NOTES AND CORRESPONDENCE

A Newly Found Jet in North Kenya (Turkana Channel)

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ABSTRACT

On the basis of recent pilot balloon observations which have become available in northern Kenya, it is shown that there exists a strong southeasterly low-level jet in the Turkana Channel which separates the Ethiopian Highlands and the East African Highlands. The jet exists throughout the year, with speeds exceeding 30 m s^{-1} (60 kt) on a number of occasions and sometimes exceeding 50 m s^{-1} (100 kt). During February and March, the mean monthly winds based on the morning observations exceed 25 m s^{-1} (50 kt). The morning winds are stronger than afternoon winds, presumably due to stronger vertical mixing and dilution of the jet maximum in the afternoon. The hodograph turns in a counterclockwise direction from the lowest levels up to 0.75 km (2500 ft) above ground level and sometimes even aloft. Up to 0.45 km (1500 ft) above ground level, the hodograph manifests some of the characteristics of the Southern Hemisphere Ekman layer.

This jet is different from the now well-known East African low-level jet (Findlater 1966, 1977). Earlier climatological charts give no indication of the existence of this jet stream throughout the year. Orographic channeling of flow seems to be responsible for this jet.

1. Introduction

The East African low-level jet near the East African coast which was first observed by Bunker (1965) and Findlater (1966) is now a well-recognized system which has been studied through observational and theoretical models (Anderson, 1976; Krishnamurti *et al.*, 1976; Findlater, 1977; Hart *et al.*, 1978; Bannon, 1979a,b). It crosses the equator approximately from south to north and is most pronounced during the Northern Hemisphere summer (June to August). It builds in April and May and decays in September and October. During the northern winter (December to February), the low-level flow near the coast of East Africa is mainly northeasterly. Recent observations described in this paper suggest that, quite distinct from the above-mentioned low level jet, there is another jet stream over northern Kenya which persists throughout the year. The direction of its flow is southeasterly. We shall refer to it as the Turkana Channel Jet.

The existence of this jet is established from pilot balloon observations taken since 1979 at Marsabit, Kenya. (This is the region where the remains of primitive man were discovered by Dr. Leakey; due to archaeological and historical interest, there have been many expeditions in this region; aircraft pilots have generally complained of very strong winds and severe turbulence experienced during landing and take off.)

2. Observations

Marsabit is located at 02°18′N, 37°54′E. Pilot balloon observations were started there in November 1977, but they were very irregular. Records made available by the Kenya Meteorological Department show that the observations were more regular from approximately mid-1979. We have analyzed observations for the 12-month period July 1979 to June 1980. The observations at 0600 GMT [0900 EAST (East African Standard Time)] and 1200 GMT were used for the study. In general, there are fewer observations available for the morning ascent. For each of the twelve months, we have more than twenty observations in the afternoon, but fewer (~10) observations in the morning. The availability of observations for the entire 12-month period is shown in Table 1, which gives the monthly mean values of Marsabit winds at various levels, separately for morning and afternoon ascents. The observations were almost evenly distributed among the twelve months. The original pilot balloon registers had tabulations at height intervals of 500 ft (152 m). The station height itself is 1345 m (4413 ft) above MSL. The first reporting level for upper air winds is 1497 m (4913 ft). Hence, Table 1 shows height values at intervals of ~152 m.

Hodographs have been examined separately for each of the twelve months for 0600 and 1200 GMT,

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TABLE 1a. Monthly and annual mean vector winds (deg, kt)* at Marsabit, 0600 GMT, July 1979–June 1988. Strongest winds are underlined.

Height above ground (m)	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Year	Number of observations during year
152	161	168	160	165	155	153	153	158	161	151	168	161	169	142
	23.6	24.2	23.0	25.6	19.8	20.6	19.6	25.4	23.2	16.6	18.8	22.4	20.0	
305	162	163	157	162	145	128	148	154	153	148	167	161	153	142
	37.8	35.7	30.4	44.0	28.2	21.6	30.8	36.8	42.9	22.0	31.2	37.1	30.0	
457	160	154	160	156	135	134	139	150	152	144	162	156	148	142
	37.8	38.1	30.2	51.3	31.8	29.2	35.2	45.6	56.8	22.6	31.2	40.0	34.0	
610	154	142	156	132	126	122	128	143	148	140	155	150	141	142
	24.0	30.8	31.0	27.4	24.4	31.0	40.8	56.1	57.6	25.0	21.6	26.8	32.4	
762	153	166	151	125	113	114	121	127	133	132	149	022	120	142
	8.9	1.6	18.8	21.7	20.2	31.8	46.8	30.6	53.6	24.6	14.8	3.7	19.9	
914	337	045	154	121	078	094	111	079	113	107	349	015	098	141
	9.8	6.5	6.9	17.1	14.9	27.6	37.6	13.8	32.8	18.4	3.1	3.9	21.8	
1067	327	332	171	004	043	062	087	076	074	083	353	015	072	140
	8.5	8.9	11.1	15.2	12.0	22.6	22.4	15.2	26.2	12.9	3.4	3.9	8.4	
1219	340	335	151	008	023	031	043	043	038	075	007	360	027	139
	8.1	13.2	5.7	4.2	10.2	17.3	14.9	16.1	21.4	20.7	5.2	1.3	9.8	
1372	345	333	156	039	042	019	032	019	022	054	020	345	023	138
	7.0	11.0	4.4	3.8	9.6	16.9	17.6	17.4	19.8	12.2	4.0	4.8	9.1	
1524	312	318	128	044	037	032	015	046	012	065	075	333	024	135
	5.7	7.8	4.8	19.2	9.6	16.0	18.2	13.7	14.8	11.9	10.8	7.0	10.0	

* Top number on each pair is degrees, the bottom number is knots.

TABLE 1b. As in Table 1a, but for 1200 GMT.

Height above ground (m)	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Year	Number of observations during year
152	151	153	149	149	143	146	144	151	154	155	149	150	150	311
	16.0	18.4	18.1	22.8	15.0	14.3	18.2	19.6	20.0	17.4	11.7	14.8	17.1	
305	146	156	148	145	140	139	138	148	155	144	149	149	145	311
	22.2	24.0	25.6	14.2	18.2	19.1	25.8	25.6	31.6	26.0	13.1	16.3	21.0	
457	151	144	148	144	132	134	139	145	145	138	154	145	141	311
	32.4	23.2	30.6	15.6	21.1	21.8	24.4	30.2	23.4	23.2	13.3	15.8	25.0	
610	149	150	148	146	125	122	129	139	144	141	152	149	142	310
	28.6	26.6	36.4	17.9	19.5	21.5	24.3	35.4	24.4	33.8	12.3	12.7	26.0	
762	145	150	145	141	134	113	113	096	134	139	139	156	130	310
	21.6	16.7	29.4	30.4	11.7	23.2	34.2	26.6	26.6	29.0	7.9	10.3	21.9	
914	151	144	150	130	071	111	102	062	117	131	150	090	108	307
	15.0	5.7	12.5	14.9	18.2	21.0	16.9	17.6	21.5	23.0	7.6	1.6	12.2	
1067	149	014	170	108	049	099	046	078	103	100	121	265	095	306
	7.9	2.5	6.7	8.4	4.5	15.0	12.3	14.9	18.4	9.1	1.2	2.4	6.8	
1219	204	332	207	101	078	060	034	091	073	107	115	245	079	306
	1.9	3.0	2.2	6.3	11.3	11.6	13.3	15.8	13.4	13.4	2.9	2.9	6.1	
1372	289	335	063	080	058	048	029	049	067	108	072	257	052	305
	4.9	3.3	3.1	7.3	11.5	12.0	12.8	19.3	13.1	12.4	3.2	2.7	6.6	
1524	329	318	045	078	047	042	034	048	057	111	051	234	046	299
	8.2	2.7	3.4	4.9	10.3	11.5	14.0	13.7	13.8	13.9	2.8	1.7	7.0	

* See Table 1a footnote.

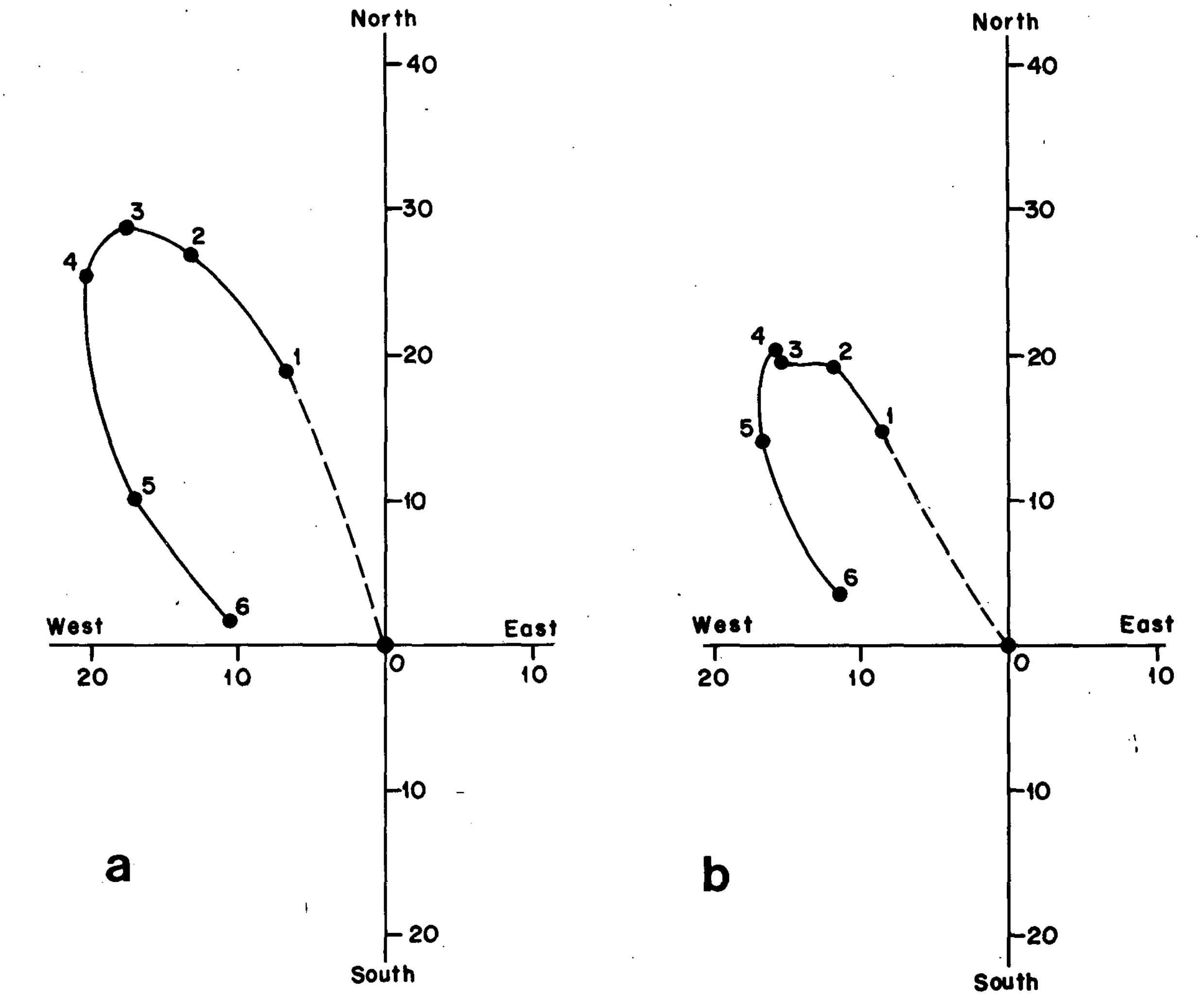

FIG. 1. Annual hodograph of winds (knots) at Marsabit: (a) 0600 GMT, (b) 1200 GMT.

and they show similar features. For illustration, we present only the annual mean wind hodographs (Fig. 1) for 0600 and 1200 GMT. Ground level is referred to as level "0" and subsequent levels at intervals of 152 m as levels 1, 2, 3, 4, etc.

Tables 1a and b, hodographs and higher-level data,

TABLE 2. Frequency distribution of wind speed (kt) for the entire year, 0600 and 1200 GMT. Heights above ground are given at intervals of 152.4 m.

Height above ground (m)	<10	>10 ≤20	>20 ≤30	>30 ≤40	>40 ≤50	>50 ≤60	>60 ≤70	>70 ≤80	>80 ≤90	>90 ≤100	>100	Total number of observations
							0600 GMT					
152	3	48	74	13	4	—	—	—	—	—	—	142
305	2	16	30	46	36	8	3			1		142
457	12	12	27	31	26	16	10	1	5		2	142
610	32	17	19	19	16	13	6	4	8	1	7	142
762	50	27	13	12	12	9	6	3	3		7	142
914	56	31	15	14	6	7	1	6	2	2	1	141
							1200 GMT					
152	52	164	68	23	4							311
305	53	104	79	33	23	11	2	3	2		1	311
457	45	96	90	35	20	7	8	4	2		4	311
610	69	86	54	43	16	19	6	6	4	1	6	310
762	95	85	50	21	17	13	12	4	3	2	8	310
914	135	72	37	32	11	4	4	4	3	2	3	307

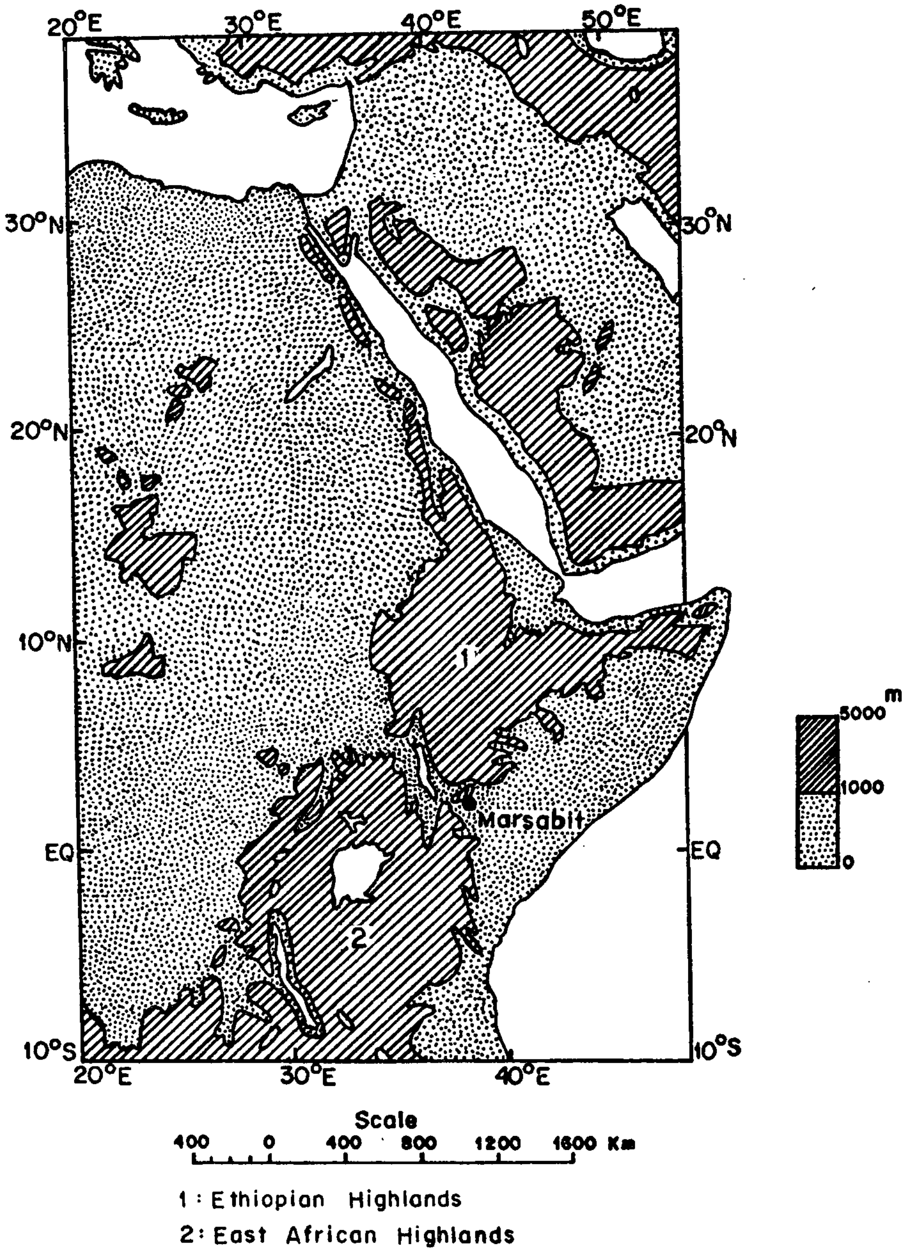

FIG. 2. Large-scale topography of northeast Africa with location of MARSABIT pilot balloon station. 1: Ethiopian Highlands. 2: East African Highlands.

not given here, reveal the following characteristics of the monthly and annual mean winds:

1) Throughout the year, the winds in the lowest 0.75 km (2500 ft) are from the southeast. At levels above 1.5 km (5000 ft), the winds are generally from northwest to northeast during northern summer (June–September) and from northeast during the rest of the year.

2) The southeasterlies increase in intensity from the ground to 0.5–0.8 km and then decrease aloft. The intensity of mean monthly winds exceeds 50 knots during February and March in the morning.

3) The hodograph turns in a counterclockwise direction from the lowest levels up to 0.75 km (2500 ft) and sometimes even aloft. Up to 450 m (1500 ft), the hodograph manifests some of the usual characteristics of the Southern Hemisphere Ekman layer.

4) Morning maximum winds are stronger than afternoon maximum winds. This may be due to stronger vertical mixing and the consequent dilution of the jet maximum in the afternoon.

Table 2, based on combined data for all months, shows that on a significant number of occasions, the wind speeds exceed 30 m s^{-1} (60 kt) and sometimes

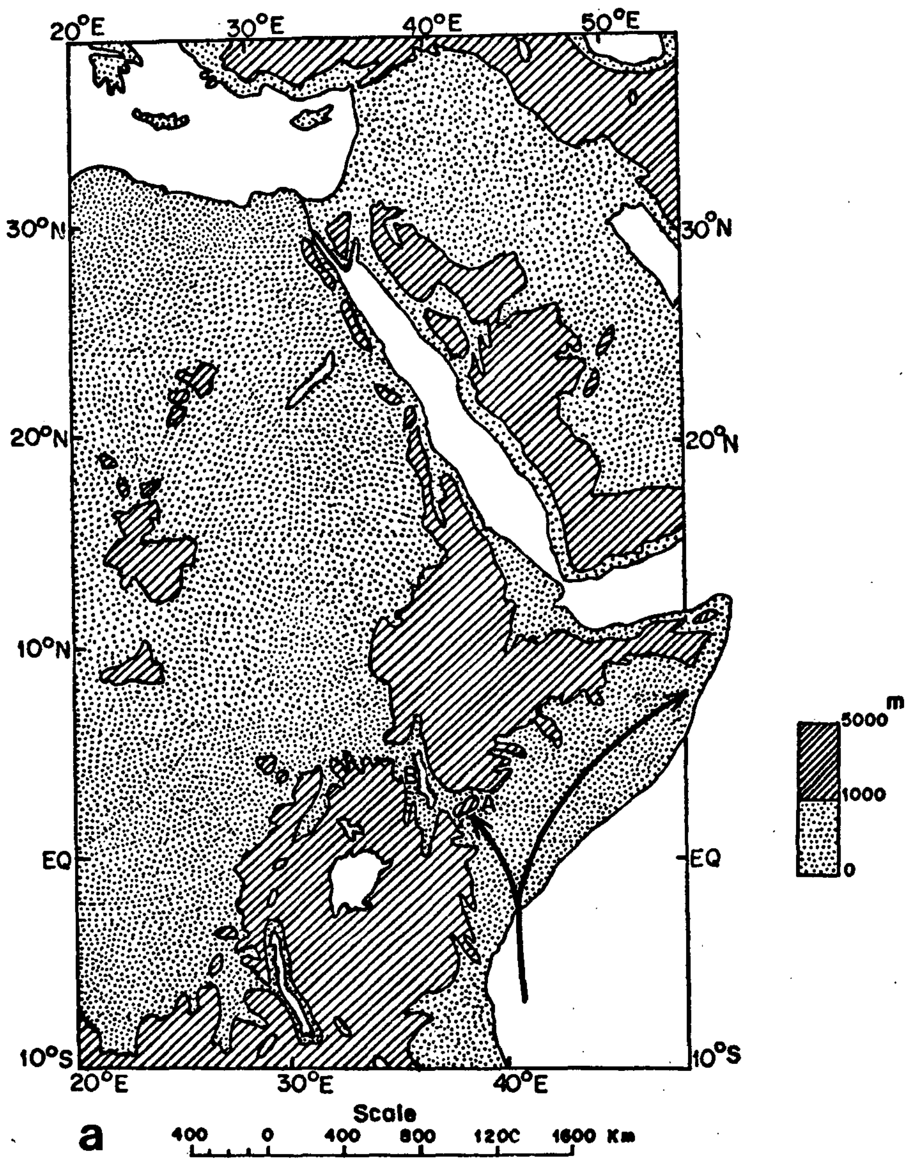

FIG. 3. Simplified model of flow near Marsabit, entrance into Lake Turkana Channel: (a) during northern summer, (b) during northern winter.

exceed 50 m s^{-1} (100 kt). At 0.6 km (2000 ft) above the ground, on more than 15% of the occasions in the morning, the speeds exceeded 30 m s^{-1} (60 kt). About 5% of the time, the wind speed exceeded 50 m s^{-1} (100 kt).

Examination of individual flights showed that on some rare occasions the speeds exceeded 75 m s^{-1} (150 kt). However, with extremely strong low-level winds, the angles of elevation become low and slight errors in the reading of angles with the theodolite could cause considerable errors in the computation of horizontal wind speeds. One should therefore treat with caution reports of extremely strong winds in Marsabit reports. In spite of this, the body of observations leaves us in no doubt that wind speeds of 50 m s^{-1} (100 kt) and more do occur in this region.

3. Conclusion

Fig. 2 shows the large-scale orographic features of northeast Africa. Lake Turkana lies in the relatively low-level region separating the Ethiopian Highlands and the East African Highlands. Marsabit is near the eastern side of this low level region. In a simplified form, we can look at the flow in this region as shown in Fig. 3. Fig. 3a shows the situation during the northern summer, characterized by the well-known East African low-level jet. Some air near the equator branches off from the coast and enters the Turkana Channel. Near Marsabit (A) there is a narrowing of the channel and near B there is a broadening. A small hill near Marsabit may have its own local effect, but we believe that the strong winds observed at Marsabit

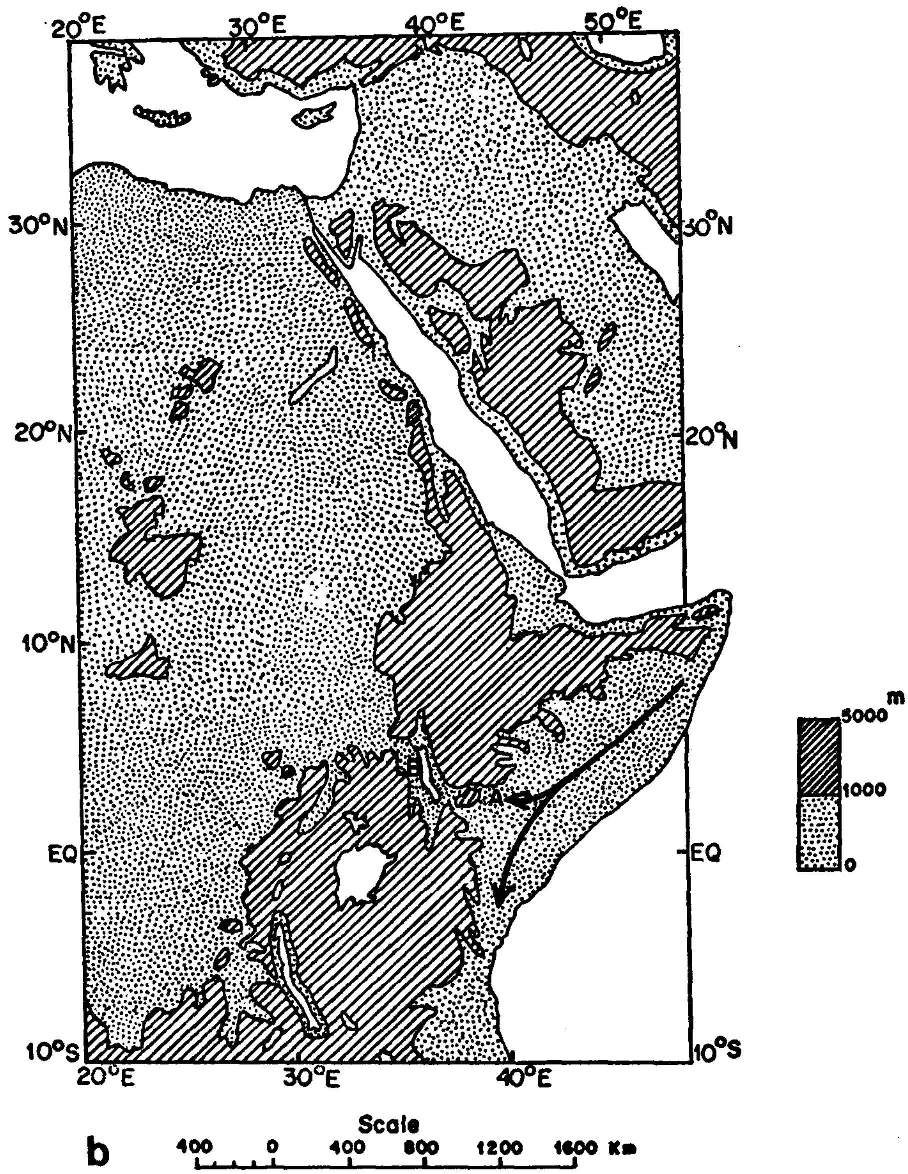

FIG. 3. (*Continued*)

are not the result of this hill, but of the large-scale orography of the Ethiopian and East African highlands. The winds strengthen due to the narrowing of the channel entrance at A.

Similarly, during the northern winter (Fig. 3b) the northeasterlies enter into the gap at A and intensify. Therefore, the orography is such that throughout the year the winds strengthen at A.

Because observations from Marsabit have only recently become available, earlier climatological charts did not indicate a strong low-level southeasterly jet in this area throughout the year.

While the data presented are based on pilot balloon observations from one station (Marsabit) for one year only, these observations have shown a great deal of consistency. They are also consistent with the well-known principles of orographic channeling. Further analysis of the continuing observations from Marsabit will undoubtedly lead to a greater understanding of the structure of the Turkana Channel Jet and its orographic forcing.

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