BATH'S LAW AND THE GUTENBERG-RICHTER RELATION

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Abstract. We revisit the issue of the so called Bath's law concerning the difference D_1 between the magnitude of the mainshock, M_0, and the second largest shock, M_1, in the same sequence, considered by various authors, in the past, approximately equal to 1.2. *Feller* demonstrated in 1966 that the D_1 expected value was about 0.5 given that the difference between the two largest random variables of a sample, N, exponentially distributed is also a random variable with the same distribution. *Feller*'s proof leads to the assumption that the mainshock comes from a sample, which is different from the one of its aftershocks.

A mathematical formulation of the problem is developed with the only assumption being that all the events belong to the same self-similar set of earthquakes following the Gutenberg-Richter magnitude distribution. This model shows a substantial dependence of D_1 on the magnitude thresholds chosen for the mainshocks and the aftershocks, and in this way partly explains the large D_1 values reported in the past. Analysis of the New Zealand and PDE catalogs of shallow earthquakes demonstrates a rough agreement between the average D_1 values predicted by the theoretical model and those observed. Limiting our attention to the average D_1 values, Bath's law doesn't seem to strongly contradict the Gutenberg-Richter law. Nevertheless, a detailed analysis of the observed D_1 distribution shows that the Gutenberg-Richter hypothesis with a constant b-value doesn't fully explain the experimental observations. The theoretical distribution has a larger proportion of low D_1 values and a smaller proportion of high D_1 values than the experimental observations. Thus Bath's law and the Gutenberg-Richter law cannot be completely reconciled, although based on this analysis the mismatch is not as great as has sometimes been supposed.