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Full Length Research Paper

Spatial and temporal analysis of recent climatological data in Tanzania

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Recent climate variability over Tanzania is evaluated through the analysis of spatial and temporal distributions of meteorological variables including rainfall, relative humidity (RH), maximum temperature (Tmax) and minimum temperature (Tmin) in an annual and seasonal time scale for 30 years (1971 - 2000) at 45 meteorological stations for rainfall and 27 stations for Tmax, Tmin and RH. Statistical parameters including mean (ME), coefficient of variation (CV) and skewness (SK) are computed and analyzed. These parameters are mapped using Surfer software. Seasonal contribution of each of the four seasons (JF, MAM, JJAS and OND) is assessed. It has been found that, for most of the bimodal areas, nearly 50% of the annual rainfall is contributed by MAM season. In all four seasons, rainfall, in most of the stations is characterized by a slight asymmetrical distribution with stronger spatial and temporal variability. Tmax, Tmin and RH however, exhibit a near normal distribution with significantly less variability.

Key words: ITCZ, statistical moments; coefficient of variation, skewness.

INTRODUCTION

The variability of climatic elements such as rainfall, temperature, evaporation and relative humidity has an effect on agricultural and other socio-economic activities. However, rainfall is the most important climatic element in Tanzania, since extreme interannual, seasonal and monthly variability of rainfall and prolonged drought can lead to serious economical problems and ecological catastrophes (Muriuki, 1998). Recently, in 2003 and 2005 the country experienced severe drought with severe economic implications. The drought of 2005 contributed to serve power shortage in the country leading to severe economic decline. The impact of drought was more pronounced in the first quarter of 2006, whereby the water level at Mtera dam fell below dead storage level, which is 690 m for Mtera dam leading to the decrease in the growth rate of electricity sub activities by - 1.9%. In 2007, electricity generated through the National Grid increased from 1,453.17 GWh to 2,512.83 GWh in 2006, equivalent to an increase of 73%. The increase was due to availability of abundant water in hydro power plants at Mtera and Kidatu, following good rainfall season (Kijazi and Reason 2008).

Having clear understandings of the spatial and temporal variability of rainfall and other climatological elements will facilitate policy and decision makers, and other relevant stakeholders in developing effective strategies in addressing current climate variability and projected climate change in Tanzania. However, very few studies with a shorter period of data set have attempted to describe the current climate variability through the statistical moments of the main climatological elements in Tanzania. In this study, the most recent quality controlled climatological data set with a longer period from 40 meteorological

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Abbreviations: Tmax, Maximum temperature; **Tmin,** minimum temperature; **CV,** coefficient of variation; **SK,** skewness; **RH,** relative humidity; **ME,** mean; **ITCZ,** Inter-tropical convergence zone; **SSTs,** sea surface temperatures; **M.S.L,** mean sea level; **NE,** north east; **NW,** north west; **SE,** south east; **SW,** south west.

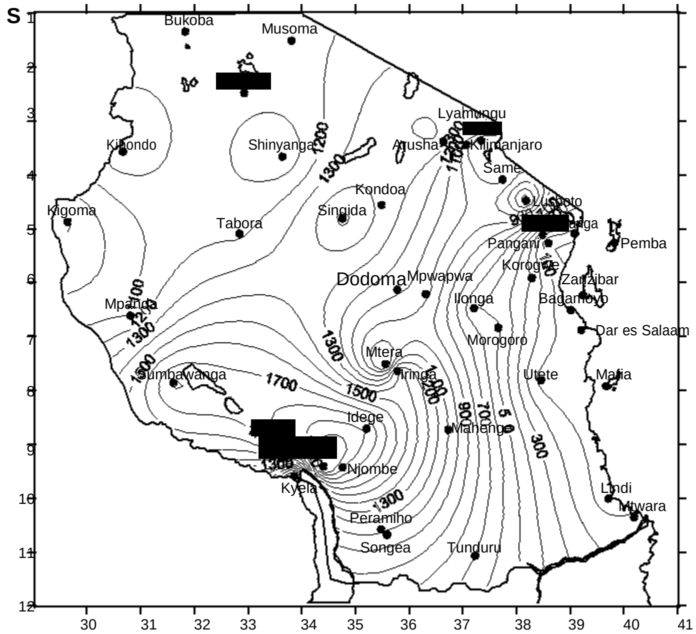

Figure 1. Location and elevation (meter above m.s.l) of the stations used in the study.

stations evenly distributed along 10 climatological regions of the country has been used to describe the current status of climate variability in Tanzania. Statistical moments such as mean (ME), coefficient of variation (CV) and skewness (SK) have been calculated and illustrated in annual and seasonal manner for rainfall, maximum temperature (Tmax), minimum temperature (Tmin), and relative humidity (RH). These statistical parameters are computed over a 30 - year period from 1971 to 2000.

DESCRIPTION OF THE STUDY AREA

The United Republic of Tanzania is one of East African countries lying between 1 – 12° S and 29 - 41° E with an area of 950,000 km^2 and a population of more than 35 millions. The country is surrounded by the great East African Lakes, namely: lakes Victoria to the north, Tanganyika to the west, Nyasa to the south and other small lakes like Rukwa, Eyasi, Manyara and Natroni. The Indian Ocean is to the east. The country includes Africa's highest Mountain (Mt. Kilimanjaro) with a height of 5,950 m above sea level and the low lying area (Lake Tanganyika, with 358 m below sea level) is found along the East African rift valley. With an exceptional of coastal areas, most part of the country lies 200 m above mean sea level (Figure 1) . The country experience two main rain seasons namely the long rains and the short rains which are associated with the northwards and southward movement of the ITCZ respectively. Most of the rainfall is convective in nature and distinctly organized. The northern part of the country and the northern coast (including Dar es Salaam, Tanga, Zanzibar and Pemba stations) experience bimodal rainfall regime, whereby the first maximum occur in the period of March, April and May (MAM) while, the second maximum in the period of October, November and December (OND). Central, Southern and Western areas have a prolonged unimodal rainfall regime starting from November continue to the end of April. Annual rainfall varies from 550 mm in the central part of the country up to 3690 mm in some parts of Southwestern Highland.

MAIN CLIMATOLOGICAL FACTORS IN TANZANIA

The forcing factors responsible for spatial and temporal characteristics of rainfall in Tanzania are Inter-Tropical Convergence Zone (ITCZ), Monsoon circulation, El-Nino Southern Oscillation (ENSO), Tropical cyclones, Easterly waves, Congo air mass, and Mascarine, St. Elena and Siberian high pressure cells. These factors affect the distribution and the trend of all climatic elements in Tanzania. However, since rainfall is the mostly affected element, in this section more focus will be put on rainfall. The intensity, location and orienttations of these high pressure cells often influence the direction and rate of moisture transport by monsoon winds. The characteristics of the St. Helena high pressure cell which is located over the south eastern Atlantic Ocean is however very crucial in determining the patterns of westerly moisture influx into the region from Atlantic Ocean and the moist Congo forest. Local mesoscale circulation features also have pronounced impacts on rainfall distribution in different parts of Tanzania.

Teleconnections between Tanzania rainfall anomalies and anomalies in the general circulation worldwide play a significant role in modifying spatial and temporal distribution of rainfall in Tanzania. The teleconnected systems among others include ENSO, Sea Surface Temperatures (SSTs) and Solar activity. Relationships between many of these regional systems and atmospheric circulations have been discussed by many authors including Ogallo (1989), Krishnamurti (1961), Kijazi and Reason (2005, 2008), Mapande and Reason (2005), and Chang'a (2005). The ITCZ migrates north and south following the movement of the Sun, with a time lag of one month (Johnson 1962; Ogallo 1982). From December to February, the ITCZ lies between 10 -15° S. During that time the prevailing winds over the East African countries are the North East (NE) monsoon, changing their direction to North West (NW) after crossing the equator (Amaglo, 1997; Nieuwolt, 1979;Odiyo, 1994; Ogallo, 1994).

These winds are relatively dry due to their continental origin and their long track over the dry land of north eastern Africa and Arabia. As a result, the northern part of the country experiences relatively dry weather. However, during this period orographic lifting and convergence around ITCZ area causes a significant amount of rainfall in the southern part of the country (Odiyo 1994). From March to May, the ITCZ migrate to Tanzania from south. Due to large scale convergence and instability of the prevailing air masses originating from the Indian Ocean, significant amount of rainfall, mostly of convectional type occur, these rains are known as Long rains (Zorita and Tillya 2002; Mhita 1990; Nyenzi et al. 1999; Vinay and Conway 2003). From May to September the prevailing winds are the SE monsoons, changing their direction to SW after crossing the equator (Glover et al. 1954; Jury et al. 2002; Nieuwolt 1979). They are relatively dry and cold, this is because they are originated from the anticyclone area (Mascarene high pressure cells) around Mascarene Island near Antarctic, losing much of their moisture along the mountains in Madagascar. From September to December the ITCZ moves from north to south relatively faster than its movement from south to north. During this period the northern part of the country and the Indian coast receive Short rains.

DATA DESCRIPTION AND ANALYSES

Rainfall, Tmax, Tmin and RH data analyzed in this paper were collected from Tanzania Meteorological Agency (TMA). Due to shorter time series other climatological data such as pressure and winds have not been included in the analysis. All 40 meteorological stations that are used in this paper are presented in Figure 1. A first glance of spatial distribution of these stations (Figure 1) indicates that in the western part of the country the stations are few and not evenly distributed. Most of the stations are above mean sea level (m.s.l). In the assessment of meteorological data at each station, a similar approach to that of Muwaffaq and Mikdata (2007) is adopted. Three statistical parameters which are ME, CV and SK are computed and analyzed. As explained in Muwaffaq and Mikdat (2007), each parameter depicts different features of the data. The mean value shows the annual constant value that can be taken as a representative for the data. The standard deviation shows the average squared deviations from the mean value, hence depicts variability of the meteorological series. Although, the coefficient of variation has almost the same depiction, but its inclusion is for expressing variability in a dimensionless manner to facilitate comparison in variability among different meteorological variables.

In mathematical modeling of meteorological phenomena, most often the variability are required to abide by normal (Gaussian) distribution function, where it is considered that the data is symmetric about the mean (SK = 0) and for this purpose, SK parameter is considered in this study. The spatial and temporal variation of ME, CV, and SK parameters of rainfall, Tmax, Tmin and RH are computed and illustrated in maps (Figures 2 - 17).

RESULTS AND DISCUSSION

Statistical moments of rainfall

Figure 2a shows that the area around southwestern highland (Iringa, Mbeya, Njombe, Idege and Sumbawanga stations) and western part of Lake Victoria (Bukoba station) has highest annual rainfall amount. Idege station in Southwestern highland do receive an average of 3690 mm per annum while in Bukoba mean annual rainfall is 2028 mm. This indicates the influence of topography and lake effect in spatial and temporal distribution of rainfall.

Central areas (Dodoma, Singida, Mtera and Mpwapwa stations) and some parts of Northeastern highland (Same, Arusha and Kilimanjaro) which are mostly semi arid, are characterized by mean annual rainfall less than 800 mm. Being deep inland, central areas are less favoured by moisture influx from both Congo air mass and from the Indian Ocean. Generally mean annual rainfall tend to increase from central areas. Main forcing factors that contribute to the observed spatial variability of rainfall include: complex topographic features of the country, monsoon circulation, Congo air mass and Inter-Tropical Convergence Zone (ITCZ). Figure 2b shows that coefficient of variation is less than 20% in areas around Lake Victoria basin, Indian Ocean coast and some parts of Northeastern highlands (Iringa, Mbeya and Songea). The highest CV value is 60% in Mpanda. The smaller the CV value, the more persistent is the rainfall occurrences by time. Hence coastal areas, areas around Lake Victoria basin, especially the western side of the lake and some parts of the northeastern highlands are characterized by relatively persistent rainfall occurrences. The lower CV values are more dominant to areas close to large water bodies, indicating the influence of large water bodies and their associated synoptic scale circulation phenomena in modifying climate of an area.

The SK coefficient for mean annual rainfall shows positive values in most of the stations (Figure 2c). This indicates that low intensity rainfall occurrence frequencies are greater than higher intensity rainfall occurrences. Hence, rainfall distribution exhibits either an exponential, logarithmic or gamma distribution pattern. The spatial distribution of the meteorological variables is considered for ME, CV and SK through JF, MAM, JJAS and OND rainfall seasons. From Table 1 it can be concluded that for bimodal areas nearly 50% of the total annual rainfall amount is observed in MAM, 15 - 36 % in OND, 4 - 20% in JF and 3 - 22% in JJAS seasons. For most of the stations JJAS is the dry season. The percentage contribution of JJAS rainfall in mean annual rainfall is near zero for most of the central areas (Figure 2a). However stations that are close to large water bodies like the Indian Ocean and Lake Victoria basin and some parts of Southwestern highland do experience mesoscale driven rainfall during JJAS. Figure 3 depicts spatial distribution of seasonal rainfall for the JF, MAM, JJAS and OND seasons. During JF season, maximum rainfall is concentrated in the southern part of the country, especially over Southwestern highland as the ITCZ is at its extreme southern location. For most of the unimodal areas this is the peak rainfall period, while for bimodal areas JF is liken to transition period. During MAM season most part of the country experience significant amount of rainfall as the ITCZ is almost at the middle of the country. However higher amounts are concentrated over some parts of Southwestern highlands and over the western side of the Lake Victoria basin. JJAS is the dry season for most part

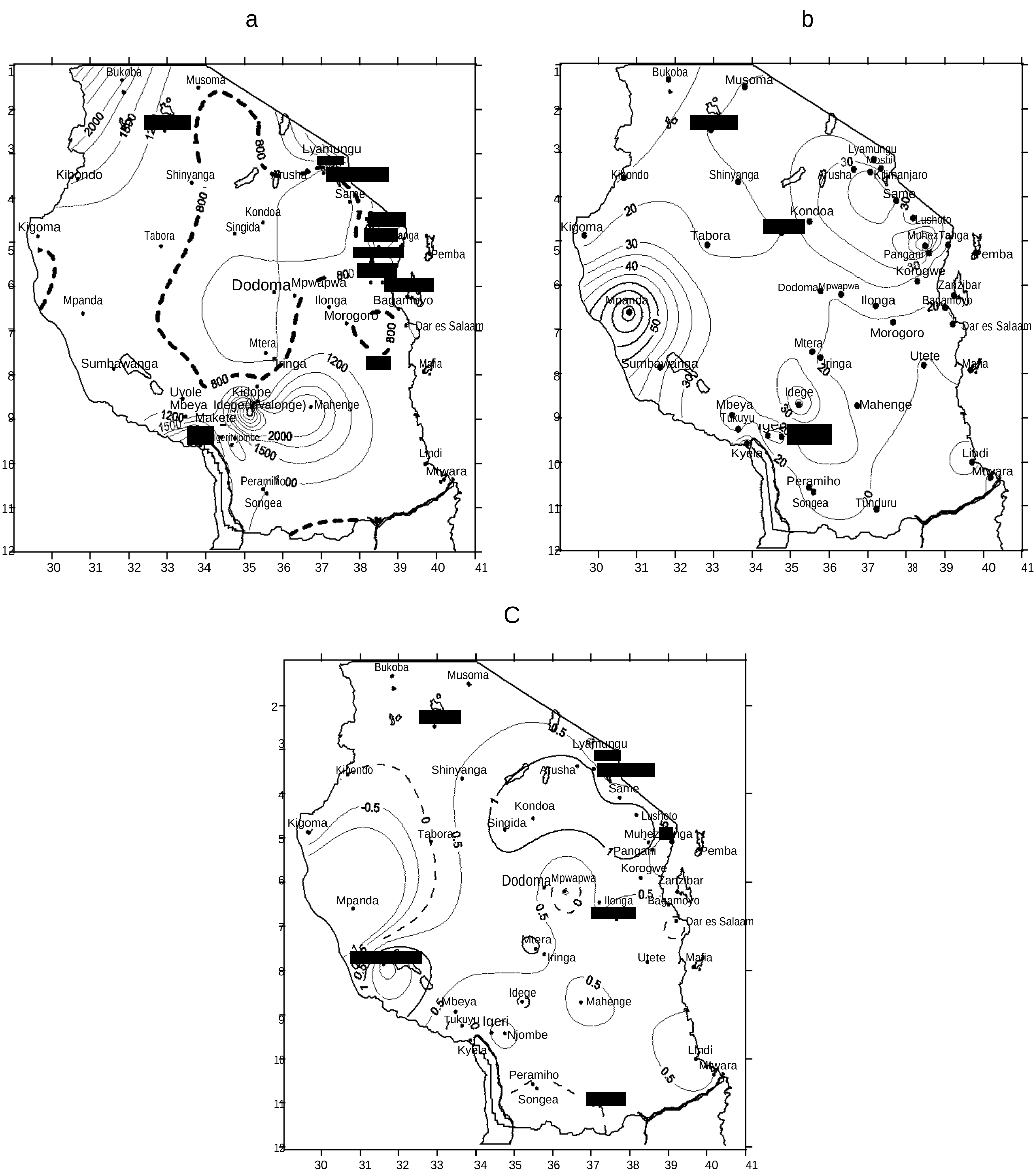

Figure 2. Annual (A) mean rainfall (mm), (B) coefficient of variation (%), and (C) skewness.

Table 1. Mean seasonal rainfall and its percentage contribution in mean annual rainfall (mm) for the period 1971 – 2000 for selected stations.

Rainfall regime	Station	JF		MAM		JJAS		OND		Annual
		ME	%	ME	%	ME	%	ME	%	
Bimodal rainfall regime	Arusha	126.4	15.5	437.0	53.9	30.6	3.8	216.2	26.7	810.2
	Kilimanjaro	89.6	16.8	305.1	57.1	30.9	5.8	108.9	20.3	534.5
	Moshi	80.4	9.0	607.3	67.8	68.1	7.6	139.3	15.6	895.1
	Same	96.7	17.2	260.5	46.3	39.9	7.1	165.4	29.4	562.5
	Dar es Salaam	131.3	11.4	590.1	51.3	115.3	10.0	313	27.2	1149.7
	Tanga	62.8	4.7	642.1	48.3	287.7	21.7	336.3	25.3	1328.9
	Zanzibar	144.0	8.4	862.2	50.3	193.9	11.3	514.6	30.0	1714.7
	Bukoba	303.5	15	888.1	43.8	281.6	13.9	554.7	27.4	2027.9
	Musoma	131.0	15.1	405.1	46.7	88.3	10.2	243.5	28.1	867.9
	Mwanza	212.1	20.2	380.9	36.2	76.4	7.3	381.7	36.3	1051.1
Unimodal rainfall regime	Kondoa	236.3	34.2	257.5	37.2	1.9	0.3	195.8	28.3	691.5
	Dodoma	248.8	43.1	177.0	30.7	0.1	0.0	151.6	26.3	577.5
	Kigoma	234.2	23.7	336.9	34.1	33.9	3.4	383.1	38.8	988.1
	Mtwara	333.7	30.7	469.7	43.2	46.7	4.3	238.4	21.9	1088.6
	Tabora	282.5	29.7	319.3	33.6	5.6	0.6	342.2	36.0	949.4
	Mpanda	255.1	26.5	300.5	31.2	2.5	0.3	405.8	42.1	963.8
	Iringa	249.3	41.7	201.4	33.7	0.9	0.2	146.5	24.5	598.1
	Mbeya	365.7	39.4	297.4	32.0	4.1	0.4	260.8	28.1	927.9
	Mahenge	601.1	27.4	1028.2	46.9	72.3	3.3	491.7	22.4	2193.3
	Idege	887.7	24.1	1929.7	52.3	143.8	3.9	728.6	19.7	3689.9
	Sumbawanga	336.9	35.6	282.6	29.8	12.4	1.3	315.2	33.3	947.1
	Songea	488.9	44.5	367.3	33.4	3.8	0.3	239.2	21.8	1099.3

of the country, as it can be observed from Figure 3; most of the central areas receive less than 20 mm of rainfall during this season. However areas around the Indian Ocean coast receive more than 80 mm of rainfall as the results of moisture influx from the Indian Ocean enhanced by SE monsoon, which is the prevailing wind in JJAS season. Higher rainfall amounts over the western side of the lake can be explained by the semi permanent observed low pressure and the general lake effects. OND is normally termed as the short-rain season for bimodal areas. However, for most of the unimodal areas, the onset of their seasonal rainfall is mostly at the end of November. This explains the higher amounts of rainfall that are observed over some parts of Southwestern high-land.

In JJAS season, which is the typical dry and cold period in Tanzania, the CV values are relatively large in all stations (Figure 4). It is more than 100% for the central, western and southern parts of the country. Of the four seasons, CV values are relatively lower in the MAM season; with the exception of the western areas where most part of the country is characterized by CV values of less than 40%. It can also be noted that in all the four seasons relatively less CV values are over the areas close to the Lake Victoria basin, especially the western side of the lake and to the Indian Ocean coast. Spatial distribution of skewness coefficient is presented in Figure 5. Skewness measure the degree of symmetry of the data set about the mean. A positively skewed distribution is one in which relatively small values is more likely than larger values, and vice versa. In all the four seasons most of the stations are characterized by SK values between -1 and 1 indicating a slight asymmetrical distribution, but the values are higher during JJAS season. In general, the drier the climate the more positively skewed distribution of annual rainfall. That is relatively small values are more likely than larger values.

Statistical moments of maximum temperature

Figures 6a and 7 depict spatial distribution of mean annual and seasonal maximum temperature. Areas along the Indian Ocean coast which are 0 to 200 m above m. s. l. (Figure 1) are characterized by annual mean maximum temperature greater than 30°C, with Dar es Salaam and Zanzibar regions having a mean annual maximum temperature of 30.8°C. The influence of topography is much more vivid over Southwestern and Northeastern highlands as mean annual Tmax is less than 28°C in most of the stations, with Igeri station recording the lowest mean annual Tmax of 19°C. The

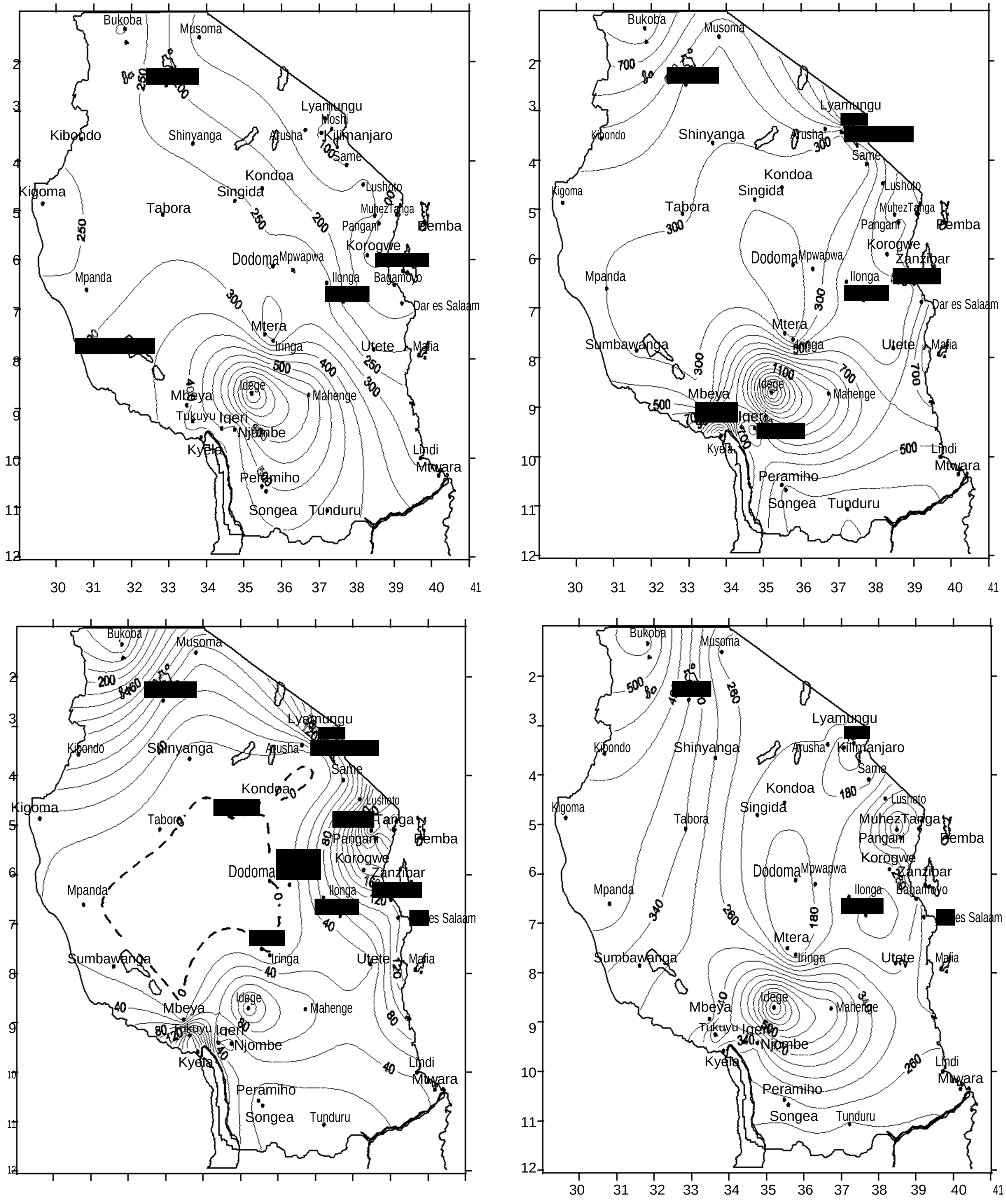

Figure 3. Mean seasonal rainfall for four seasons (JF, MAM, JJAS and OND).

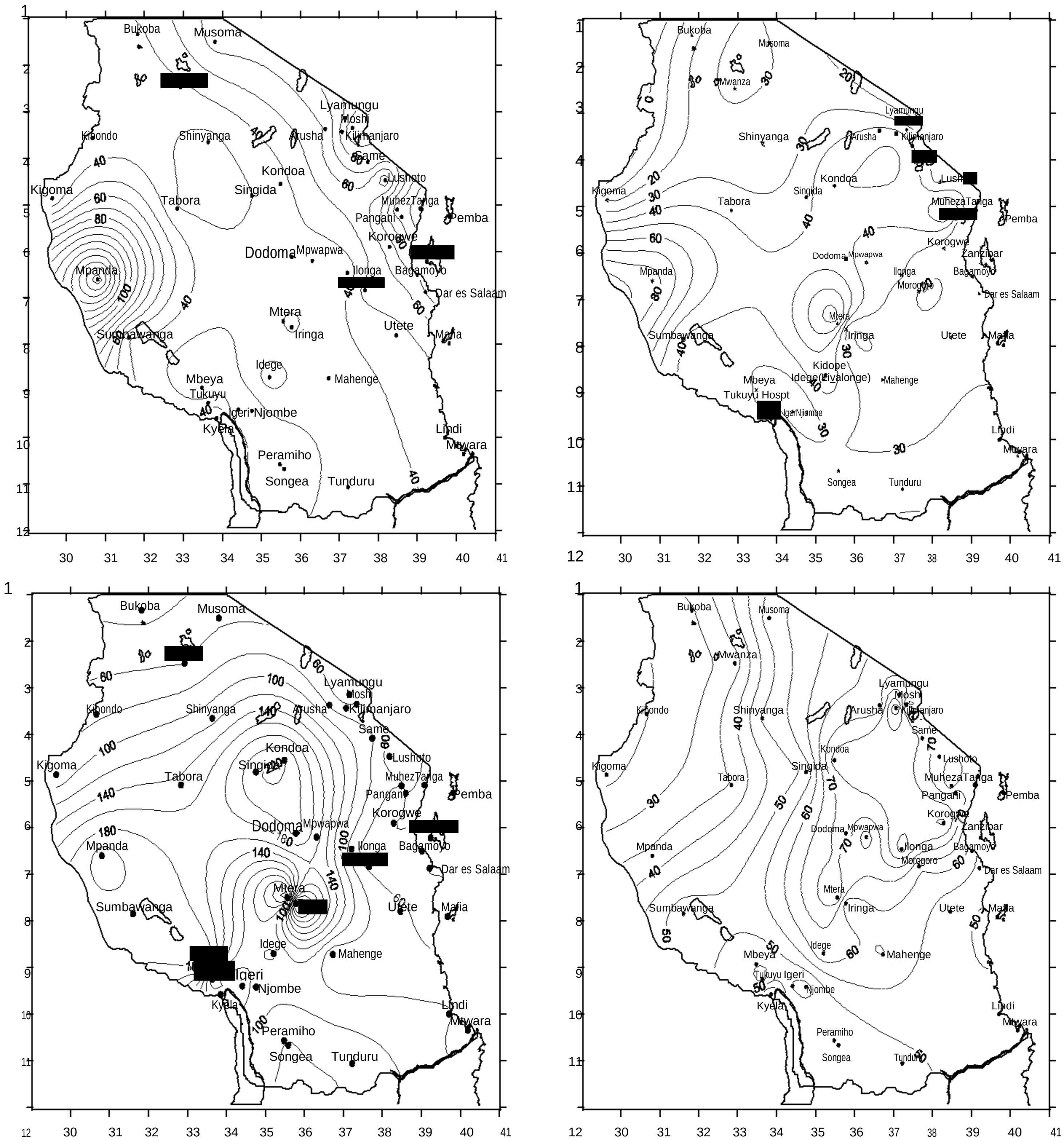

Figure 4. Rainfall coefficient of variation for four seasons (JF, MAM, JJAS and OND).

spatial pattern of mean seasonal Tmax is similar to that of the annual pattern (Figure 7). In all four seasons, areas along the Indian Ocean coast are characterized by higher values of Tmax as compared to the rest of the country. In

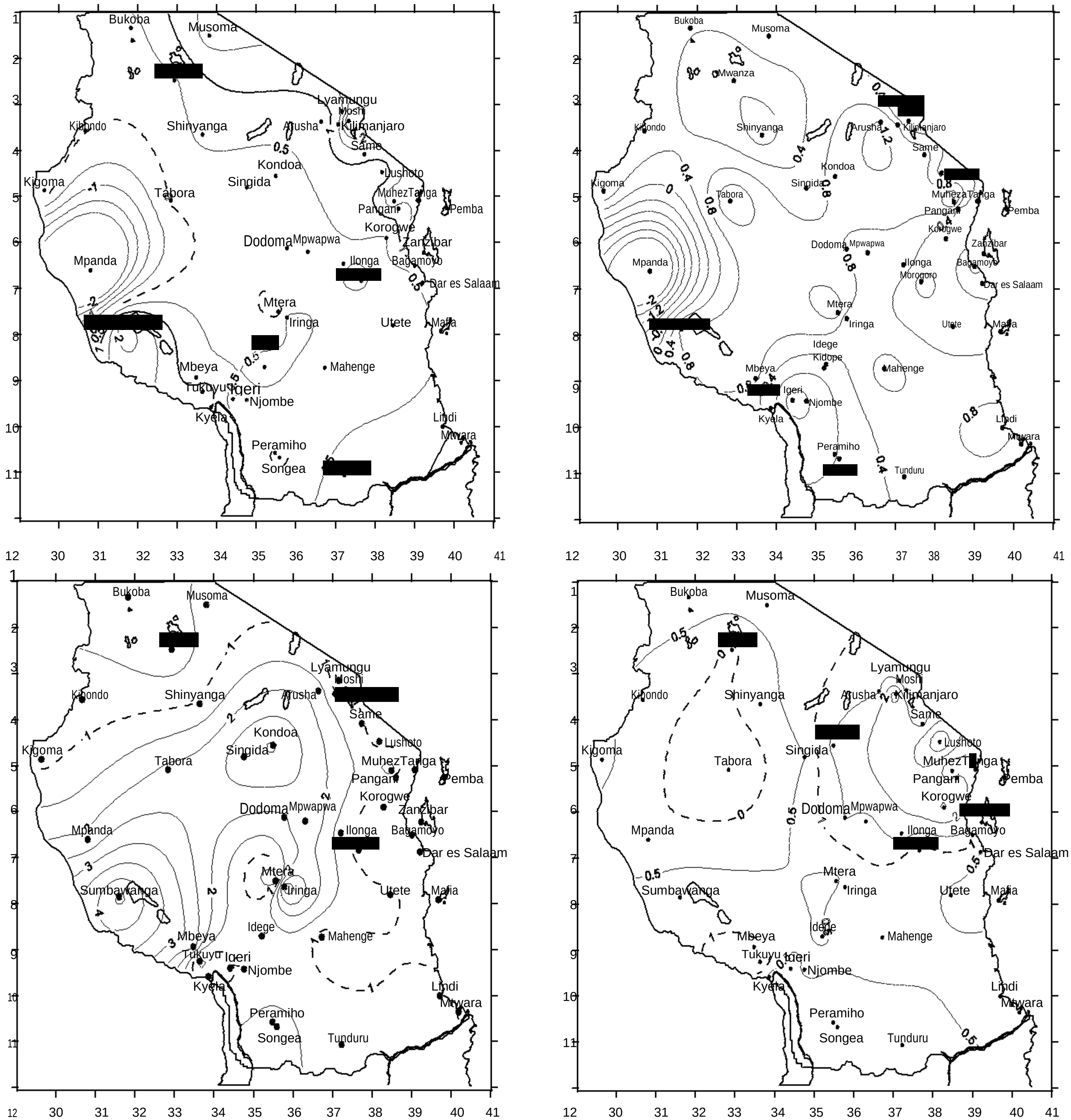

Figure 5. Rainfall skewness coefficient for four seasons (JF, MAM, JJAS and OND).

JF season mean Tmax values are slightly higher than 32°C in most of the stations in the Northern coast. JJAS is the coldest season with relatively lower values of Tmax centered on Northeastern and Southwestern highland. In general, Tmax data in Tanzania are characterized by very low spatial and temporal variability with well defined

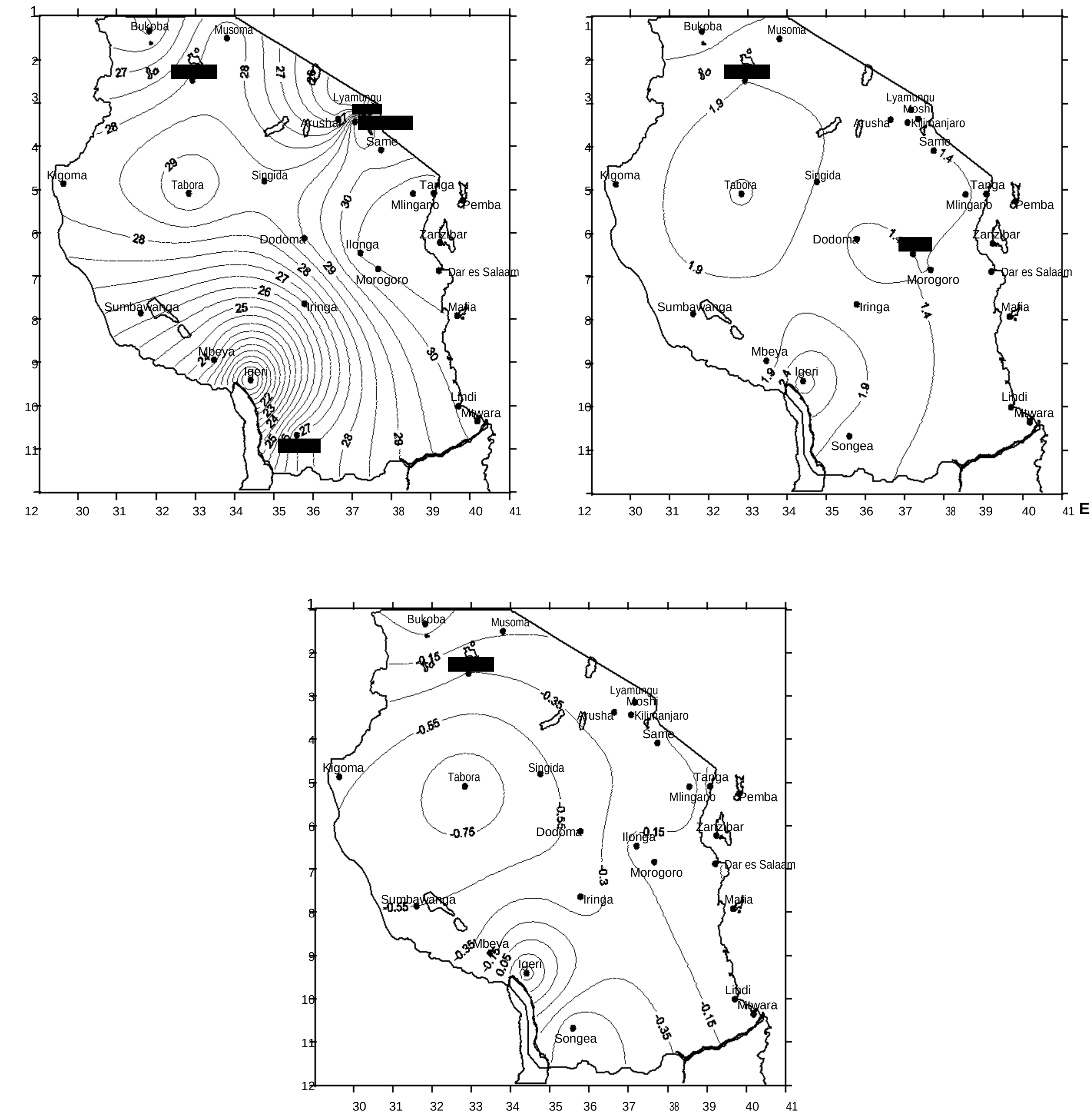

Figure 6. Annual (a) mean maximum temperature (^{0}C), (b) coefficient of variation (%), and (c) skewness.

pattern governed by topography and influence from Congo airmass and proximity to the Indian Ocean. There is a clear temperature gradient in southwest-northeast orientation (Figure 7). CV values for mean annual Tmax and values for JF, MAM, JJAS and OND seasons areless than 5% (Figures 6b and 8), indicating the strong persis-

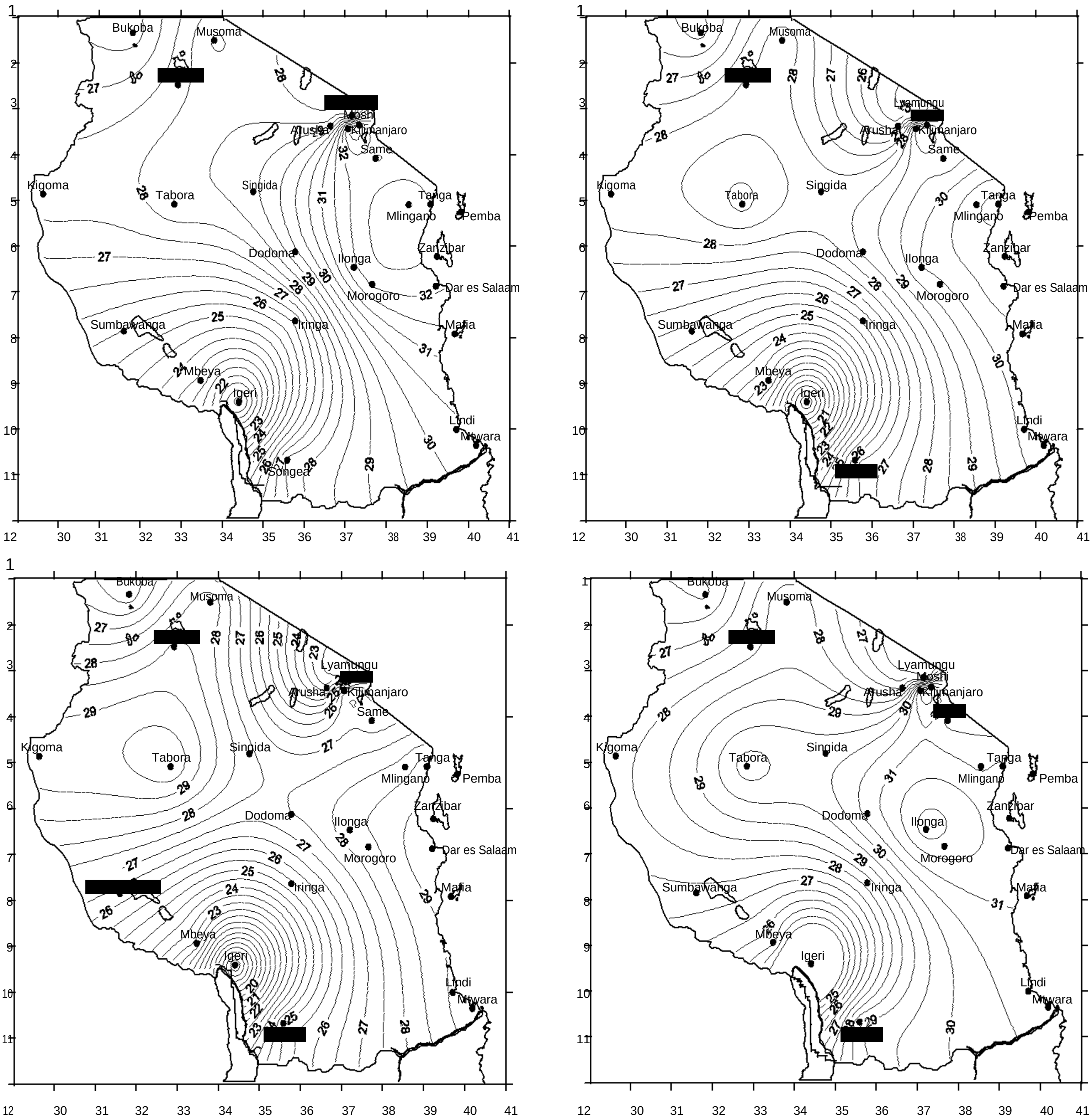

Figure 7. Mean maximum temperature (°C) for four seasons (JF, MAM, JJAS and OND).

tence in the Tmax time series. Figure 9 depicts seasonal distribution of SK coefficient. In all four seasons SK values are close to zero in most of the stations. This implies no remarkable departure from the normal distribution.

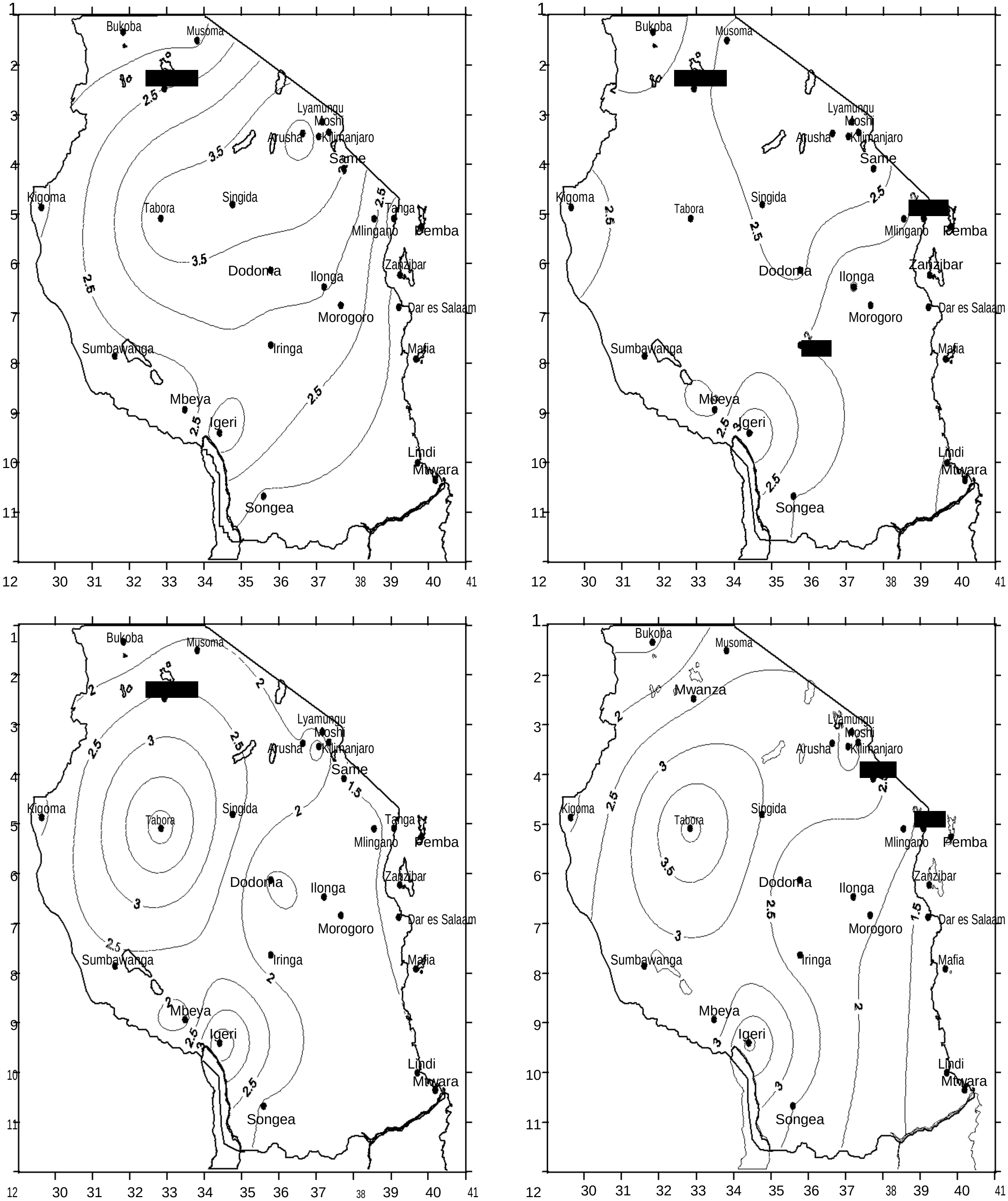

Figure 8. Maximum temperature coefficient of variation (%) for four seasons (JF, MAM, JJAS and OND).

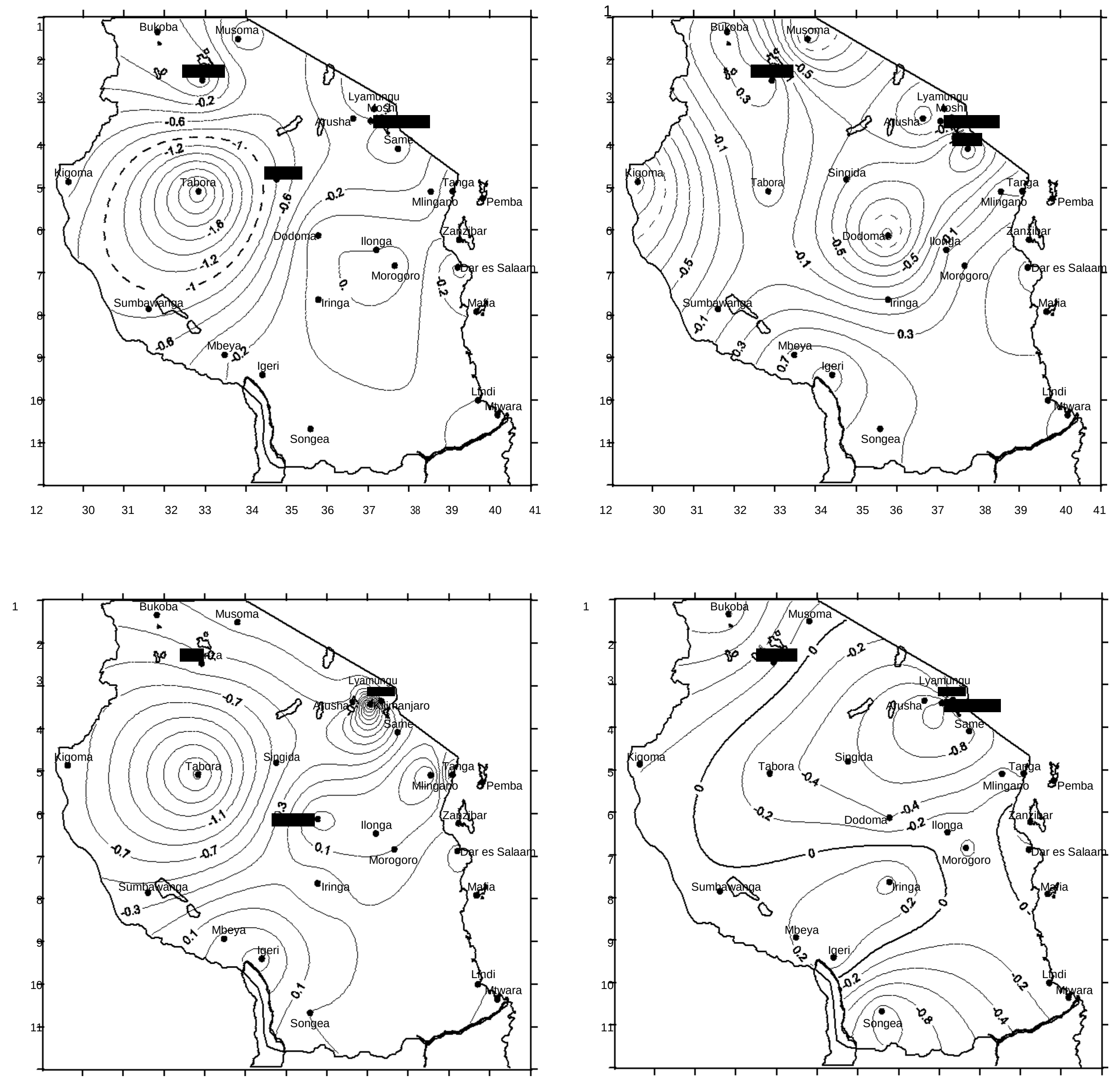

Figure 9. Maximum temperature skewness coefficient for four seasons (JF, MAM, JJAS and OND).

Statistical moments of minimum temperature

Minimum temperature is an important climatic element due to its deterministic relationship to various activities. It has an agricultural importance because its relation to frost and fogs formation and dormancy period of plants, to transportation especially in airports because it is one of the factors that lead to radiation fog formation, which frequently occurs in some parts of Tanzania. Spatial and temporal pattern of mean Tmin are presented in Figures

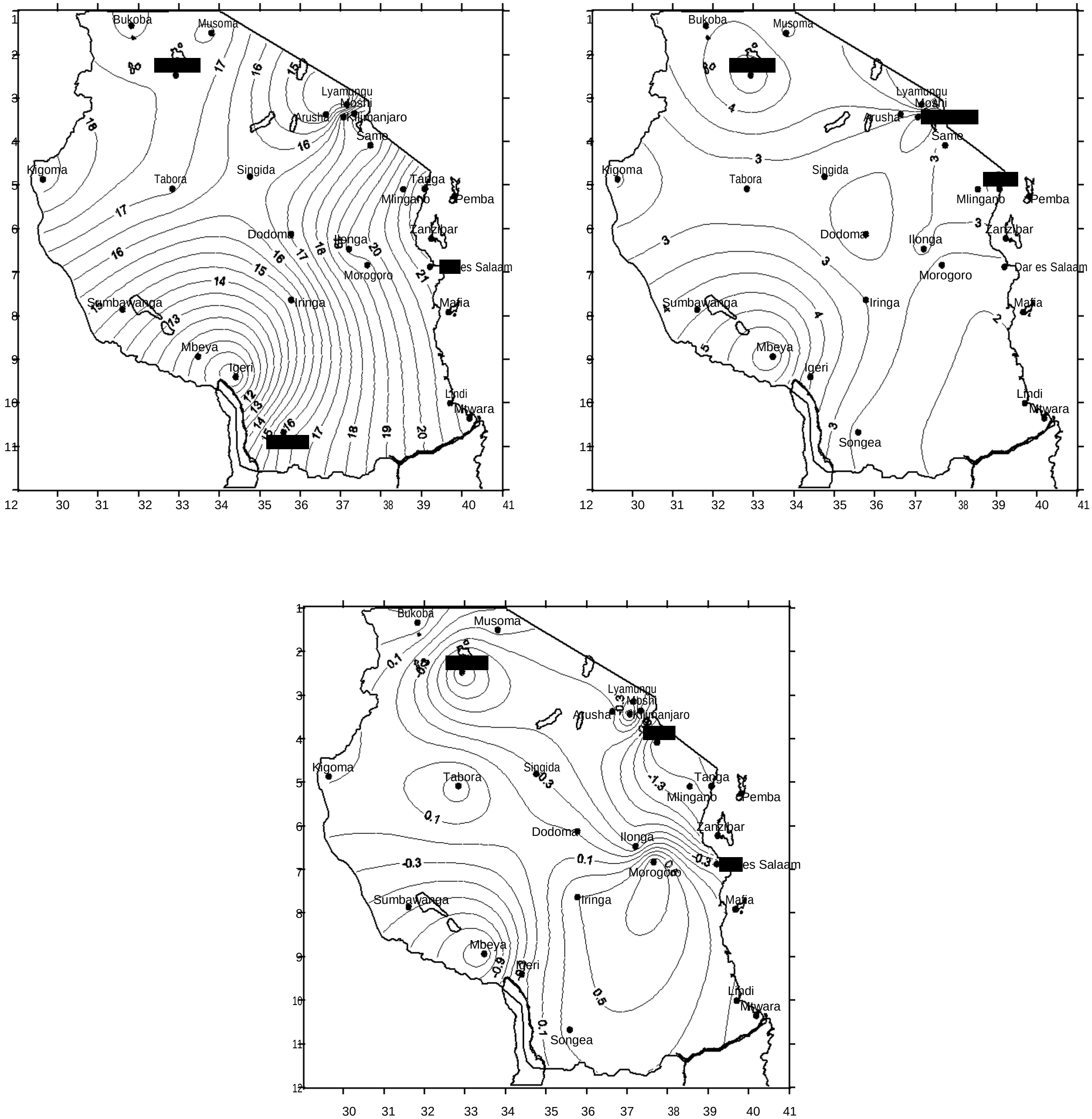

Figure 10. Annual (A) mean minimum temperature (°C), (B) coefficient of variation (%), and (C) skewness.

10a and 11. Distribution of Tmin is identical to that of Tmax, lower values of Tmin are centered on South-western and Northeastern highlands for all four seasons and southwest-northeast temperature gradient can be discerned from the maps. Mbeya and Igeri are the stations with the lowest Tmin values of around 7°C observed

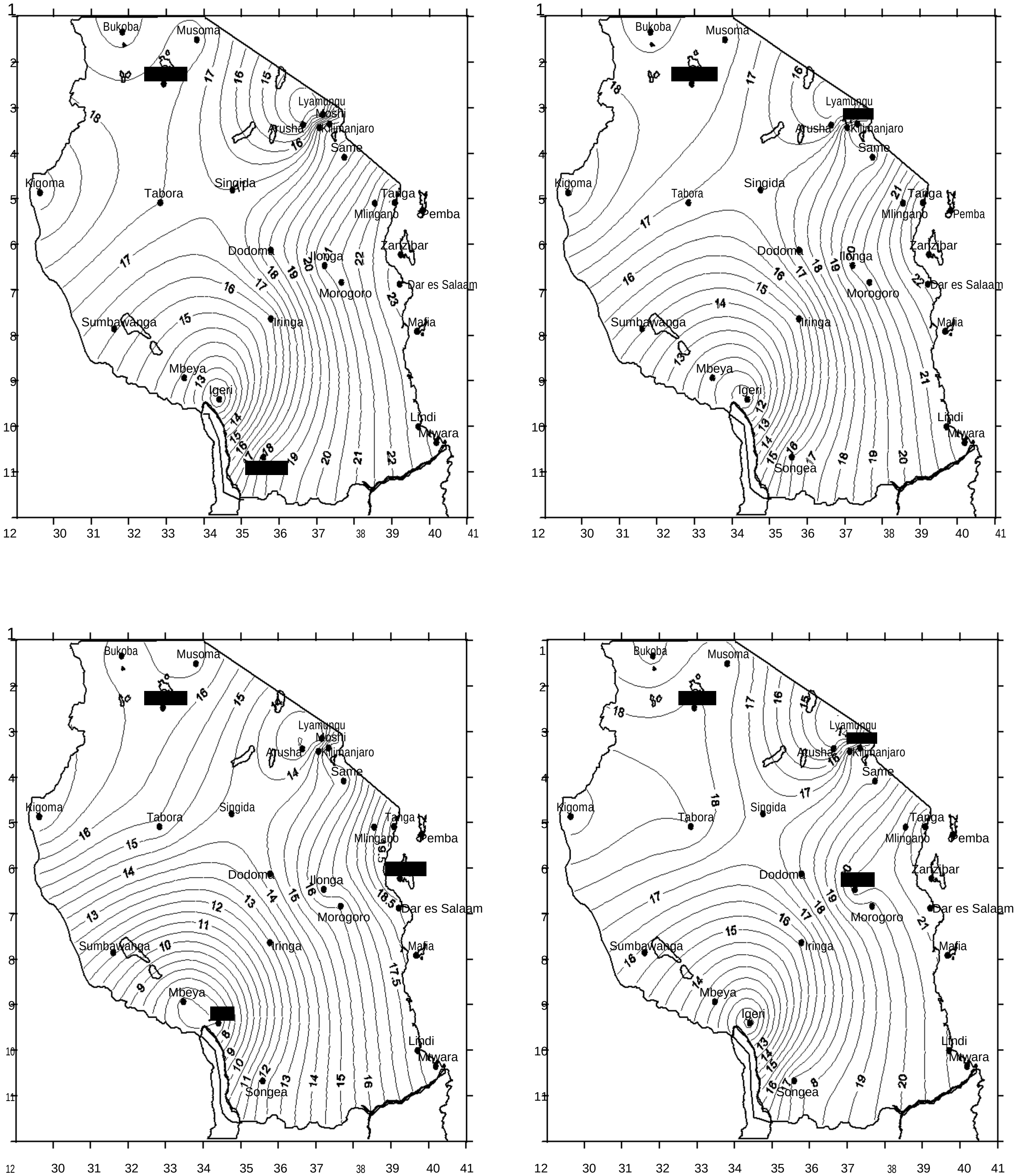

Figure 11. Mean minimum temperature (°C) for four seasons (JF, MAM, JJAS and OND).

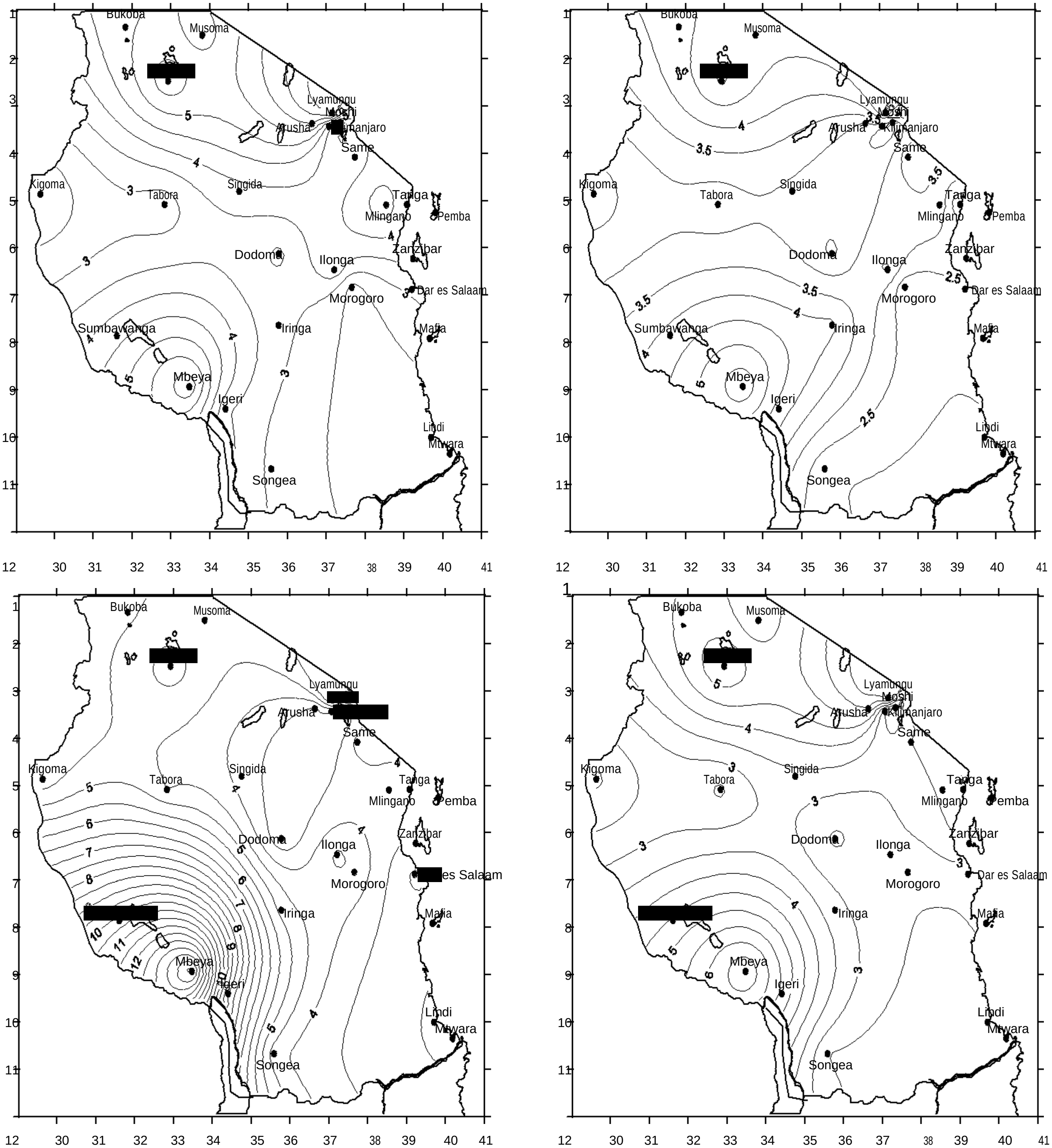

Figure 12. Minimum temperature coefficient of variation (%) for four seasons (JF, MAM, JJAS and OND).

during JJAS season. Higher values of Tmin are centered along the Indian Ocean coast, where in J F season, thehighest value of Tmin is 23°C and is typical for Dar es Salaam, Pemba and Zanzibar stations. During MAM

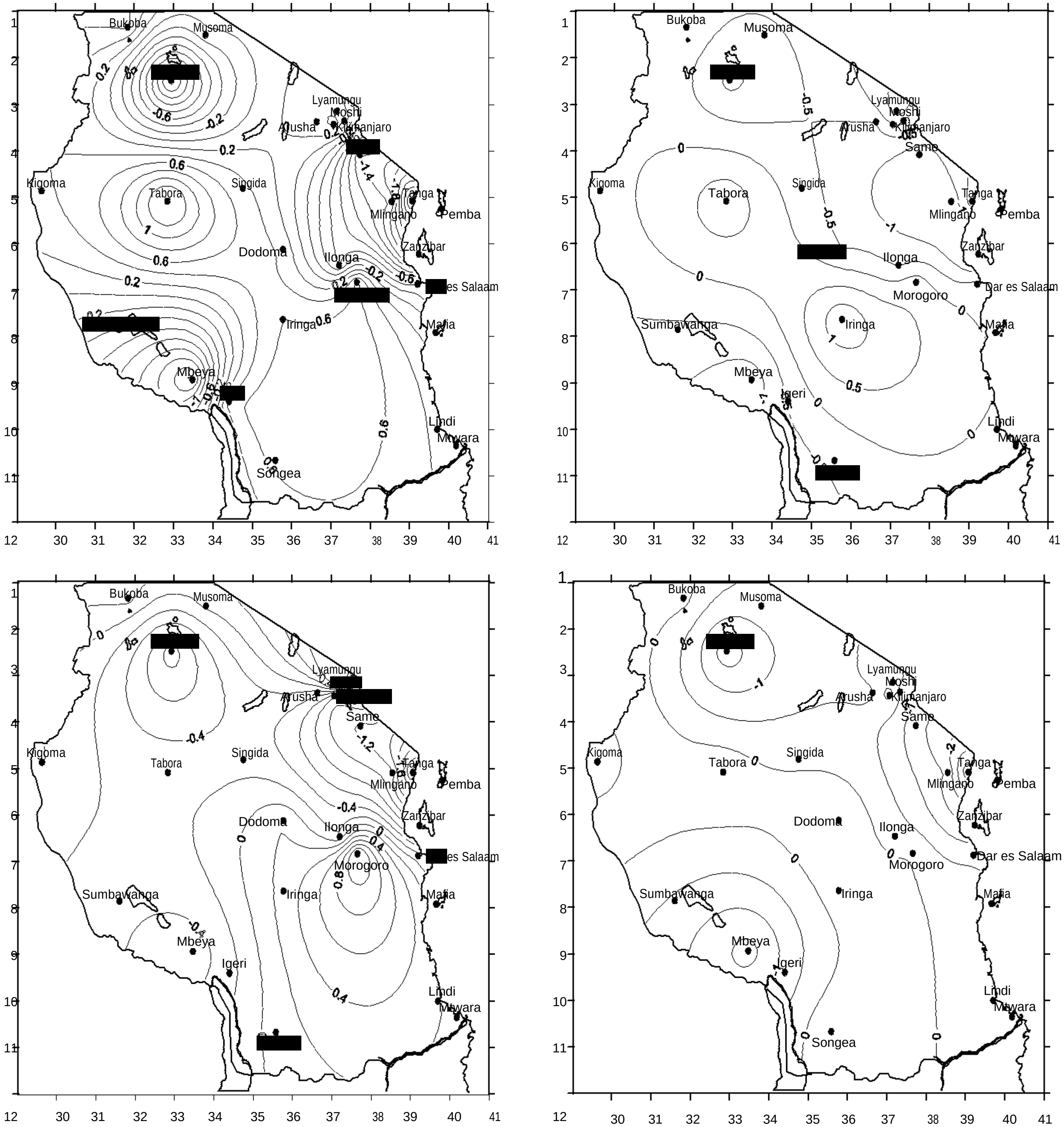

Figure 13. Minimum temperature skewness coefficient for four seasons (JF, MAM, JJAS and OND).

season, the highest value of Tmin is slightly above 22°C observed over Dar es Salaam, Zanzibar and Pemba stations. During JJAS season (the coldest period) for the entire country with Tmin values less than 20°C decreasing from east to west with northeast – southwest temperature gradient (Figure 11).

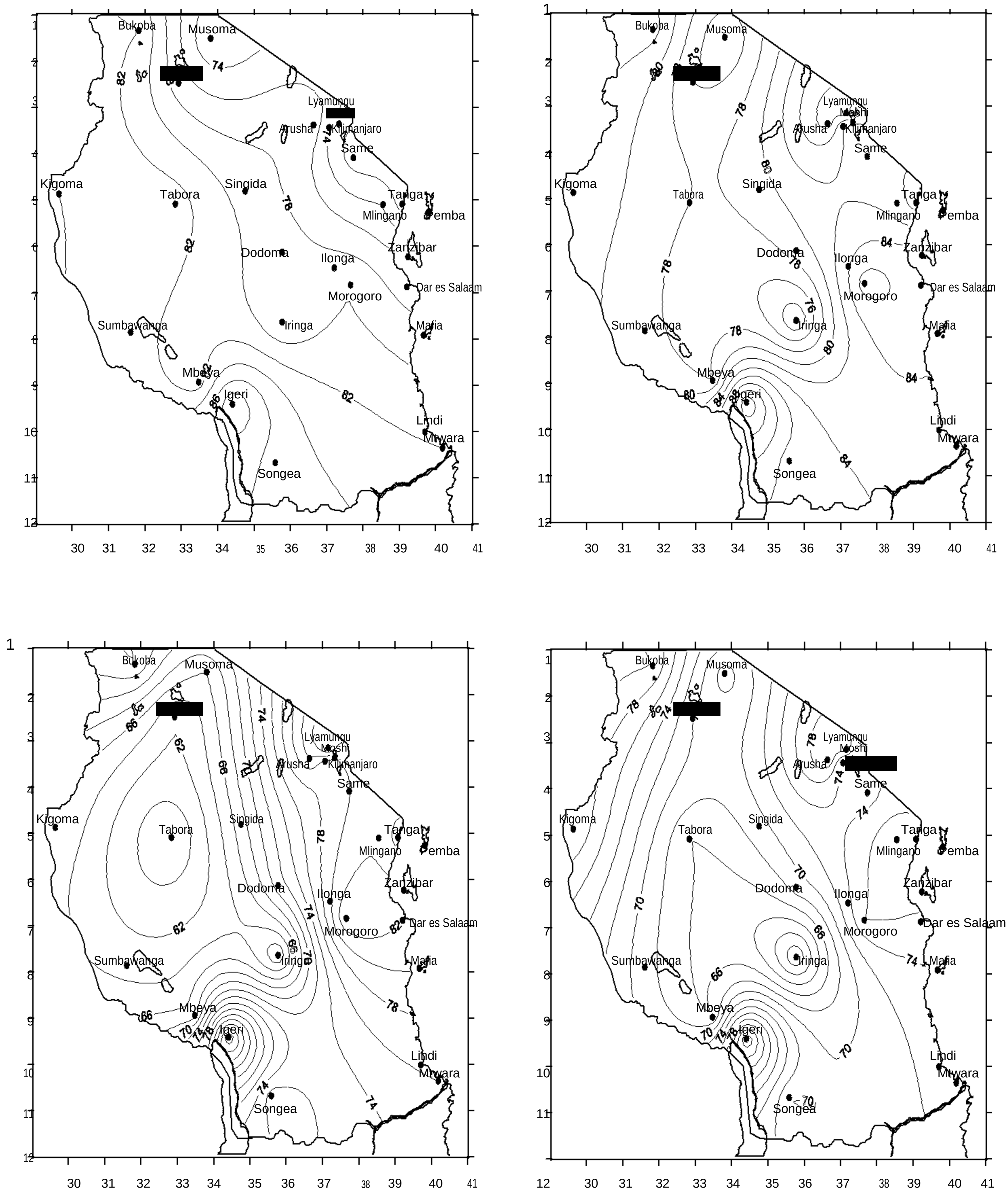

Figure 14. Mean relative humidity (%) for four seasons (JF, MAM, JJAS and OND).

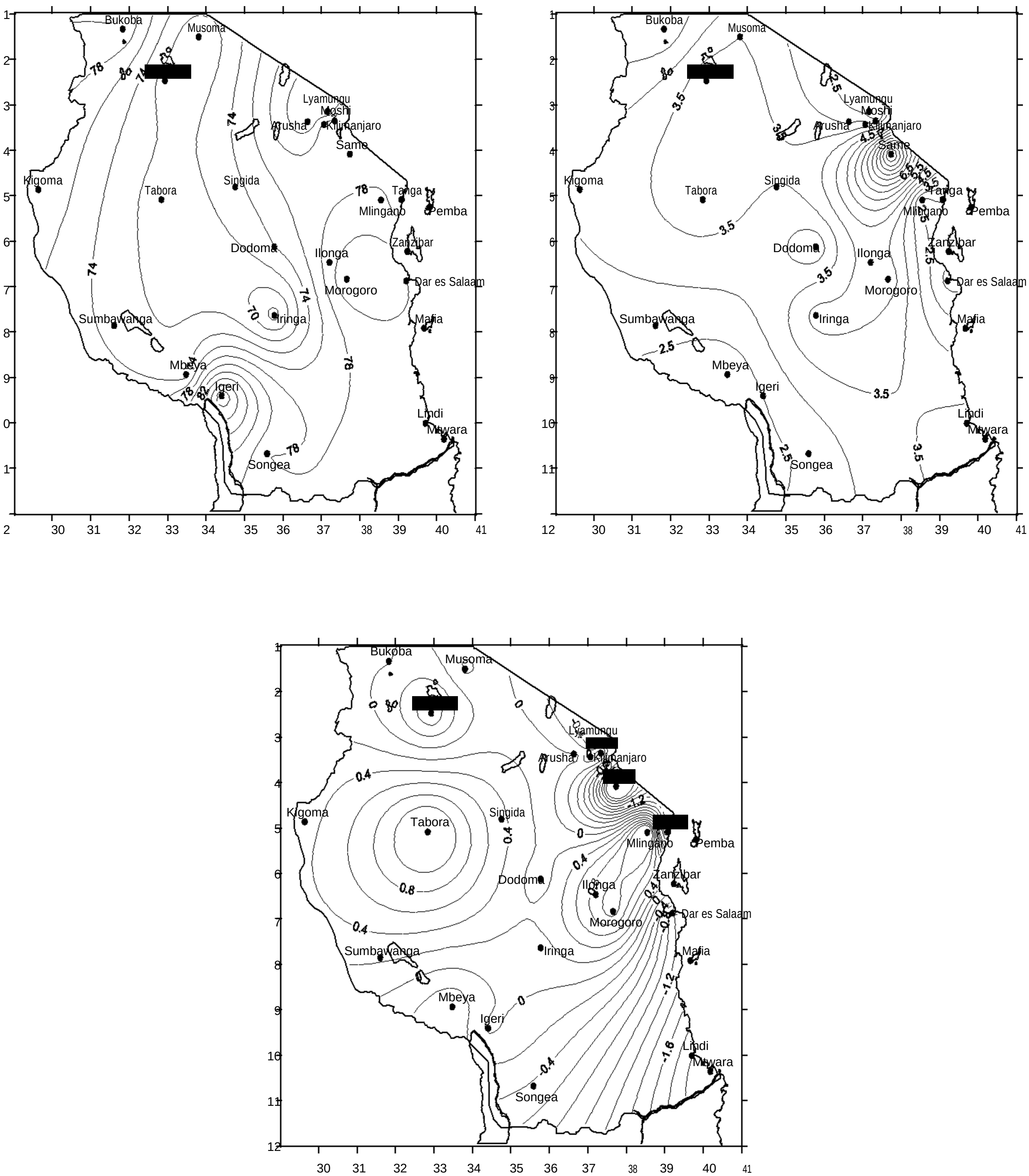

Figure 15. Annual (A) mean relative humidity (%), (B) coefficient of variation (%), and (C) skewness.

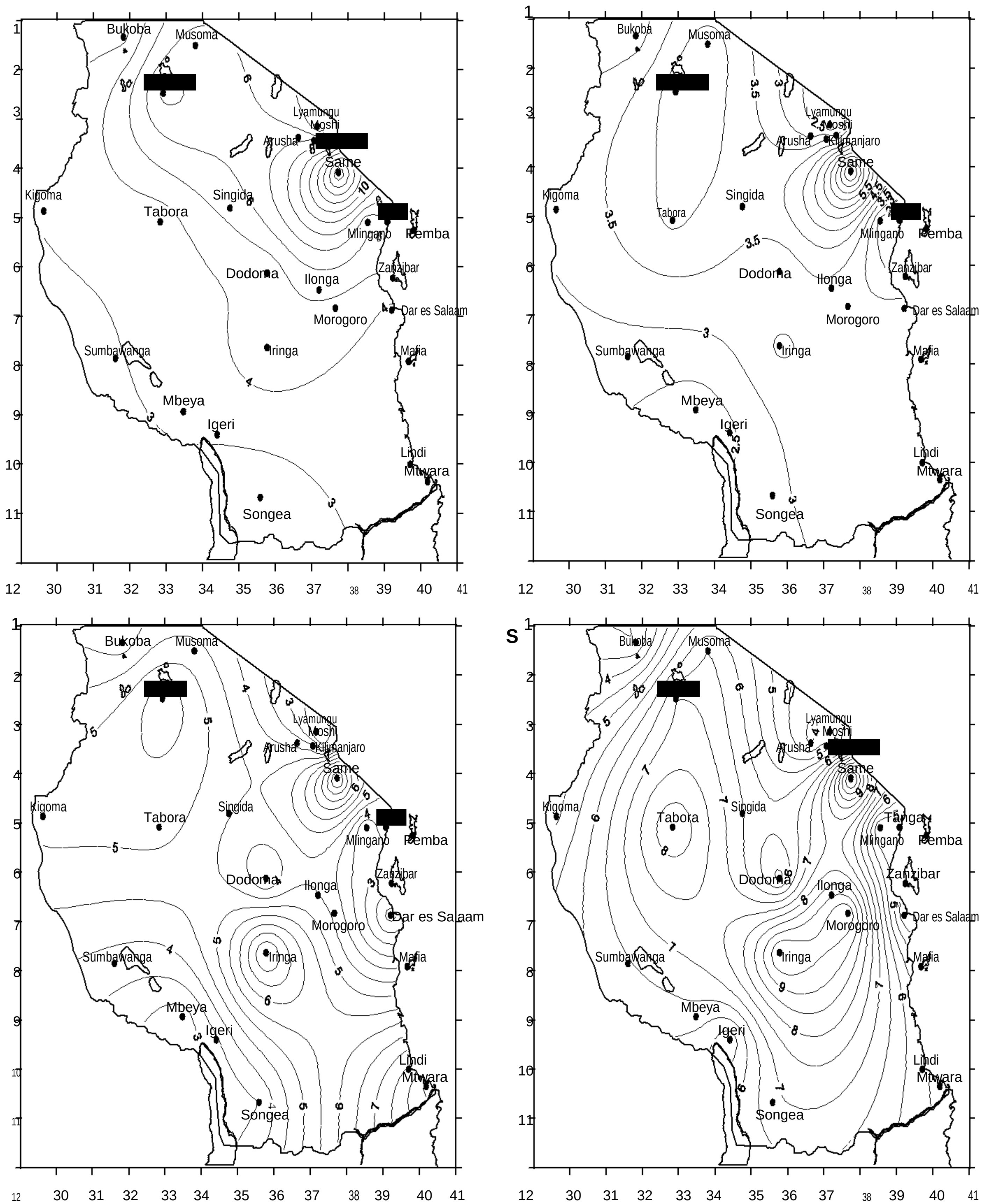

Figure 16. Relative humidity coefficient of variation (%) for four seasons (JF, MAM, JJAS and OND).

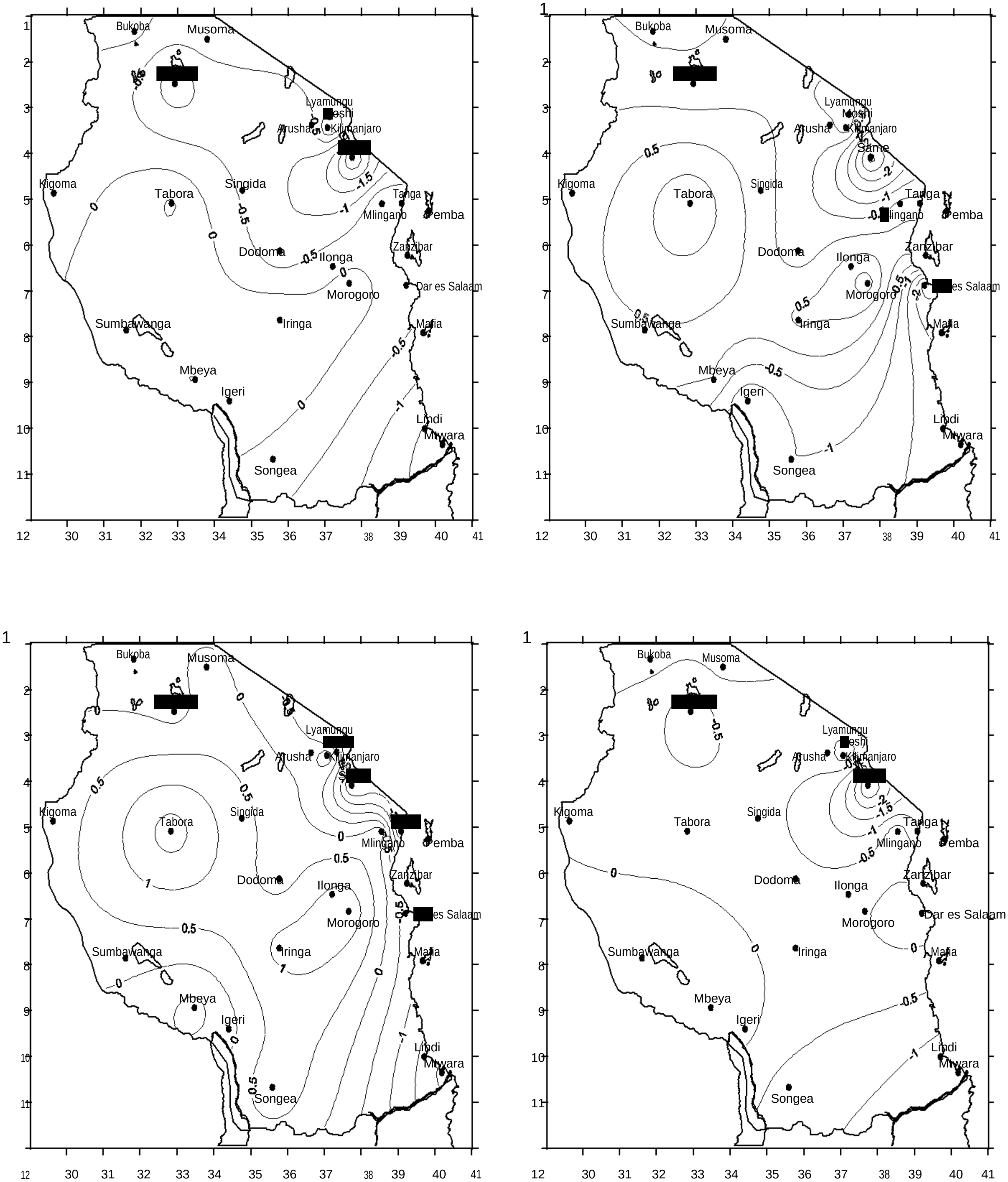

Figure 17. Relative humidity skewness coefficient for four seasons (JF, MAM, JJAS and OND).

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Figure 12 depicts spatial and temporal variability of Tmin. In all four seasons area around Southwestern highlands are characterized by relatively higher values of CV as compared to the rest of the country. CV values in Mbeya station is 6 during JF, 5.5% during MAM, 14% during JJAS and 6.5% during OND seasons. The rest of the stations are characterized by CV values less than 5% in all four seasons. Figure 13 depicts the spatial and temporal distribution of SK coefficient for Tmin. SK pattern for Tmin resembles that of Tmax.

Statistical moments of relative humidity

The presence of large water bodies (Lake Victoria, Tanganyika and Nyasa) and its proximity to the Indian Ocean play a vital role in the distribution of moisture pattern in Tanzania. Different air masses associated with synoptic systems dominate the country throughout the year, and play the second important role in the moisture distribution. The source and the track of the air mass, and consequently the wind direction determine the quantity of moisture at a particular station. SE monsoon, which is a prevailing wind during JJAS, NE monsoon prevailing from October to March and Congo air mass have significant influence in the moisture distribution in Tanzania. Topographic nature of the areas, also play important role in modulating RH distribution at various stations. Figure 15 shows that annual mean RH is minimum in the central areas and increases to the east and to the west. It ranges between 70 and 74%. Areas around the Indian Ocean coast, Northeastern and Southwestern highlands and western side of the Lake Victoria basin are characterized by higher values of RH, mostly greater than 78%, which indicate the positive influence from the lake, ocean and topography.

During JF season, the ITCZ is at its most southern location in the southern hemisphere (at around 15 - 20°S) and it is also the peak rainfall season for most of the stations in the central, southwestern highlands and southern areas which experience unimodal rainfall regime. This will explain why during JF season those areas have higher RH values of around 82% and above. Higher values of RH in western areas may partly be attributed to the meridianol arm of the ITCZ and some influence from Congo air mass. RH in MAM is slightly higher than in OND season, for instance during MAM season, stations including Morogoro, Dar es Salaam, Mafia and Zanzibar has RH values around 85%, while during OND season, RH is around 75% in those stations (Figure 14). JJAS is a typical dry season for most of the stations and RH is around 60% in the western and some parts of central areas increasing towards east to around 82% for stations along the Indian Ocean coast including Morogoro and Dar es Salaam. Spatial variability of RH is explained by CV values for mean annual and mean seasonal RH (Figures 15a and 16). The annual CV in Figure 15b is too small in all stations, and increases from southwest to northeast. It ranges between 2 and 3.5% in the Southwestern highlands and western areas and increases to 8% in Northeastern highlands, in same station. Notably, as expected in all four seasons, CV are comparatively large in semi arid area of the country, which include central areas and some parts of North-eastern highlands.

CONCLUSION AND RECOMMENDATION

The annual and seasonal spatial and temporal variability in statistical moments such as mean, coefficient of variation and skewness of rainfall, relative humidity, maximum and minimum temperature have been discussed in detail and illustrated in maps for Tanzania. It has been found that areas around Southwestern highland and western part of Lake Victoria have highest annual rainfall amount, with Idege station recording an average of 3690 mm per year. Lower amount of rainfall are typical for most of the central areas and some parts of North-eastern highland, with Dodoma station recording 558 mm per year. For most bimodal areas, nearly 50% of the annual rainfall is contributed by Masika rainfall in MAM season. In all four seasons, rainfall in most of the stations is characterized by a slight asymmetrical distribution with stronger spatial and temporal variability. During the JF, MAM and OND seasons, the CV of rainfall varies between 20 to 80%. The lower CV values are more dominant to areas close to Lake Victoria and along the Indian Ocean coast.

Areas along the Indian Ocean coast are characterized by slightly higher values of mean annual Tmax ranging from 30 to 30.8°C. Lower values of Tmin are centered on Southwestern highland and Northeastern highland. For both Tmax and Tmin pattern, a southwest-northeast temperature gradient is discerned. Mean annual RH ranges from 70% in the central areas to 78% for the Northern coast, Northeastern and Southwestern highlands and the western side of Lake Victoria. In all four seasons SK values for Tmax, Tmin and RH are close to zero in most of the stations and hence exhibit a near normal distribution with significantly less variability. In all four seasons, Tmax, Tmin and RH data are characterized by very low spatial and temporal variability. CV values for Tmax, Tmin and RH are less than 5% for most of the stations. The following recommendations shed light on the future development of this and related studies:

1. More studies should be conducted to investigate the statistical moments and their variability on monthly basis.
2. Studies should be conducted to investigate the predict-tability of temperature and rainfall on monthly, seasonal and annual time scales.

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