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A modelling approach to assessing the timescale uncertainties in proxy series with chronological errors

D. Divine (1,2), F. Godtliebsen (1,2), and H. Rue (3)

(1) Department of Mathematics and Statistics, University of Tromso,Tromso, Norway, (2) Norwegian Polar Institute, Tromso, Norway (dima@npolar.no), (3) Department of Mathematical Sciences, Norwegian University of Science and Technology, Trondheim, Norway

Detailed knowledge of past climate variations is of high importance for gaining a better insight into the possible future climate scenarios. The relative shortness of available high quality instrumental climate data conditions the use of various climate proxy archives in making inference about past climate evolution. It, however, requires an accurate assessment of timescale errors in proxy-based paleoclimatic reconstructions. We here propose an approach to assessment of timescale errors in proxy-based series with chronological uncertainties. The method relies on approximation of the physical process(es) forming a proxy archive by a random Gamma process. Parameters of the process are partly data-driven and partly determined from prior assumptions. For a particular case of a linear accumulation model and absolutely dated tie points an analytical solution is found suggesting the Beta-distributed probability density on age estimates along the length of a proxy archive. In a general situation of uncertainties in the ages of the tie points the proposed method employs MCMC simulations of age-depth profiles yielding empirical confidence intervals on the constructed piecewise linear best guess timescale. It is suggested that the approach can be further extended to a more general case of a time-varying expected accumulation between the tie points. The approach is illustrated by using two ice and two lake/marine sediment cores representing the typical examples of paleoproxy archives with age models constructed using tie points of mixed origin.