What is the control knob of the Earth's thermostat?

Why is a trace gas, such as carbon dioxide, (only 0.04% of air) referred to as the control knob of the Earth's thermostat? How can a small change in carbon dioxide (CO_2) content make a critical difference to the actual global surface temperature of the Earth? Nitrogen and oxygen comprise the bulk of the atmosphere but do not absorb the earth's heat radiation. Although water vapour and clouds together absorb 75% of the Earth's heat radiation[1] they cannot determine the temperature of the atmosphere. Water vapour and clouds depend on temperature and air circulation in ways that CO_2 does not. They condense and cannot maintain a *temperature structure* for the atmosphere. CO_2 accounts for 80% of the non-condensing gases that maintain the temperature structure of the Earth and acts as the control knob of the Earth's thermostat. It controls the amount of water vapour and clouds.

CO_2 absorption is strong as it absorbs in the frequency range where the Earth's heat emission (Planck field) is strongest. The instant *doubling* of CO_2 content (e.g. from pre-industrial 280 ppm to 560 ppm) would reduce the Earth's emission of heat radiation to space by about 4 Watts for every square metre of the Earth's surface. CO_2 absorption is that strong. The atmospheric temperature must be raised to radiate an extra 4 Watts per square metre to restore the Earth's energy balance. The increased surface temperature of 1.2^{o}C from the instant doubling of CO_2 content allows an increased water vapour content by maintaining a constant relative humidity. The extra water vapour increases the overall absorption by water vapour itself raising the surface temperature further by about 1.2^{o}C. The total increase is about **3^{o}C** when all feedbacks are included.

Although the temperature of Mars, Earth and Venus are affected by their distance from the Sun and by the sunlight they reflect to space, their surface temperature is strongly determined by their atmospheric density of carbon dioxide and water vapour as shown in the table:

	Mars	**Earth**	**Venus**
CO_2 density	very low	Significant	extremely high
Water vapour	little (0.03%)	global average 0.4%	little left (0.002%)
Average surface temp.	**minus 50^{o}C**	**15^{o}C**	**460^{o}C**
Greenhouse effect	**minus (5C^{o})**	**significant (+33C^{o})**	**"runaway" (+400C^{o})**

Table 1 - Surface temperature is strongly determined by the atmospheric density of carbon dioxide and water vapour

Figure 1 gives the climate impact for increasing concentrations of CO2:

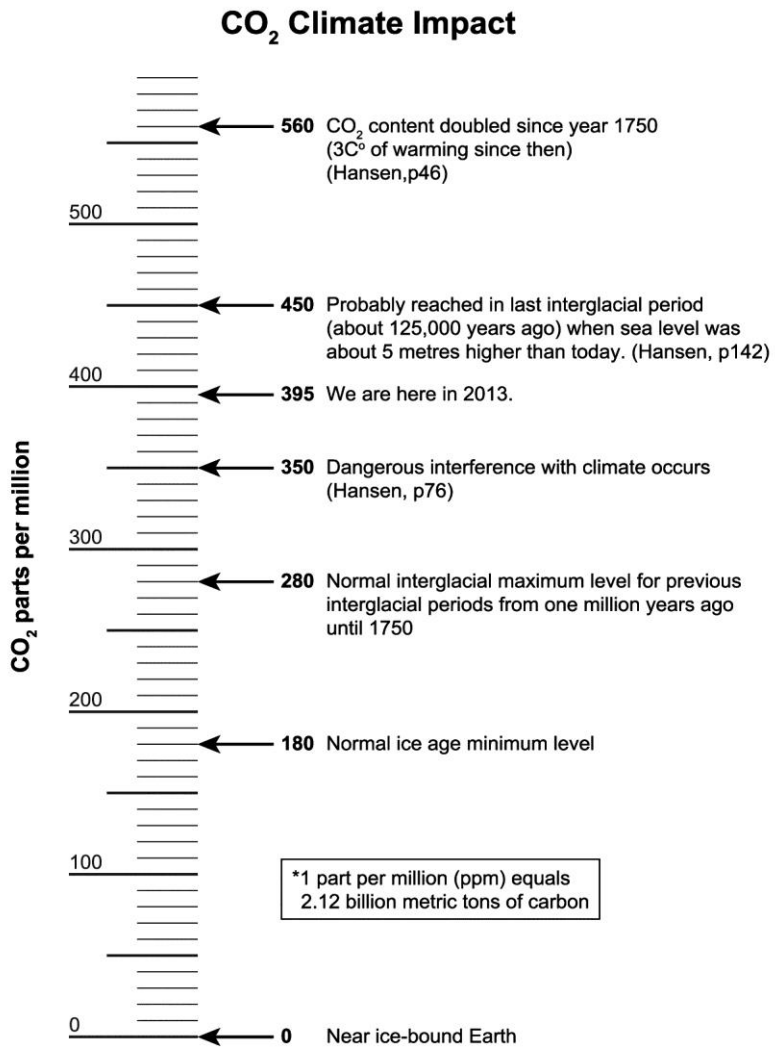

Figure 1 – Climate impact for increasing concentrations of CO_2

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