Comments on “Episodes of relative global warming, by de Jager en Duhau”

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Abstract
De Jager and Duhau (2009 [dJ-D]) derived a statistical relation between solar magnetic activity and terrestrial Northern Hemisphere (NH) temperatures in the period 1600 – 1995. Surprisingly, they concluded that the late 20th century episode of global warming was similar to earlier episodes of global warming, the difference between observations and their fit being less than about 0.2 °C. On repeating their analysis I found this conclusion to be incorrect. In fact, I obtained a value of about 0.5 °C for the residual, which is larger than the residuals in earlier episodes of relative warming, and therefore remains unexplained in the model considered by dJ-D. The main finding of dJ-D, namely the existence of a (weak) correlation between solar activity and terrestrial temperature in the period 1600 -1900, also follows from the new analysis. However, it seems premature to attribute this to solar magnetic variations, involving an unknown mechanism, since there are several studies explaining NH temperature variations in terms of solar irradiance variations and other known physical processes.

1. Introduction

There exists a significant body of literature on the reconstruction of terrestrial Northern Hemisphere temperature variations in the past millennium. Many additional studies have attempted to understand these variations in terms of known physical mechanisms.

From about 1850 onwards instrumental observations have been made more or less on a routine basis. A typical example of a temperature reconstruction based on these observations with estimates of the accuracy can be found in Brohan et al (2006). The reconstruction of earlier periods is mainly based on palaeoclimatic data. A typical example is Moberg et al (2005). See Figure 1.

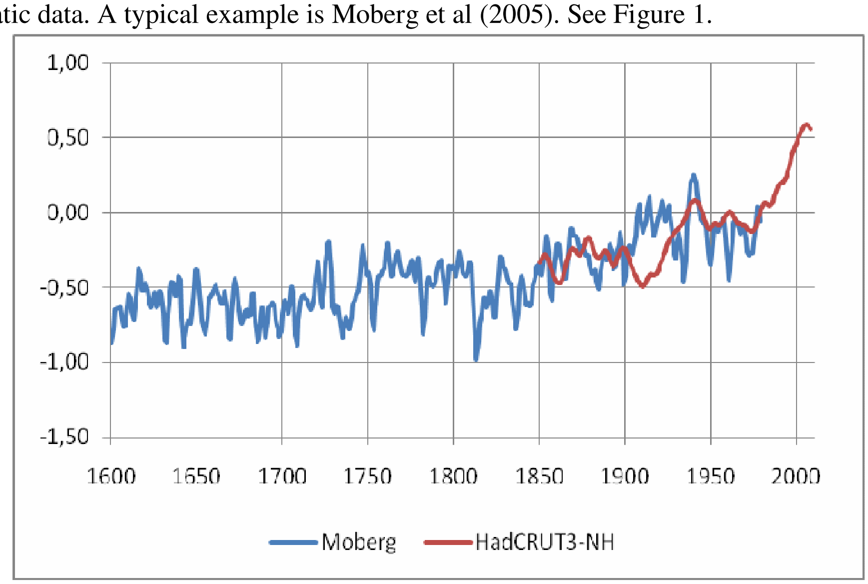

Fig 1 NH temperature variations since 1600 according to two typical reconstructions: Moberg et al (2005) and Brohan et al (2006; HadCRUT3-NH, updated smoothed annual series).

A review of different reconstructions can be found in IPCC (2007) on p241 – 249 for the instrumental observations and on p466 – 469 for the palaeodata. A comparison of millennial temperature reconstructions was also made by Juckes et al (2007).

IPCC (2007; p 476) lists 12 models that have been used to simulate the temperature variations over de last millennium. These models range from rather simple energy balance models to full GCMs and have been driven by reconstructions of volcanic forcings, solar irradiance forcing and 'other forcings'. All models are more or less successful in reproducing the observed variations (see IPCC, 2007, figure 6.14 on page 479), but some of these models have been highly tuned and the accuracy of the reconstructed forcings is limited. Also, all models used preindustrial solar irradiance forcings which are now thought to be too high, and the presumed high climate sensitivity to solar forcing is still a subject of active research (see e.g. Meehl et al, 2009). Nevertheless, the contribution of solar irradiance variations to temperature variations is relatively small. 'Other forcings' (orbital forcing, well mixed Greenhouse gases, tropospheric sulphate aerosols, land use change, etc) are increasingly significant from 1800 onward, but models differ in their representation of these processes. Fig 2 illustrates the complex interplay between different forcings in one particular study (Tett et al, 2007). Using these forcings one can understand past NH temperature variations.

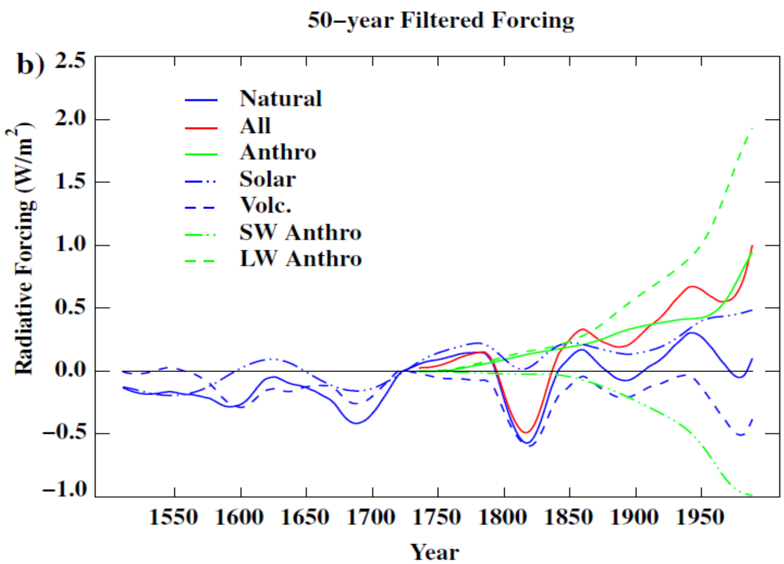

Fig 2 Reconstructed forcings in Tett al (2007).

Recently, de Jager (2008) and de Jager and Duhau (2009; hereafter referred to as dJ-D) have followed an alternative approach, wondering to what extent the NH temperature increase from the 17th century Maunder minimum to the 20th century could be 'explained' by a solar influence. More specifically, they speculate that the high temperatures in the late 20th century are the result of a natural centennial time-scale fluctuation imposed on a slow but significant solar-induced warming. (Note that the temperature rise in the 19th century in the Moberg reconstruction is of the same magnitude as the 20th century rise in the Brohan data .) Ignoring feedbacks in de climate system, a straightforward calculation of the temperature response to the solar irradiance variation between the Maunder minimum in the late 17th century and the early 20th century yields values of approximately 0.1 °C, which is not enough to explain the observed temperature increase. Therefore, they conclude that other than direct variations in solar irradiance should be investigated and they chose to study magnetic variations.

In this approach they speculate that these variations might have an effect on terrestrial temperatures through an unknown mechanism. As a first test of this hypothesis they studied the statistical relation between the NH temperature variations and variations in the toroidal and poloidal solar fields, characterized by two parameters R and aa, assuming the following relationship

$$T = a + b\,R + c\,aa \qquad (1)$$

Using reconstructed values for aa and R and temperature data from seven NH temperature reconstructions in the period 1844 – 1960 they obtained $b = 0.144 \pm 0.031$ and $c = 0.043 \pm 0.009$. They then proceed their analysis by applying equation (1) with these values of b and c to the full period 1600 – 2005, and by studying the residual temperature fluctuations $T_{obs} - T_{fit}$. for the period 1620 – 1995. Some of these residuals can be attributed to volcanic forcings. Of special interest is the magnitude of the residual temperature fluctuation at the end of the 20th century. This was found to be no more than 0.2 °C, which led to the following conclusion. (A) *The amplitude of the late 20th century period of global warming does not significantly differ from other episodes of relative warming.* Obviously, this is at variance with other studies, which have shown that the recent warming is unusual. IPCC (2007; p 702) summarized as follows (B*) It is very unlikely that the 20th-century warming can be explained by natural causes.*

This note addresses the inconsistency between (A) and (B) (section 2) and further considers sun/climate correlations in the period 1600 – 1900 (section 3).

2. How special is the 20th century?

To get a feeling for the results of de Jager and Duhau I have computed T_{fit} from equation (1) and plotted the results together with the NH temperature reconstructions of Moberg et al (2007) and Brohan et al (2007).

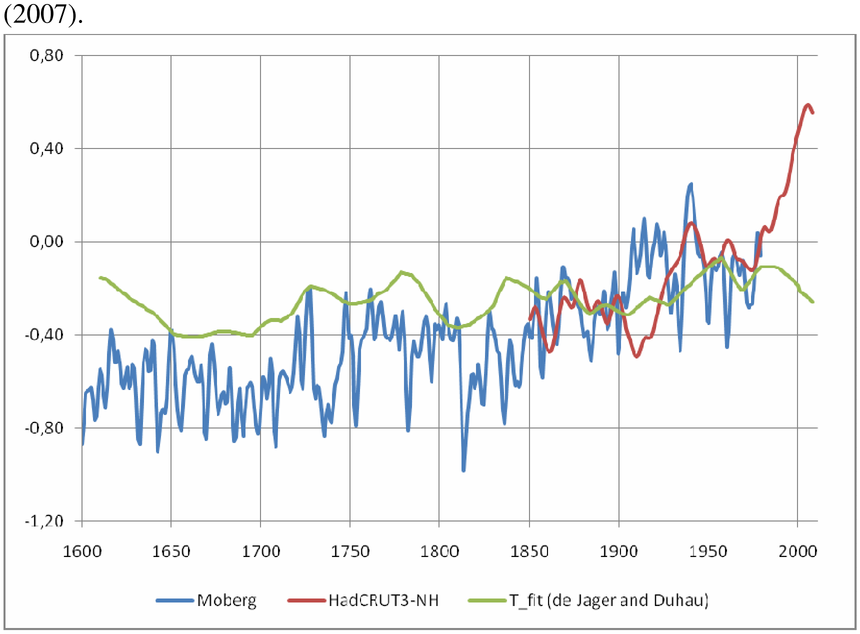

Fig 3 Comparison of NH temperature variations according to two reconstructions [Moberg et al (2005) and Brohan et al (2006)] with the results of de Jager and Duhau (2009) [T_fit].
Vertical axis: temperature variations in degrees centigrade.

For the computation of T_{fit} I have used the same data for R and aa as de Jager and Duhau. Before inserting these into equation (1) they were made dimensionless, normalizing them by the coordinates of the Transition Point in the (R, aa) phase diagram, estimated at 89.7 sunspot units and 9.7 nT (de Jager, private communication). It was understood that the temperature did not require any normalization. The constant a is essentially free, since equation (1) describes variations with respect to an undetermined baseline. I took a = - 0,45, in order to eliminate a bias in the period 1844 – 1960, the period on which the determination of the constants b and c was based.

The results are shown in Figure 3. Quite surprisingly, because in disagreement with the original analysis of dJ-D the late 20th century warming is different in comparison with other episodes of relative warming. In my figure 3 the residual temperature fluctuation in 1995 has a value of 0.45 °C, (reaching 0.66 in the year 2000 and 0.8 in the early 21st century) as compared to 0.2 °C in figure 4 of dJ-D. This is suggestive of a flaw in the original analysis of de Jager (2008) and dJ-D. Further evidence for this came from de Jager (private communication) who was unable to reproduce the original results and indicated that he would want to further study a "fascinating feature in the mathematical technique" as possible cause of the irreproducibility.

My conclusion: the statements by de Jager (2008) and dJ-D concerning the nature of recent warming are NOT supported by their statistical relation between solar magnetic variations and terrestrial temperatures. It is also remarkable that their model, as shown in my Figure 3 overestimates the Moberg data before 1850. In particular, it does not reproduce the temperature trend between the Maunder minimum and the early 20th century, refuting the hypothesis of a slow but significant solar-induced warming.

3. Solar activity and NH temperatures in the period 1600 – 1900

The contested statement of dJ-D was only a by-product of their study. Their main conclusion concerns the existence of a relation between solar magnetic activity and tropospheric temperature, involving both toroidal and poloidal components of solar magnetism. Although the overall correlation is weak, there are some striking correspondences, such as the NH temperature minima during the Maunder minimum (1645 to 1715) and the Dalton minimum (~1835). In figure 3, these period are seen as minima, both in the curve based on solar activity and in the temperature curve. The interpretation of this result is not as straightforward as one might think. There are several complications:

- There is no confirmed causal mechanism that explains the effect of solar magnetic variation on the terrestrial temperature.
- The type of statistical analysis made by dJ-D should preferably start from a period with 1. accurate temperature reconstructions; and 2. negligible anthropogenic forcings. Unfortunately, such a period does not seem to exist. Tett et al (2007) compare their simulation driven by anthropogenic and natural forcings with their natural-only simulation and conclude that anthropogenic forcings have had a significant impact on, particularly tropical, climate since the early nineteenth century.
- Finally, attribution of observed correlation to solar *magnetic* activity will form a major challenge, because such correlation can also be explained with known physical forcings (see IPCC, 2007, p 476, and my brief discussion in section 1 of this note). In these models the NH temperature minima during the Maunder minimum and the Dalton minimum are explained by variations in solar *irradiance* forcing, strengthened by climate feedbacks, but above all by strong volcanic cooling which happened to occur in those periods.

4. Summary of conclusions

This note is written as a quick comment on the papers by de Jager (2008) and dJ-D. It does not present any new results. This would require a longer study involving different datasets and more detailed statistics etc. However, this does not seem essential for reaching the main conclusions

1. The statement by de Jager (2008) and dJ-D concerning the nature of recent warming is NOT supported by their statistical relation between solar magnetic variations and terrestrial temperatures.
2. Correlations between solar magnetic activity and terrestrial NH temperatures are likely to be contaminated by other forcings, not only in the 20th century but also in earlier centuries.
3. Models forced with solar irradiance variations and other established physical mechanisms have successfully simulated the evolution of the NH-temperature in the period under consideration, confirming the existence of a certain amount of correlation between NH temperatures and solar activity, especially in the period prior to the 20th century, where two temperature minima coincide with the Maunder and the Dalton minimum. The magnitude of the temperature variations is consistent with estimates in solar irradiance and volcanic forcing.
4. Attribution to solar magnetic variation through an unknown mechanisms as made by dJ-D seems premature, since the reconstructed NH temperature can also be understood in terms of solar irradiance variations and other known physical processes.

One may hope that a future more detailed analysis announced by De Jager and co-workers will help clarify these issues.

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