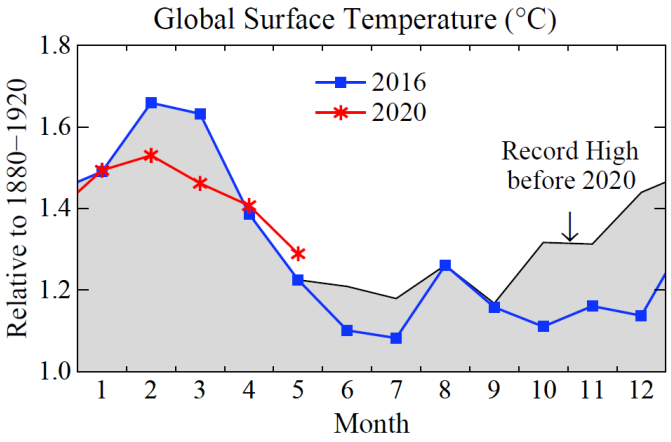

Well, the race is on, and here comes…

12 June 2020

James Hansen and Makiko Sato

Global temperature in May 2020 set a record for May (1.29°C, relative to 1880-1920) for the period of adequate data, i.e., since 1880. That is the third monthly record in the first five months of 2020, despite the fact that temperatures this year are not boosted by a strong El Nino.

2020 and 2016 will be the two warmest years, but which one will wear the crown? The answer is of little import – they will be close, likely a statistical dead heat – but in this Covid-19 year we need to have a little fun, and we can set the stage to learn something from the result.

2020 is a bit cooler than 2016 so far (graph above), but 2020 could pass 2016 to become the warmest year, because late 2016 was cooled by a La Niña (see May Update and graph above).

However, we suggested caution about confident predictions that 2020 would be the warmest year, because there is evidence that 2020 is also headed into a La Niña.

Below, global temperature fluctuations are compared with temperature in the Niño3.4 region in the tropical Pacific. These temperatures are detrended to take out long-term warming. The correlation of the two curves is over 60 percent – it would be still higher without the global cooling effect of aerosols after the 1991 Pinatubo volcanic eruption. This shows that ENSO (El Niño Southern Oscillation) strongly controls short-term global temperature fluctuations. Lag of the detrended global temperature anomaly behind the Niño anomaly averages 4.5 months.

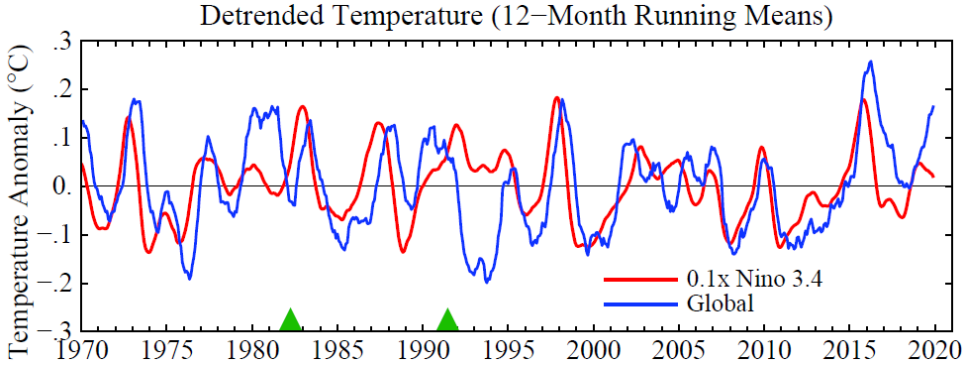

Fig. 2. Global and Nino3.4 temperature anomalies, correlation 61%, global lags by 4.5 months.

The ENSO Expert Assessment kindly provided by NOAA each week seems to be gun-shy in predicting El Niño or La Niña, almost waiting until one is in progress to "predict" it. However, in the same report, the NCEP (National Center for Environmental Prediction) dynamical model has been consistently showing a developing La Niña for several weeks. The 12-month running mean of Niño3.4 temperature is already turning down, albeit slowly (Fig. 2).

Niño predictions are notoriously fickle in the Spring, but we are well into June. We assume that the NCEP model, based on fundamental equations and using updated observations, deserves respect, and combined with observed negative subsurface temperature anomalies in the Eastern Equatorial Pacific Ocean, it leads us to anticipate near-term La Niña conditions.

The El Niño/La Niña cycle is the dominant source of short-term global temperature variability, but global climate forcings also play a role. Three climate forcings warrant mention:

Greenhouse gases (GHGs). Climate forcing by GHGs is increasing about 0.04 W/m^2 per year (Fig. A1). So 2020 has an additional climate forcing of +0.16 W/m^2 compared to 2016.

Solar irradiance decreased over the past four years. Global temperature response to the solar cycle lags the irradiance by 1-2 years, so we average the climate forcings in Fig. A2 over the periods 2014-2016 and 2018-present. Result: 2020 has a negative solar irradiance forcing relative to 2016 of -0.11 W/m^2, thus partially off-setting GHG forcing.

The net of GHG and solar forcings gives 2020 only a tiny boost, +0.05 W/m^2.

Tropospheric aerosols are a wild card. The impact of Covid-19 on industry and travel has caused a noticeable reduction of particulate pollution. This may have reduced the magnitude of the negative (cooling) forcing by aerosols, which would give a boost to 2020 temperature. Unfortunately, global aerosols are not being measured with an accuracy adequate to define their forcing. We doubt that their change is having a large effect, but we need good measurements!

Important aside: The climate forcing growth rate of crucial importance to "bend the climate curve" is the GHG annual climate forcing change. As Fig. A1 shows, that curve is bending in the wrong direction! It should be following the RCP2.6 path if warming is to be curtailed. The problem is still solvable, because of long delay times in the climate system, as we discuss in "bending the curves" and in *Sophie's Planet*. We must bend the CO_2 curve (Fig. A3) in order to bend the GHG curve (Fig. A1).

Long-term bending of the GHG forcing curve is needed to bend the long-term climate curve, but short-term (2016-2020) variations of GHG forcing have little effect on short-term temperature. Instead, short-term warming depends more on the "unrealized warming," i.e., the warming still "in the pipeline" from GHG increases over the past century. This "delayed response," due mainly to the ocean's great thermal inertia, causes Earth to be out of energy balance: solar energy absorbed by Earth now exceeds heat radiated back to space by 0.75 ±0.25 W/m^2.

We could use this imbalance to estimate GHG-driven warming for a 4-year period (2016-2020), but it is messy, because much of the imbalance is associated with slow "recalcitrant" warming.

That's too hard. A simpler way is to note that the global warming rate over the past several decades has been about 0.18°C per decade. In four years, that's a warming of 0.07°C. That's the edge that 2020 gains over 2016 from being four years later.

Compare that with the difference between a super-El Niño (such as 2015) and a piddling-El Niño (such as 2019). 2016, enhanced by a super-El Niño should gain about 0.1°C relative to 2020.

Other things equal, 2016 seems to have a slight edge – unless the underlying warming rate has accelerated in recent years, which may be consistent with the increased growth rate of GHG forcing (Fig. A1) – or if there really has been a substantial decrease of atmospheric aerosols.

It looks like a close horse race, which likely will come down to the final furlong.

Where's the fun in this? We let George Jones call the race : "The race is on and here comes pride up the back stretch, heartache a goin' on the inside. My tears are holdin' back, their tryin' not to fall…"

BTW, did you hear that George Jones is a cowboy philosopher, who once quoted Alfred Lord Tennyson: "Tis better to have loved and lost, than never to have loved at all."* Oh, maybe not, we must be going a little wacky in this Covid isolation…

*also applies to climate predictions, space experiments, scientific theories…

Appendix

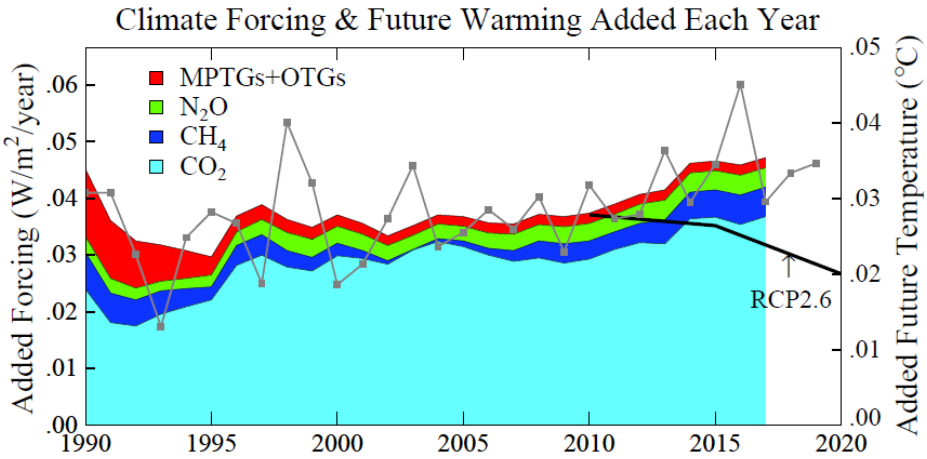

Fig. A1. Global climate forcing added each year. Equilibrium warming added each year (right hand scale) assumes an equilibrium climate sensitivity of 0.75°C per W/m^2 of climate forcing. Colored areas are 5-year running means; gray line is the annual forcing growth.

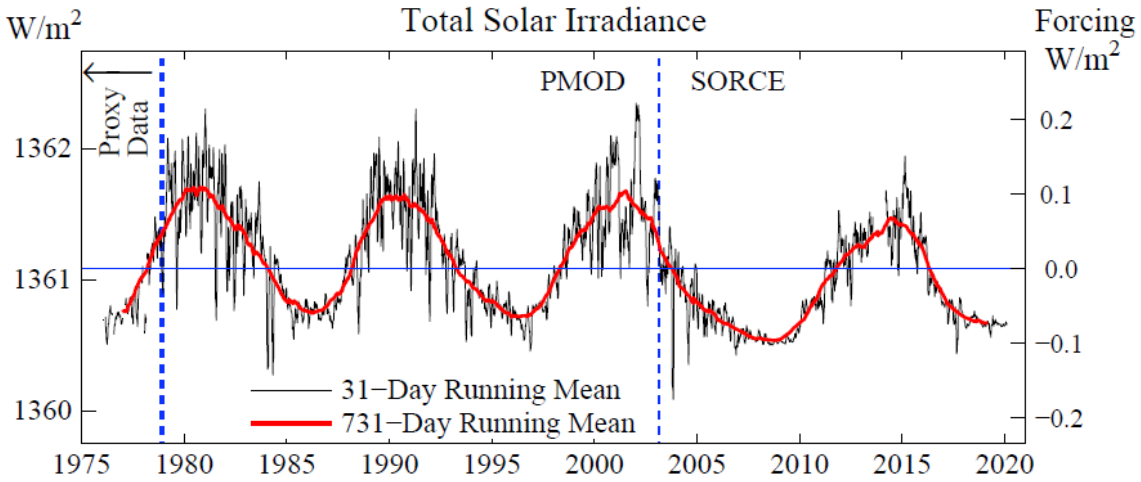

Fig. A2. Total solar irradiance. The climate forcing variation caused by solar variability is shown by the scale on the right.

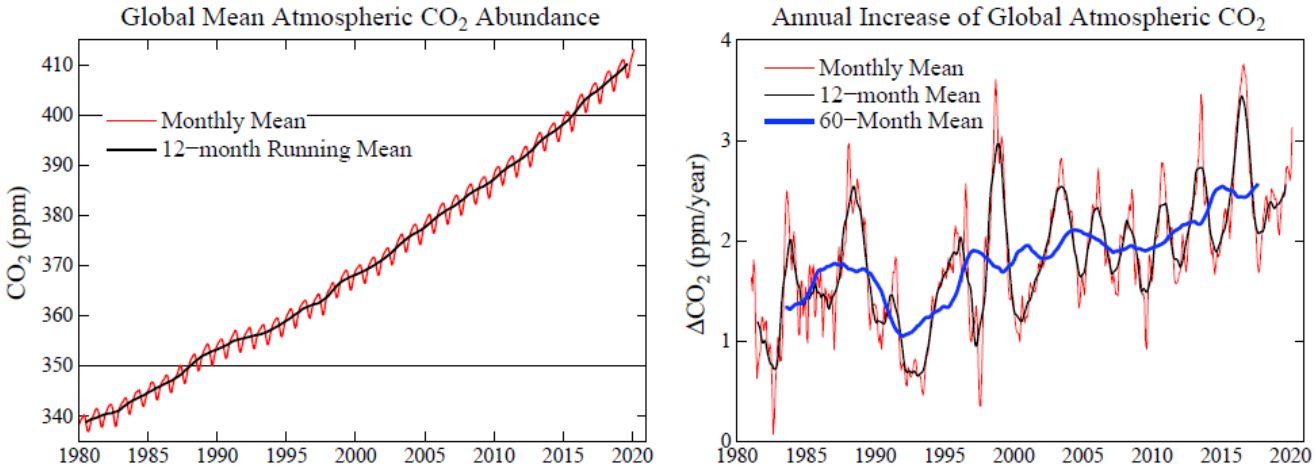

Fig. A3. Global mean CO_2 abundance (left figure) and its annual increase (right).