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Modelling Grain-Size Distributions of Aeolian Dust with Finite Mixture Models - Power and Pitfalls

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Grain-size distributions obtained in sedimentary sequences are a palaeoclimatic proxy that has attracted increasing interest during the last decades. Different sources and transport and deposition mechanisms lead to a varying shape which may be interpreted in terms of climate variability. To extract the palaeoclimatically relevant information, a non-parametric decomposition of the size-frequency data is often performed (e.g., within the framework of the so-called endmember modelling). Alternatively, a parametric description of the distribution function may allow access to climate variability via changes of the resulting parameters, yielding a more direct interpretation of the record in terms of climatic parameters.

Whereas grain-size distributions of sediments from a unique source of material may be (under some idealizations) described by standard functions like log-normal or Weibull (Rosin-Rammler) distributions, sedimented grains from geological sequences (but also dust particles confined in ice cores or advected by present atmospheric circulation) frequently show a multimodal size distribution which cannot be explained by a pure source, but requires a mixture of appropriate components. Such multimodal real-world grain-size distributions can be parametrically described in terms of finite mixture models whose parameters may be calculated by appropriate statistical methods, e.g., the expectation-maximization algorithm. However, whereas the best-fit parameters of the corresponding model distributions are often considered, their corresponding uncertainty as well as the uncertainty of the entire model is usually not discussed.

In our presentation, we demonstrate that there is no standardized procedure to find the optimum number of components in such a mixture model. Even in models with only

few components, the parameter uncertainty arising due to the component overlap may be of an order which does not allow to palaeoclimatically interpret the variations of parameters. We illustrate these pitfalls on different records of aeolian dust deposits. Possible generalizations of our findings to the application of non-parametric decomposition techniques are outlined.