Application of PCA in atmospheric sciences

Cristina Andrade[1], João Santos[2], and João Corte-Real[3]

[1] *Polytechnic Institute of Tomar, Portugal*
[2] *Trás-os-Montes e Alto Douro University, Portugal*
[3] *University of Évora, Portugal*

Abstract

The majority of applications of the Principal Component Analysis to atmospheric data have involved analysis of certain fields. The most common are the geopotential heights, temperatures and precipitation. The goal of this analysis is usually to explore the joint space and time variations of many variables in the data set. The locations at which the field is sampled are spread over a two/three dimensional space, however from each location (latitude-longitude, assigned with a number) at a given observation time the data is arranged in a one dimensional vector $\mathbf{x}$. Notice that each time series of principal components will be uncorrelated with the time series of all the other principal components.

Considering that there are K time series in the original data, there will be K elements of $\mathbf{x}$ that are measurements at different locations in space, therefore, the eigenvectors can be displayed graphically in a quite informative way. Each eigenvector element can be plotted on a map at the same location as its corresponding data value, and this field of eigenvector elements can itself be displayed with smooth contours in the same way as ordinary meteorological fields.

Our study is devoted to the analysis of the atmospheric circulation mechanisms related to the occurrence of extremes in the winter precipitation over Portugal for the period of 1945 to 2007. This is undertaken by a diagnosis of the main forcing dynamical mechanisms that generate and maintain the anomalous flow, the empirical forcing functions. These functions can be deduced from the time-averaged potential vorticity equation for asymmetric eddies. This approach enables a quantification and a geographical distribution of the total contributions made by the transient and stationary eddy transports of enthalpy (the third forcing function) and angular momentum (the sixth forcing function). These forcing functions are spacio-temporal atmospheric fields that can be analised by Principal Component Analysis. The Empirical Orthogonal Functions (EOFs) and the corresponding Principal Components are shown to be a valuable tool in the interpretation of these fields, since small scale details and inhomogeneities are filtered out.

Keywords

Principal component analysis, empirical orthogonal function, empirical forcing functions.