The hockey stick and the hiatus: AGW in a nutshell

Vaughan R. Pratt
Stanford University

June 9, 2020

This note seeks to address some of the more common questions about anthropogenic global warming (AGW). We take CO_2 as a proxy for well-mixed greenhouse gases (GHGs) such as CH4 but excluding H_2O.

The blue curve in Figure 1 plots the combined mass of water vapor (assumed constant at 12.9 exagrams[1]) and CO_2 for the 1.68 centuries 1851-2019. Trends in global mean land temperature in °F are shown in red.
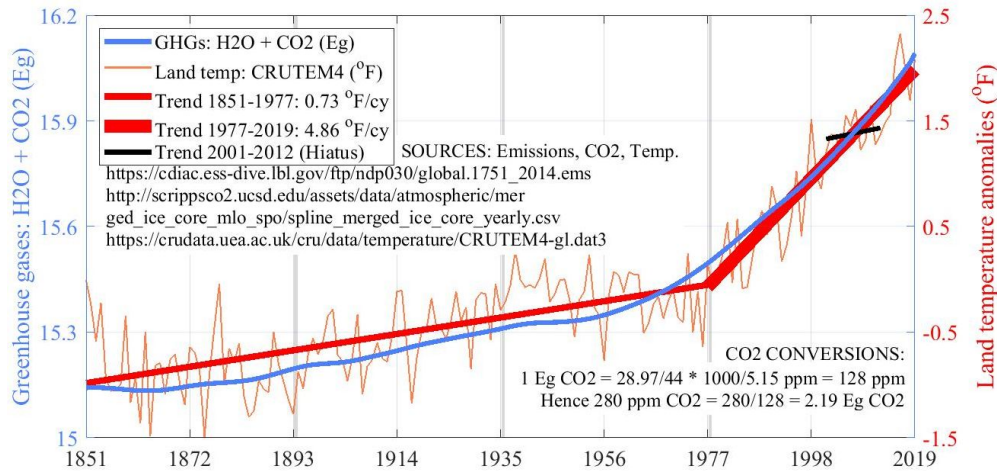

Figure 1. Greenhouse gases and land temperatures: 1851-1977-2019

Both GHGs and temperature have a hockey-stick shape whose shaft lies in the first three-quarters (1.26 centuries) and whose blade occupies the remaining 0.42 centuries. Columns 1-7 of Table 1 quantify respectively the hockey stick's butt end (1851), shaft (rise and centennial rate), heel (1977), blade (rise and centennial rate), and toe (2019). The table adds a row at the top for cumulative CO_2 emissions, also in exagrams.

Year(s):	Butt:1851	Shaft Δ	Δ/1.26	Heel:1977	Blade Δ	Δ/0.42	Toe:2019
CumEm (Eg):	0	0.54	0.43 Eg/cy	0.54	1.12	2.67 Eg/cy	1.66
GHGs (Eg):	15.14	0.36	0.29 Eg/cy	15.50	0.59	1.40 Eg/cy	16.09
Temp trend (°F):	-0.98	0.92	0.73 °F/cy	-0.06	2.04	4.86 °F/cy	1.98

Table 1. Cumulative emissions, GHGs, land temperatures: 1851-1977-2019

In theory, when a gas is in equilibrium between two adjacent regions and its quantity in one region is subsequently increased it will tend to redistribute itself more evenly. And indeed during 1851-1977 a significant fraction of the 0.54 Eg CO_2 added to the atmosphere was redistributed to the surface leaving 0.36 Eg in the atmosphere. This unintentionally conducted experiment was repeated during 1977-2019 by adding a further 1.12 Eg of CO_2 to the atmosphere, which again redistributed itself leaving 0.59 Eg behind.

In theory, according to Fourier (1824), Tyndall (1865), Arrhenius (1896), Callendar (1938), and others, greenhouse gases warm Earth's surface. And indeed during 1851-1977 we saw a slow rise in GHGs of 0.29 Eg/cy accompanied by a slow warming of 0.73 °F/cy, followed by a fast rise in GHGs of 1.40 Eg/cy along with a fast warming of 4.86 °F/cy (the red entries). The decade 2001-2012 held out the promise of a respite in temperature (black trend line), but that hiatus turned out to be short-lived.

In theory, without the preindustrial 15 Eg of GHGs Earth's surface would be about 60 °F cooler, whence each Eg must have added an average of 4 °F. Hence theoretically the additional 0.59 Eg of GHGs during 1977-2019 should warm the surface by a further 2.4 °F when equilibrium is reached. And indeed the surface has warmed by 2.04 °F so far, which should be much of the way to that equilibrium absent additional GHGs.

Supplementary material is at http://clim8.stanford.edu/agw/.

---

[1] 1 Eg (exagram) = 10^{18} grams or a trillion (10^{12}) metric tonnes.