GC23C-1085: Multidecadal Climate to Within a Millikelvin

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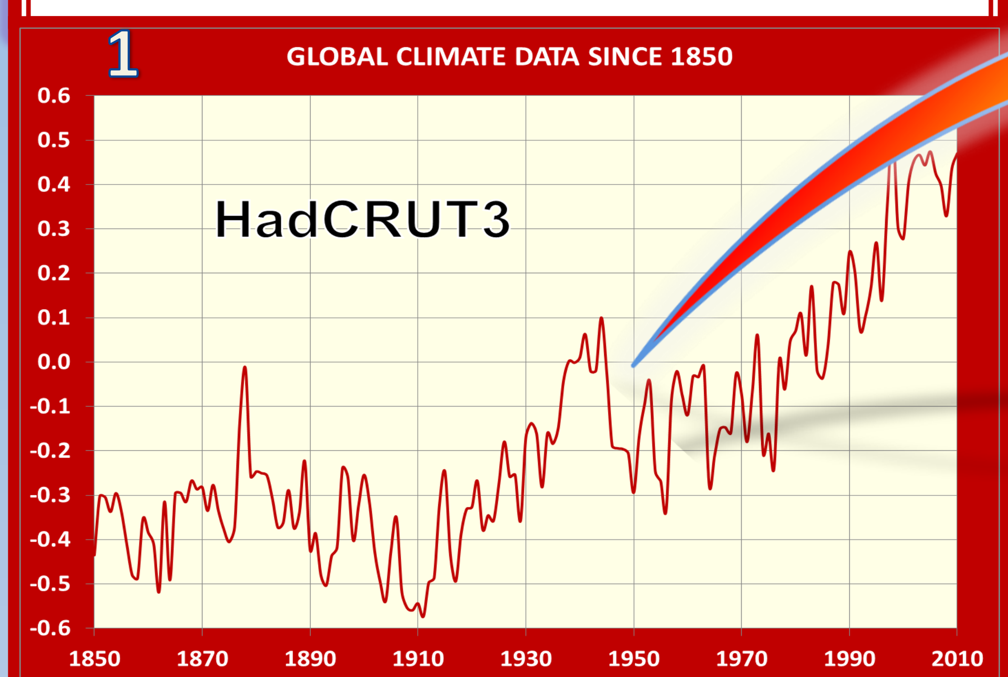
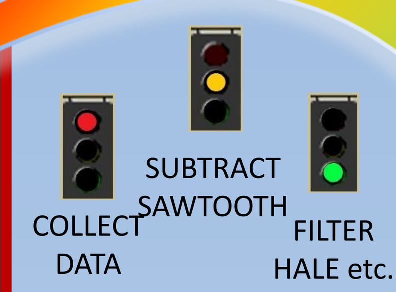
BACKGROUND

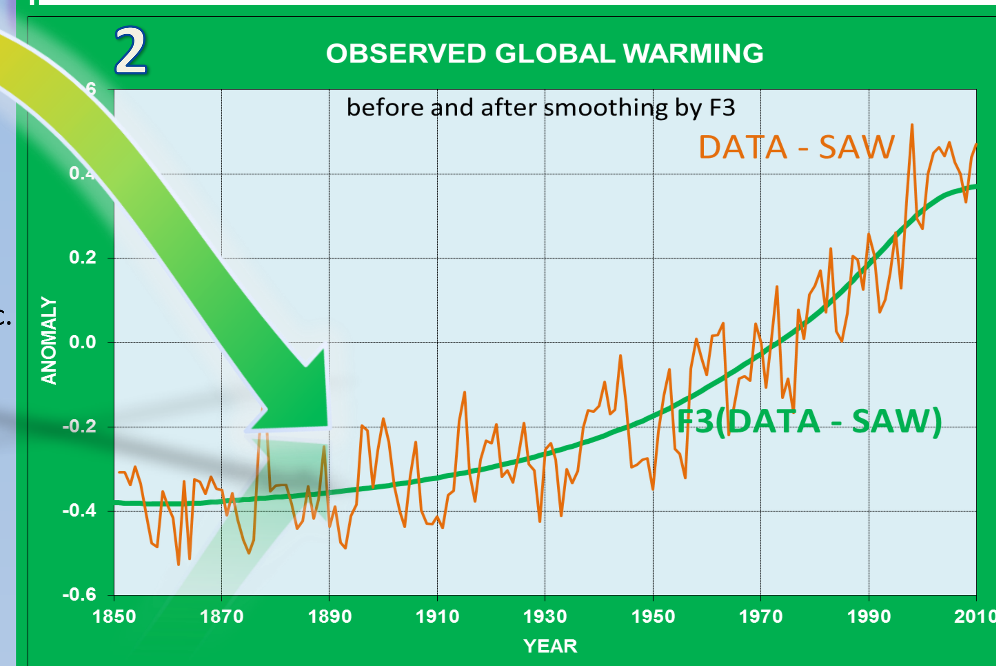
Global warming is clearly visible in HadCRUT3 since 1970





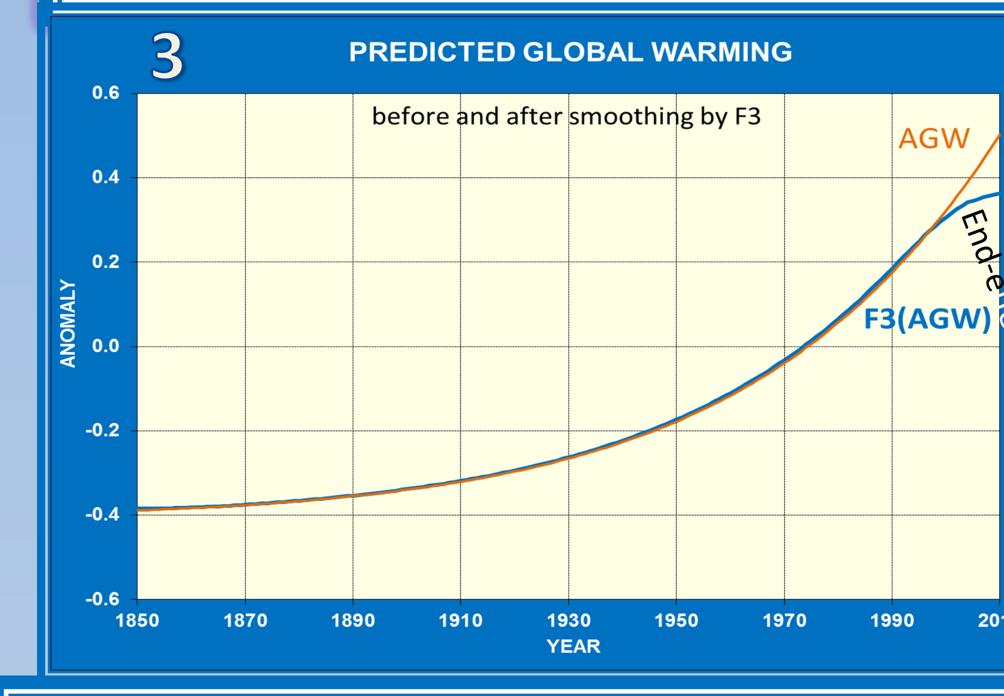
FIRST RESULT

Removing a "sawtooth" and all variations faster than the Hale cycle extends visibility to 1850



SECOND RESULT

Arrhenius, Hofmann, and Hansen jointly account for global warming to date with an R2 of 99.98%



End-effect artifact of filtering

Yeah but the even decade 2000-2009 didn't trend up as strongly as the odd decade 1990-1999.

Well, ok, but every odd decade since 1870 has trended up, and moreover every even decade has trended more negatively than the odd decade on either side.

MECHANISMS

We discuss a possible mechanism for the sawtooth, and how we estimated Hansen delay.

SPACE FOR WRITTEN COMMENTS

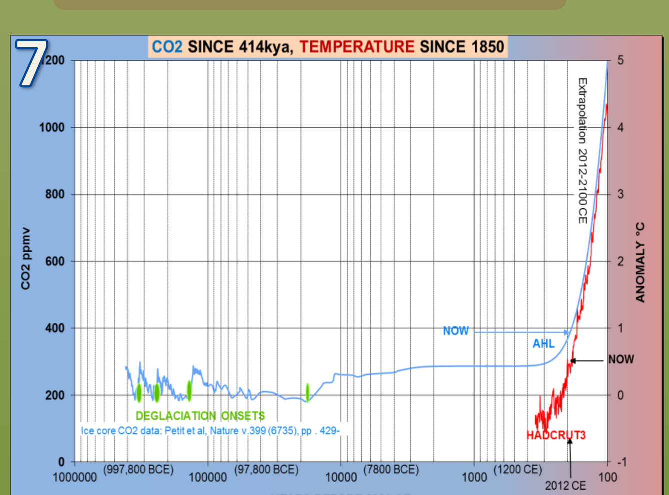
SHOWING OUR WORK

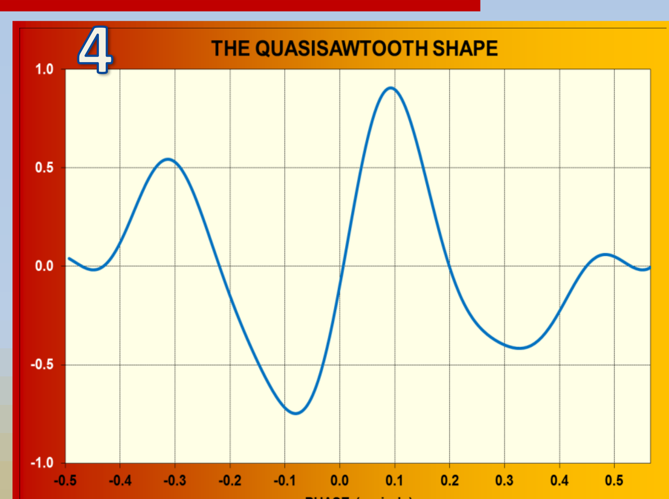
All the graphs in this poster are in an Excel spreadsheet downloadable from http://clim.stanford.edu . The spreadsheet includes nine sliders to adjust the six sawtooth parameters and three AHH parameters.

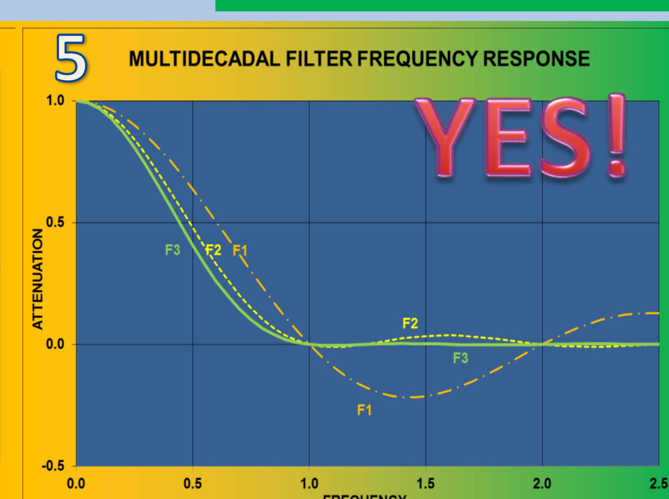
The MRES plot is displayed above the sliders. It gives a sense of how each of the nine parameters influences the accuracy of the AHH model.

PAST AND FUTURE TRENDS

The curves below show past CO2 and business-as-usual future CO2 on a log time scale. Future is simply the extrapolation of SAW and AGW.







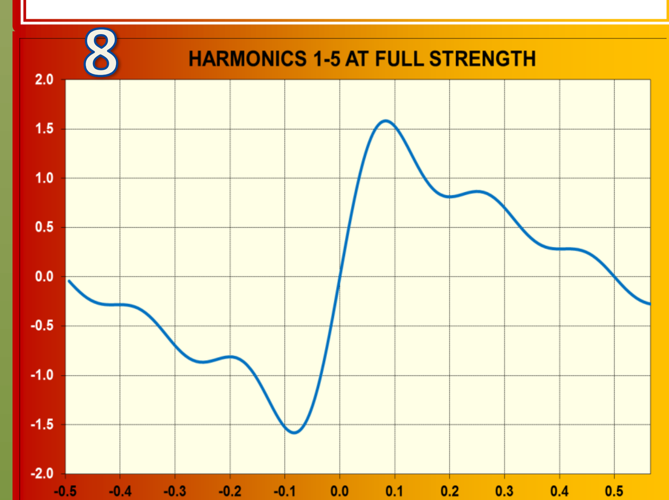
YES! WITHIN MILLIKELVINS!

THE QUASISAWTOOTH

We unify all multidecadal ocean oscillations as a single phenomenon, namely a sawtooth. The *n*-th harmonic of a sawtooth is $\sin(2\pi nx)/n$. Our "quasi-sawtooth" consists of harmonics 2 through 5. Harmonics 2 and 3 are untouched while 4 and 5 are attenuated by factors of 0.13 and 0.46 respectively and jointly delayed by 3% of a period (three parameters). Three more parameters fitting the shape to the data yield SAW:

PERIOD: 151 years
PHASE 0: 1924.5 CE
AMPLITUDE: 0.18 °C

(The sawtooth shape is more apparent when harmonics 1-5 are at full strength as below.)

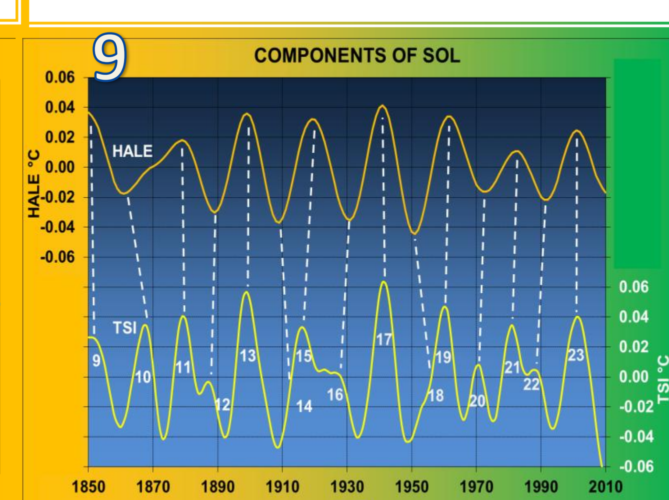


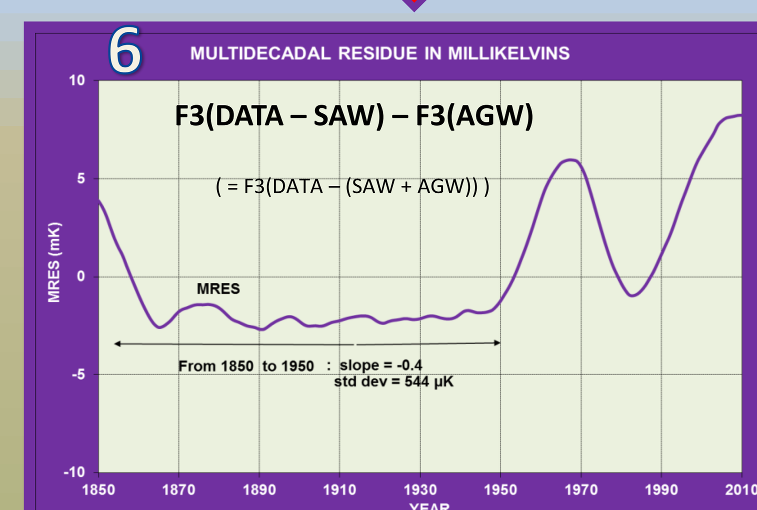
REMOVING HALE ETC

We convolve a box filter F1 with two different such giving F2 and F3. F3 passes at most 0.4% of all frequencies above the cutoff at 1.0 while still maintaining good temporal locality of what it does pass as well as zero phase distortion for sinusoidal signals. We set the cut off at the 21-yr Hale period.

The box filters are 21, 17, and 13 years wide respectively. The first kills Hale and TSI while the latter two push up the first side lobe of F1 = sinc(x) .

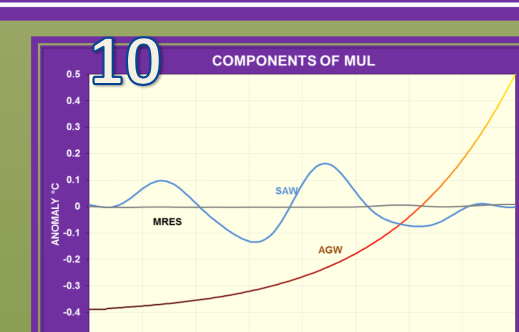
The corresponding widths for separating HALE from TSI are 11, 9, and 7 years, and for separating TSI from DEC (per bottom right) 7, 5, and 3 years. We isolate Hale to show that it's essentially all that's in that octave.

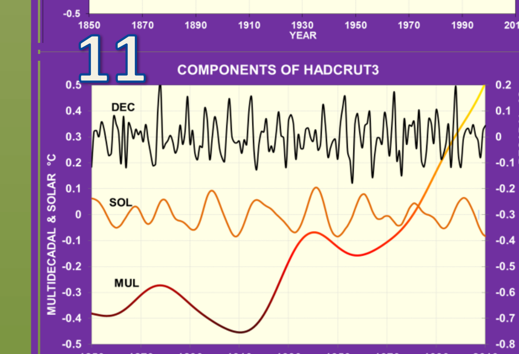




ATMOSPHERIC POLLUTION?

Our assumptions for AGW say nothing about brown-cloud pollution, which is presumed to have a non-trivial impact on global warming [Jacobson 2002]. If we are to expect some sign of it, the two 10 mK bumps in MRES around 1970 and 2000 are as much as this analysis can offer.





THE ARRHENIUS-HOFMANN-HANSEN LAW

$$AGW(y) = 2.83 \log_2\left(287 + 2^{\frac{y-1834}{28.6}}\right)$$

ASSUMPTIONS FOR LAW

1. Prevailing* climate sensitivity: 2.83 °C /doubling of CO2.
2. Preindustrial CO2: 287 ppmv (cf 284.7 in 254 BCE [Petit et al]).
3. Excess CO2: 1 ppmv in 1819 doubling every 28.6 years. [Hofmann et al, 2009; but with 280 instead 287]
4. Hansen oceanic-mixed-layer pipeline delay: 15 years (added to 1819).

The two parameters in assumption 3 are computed directly from the Keeling curve at 1975 and 2005, respectively 314 and 381 ppmv. By assumption 2 the corresponding excesses were 44 and 91 ppmv, hence doubling in $30/\log_2(91/44) = 28.6$ years. There were $\log_2(44) = 5.46$ doublings up to 1975 whence the excess was 1 in 1975 – 28.6* 5.46 = 1819.

The remaining three parameters, 2.83, 287, and 15, are estimated by a least squares fit of F3(AGW(y)) to F3(DATA – SAW). By linearity of F3 this is equivalent to minimizing the variance (and hence standard deviation) of F3(DATA – (SAW + AGW)), which is naturally thought of as the multidecadal residual MRES shown here.

* Climate sensitivity depends on the prevailing circumstances, which we take here to be what obtained "on average" during 1850-2010. The profound disequilibrium of modern climate makes its circumstances very different from those of the deglaciations of the past million years, in which CO2 changed two orders of magnitude more slowly.

CONCLUSION

We infer from this analysis that the only significant contributors to modern multidecadal climate are SAW and AGW, plus a miniscule amount from MRES after 1950.

Whether SAW describes a single phenomenon or several is an excellent question, see our speculation on the right. What we *can* say is that the three curves in the figure to the upper left give one plausible account of multidecadal climate, MUL, since 1850. This in turn leads to the analysis shown at lower left, namely

HadCRUT3 = MUL + SOL + DEC.

We are unaware of other analyses claiming millikelvin precision.

The Arrhenius logarithmic law dates back to 1896, Hofmann's principle of exponentially growing anthropogenic CO2 only back to 2009; we accept both here. The two principal novelties in our work are the sawtooth model of ocean oscillations and the observability of Hansen delay in the global temperature record, which we discuss in turn.

We conjecture that the former results from seismic events where the inviscid mantle becomes more viscous, due to decreasing temperature above and increasing pressure below. Rotation of the Earth's core relative to the crust can be expected to generate such events above and/or below the mantle. Each such event would temporarily redistribute heat so that the bottom of the crust would experience a sudden temperature increase followed by a slow return to equilibrium, a sawtooth. Thermal and mechanical effects would attenuate respectively low and high harmonics.

For the latter, in 1985 Hansen et al [1] proposed that the oceanic mixed layer acts as a heat sink delaying the warming impact of the greenhouse effect, much like a CPU with a heatsink but no fan. This should create a delay between radiative forcing and its impact on surface temperatures while the ocean surface layer warmed, call this the Hansen delay.

If CO2 rose at an exponentially growing rate, for example as assumed by the AR4 notion of transient climate response based on an increase of 1% a year, the Arrhenius law would cancel that out and surface temperature would depend linearly on time. It would then be theoretically impossible to separate climate sensitivity and the delay based just on HADCRUT.

This is not the case with the "raised-exponential" Hofmann model of CO2 growth, which gives rise to the concave-upwards shape of the AGW curve. We estimated the delay by sliding the AGW curve sideways to locate the best match of its shape to that of the observed temperature. The spreadsheet referred to at far left provides those equipped with Excel to perform this estimate for themselves.

[1] J. Hansen et al. Climate response times: Dependence on climate sensitivity and ocean mixing. Science, 229, 1985.