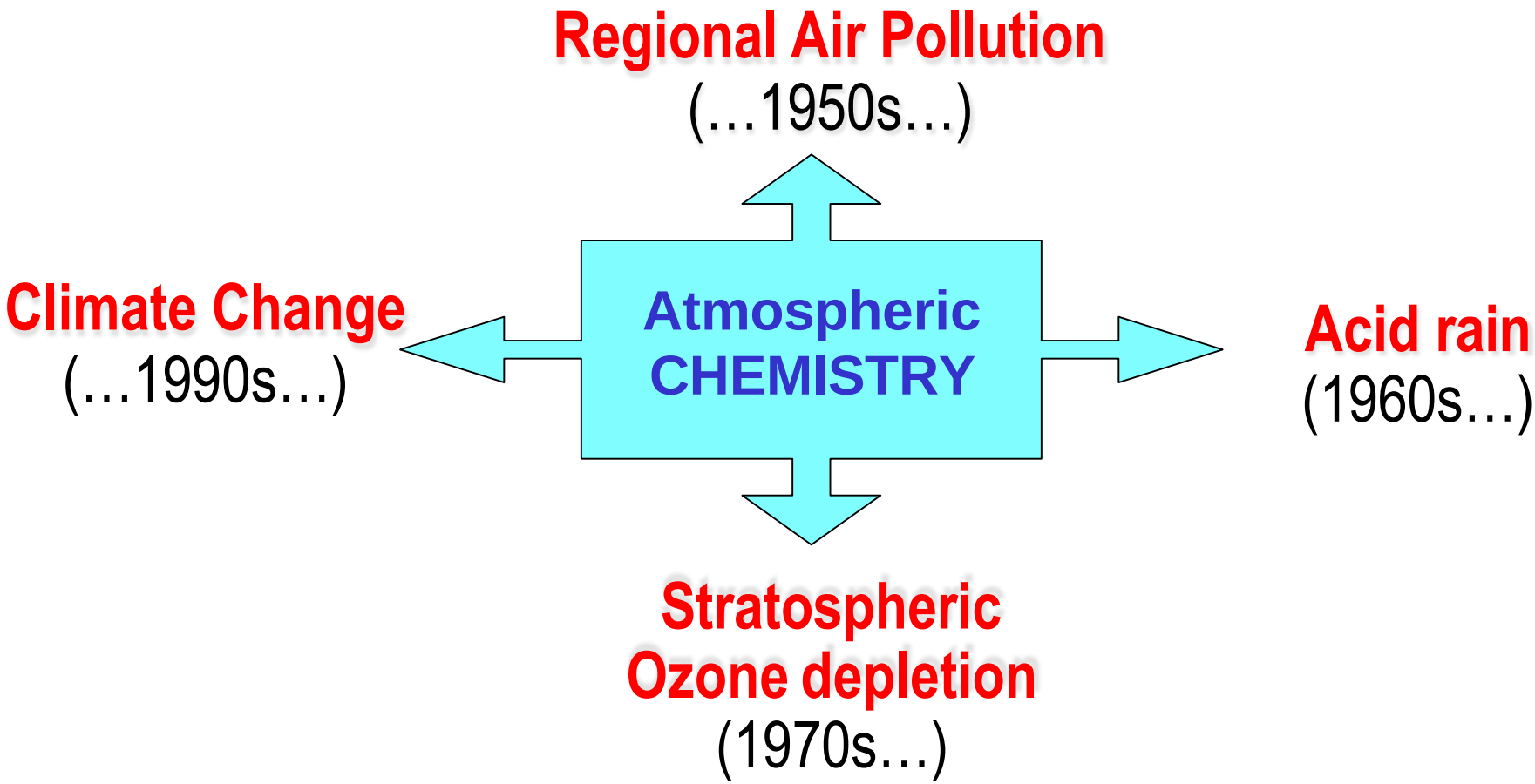
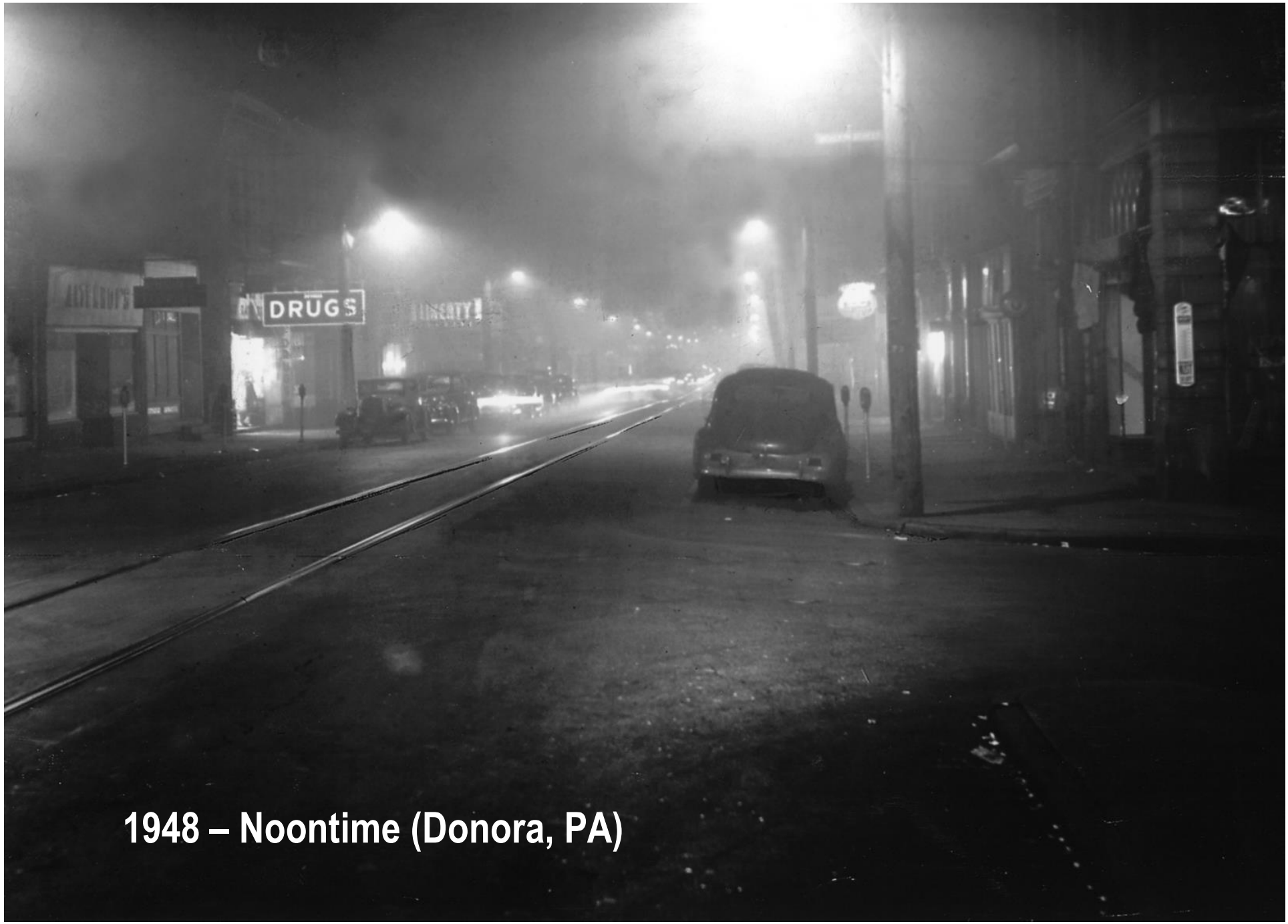
Dr.Nadia Mohammed

# Atmospheric chemistry




➔ **Factors controlling the natural composition of the atmosphere**

➔ **Effects of human activities in changing atmospheric composition**




1948 – Noontime (Donora, PA)

# Urban smog around the world today


New Delhi

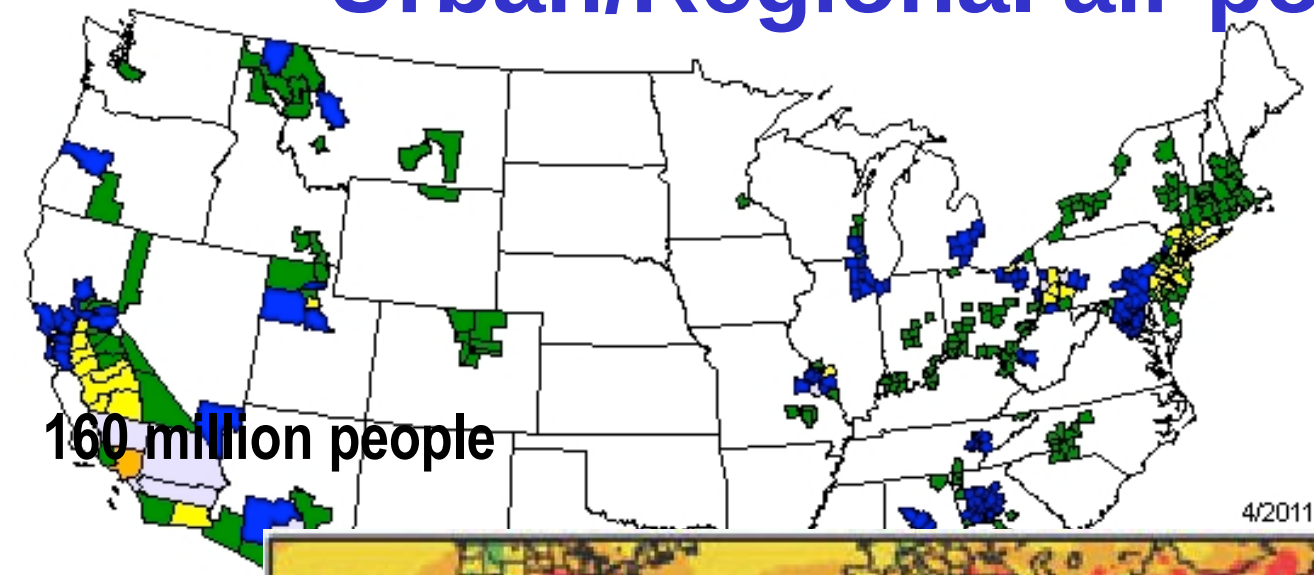
Mexico City

Seoul

Beijing

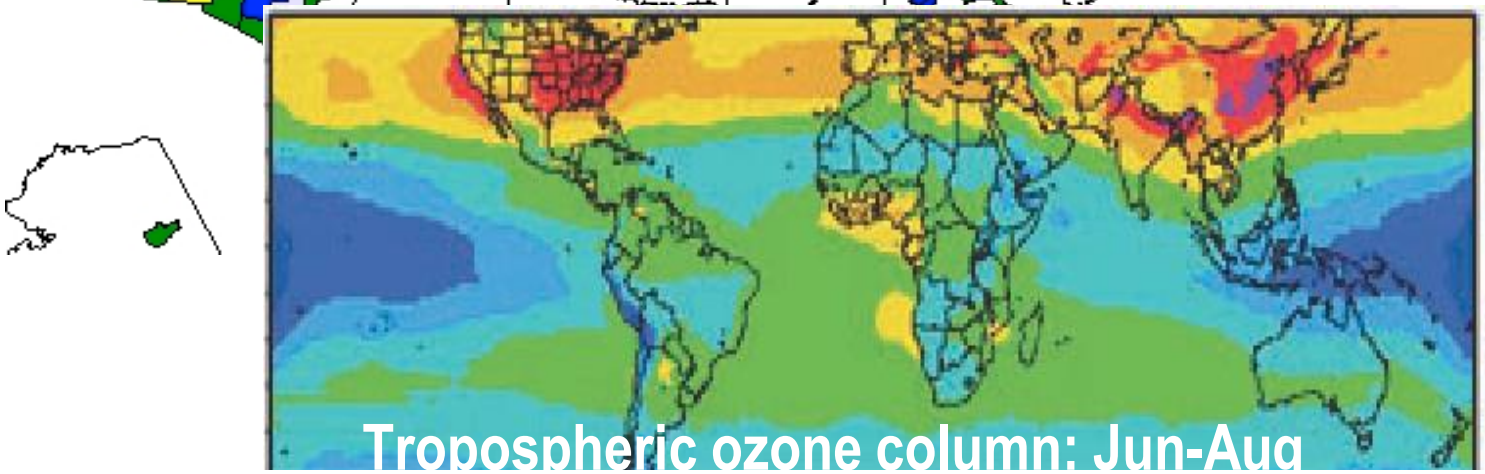
Los Angeles

# Urban/Regional air pollution



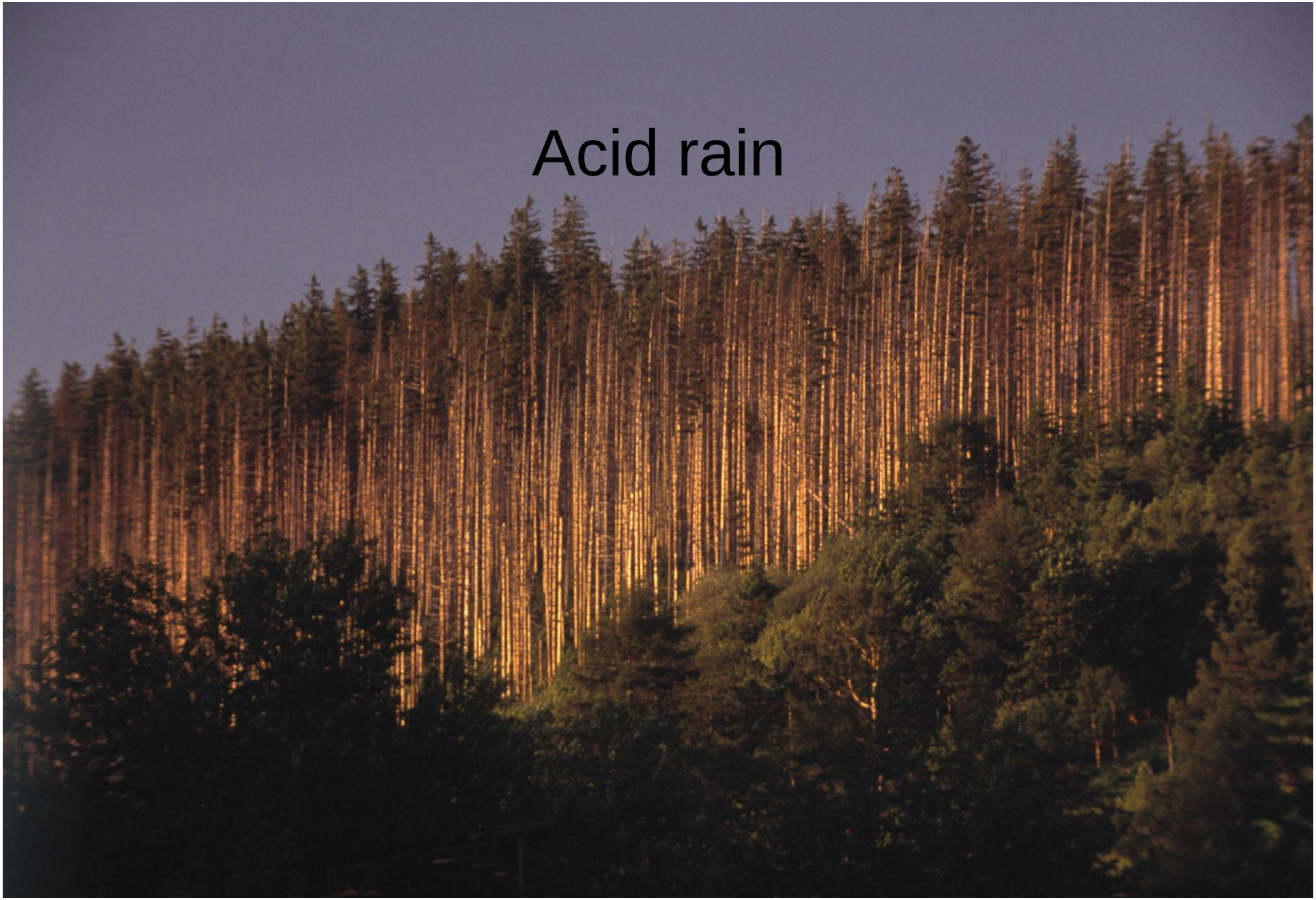
160 million people

4/2011



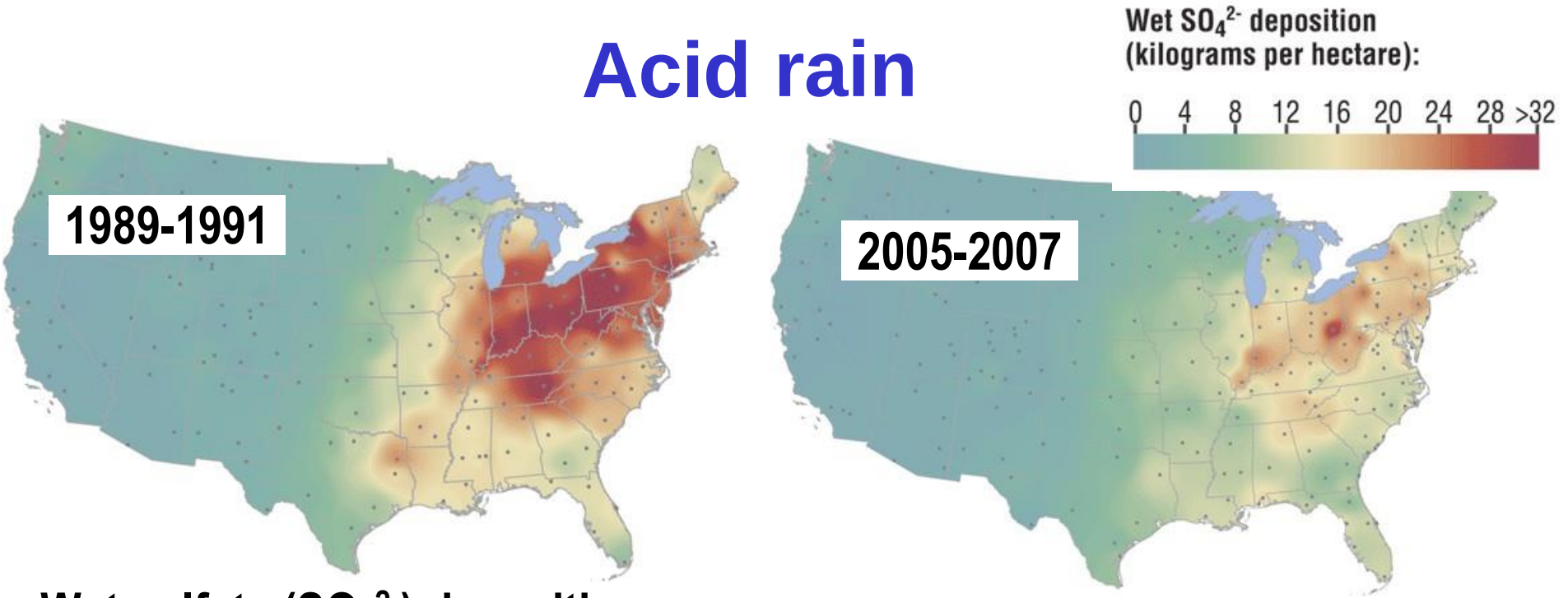
nattainment for 5 NAAQS Pollutants
nattainment for 4 NAAQS Pollutants
nattainment for 3 NAAQS Pollutants
nattainment for 2 NAAQS Pollutants
nattainment for 1 NAAQS Pollutant

Tropospheric ozone column: Jun-Aug




Acidified Forest, Oberwiesenthal, Germany (1991)

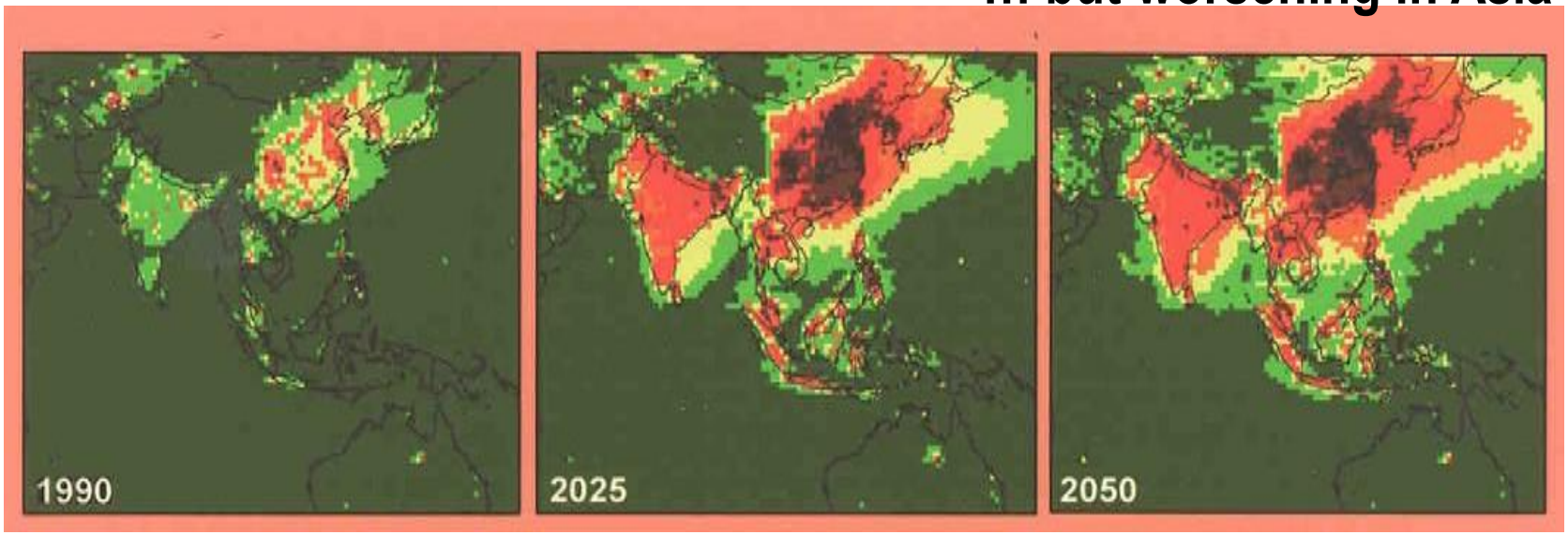
# Acid rain



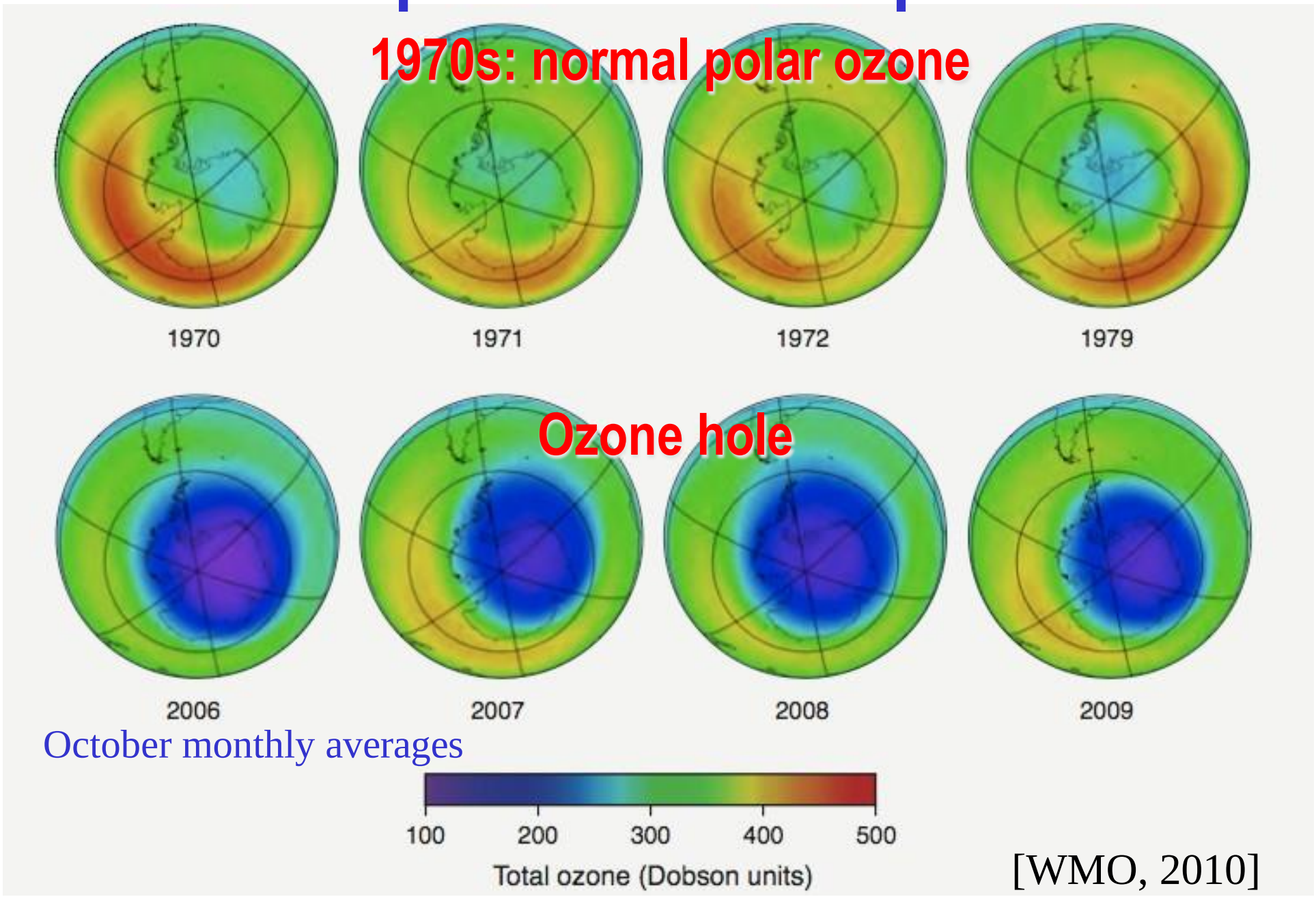

Wet sulfate ($SO_4^{2-}$) deposition

Getting better in the U.S. …

… but worsening in Asia

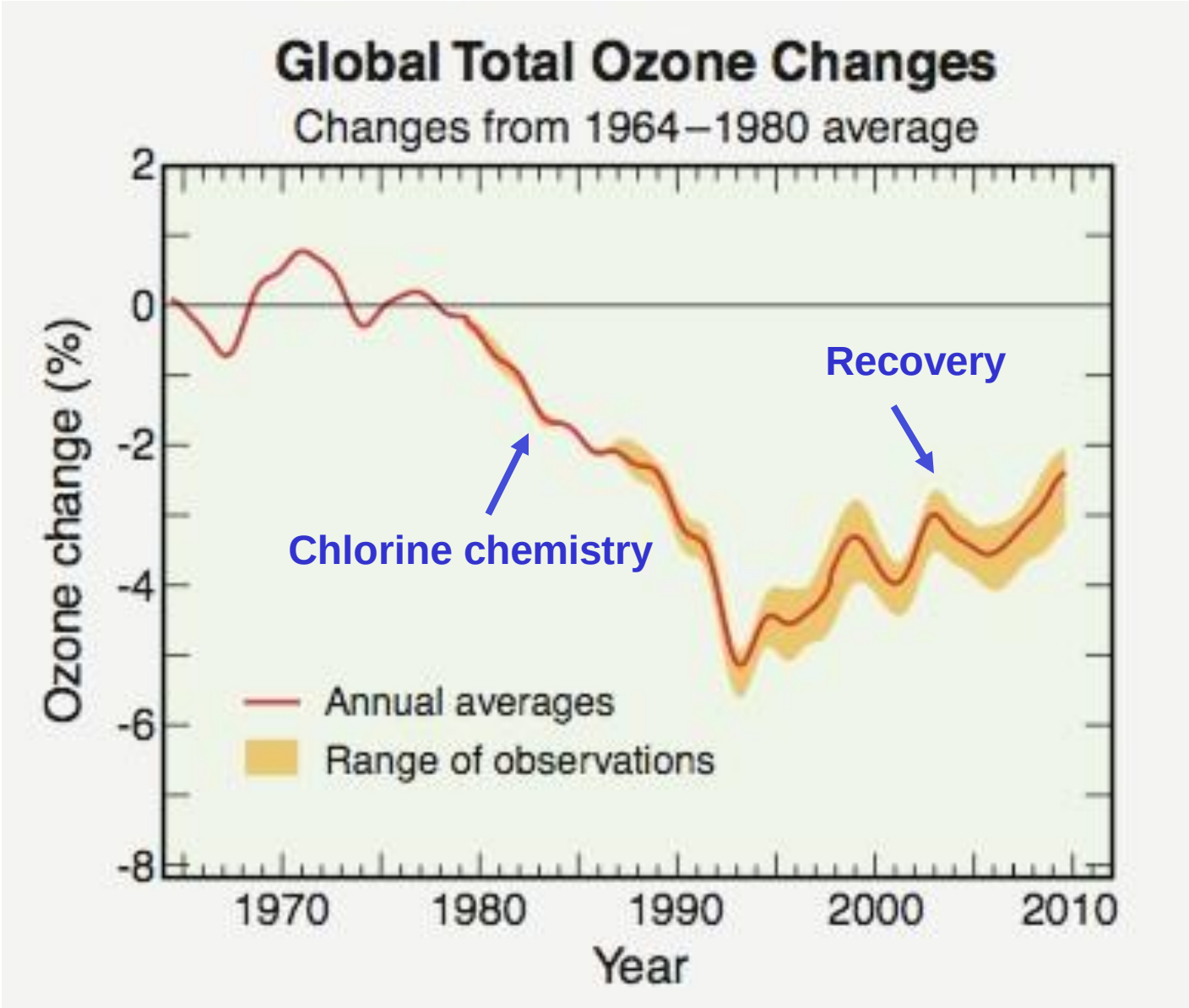


# Stratospheric ozone depletion



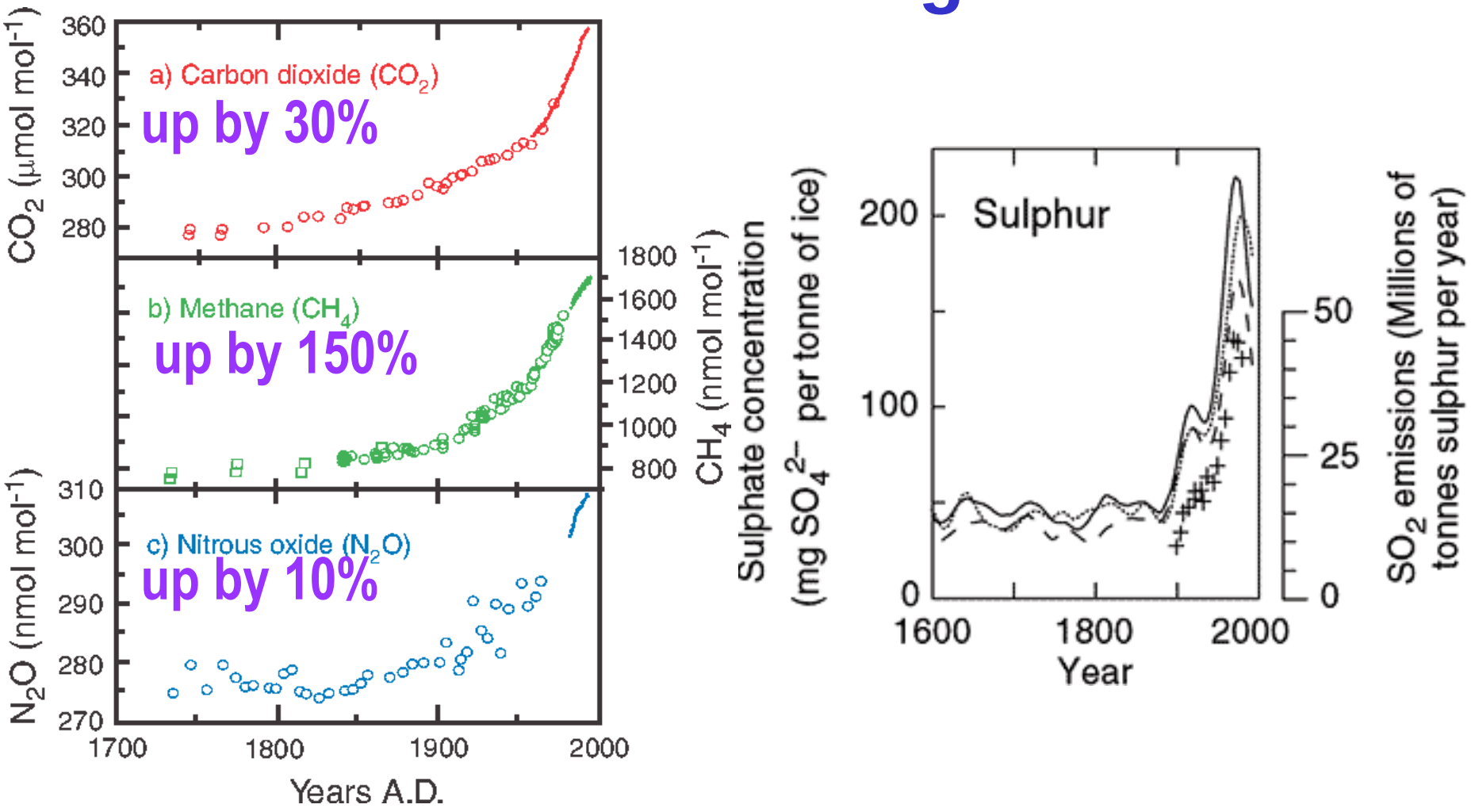

[WMO, 2010]

# Stratospheric ozone depletion




➔ Downward trends in ozone column on a global scale

# Climate change



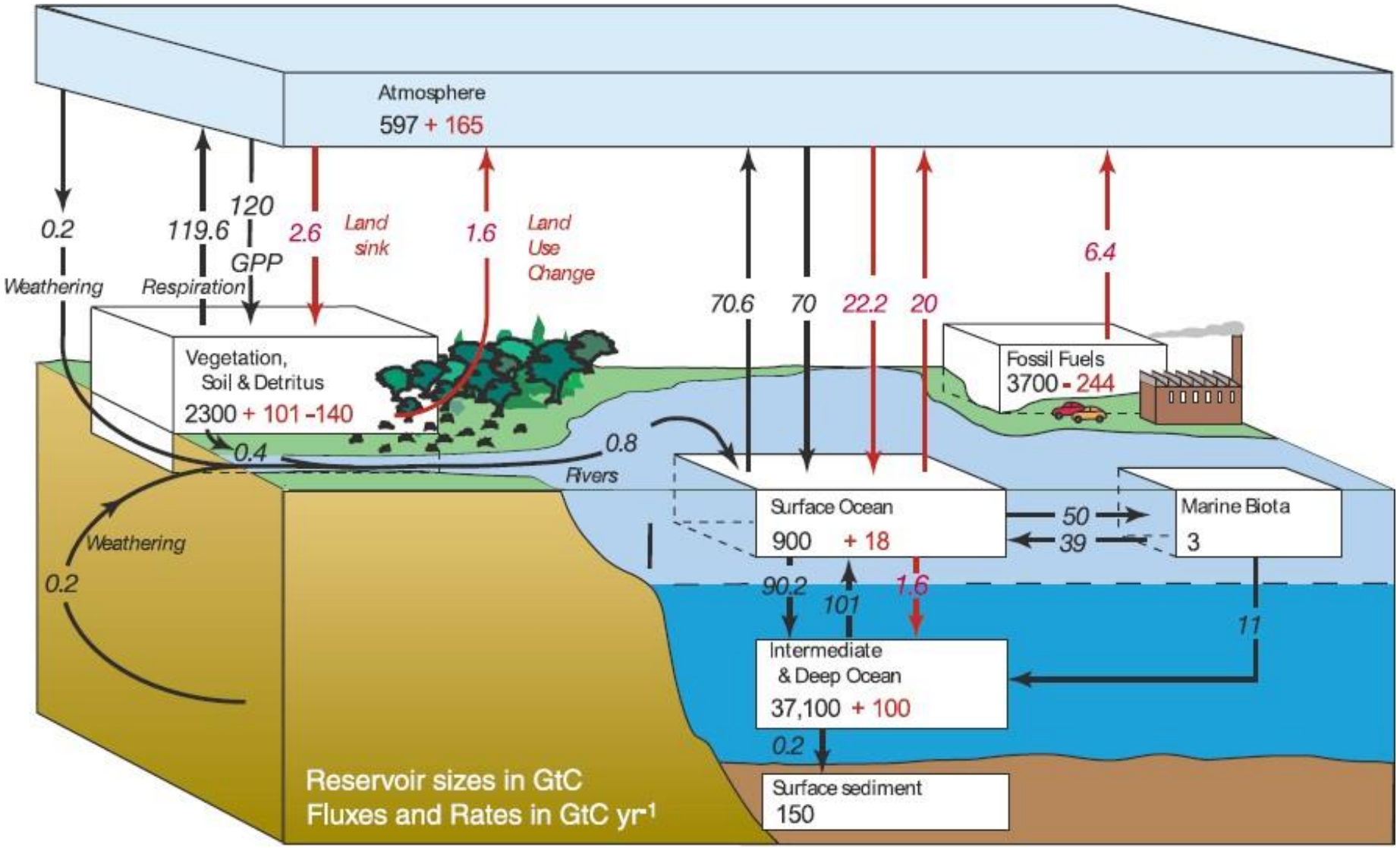

**Large increases in greenhouse gases and aerosols since pre-industrial times**

**bl 5.1**

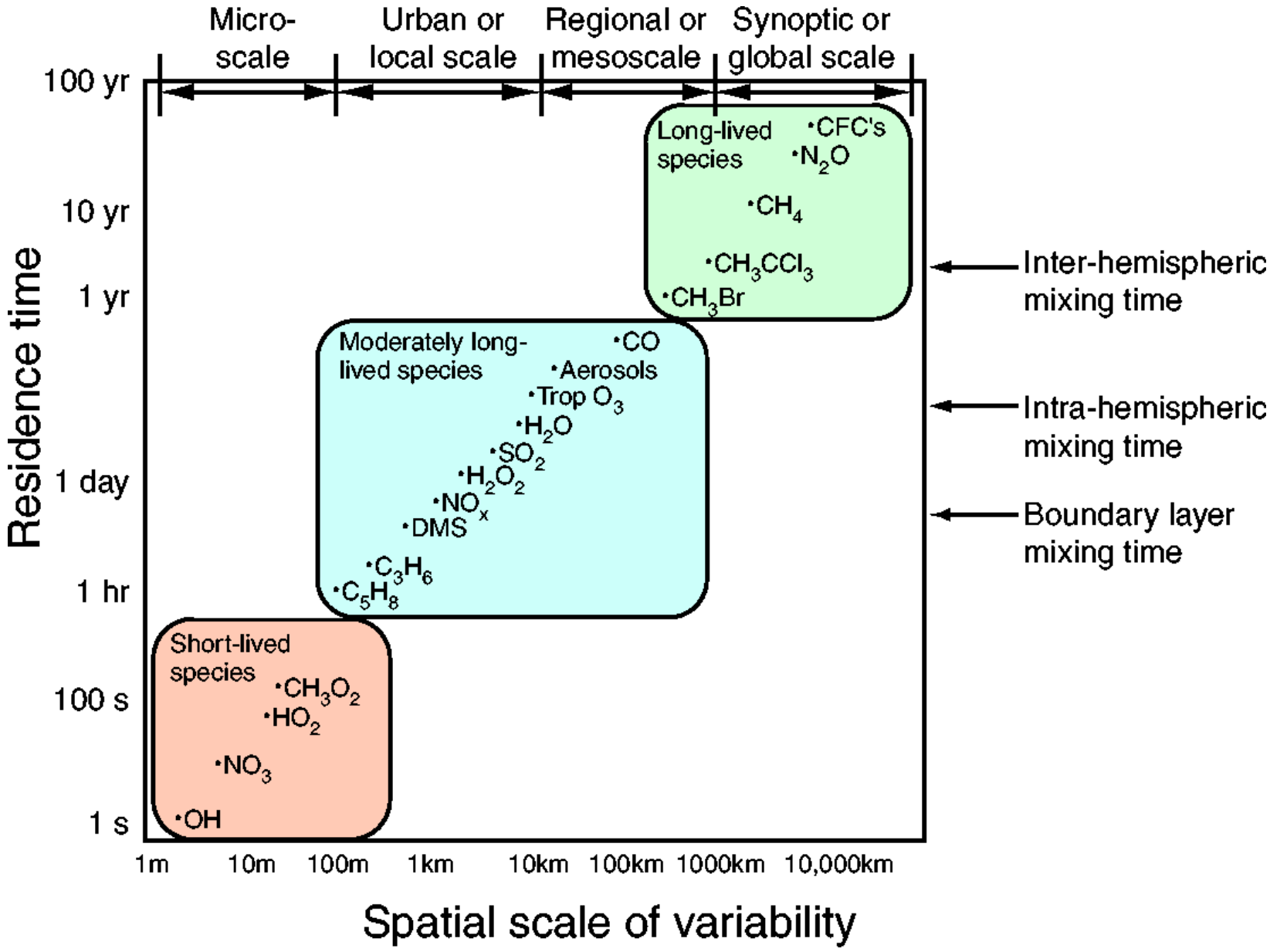
Some gases in dry tropospheric air[a]

| | Chemical formula | Fraction of volume of air occupied by the gas[b] | Residence time (or lifetime)[c] | Major sources |
|---|---|---|---|---|
| Nitrogen | $N_2$ | 78.084% | $1.6\times10^7$ years | Biological |
| Oxygen | $O_2$ | 20.946% | 3,000-4,000 years | Biological |
| Argon | Ar | 0.934% | — | Radiogenic |
| Carbon dioxide | $CO_2$ | 380 ppmv | 3-4 years[d] | Biological, oceanic, combustion (Concentration increasing) |
| Neon | Ne | 18.18 ppmv | | Volcanic (?) |
| Helium | He | 5.24 ppmv | | Radiogenic |
| Methane | $CH_4$ | 1.7 ppmv | 9 years | Biological, anthropogenic |
| Hydrogen | $H_2$ | 0.56 ppmv | ~2 years | Biological, anthropogenic |
| Nitrous oxide | | 0.31 ppmv | 150 years | Biological, anthropogenic |
| Carbon monoxide | | 40-200 ppbv | ~60 days | Photochemical, anthropogenic |
| Ozone | O | 10-500 ppbv | Hours | Photochemical |
| Non-methane hydrocarbons (NMH | | 5-20 ppbv | Variable | Biological, anthropogenic |
| Halocarbons | | 3, ph, | Variable | Mainly anthropogenic |
| Hydrogen peroxide | $H_2O_2$ | o i- • v | 1 day | Photochemical |
| Formaldehyde | HCHO | 0.1-1 ppbv | ~1.5 hours | Photochemical |
| Nitrogen species ($NO + NO_2$ (=$NO_x$) + $NO_3$ + $N_2O_5$ + $HNO_3$ + PAN) | $NO_y$ | 0 pptv-1 ppmv | Variable | Soils, anthropogenic, lightning |
| Ammonia | H | 10 pptv-1 ppbv | i-IDO d | Biological |
| Sulfur dioxide | | 10 pptv-1 ppbv | Dv | Photochemical, ani, anthropogen |
| Dimethyl sulfide (DMS) | $CH_3SCH$ | 10-100 pptv | 0.7 days | Biological |
| Hydrogen sulfide | $H_2S$ | 5-500 pptv | 1-5 days | Biogenic, volcanic |
| Carbon disulfide | $CS_2$ | 1-300 pptv | ~120 hours | Biological, anthropogenic |
| Hydroxyl radical | OH | 0.1-10 pptv | ~1 second | Photochemical |
| Hydroperoxyl radical[e] | $HO_2$ | O. -W pptv | | Photochemical |

# The global carbon cycle for the 1990s



# Residence times and spatial variability

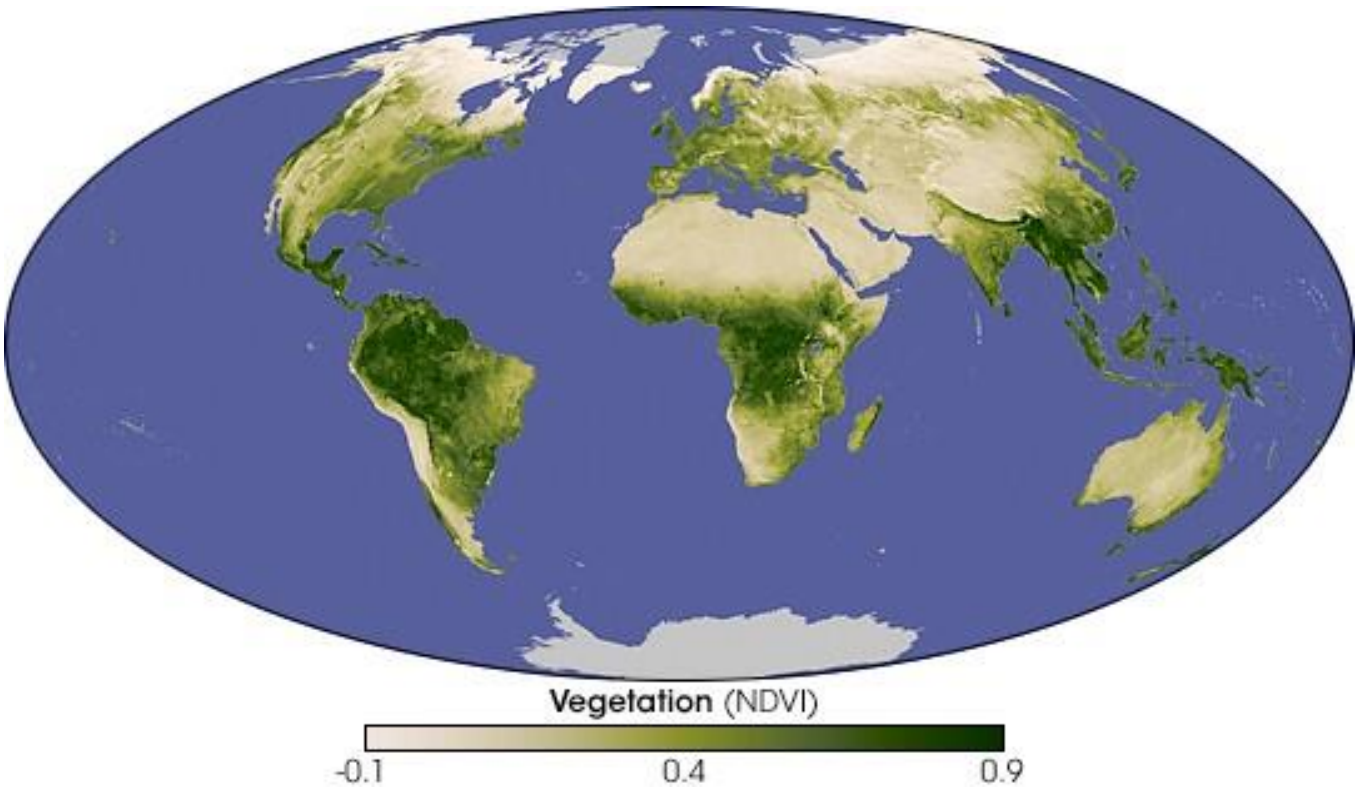


# Sources of gases

- Biological: Land/Ocean
- Solid earth
- Mechanical generation (sea salt and dust)
- Anthropogenic: Fossil fuel, biomass burning, industrial
- Photochemical

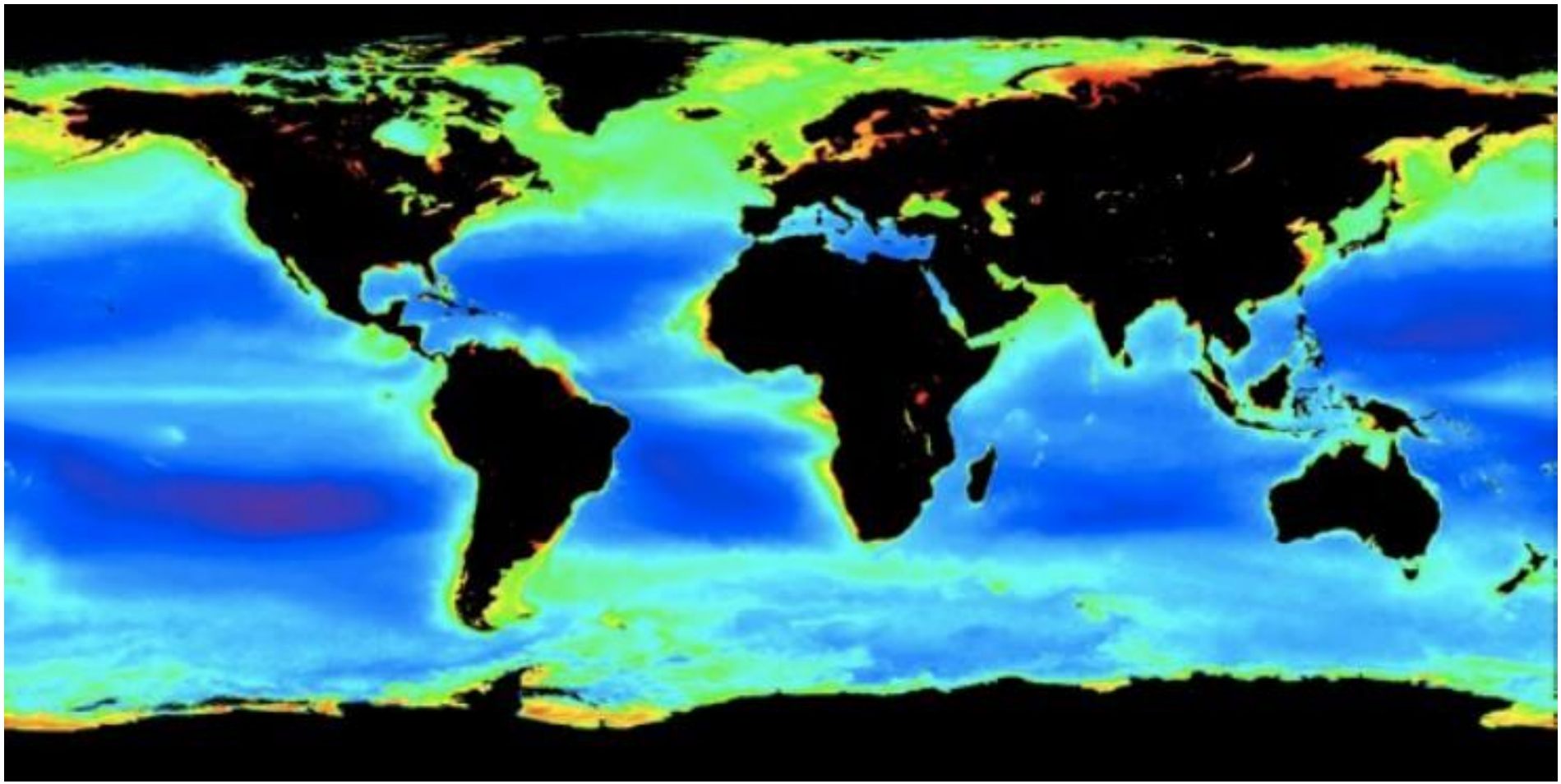
# Biological sources - Land

- [redacted]
- Biological source of $CH_4$: swamps, rice paddies, termites, ruminants
- Biological sources of $N_2O$ and NO: nitrifying and denitrifying bacteria in soils
- Plants: Reactive hydrocarbons (isoprene, terpenes, etc…)



# Biological sources - Oceans

- Oceans: DMS, $H_2S$, COS, $CH_3Cl$, $CH_3I$, hydrocarbons



# Solid earth

Figure 13. Eruption of Mount Pinatubo in the Phillipines in 1991. This type of explosive eruption injects large amounts of material into the stratosphere to altitudes of greater than 30 km.

- Volcanoes: $SO_2$, $H_2S$, COS, particles, $H_2O$, $CO_2$, HCl…

- Rocks (radiogenic): He (decay of uranium and thorium), Argon (decay potassium-40), radon (decay of uranium-238 )

- Weathering of $CaCO_3$ rocks

# Dust and sea salt = generation by the action of wind

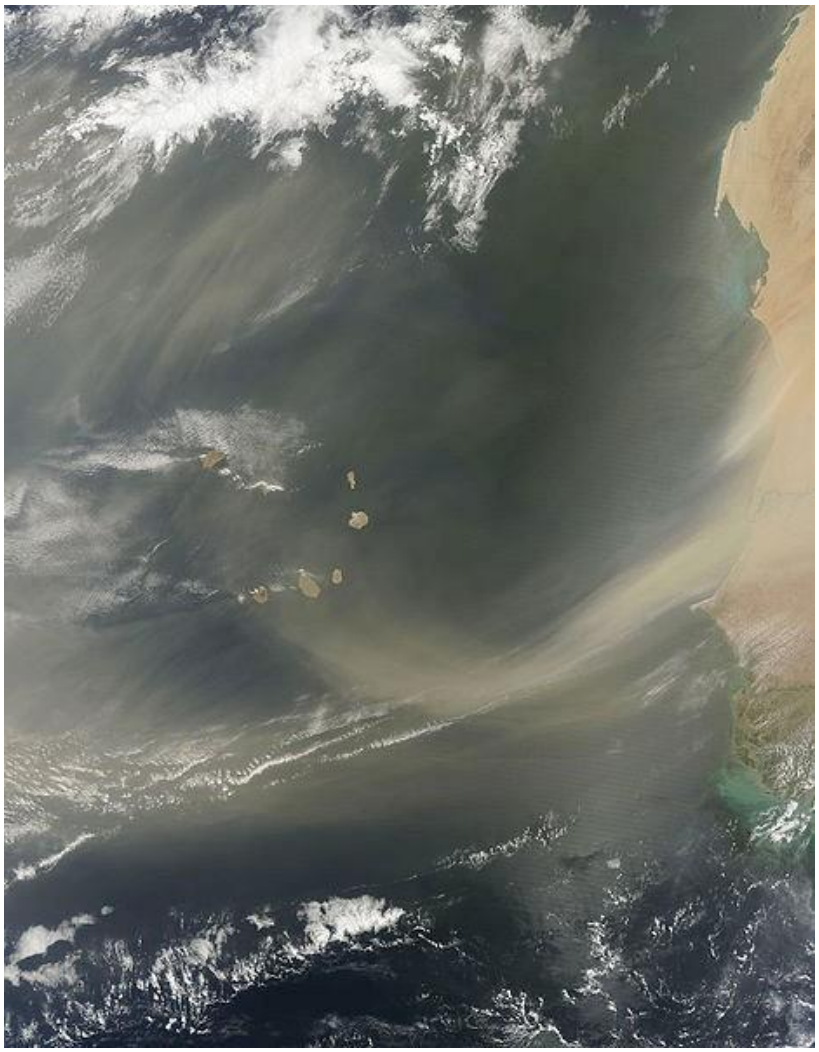
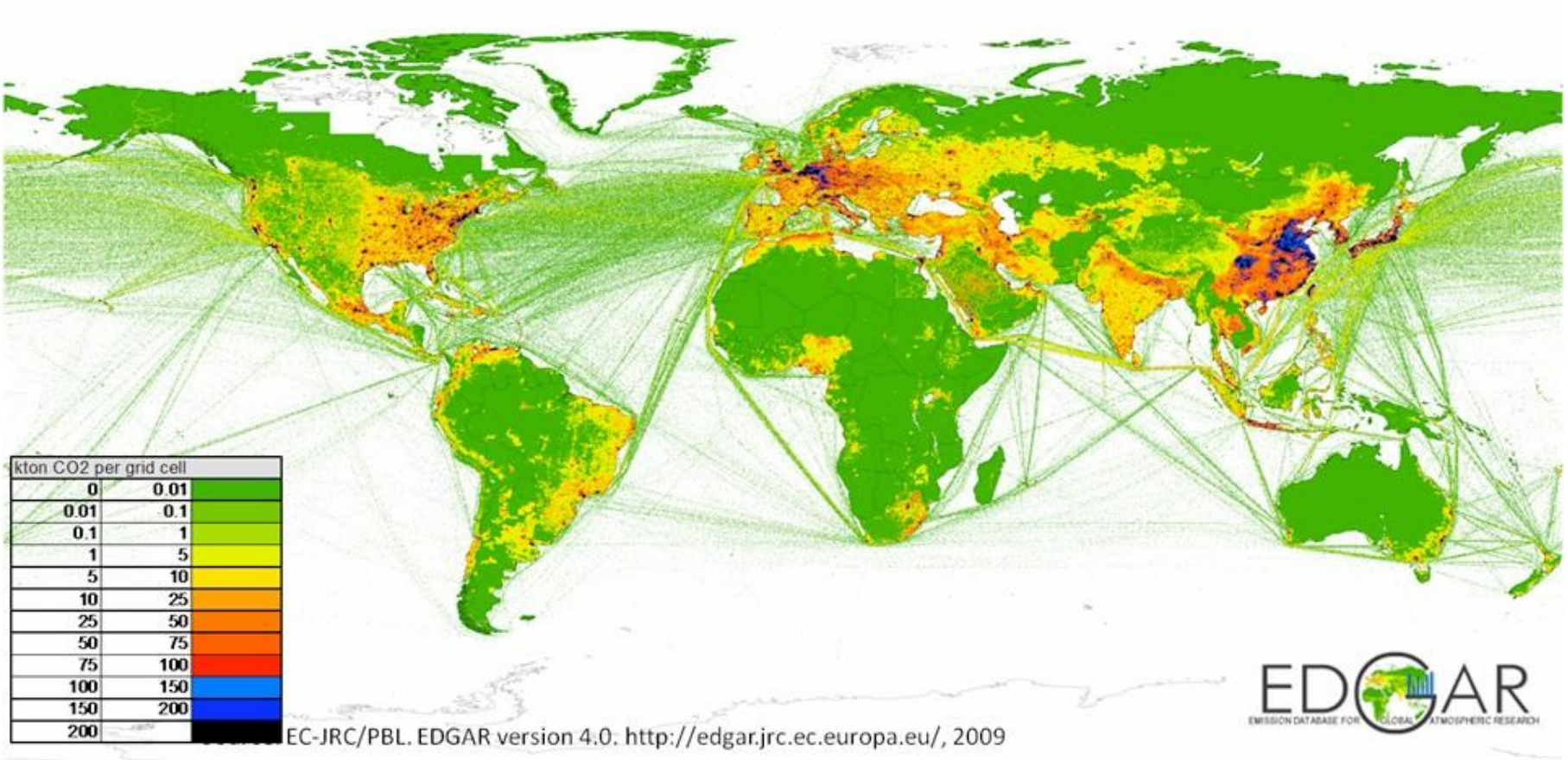
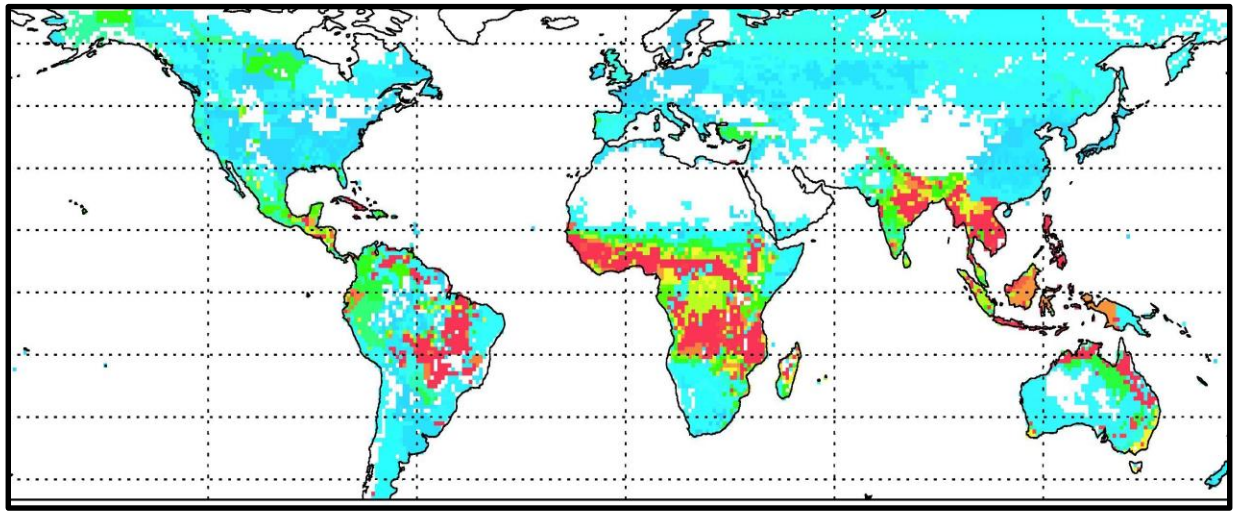



Figure 1. Air entrainment in sea water and aerosol injection into the atmosphere.

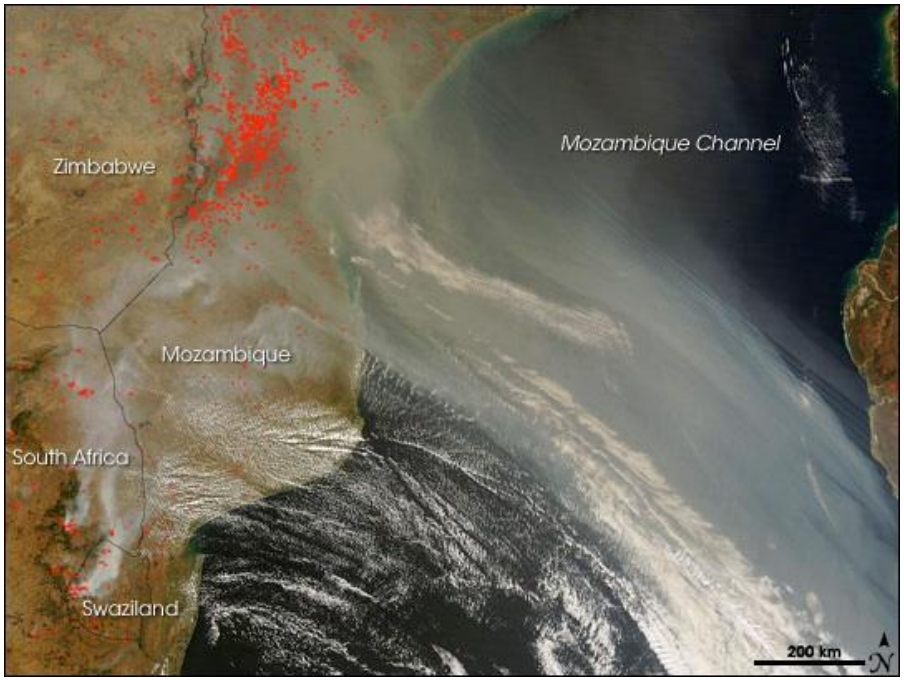
**Fossil fuel emissions** (concentrated in the northern hemisphere)

# Biomass burning

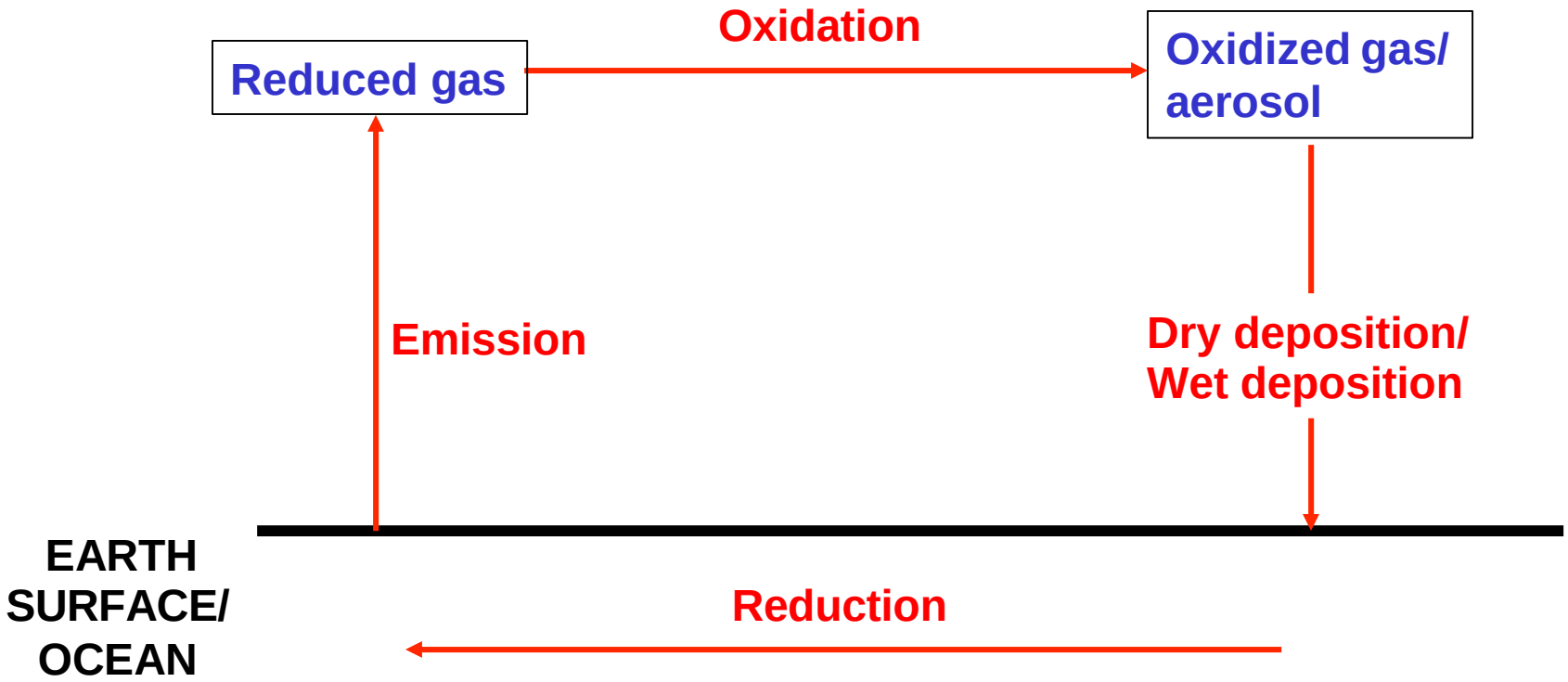


**Biomass burning emissions** (concentrated in the tropics)
Agricultural and natural (lightning)



# Photochemical sources/sinks

- Gases produced photochemically in the atmosphere: $O_3$, OH, $HO_2$, HCHO, $H_2O_2$, $CH_3OOH$, $NO_2$, $NO_3$, $HNO_3$, CO, $SO_2$, etc…
- Sinks: atmospheric oxidation followed by dry or wet deposition



# Some important Trace gases

- Hydroxyl radical (OH)
- Reactive nitrogen species and the nitrogen cycle
- Hydrocarbons, Carbon monoxide
- Ozone