# A model for the identification of tropical weather systems over South Africa

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## Abstract

South Africa forms the southern end of Africa with its northern boundary at approximately 22°S and the southern-most point, Cape Agulhas, at approximately 35°S. During most of the year atmospheric circulation over South Africa, especially the central and southern regions, is dominated by extra tropical weather systems such as cut-off lows, cold fronts and the ridging Atlantic Ocean High. Weather forecasters in South Africa are trained on and experienced in forecasting rainfall from these systems. During late summer weather systems from the tropics invade the northern regions of South Africa. Because tropical weather systems only appear during three or four months of the year weather forecasters often lack the experience to identify them timeously. Invading tropical weather systems are often associated with heavy rainfall and flooding (February 1988, February 1996, February 2000). It is very important that forecasters identify these tropical systems and apply appropriate forecasting techniques. Prior to this research no objective system to classify tropical systems and to pinpoint areas of significant to heavy rainfall was employed locally. This research resulted in the model for the identification of tropical weather systems (MITS). MITS has five components based on the atmospheric dynamics important for the development of convective rainfall from tropical systems. The application of MITS is detailed in a case study of heavy rainfall from a tropical system over the country on 8 February 2000. MITS identified the tropical nature of the system and successfully located areas of convective rainfall. MITS is available on the software system PCGRIDDS currently in operational use in South African forecasting offices. It operates on the prognostic fields generated by the South African Weather Service limited-area model Eta. Trial runs of MITS in the Central Forecasting Office of the South African Weather Service (SAWS) provided a positive response from weather forecasters and a full operational implementation is imminent.

## Introduction

The subtropical high-pressure belt dominates the weather over Southern Africa, which is, except during a few winter months, split by the continent to become the Atlantic Ocean High (AOH) and the Indian Ocean High (IOH). Variations in position and intensity of the two high-pressure systems play an important role in the rainfall distribution over South Africa (Shulze, 1965). The mid-latitude westerly circulation, extending northwards to, and in association with, these two high-pressure systems, controls to a large extent, the weather of South Africa (De Coning, 1997). During the summer months, as the high-pressure systems migrate southwards, the influence of the westerly circulation is diminished.

In the summer the intertropical convergence zone (ITCZ), identified by large convective cloud structures, moves southwards to approximately 17°S (Taljaard, 1994) bringing tropical weather to South Africa's northern regions. Van Heerden and Taljaard, contributing to Karoly and Vincent (1998), suggested that during this time of the year tropical weather systems invade Southern Africa in the form of tropical cyclones, tropical lows and easterly waves. They described how a tropical low over the interior of Southern Africa could be identified on loops of half-hourly geostationary satellite images by locating the low-level cyclonic- and anti-cyclonic upper tropospheric circulation as depicted by the cloud motion. Tropical systems generally move from east to west over the subcontinent rarely reaching the African west coast. Tropical cyclones degenerating to tropical lows favour the large river valleys in their westward migration. Crimp et al. (1997), researching the link between the tropical and temperate circulation systems, gave a thorough description and stressed the importance of this link referred to as the tropical temperate trough (TTT) in producing rainfall over South Africa. They estimated that approximately 39% of the mean annual rainfall could be attributed to the TTT. The TTT is easily identified on satellite imagery as long cloud bands linking the tropical convective systems to the mid-latitude (temperate) frontal systems. Lindesay and Jury (1991) suggested that the weather system responsible for heavy rainfall over the central interior of South Africa during February 1988 was a tropical-temperate trough. Triegaardt et al. (1991), on the other hand, made a detailed analysis of the dynamics of this weather system and stressed the tropical nature of the atmospheric circulation during this event. Taljaard (1985) in discussing the cut-off low (COL) provided a brief description of the tropical easterly low over Southern Africa, specifically referring to the higher than normal upper tropospheric temperatures above the low. Preston-White and Tyson (1993) proposed that an easterly wave could be distinguished from an easterly low by considering the level of maximum wind divergence. In the latter case they found that the wind divergence frequently occurred at higher levels in the troposphere.

Heavy rainfall and flooding are not rare over South Africa. Viljoen, cited in Alexander and Van Heerden (1991), lists 184 noteworthy flood events during the years from 1911 to 1988. Close to 30% of these events occurred over KwaZulu-Natal and 42% over the four northern and central provinces of South Africa. Some 67% of all these flood events occur during the summer rainfall season (October to March). Research results of Alexander and Van Heerden (1991) indicated that the month with the highest frequency of floods is February. They also claimed a marked increase of serious floods from 1970 to 1990 and postulated that the frequency of serious flood events may in fact be increasing. These results are echoed by recent research results of Poolman (1999). He found that most heavy rainfall events occurred during the summer months

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*Received 13 August 2001; accepted in revised form 5 June 2002.*