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Evaluating the Accuracy of Biologically Relevant Variables Generated by ClimateAP

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Abstract : Climate data quality significantly affects the reliability of ecological modeling. In the Asia Pacific (AP) region, low-quality climate data hinders ecological modeling. ClimateAP, a software developed in 2017, generates high-quality climate data for the AP region, benefiting researchers in forestry and agriculture. However, its adoption remains limited. This study aims to confirm the validity of biologically relevant variable data generated by ClimateAP during the normal climate period through comparison with the currently available gridded data. Climate data from 2,366 weather stations were used to evaluate the prediction accuracy of ClimateAP in comparison with the commonly used gridded data from WorldClim1.4. Univariate regressions were applied to 48 monthly biologically relevant variables, and the relationship between the observational data and the predictions made by ClimateAP and WorldClim was evaluated using Adjusted R-Squared and Root Mean Squared Error (RMSE). Locations were categorized into mountainous and flat landforms, considering elevation, slope, ruggedness, and Topographic Position Index. Univariate regressions were then applied to all biologically relevant variables for each landform category. Random Forest (RF) models were implemented for the climatic niche modeling of Cunninghamia lanceolata. A comparative analysis of the prediction accuracies of RF models constructed with distinct climate data sources was conducted to evaluate their relative effectiveness. Biologically relevant variables were obtained from three unpublished Chinese meteorological datasets. ClimateAPv3.0 and WorldClim predictions were obtained from weather station coordinates and WorldClim1.4 rasters, respectively, for the normal climate period of 1961-1990. Occurrence data for Cunninghamia lanceolata came from integrated biodiversity databases with 3,745 unique points. ClimateAP explains a minimum of 94.74%, 97.77%, 96.89%, and 94.40% of monthly maximum, minimum, average temperature, and precipitation variances, respectively. It outperforms WorldClim in 37 biologically relevant variables with lower RMSE values. ClimateAP achieves higher R-squared values for the 12 monthly minimum temperature variables and consistently higher Adjusted R-squared values across all landforms for precipitation. ClimateAP's temperature data yields lower Adjusted R-squared values than gridded data in high-elevation, rugged, and mountainous areas but achieves higher values in mid-slope drainages, plains, open slopes, and upper slopes. Using ClimateAP improves the prediction accuracy of tree occurrence from 77.90% to 82.77%. The biologically relevant climate data produced by ClimateAP is validated based on evaluations using observations from weather stations. The use of ClimateAP leads to an improvement in data quality, especially in non-mountainous regions. The results also suggest that using biologically relevant variables generated by ClimateAP can slightly enhance climatic niche modeling for tree species, offering a better understanding of tree species adaptation and resilience compared to using gridded data.

Keywords : climate data validation, data quality, Asia pacific climate, climatic niche modeling, random forest models, tree species
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