Comment: Unit Root and Structural Changes in Tropical Sea Levels

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1. INTRODUCTION

This NRC report provides an informative account for researchers who are interested in the interaction between statistics and oceanography. The committee should be complimented for accomplishing such a difficult mission. While the report offers a wide spectrum of interesting activities in these two fields, this discussion is limited to a specific component, namely, the data smoothing aspect of oceanographic data. A main purpose of this note is to illustrate how time series techniques that are developed mostly for econometric problems may find applications in physical oceanography.

Specifically, the wind-driven numerical model of the equatorial sea level of the South Pacific given in Miller and Cane (1989) is considered. In Miller and Cane (1989), a Kalman filter approach is used to estimate and to forecast the sea level based on a linear wind-driven numerical model. This model is useful since it provides not only a systematic treatment of missing observations (temporal gaps), but also allows extrapolation to points where direct measurements are difficult (spatial gaps).

In this discussion, the so-called unit root and trend break asymptotics are employed to analyze the data given in Miller and Cane (1989). These techniques have been developed mainly by economists and statisticians to handle nonstationary data; see, for example, Nelson and Plosser (1982), Chan and Wei (1987), Phillips (1987) and Perron (1989), among others. A fundamental idea in this approach lies in incorporating the knowledge of an external event into the analysis of the underlying nonstationary pattern of the data. In this context, one may consider the El Niño phenomenon as an intervention to the sea level. The series can then be divided into two parts. The first part consists of the data obtained prior to the El Niño effect while the second part consists of the post–El Niño data. Although a random walk model is first found to be adequate, further trend break analysis reveals that the unit root nonstationarity may be an artifact attributed to the El Niño effect. This seems to be the first analysis applying trend break techniques to a noneconometric data set. In contrast with the computationally intensive Kalman filter approach, a simple stationary first-order autoregressive series is obtained which gives an efficient model for estimation and prediction. It is hoped that this discussion provides an illustration on the statistical analysis of some of the issues raised in the NRC report.

This note is organized as follows. A description of the data set is given in Section 2, the unit root and trend break asymptotics are reviewed in Section 3 and their applications to analyzing the sea level data are given in Section 4. Concluding remarks are listed in Section 5.

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2. THE DATA

The sea level data in Miller and Cane (1989) contains observations of the sea level heights for several islands in the tropical Pacific. It consists of monthly means with tides removed. That is, each data point is the average of approximately 720 (30×24) hourly observations for each month with the effect of tides removed. The following islands are of interest: Rabaul, Nauru, Jarvis, Christmas, Santa Cruz, Callao, Kapingamarangi, Tarawa, Canton and Fanning. These islands, shown in Figure 1, are chosen because they provide the longest overlapping time series. For Rabaul, Nauru, Christmas and Tarawa, the observations were taken from 1974 to 1983; for Jarvis from 1977 to 1984; for Santa Cruz from 1978 to 1983; for Callao from 1942 to 1984; for Kapingamarangi from 1978 to 1983; and for Fanning from 1972 to 1983. In this way, the overlapping period is 1978–1983.

The measurements have been filtered in the following way. For a particular island, let Z_{ij} denote the observation at the jth hour of the ith month with tide effects removed $i = 1, \ldots, 72\,(12 \times 6)$, $j = 1, \ldots, 720\,(30 \times 24)$. Define Z_i to be mean of the ith month:

$$Z_i = \frac{\sum_{j=1}^{720} Z_{i,j}}{720}.$$