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Annual carbon-14 variability in tree-rings: Causes and Implications for the calibration curve

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Various 14C excursions apparently caused by an increase of incoming cosmic rays on a short time-scale found in the Late Holocene have generated widespread interest and have been reproduced in many different tree-ring records (Miyake et al. 2012, 2013 2017; Büntgen et al. 2018). The excursions at AD 774-775AD 993-994 are well-documented but with an increasing number of studies using annual 14C analysis a range of new structures are being revealed. This includes rapid increase events such as at 660BC (Park et al. 2017) and 3372BC (Wang et al. 2018) likely due to extreme solar proton events (SPE). However, other types of change in 14C production seem more likely the result of other solar processes, such as around 5480BC (Miyake et al. 2017),and in the sixteenth century BC (Pearson et al. 2018) and 815BC (Jull et al. 2018). A diverse range of processes have the potential to effect cosmic-ray flux, including solar events, gamma-ray bursts, geomagnetic shifts and supernova. While research on the latter has proved inconclusive (Dee et al. 2017), such studies are providing a wealth of new information through which to characterize new ‘events’ in 14C structure and to begin to understand the processes behind them. This research has much modern relevance in terms of understanding solar-climate forcing as well as the potential damages to technology brought about by events such as solar flares. These effects are also highly relevance to dating using the current international radiocarbon calibration curve based on decadal data. The difference in the shape of a calibration curve based on annual data (see Pearson et al. 2018) demonstrates potential to improve the calibration process using annually-derived data but also indicates that error ranges will likely be increased with a more undulating curve which features the range of structural variability. Finally, a large amount of new annual data provides exciting new opportunities to explore aspects of accuracy and precision between labs and to explore the complex issue of regional 14C variability in greater detail than ever before. We highlight the importance of these annual data to improve the international radiocarbon calibration, and how these improvements may affect evaluation of radiocarbon data. Such an effort requires a broad-based international collaboration to address this complex issue.