First of we thank the Referee for his/her helpful comments which allowed to improve the analysis performed in this paper. The changes made on the manuscript are underlined in bold in the new version of the paper.
In the following, our detailed response.

Sincerely,

A. Vecchio, V. Capparelli and V. Carbone

1) The fact that EMD does not capture seasonal oscillations in 1 mode seems to call into question the appropriateness of EMD for analyzing the seasonal cycle. The authors do address this in the text, and the apparent presence of a relationship with nutation suggests that the decomposition is physically meaningful. However, it is not altogether clear how to physically interpret the number of instantaneous frequency excursion events of an IMF that only partially describes the seasonal component of variability (in combination with a second mode). Figure 2 seems to indicate that the method used here essentially detects instances in which seasonal variability (transiently) switches from the j=1 to the j=2 mode. It is not clear why the seasonal cycle at times is transiently expressed in the j=2 mode rather than the j=1 mode, nor how we should physically interpret these events, which appear to have some relationship with nutational variability.

Response: the EMD is a technique highly sensitive to the local frequency (or phase, being omega=d(phi)/dt) fluctuations. In case of regular seasonal cycle, namely when its phase is constant, only one seasonal IMF is detected. On the other side, when the frequency of season locally variates, the EMD identifies two modes for the season. For these cases, the presence of two IMFs depends on the EMD property for which each mode of the decomposition is associated to a well defined time scale. If a given time scale is present only during a small portion of the signal, namely t*, the IMF describing this oscillation will be significantly different from zero only during t*. Since the frequency of the season is slightly different from the expected one during anomalous period, this oscillation is isolated in a single IMF, namely θ_2. Moreover, being the modes orthogonal, the features observed by one mode cannot be found in other IMFs.
The mode j=2 simply provides the value of the "anomalous" frequency and the time intervals in which it occurs. The meaningful quantity is the sum $\theta_1+\theta_2$ describing the full contribution of the seasonal cycle to the temperature record. In this application, the usefulness of EMD resides in its ability to highlight the periods of anomalous seasonal frequency that have been related to variation of the insolation due to the Earth's nutation.
We have to remark that the EMD represents a powerful tool to deseasonalize the temperature record under analysis (see Vecchio and Carbone, PRE in press). In fact, by subtracting $\theta_1+\theta_2$ from the raw record, the seasonal contribution is cut off. This kind of approach is more efficient than the classical deseasonalization procedure involving time averages, since the temperature records are far to be stationary.

To better explain all these concepts we add a brief discussion on page 15542 line 22.

2) P: 15543, line 6: Need to clarify how criteria B is evaluated and what is meant by “identifies the duration of each anomaly”. As written it reads as if the criteria is reached when theta(t) is small, which makes little sense. It may make sense to only use criteria A.

Response: to discuss statistically the results of our analysis over 1167 stations, we needed an automatic and as objective as possible criterion to identify the anomaly occurrence. As an example

we developed two independent methods whose results are consistent. We agree with the Referee comment about the unclear description of the method B and we think that a more complete description of the steps, performed to identify the anomaly occurrence through the method B, would help the comprehension of the paper.
The method B works as it follows:
+ we identify the IMF with a time behavior like those shown in fig2 panel b,for which the amplitude increases in correspondence of the season anomalies.
+the points of each interval where the absolute value of the amplitude exceeds two standard deviations of the chosen IMF are identified.
+for each interval the distance between extreme points, satisfying the previous threshold, defines the duration of the anomaly and identifies it.

We think that two methods strengthen the obtained result, so we prefer to keep in the paper also the method B. The description of the method B has been rewritten in the manuscript to clarify how it works.

3) Criteria A defines an “occurrence” as a time when the local frequency is greater than two standard deviation of its average. Anomalies in phase could, in principle, be either direction (that is, represent either positive or negative excursions in instantaneous frequency). Are anomalies towards small instantaneous phase also seen? Or are all large local extrema in instantaneous frequency in the positive direction?

Response: anomalies are detected toward both small and large instantaneous phases . Criteria A is defined by using the absolute value of frequency. This has been clarified in the new version of the manuscript.

4) P: 15539, line 19: Thomson [1995] showed a local trend in phase towards later seasons at Central England. There was no indication of a global phase trend towards later seasons in his work.

Response: according to the Referee suggestions we rearranged the sentence on P: 15539, line 19 ,

5) P: 15541, line 14: “The 66% of stations show an anomalous seasonal oscillation characterized by intermittent local decreases of the amplitude of the j=1 mode”. How is this assessed? Is this according to criteria A given below? I.e. 66% of station contain at lease one type A “occurrence”?

Response: the method A has been used to calculate this percentage. We have to remark that the criterion B provides a consistent result.

6) P: 15543, line 13: “phase-shift events undoubtedly show an oscillating behavior characterized by a period of about P=18.9 +/- 0.2 yr”. Need to explain how time period of 18.9 was recovered from values shown in figure 3, and basis for statement that the peak is “undoubtable”. Are there any other significant peaks?
8) Figure 4: In figure caption, how “period of modulation” and it’s uncertainty are calculated should be explained. Two methods for assessing the “period of modulation” are referred to, but only one number is reported. How are peaks picked for method A (and how is uncertainty assessed)? Does “by Fourier transform” for method B mean that a significant spectral peak has been found near 1/18.7 years in the periodogram of time series B? Is this the only peak?

Response: since the frequency of the ~18 yr oscillation is close to the Nyquist critical frequency, the value of the period reported in the paper refers to the peak to peak time distance calculated from a sinusoidal fit over the black curve in fig 4. The corresponding uncertainty is derived from the fitting procedure.

For completeness, in the new version of the paper we report a table in which the values of the periods have been extracted in two ways.
The periods are calculated though a sinusoidal fit, over the red and black curve of figure 4, and by identifying the dominant peak in the Fourier periodograms reported in the new figure (fig 5.).

	sin fit	Fourier
Method A	18.8 ± 0.4	20±5
Method B	18.7±0.2	18.5±3.5

The uncertainties have been calculated from the fitting procedure and from the Fourier period resolution at the peaks.

The Fourier spectra reveal other peaks, at low energy with respect the dominant one, corresponding to the following periods:
P1=13.9±0.6 yr; P2=10.1±0.8 yr; P3=8.5±2.1 yr
The periods P1,P2, P3 have correspondence in previous works. I details, P1 is consistent with the ~15 yr periodicity in coastal surface air temperature in the Gulf of Alaska (Wilson R. et al. Clim Dyn. 28:425–440, 2007) attributed to large-scale coherent Pacific climate variability. P2 can be related to the ~11 yr periodicity in ice core sequences (Royer T. C. J Geophys Res, VOL. 98, NO. C3, PAGES 4639-4644, 1993) attributed to solar cycle effects. P3 might be attributed to changing tidal current speeds due to interannual variability of the lunar orbit, in particular to the period of rotation of the lunar perigee around the Earth of 8.85 yr (McKinnell S.M., J Geophys Res VOL. 112, C02002, 2007). It must be remarked that a periodicity of about 7.8 yr has been also found in drought data (Cook E. R. et al, J Clim 10:1343–1356, 1997).

In the new version of the paper we add a more detailed explanation about the period determination and the caption of figure 4 has been rearranged. Moreover a brief discussion about the physical meaning of P1,P2,P3, as reported in previous works, has been added.

7) P: 15543, line 18 and Figure 4: From visual inspection, there clearly appears to be a relationship between the inclination of the moon’s orbit relative to the equatorial plane and the occurrence of annual cycle phase anomalies in the US historical climatology record. However, a quantitative comparison should be made as well and the significance of the relationship should be evaluated.

Response: to make a quantitative estimate of the relationship between the inclination of the Moon’s orbit, relative to the equatorial plane, and the occurrence of phase anomalies the linear Pearson's correlation coefficient has been calculate. The found value is 0.57. In the new version of the paper we add a sentence about this calculation.