Vertical structure of the atmosphere during wet spells over Southern Africa

Mark R Jury* and Kevin M Levey
Climate and Weather Research Laboratory, Oceanography Department, University of Cape Town, Rondebosch 7700, South Africa

Abstract

Vertical sections of atmospheric structure during wet spells over Southern Africa are analysed in terras of ECMWF meteorological variables. Six cases occurring between December and March 1986 to 1992 are averaged to form a single composite pattern and the mean is subtracted to highlight structure. Vertical uplift is vigorous over Southern Africa and compensated by sinking motions over the surrounding oceans and Congo basin. Temperature departures indicate predominantly barotropic easterly wave conditions and a cool dome near the surface. A warm region to the south is coincident with easterly wind anomalies. Evidence points to the need for both a mid-latitude ridge and tropical Hadley overturning. The requisite convergence of airstreams from the southern Mozambique Channel and Congo basin are viewed as a brief southward excursion of the ITCZ over Southern Africa. The wet spells help overcome large moisture deficits built up in the preceding winter and spring, and enable adequate crop yields and water resource replenishment over the dry sub-continent of Southern Africa.

Introduction

Water is a limited commodity in Southern Africa which constrains economic activity and resource availability. Summer rains over the central plateau are highly variable at all scales, and take the form of wet spells of 3 to 7 d duration at near-monthly intervals from November to March (Jury et al., 1996). Each major wet spell can contribute up to 25% of the seasonal total, so an understanding of their meteorological structure and wider climatic links would be of significant value.

The climate of Africa south of 15°S has received increasing attention since the devastating drought of 1982 to 1984, when maize crop yields declined to 10% of historical values and numerous sources of water dried up. Previous studies which have detailed the characteristics of multi-day rainfall events include (Lindesay and Jury, 1991;Lyons, 1991;Barclay, 1992;D'Abreton, 1992). Other research has analysed more sustained multi-week wet spells (Taljaard, 1981; Harrison, 1986; Matarira and Jury, 1990). Common features of intra-seasonal composite wet and dry spells have been identified (Taljaard, 1986; Matarira and Flocas, 1989; Levey 1993). However, detailed vertical section analyses of composite wet spells using high quality, model-interpolated weather data are limited.

Background and methods

Daily rainfall and class-A pan evaporation data were collected for stations within a 200 km radius of 25°S, 25°E; an agriculturally productive area prone to El Niño-induced drought (Fig. 1). The shortcomings of class-A pan data are recognised (Geiger, 1965; Wiesner, 1970). An area-averaged precipitation minus evaporation (P-E) index was calculated from the individual station data in the period 1970 to 1992. To limit random, short-term weather variability, the data were averaged into pentads (discrete 5 d means). Wet spells were designated when the normalised P-E index time series was in the range +1.0 to +2.0 times the standard deviation. This criterion was met six times in the austral summer (December to March) in the years 1986 to 1992 when overlapping gridded weather data were available.

Meteorological features of the composite wet pentad are illustrated using ECMWF (European Centre for Medium Range Weather Forecasts) data. The data are at a resolution of 2.5° at 12 UT each day. The atmospheric levels used for construction of vertical sections are: 1 000, 850, 700, 500, 300, 200 and 100 hPa, except for the moisture variable, which is from 850 to 300 hPa. Vertical sections are along 25°S and 25°E and extend from 30°W to 100°E and 20°N to 60°S. Composite *anomalies* are formulated by subtracting the 1986 to 1992 mean for the December to March period from the six-case ensemble average. Apparent inconsistencies at the crossing point for zonal and meridional sections are the result of mean and derivative calculations and differencing, and the smoothing and contouring routines applied.

Meteorological parameters include: geopotential height, temperature, wind components, vertical motion and specific humidity. Derivative variables include the velocity potential and stream

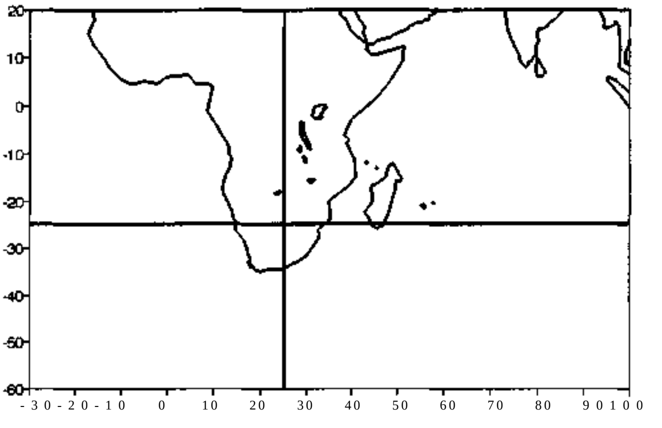

Figure 1
Location map of Southern Africa and cross-section lines

* To whom all correspondence should be addressed.
New address: Geography Department, University of Zululand, KwaDlangezwa 3886, South Africa
(021) 650-3979; fax (021) 650-3979; e-mail jury@physci.uct.ac.za
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