METR/ENVS 113

Lecture 8: Satellite Detection of Air Pollution (Part 1)

SJSU Fall Semester 2020

Module 3: Outdoor Air Pollution (Ozone & PM2.5)

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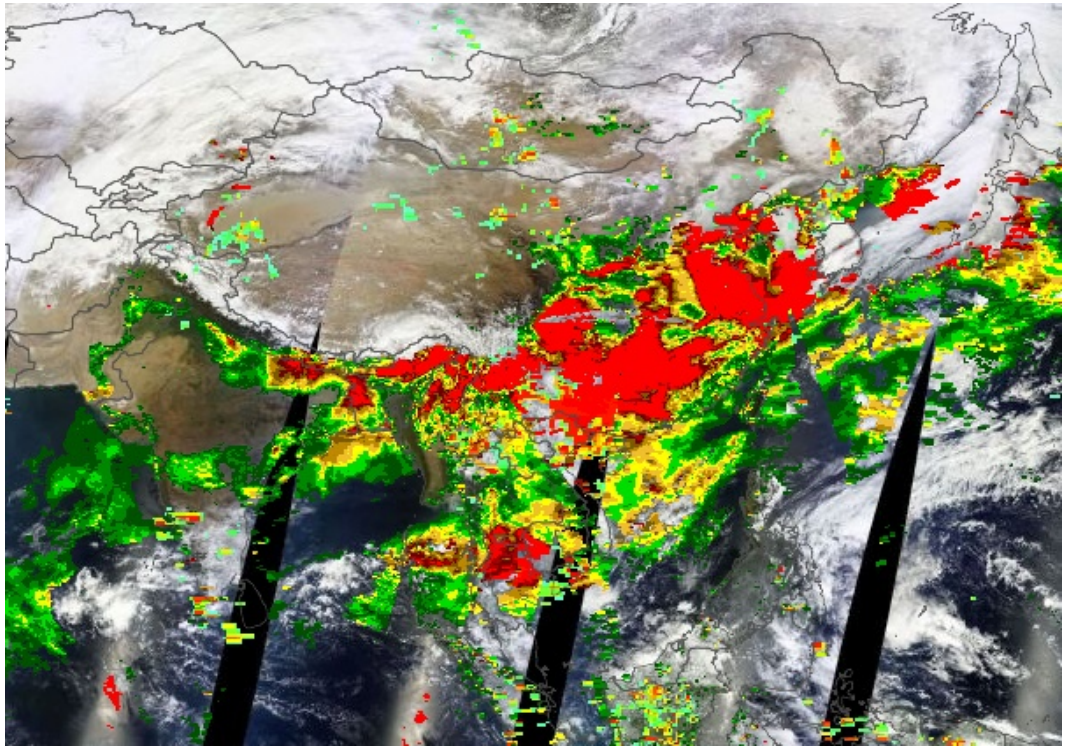
Outline

- **Background: Satellite Measurement of Air Pollution (Part 1)**
  - Motivation: Broader Spatial Coverage
  - Geostationary vs. Polar Orbiting
  - Visible vs. Infrared
  - Total column abundance
- **Demonstration (Part 2)**
  - Hourly tracking of wildfire PM2.5 & fires in California (GOES-17 & Suomi)
  - Daily tracking of wildfire smoke across U.S. via carbon monoxide (Sentinel-5p)
  - Locating major urban emission centers via nitrogen dioxide (Sentinel-5p)

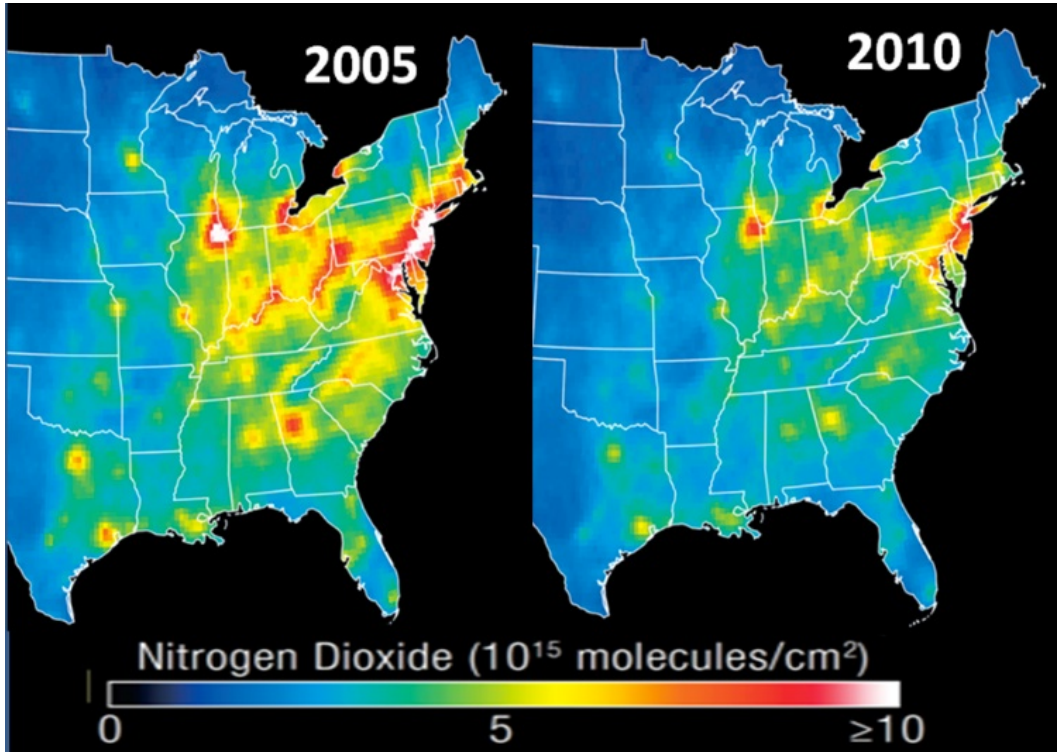
Background: Main advantage of satellite measurements

- Continuous global coverage:
- “See” pollutants where no monitors exist

Aerosol Optical Depth (AOD): South & East Asia



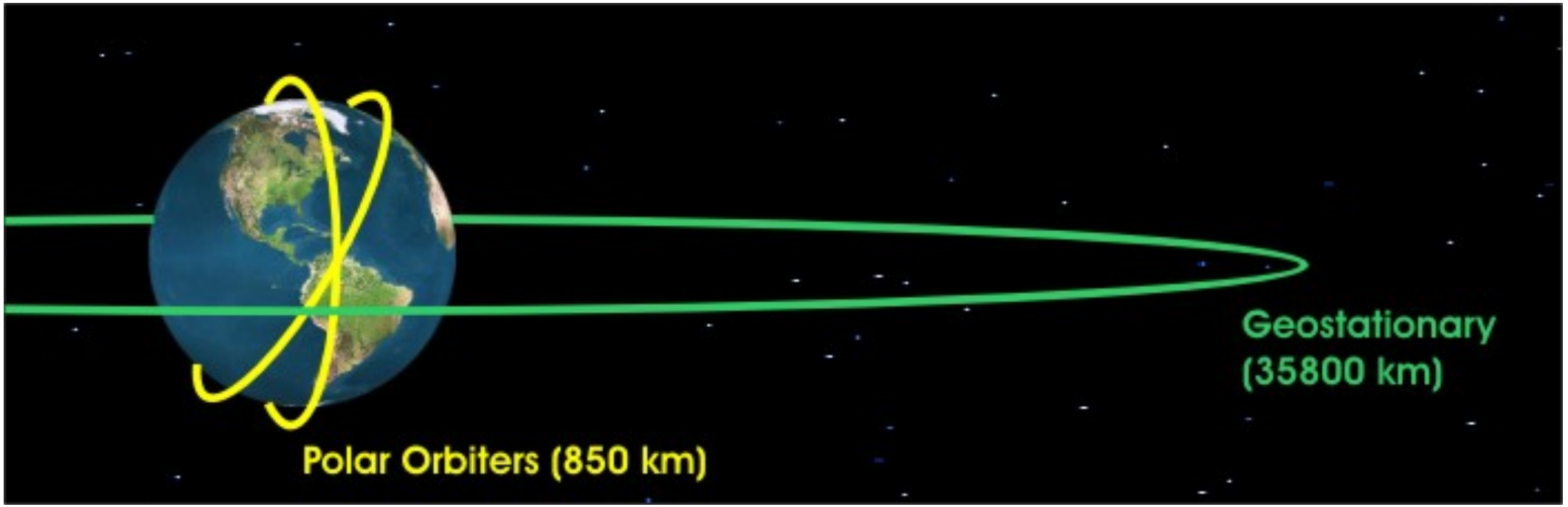
Nitrogen Dioxide over the Eastern U.S.



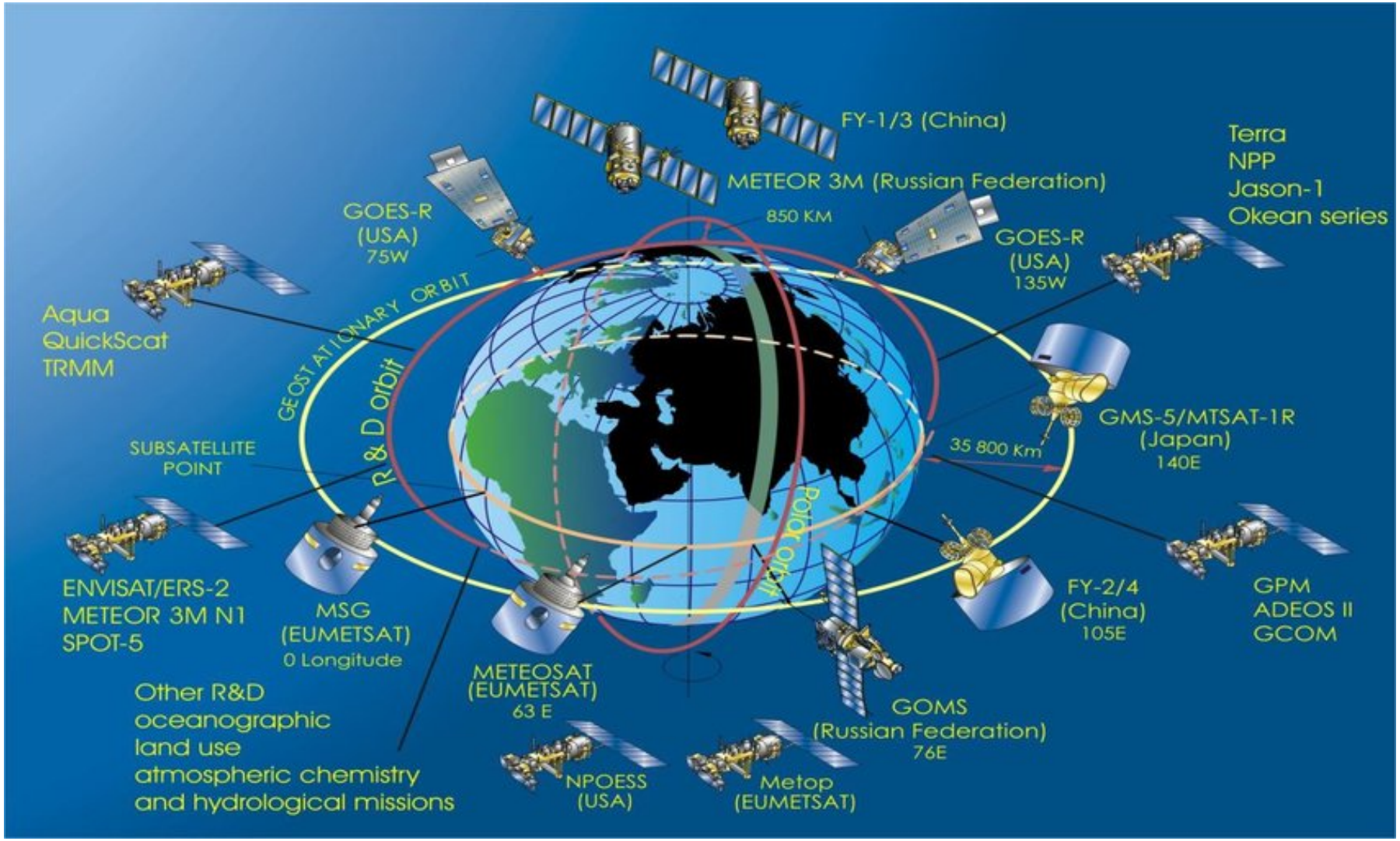
Background: Different types of satellites

- **Geostationary**
  - Fixed in place relative to rotating earth
  - Continuous coverage in time (hour by hour)
  - Geostationary Operational Environmental Satellite 16 (GOES-16): Eastern U.S.
  - Geostationary Operational Environmental Satellite 17 (GOES-17): Western U.S.
- **Sun Synchronous (“Polar Orbiting”)**
  - Orbits around the earth’s poles
  - Passes over a place on earth once a day (usually around mid-day)
  - Daily snapshots (at around mid-day)
  - Several different satellites (e.g. Suomi, Sentinel-5P)

Geostationary vs. Polar Orbiting Satellite (Visual)



Global Suite of Environmental Monitoring Satellites

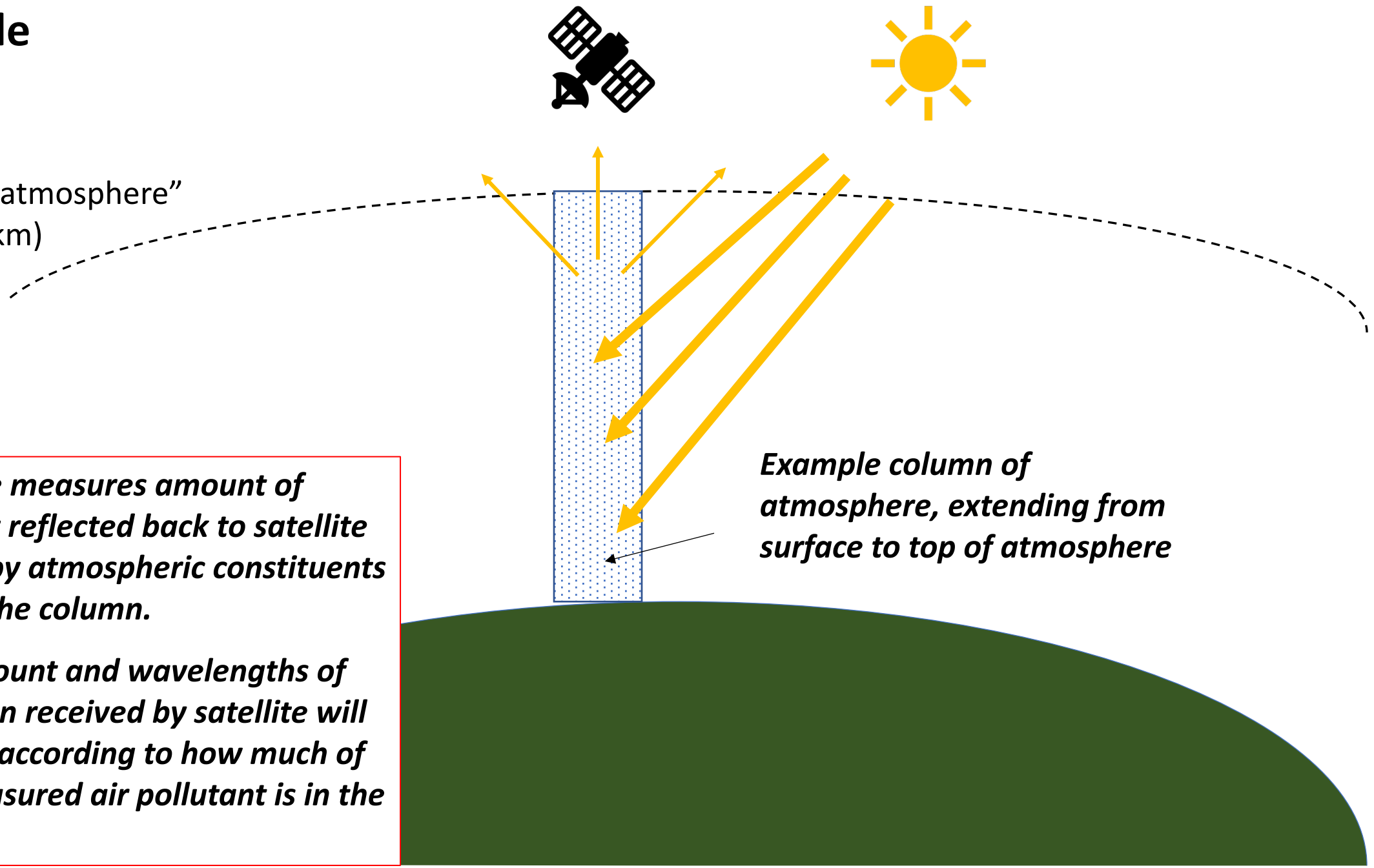


Note: Not current … several more recent launches and replacements of those shown above

Background: Ways satellites measure air pollution

- **Visible sunlight**
  - Visible sunlight reflected back to satellite sensor
  - Examples: Smoke, Dust, Urban/industrial PM2.5, nitrogen dioxide (NO2)
- **Infrared radiation**
  - Infrared radiation (“heat”) emissions by gases to satellite sensor
  - Example: Carbon Monoxide (CO)
- **For both, satellite measures total column abundance**
  - Total amount of air pollutant in column from surface to top of atmosphere.
  - Commonly as “aerosol optical depth” (AOD) for aerosols (smoke, dust, PM2.5)
  - Commonly as # of molecules per surface area for gases (NO2, CO)

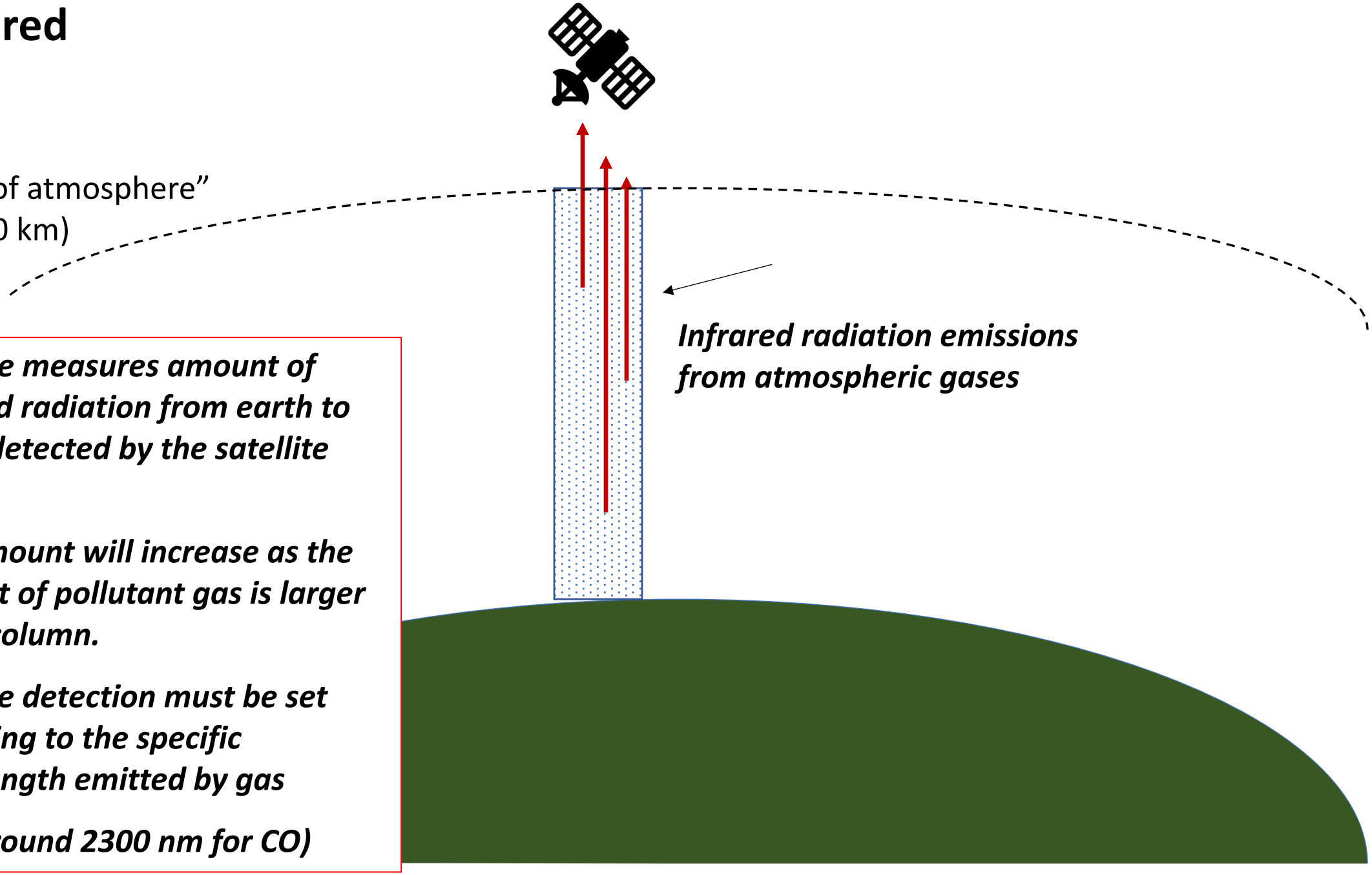
Visible



Satellite measures amount of sunlight reflected back to satellite sensor by atmospheric constituents within the column.

The amount and wavelengths of radiation received by satellite will change according to how much of the measured air pollutant is in the column.

Infrared



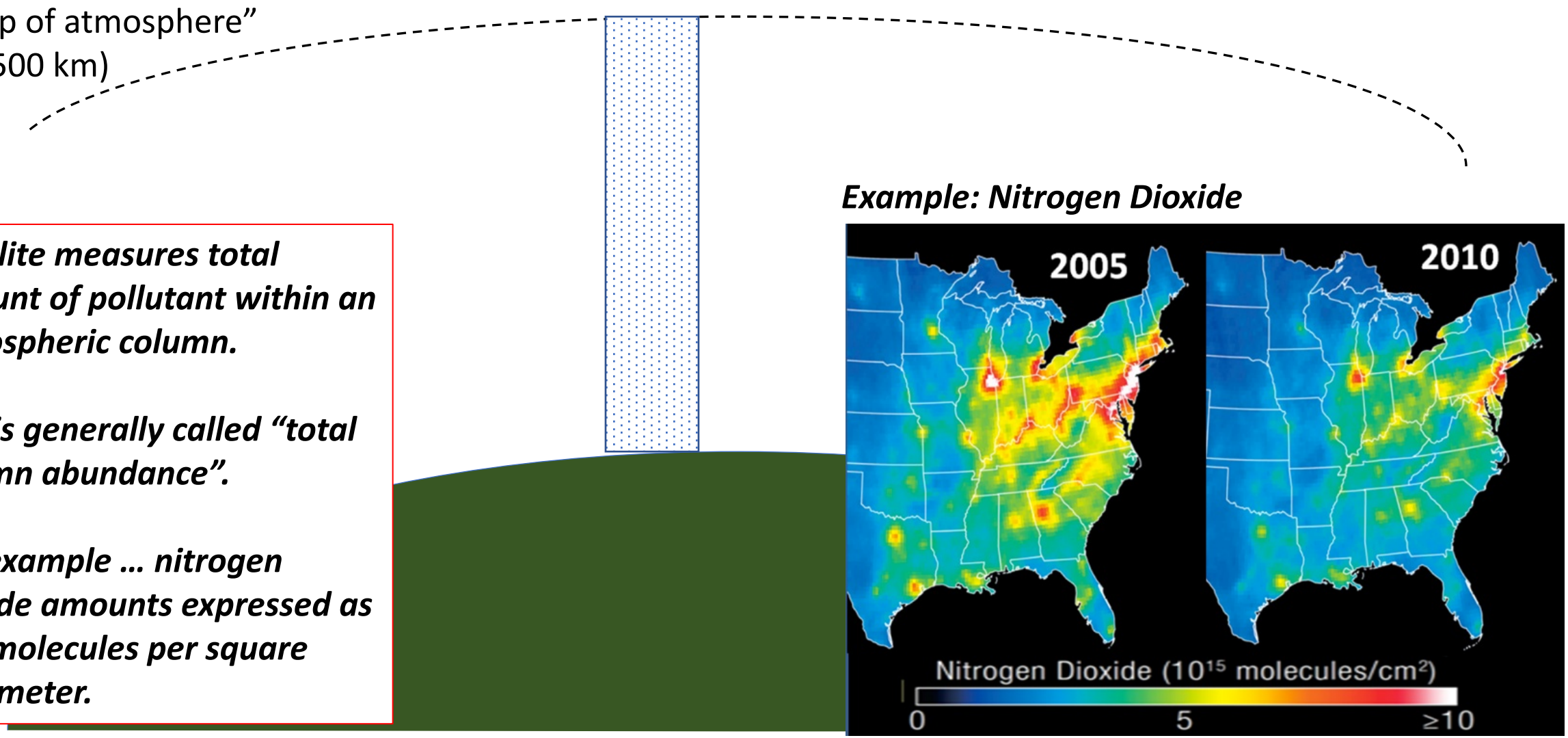
Satellite measures amount of infrared radiation from earth to space detected by the satellite sensor.

This amount will increase as the amount of pollutant gas is larger in the column.

Satellite detection must be set according to the specific wavelength emitted by gas

(e.g. around 2300 nm for CO)

Total Column Abundance



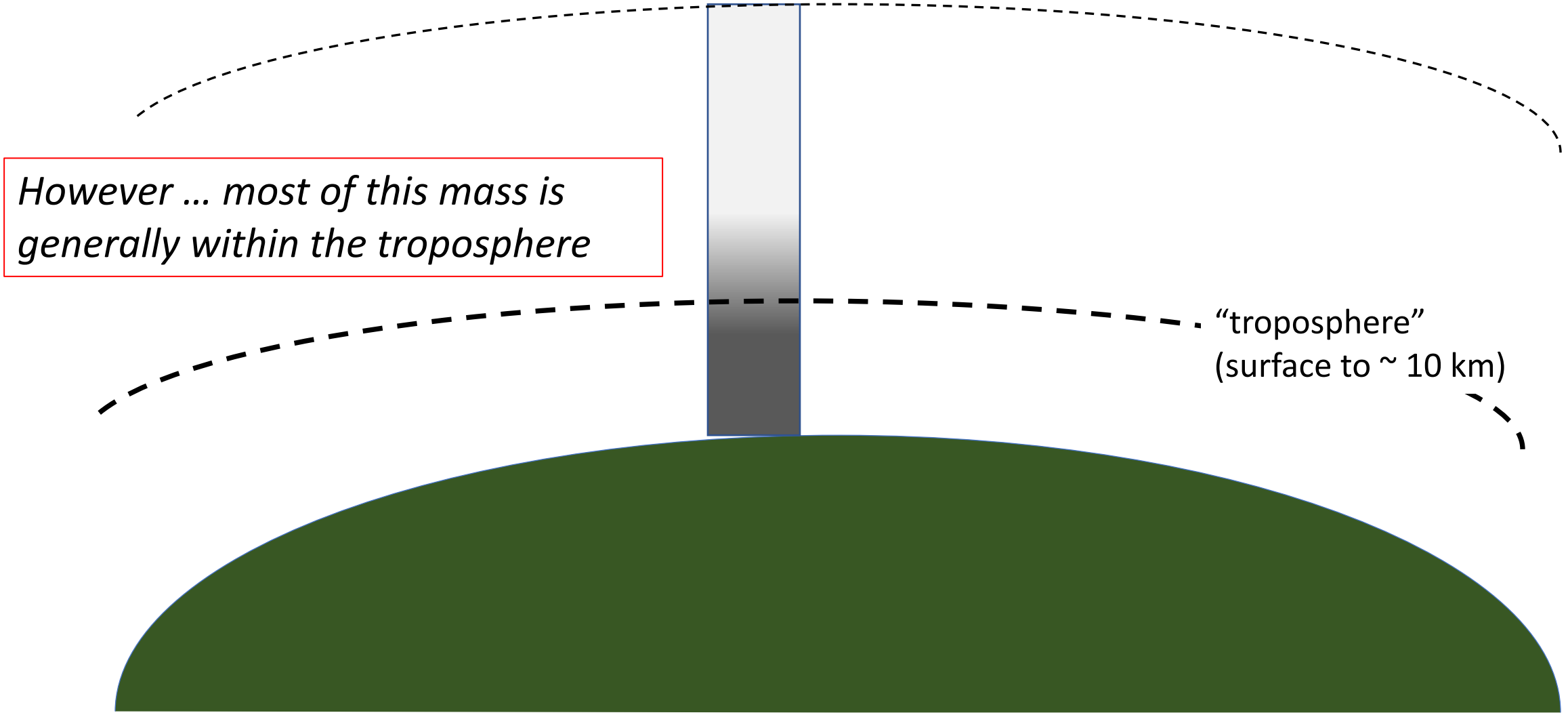
Satellite measures total amount of pollutant within an atmospheric column.

This is generally called "total column abundance".

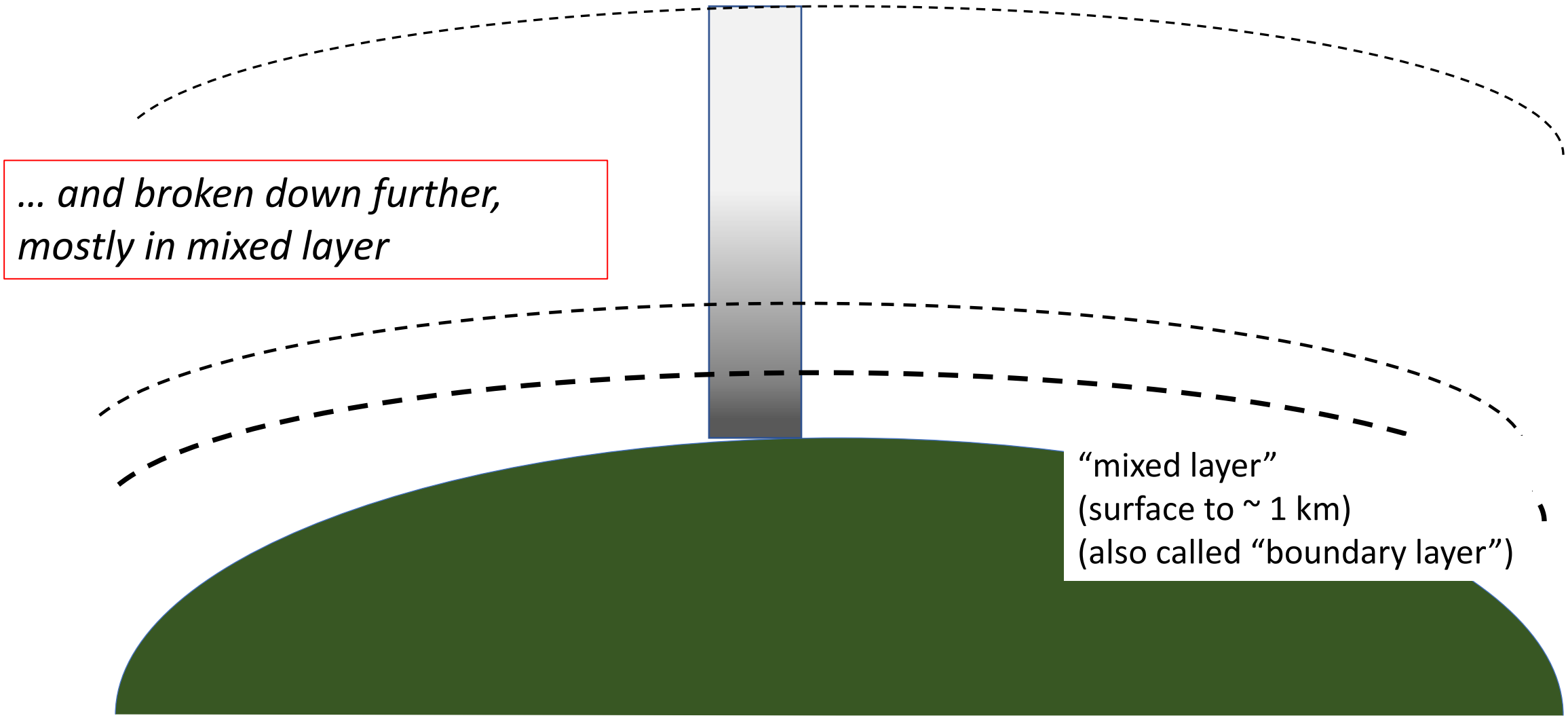
See example … nitrogen dioxide amounts expressed as # of molecules per square centimeter.

Example: Nitrogen Dioxide

Total Column Abundance

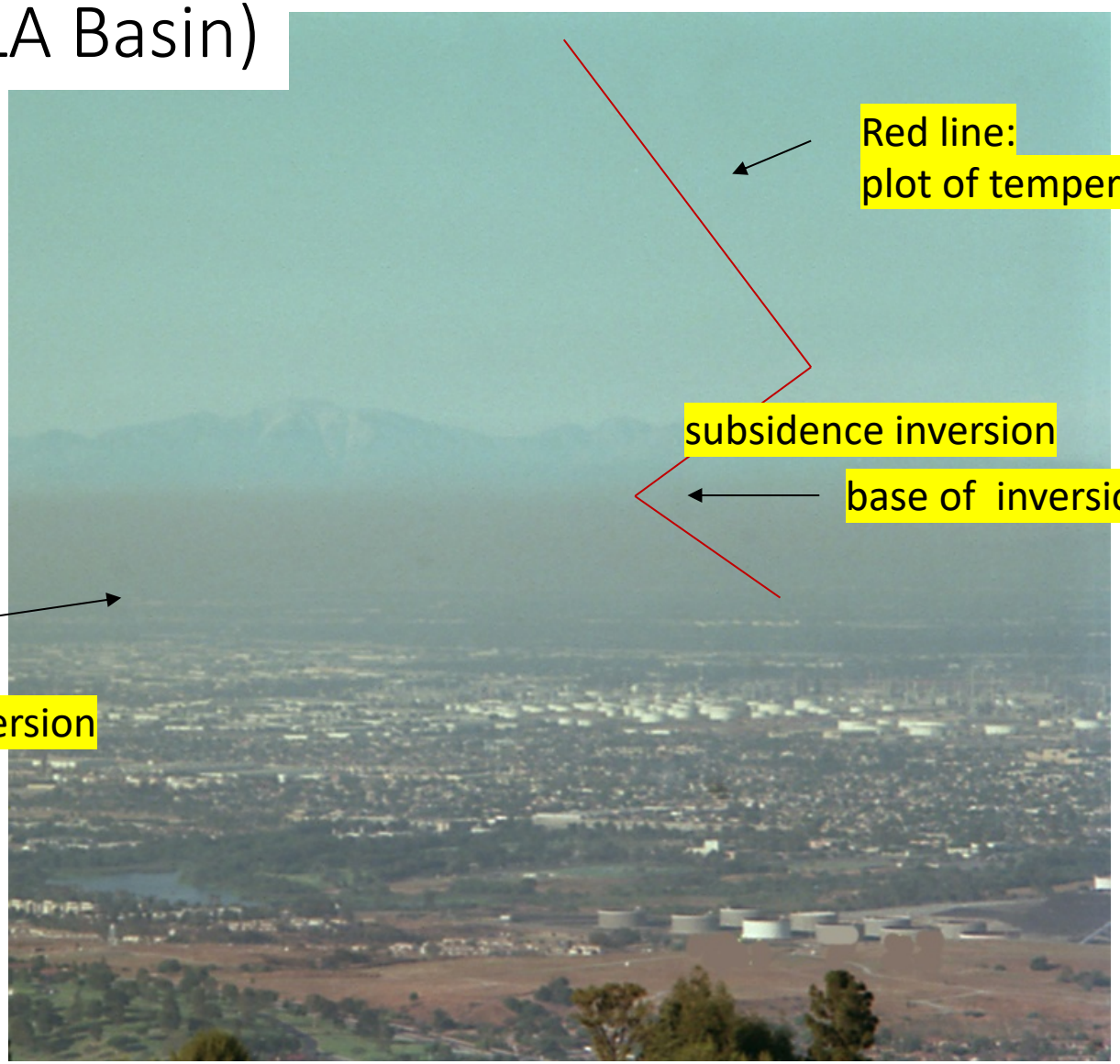


Total Column Abundance



Reminder from Lecture 7

(Photograph looking over LA Basin)



Demonstration

(see part 2 of lecture video)

Websites to be shown …

- https://www.star.nesdis.noaa.gov/jpss/mapper/
- https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/
- https://fire.airnow.gov

Another site with many remotely sensed environmental measurements

- https://worldview.earthdata.nasa.gov/