Incorporating spatial autocorrelation into species distribution models alters forecasts of climate mediated range shifts

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Abstract: Species distribution models (SDMs) are widely used to forecast changes in the spatial distributions of species and communities in response to climate change. However, spatial autocorrelation (SA) is rarely accounted for in these models, despite its ubiquity in broad-scale ecological data. While spatial autocorrelation in model residuals is known to result in biased parameter estimates and the inflation of Type I errors, the influence of unmodeled SA on species' range forecasts is poorly understood. Here we quantify how accounting for SA in SDMs influences the magnitude of range shift forecasts produced by SDMs for multiple climate change scenarios. SDMs were fitted to simulated data with a known autocorrelation structure, and to field observations of three highly spatially autocorrelated mangrove communities from northern Australia. Three modelling approaches were implemented: environment-only models (most frequently applied in species' range forecasts), and two approaches that incorporate SA;autologistic models and residuals autocovariate (RAC) models. Differences in forecasts among modelling approaches and climate scenarios were quantified. While all model predictions at the current time closely matched that of the actual current distribution of the simulated organism and the mangrove communities, under the climate change scenarios environment-only models forecast substantially greater range shifts than models incorporating SA. Furthermore, the magnitude of these differences intensified with increasing increments of climate change across the scenarios. When models do not account for SA, forecasts of species' range shifts indicate more extreme impacts of climate change, compared to models that explicitly account for SA. Therefore, where biological or population processes induce substantial autocorrelation in the distribution of organisms, and this is not modelled, model predictions will be inaccurate. These results have global importance for conservation efforts as inaccurate forecasts lead to ineffective prioritization of conservation activities and potentially to avoidable species extinctions.