DEVELOPING A WARM SEASON CLIMATOLOGY OF PRECIPITATING SYSTEMS IN AFRICA

Arlene G. Laing[1], Richard Carbone[2], Vincenzo Levizzani[3]

[1]Department of Geography, University of South Florida, Tampa, FL USA
[2]National Center for Atmospheric Research, Boulder, CO, USA
[3]CNR-Institute of Atmospheric Sciences and Climate, Bologna, Italy

1. INTRODUCTION

The prediction of precipitation, particularly quantitative precipitation forecasting (QPF) remains one of the greatest problems in weather forecasting. Warm season precipitation presents an even greater challenge as the precipitation forms under relatively benign synoptic conditions and is strongly modulated by diurnal heating. The goal of this study is to develop a climatology for warm-season precipitation in Africa based on the propagation characteristics of convective precipitation. The term "warm season" as applied to Africa, a continent that straddles the equator, is more indicative of the precipitation regime change than the temperature.

In the United States (US), investigations of the lifecycles of mesoscale convective systems (MCSs) have found that the majority of these systems initiate in the lee of the Rocky Mountains, move towards the east and produce an overnight maximum in precipitation across the central plains, sometimes while undergoing various cycles of regeneration (Maddox 1980, Fritsch et al. 1986; Augustine and Caracena, 1994; Davis and Anderson and Arritt 1998, Trier et al. 2000). Using the Weather Surveillance Radar-88 Doppler (WSR-88D) data, Carbone et al. (2002) found that clusters of heavy precipitation display coherent patterns of propagation across the continental US with propagation speeds for envelopes of precipitation that exceed the speed of any individual MCS. Wang et al. (2003) developed a similar climatology for warm season precipitation in East Asia using infrared brightness temperatures from the Japanese Geostationary Meteorology Satellite (GMS). Their study showed propagation of cold-cloud clusters (or quasi-precipitation episodes) across a zonal span of 3000km with a duration of 45h compared with 60h for the precipitation episodes in the US. The discovery of similar coherence is not surprising as MCSs in both regions have similar properties (Ma and Bosart 1987; Miller and Fritsch 1991).

Given the similarity in the properties of MCSs globally (Laing and Fritsch 1997), coherence in propagating characteristics is expected for precipitation over Africa. For example, the escarpment of South Africa serves as the initiating point for convection that propagates to the east (Garstang et al. 1987; Laing and Fritsch 1993). In Sahelian Africa, the Jos Plateau (west Africa), the mountains of Dafur (western Sudan), and the Ethiopian highlands are regions where squall lines and mesoscale convective complexes originate (Tetzlaff and Peters 1988; Laing and Fritsch 1993). Other studies of west African squall lines and cloud clusters have found that systems are modulated by easterly waves, the low-level jet, and moisture convergence in the lower troposphere (e.g., Payne and McGarry 1977; Frank 1978; Bolton 1984; Machado et al. 1993; Rowell and Milford 1993; Thorncroft and Haile 1995).

Convection and precipitation over Africa also varies inter-annually (Duvel 1989, Ba et al. 1995). Desbois et al. (1988) found that African squall lines had different initiation points, tracks, and speed for July 1983 and July 1985. Those differences are related to the large-scale dynamics such as the seasonal migration of the Inter-tropical Convergence Zone (ITCZ).

2. DATA AND METHODS

Digitized images from the European geostationary satellite (Meteosat) for a multi-year period will be used to document convective precipitation episodes over Africa. The initial study period is May through August of 1999. The infrared (11.5µm) images have a spatial resolution of 5km at the satellite sub-point (0, 0) and are available at 30 minute intervals. A threshold technique is used to identify the cold cloud systems that are most likely to be precipitating. Further discrimination between precipitating and non-precipitating cold clouds is accomplished by comparisons with radar and microwave derived rain rates from the Tropical Rainfall Measurement Mission (TRMM) Precipitation Radar and TRMM Microwave Imager (TMI) respectively. Consideration is also given to techniques for calibrating Meteosat IR with passive microwave measurements from the Special Sensor Microwave Imager (SSM/I) (Levizzani et al. 1996). Comparisons are made with the corresponding water vapor images, which helps to indicate differences between deep layer moisture of precipitating thunderstorms and a layer with mostly cirrus.

Propagation characteristics are determined using a methodology similar to that employed by Carbone et al. (2002) and Wang et al. (2003). Based on the prevailing low-level flow, the continental boundaries,

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Corresponding author address: Arlene Laing, Visiting Scientist, NCAR/MMM, P.O. Box 3000, Boulder, CO, e-mail: laing@ucar.edu

and tracks of mesoscale convective systems, two domains are used for the Hovmoller calculations (Fig. 1). The northern domain covers 5ºS to 20ºN and 20ºW to 40ºE from May to September. The southern domain is 35ºS to 5ºN and 5ºE to 40ºE from October to April. The second domain includes prevailing easterly flow north of 15ºS and prevailing westerly flow to the south. Hovmoller strips of 0.1 degree longitude are drawn through each domain.

Global Reanalysis data are used to analyze the large-scale environments associated with deep convective development. Reanalysis pressure level data has a 2.5 degree grid and are provided daily at 0000, 0600, 1200, and 1800UTC.

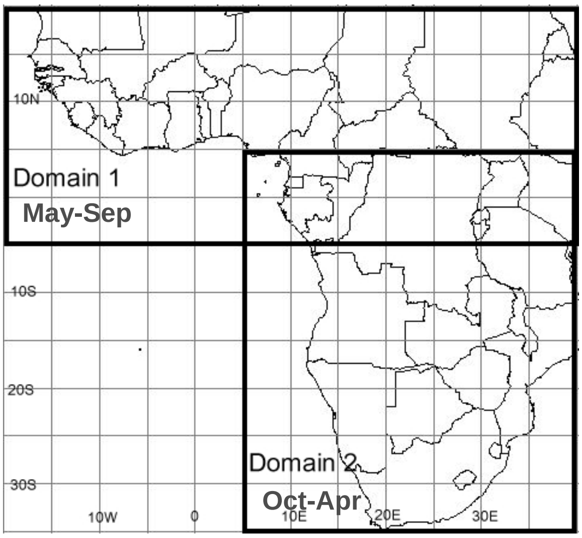

Fig. 1. Domains for the Hovmoller calculations (marked by thick lines)

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