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Interactive comment on "Smoothing data series by means of cubic splines: quality of approximation and introduction of an iterative spline approach" *by* Sabine Wüst et al.

Anonymous Referee #1

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The paper by Wüst et al. deals with the use of cubic splines for smoothing of data series that contain a superposition of (different) gravity waves and a background state. The authors describe the dependence of the quality of the spline fit on the number and location of sampling points in relation to the wavelength and phase of the wave, respectively. In the atmosphere the wavelengths of the observed waves are typically not well known before detailed analysis and not constant across the data set. A distinct phase relation may in this case result in large approximation errors of the spline fit. The authors therefore propose an "iterative" approach with variable phase relation. The new method is applied to temperature data from TIMED/SABER and used to derive gravity wave activities. The manuscript is well written and the figures are instructive. On the other hand there is some confusion in the structure and content that needs to be resolved before publication. I describe my concerns in detail below.

Major comments

As the authors describe, splines are mainly used for smoothing of a data series. This can be done to extract a “background state” like a temperature profile undisturbed by gravity waves, to produce a smooth data set including only a subset of waves, or to retrieve the residuals that are then treaded as a wave disturbance and examined further. The purpose of spline fitting largely determines the spline parameters and the quantities that should be evaluated. From my point of view the actual manuscript mixes up between a spline for optimal description of a background (and extraction of waves as residuals) and for optimal wave description (minimizing residuals). For example:

- In line 11 (page 1) the authors mention the approximation of undisturbed conditions, but in line 14 they discuss effects of increasing number of sampling points, even if this obviously contradicts the purpose of getting a background state.

- In line 4/5 (page 2) the authors indeed state the goal of getting a “sufficiently low number of sampling points” to describe the background.

- In Section 3 a much shorter sampling point interval compared to the Introduction is used. Accordingly a wave with small vertical wavelength is examined. Even if residuals between the spline fit and the original are calculated, they are minimized (“approximation error”) in order to get an optimal reproduction of the wave.

- In the case with CIRA and superposed waves (Section 3 and Figure 7) again a very small sampling point distance is used in the example. If the spline shall be used to extract an “undisturbed” profile, I suggest to calculate the squared difference between the fitted and the original CIRA profile, not between the fitted and the disturbed profile.

- In section 4 (p. 7, l. 2) again the “ability of a spline to approximate oscillations” is described, not the smoothing of the oscillations to retrieve the background.

- In Fig. 8, again a larger sampling point distance is applied and the residuals are examined.

- In the Summary (p. 9, l. 8) the “ability of a spline to approximate oscillations” is mentioned, not the ability to reproduce a background state (and wave-induced residuals).

Please clarify.

Minor comments:

- Introduction: I am surprised that the 10 km oscillations appear so steadily in the averaged data. The later analysis suggests that there is a gravity wave with fixed wavelength and phase that comes out in all altitudes and in all years. This is quite unexpected. Effects of changing temperature gradients (p. 8, l. 20) should appear locally in the profiles.

- P. 3, l. 16-18: This sentence structure is rather complicate. I suggest rephrasing and, e.g., separating in two sentences.

- Section 2 (and others): I find the term “iterative” misleading. Typically it is used for some processes where the adaptive change of parameters produces some converging results. What is done here is that the algorithm averages across all phase differences that are possible between sampling points and the shortest resolvable wave.

- Figure 7 b: It would be interesting to see the error also for the non-interative spline fit.

- P. 7, l. 5: If the wavelength of the sine is so close to the shortest resolvable wavelength, this dependence is not surprising. The problem should be much smaller, if less sampling points are applied and the spline is used to extract the residuals.

- P. 7, l. 25: Is it intended to compare the non-iterative and iterative method (Fig. 3 and 6a) or constant or CIRA background (Fig. 7) as suggested in l. 22. For Fig. 7 it should be noted that the scaling of error and sampling point distance differs from the other plots.

- P. 8, l. 1: I do not see that wave activity is less variable compared to higher altitudes. I only see that amplitudes show a much smaller increase with altitude compare to below and above.

- Section 4: In general it would be helpful to see the results of standard and iterative spline fitting also for a single SABER profile, containing a superposition of background and different waves. This may help to understand the mean profiles of non-squared and squared residuals.

- P. 8, l. 17-18: i) It is still surprising that the annual mean residuals ($\sim$500 profiles) show such a pronounced oscillation. Please comment on this. ii) The amplitudes shown in Fig. 8 c) and d) are non-squared averages and the individual residuals should me much larger. On the other hand the iterative approach should have largest effect if the wavelength is close to double the sampling point distance. This should mainly appear in cases of wave approximation and less in cases of background approximation.

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