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Reply to Comment on “The Misorientation index: Development of a new method for calculating the strength of lattice-preferred orientation”

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We welcome the opportunity to respond to the comments made by Professor Schaeben regarding our recent paper (Skemer et al., 2005), in which we point out some practical issues that arise during the calculation of the J-index (or texture index) and propose an alternative method (the M-index) for quantifying the strength of lattice-preferred orientation. Professor Schaeben has made a number of excellent points, which we will address individually, however we should preface our remarks with a statement on the intentions of the paper, as they appear to have been misinterpreted by Professor Schaeben. It was not our intention to replace or discount the texture index or reinvent the field of texture analysis. Our intention was simply to advise the Earth science community of the practical shortcomings of the texture index, and provide an alternative, simple, and intuitive metric to characterize the strength of lattice-preferred orientation. While the M-index is not a perfect measure of fabric strength, we believe that it is convenient and useful for most Earth science applications.

The first comment by Professor Schaeben is that one cannot describe “a three-dimensional entity with one single number.” We agree entirely. Indeed, we note in the conclusion of our paper that a scalar can never completely characterize all features of a fabric, because a fabric is not a scalar quantity. Both the M-index and the texture index are scalars, and as such only contain partial information about a fabric. To quantify the strength of lattice-preferred orientation, it is not essential that all of the textural details of the orientation distribution function (ODF) be reproduced.

Professor Schaeben then comments on the advantage of “geostatistics” over classical statistics. Again, we do not disagree. In theory, one would like to understand how orientation data are distributed in space. However, given the practical limitations of most Earth-science data, we have applied the common mathematical abstraction of removing spatial information from the dataset. Removing this information necessarily limits what we may conclude about a given dataset, but from a practical perspective rarely compromises our ability to characterize lattice-preferred orientation.

Professor Schaeben’s subsequent comments refer to the necessity of truncating the spherical harmonic expansion in the texture index. He states that it is inappropriate to truncate the expansion at degrees “as small as 2 to 34.” As we emphasized in the paper, the decision of where to truncate the expansion depends

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largely on the scale of the features of interest (c.f., Bunge, 1982). Professor Schaeben notes, in apparent agreement with our observations, that biases to the estimator of the texture index are introduced by the truncation of the spherical harmonic expansion, and by the numerical necessity of binning data. We were, admittedly, unaware of the recent thesis by Boogaart (2001) in which procedures were derived to correct for these biases. These corrections certainly enhance the utility of the texture index.

The suggestion that the M-index be normalized is reasonable.

$$M' = \chi^2 \equiv \sum_{i=1}^{n} \frac{(R_i^O - R_i^T)^2}{R_i^T} \quad (1)$$

The advantage of a chi-squared test is that it can be used to determine the significance of the difference between two distributions (e.g. Davis, 1973). However, in most cases we are simply describing the strength of a fabric, rather then asserting that a fabric is non-random. A chi-squared formulation is extremely sensitive to singularities that may occur when the expected values of the reference distribution are small. Indeed, in highly deformed samples one frequently observes a modest number of very small (<1°) uncorrelated misorientation angles (R^O), whereas in a random fabric the expected frequency of these very small misorientation angles (R^T) approaches zero. This makes it difficult to distinguish between various highly deformed samples. The original formulation of the M-index:

$$M \equiv \sum_{i=1}^{n} \left| R_i^T - R_i^O \right| \cdot \frac{\theta_{\max}}{2n} \quad (2)$$

does not contain any singularities and is therefore preferable as an estimator of fabric strength for a broad range of deformed samples.

In conclusion, we wish to emphasize that the derivation of the M-index was a practical decision based on the nature of data typically available in the Earth-sciences. As we are often restricted to studying systems for which there are only a small number of data, it is desirable to have a metric for fabric strength that does not require thousands or tens of thousands of discrete data (Matthies and Wagner, 1996). Even if corrections to the texture index can account for variously sized datasets and other numerical artifacts (Boogaart, 2001), it is still preferable to have a metric for which no extrapolation is required. Professor Schaeben's objections to the M-index appear to be rooted in the fact that spatial and textural information is lost from the original dataset during the analysis. Certainly, there may be important information contained in the ODF that is left unexamined when the M-index method is applied. We look forward to future contributions that inform us of the utility of this information.

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