

# Ozone ( $O_3$ ) in the Atmosphere

The good, the bad, the mesospheric?

# In the Troposphere (“Bad Ozone”)

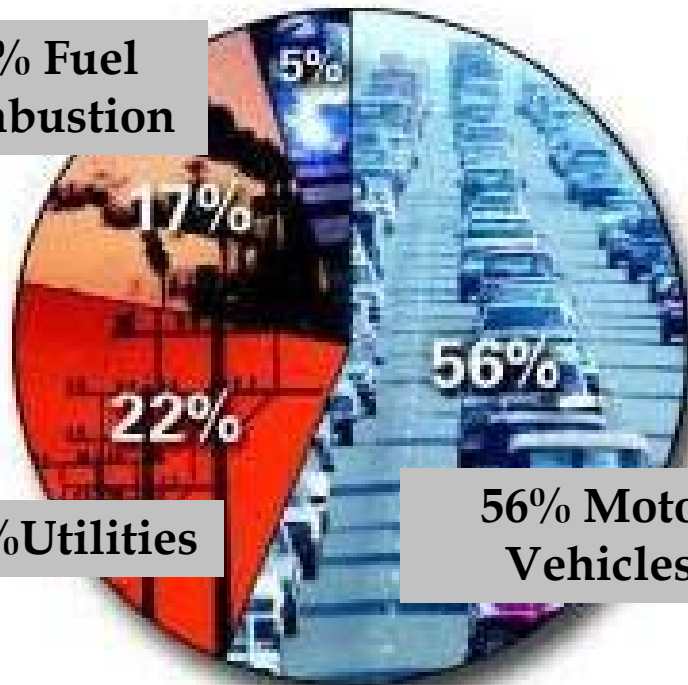
- Harmful pollutant
- Created in a reaction between nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs) and sunlight
- Highest concentrations in warm summer weather
- Created in urban areas, blown hundreds of miles by the wind

# Sources of NOx and VOCs?

## Human Pollution!

5% Other

17% Fuel  
Combustion



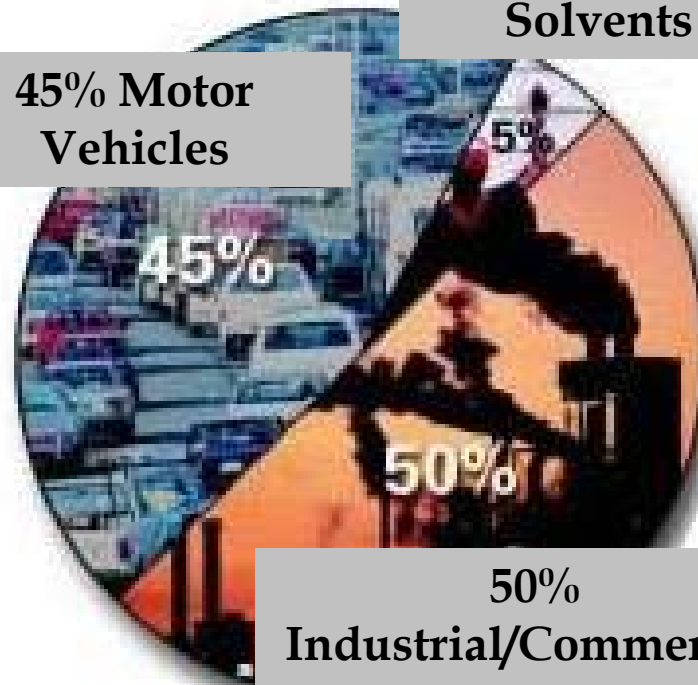
56% Motor  
Vehicles

22% Utilities

Sources of NOx

5% Consumer  
Solvents

45% Motor  
Vehicles



50%  
Industrial/Commercial  
Processes

Sources of VOCs

# Why should we care?

- Breathing ozone can reduce lung function and create scar tissue in the lungs
- Ozone damages vegetation
  - Harms ecosystems
  - Reduces agricultural yields



*Image Source: [www.arcweb.archives.gov](http://www.arcweb.archives.gov)*

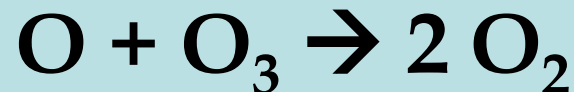
# In the Stratosphere ("Good Ozone")

- ~99% of ozone is found here
- Ozone layer is produced naturally



(M is inert, usually O<sub>2</sub> or N<sub>2</sub>)

- Also destroyed naturally



# **In the Stratosphere ("Good Ozone")**

- **Through these reactions, Ozone absorbs harmful radiation from sun (UVC and some UVB rays)**
  - **This protects plants and crops from damage, protects UV-sensitive marine life, and protects humans from skin cancer**
  - **Also warms the stratosphere**

# What about the ozone hole?

- **In the Stratosphere**
- **Human use of aerosol sprays and air conditioners has changed chemistry of the atmosphere**
  - **Chlorofluorocarbons (CFCs) contain chlorine (Cl) and bromine (Br)**

# Cl destroys O<sub>3</sub> in Stratosphere



Chlorine is now free to react with O<sub>3</sub>





**Cl is a “serial killer”**



**Ozone is destroyed, but Cl is unchanged**

**It lives to kill again!**

# Why is the hole over Antarctica?

- Very cold winters and surrounding oceans combine to create “polar vortex” of extremely cold air
- Polar Stratospheric Clouds form
- Droplets in clouds provide sites for chemical reactions that set the stage for ozone destruction when the sun comes out in the spring

# Is the O<sub>3</sub> hole still a problem?

- Global community agreed to phase out O<sub>3</sub> depleting chemicals in 1987 (Montreal Protocol)
- CFCs are long-lived in atmosphere; O<sub>3</sub> layer not expected to recover before 2050

# Ozone in the Mesosphere

- ~1% of atmospheric ozone is found here
- Ozone is created each night and then destroyed each day
- Seasonal variations?
- Protects Stratospheric ozone layer?

# Ozone in the Mesosphere

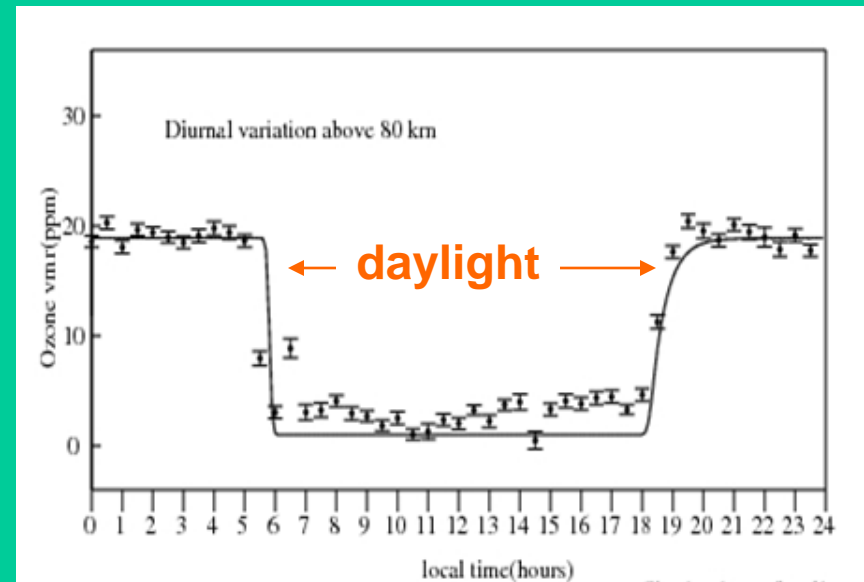
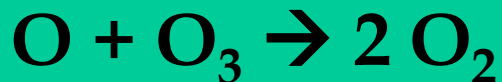
## Diurnal Variations

- $O_3$  is created at night



(M is inert, usually  $O_2$  or  $N_2$ )

- And destroyed during the day



MOSAIC data

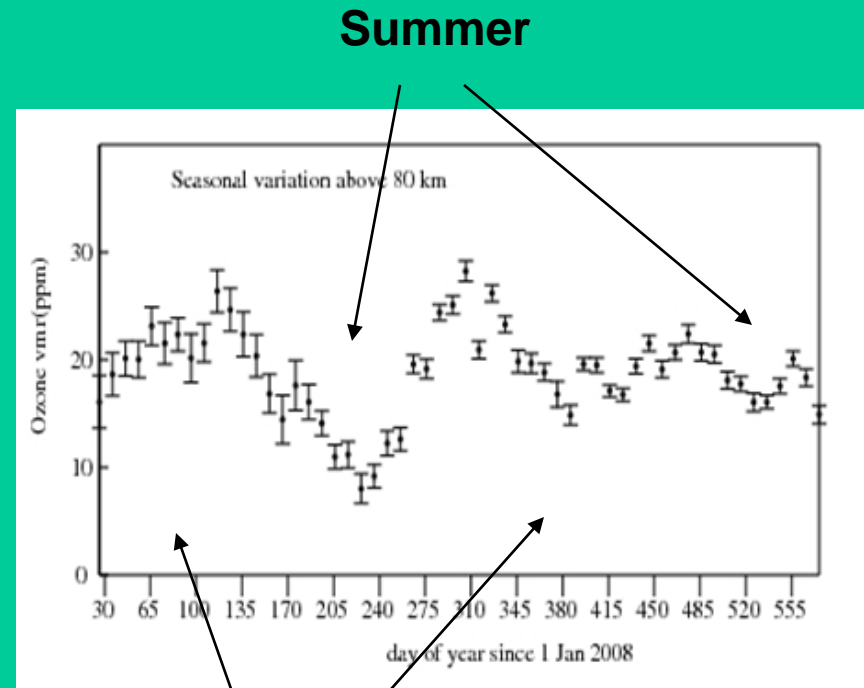
# Ozone in the Mesosphere

## Seasonal Variations

- Water vapor and sunlight destroy  $O_3$   
 $H_2O + \text{UV radiation} \rightarrow H + OH$



- More water vapor in mesosphere during winter and summer?



MOSAIC data

Winter

# No Ozone in the Thermosphere

- O atoms are too far apart to combine into O<sub>3</sub> molecules