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Statistical consensus methods improve the predictive performance of spatial models in geomorphology

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Currently, statistical models, which relate the spatial distribution of landforms and processes with environmental conditions, are widely used in geomorphological mapping. However, because models are the result of both simplification and imperfect representation of reality, model predictions may be tainted by errors. In this study, we evaluated the ability of four statistical consensus methods (namely Median(All), Mean(All), Best and Weighted Average) to improve the accuracy of predictions based on models. The spatial distributions of twelve geomorphological features were recorded at a 500 x 500 m resolution in subarctic Finland. Nine topographical, surficial ground material and land cover variables were used to predict the distribution of geomorphological features using eight widely used "single-modelling" techniques [including Generalized Linear Models (GLMs), Generalized Boosting Method (GBM), Generalized Additive Models (GAMs), Classification Tree Analysis (CTA), Artificial Neural Network (ANN), Multivariate Adaptive Regression Splines (MARS), Mixture Discriminant Analysis (MDA) and Random Forest (RF)]. The outputs of the single-models (i.e. probability values of occurrence) were combined using consensus algorithms. The accuracy of the predictions was evaluated on spatially independent data by the area under the curve (AUC) of a receiver operating characteristic (ROC) plot. The mean AUC values of the eight single-models varied between 0.711 (CTA) and 0.755 GAM), whereas mean AUC values of consensus methods ranged from 0.752 [Median(All)] to 0.784 [Mean(All)]. Consensus methods based on the average function were the most efficient to improve the accuracy of the predictions. For eleven geomorphological features out of twelve, Weighted Average and Mean(All) provided more accurate predictions than those based on the best single-modelling technique (GAM). The results of this study suggest that consensus methods are powerful to increase the accuracy of predictive models. These methods should be used more often in applied and theoretical geomorphology.