

# Unit 11: Climate Change

## Lecture 2

### Objectives:

E5.4A - Explain the natural mechanism of the greenhouse effect including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).

E5.4g - Compare and contrast the heat trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat trapping capacity.

# The Greenhouse Effect

- The greenhouse effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane, for example) trap energy from the sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 60°F colder. Because of how they warm our world, these gases are referred to as greenhouse gases.

# Greenhouse Gas Concentrations

Current greenhouse gas concentrations<sup>[6]</sup>

Gas	Pre-1750 tropospheric concentration <sup>[48]</sup>	Recent tropospheric concentration <sup>[49]</sup>	Absolute increase since 1750	Percentage increase since 1750	Increased radiative forcing (W/m <sup>2</sup> ) <sup>[50]</sup>
Carbon dioxide (CO <sub>2</sub> )	280 ppm <sup>[51]</sup>	395.4 ppm <sup>[52]</sup>	115.4 ppm	41.2%	1.88
Methane (CH <sub>4</sub> )	700 ppb <sup>[53]</sup>	1893 ppb / <sup>[54]</sup> 1762 ppb <sup>[54]</sup>	1193 ppb / 1062 ppb	170.4% / 151.7%	0.49
Nitrous oxide (N <sub>2</sub> O)	270 ppb <sup>[50][55]</sup>	326 ppb / <sup>[54]</sup> 324 ppb <sup>[54]</sup>	56 ppb / 54 ppb	20.7% / 20.0%	0.17
Tropospheric ozone (O <sub>3</sub> )	237 ppb <sup>[48]</sup>	337 ppb <sup>[48]</sup>	100 ppb	42%	0.4 <sup>[56]</sup>

# Greenhouse Gas Concentrations

Compound	Formula	Concentration in atmosphere <sup>[24]</sup> (ppm)	Contribution (%)
Water vapor and clouds	H <sub>2</sub> O	10–50,000 <sup>(A)</sup>	36–72%
Carbon dioxide	CO <sub>2</sub>	~400	9–26%
Methane	CH <sub>4</sub>	~1.8	4–9%
Ozone	O <sub>3</sub>	2–8 <sup>(B)</sup>	3–7%

**notes:**

(A) Water vapor strongly varies locally<sup>[25]</sup>

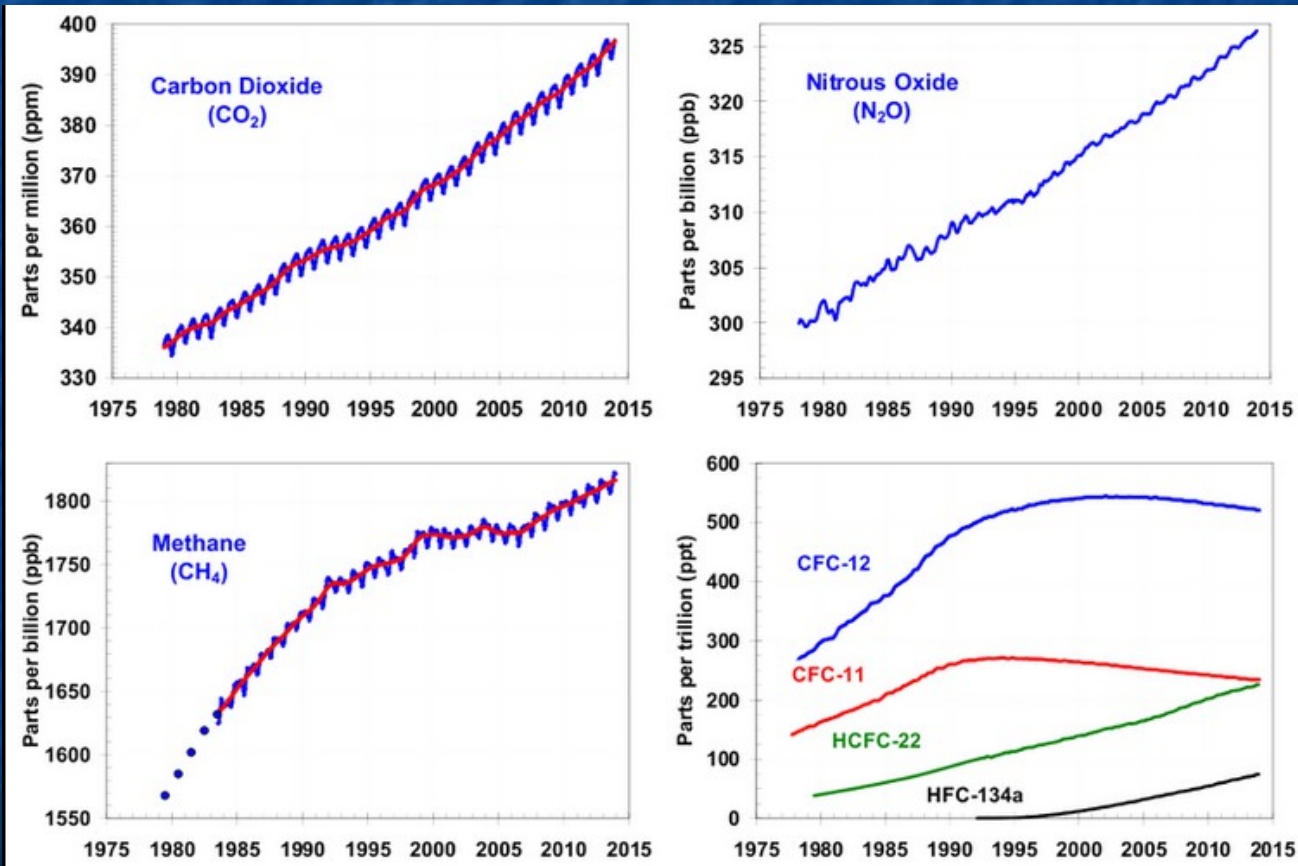
(B) The concentration in stratosphere. About 90% of the ozone in Earth's atmosphere is contained in the stratosphere.

# Global Warming Potential

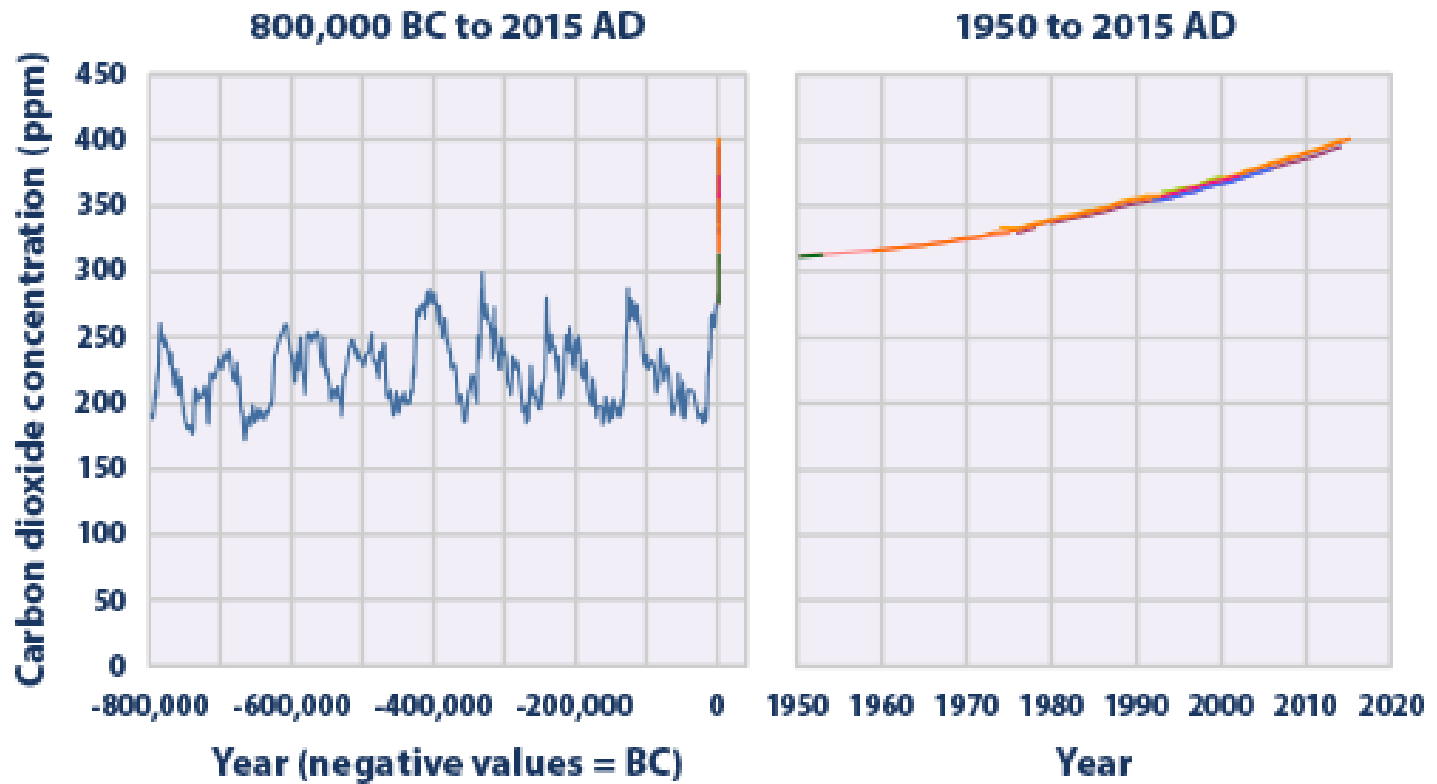
Atmospheric lifetime and **GWP** relative to CO<sub>2</sub> at different time horizon for various greenhouse gases.

Gas name	Chemical formula	Lifetime (years)	Global warming potential (GWP) for given time horizon		
			20-yr	100-yr	500-yr
Carbon dioxide	CO <sub>2</sub>	30–95	1	1	1
Methane	CH <sub>4</sub>	12	72	25	7.6
Nitrous oxide	N <sub>2</sub> O	114	289	298	153
CFC-12	CCl <sub>2</sub> F <sub>2</sub>	100	11 000	10 900	5 200
HCFC-22	CHClF <sub>2</sub>	12	5 160	1 810	549
Tetrafluoromethane	CF <sub>4</sub>	50 000	5 210	7 390	11 200
Hexafluoroethane	C <sub>2</sub> F <sub>6</sub>	10 000	8 630	12 200	18 200
Sulfur hexafluoride	SF <sub>6</sub>	3 200	16 300	22 800	32 600
Nitrogen trifluoride	NF <sub>3</sub>	740	12 300	17 200	20 700

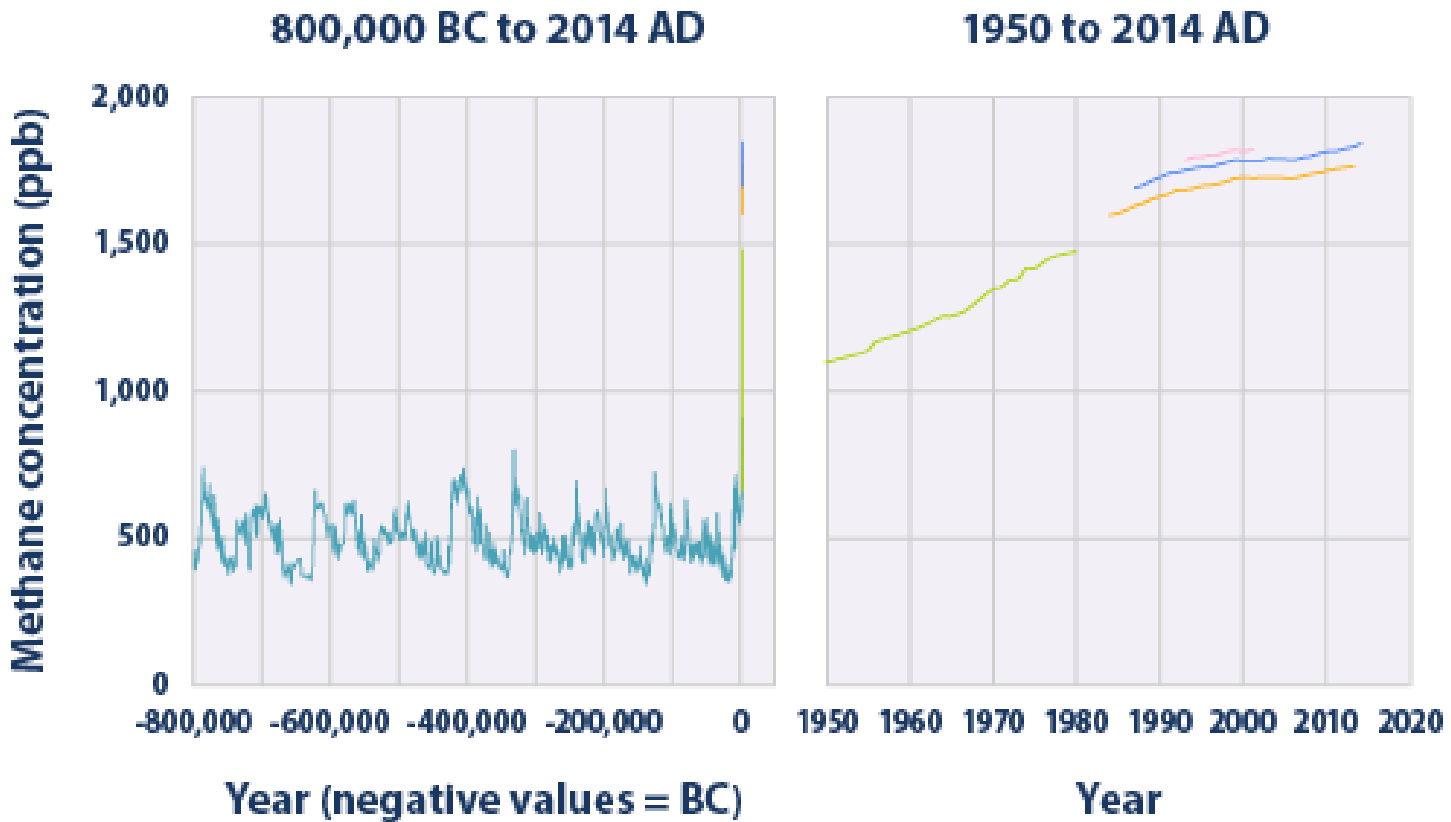
# Greenhouse Gas Trends



# CO2 Concentrations



# Methane Concentrations

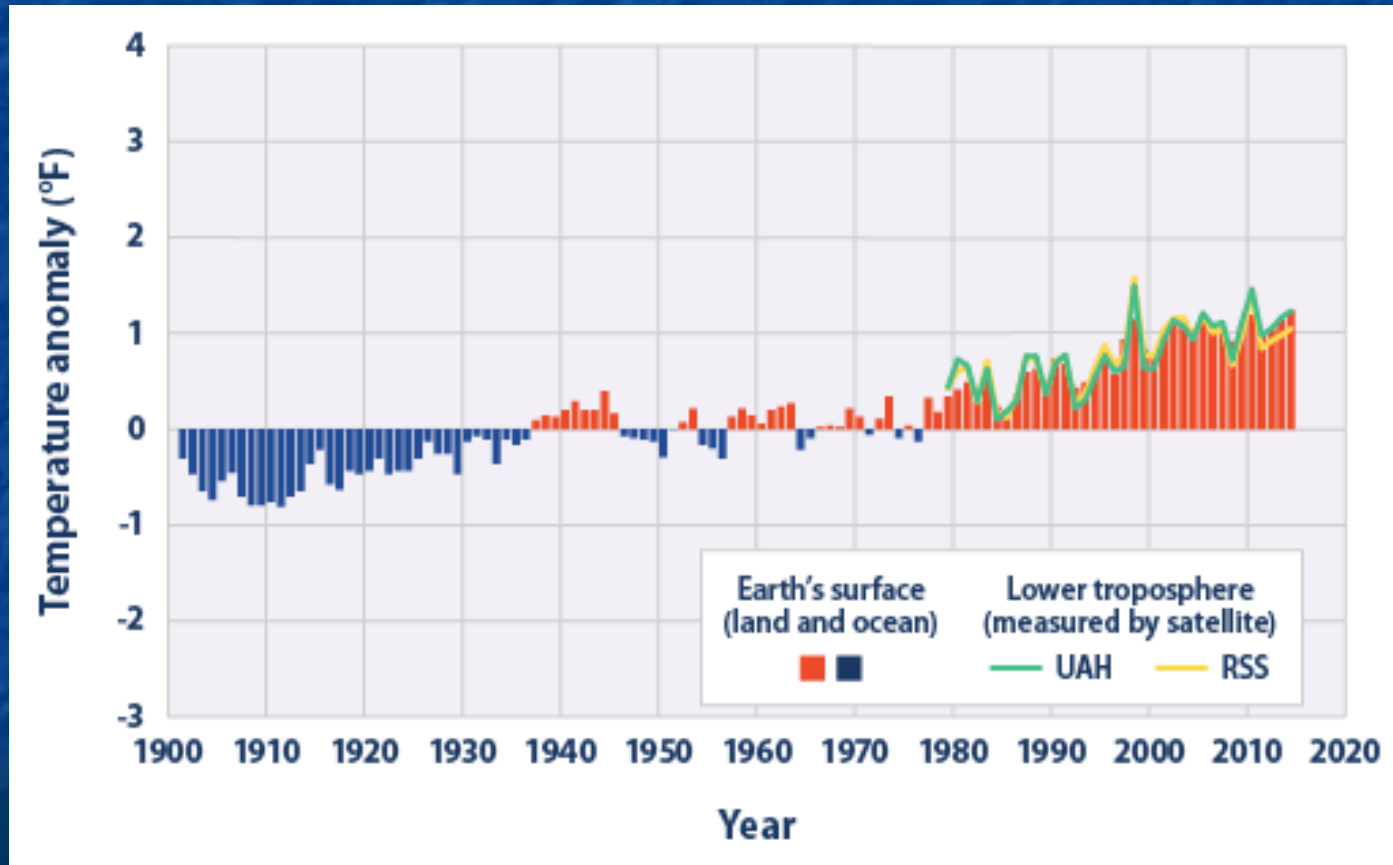




# Heat Trapping Capacity

- Methane has 20 times carbon dioxide's heat trapping capacity per molecule.
- CFC molecule has about 20,000 times the heat-trapping power of a CO<sub>2</sub> molecule.
- Halocarbons – coolants (up to 11 000 x as heat trapping as CO<sub>2</sub>) AC and older appliances
- Nitrous oxides – fertilizers from agriculture (310 x as heating trapping as CO<sub>2</sub>)

# Outcomes



# In the News

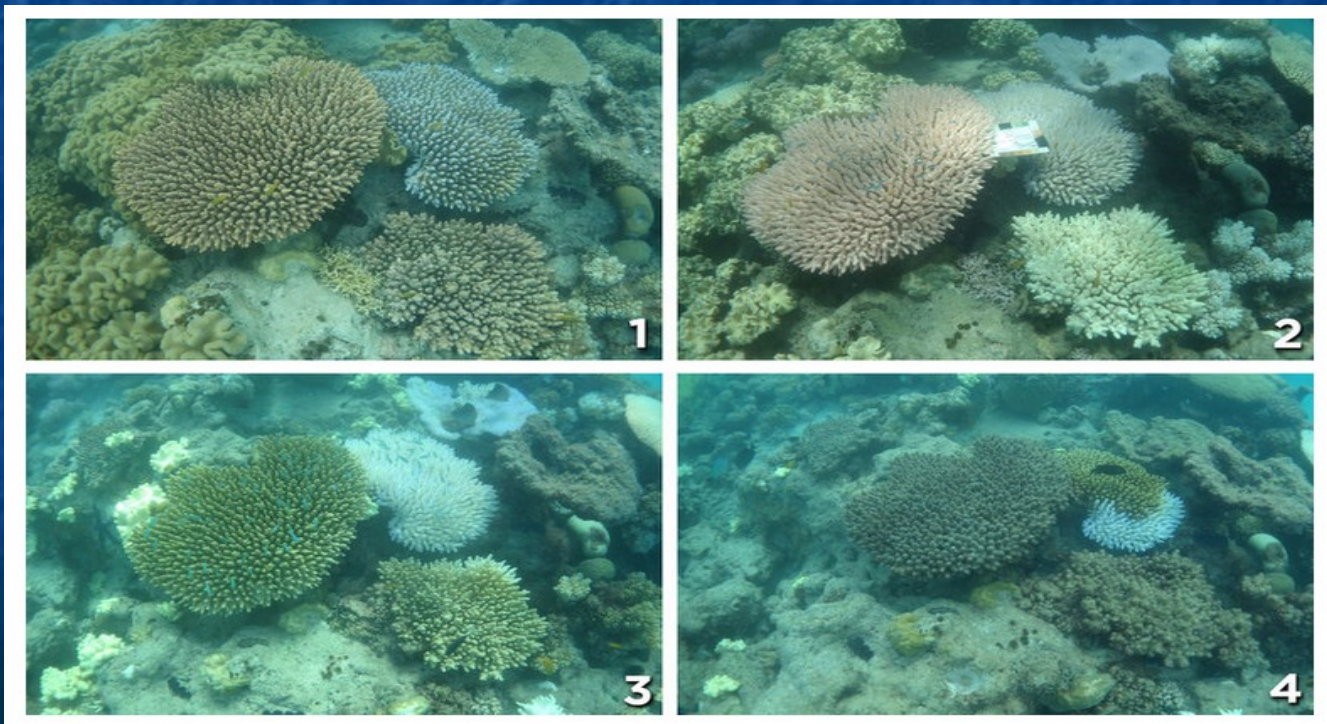
- Climate Change-Induced Floods Would Affect Over A Billion People By 2060, Report Warns  
– International Business Time 5/16/16

Country rankings in 2060	Coastal population exposed by 2000 (in millions)	Coastal population exposed by 2030 (in millions)	Coastal population exposed by 2060 (in millions)
1. China	144.0	204.1	<b>244.8</b>
2. India	63.9	120.8	<b>216.4</b>
3. Bangladesh	63.1	85.1	<b>109.5</b>
4. Indonesia	39.3	61.9	<b>93.7</b>
5. Vietnam	43.1	58.7	<b>80.4</b>
6. Egypt	25.5	45.0	<b>63.5</b>
7. Nigeria	7.4	19.8	<b>57.7</b>
8. US	23.4	34.0	<b>43.9</b>
9. Thailand	16.4	24.7	<b>36.8</b>
10. Philippines	13.0	23.8	<b>34.9</b>

# In the News

Coral Bleaching on the Great Barrier Reef- NPR 5/14/16

93%



# In the News

April breaks global temperature record, marking seven months of new highs.

Delhi schools ordered to close early for summer as temperatures soar. (111 F)