THE UNUSUAL TROPICAL STORM OF JANUARY 1996

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ABSTRACT

Tropical cyclones of the south west Indian Ocean region usually recurve near the eastern African coast and move away to the south east as extra-tropical depressions. A good number are known to cross the African coast once every few years and weaken fast due to friction and insufficient moisture over land. A few have been observed to travel a considerable distance inland, in a weakened state, before eventually dying out. Tropical cyclone Bonita of January 1996 was the first documented storm to have traversed the entire breadth of the southern African subcontinent, from the Indian Ocean to the southern African Atlantic coast.

This synoptic analysis, based on isobaric charts and satellite imagery, brings into perspective the existence of two conditions that have long been identified as favourable for a cyclone penetration into the southern African subcontinent:

- a well marked low pressure in the African interior, associated with the ITCZ trough;
- a strong subtropical ridgeline which inhibits any penetration of polar fronts into the subtropics

The analysis also seems to suggest that Bonita's encounter with the cold waters of the African east Atlantic coast led to her demise.

During its passage over the subcontinent, Bonita contributed positively to the 1996 total seasonal rainfall at a few Zambian stations close to its track in the south and west of the country (up to 20 per cent of 1996 seasonal rainfall fell during the cyclone period). Over the larger part of Zambia, however, Bonita's contribution to 1996 seasonal rainfall was insignificant, and in some cases, negative. This episode provides an interesting laboratory demonstration of the theory of tropical cyclones, from the warm waters of the south west Indian Ocean, through the continental southern african land mass, to the cold waters of the south east Atlantic.

1. INTRODUCTION

During the South West Indian Ocean tropical cyclone season, from November to April, tropical cyclones are observed to form either in the Mozambique channel or east of Madagascar. A fairly comprehensive tropical cyclone climatology of the region is given by Malick and Mercusot (1976) and Baghare (1978), and summarised by Mumba and Chipeta (1984).

A tropical cyclone in the Mozambique channel is associated with dry conditions over the southern half of Zambia. It is perceived that moisture is diverted into the cyclone, and a divergent south easterly flow into Zambia pushes the ITCZ well to the north. A tropical cyclone moving into the African interior on the other hand can have devastating effects on the coastal areas of Mozambique and Swaziland. Its effects can be felt as far inland as southern Zambia, depending on how far the cyclone penetrates into the African continent. A tropical cyclone on the southern African interior is believed to induce the ITCZ to move southwards to pass through the weakened storm.

Instances of tropical cyclones crossing the eastern coast of southern African are rare. Mumba and Chipeta (1984) document two such cases. Tropical cyclone Benedicte crossed the coast on 22nd December, 1981 and became unidentifiable over central Mozambique on 26th.

Tropical cyclone Electra, which crossed the African coast on 4th February 1982, moved all the way into the Southern Province of Zambia and back to central Zimbabwe where it became unidentifiable on the 9th. During the 1995/96 season, tropical cyclone Bonita, which formed near 65 East on 6th January, moved West and crossed the coast on 14th and traversed the whole breadth of the southern African subcontinent until it was no longer identifiable near the west coast on 20th January. This is a very unusual occurrence indeed. Substantial rainfall and strong winds were recorded over Zambia on 15th and 16th at the passage of this storm. This paper is a documentation of this unusual event. Section II of this paper gives synopses of the storm from 12th January when it was in the Mozambique Channel to its dissipation on 20th. A discussion of the factors associated with its track and longevity over land is in section IIb and a conclusion is in section IV.

2. SYNOPTIC SEQUENCES

a) Preamble

Tropical cyclone "Bonita" started as an area of disturbance over the Indian Ocean on Saturday 6th January 1996. This disturbance was in the form of a weak tropical low. After developing into a strong vortex just east of Madagascar on 9th January, "Bonita" moved northwestwards to northern and then central Madagascar on 10th and 11th January respectively. By 12th January the Cyclone moved to the west coast of the Island. By this time significant reduction of rainfall over the Southern half of Zambia was observed.

b) Synoptic Developments

By Friday 12th January, the storm was a full-fledged tropical cyclone over the warm waters of the Mozambique Channel, battering coastal areas of the central Mozambique province of Zambesia, including the provincial Capital - Quelimane. Press reports indicated winds of up 110km per hour, and 213 millimetres of rainfall was reported to have been recorded in the space of twelve hours in Quelimane. Houses were reported to have been flooded, and in some cases, roofs blown off, though there were no reports of any deaths up to this point in time.

Figures 1a and 1b show the Meteosat visible and infra red images for 1200 UTC on 12th January, with the surface isobaric and 700 hpa streamline patterns superimposed, respectively. Both images clearly show the inverted comma-shaped overcast associated with Bonita in the channel, and the ITCZ cloud band from northwest of the storm to the African interior.

It is apparent from the synoptic pattern that the two conditions identified by Bhalotra, as quoted by Mumba and Chipeta (1984), for the westward movement of a tropical cyclone into the african interior were satisfied. These were:

- the existence of a well marked low in the interior, along the ITCZ trough. Widespread rain was reported over Zambia and the neighbourhood on the 12th, in association with this low.

- the existence of a strong subtropical ridgeline near 35S, which inhibited northward penetration of polar fronts passing further to the south.

By 13th (not shown), Bonita showed a well-defined eye very close to the African coast, and the ITCZ had moved well to the north over central parts of the subcontinent. On 14th, (Figure 2a, 2b) Bonita was positioned over the lower Zambezi valley, well inside the African continent, but with no visible eye. The IR image shows extensive cirrus debris to the north and east of the storm. Further to the west and south, favourable conditions for the continued westward movement of the weakened storm persisted. By Monday 15th January, the Tropical Cyclone was over Eastern Zimbabwe. At the surface, both the 0600 and 1200 UTC charts were showing a westward trough extension from the centre of the storm, linking with an Eastward extension of the seasonal

Angola low. The linking formed a well-defined ITCZ trough along the Zambezi valley, a more southerly position than that of 13th and 14th January. Both 0600 and 1200 UTC charts were showing widespread reports of rain over both Zimbabwe and Zambia. Over Zambia, cloudy to overcast conditions with steady rain prevailed throughout the day. Some of the significant amounts reported for 15th were: Isoka 34mm, Lusaka 38, Zambezi 40, Magoye 45, and Kafue 58mm.

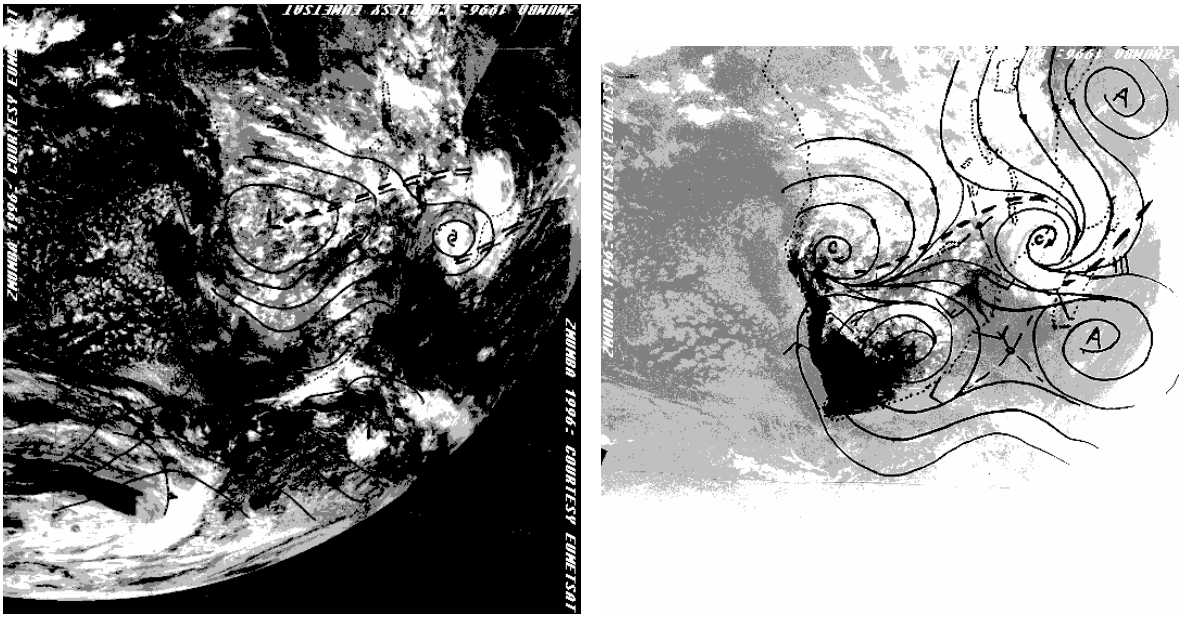

Figure 1. (a) Meteosat VIS Image at 1200 UTC on 12 Jan. 1996. (b) Meteosat IR Image at 1200 UTC on 12 Jan. 1996

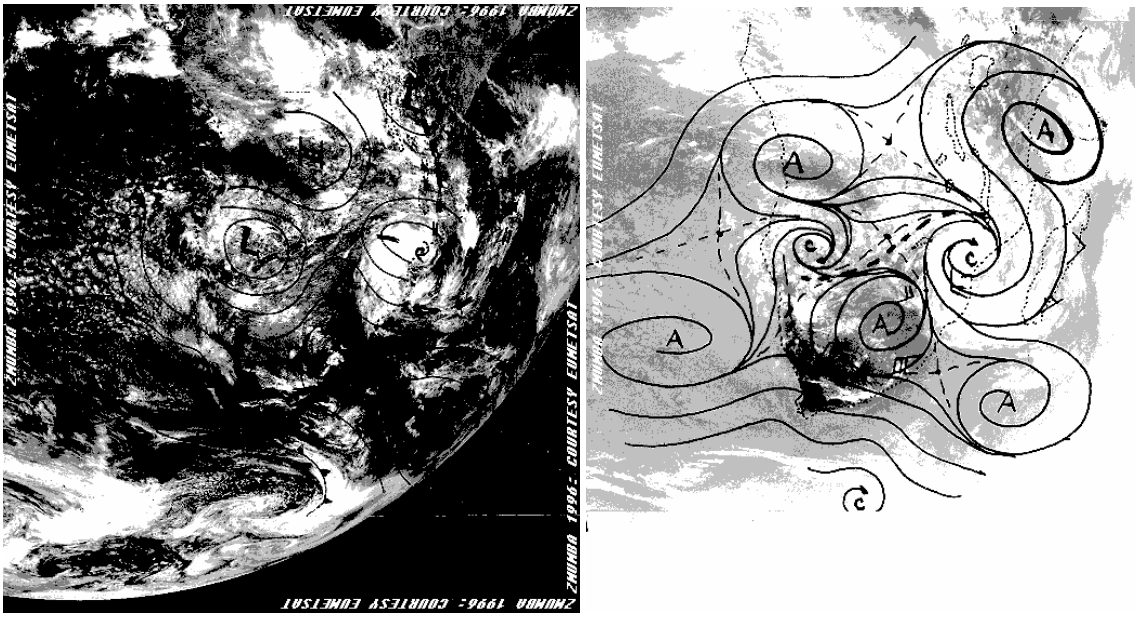

Figure 2. (a) Meteosat VIS Image at 1200 UTC on 14 Jan. 1996. (b) Meteosat IR Image at 1200 UTC on 14 Jan. 1996

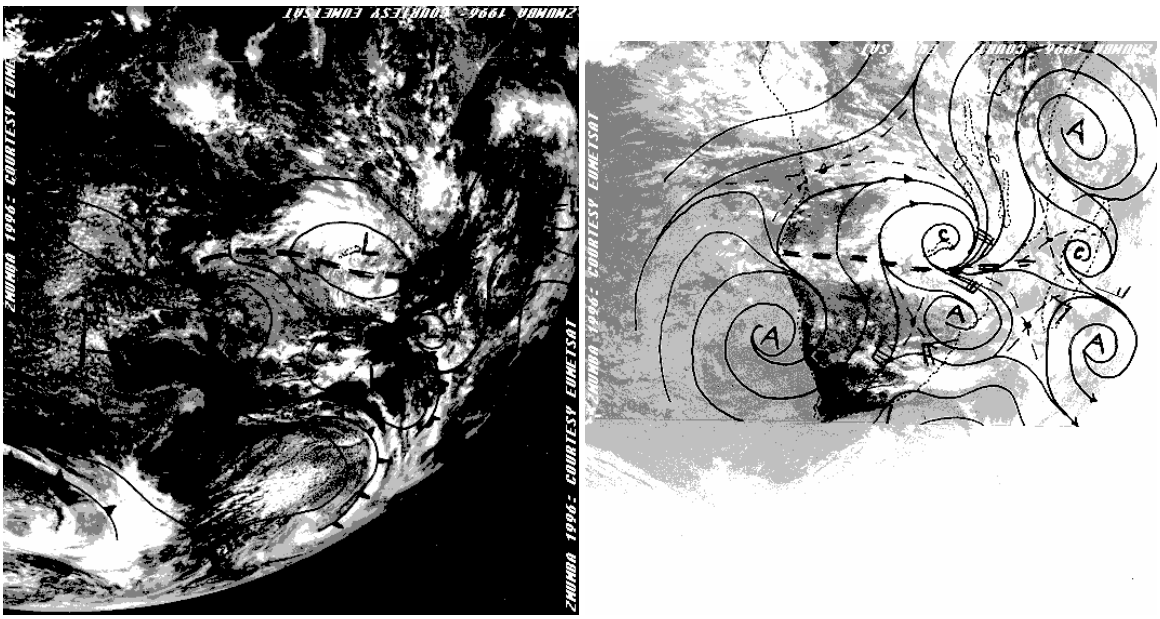

Figure 3. (a) Meteosat VIS Image at 1200 UTC on 16 Jan. 1996. (b) Meteosat IR Image at 1200 UTC on 16 Jan. 1996

On Tuesday 16th January (Figures 3a and 3b), "Bonita" was over Northern Zimbabwe after taking a North-westerly track. Both the visible and infrared images show a cloudy to overcast situation with rainfall in many parts of Zambia. On the surface chart was a well marked broad trough from western Zambia, extending to the centre of the storm over Zimbabwe, which had by this time merged with the Angola low, up to the coastal areas of Mozambique, onto northern Madagascar.

Sustained unseasonably strong winds, though nowhere near tropical cyclone strength (15-20 knots compared to less than two knots which is the normal for this time of year) were experienced throughout the 16th over most stations in the southern, central and western parts of Zambia. Such wind speeds at this time of the year can be damaging to the standing maize crop. The heaviest falls of rain occurred on this day at many Zambian stations: Choma 134mm, Senanga 104, Magoye 66, Mongu 63, Kafue 54 and Lusaka 34mm.

Zambia normally receives about 5% of the total seasonal rainfall during the 7-day period 12-18 January (based on the 1961-90 normal period). Over the same period of the 1995/96 season, the contribution to seasonal rainfall was substantial (18-20 per cent) in parts of central, southern and western provinces, but marginally above or below the normal contribution over the rest of Zambia. Figure 4 below shows the difference between the percentage of seasonal rainfall normally received during 12-18 January and that received during the same period in 1996. A detailed tabulation of these statistics is provided in Table 1 below.

Table 1. Normal and Actual Rainfall During the period 12 -18 January 1996

Station	Normal R/fall (mm) 12-18 Jan (1961-90 Normals)	% of Normal Seasonal R/fall	Total R/fall 12-18 Jan. 96 (mm)	% of 1996 Seasonal R/fall
Chipata	56	5.8	75	7.7
Choma	37	5.0	162	17.9
Kabompo	54	5.5	63	11.5
Kabwe	51	6.1	38	5.6
Kaoma	49	5.9	36	5.6
Kasama	65	5.1	56	4.0
Kasempa	49	4.5	46	3.6
Kawambw	52	3.9	60	4.8
L/stone	52	6.1	52	8.9
Lundazi	56	6.8	73	8.3
Lusaka	50	6.3	79	11.6
Mansa	54	4.8	71	5.9
Mbala	56	4.6	51	5.1
Mongu	49	5.8	182	22.8
Mpika	54	5.4	57	7.2
Mwinilun	51	3.8	39	
Ndola	45	3.8	28	2.1
Petauke	62	6.9	27	2.8
Solwezi	56	4.5	56	5.2
Zambezi	50	5.3	154	19.8
Isoka	32	3.0	47	4.3
Mumbwa	50	6.4		
Magoye	43	6.6	135	19.2
Mfuwe	48	6.5	32	4.8
Senanga	35	5.6	178	24.2
Kafue	37	5.3	123	16.5
Kafiron	53	4.3		
Serenje	61	5.8		
Sesheke	28	4.7		

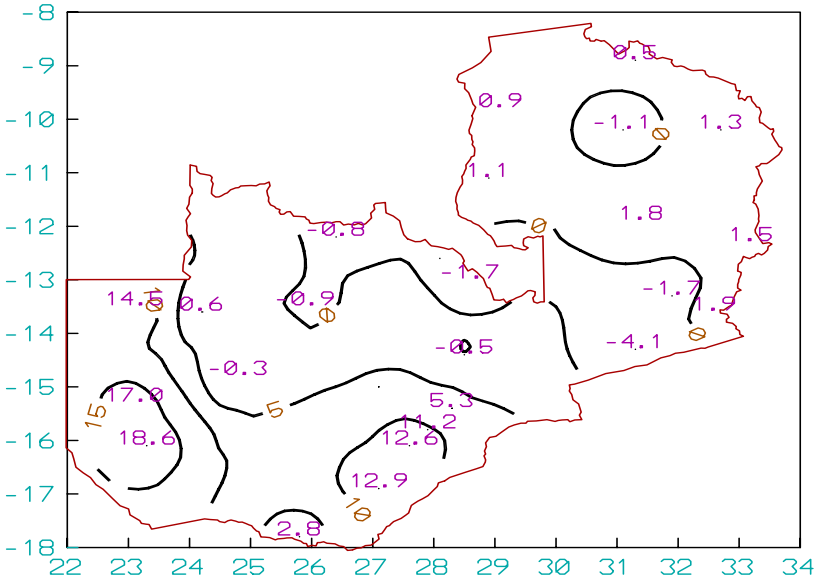

Figure 4. Contribution of Tropical Cyclone Bonita, 12th - 18 January, 1996, to Seasonal Rainfall Over Zambia, over and above the normal rainfall usually received during 12 - 18 January.

On Wednesday 17th January, "Bonita" had weakened further. Both 0600 and 1200 UTC charts showed a broad trough extending from Western Zambia through central Zimbabwe to Mozambique. Over Zambia, the whole day was cloudy initially with short sunny intervals up to mid-day, but cloudy with fairly widespread rain in the afternoon. A few heavy falls were recorded (30mm or more) over the southern and western parts.

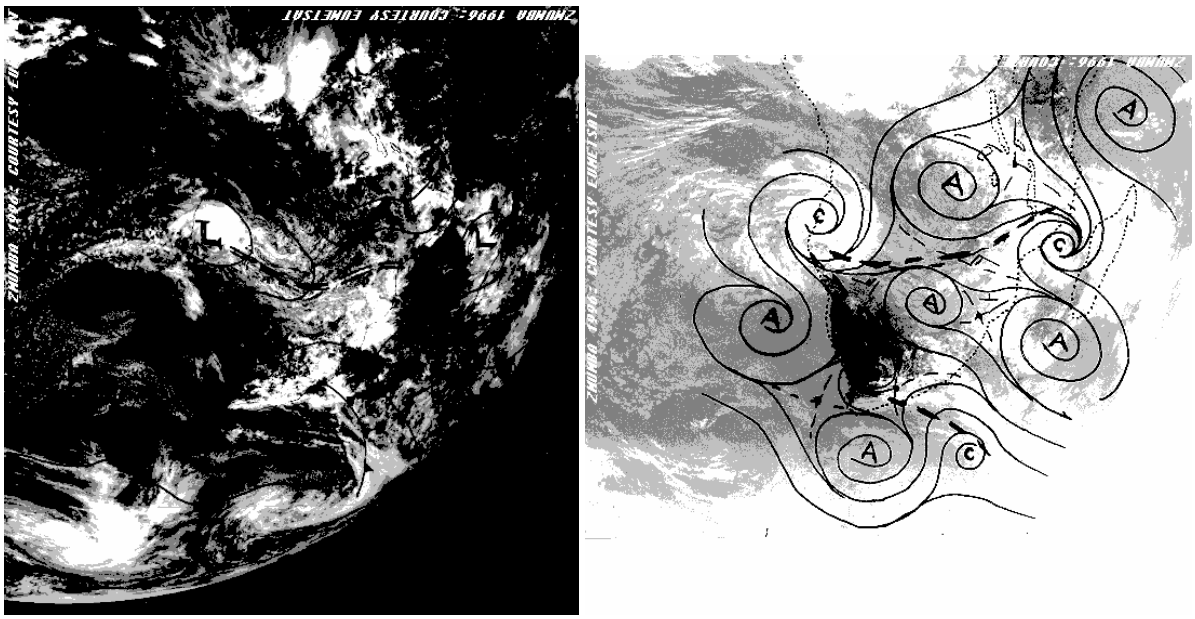

Figure 5. (a) Meteosat VIS Image at 1200 UTC on 18 Jan.1996. (b) Meteosat IR Image at 1200 UTC on 18 Jan.1996

By Thursday 18th January Bonita was still evident as a very active tropical low over Angola on the Atlantic coast. The ITCZ spanned the breadth of the subcontinent from this low, to the channel, along 20S. Settled weather characterised most of the subcontinent, with an extensive cirrus deck donning the eastern seaboard. Over Zambia a significant change in weather was observed with sunny weather from morning up to about mid-day, and scattered afternoon showers.

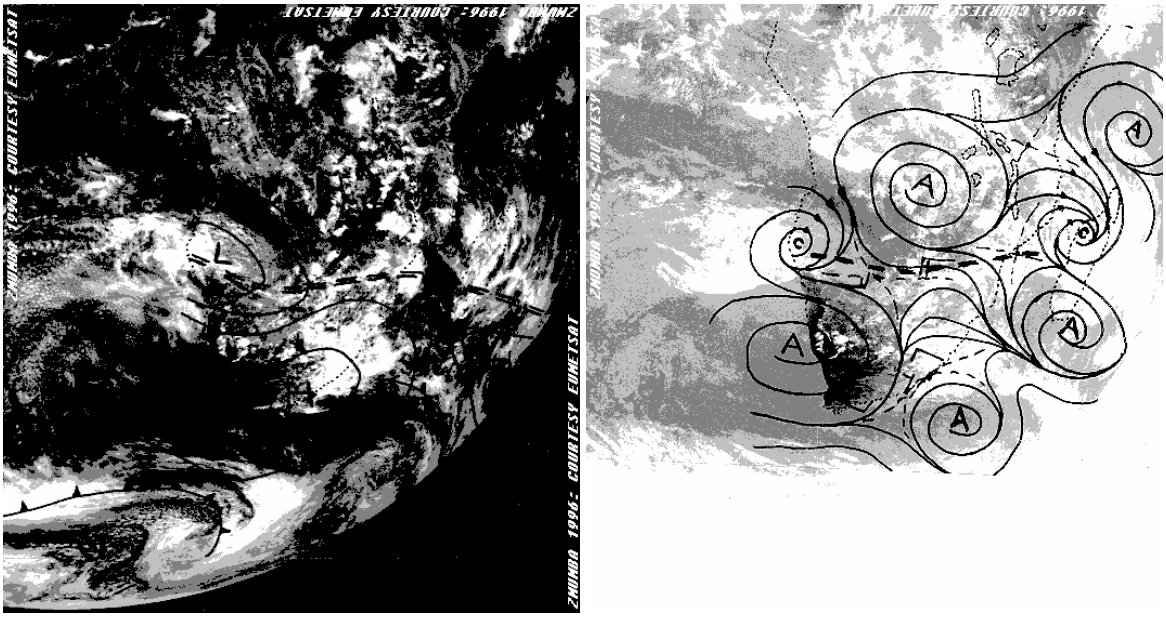

Figure 6. (a) Meteosat VIS Image at 1200 UTC on 19 Jan.1996. (b) Meteosat IR Image at 1200 UTC on 19 Jan.1996

On 19th (Figures 6a and 6b), the remnants of Bonita were still visible on both the visible and infra red images, off the coast of Angola. More settled weather set in over the whole subcontinent, with very little convection associated with the ITCZ trough. By 20th January, there was no trace of Bonita. From the satellite evidence of 19th January (Figure 6) It is apparent that the dissipation of Bonita resulted from the cold waters of the south east Atlantic on the southern African west coast.

3. DISCUSSION

Baghare (1977) found that though a high percentage of storms striking the Eastern coast of southern Africa dissipate rapidly, a few have been observed to retain their identity for two to six days after crossing the coast. From the historic cyclone tracks presented by Baghare the westernmost point of any recorded cyclone track is 20E. Bonita therefore represents a record westward penetration of a tropical cyclone ever documented in the south West Indian Ocean tropical cyclone region. From case studies, Baghare concluded that severe weather conditions did not occur over Zambia in association with the passage of the weakened storms into or near the country, and total rainfall in different parts of Zambia for the storm days tended to be below normal. However a common forecasting practice in Zambia is to clear the weather over the southern half of the country with a cyclone in the channel, in anticipation of a divergent southerly flow into Zambia due to inflow into the storm. If the storm moves inland, the ITCZ is usually expected to shift southwards to pass through the weakened storm, and widespread rain is usually forecast over Zambia, (Mumba and Chipeta, 1984).

Below is a tabulation of the 30-year normal rainfall during the period 12-18 January (based on the 1961-90 normal period) and rainfall during the storm passage in the same period of 1996.

Column 3 of this table shows the percentage of total seasonal rainfall normally received during the 7-day period 12-18 January (1961-90 normal period), and column 5, the percentage of total rainfall received during the same period in 1996. The difference between these two columns is shown in Figure 4 above.

It is apparent from this case study that severe weather (heavy rainfall and strong winds) can occur over Zambia, in association with the passage of a weakened storm into or near the country. It is equally apparent that certain parts of Zambia can suffer deficits of rainfall as a result of such a cyclone event.

4. CONCLUSION

This case study seems to lend support to the view that the two major factors influencing an inland penetration of a tropical cyclone over southern Africa are:

- the existence of a well marked low in the interior, along the ITCZ trough.
- the existence of a strong subtropical ridgeline near 35S, which inhibited northward penetration of polar fronts passing further to the south.

Overland a tropical cyclone weakens due to frictional dissipation and insufficient moisture. However, this case shows that fairly heavy localised rain can be associated with such lows, and hence under such conditions, extra vigilance and prudence can be a plus to skill in short range forecasting. The southern African tropical cyclone theatre is a contrast to its West Africa counterpart where tropical depressions rejuvenate over the warm waters of the equatorial north Atlantic, and go on to ravage the Caribbean and North American continent.

Although Bonita successfully survived the continental frictional dissipation forces and a reduced energy supply from condensational latent heat release, the cold waters of the south east Atlantic proved to be too much for her continued survival. This episode therefore provides an interesting laboratory demonstration session for a possible refinement or consolidation of the theory of tropical cyclones, from the warm waters of the south west Indian Ocean, through the continental land mass to the cold waters of the south east Atlantic. Unfortunately the dearth of upper air data precludes any further and detailed study of the thermal and kinematic structures. This case is worth further study, should objective analysis data be available.

5. REFERENCES

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6. ACKNOWLEDGEMENTS

We express our sincere thanks to the Management of Eumetsat, through Mr Richard Francis, for making available, very promptly, the satellite pictures which have been used in this study. We also wish to thank the Director, Zambia Meteorological Department for permission to publish this paper.