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Rafael Falquina, Clemente Gallardo

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Development and application of a technique for projecting novel and disappearing climates using cluster analysis

Rafael Falquina[1*], Clemente Gallardo[2]
1 Universidad Complutense de Madrid, Facultad de Ciencias Físicas, Av. Complutense s/n, 28071 Madrid, Spain.
2 Universidad de Castilla La Mancha Facultad de Ciencias Ambientales y Bioquímica, Av. Carlos III s/n, 45071 Toledo, Spain
*Corresponding author

Abstract

We present an objective climate classification method based on cluster analysis, and its application for the assessment of local impact of the projected global climate change in the RCP8.5 IPCC AR5 scenario. The novelty of the method is in the use of cluster analysis to identify novel and disappearing climates. We detect the absence of a climate type by classificating the local climates of two different time periods in a single cluster analysis. If any of the resulting clusters contains only local climates taken from one of the time periods, the climate type represented by that cluster is not present in the other time period. We present the application of this method to the ends of the 20th and 21st centuries on a global scale, and the results of the equivalent analysis restricted to a circle of 500 km radius around each location. They show that, in large areas, many current ecosystems would not find 20th century conditions in a near place at the end of 21st century.

Keywords: climate change; cluster analysis; climate classification

1. Introduction

Since the detection of climate change induced by human activity, there has been considerable interest in forecasting how it will affect both natural and managed ecosystems (Lobell et al., 2011; Ohlemüller et al., 2006; Torregrosa et al., 2013; Williams et al., 2007). Despite the efforts to directly model wild and domesticated species adaptation to changing climate conditions this has revealed as a difficult task due to lack of data and intricate species interactions among themselves and with non-climatic factors (Araújo and Peterson, 2012; Ewert et al., 2015; Ohlemüller et al., 2006). Many authors have followed an alternative approach based on the correspondence between species ranges and climate. This correlation has been the base for pioneering climate classifications (Köppen, 1936) and many later classifications (e.g. (Budyko, 1961; Cowie, 1980; Geiger, 1961; Thornthwaite, n.d.)), where climate data characterization and associated vegetation were used interchangeably for the definition of a climate. Based on this correlation one can assess the risk faced by species based on the evolution of climate availability (Garcia et al., 2016), at least as a first estimate.

Different authors have proposed several methods to assess the regional climate change in terms of simulated climate variables trends. In general, those methods quantify the change in several climate variables as reviewed and analyzed in (Garcia et al., 2014), and some of them focus on identifying novel and disappearing climates (Ackerly et al., 2010; Ohlemüller et al., 2006; Williams et al., 2007). However, the proposed methods in these and other works present a significant degree of subjectivity because they need to define climate variables ranges and metric thresholds beyond which a present climate has disappeared or a future climate has no past analogue. In turn, the climatic variables selected are crucial for species spatial spread and suitability