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Mismatch between acceleration of reconstructed sea levels and gradient of reconstructed temperatures

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ABSTRACT

Sea levelrises faster as it gets warmer for the thermal expansion effect. Similarly, the ice melts faster as ice sheets and glaciers get warmer. Semi-empirical models link the sea level rate of rise and the temperature change, and therefore the sea level acceleration to the temperature gradient. It is shown here that while the reconstructed temperatures of land and sea or land (GISS, ERSSTV3b) exhibit a quasi-60 years periodic oscillation with very likely another longer term periodicities, the reconstructed global mean sea level (CSIRO) is a monotonically increasing curve. While the sea level accelerationmatches the gradient of anthropogenic carbon dioxide emission, the mismatch with the temperature gradient is evident.

SEMI-EMPIRICAL MODELLING OF SEA LEVELS

Temperatures and sea levels were supposed to move accordingly, with rates of rise of sea levels correlated to the temperature increase, and popular semi-empirical models[1,2] "*try to exploit the link between observed sea level rise and observed global temperature changes in the past in order to predict the future*".

Starting point for these models is the simple physical idea that sea level rises faster as it gets warmer following the equation:

$$dH/dt = a\cdot(T(t) - T_0) \quad (1)$$

where H is sea level, t is the time, T is global temperature and T_0 is a baseline temperature at which sea level is stable.

The "sea level sensitivity" a measures how much the rate of sea level rise accelerates for a unit change in global temperature. Similar approach is used to model the surface mass balance of ice sheets and glaciers. The warmer it gets, the faster the ice melts.

Equation (1) implies that

$$d^2H/dt^2 = a\cdot dT/dt \quad (2)$$

The sea level accelerations should therefore be proportional to the temperature gradients. Therefore, the reconstructed temperatures and the reconstructed sea levels should correlate each other.

RECONSTRUCTED SEA LEVELS AND TEMPERATURES

In the reconstructed temperatures and sea levels, while approaching the present time the temperatures have a mostly negative acceleration and a reducing gradient, the GMSL has a positive acceleration and the rate of rising of the acceleration is increasing. This is clear from Figure 1 and 2.

Figure 1 presents the GISSland and sea (L&S) reconstructed temperatures (data from[5,6], analysis from[3,4]) while Figure 2 compares the GISSL&S temperatures (data from[5,6]), the ERSSTV3b sea surface temperatures (SST) (data from[5,7]), the CSIRO global mean sea levels (GMSL) (data from[8,9]) and the CDIAC carbon dioxide emissions(data from[10]). In Figure 2.d, all emission estimates are expressed in million metric tons of carbon. To convert these estimates to units of carbon dioxide (CO_2), simply multiply these estimates by 3.667.

While the reconstructed L&Stemperatures andSST show an oscillating behaviour characterised by a significant quasi 60-years oscillation and the opportunity of even longer periodicitiesof oscillations[3,4], the reconstructed global mean sea level(GMSL) has a monotonically increasing trend.

The L&S temperatures data set 1910 to present shows almost perfect sinusoidal oscillations of periodicity quasi-60 years (about 63 years)around a linear

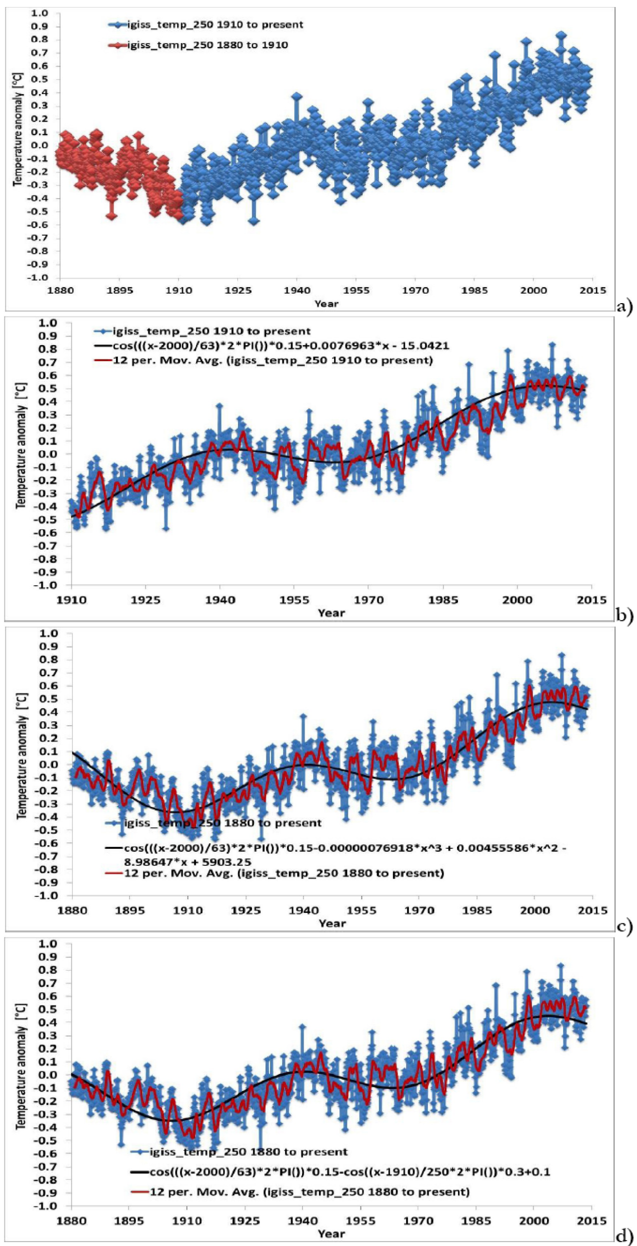

Figure 1 : G]ISSL&S reconstructed temperatures (data from[5,6], analysis from[3,4]): a) data 1880 to 1910 and 1910 to present; b) data 1910 to present with linear and 63 year period cosine fitting; c) data 1880 to present with 3rd order polynomial and 63 years period cosine fitting; d) data 1880 to present with 63 and 250 years periods cosine fitting.

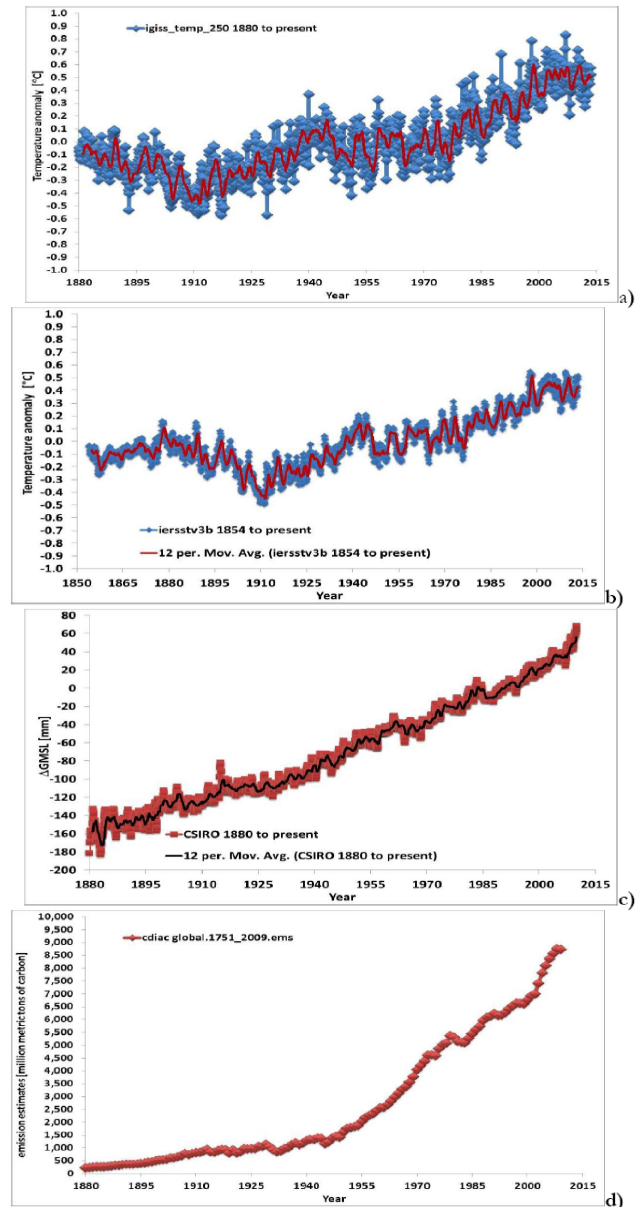

Figure 2 : Comparison of L&S temperatures, SST, GMSL and carbon dioxide emissions: a) GISSL&S reconstructed temperatures (data from[5,6]); b) ERSSTV3b reconstructed SST (data from[5,7]); c) CSIRO reconstructed GMSL (from[8,9]); d) CDIAC Global Fossil-Fuel Carbon Emissions (from[10]).

trend of slope 0.0077 °C/year.

The data set 1880 to present shows same sinusoidal oscillations but around a more complex curve, that may approximated with a 3rd order polynomial or a sinusoidal curve of periodicity 250 years with equal accuracy.

Clearly, there is a different trend in the reconstructed data of L&S temperatures before and after 1910, but there is not enough information to better understand if the post 1910 warming has similarities with prior events in part or in full.

The SST has a similar behaviour to the L&S temperature.

The reconstructed GMSL correlatesrelatively well to the gradient of the anthropogenic carbon dioxide emission, but it does not correlate too much with the reconstructed L&Stemperatures or the SST.

DISCUSSION OF THE RELIABILITY OF THE RECONSTRUCTED TEMPERATURES AND THE WARMING OVER THE LAST CENTURY

The GISS reconstructed temperatures (Figure 1) show the existence of multi-decadal oscillations with a sure close to 63 years periodicity, and possibly a longer periodicity of oscillations close to 250 years (Figure 1.d) or a warming since 1910 (Figure 1.b), that however the data do not permit to evidence more clearly.

The post 1910 warming may be in part a longer term natural oscillation, in part the result of global warming, in part the result of other anthropogenic bias.

As pointed out by[21,22], the global surface temperature records are characterized by climatic oscillations synchronous with specific solar, planetary and lunar harmonics. Over the last 130 – 150 years the shorter periodicity oscillations are superimposed to a background warming that may be related to longer periodicity oscillations or be the result of changes in the chemical composition of the atmosphere[21]. The opportunity of other anthropogenic biases not connected to the carbon emission is mentioned in[21] but not accounted for.

As observed in[21,22], the current climate models, CMIP3 or CMIP5, fail to reconstruct the observed climatic oscillations. Conversely, empirical models that use a specific set of decadal, multi-decadal, secular and millennial astronomic harmonics plus an attenuated anthropogenic forcing through the carbon emission perform much better than the CMIP3 and CMIP5 models[21]. The simple line and cosine or double cosine fitting of Figures 1.b and 1.d already produce better agreement with the reconstructed temperatures than the climate models[3,4].

According to[21], 50-60% of the warming observed over the last century was induced by natural oscillations likely resulting from harmonic astronomical forcings, and not more than 40-50% of the warming was the result of the anthropogenic carbon emission. It is however an open debate how much of this warming is the result of artefacts or localised anthropogenic warming (heat islands, change of land use, waste heat)[3], longer periodicity oscillations or global warming, and the anthropogenic carbon emission may account for much less than that 40-50% of the warming experienced during the last century.

The GISS reconstruction is certainly biased towards much larger warmings for multiple other anthropogenic factors not related to the carbon. This is demonstrated by the many cases of inaccuracies always in the direction of magnifying the present warming[3], with some examples reproposed below.

For the latitude and longitude of Alice Spring, NT of Australia, a remote station without any neighbouring other stations to confuse with, the GISS reconstructed L&S temperature has a gradient 1880 to present of 0.009 °C/year, while the truly measured data is 0.003 °C/year[3].

In 1880, west of the just open Alice Spring, NT of Australia station, not a single measurement was available for the land or the sea of Australia, and the GISS reconstruction show data where data were not available.

While the 2004 to present (March 2013) much more reliable data of ARGO 0 bar SST may be fitted with a line having a slope of -0.0054 ºC/year, the reconstructed ERSST v3b2 SST 2004 to present (June 2013) has a slope of -0.0027 °C/year.

For Melbourne, VIC, Australia the measured temperature subject to severe heat island effects in a downtown location has a gradient of 0.0102ºC/year. The nearby Ballarat, VIC, Australia, less than 100 km away has temperatures exhibiting a gradient of only 0.0014 ºC/year (the minimum temperatures are actually significantly reducing in Ballarat).

Therefore, of the warming experienced over the last century rated at 0.0077 °C/year in the reconstructed signal (Figure 1.b)it is hard to say how much is really related to changes in the chemical composition of the atmosphere, how much it is a longer term natural oscillation and how much it is other anthropogenic bias.

Being this warming the product of two almost identical upwards phases of the quasi-60 years oscillation, from 1910 to 1945 and from 1975 to 2000, the effect of the changes in the chemical composition of the atmosphere are possibly minimal.

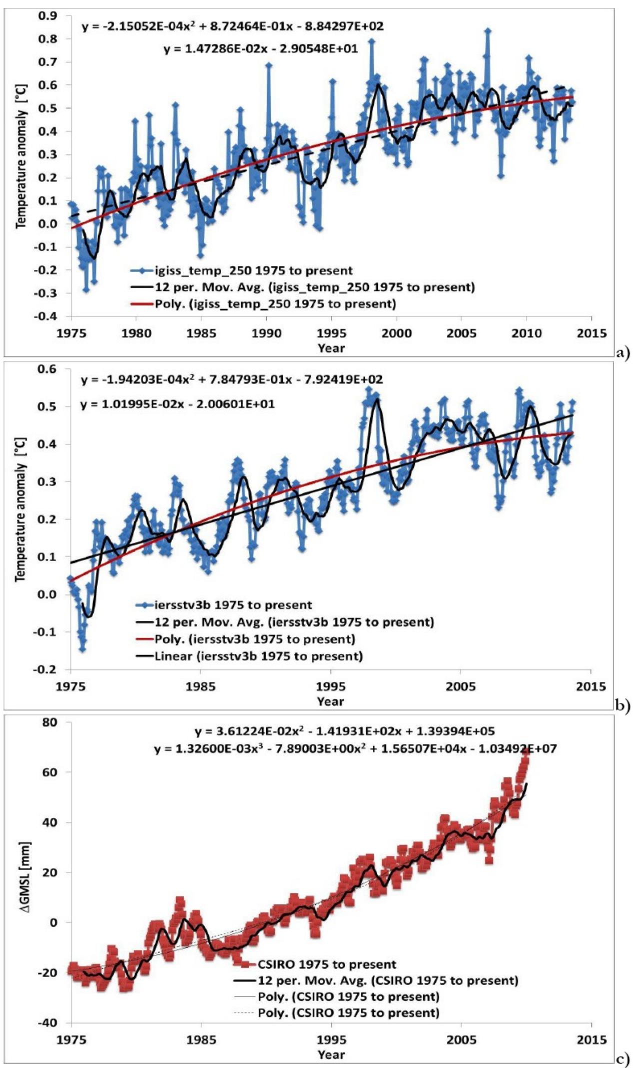

Figure 3 : Comparison of L&S temperatures, SST and GMSL over the period 1975 to present: a) GISSL&S reconstructed temperatures (data from[5,6]); b) ERSSTV3b reconstructed SST (data from[5,7]); c) CSIRO reconstructed GMSL (from[8,9]).

SEA LEVEL ACCELERATION AND TEMPERATURE GRADIENT MISMATCH

The mismatch of sea level acceleration and temperature gradient is clear in Figures 1 and 2 but it become more and more evident focusing on a shorter time window approaching the present time where more reliable data are available.

While the temperatures are oscillating with a quasi-60 years (and very likely longer) periodicity, and temperature gradients 1975 to 2000 were previously experienced 1910 to 1945 ([3,4] and Figure 1), the GMSL is always increasing in time with an always increasing acceleration (Figure 2).

Figure 3 presents the GISSL&Sreconstructed

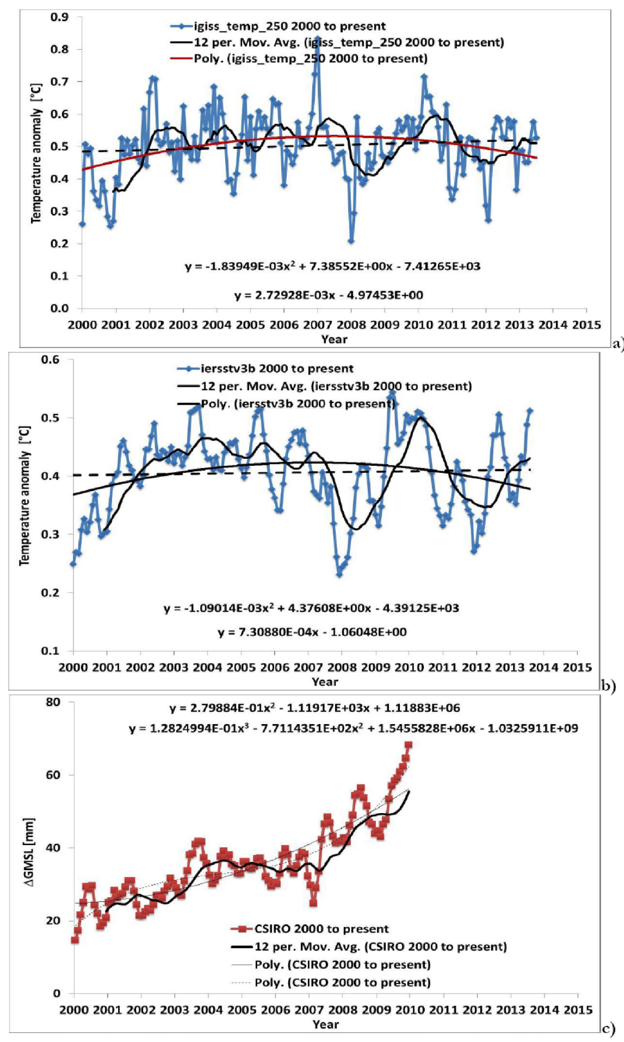

Figure 4 : Comparison of L&S temperatures, SST and GMSL over the period 2000 to present: a) GISSL&S reconstructed temperatures (data from[5,6]); b) ERSSTV3b reconstructed SST (data from[5,7]); c) CSIRO reconstructed GMSL (from[8,9]).

temperatures (data from[5,6]), the ERSSTV3b reconstructed SST (data from[5,7]) and the CSIRO reconstructed GMSL (from[8,9]) over the time window 1975 to present, while figure 4 presents the same temperatures and sea levels over the period 2000 to present. The time window 1975 to present includes the upwards phase of the quasi-60 years oscillation plus part of the downwards phase, the time window 2000 to present only includes this latter downwards phase.

If we consider equation (2) where H=GMSL and t=x, the sea level accelerations should be proportional to the temperature gradients. Therefore, where larger is the temperature gradient, larger has to be the acceleration, and when the temperature gradient vanishes, the acceleration should also vanish.

Linear and polynomial fittings are introduced to evaluate the temperature gradients and the sea level accelerations over the different time windows. Linear fitting of temperatures and 2nd order polynomial fittings of sea levels return the average temperature gradient and sea level acceleration over the time window.

2nd order polynomial fitting of temperatures and 3rd order polynomial fittings of sea levels return the average rate of change of temperature gradient and rate of change of sea level acceleration over the time window.

While the temperatures have a mostly negative rate of change and a reducing gradient, the GMSL has a positive acceleration and the rate of change is positive.

Over the period 1975 to present, the average sea level acceleration of the CSIRO reconstruction is 0.0722 mm/year^2, while the GISS and ERSST temperature gradients are 0.0147 and 0.0102 °C/year.

Over the period 2000 to present, the average sea level acceleration of the CSIRO reconstruction is a much larger 0.5600 mm/year^2, while the GISS and ERSST temperature gradients aremuch smaller 0.0027 and 0.0007°C/year.

TheCSIRO reconstruction returns the largest sea level acceleration on record over a decade of no warming.While the sea level acceleration of the CSIRO reconstruction is always increasing over the two time periods, the temperature gradients are always reducing in the GISS and ERSST reconstructions.

CONCLUSIONS

The reconstructed temperatures 1910 to present show quasi-60 years oscillations around a nearly constant warming trend of 0.0077 °C/year (Figure 1.b). It is hard to say how much of this warming is related to changes in the chemical composition of the atmosphere (global warming), how much it is a longer term natural oscillation and how much it is bias by other anthropogenic factors not related to the chemical composition of the atmosphere.

This warming is the product of two almost identical upwards phases of the quasi-60 years oscillation, from 1910 to 1945 and from 1975 to 2000, separated by a downwards phase 1945 to 1975, that seems to be reproduced since 2000.

The effects of the changes in the chemical composition of the atmosphere are certainly smaller than what is assumed in the CMIP3 and CMIP5 modelsand very likely also smaller than the longer term natural oscillation effect or the effect of other anthropogenic biases.

The oscillating behaviour of the reconstructed temperatures does not match with the always accelerating reconstructed sea levels. The mismatch in between sea level acceleration and temperature gradients is clear from the ensemble of Figures 1 to 4. Sea levels cannot be larger when the temperature gradients vanish than when the temperature gradients are much larger.

This mismatchfurther supports the claim that the sea level reconstructions of[8,9] arevery far from reliable, as previously suggested by comparing the always accelerating GMSL reconstructions with the not accelerating individual long term tide gauges[11-20].

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