14.2 FREQUENCY ANALYSIS OF INTRASEASONAL VARIATIONS IN THE NORTH AMERICAN MONSOON SYSTEM

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1. INTRODUCTION

The North American Monsoon System regime experiences climate variations on timescales ranging from intraseasonal to decadal. The challenge facing the climate community is to develop and implement a capability to forecast these variations Higgins (2001). This study investigates the hypothesis that the seasonal evolution of the North American Monsoon System (NAMS) is modulated by intraseasonal variations in atmospheric circulation. The monsoon phenomenon undergoes considerable intraseasonal variability with alternating periods of widespread, heavy thunderstorm activity (bursts) and drier periods (breaks). In this study, intraseasonal fluctuations of observed annual and warm season precipitation for Arizona/New Mexico are analyzed to ascertain their spatial/temporal coherence.

2. BACKGROUND

The tendency of the planetary circulation to display low-frequency variability, with timescales of several weeks to years, and with distinct geographic distribution, is an important problem in climate dynamics and long-range prediction Barry and Carleton (2001). Numerous observational studies during the past few decades have been of considerable use in understanding active and break monsoon periods in terms of subseasonal oscillations of the Indian summer monsoon. The early works of Keshavamurty (1973) and Murakami (1977) indicated the existence of a 10-20 day oscillation in the meridional wind data over north Indian stations. Krishnamurti et al. (1973) for the first time pointed out that the spectrum of the Tibetan high showed a dominant periodicity of around 13 days. Krishnamurti and Bhalme (1976) identified a quasi-biweekly oscillation in most of the salient elements of the Indian summer monsoon system. The existence of longer period oscillations of approximately 30 days over the Indian summer monsoon region was noted by Dakshinamurti and Keshavamurty (1976). Hartmann and Michelsen (1989) indicated a spectral peak with a periodicity of around 40 days by examining 70 years of daily precipitation data over the Indian subcontinent. In their comprehensive reviews, Madden and Julian (1971; 1994) discuss several other important studies related to 40-50 day fluctuations over the Indian summer monsoon. In analysis of NAMS variability, Reyes et al (1994) performed spectral analysis for precipitation over northern Mexico and found the majority of variance was in timescales longer than the synoptic. Further spectral analysis by Mullen et al. (1998) indicates that warm-season precipitation over southeastern Arizona appears to be significantly modulated by a 12-18 day quasi-periodicity. In recent work, Higgins and Shi (2001) compared principal modes of interannual and intraseasonal variability within the North American Monsoon System.

3. METHODS

For this investigation, spectral characteristics of intraseasonal burst/break activity within NAMS are examined using a 41-year dataset of total daily precipitation averaged over stations in two regions: Arizona and New Mexico. By decomposing a time series into time-frequency space, wavelet analysis is used to explore both the dominant modes of variability and how those modes vary in time (Torrence and Compo 1997). For each region, we perform a continuous wavelet transform using the Morlet wavelet basis to compute the wavelet power spectrum for each year of precipitation data. The 95% confidence level is computed based on a Gaussian white noise process.

4. RESULTS

Our preliminary analysis of burst/break activity associated with the NAMS indicates the existence of varying 10-20 day, 20-40 day, and 40-50 day periodicities. In fig. 1, the wavelet spectrum indicates strong periodicities of 10-20 days and 20-40 days throughout the July-August monsoon season for 1990. A 12-18 day periodicity is also persistent in this year. In contrast, the wavelet spectrum for 1993, shown in fig. 2, there are no significant periodicities. This latter pattern is consistently present in 4-year intervals and is the same for both regions. These periodicities suggest that summer rainfall in the southwest U.S may be modulated by large-scale, low frequency dynamics. Modulation at 10-20 days also occurs in the Asian monsoon due to westward propagating modes (e.g. Krishnamurti and Ardanuy, 1980). This analysis is part of a broader investigation that will examine surface – atmosphere interactions as they relate to the North American Monsoon System. Further analyses will examine possible relationships between NAMS periodicities and indices of large-scale atmospheric features i.e., ENSO, PNA, and MJO, and North American snow cover forcings.

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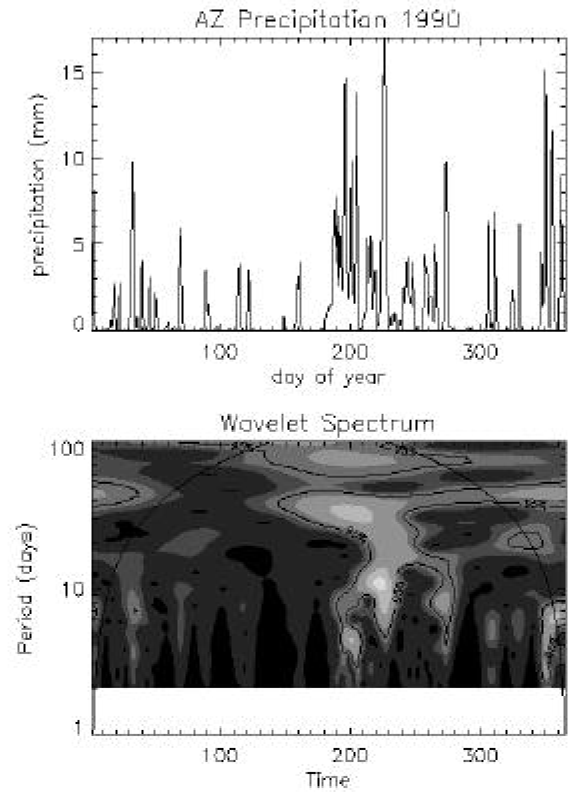

Fig. 1. Wavelet spectrum for Arizona, 1990 indicates strong ~10-day and ~40 day periodicities.

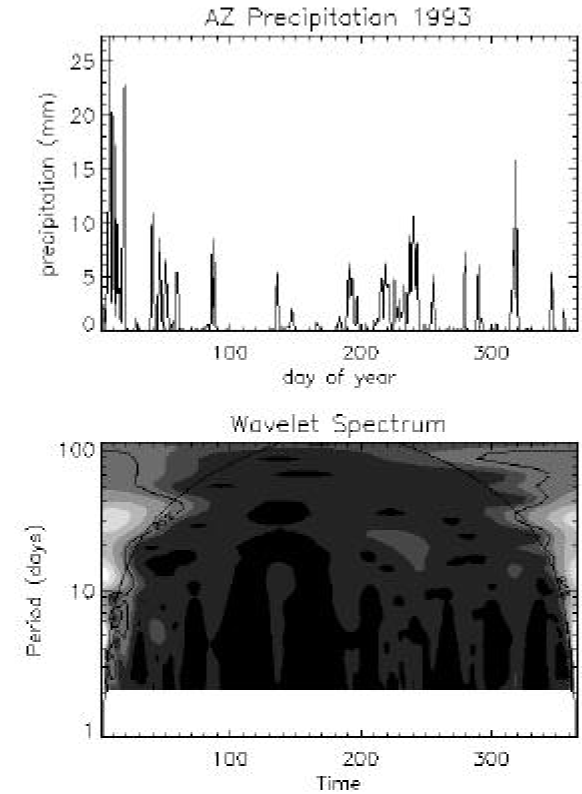

Fig. 2 Wavelet spectrum for Arizona, 1993 indicates no periodicity in precipitation throughout the annual cycle.

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