Gaussian Emission Function, and Atmospheric CO2 Accumulation (Model #7)

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For Model #7, I assumed a Gaussian Emission Function, E(x), skewed by a diminishing linear factor in time, x, (which factor is 1000 at x=0, 0 at x=1000). So E(x) is centered just before x=130 years on the timeline (~2028, in 8 years). Think of x=0 as year 1900. That function is scaled in units of GtC/y.

Figure 1 shows a comparison of E(x) with Fossil Emissions Data for the years 1960-2019 (in units of GtC/y).

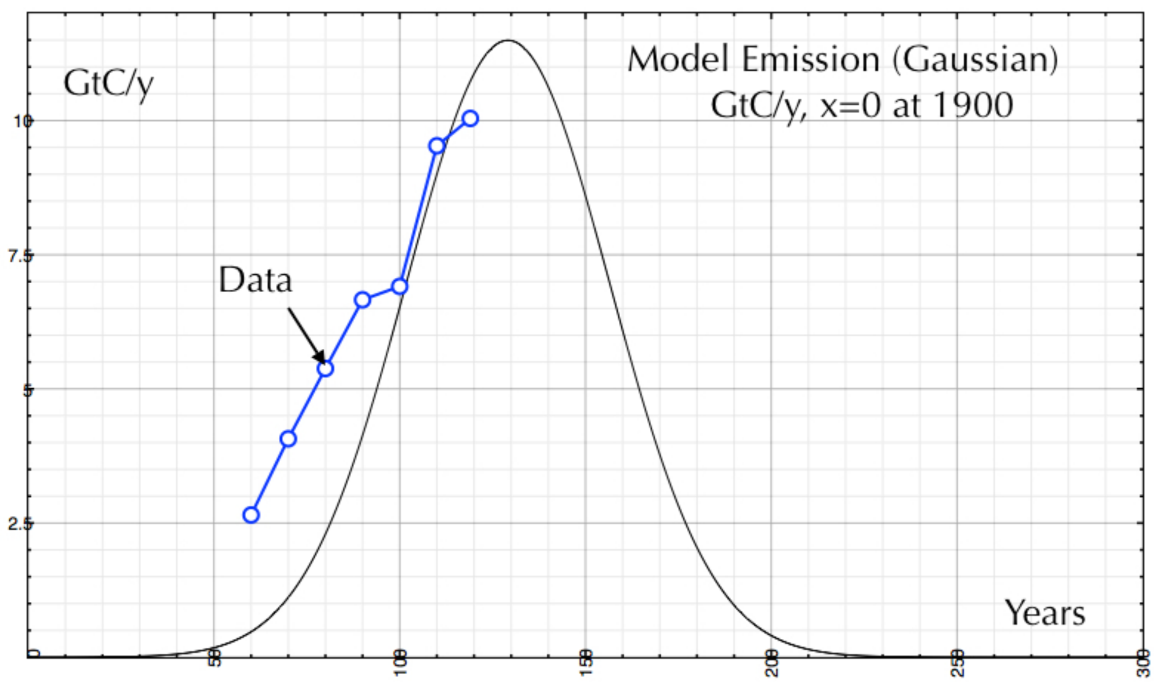

Figure 1: Gaussian Model Emission Function, and Data

The rate equation here for carbon dioxide accumulation in the atmosphere is based on these assumptions:

- 70% of the emissions accumulate in the atmosphere,

- 30% of the emissions are immediately absorbed by the oceans (surface waters),

- the only sink (mainly photosynthesis) is characterized by a relaxation time of 238 years,

- emissions peak in ~2028 at 11.5GtC/y (42.1GtCO2/y) and die away skew-symmetrically thereafter.

Figure 2 shows the resulting projected temporal profile of atmospheric CO2, in units of ppm. Also shown is the emissions function, E(x), scaled by 50x GtC/y. The unperturbed baseline concentration is assigned as 277ppm.

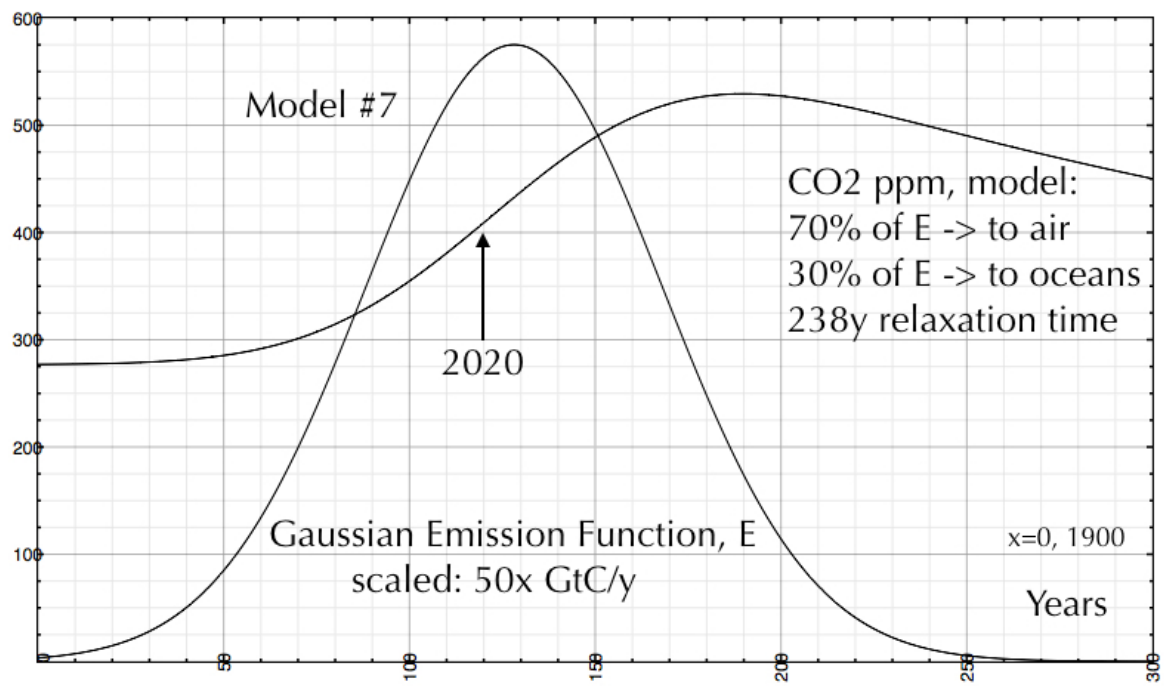

Figure 2: Time Profile of Atmospheric CO2 Concentration, for given Gaussian emissions pulse

In this scenario, the CO2 concentration peaks at 529ppm for years 180<x<200 (years 2080-2100). The continuation of this story out to year x=1200 (year 3100) is shown in Figure 3.

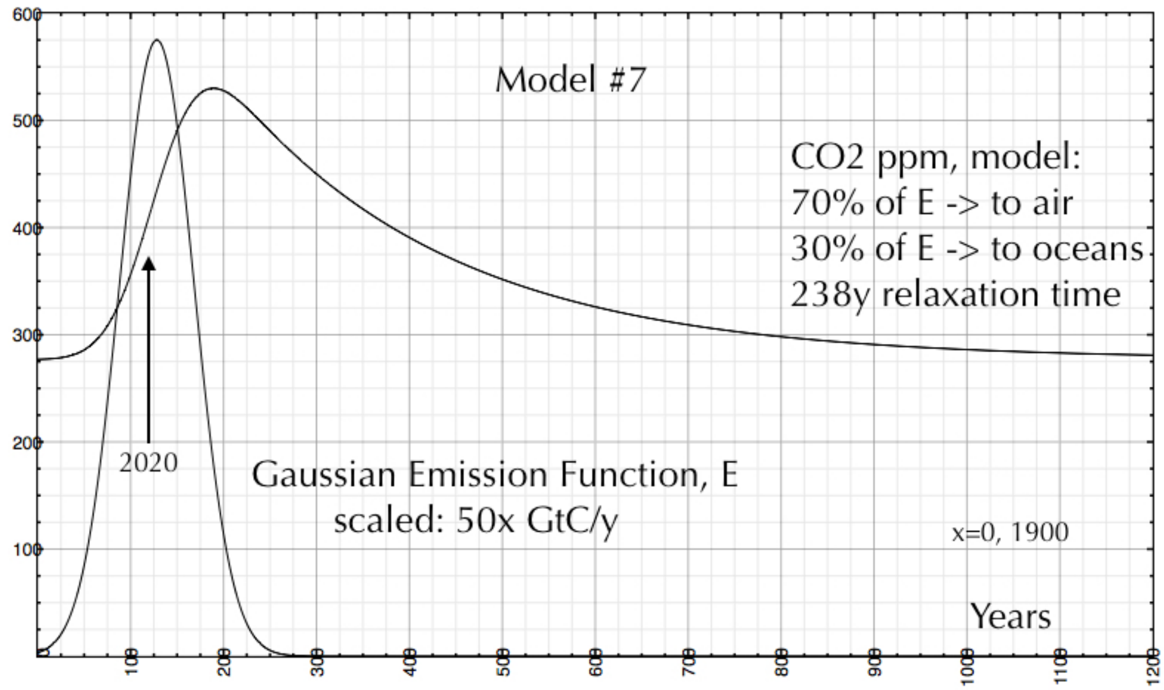

Figure 3: Time Profile of Atmospheric CO2 Concentration, to year 3100

Choosing a longer relaxation time (e.g., ~1000y) would significantly reduce, or eliminate, the decay of the concentration over time (the air CO2 would "never" go away). A long relaxation time would be the case if weathering were the dominant absorption phenomenon (with relaxation time ~12,000 to ~14,000 years), because the photosynthesis and absorption by the oceans sinks were saturated (as was the case during the 200,000 year-long clearing of atmospheric CO2 during the Paleocene-Eocene Thermal Maximum, PETM, 55.5 million years ago).

Figure 4 shows the increase in global temperature, in °C, corresponding to the CO2 concentration profile, shown above.

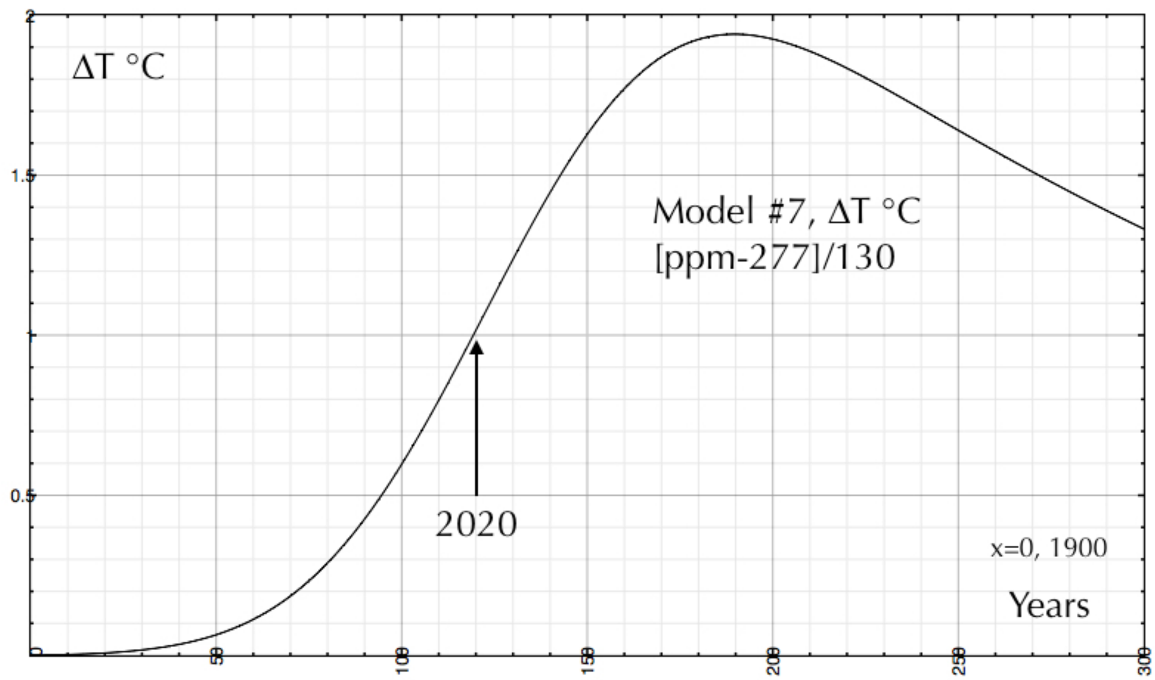

Figure 4: Average Global Temperature Increase corresponding to model CO2 concentration profile

The global temperature increase above baseline, for this scenario, is projected to peak at +1.94°C in year x=190 (2090); it arrives at +1.5°C at x=142 (year 2042).

It is obvious that if the future reality of anthropogenic CO2 emissions is an increasing trend, that the consequent time profile of atmospheric CO2 concentration will be a continuously rising trend as well. That would mean higher global temperature increases, and sooner, than those shown here.

The Gaussian emissions pulse used here is an "optimistic" scenario in that the annual rate of anthropogenic emissions peaks in 8 years, and then decreases nearly symmetrically to its profile of increase prior to 2028. This scenario would have us avoid crossing the +2°C threshold. But, the global warming would remain above +1.5°C for the 130 years between 2042 and 2172, undoubtedly degrading many environments.

Figure 5 shows a comparison of the model CO2 concentration profile found here, and data by NOAA. Not bad.

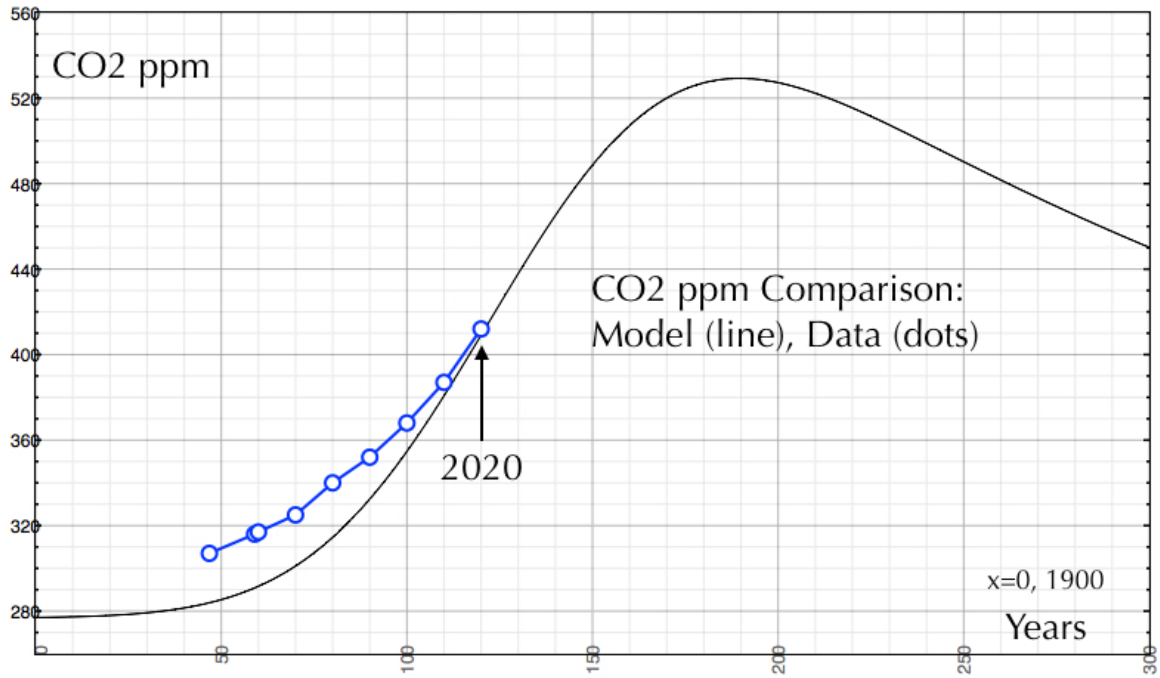

Figure 5: CO2 ppm comparison, model and data (NOAA)

The important implication of this model is already well-known: if we begin reducing anthropogenic CO_2 emissions very soon, and continue doing so at a steady rate so as to eliminate them completely within a century, we can avoid having Planet Earth warm up by a total of +2°C, relative to the 19th century.

The corollary to this observation is that if we instead continue increasing our CO_2 emissions, it will get warmer sooner for longer.

Also, whatever we do (or don't do) about CO_2 emissions, their accumulation in the atmosphere will linger for centuries. The clearing of this atmospheric CO_2 will occur on several parallel timescales:

- absorption through photosynthesis (happening daily),

- capture by the surface waters of the oceans over the course of years, decades and centuries (and eventual sequestration at the sea bottom in a surface-to-bottom mixing cycle of millennial time scale), and

- the chemical reactions of rock weathering (on a tens-of-millennia time scale).

Injecting CO_2 into the atmosphere can be done instantly; removing it requires a long time.

So, it would be wise to stop emitting it.

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