

Book review

Principal Component Analysis in Meteorology and Oceanography by Rudolph W. Preisendorfer (Elsevier Science Publishers 1988) ISBN 0 444 43014 8. Pp xviii + 426, US\$110.50.

In the last decade or so the meteorological and oceanographical communities have taken to using Principal Component Analysis (PCA) with a will. Accordingly, the publication of this text is very timely. There have been a number of books, or chapters of books, published on this topic but this one stands in select company in discussing all the important aspects of the topic with mathematical rigour and physical insights, and by extending into areas which usually receive little attention.

Preisendorfer clearly introduces the use of PCA in that it suggests ways to reduce the dimensionality of the representation of physical fields. He cautions, however, that 'PCA is not an end in itself but a means toward an end'. This underlies his view that PCA is a probing tool and a preliminary testing device which should be used to lead to a more profound understanding.

Part of the charm of the volume lies in the examples chosen for exploration. These often take the application of PCA outside the realms to which we are accustomed. For example, Preisendorfer considers the case of a set of coupled harmonic oscillators, each subject to forcing and friction as a problem in asymptotic PCA. Another example of interest is the equation of damped two-dimensional wave motion. The author addresses the topic of multivariate PCA in some detail and exemplifies it by the novel application to the PCA of storm tracks, from which are derived 'eigentracks'!

There is an excellent chapter on selection rules which is comprehensive, rigorous and well explained. One of the problems of PCA is determining which of the components represent signal and which noise. It is the task of 'selection rules' to differentiate between the two. Three classes of rules are considered. The first of these are the 'dominant-variance' rules which select only those modes whose eigenvalues (and therefore variance explained) exceed some threshold value. Preisendorfer warns, however, that these popular selection rules may not always be appropriate. He argues that some fields may have signals buried in

them that are not of dominant variance. It may be that a component with small eigenvalue has a coefficient whose temporal evolution is packed with physically meaningful variations. On the other hand the temporal structure of the coefficient of the first mode may be pure noise. These lead the author to a discussion of 'time-history' selection rules which are based on the spectral whiteness of a particular principal component time-series. A third class of rules he considers are 'space-map' selection rules. These compare the eigenmodes with, for example, the normal modes of a dynamical system which is hypothesised to have generated the data set considered.

The desirability of rotating principal components is discussed well, and illustrated with simple examples. The orthogonal 'varimax' is treated in some detail and the 'procrustes' technique is spelled out as an example of oblique rotation.

In the last part of the book Preisendorfer presents chapters on the connection between, or enhancement of, factor analysis, canonical correlation analysis, linear regression analysis and PCA.

A nice feature of the publication is the inclusion of 'Bibliographic Notes' at the end of every chapter. These contain interesting reviews or historical information and, in an easily read format, present interesting sidelines or puzzles related to the work presented in the foregoing chapter.

This book was not finished at Preisendorfer's untimely death in 1986, and the final manuscript was compiled and edited by Curtis Mobley. It is pleasingly presented and well organised.

Principal Component Analysis in Meteorology and Oceanography treats the subject with rigour and depth. A great many topics are covered, always with an eye to the physical or dynamical interpretation. There are many previously unpublished and novel applications of PCA which should serve to widen the vision of researchers who use these techniques. The book is to be recommended to postgraduate students and researchers in this area of activity.

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