LETTER

Reply to Screen and Simmonds: From means to mechanisms

Our recent article on quasiresonant amplification of planetary waves (1) has been addressed in a letter by Screen and Simmonds (2). They report, in particular, that they do not find statistically significant trends in the mean amplitudes of $m = 6$–8 waves in the 1979–2012 period. This observation does not contradict the statements made in our paper–it actually complements our work and helps to clarify several important issues:

First, note that we present very similar results in figure 3 of ref. 1, where the linear trends are shown as dotted lines.

Second, let us repeat here that the 32-y period analyzed in our study is too short to draw firm conclusions regarding the statistics of high-amplitude events, because the number of these events is small. We found that half of the quasiresonant events since 1980 have occurred since 2003 (figure 3 of ref. 1), but we do not claim that this recent cluster represents a statistically significant trend; it could also be due to random variability. In either case, it is not associated with a trend in the mean wave amplitudes, nor does a change in the tail of the probability distribution require any trend in the mean.

Third, and this is our crucial point, our paper is about the physics, not statistics, of extreme events. We propose a physical mechanism based on planetary wave theory, which can generate extreme weather situations in a distinctive way, namely through quasiresonant amplification (3). We find that a large part of the occurrences with high-amplitude $m = 6$–8 wave events happened under the derived resonance conditions (see again figure 3 in ref. 1), whereas resonance conditions rarely occurred during months without high wave amplitudes.

Finally, regarding possible nonstationarity, we stated in ref. 1 that "there exist some indications for more favorable conditions for the occurrence of the above peculiarity in the shape of U in recent decades." This sentence referred to an observed change in the large-scale shape of the zonal winds that would support resonance generation. We also argued that the generation mechanism might be affected by various subtle processes (such as differential warming) associated with anthropogenic climate forcing. These arguments in our discussion section are based on the consideration of the pure physics involved.

In summary, we feel we identified a physical mechanism that helps to understand the exceptional nature of many recent extreme events associated with persistent (quasistationary; see ref. 3) large-scale weather patterns. How this mechanism may affect the future incidence of such events clearly requires further study. Linear trend assessment as presented by Screen and Simmonds does not call into question any of our results.

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1 Petoukhov V, Rahmstorf S, Petri S, Schellnhuber HJ (2013) Quasiresonant amplification of planetary waves and recent Northern Hemisphere weather extremes. *Proc Natl Acad Sci USA* 110(14): 5336–5341.

2 Screen JA, Simmonds I (2013) Caution needed when linking weather extremes to amplified planetary waves. *Proc Natl Acad Sci USA*, 10.1073/pnas.1304867110.

3 Palmer TN (2013) Climate extremes and the role of dynamics. *Proc Natl Acad Sci USA* 110(14):5281–5282.

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The authors declare no conflict of interest.

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