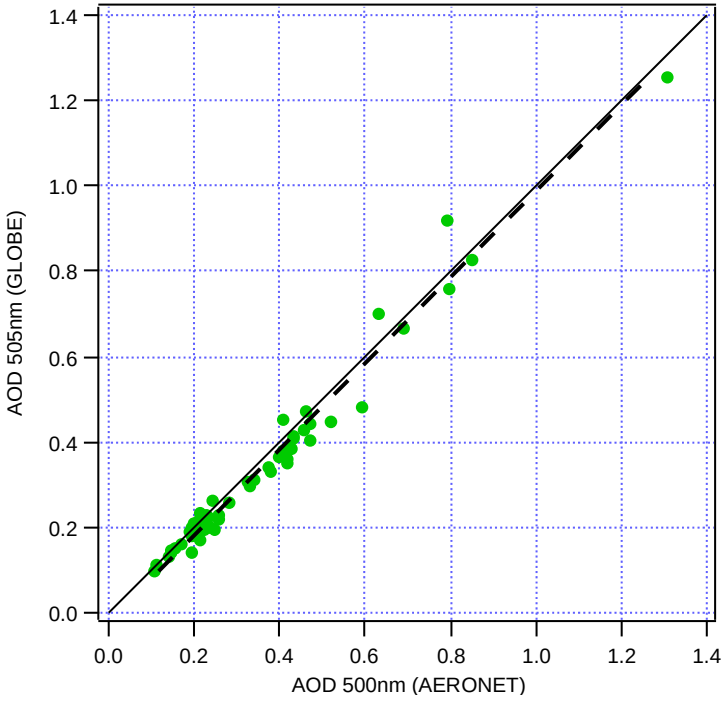
- sun photometer
- uses LEDs at 505nm and 625nm
- outputs voltage readings
- equations to calculate AOD
- *instrument availability limited*

- simple kit to build instrument

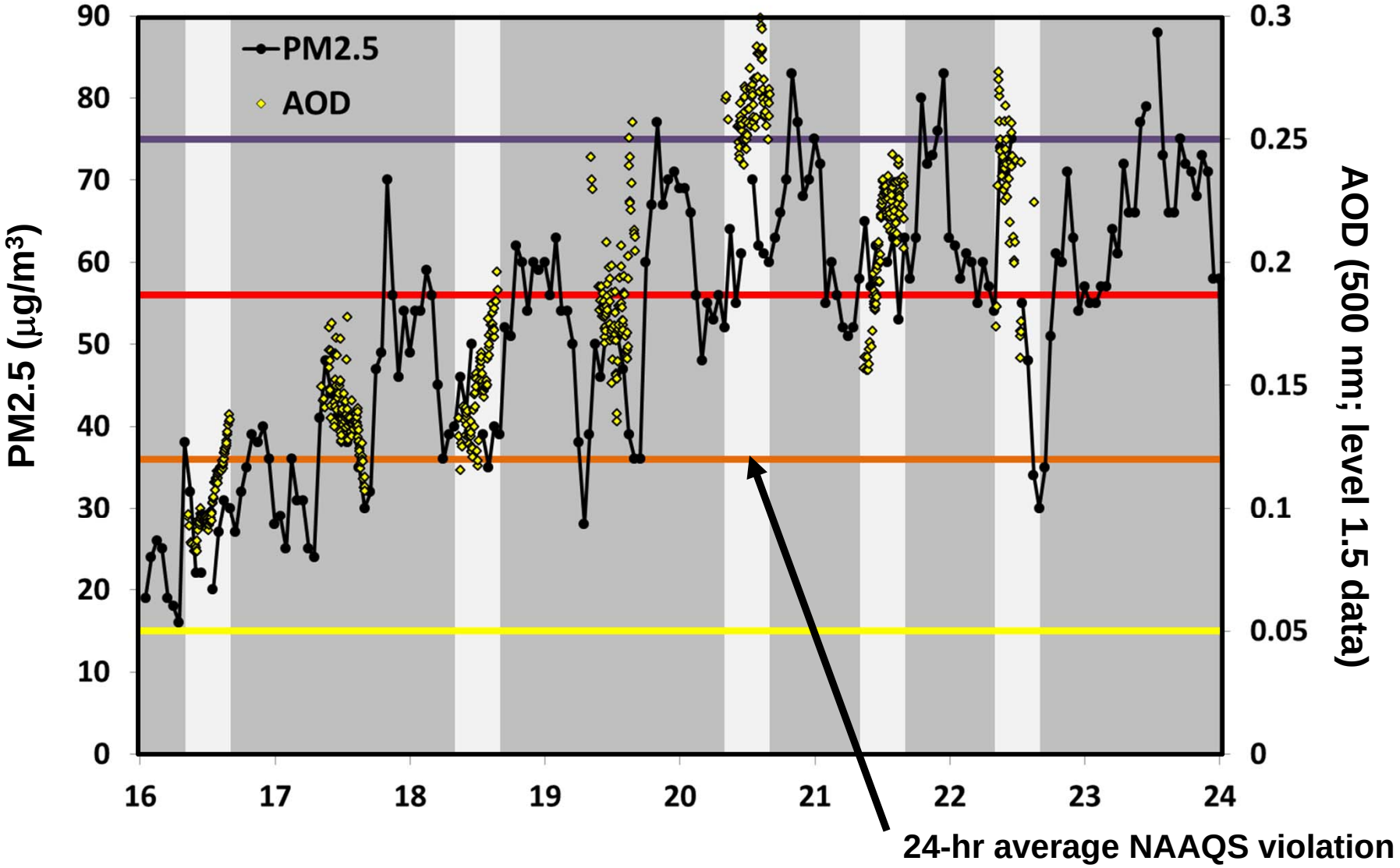
AERONET Cimel Sun Photometer
at Langley's CAPABLE site

GLOBE sun photometer data collected during summer 2012 and 2013 compares very well with the research-grade sun photometer in the AERONET network

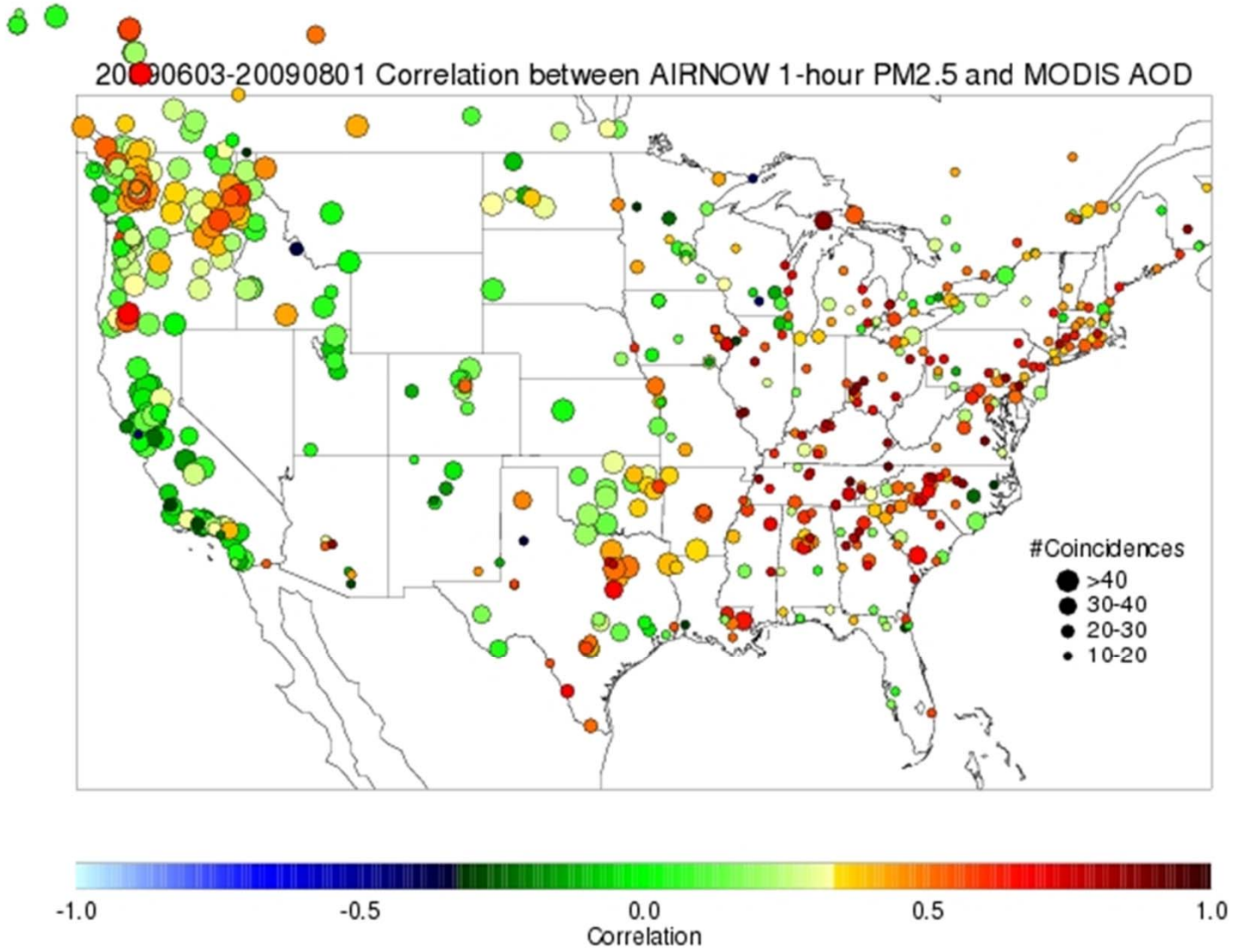
Comparison at 505nm



PM2.5 and Aeronet AOD build-up in Bakersfield, CA (16-24 Jan 2013)



Example of PM2.5 and MODIS Satellite AOD correlations



IDEA: Infusing satellite Data into Environmental Applications
(http://www.star.nesdis.noaa.gov/smcd/spb/aq/)

The Problem

Near-surface pollution is one of the most challenging problems for Earth observations from space…

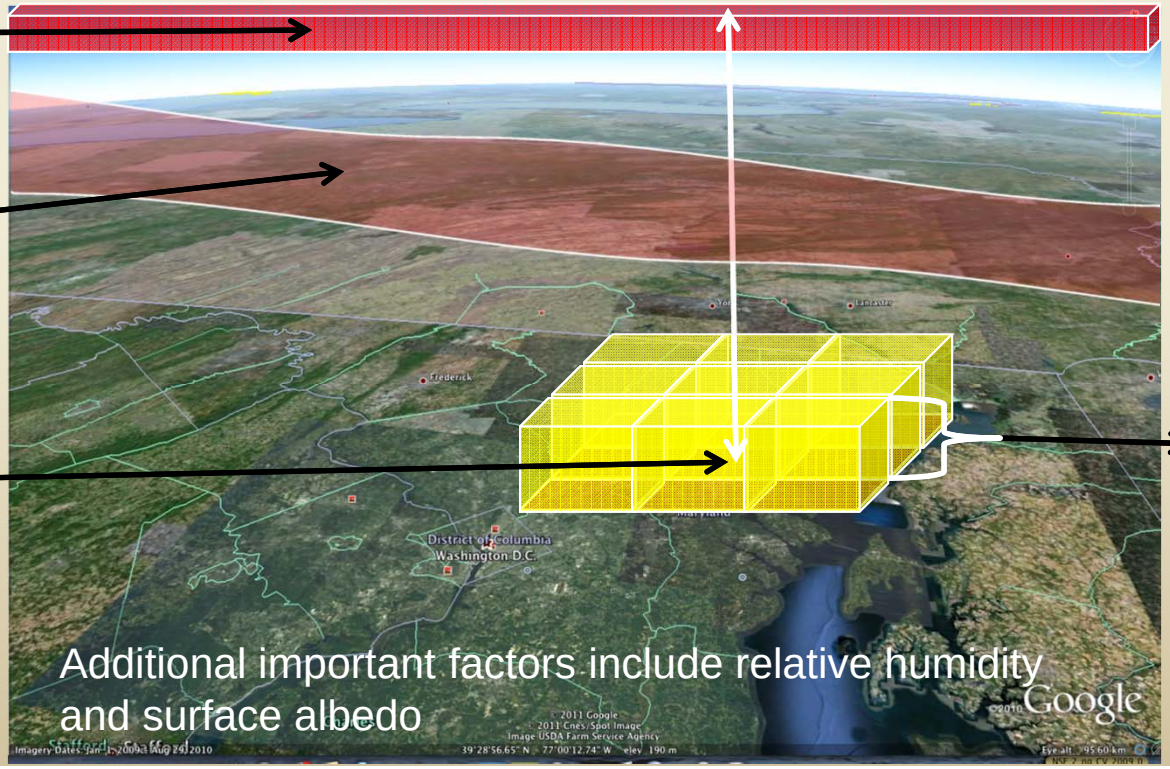
Near-surface information must be inferred from column-integrated quantities obtained by passive remote sensing from downward-looking satellite instruments.

Some constituents have large relative concentrations in the stratosphere and/or free troposphere (e.g., O_3 and NO_2) making it difficult to distinguish the near-surface contribution to the total column.

Stratospheric Burden

Long-range transport of pollution aloft

From space, the size of the measurement pixel matters (as does grid size for models)



Additional important factors include relative humidity and surface albedo

Boundary layer depth influences the volume over which surface pollution is mixed

It also matters how well the pollution is mixed

Investigation Overview

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

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

Objectives:

1. Relate column observations to surface conditions for aerosols and key trace gases O_3, NO_2, and CH_2O

2. Characterize differences in diurnal variation of surface and column observations for key trace gases and aerosols

3. Examine horizontal scales of variability affecting satellites and model calculations

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)

Deployment Strategy

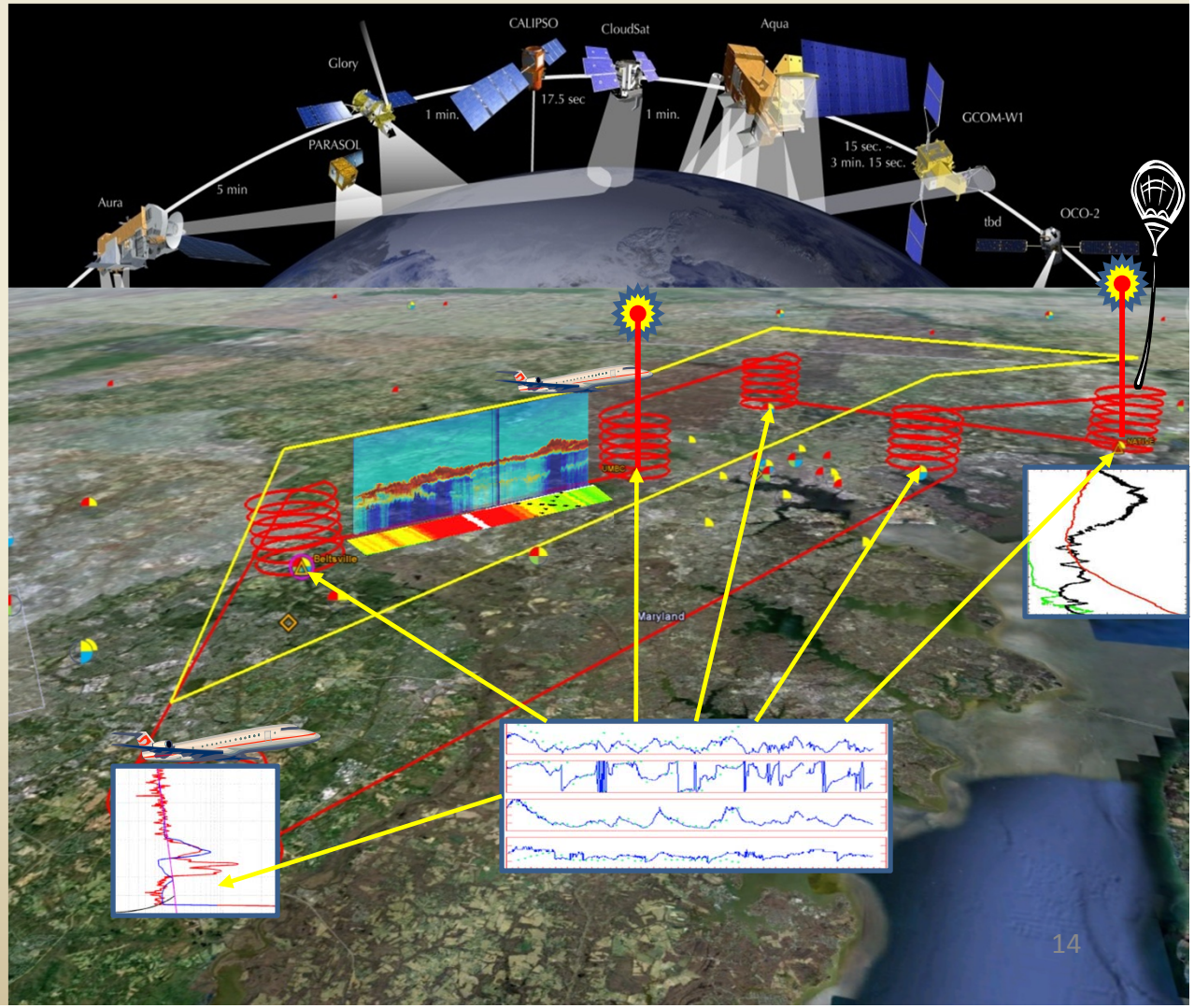
Systematic and concurrent observation of column-integrated, surface, and vertically-resolved distributions of aerosols and trace gases relevant to air quality as they evolve throughout the day.

Three major observational components:

<u>NASA King Air (Remote sensing)</u>
Continuous mapping of aerosols with HSRL and trace gas columns with ACAM

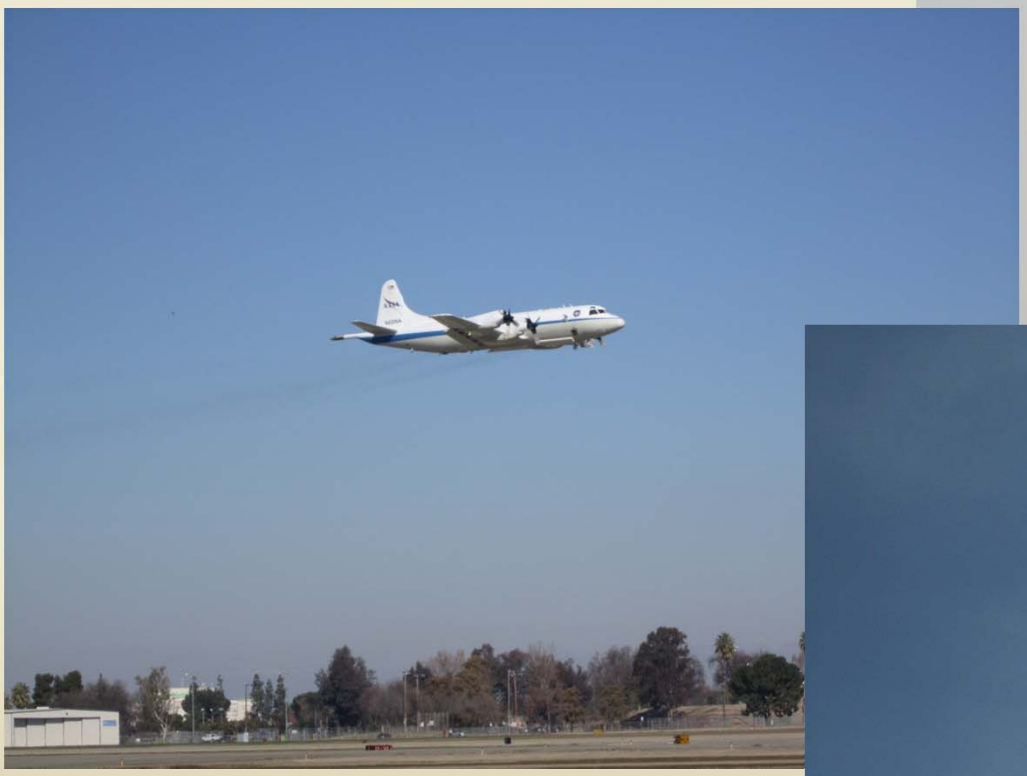
<u>NASA P-3B (in situ meas.)</u>
In situ profiling of aerosols and trace gases over surface measurement sites

<u>Ground sites</u>
In situ trace gases and aerosols
Remote sensing of trace gas and aerosol columns
Ozonesondes
Aerosol lidar observations



DISCOVER-AQ

P-3B in action

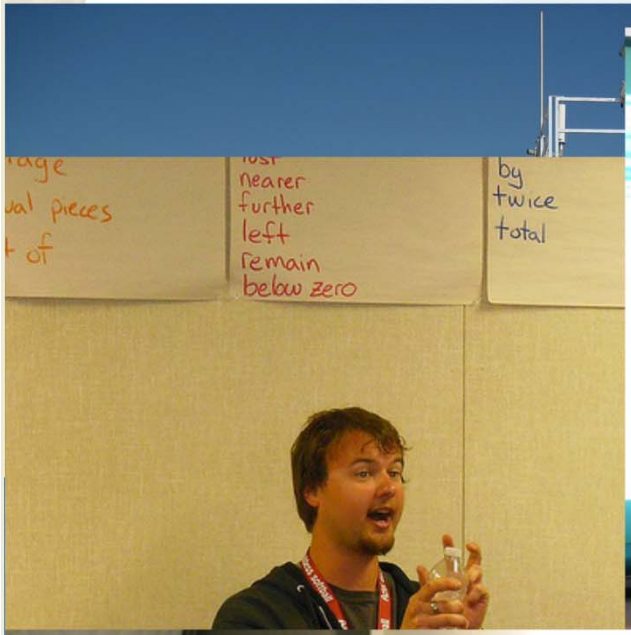


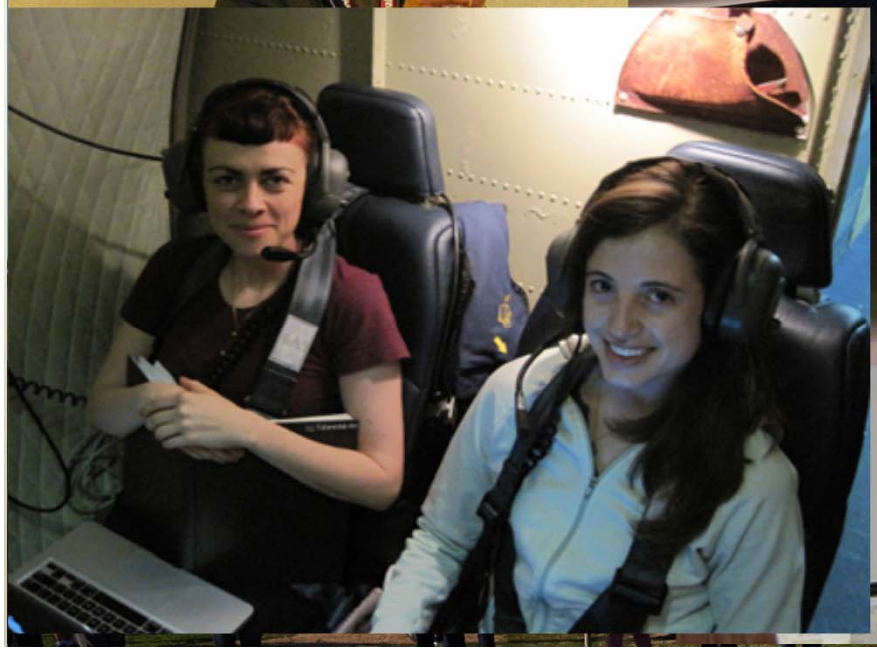
Outreach through Information and Data Management

https://discover-aq.larc.nasa.gov/

http://www-air.larc.nasa.gov/missions/discover-aq/discover-aq.html

Outreach through Engagement





Outreach through Participation

Small Sensor technology is advancing at a rate that offers the possibility of widespread use of personal air quality monitors in the near future.

EPA has been evaluating these technologies.

Sensors will be shared with eight schools in the Houston area to determine the assess the current state-of-the-art and utility of these measurements.

Measurements will contribute to the much larger and more extensive DISCOVER-AQ network of observations.

Students will get to see how their monitors compare to conditions at nearby regulatory air monitoring sites.

DISCOVER-AQ

Geotech AQMesh-5

The unit requires no power and operates unattended.

Subsequent to installation, visits would be only on an as needed basis and in many cases may not be necessary at all.

Sensors can be mounted on any pole (sign, flag, fence, etc.)

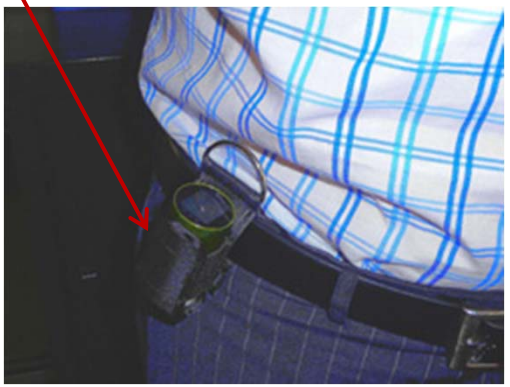
Units will continuously monitor five key pollutants:

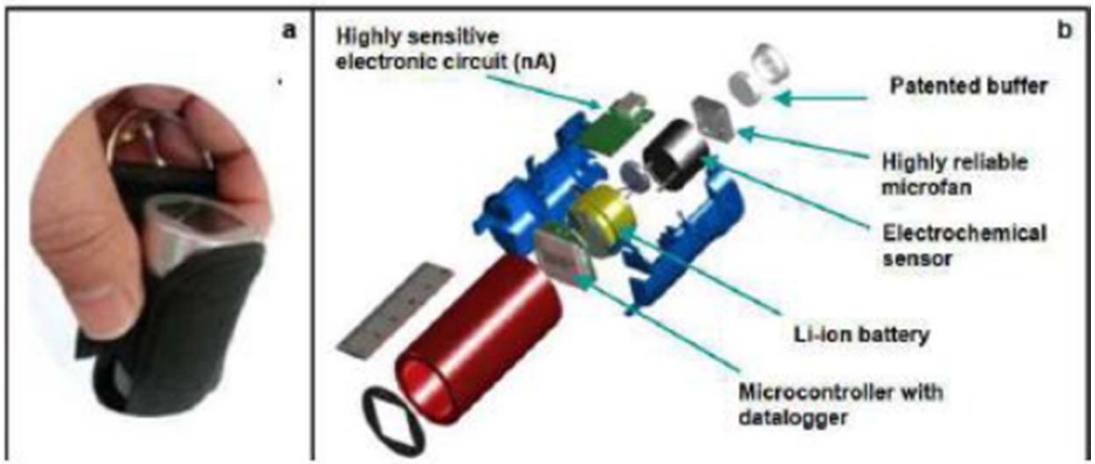
- **Ozone (O_3)**
- **Nitrogen Dioxide (and NO_2)**
- **Nitrous Oxide (NO)**
- **Carbon monoxide (CO)**
- **Sulfur dioxide (SO_2)**

CairClip Air Pollution Sensor

CairClip is an easy to use, air pollution sensor that measures ozone (O_3) and nitrogen dioxide (NO_2). These pollutants are regulated because they are formed by a number of pollution sources (such as vehicles and industry) and are known to cause harmful effects on human health and the environment. The **CairClip** sensor is made by CairPol, located in France.

Carrying Case for portable use



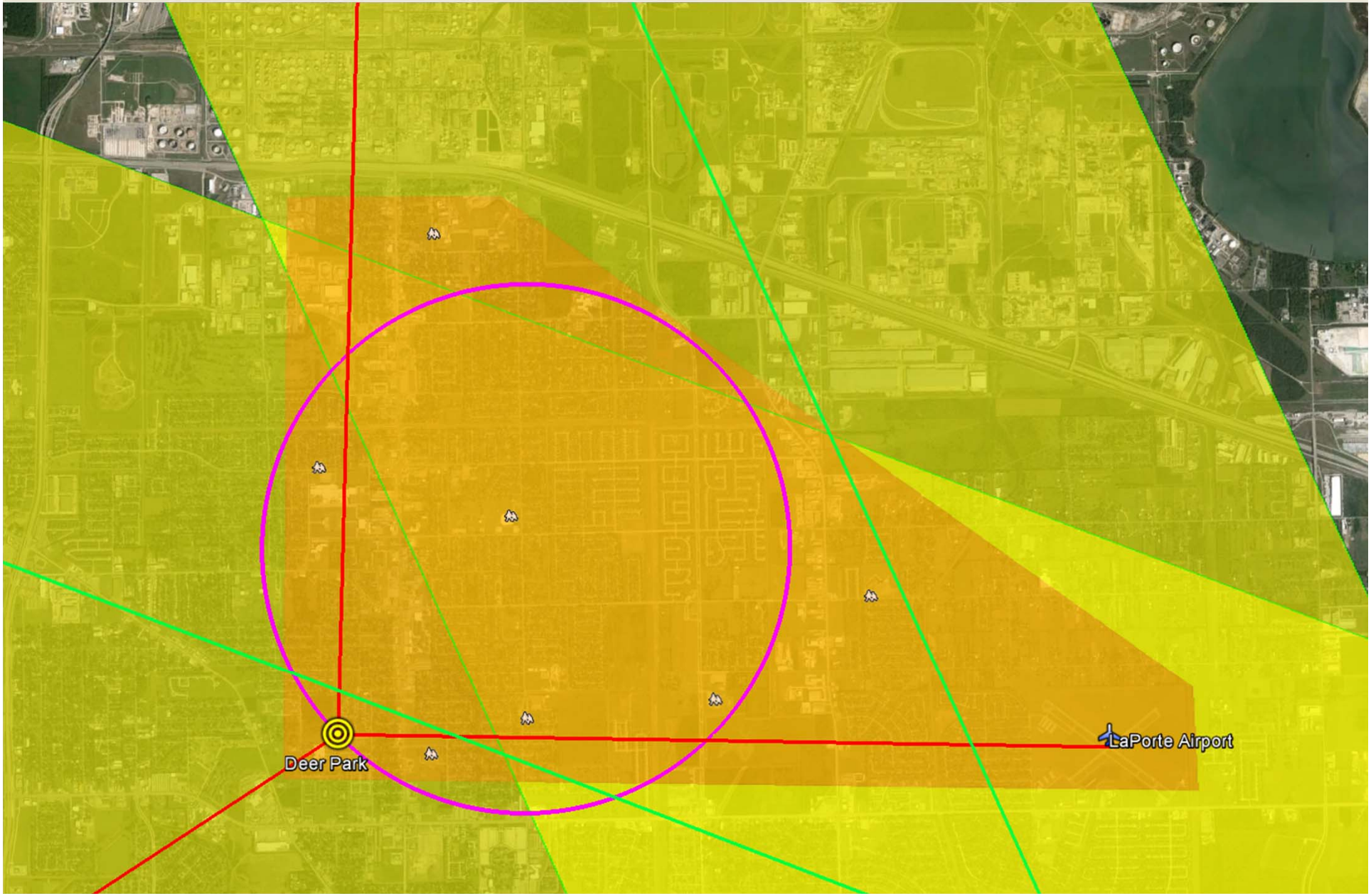


(a) Picture of a Cairclip (b) schematic représentation of its main components

Features of the CairClip Sensor

- ✓ Detection range for O_3 and NO_2: 0 to 250 ppb
- ✓ Weight: 55 grams (about 0.12 pounds)
- ✓ Dimensions: 32 mm (1.26 inches) wide, 62 mm (2.44 inches) long
- ✓ Battery life: 24 hours
- ✓ Recharging battery: 4 hours to completely charge
- ✓ Battery charged with either a USB cable or AC adapter
- ✓ Can store about 28,800 data points; for example…
  - 1 point every minute = 20 days of data
  - 1 point every 15 minutes = 300 days of data
- Cairsoft user software (on provided USB thumb drive) to retrieve measurement data and set up measurement parameters

Small Sensor Network



Interested in Following DISCOVER-AQ Houston?

Even if you are not in Houston, there are opportunities to interact with DISCOVER-AQ scientists.

Online flight tracking and chat sessions during flights with active scientists is available.

For more information, contact Melissa Yang (melissa.yang@nasa.gov)

At least 10 flights are planned during September 2013, however, the actual flight days depend on weather conditions.

Flight announcements will be sent by email the afternoon before each flight day.

Flights last 8 hours, so there is plenty of time during the day to look in on us and ask questions.

DISCOVER-AQ

Education and Public Outreach Team

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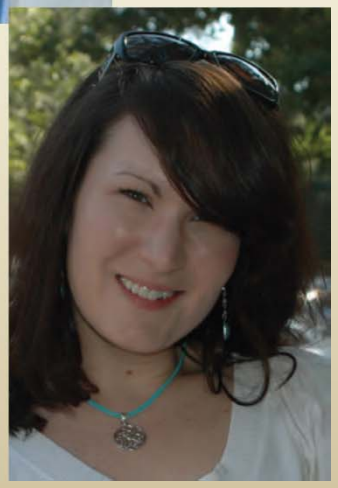

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