EMPIRICAL METHODS IN SHORT-TERM CLIMATE PREDICTION

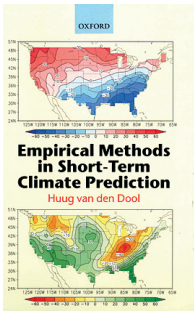
Huug van den Dool, 2007, 215 pp., $89.95, hardbound, Oxford University Press, ISBN 0-19-920278-8

Why should someone be interested in empirical short-term climate prediction (seasonal forecasting) at a time when many regard statistical forecasting approaches for lead times of two weeks and longer to be obsolete, because of the extensive effort devoted to application of dynamical prediction methods to this problem? As the late Edward Lorenz notes in his foreword to this book, there are two good reasons. First, much of our knowledge and understanding of the atmosphere has been and continues to be gained empirically. Because climate analysis and diagnosis are prerequisite to well-designed empirical forecasting procedures, this book also has much to say about methods aimed at discovering properties of the physical climate system from available observations. Second, Lorenz observes that dynamical forecasting "still fails to outperform some much simpler empirical methods at ranges of a few weeks or months, presumably because of the chaotic nature of the atmosphere."

The scientific literature on empirical seasonal prediction is relatively sparse, despite its ongoing practical importance, and documentation of how these methods are used at the operational forecasting centers is difficult—if not impossible—to find. Collecting this information in one place for the interested reader is a major strength of this book. The content is informed by Huug van den Dool's many years of experience at the Climate Prediction Center (CPC) of the U.S. National Weather Service, and the personal accounts scattered through the book add color and interest to the presentation. There are no comparable treatments of this material elsewhere.

The mathematical level of the most advanced material is relatively high, as van den Dool assumes a fairly substantial background in both mathematics (linear algebra and eigenanalysis) and statistics (regression, time series, and spectral analysis). However, a brief review of covariance, correlation, and orthogonal functions is provided in chapter 2, and chapter 5 contains a thorough discussion of the application of Principal Component (a.k.a. EOF) Analysis to the gridded geophysical data that form the basis of most seasonal predictions. Overall, the content will be readily understood by those involved in atmospheric or oceanographic research, and the book could easily form the basis of a semester-long graduate course. This is not to say that the presentation is heavily mathematical—it is not, and much of the material in several of the chapters is qualitative in nature.

There are several lines of development presented in this book, generally spanning two or more chapters. One of these sequences consists of a short chapter on estimating the number effective "degrees of freedom" in a dataset or climate process, followed by a longer chapter on forecasting through analogs. The former topic might seem like pretty dry stuff, but it informs the latter forecasting topic quite fundamentally: in order to provide a good forecast from a historical analog, the analog should match the current initial state reasonably well with respect to a number of features approximately equal to its number of degrees of freedom. Van den Dool estimates that the winter northern hemisphere 500-mb height field contains approximately 30 degrees of freedom (or, might be thought of as occupying a phase space with approximately 30 dimensions), and he calculates that finding a match for all of these concurrently to the tolerance of observational error would require a historical data set approximately 10^{30} years long! No wonder that natural analogs have not provided successful large-scale forecasts, although over relatively small areas analog methods can be quite successful (for example, in "downscaling" dynamical forecasts—see the 2006 *BAMS* article by Hamill et al. for an interesting application) because the many fewer degrees of freedom constrain identification of good analogs to a much smaller extent.



For many readers, the most interesting part of this book will be the two chapters on prediction methods and on the operational use of these methods. The first of these chapters treats the full range of seasonal forecast methods, from climatological information (mainly as a skill baseline, so that a worthwhile forecast must predict more than winter being colder than summer, for example) and persistence (zero time derivative), through ordinary regression, "pattern regression" (for example, the often successful canonical correlation approach), and a few more exotic methods. Interestingly, there is also a section here on dynamical seasonal forecasts (the extension to long lead times, and including ocean circulation, of the first-principles physical models that are so suc-

cessful for shorter-range weather forecasting), even though these forecast models are usually not thought of as empirical. However, van den Dool points out that raw dynamical forecasts typically exhibit sufficiently strong biases at these long lead times that they require statistical postprocessing to be useful, and that these corrections are necessarily empirical and data-based.

The following chapter, on operational procedures ("a look in the kitchen"), draws heavily on van den Dool's experience at CPC. Here, the main CPC forecast tools are discussed, and the sometimes mysterious three-category "tercile" format is explained. Many readers will be surprised that so much of currently achievable seasonal forecast skill for temperature appears to derive from exploiting multidecadal low-frequency variations—mainly trends reflecting recent climate warming—even though relatively little effort has so far been devoted to this component of the seasonal forecast problem.

At several points in the book van den Dool remarks on the "puzzling" failure to date of dynamical seasonal forecasts to outperform relatively simple linear statistical methods, even though enormous human and monetary investments have been made in the former over the course of decades. In the final chapter, he offers thoughts on why this might be so. The essence of his argument is that the seasonal forecast problem (as distinct from seasonal simulation) has so few effective degrees of freedom that it is essentially linear. The advantage of dynamical over linear statistical forecast methods will be in the execution of nonlinear terms, but at long lead times these nonlinear terms add essentially random elements to the seasonal forecast, which then require large (and expensive) forecast ensembles to average out. This line of reasoning is labeled clearly as "conjecture," but—like much else in this book—it is thoughtful, original, and worthy of serious consideration.

—Daniel S. Wilks

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FOR FURTHER READING

Hamill, T. M., J. S. Whitaker, and S. L. Mullen, 2006: Reforecasts: An important dataset for improving weather predictions. *Bull. Amer. Meteor. Soc.*, **87**, 33–46.