Lecture 5: Ultraviolet and Ozone

Announcements:
-homework assignment coming soon (tomorrow)
- reading by Thursday: The full Dixy experience
- bonus credit opportunities

This lecture

• Ultraviolet (UV) light and its biological effect

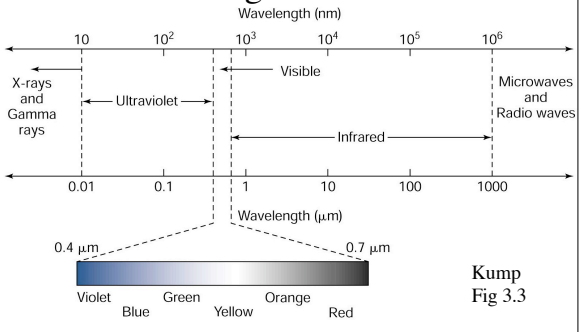
• How ozone is produced from oxygen in the stratosphere

Bonus credit opportunities

- Prof. Tad Anderson (UW Atmospheric Sciences)
  "*Can Regulation of Soot Save Us From Global Warming?"*
  January 29: Place/time to be added.

- Prof. Stephen Schneider (Stanford University)
  "*Can we define what is "dangerous" climate change? Can the Intergovernmental Panel on Climate Change (IPCC) deal with it?"*
  February 13: 3:30-4:20 pm, PAA 114

Electromagnetic radiation



Kump Fig 3.3

"UV" (ultraviolet radiation)

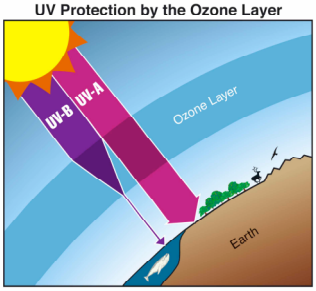
• ultraviolet is highly energetic
  - drives photochemical reactions
  - causes harm to life (sunburn, genetic damage, cancer)

• 3 classes: A, B, C
Different parts of the spectrum:

UVA = 320-400 nm
UVB = 290-320 nm
UVC = 200-290 nm

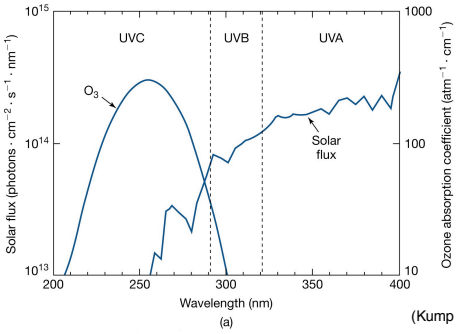
-UVA not harmful (maybe)
- UVC extremely harmful, but none gets to surface
- UVB is the big concern

UV Protection by the Ozone Layer



The ozone layer makes complex life on land possible

UV radiation

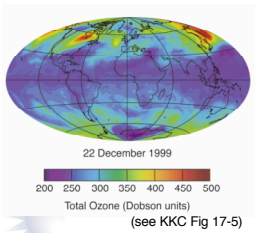


(Kump Fig 17-1a)

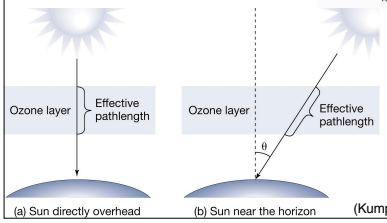
UV dose

• **UV dose** is the number of UV photons per second that lead to a biological response (such as sunburn)

• Give **two** reasons why UV dose is normally higher in the tropics (like Hawaii) than at high latitudes (like Seattle)?



(see KKC Fig 17-5)



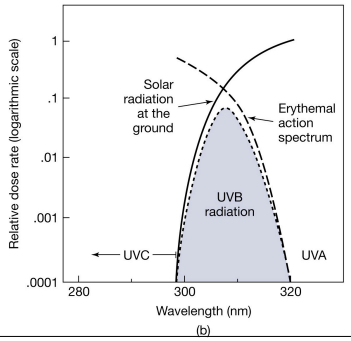
(Kump Fig 17-4)

two factors control UV dose

• ozone column depth

• solar zenith angle

Significance of UVB radiation

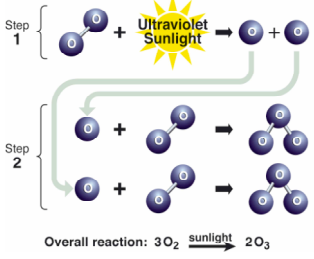


(Kump Fig 17-1b)

Ozone Production in the stratosphere

Where does the ozone come from? Answer: Oxygen molecules.

(1) O_2 + UV photon --> O + O (slow)
(2) $2O_2$ + 2O --> $2O_3$ (fast)



Step 1, the slow reaction, is the rate-limiting step.

(Production rate depends entirely on rate at which Step 1 occurs.)

Figure source: http://www.al.noaa.gov/WWWHD/pubdocs/Assessment02/Q&As.html

Ozone equilibrium from oxygen-only reactions: The Chapman scheme

(1)	O_2	+	photon	-->	O	+	O	(slow)
(2)	$2O_2$	+	2O	-->	$2O_3$			(fast)
(3)	O_3	+	photon	-->	O_2	+	O	(fast)
(4)	O_3	+	O	-->	O_2	+	O_2	(slow)

(Kump Tables 17-2, 17-3)

- Production of ozone: (1) and (2)
- Destruction: (3) and (4)
- Odd-oxygen: O & O_3 (reactive, rare)
- Odd-oxygen cycling - (2) and (3) - is fast
- Real production: (1) convert O_2 to odd-oxygen
- Real destruction: (4) convert odd-oxygen back to O_2

Calculate the NET reaction…

(1)	O_2	+	UV	-->	O	+	O	
(2)	$2O_2$	+	2O	-->	$2O_3$			
(3)	O_3	+	UV	-->	O_2	+	O	
(4)	O_3	+	O	-->	O_2	+	O_2	
	UV	+	UV	-->	heat !			

- There is no net production or destruction of any chemical species.
- This cycle of reactions produces:
  - heat (warming the stratosphere)
  - an *equilibrium* concentration of O_3 (also of O)
  - "dynamic equilibrium"

Given solar energy (UV flux) and O_2 concentration…

- equilibrium concentration of O_3 depends on rate of reaction (4).