



Reply to Benestad’s comment on “Discussions on common errors in analyzing sea level accelerations, solar trends and global warming” by Scafetta (2013)

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I found Benestad (2013, hereafter B13)’s criticism of Scafetta (2013a, hereafter S13) misleading. More significantly, B13 did not find any physical nor mathematical error in S13. Thus, S13’s scientific results remain fully confirmed.

B13 complained that S13 would have misrepresented Benestad and Schmidt (2009, hereafter BS09) because BS09 too argued that the regression models studied in BS09 are flawed because of multicollinearity of the constructors. However, BS09 did conclude that “the most likely contribution from solar forcing a global warming is 7 ± 1 % for the 20th century” using regression models of the global surface temperature. S13 questioned this conclusion and demonstrated that their result is consistent only with outdated *hockey-stick* paleoclimatic temperature reconstructions (e.g. Mann et al., 1999).

BS09 studied two regression models for the 1900–2000 global mean temperature. Equation (1) uses as constructors the solar and GHG forcings, which are collinear because both trend upward: $\langle T \rangle = \alpha_0 + \frac{0.7}{4} \alpha_1 S + 5.35 \alpha_2 \times \ln(\rho) + \mu$ (e.g. Lean and Rind, 2008). Equation (2) uses the 10 GISS forcings, and 9 functions out of 10 are collinear to each other: $\langle T \rangle = \beta_0 + \beta_1 F_S + \beta_2 F_{\text{GHG}} + \beta_3 F_{\text{O}_3} + \beta_4 F_{\text{H}_2\text{O}} + \beta_5 F_{\text{land}} + \beta_6 F_{\text{snow}} + \beta_7 F_{\text{Aer}} + \beta_8 F_{\text{BC}} + \beta_9 F_{\text{Refl}} + \beta_{10} F_{\text{AIE}} + \mu$. The solar contribution to the 20th century warming is estimated to be ~ 10 % using Eq. (1) and ~ 7 % using Eq. (2). The latter result is consistent also with the GISS ModelE prediction (S13, Fig. 6d).

B13 complained that BS09 compared “climate models and observations” that “only included two co-variates”, not 10 as shown in BS09 Eq. (2) and as S13 would have claimed. However, S13 (Table 1) demonstrated that during the 20th century solar forcing is collinear ($r \approx 0.7$) with other 8 constructors taken *singularly*. Volcano forcing was the only exception. A regression model is misleading also if it is based on just two

collinear constructors, as B13 claimed to have done. At the end, BS09’s “7 %” claim is only supported by the GISS ModelE prediction; the result remained not validated by robust data analysis and, therefore, BS09’s argument falls into circular reasoning.

Indeed, demonstrating the multicollinearity flaws of the regression models studied in BS09 was not the ultimate goal of S13. S13 proposed a solution using the regression methodology in a situation where the solar forcing is not collinear ($|r| \lesssim 0.2$) with other forcings (S13, Table 3). Thus, B13 misunderstood S13’s argument that was based on two major results: (1) S13 (Fig. 6) demonstrates that GISS ModelE underestimates the empirical solar signature by a factor varying from 3 to 8; (2) S13 (Fig. 7) demonstrates that BS09’s conclusion that the sun contributed only ~ 7 % of the 20th century warming is compatible only with outdated *hockey-stick* paleoclimatic temperature reconstructions. For example, Mann et al. (1999) temperature reconstruction shows a preindustrial climatic variability of ~ 0.2 °C that implies a very small climatic solar effect. Yet, more recent paleoclimatic temperature reconstructions (e.g. Moberg et al., 2005) show a far greater preindustrial climate variability (~ 0.7 °C), implying a strong climatic solar effect yielding a solar contribution to the 20th century warming comparable with the anthropogenic one. These results fully confirm Scafetta and West earlier works (2005, 2006) that BS09 criticized.

S13 (Sect. 4) demonstrated that BS09 misapplied the Maximum Overlap Discrete Wavelet Transform (MODWT) by erroneously adopting the periodic padding instead of the reflection one yielding Gibbs artifacts. B13 acknowledged BS09’s math error, but surprisingly complained that Scafetta and West (2006) provided insufficient analysis

details. Benestad's opinion is not tenable, however. Using the reflection padding in decomposing trending sequences (e.g. the global surface temperature and the total solar irradiance records from 1900 to 2000) is a standard technique of analysis detailed in Percival and Walden (2000), which was properly referenced in Scafetta and West (2006). Moreover, S13 (Fig. 9) demonstrated that using the erroneous periodic padding yields a severe physical incongruity: the climate cooled when the solar forcing increased from 1995 to 2000. Noting physical incongruities to check calculations is standard practice in time series analysis. Thus, BS09 just misapplied MODWT. Still, B13 claimed that BS09 MODWT errors would not matter. Yet, B13 claim is contradicted by S13 results (Table 6, Figs. 9 and 10) and by standard signal processing strategies aimed to avoid Gibbs artifacts.

B13 argued that "taking the relative magnitudes between two bandpass filtered signals, does not identify a true connection between the two". Yet, the ability of identifying specific (solar-induced temperature) fingerprints depends on the signal-to-noise ratio strength. This strength is very small in the GISS ModelE simulations used in BS09 to test Scafetta's criticized methodology, but not in the temperature records where the methodologies are expected to properly work (Scafetta, 2009, 2013b). Assessing the skill of methods in situations where they work poorly and concluding that in no situation can they work, is logically flawed. In addition, B13 did not acknowledge that Scafetta's attribution was also based on two supporting considerations: (1) on correlation analyses, where the temperature oscillations were found sufficiently synchronous to the correspondent solar oscillations (Scafetta and West, 2005; Scafetta, 2009, 2013b); (2) on comparisons with similar empirical results found in the scientific literature that were obtained with alternative methodologies.

Essentially, B13 argued that attribution results based on data analysis must be rejected simply because they might be coincidental. Yet, regression and filtering methodologies are widely used in science. In absence of math errors, the scientific method requires critics to propose alternative and superior physical explanations to reject an interpretation based on data analysis. Alternative physical proposals to explain the observed climatic oscillations are missing in BS09 and B13.

B13 (last paragraph) wrongly claimed that "S13 further made reference to 'outdated hockey-stick paleoclimatic temperature graphs' with no factual support". Yet, S13 did provide the necessary support by referencing Moberg et al. (2005), Mann et al. (2008), Ljungqvist (2010) and Christiansen and Ljungqvist (2012) that proposed novel paleoclimatic temperature reconstructions demonstrating a far greater pre-industrial climate variability than the original hockey-stick temperature graphs (e.g. Mann et al., 1999). Finally, because most of S13 supporting references were published *after* the 2007 IPCC assessment report, B13 argument that in 2007 the IPCC still supported the original hockey-stick temperature reconstructions cannot be cogently used against S13. Additional critiques of the hockey-stick records were provided also by McShane and Wyner (2011).

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