Comment 6: Model and forecast of Central England temperatures and Atlantic tropical cyclone intensities, and their use for empirical 21st century global temperature forecasts

In order to continue complementing the ESD-2021-84 paper in discussion, with shorter temporal scales, the present comment is mainly associated with the central England and Atlantic tropical cyclone climate reconstructions and their influences on global climate.

Part 1. Central England Temperature (CET)

DATA. The Central England temperature (CET) series is the longest instrumental time series of temperature in the world (Parker et al 1992), with monthly values that extends back to 1659 (MetOffice, 2022). CET annual anomaly values are depicted in Figure 6.2.1.

MODEL. Although during last decades there has been a rapid warming in the CET that appears to be an anthropogenic influence on the climate, however here a new and non-linear Atlantic Multidecadal Oscillation (AMO) model is proposed and applied for the CET.

RESULTS. The modelling non-linear results of the CET are also displayed in Figure 6.2.1 and provide an empirical forecast for annual CET values. The CET non-linear model based on the AMO reconstructed record (Gray et al., 2004) is adjusted linearly and lagged 80 years.

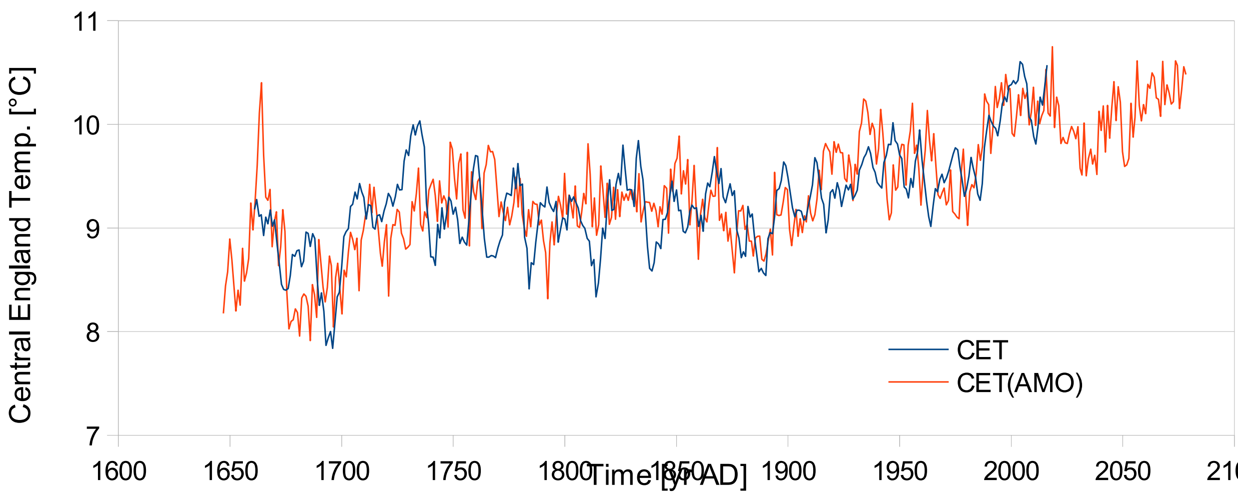


Figure 6.1.1 Central England temperatures (CET) 1660-2100 in annual values. The observed anomalies are modelled considering a AMO lagged analog located 80 yrs after. The analog model is adjusted with a linear transformation, a forced slope and a temporal lineal reduction adjustment of 5%.

APLICATION. The modelling non-linear results of the CET are adjusted to the global temperature (GT) HadCRUT5 record. The GT instrumental recordand the GT(CET) extrapolated record are also displayed in Figure 6.1.2 an empirical forecast for annual GT values.

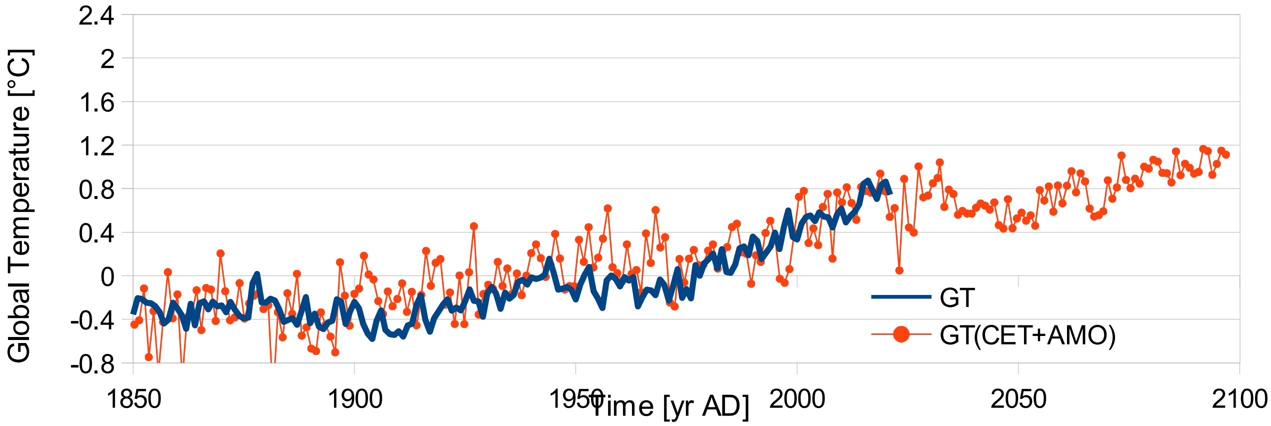


Figure 6.1.2 Global temperatures and its empirical forecast 2010-2100. a) Non-linearly adjusted CET record in annual values to the GT integrated record 238-2010, a temporal expansion of 15% was applied; b) a zoom of a) for the last 5 and next centuries.

This GT[CET(AMO)] model with a lag of around 80 years, can be justified considering previous results. The OCB in its surface currents affects firstly the NW Atlantic and later the NE Atlantic.

Part 2. Tropical cyclone intensification Index (TC-II)

In the following the main aspects of the extended abstract: “An Atlantic Tropical Cyclone Intensification Index for the last 2000 yr: A Significant ~510 yr Climate Cyclic Pulse Reconstructed” presented by the author in the AMS meeting at Orlando, Florida (Sánchez-Sesma, 2008, SS08 hereafter).

Based on historical and instrumental Atlantic Tropical Cyclones (ATC) recently updated records, and hydrological proxy records from the Caribbean, this paper proposes to reconstruct an ATC intensification index (II) for the last 2 millennia

DATA AND METHODS. Three main sources of ATC information were used in this work, one is from the instrumental measurements covering the last one and a half centuries [HURDAT (Landsea, 2005), HD hereafter], a second is the reconstructed record recently updated with Spanish documentary sources for the 1500-1850 period [García-Herrera et al. (2005), GH hereafter], and a third is the oxygen-isotope monsoon rainfall record from U/Thdated stalagmite from the Isthmus of Panama (Lachniet et al, 2004, LA07 hereafter). Instrumental, historical and proxy raw information is displayed in Fig. 6.2.1.

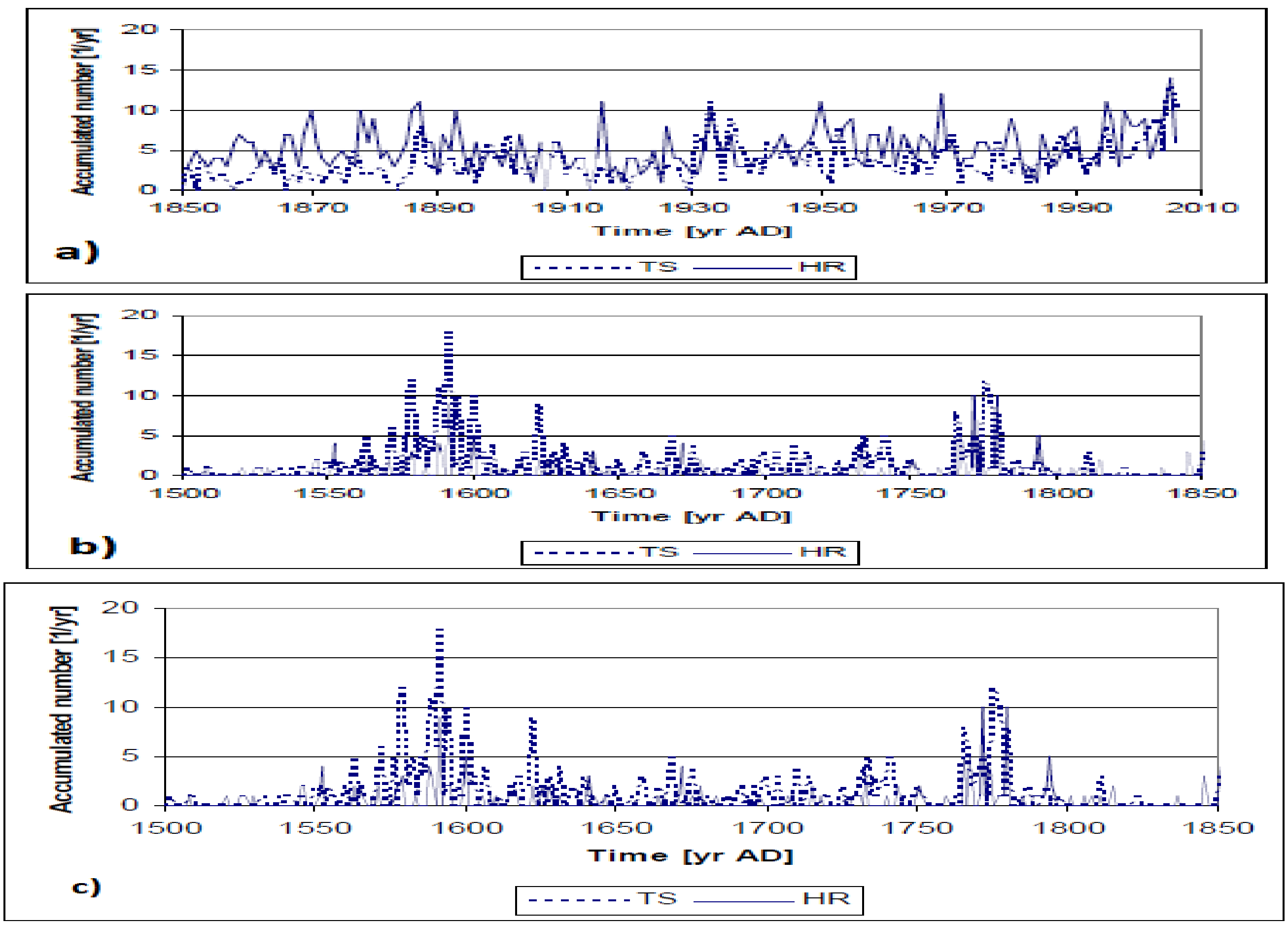


Figure 6.2.1. Raw observed and reconstructed information of TC & storms. a) Annual accumulated number of Atlantic Tropical Cyclones (ATC) as recorded by NOAA in the HURDAT data base (Landsea, 2005); b) Annual accumulated number of Atlantic TCs (ATC) from documentary sources for the period 1500-1850. (García-Herrera et al., 2005); c) A Raw δ18O values of speleothem calcite from Chilibrillo, Panama (LA04).

An Intensification Index(II). Although there is a possible bias due to missing ATC information, its reconstruction during the last 500 years provides important information. If we analyze the relative values of the hurricanes (HR) and tropical storms (TS) collected by GH and HD we can estimate trends and oscillations. To do that, an intensification index for TC is proposed as the following (SS08):

$$II(t)=[HR(t)-TS(t)]/ [HR(t)+TS(t)] \quad (6.1)$$

where II(t) is the annual intensification index value,
HR(t) is the annual number of hurricanes in the ATC records, TS(t) is the annual number of tropical storms in the ATC records, and t is the corresponding year.

The model limits II values which can oscillate between -1.0 and 1.0, when there are only tropical storms or hurricanes, respectively. II values do not change if the same factor is applied both in HR and TS. Thiis aspect is very important to cope with limitations of the colonial historical observations where subestimations could be present due to limited coverage of the Spanish float vayages and land reports.

Reconstruction of II for the last millennia. We evaluated the ATC II defined in eq. 1 over the period as 1500-2006. We applied a moving average filter (MA-21-yr) to the ATC II values to emphasize multidecadal processes. Employing GH and HURDAT archives of historical and instrumental information, respectively, it is possible to evaluate the almost complete ATC II history of the last 500 years. The reconstructed ATC-II values are shown in Figure 6.2.2a. An iterative process that looks for the minimum RMS error adjusted to ATC-II values a sine function with a period of 496 years; it is also shown in this Figure. 6.2.2a. The Atlantic Ocean intensification index (ATC II) defined in Equation 6.1 with annual accumulated values filtered with a 41-yr moving average are displayed in Figue 6.2.1a. In the same Figure, an adjusted sine function with a 496 yr period is also displayed.

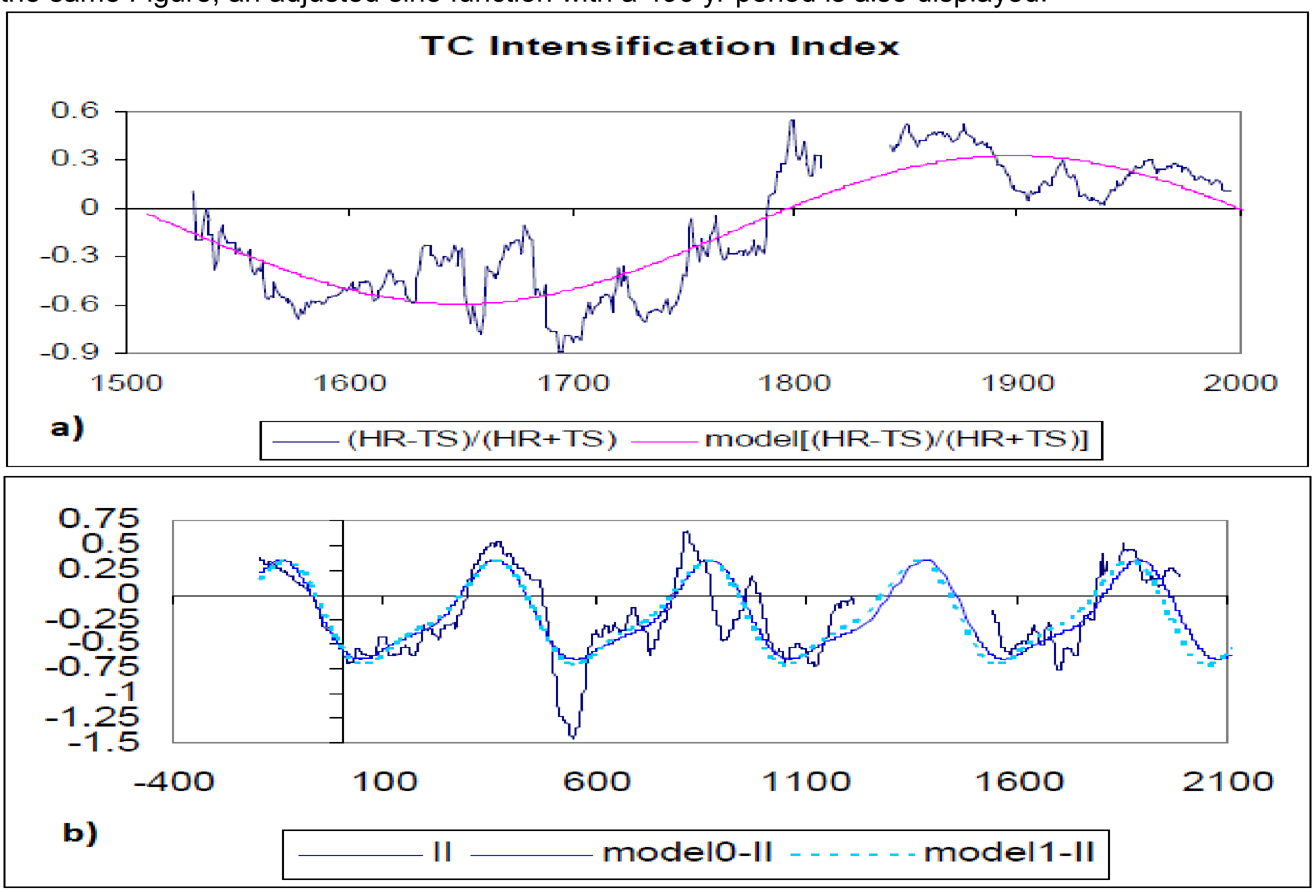


Figure 6.2.2. Results for the Atlantic TC intensification index (ATC II). a) ATC-II based on instrumental and historical information; b) ATC-II based on instrumental, historical and detrended proxy information. In both Figures FS models with P=496 yrs,Ns=1 and P=508yrs, Ns=2, are also displayed in a and b) respectively. Model 0 was based on all data from 231 BC to 1985 A.D. In contrast, model 1 began in the same initial year, 231 BC, but ended in 1310 A.D. The models 0 and 1, explained 67.7 and 65.4% of variance for all the reconstructed period.

Figure 6.2.2b displays ATC-II linearly transformed and 81-yr moving-average proxy record for the speleothem based Central America monsoon record over 1500 yr (180 B.C.-1310 A.D.) obtained by LA04, with the historical and instrumental reconstruction, based on GH and HD data, using a 41-yr moving average on the ATC-II data as previously made.

In order to evaluate the stability of the 500 yr oscillation Fourier series with N=2 was applied both to the detrended Caribbean proxy isotope-based (LA04) and to the directly evaluated ATC-II record. Also, in Figure 6.2.2b two adjusted Fourier series models with period of 508 yrs are displayed. Model 0 was based on all data from 231 BC to 1985 A.D. In contrast, model 1 began in the same initial year, 231 BC, but ended in 1310 A.D. The models 0 and 1, explained 67.7 and 65.4% of variance for all the reconstructed period.

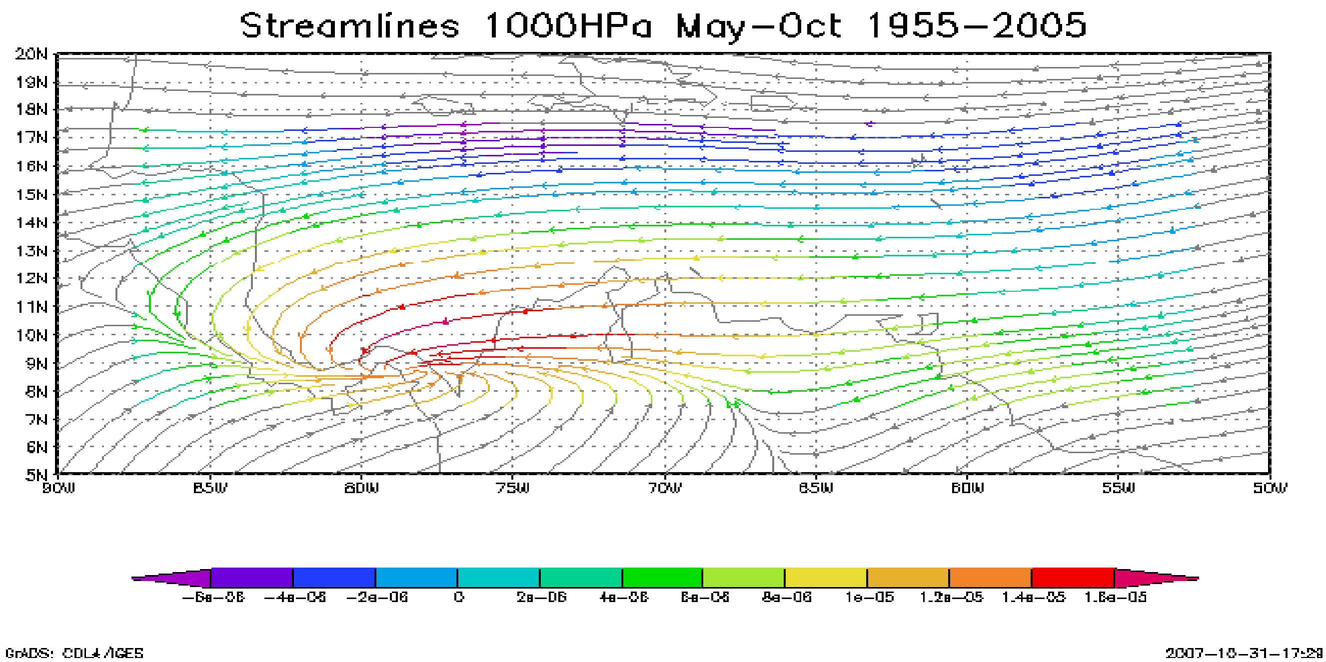


Figure 6.2.3. Surface streamlines for the May-October season during the past 51 years (1955-2005 period) based on the reanalysis information (Kalnay et al 1996).

The importance of the Panamanian stalagmite record for ATC not only is shown with its agreement with tha historical and instrumental ATC-II records, but also is shown, when the mean streamlines at 1000 mb level are displayed for the Caribbean. Based on the reanalysis information (Kalnay et al 1996), Figure 6.2.3 displays these streamlines for the May-October season during the 1955-2005 period. This graphical result shows the influence of the Caribbean (or the main development region of ATC) in the Panamanian zone in which a semi-permanent low center is located.

APLICATION. The integrated record of the ATC-II are adjusted to the global temperature (GT) reconstructed record (Singh et al., 2018). The lagged influences on GT of the ATC-II can be appreciated in the Figure 6.2.4 where the GT reconstructed record (Singh et al., 2018) is overpossed on the lagged (150 yr) ATC-II reconstructed record. This empirical model confirm a GT cooling trend for the next decades.

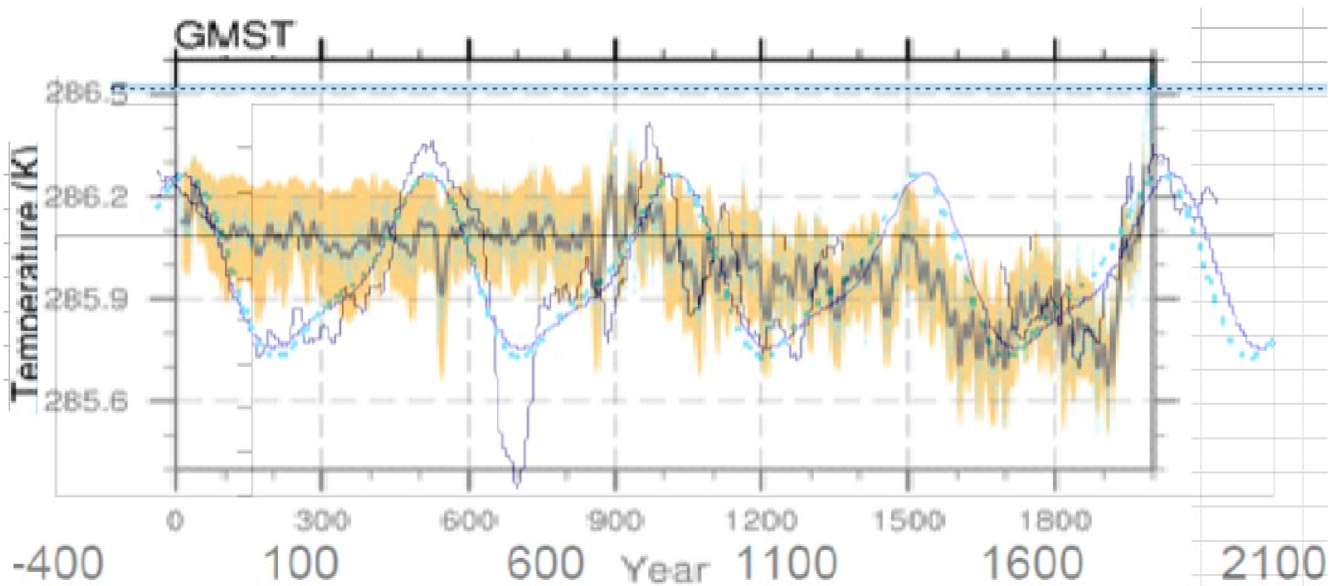
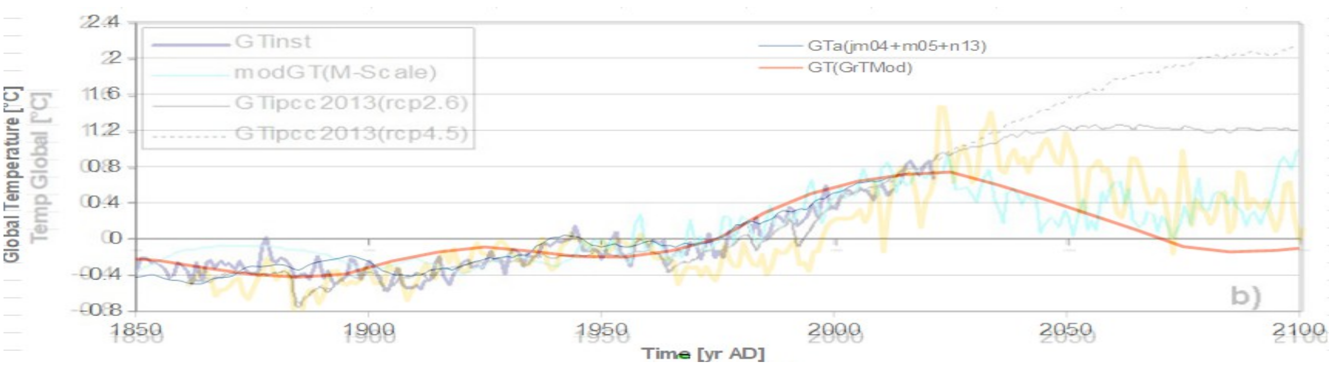


Figure 6.2.4. Global temperatures (Singh et al., 2018) and its empirical forecast 2010-2150. The adjusted model is based on reconstructed and integrated ATC-II.

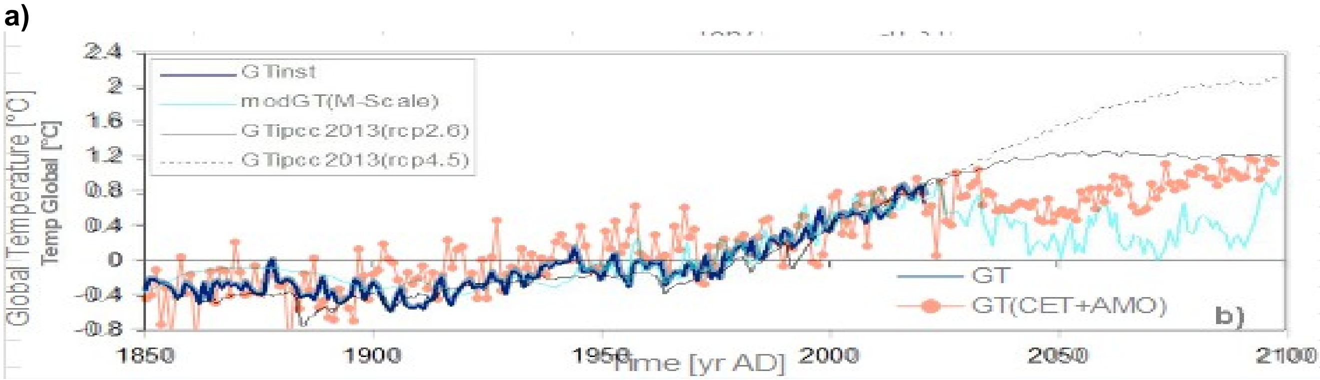
Part 3. New global temperature scenarios based on CET and ATC-II.

A simple comparison of new scenarios estimated in this study (main part of ESD-2021-84 paper in discusion and its four comments) are shown in Figure 6.3.1

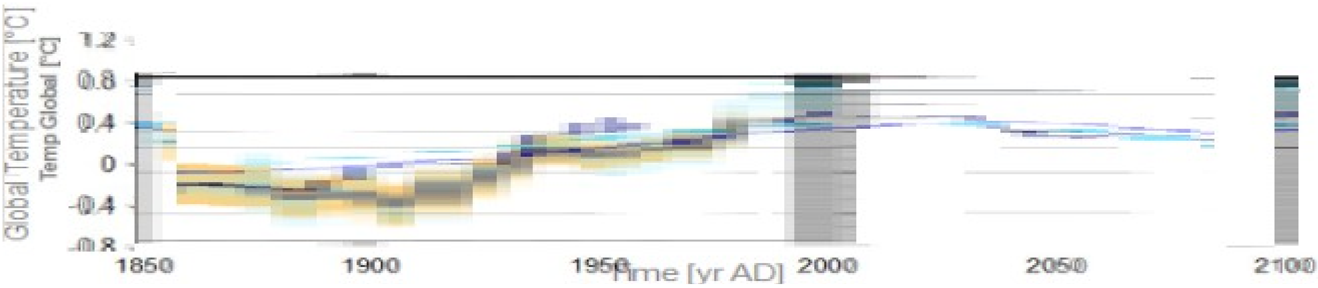
The new GT scenarios, are evaluated considering CET(AMO) and ATC-II as was explained in this comment before.



a)



b)



c)
Figure 6.3.1 Comparison of six global temperature scenarios 1850-2100. An adapted Figure 11b from the paper ESD-2021-84 in discussion with the first scenario estimated (Scenario 0, with cyan line) and the Average rcp0.0 values (Scenario 3 in yellow line) and the modelling of Arctic temperatures (T) (Scenario 4, in red wide line); b) the modelling of central England temperatures (CET[AMO]) (Scenario 7, in red dotted line); c) [a zoom of the Figure 6.2.4] the modelling of ATC-II (Scenario 8, in black line)

Part 4. Preliminary additional conclusions

The two new GT scenarios not only have shown decreasing tempertaures for the next decades,but also confirm the OCB influences over the Atlantic realm.

The two GT models, based on ATC-II and CET(AMO), shown different lags of 150 and 80 years, respectively, that can be justified considering previous results of the OCB influences due to its surface currents. The OCB firstly influences the tropical Atlantic and later the NW Atlantic, and later influence the North Atlantic and global temperature.

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