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Interactive Comment

Interactive comment on "Solar modulation of flood frequency in Central Europe during spring and summer on inter-annual to millennial time-scales" *by* M. Czymzik et al.

Anonymous Referee #1

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General comments:

This paper is an important contribution to the still widely debated topic of detection and attribution of solar forcing in climate records. While attempts to find a solar signal in the mean global temperature generally reveal at most a very weak contribution there is growing evidence for solar effects in the regional weather patterns. This paper analyses the flood frequency recorded in a sediment core of lake Ammersee. It is a good example for such a regional study because it fulfils 3 basic criteria. It covers a considerably long period (5500 years) with a high temporal resolution (1 year). In addition the sediment based flood reconstruction is complemented by an instrumental record of the

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daily discharge of river Ammer upstream of the lake covering the years 1926 to 2002. As a proxy of solar forcing the authors use measured and modelled Total Solar Irradiance (TSI) for the recent period (1926-2002) and the flux of 10Be and the production rate of 14C for older times which reflect the solar magnetic activity with a resolution of 10 to 20 years. The detection is done by correlation and spectral analysis. Although the analysis reveals highly significant results correlation is not the best choice for this task. It is very sensitive to long-term trends. For example, changes in the Earth's orbit modulate the insolation and the flood frequency while changes in the geomagnetic field intensity cause fluctuations of the 10Be flux and the 14C production rate. Spectral analysis is much less sensitive to these perturbations and shows periodicities such as the 11-year Schwabe cycle in the instrumental data and other well known decadal to centennial cycles which can be unambiguously attributed to solar forcing in the sedimentary record. The potential of the spectral detection has not yet been fully exploited and probably could make the case much stronger. As shown by the wavelet spectrum in Fig. 4 these multi-decadal spectral lines are characterized by strong fluctuations in their power. By applying cross- and covariance- wavelet analysis between flood frequency and solar activity one would get much more detailed information about the relationship between the two records. An easier but less informative option would be to replace in Fig. 4 panel c by the wavelet spectrum of either the 14C production rate or the 10Be flux because these two records are very similar and a comparison of both of them with the flood frequency as done in panels b and c does not provide any really new information. However, it would probably worth to consider specifically the pronounced peaks of the 10Be flux and the 14C production rate. These peaks correspond to grand solar minima such as the Maunder minimum and reflect therefore the other extreme of solar forcing compared to the well-studied last decades when the Sun was very active. Finally, the question arises how well the observed correlations with lags of 1-3 years and common periodicities can be attributed to solar forcing. Although only climate models taking into account all the feedback processes and additional forcing factors as well as internal variability can ultimately answer this questions the coinci-

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dence of high flood frequency with low solar activity seems to be consistent with the so-called top-down mechanism which couples dynamically the relatively strong solar effects in the stratosphere into the troposphere causing shifts in the storm tracks. The observed lags can be explained by buffering heat in the North Atlantic. It would be very desirable to use the most advanced climate models and to try to reproduce the observations at least for some interesting periods with large changes in solar forcing and little volcanic activity. Finally it may be worth mentioning that this attribution scenario leading to significant flood changes is also consistent with not finding any significant changes in the mean global temperature.

Specific comments: (page/line)

4834/26 The measured TSI varies typically over an 11-year solar cycle by 0.1% which corresponds to 1.4 Wm-2. This is also visible in the top panel of Fig. 2

Figure 2: Would it not be possible to extend this figure by solar cycle 23? A statement that the data reflect the 11-year solar cycle would be appropriate in the figure caption. Generally the agreement between TSI and river Ammer floods is good, except for cycle 21. Are there any explanations? Usually the time axis points to the right hand side.

4841/22 The statement that further effects beside TSI cannot be ruled out is certainly correct. However, while an influence due to the galactic cosmic rays is very unlikely, it should be mentioned that changes in the spectral distribution of the solar radiation plays an important role in the top-down mechanism as discussed on page 4835. 4842/6 change "… changes in solar activity from the solar cycle to ..." to "… changes in solar activity from the 11-year solar cycle to ..."

Technical corrections: (page/line)

4835/22 Change "Aim of this study is to the investigate…" to "The aim of this study is to investigate…"

Figure 3: The label of the y-axis should be "power", not "spectrum" The label of the

x-axis should have the unit “(1/year)”

4840/15 replace “. . . shielding and the flux . . .” by “. . . shielding the flux . . .”

Figure 4 This figure looks rather busy. An expansion in the direction of the time axis would improve the readability. The grey lines are hardly visible. Again the time axis points to the left hand side.

Interactive comment on Clim. Past Discuss., 11, 4833, 2015.