

The Earth and its atmosphere



The most potent greenhouse gas is H_2O - vapor



The large H_2O greenhouse effect is controlled by temperature – H_2O saturation doubles with every $10^{\circ}C$ Increase

As a result It is concentrated in the lower atmosphere of the tropics

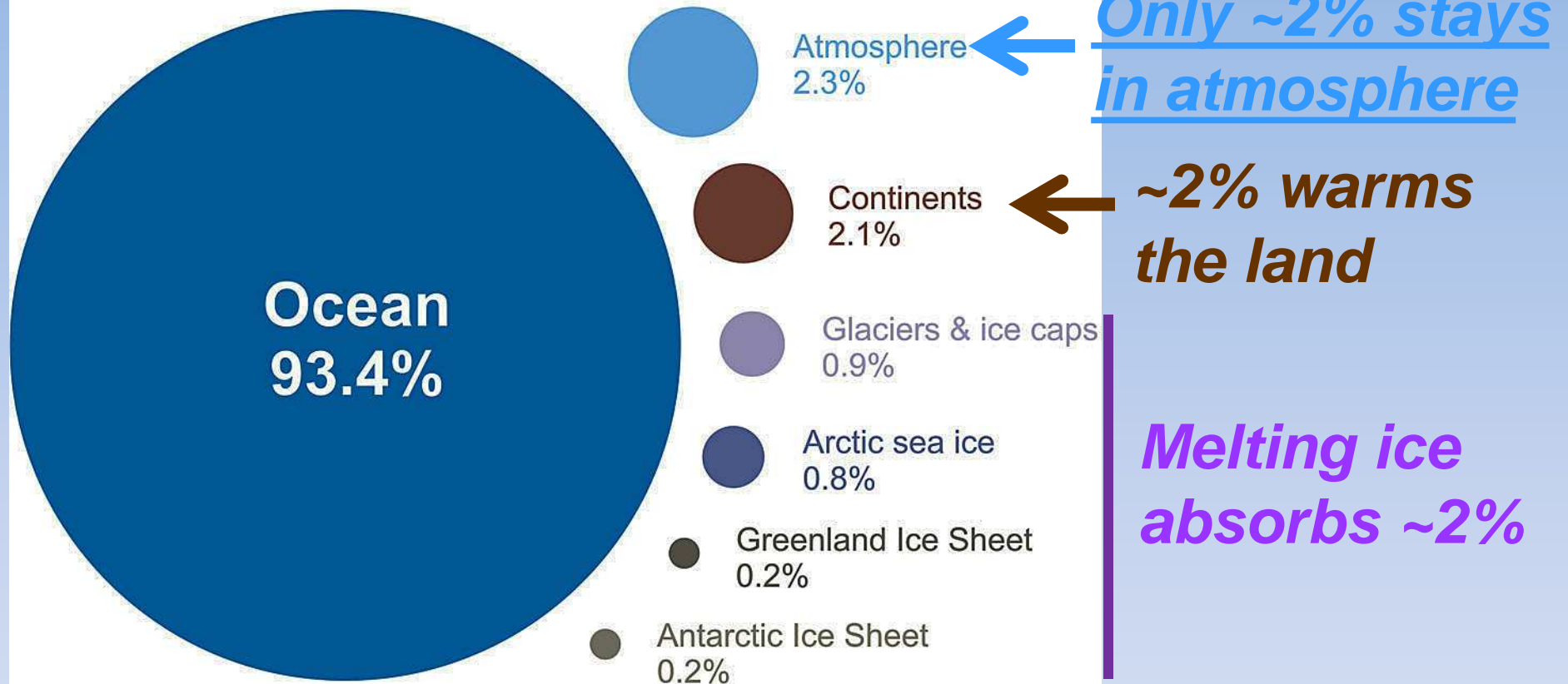
The CO₂ greenhouse gas effect is concentrated
in the polar regions !!!

**Particularly in the
Arctic !**

CO₂ is evenly
distributed throughout
the atmosphere

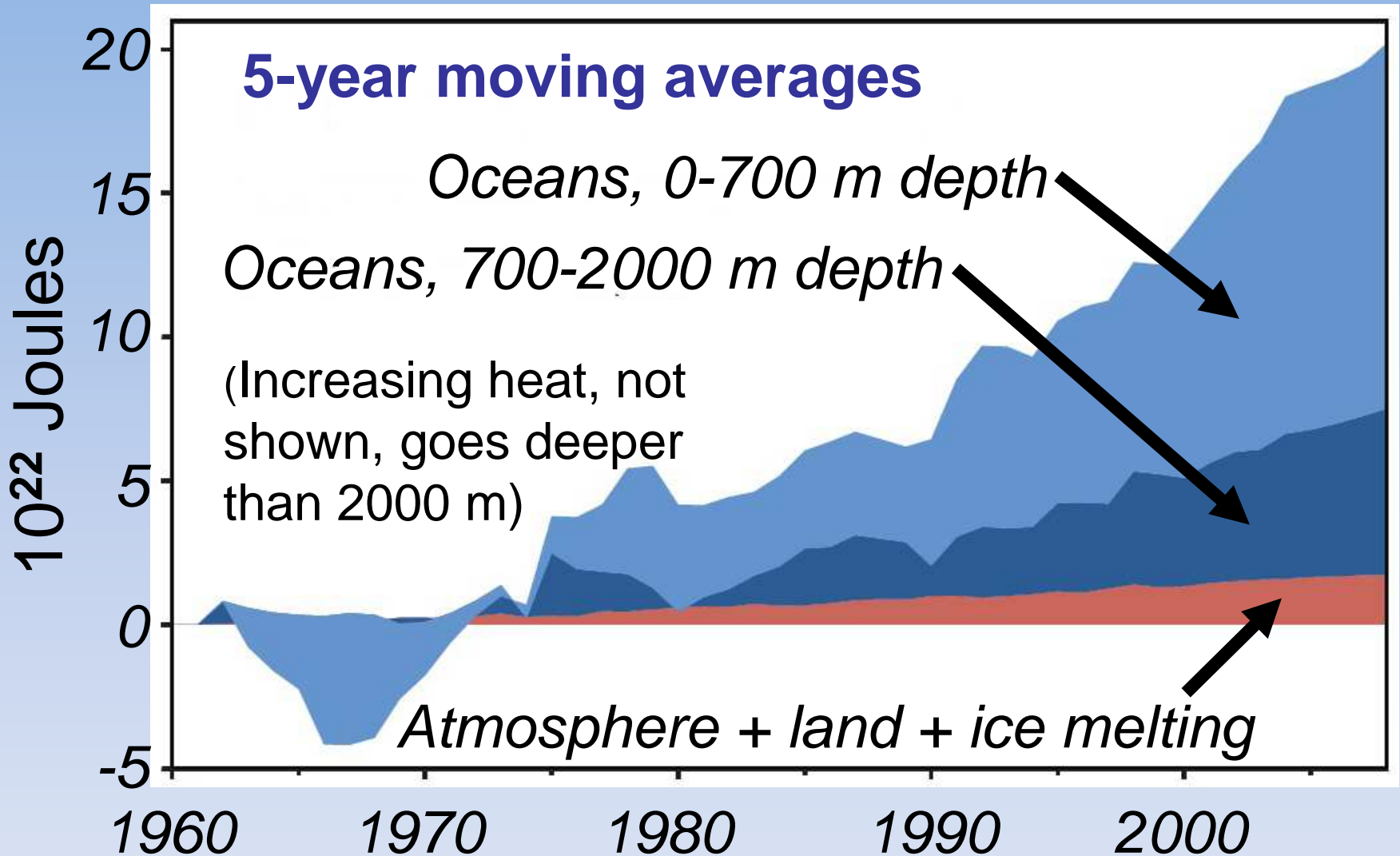


Where is global warming going?



John Cook, from IGPP 2007 data; ~93% to oceans continues (NOAA/NODC, 2012)

Change in heat content, 1958-2011



(NOAA 2012 data, Nuccitelli et al. 2012 plot)

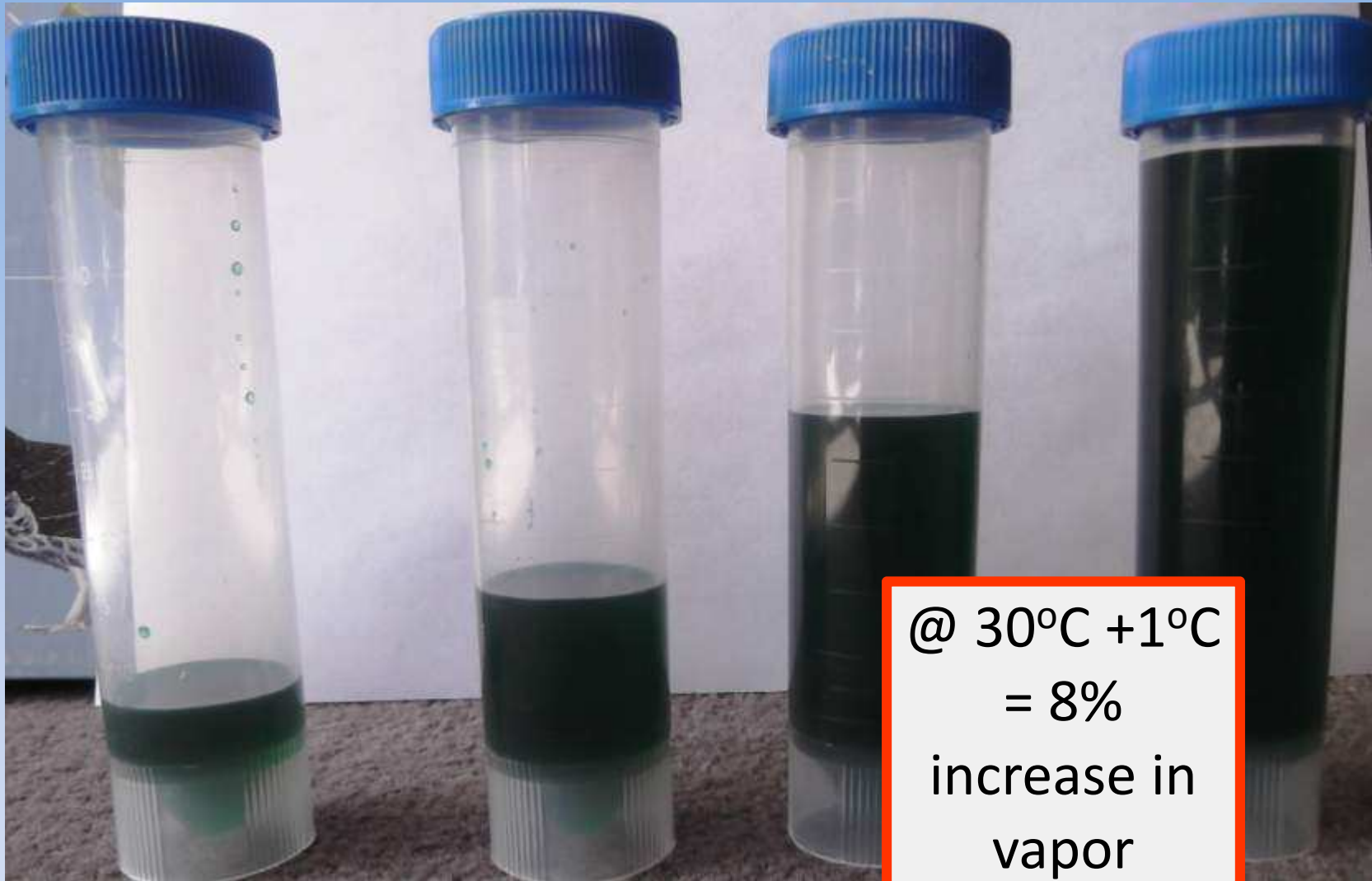
Table 1 Specific humidity of a kilogram of air (at average sea level pressure)

Temp. (°C)	Temp. (°F)	Grams of water vapor per kg of air (g/kg)
-40	-40	0.1
-35	-31	0.2
-30	-22	0.3
-25	-13	0.51
-20	-4	0.75
-10	14	1.8
0	32	3.8
5	41	5
10	50	7.8
15	59	10
20	68	15
25	77	20
30	86	27.7
35	95	35
40	104	49.8

What is the volume of 1 kg of air?

Answer:

(95 cm x 95 cm x 95 cm)



10°C =
(50°F)
7.8 cc

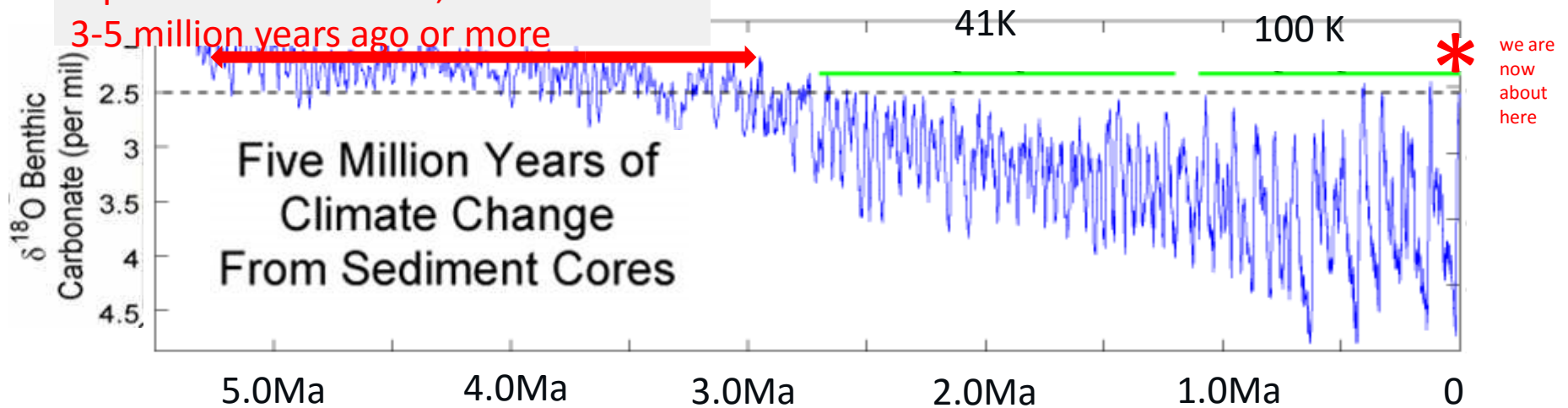
20°C =
(68°F)
15 cc

30°C =
(86°F)
27.7 cc

40°C =
(104°F)
49.8 cc

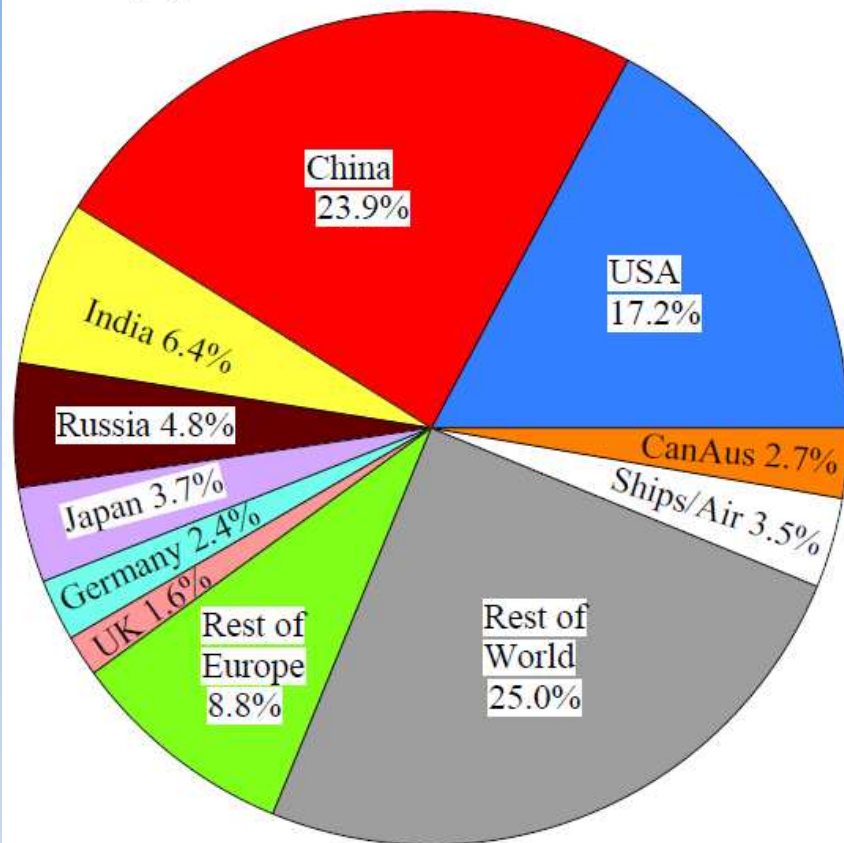
Climate Changes from Ocean Sediment Cores, since 5 Ma. Milankovitch Cycles

the last time inferred temperatures will have been this high – once equilibrium is reached, will have been 3-5 million years ago or more

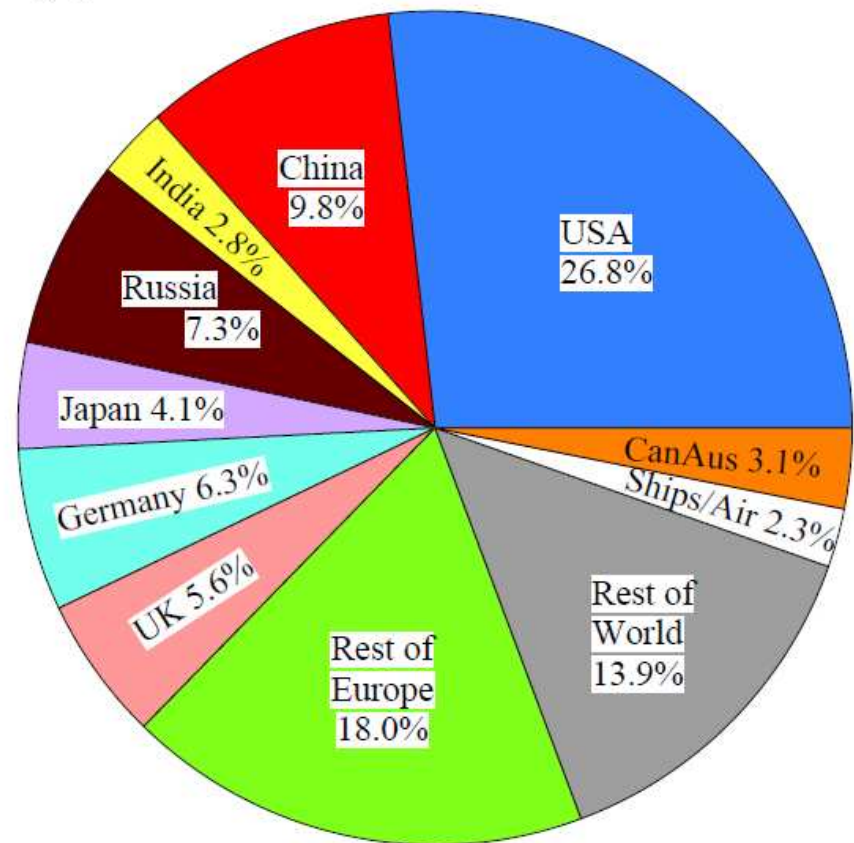


When CO_2 levels get below ~400-600 ppm Orbital parameters become more important than CO_2

(a) 2010 Annual Emissions



(b) 1751–2010 Cumulative Emissions



China has the largest fossil fuel emissions today. However, climate change is driven by cumulative emissions, so developed nations, especially the U.S., have greatest responsibility.