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Fair scores for ensemble forecasts

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We introduce the concept of fair scores for verifying ensemble forecasts. As proper scores reward probability forecasts when the verifying observations behave as if they are sampled from the forecast distribution, so fair scores reward ensemble forecasts when the verifying observations and ensemble members behave as if they are sampled from the same distribution. We define a general class of fair scores for ensembles of binary outcomes, and use this to construct classes of fair scores for ensembles of multi-category and continuous outcomes. We show that the usual Brier, ranked probability, and continuous ranked probability scores for ensemble forecasts are unfair, while adjusted versions of these scores are fair.