Analytical Study of Variations in Diurnal Maximum Temperatures over Chaklala (Islamabad)

Sadiq, N.[1,2], I. Ahmed[2]

Abstract

Diurnal maximum temperatures, changes from the former days and daily departures are calculated, analyzed and then depending upon their ranges, the changes are classified into different categories for the period 1979 to 2008. The study carried out for Chaklala (Islamabad) regarding summer months i.e. April, May and June. Frequencies of occurrence and then percentages of each category for maximum temperature and departure have also been worked out. Percentage numbers of cases in the months where the temperature either continuously falls, 'Rise's or does not change for one and more than one day have been documented separately. Results indicate that in case of changes, "Little change" together with "'Rise'" predominates and accounts for 59% for daily maximum temperatures and 41% for their departures. For all summer months, there is a gradual fall in the percentage frequencies found as the magnitude of variation of maximum temperature increases. Persistency of daily maximum temperature and departure indicates large variations in departures during all summer months for defined categories and more for the 'Rise' category. The highest persistency over Chaklala retain for '11 days and above' spell i.e. 07 events found for 'Rise' departure.

Introduction

Daily changes in the maximum temperatures during summer season is of immense importance because common man is directly and greatly concerned with these changes. Most of the previous studies have addressed the issue of changes in the mean temperatures with relation to the global warming. However changes in maximum temperatures are also equally important to investigate. Impact of climate changes are felt most strongly through changes in climate extremes. Any positive or negative trend in the maximum or minimum temperature events is also a serious concern.

One of the most significant consequences of global warming (due to increase in green house gases) is increase in magnitude of temperature which causes an increase in magnitude and frequency of extreme rainfall events. These increased temperatures can be attributed to increase in rainfall events, increase moisture levels, thunderstorm activities and large scale storm activity (Singh, 2007). In the global warming scenario, climate models generally predict an increase in large precipitation events (Houghton et al 2001). The numerical modeling community and data analysts have shown interest on the issue of extreme events occurring around the world.

For Indian region, the earlier climatological aspects of extreme summer temperature variation have been studied by Raghavan (1966), Baedeker el al. (1974) and later Dubey and Balakrishnan (1989) overhaul the same study by considering maximum temperature variation on diurnal basis. Although, for Pakistan, Sadiq and Qureshi (2010) established linear trend models regarding temperatures for major cites of Pakistan. Moreover, Sadiq and Ahmad (2010) also discussed maximum and minimum temperatures regarding microclimate study of Karachi and most recently, Shah et. al. in 2010 analyzed winter temperatures along rainfall. But all the said studies based on mean monthly data and no work has been carried out on diurnal basis. While the present study is the first attempt to study diurnal maximum temperature variations to achieve more precise probes and to get closer conclusions.

The most beneficial way to improve the accuracy of local forecast regarding changes in maximum temperature is to examine the close variations in this variable over particular station with the help of available data. With this aim in view, thirty years data of daily maximum temperature over Chaklala (Islamabad) for the summer months studied, calculated, analyzed and then changes are classified under different scales of magnitude.

[1] naeemimg@yahoo.com
[2] Pakistan Meteorological Department

Data & Methodology

Diurnal maximum temperature data of Chaklala (Islamabad) for 30 years (1979-2008) regarding pre-monsoon summer months (April, May and June) is used in this study, as defined by Faisal and Sadiq in 2009. Considering the data availability and quality, along importance as the capital of Pakistan; Chaklala (Islamabad) is selected for the study area. All the data used in this study is provided by Pakistan Meteorological Department. Changes in the maximum temperatures are calculated by subtracting the current day temperature from the previous day. Similarly departure of maximum temperature from normal has also been calculated. The variation and departure is then classified in eight categories which are summarized in Table 1.

Table 1: Classification of maximum temperature into eight categories

No change, Little change	'Rise'	Appreciable 'Rise'	Markedly 'Rise'	Fall	Appreciable Fall	Markedly Fall
±0.1 °C to ±1.0 °C	+1.1 °C to +3 °C	3.1 °C to 5.0 °C	above 5.0 °C	-1.1 °C to -3.0 °C	-3.1 °C to -5.0 °C	below -5 °C

The same practice duplicated for departures also. From the total number of cases, frequencies, percentages and persistence for both daily variations and departure variations in monthly and total forms are also calculated and depicted.

Persistency of a particular phenomenon, for the number of days is an interesting parameter which has got high forecasting value. It has been prepared to study the changes in the trend for maximum temperature. For this purpose, the temperature changes have been classified into three categories of 'No/Little change', 'Rise' and 'Fall'. 'Rise' and 'Fall' have been defined as such that the next day value is higher or less than 1 °C. Number of cases for which the temperature remains same or have little changes in different spells of days are counted, analyzed and then depicted with their respective percentages also. Similar practice has been made for other two categories i.e. 'Rise' and 'Fall' for maximum temperature.

Results and Discussion

Diurnal Maximum Temperature Variations

To improve the accuracy of local forecast regarding changes in maximum temperature is to examine the changes in the variables over the station with the help of available data. Calculations regarding eventual changes of maximum temperature over Chaklala (Islamabad) shows that cases of 'Little changes' and 'Rise' predominate in the considered months, though there is a gradual increase for little change, from 234 events (26.3%) in April to 267 events (29.9 %) in May and then decrease in June to 249 events (27.9%). It evaluates that the little changes occurs in maximum temperature during the month of April. However, this monthly trend decreases from April to June for "'Rise'" which is of 290 events (32.6%), 269 events (30.2%) and 274 events (30.6%) respectively for the summer months. Cases of 'Fall', appears next to 'Little Change' in the frequency spectrum, having a gradual increase from 102 events (11.5%) to 130 events (14.6%) and then 134 events (15.0%) for the said months respectively. 'No Change', 'Appreciable Fall' and 'Appreciable Rise' has been placed at fourth, fifth and sixth order having the mean value of 65.7, 62 and 52.7 events per month. The least value of occurrence cases appears for 'Markedly Rise' which are 2.8%, 2.1% and 0.8%. These months has the mean value of 0.6 events per month.

Number of cases found in the months of April when more than 1 °C increase in temperature for daily variation and departure has occurred, after which these number of cases falls in May, and then increase in June for 'Rise' and 'App. Rise' categories. However for Marked 'Rise' category, maximal cases are for the months of April and then decreasing tendency found for May which remains lowest

for June. All types of positive changes i.e. 'Rise' and appreciable 'Rise' have a high frequency in April. The aforesaid results may be explained by the fact that convective heating takes place at higher rates for more number of days in April, comparatively less in May & June. This higher rate of heating in the moths of April and May as compared to the June is possibly due to the currents of western disturbance (WD), which are maximum in the month of May and gently decreases in April & June. As, in General, temperature fall occurs when the station is affected by western disturbances; Case studies reveal that prior to the onset of monsoon, whenever the station is under the under the influence of WD, fall in the temperature takes place. After the sway of monsoon, similar departure occurs when the station is under the influence of monsoon depression as the station registers temperature fall in June if it is under the influence of monsoonal depression.

It has also been ascertained that the diurnal variations and departure of maximum temperature is sufficiently affected by the global phenomena of La-Nina and El-Nino as for instance, the frequency of Appreciable and Marked 'Rise' for both daily and departure of maximum temperature are maximum in El-Nino years. For example, in 1982, 1987, 1991, 1997, 2002, which are El-Nino years, the frequency of 'App. Rise' and 'Marked Rise' are exceptionally high and in 1984, 1988, 1998, 1999, and 2007, which are La-Nina years the frequency of 'App. Fall' and 'Marked Fall' are also high.

It is also observed that 'No Change' and 'Appreciable 'Rise'' together constitutes nearly 2.4 of the cases in each month. The highest mean value of events per month occurs for 'Rise' and then 'Little Change' which are 8.7 and 8.3 respectively. 'Fall' and 'Appreciable Fall' are next to 'Little Change' in the frequency scale. In case of 'Rise' there is a gradual fall from April to May and then increase in June. Frequencies of the 'Appreciable 'Rise' also follow the same trend as 'Rise'. It inferred from the Figure 1(a) that there are number of cases in the month of April when more than 2 °C increase in temperature noted. These cases show decline in May and then increase again in June. It is interesting to note that the maximum number of 'Marked Rise' as well as the 'Marked Fall' occurs in the month of April. Positive changes like 'Rise' and 'Appreciable Rise'' have a high frequency in June and the only case of 'Marked Rise' is observed in April.

Figure 1(a) further demonstrates that the numbers of events per year as well as the total number of events are highest for 'Little Change' and 'Rise' category. It intends that for summer season, most of the temperature changes lie in the range of -1 °C to +3 °C while least changes found for the category of 'Marked Rise' having most of the values between 0 and 6 events per season in an year. The next category which is greater than 'Rise' is 'Marked Fall' ranging from 2 to 6 events per year. There are also some outliers appeared for the categories of 'Marked Fall' (one), 'Fall' (one) and 'Rise' (two) and 'No Change' (one/two). It is also observed that 'Marked 'Rise'' and 'Marked Fall' are highly concentrated while 'Little Change' and 'Rise' are relatively highly spread, which obviously shows that as the temperature increases, the number of days per year becomes more and more concentrated.

Maximum Temperature Departure Variations

From maximum temperature departure, monthly and percentage frequencies for 'No Change', 'Nearly Normal', 'Above Normal', 'Appreciable Above Normal' and 'Markedly Above Normal', for the period under review have calculated. In all the months 'Above Normal' occupies the highest value of events with 173, 176 and 197 events having mean value of 182 (20.6%) events/month. Percentage frequencies for April, May and June are computed as 19.6%, 19.8% and 22.4% respectively, which indicates apprizing from April to June and acquiring highest value in June. 'Nearly Normal' having second highest value in the frequency spectrum with 173 (19.6%), 153 (17.2%) and 206 (23.4%) events and mean value of 177.3 (20.0%) events per month i.e. decrease from April to May and increase in June. The frequency of occurrence of 'Appreciable Above Normal' is third and 'Below Normal' is on fourth position which follows the same pattern as 'Nearly Normal' in the percentage frequency. The least value of events occurred for 'Marked Fall' having the mean value of 71.3 (9.0%) events per month which is obvious because the temperature gradually increases from the month of

April to May in summer. The number of cases, in which the departure from temperature is -5 °C or less, is less in number as compared to the positive values. Rate of 'Markedly Above Normal' are exceptionally high in the month of June as compared to the 'Markedly Below Normal' for the same month. Case studies reveal that due to the onset of monsoon, whenever the station is under the influence of monsoonal currents, the 'Rise' in the temperature of the order of 5 °C and more takes place, which may be helpful in the formation of local low pressure area over the region. After monsoon, in the similar fashion departure occurs when the station is under the influence of westerlies or any other well marked system.

As regards diurnal maximum temperature departure, Figure 1(b) depicts that the category of 'No Change' is confined with the values of 0 to 4 events per year. Departures of 'Nearly Normal' and 'Above Normal' are found with high starting base values i.e. approximately 10. By comparing the 'Above Normal' with 'Below Normal', it is clear from the Figure that the 'Rise' in temperature having more events in 'Above Normal' as compared to the 'Below Normal'. The most scattered and wide range category is of 'Appreciable Above Normal' ranging from 1 to 33 followed by 'Marked Above Normal, whose range is from 0 to 24. 'Marked Fall' is ranging from 0 to 22 while most of the data is concentrated in the range of 0 to 6.

Monthly and Total Frequencies of Daily Maximum Temperature Variations

In this connection, frequencies for different categories in the form of number of events for the given period are computed. They appear higher for ''Rise'' in summer with the values of 290 (April), 269 (May) and 274 (June) while for 'Fall', the pattern is reversed having highest values for June (Figure 2a). The frequency of 'Appreciable Rise' is nearly the same for all the three months while 'Appreciable Fall' has an ascending trend from April to June. Again the frequency descends for 'Marked Rise' from April to June being maximum in the month of April which shows a rapid increase of temperature in the month of April. In the similar manner, 'Marked Fall' has the same trend being highest in April.

The share of each category, in total frequency of daily temperature, is out of 2673 days of 30 years. It shows the major share of 'Rise' (833) followed by 'Little Change' (750) and 'Fall' (365). The smallest share is of 'Marked Rise' (52) after which 'Marked Fall' (132) and 'Appreciable Rise' (158) has come (Figure 3a). 'Appreciable Fall' and 'No Change' comprises of 186 and 197 days.

Monthly and Total Frequencies of Maximum Temperature Departure Variations

In the month of June, the temperature is more 'Nearly Normal' as compared to the other months. By comparing the categories 'Above Normal' and 'Below Normal', it is evident that mostly temperatures remain 'Below Normal' in summer being highest in June (Figure 2b). Comparison of 'Appreciable Above Normal' with 'Appreciable Below Normal' follow the same pattern as said. In category 'Marked Above Normal', the highest frequency falls out in April which displays departure of +5 °C or more from the normal. However, the temperatures mostly remain below -5 °C or more; and fall in the category 'Marked Below Normal' in May as compared to the remaining months. Categories for the values lower than normal contain greater number of 'Below Normal', 'Appreciable Below Normal' and 'Marked Below Normal' respectively as compared to their 'Rise' counterpart. Further the total and mean values are also summarized in Figure 2b.

The total frequency departure exhibits two greatest shares of 'Rise' (546) and 'Little Change' (532). 'Appreciable Fall', 'Marked Rise' and 'Marked Fall' have nearly equal share of 240, 255 and 214 (Figure 3b). 'Appreciable Rise' has 455 while 'Fall' has 382 days. The least share is of 'No Change' i.e. of 31 days only.

Percentage Variations of Changes in Daily Maximum Temperatures and Departures

The maximum variation in maximum temperature mostly occurs in the range from +1.1 to +3.0 for the category 'Rise'. Among the three months, the highest value for 'Rise' is in the month of April which is obvious because in this month the temperature usually start ascending day by day (Fig 4a). For 'Little Change' the variation mostly occurs in the month of May. 'Little Change' with 'Rise' nearly contribute to two third of the changes. Compare to 'Rise' (mean value of 31.1%), 'Fall' category has the mean value of 13.7% which designates the positive changes in these months. The 'Rise' in temperature mostly occurs in April and mostly drops in June. The highest value for 'Appreciable Rise' occurs in April which is 6.5% and again having the same trend, it has 'Appreciable Fall' in the month of June which is 8.3 %. Same trend with highest value in April for 'Marked Rise' and again for 'Marked Fall' in the month of June is observed.

Figure 4(b) shows that the highest variation of maximum temperature departure occurs for 'Nearly Normal' (+1 to -1) and 'Above Normal' (+1.1 to +30.0) and accounts for more than 40%. Again for both classes, the maximum temperature variation occurs in the month of June. It further shows that the departure of maximum temperature from the normal is not so high. The departure changes in the 'Fall' category is 14.4% and again reaches to maximum in June. The 'Appreciable Rise' in the frequency spectrum is next to 'Nearly Normal' and 'Above Normal', which is 17.1% and has the highest value in the month of May. The 'Appreciable Fall' is 9.0% and having highest value in the month of April. The noticeable categories are 'Marked Rise' and 'Marked Fall' having 9.6% and 8.1% and acquiring highest values in May and April simultaneously.

In short, highest and lowest temperature changes from the previous day maximum temperature, ranges from 3.1 to 5.0 (above occurs in the month of April) and from -3.1 to -5.0 (below occurs in the month of June) respectively. The top values of maximum temperature departure occur in the month of May and bottom values occur in April.

The highest value of total number of events comes out for the 'Rise' category having value of 93.4 (31%) and second highest category is of 'Little Change' carrying value of 84.1 (28%) (Figure 4c). Both categories combined accounts for nearly 60%. The next highest value is that of 'Fall' and 'Appreciable Fall' having values 41 (14%) and 21 (7%) simultaneously. Total number of events occurred for 'Marked Fall' is little greater i.e. 2.5 times (5%) than the 'Marked 'Rise' (2%).

The highest value of total number of events comes out for the 'Above Normal' category having value of 61.6 (21%) while second highest category is 'Nearly Normal' which has very close carrying value of 60.1 (20%) (Figure 4d). Both categories combined accounts for nearly 40% of the total 'Appreciable Above Normal' and 'Below Normal' having values 51.4 (17%) and 43.2 (14%) simultaneously. Total number of events occurred for 'Marked Above Normal' is greater (10%) than 'Marked Below Normal' (8%).

Persistence

Another interesting parameter which has got high forecasting value is the persistency of a particular phenomenon for the number of days. Study of changing tendency for this parameter, it has been divided into three classifications, viz., 'No Change', 'Rise', or 'fall'. 'Rise' includes the cases where the next day value is higher than previous day value by 1 °C or more. The number of days for which one type of change has occurred is counted as one unit and further analysis regards whole data, looking individual days were performed at this principle. Initially sum up of all cases for the same month in different years under each category has been taken in account and then respective percentage calculated. The results are depicted in the Figure 5 (a-f) and Figure 7 (a & b) in which percentage number of continuous days on which the maximum temperature either does not change or 'Rise's or falls continuously, are shown.

In respect of total seasonal changes for all considered summer months and for all the three types of changes, there is a gradual fall observed with increase in the number of days. But for the same number of days, it increases from April to June for 'Rise' and decreases for 'Fall'. Probably 'Rise' is due to the fact that the temperature increases gradually from April to June. Changes that persist for one day account for nearly 49.8% of the cases, i.e. nearly 35.5% for 'No/Little change', 9.7% for 'Rise' and 14.6% for 'Fall' departure. Percentage of cases lasting two days account for nearly 18.2% comparing the highest value for 'Rise' i.e. 8%. In conclusive way, changes lasting for one or two days together account for 68% of the total cases. Changes that last for one day is high for 'No/Little change' as compared to the other changes for all the months taken together. For changes that last for two days, the magnitude is considerably high for 'Rise'. Changes that last for three days follow the same pattern of 'Rise', but for four day's shows a high 'Fall' as compared to 'Rise' and 'No change'. It is noticeable that for changes of five days duration and more, number of cases are just few for 'Rise' and 'Fall' and nil for 'No change'. Thus the 'Rise' departure continuous up to 11 persistent days for May and June that may raise the chances of heat waves to be occurring in summer months. As if, there is a continuous 'Rise' of temperature last for more than four days, is considered useful for forecasting the changes in maximum temperature.

The 'Rise' category is more persistent of maximum daily and departure in the months of May and June, which is perhaps due to the moving sun towards the tropic of cancer during its journey in Northern Hemisphere (NH). The daily departure remains persistent 7 & 12 cases for 11 & above days for the months of April and May respectively, as one may expect the rising of temperature in these months. For fall categories, May and April are more persistent months respectively and the possible reason for temperature fall is due to the fact that the days and events of Western Disturbances (WD) are maximum in these months for Islamabad i.e. 145 events and 582 days for May and 141 events and 583 days for June for the aforementioned period.

For all persistence days the numbers of events are gradually decreases with increasing length of spell for daily values of maximum temperature. However it is observed that the numbers of events are maximum for the daily 'Rise' of one day and there are least variations occur for all the three months (Figure 5a, c&e).

It is observed that for all the persistence days the numbers of events are also gradually decreasing with the increasing length of spell for daily values of maximum temperature departure (Figure 5b, d&f). However numbers of events are maximum for 'No/Little change' for one day and for all the three months variations are maximum as compared to the maximum values of daily temperature, although it is maximum for the category of 'Rise' of maximum temperature departure. 'No/Little change' is more persistent during the month of June i.e. 1 case up to 11 and above days which may be because of the prevalence of monsoon system in the area.

Percentage of persistency and their departures for all categories are also worked out (Figure 6). It explores the same trends and attitudes like persistence days and departures described earlier.

Seasonal Percentages for 'No/ Little Change', 'Rise' and 'Fall'

The plotted data of seasonal percentage of daily maximum temperature variation for 'No/Little change', 'Rise' and 'Fall' indicates the Maximum values of these parameters as 37, 43 and 42 with the least value of zero respectively (Figure 7a). Note that for spell 1 to 2 'Rise' and 'Fall' are closer while after spell three 'No change' and 'Fall' values are closer, The number of occurrence three shows the farthest points for 'Rise' (2.2), 'No Change' (4.9) and 'Fall' (7.5) categories.

The plotted data of 'No/Little change', 'Rise' and Fall regarding the maximum temperature departure shows the maximum values of these parameters are 26.10, 14.60 and 9.7 and minimum values are 0, 0.4 and 1.2 respectively (Figure 7b). There are much more fluctuations found in departure than the daily data.

Conclusion

As regards diurnal maximum temperature variations, total numbers of events as well as events per year are highest for 'Little Change' and 'Rise' while minimum changes found in 'Marked Rise'. It is also observed that 'Marked 'Rise'' and 'Marked Fall' are highly concentrated in the lower values of number of occurrences while 'Little Change' and 'Rise' are highly spread over relatively high values.

Departure of 'Nearly Normal' and 'Above Normal' are found with high starting base values i.e. around 10 whilst 'No Change' is confined within 0 to 4 events per year. Comparison of 'Above Normal' and 'Below Normal' explores the 'Rise' in temperature with more events in 'Above Normal' as compared to the 'Below Normal'. The most scattered and wide range category is of 'Appreciable above Normal'.

For daily variations, major and minor shares of days are found for ''Rise'' (833) and 'Marked 'Rise'' (52). 'Little Change' (750) and 'Fall' (365) comes out with second and third rankings. 'Marked Fall' (132) and 'Appreciable 'Rise'' (158) have close number of days. 'Appreciable Fall' and 'No Change' comprises the values of 186 and 197 days.

Total frequency departure shows greatest shares for 'Rise' (546) and 'Little Change' (532). 'Appreciable Fall', 'Marked Rise' and 'Marked Fall' have close contribution of 240, 255 and 214 days. 'Appreciable 'Rise'' has 455 while 'Fall' has 382 days. 'No Change appears with least part i.e. of 31 days.

Most of the 'Rise' and 'Fall' categories occur in the months of April and June respectively which indicates that ''Rise'' in variations of maximum temperature start ascending from April and descending in the month of June, for daily variations.

'Nearly Normal' and 'Above Normal' accounts for more than 40% having highest values (Least variation from the normal) for the month of June's departures. The high variation from the normal for maximum temperature departure in the range from 3.1 to 5.0 and above 5.0 occur in the month of April and that for -3.1 to -5.0 and below occurs in the month of April.

The highest persistency occurs through out the season for one day for the month of April among the three months. The temperature remains more persistent for 'No/Little change' in the month of April and has the highest persistency for the month of June up to 11 days (1 event). The 'Rise' category is more persistent for the month of April and has high persistency in April and May, up to 6 days (2, 2 events). For 'Fall' category, the most and highest persistent month is June. The more consistent month for 'No/ Little Change' departure is June having 1 event of 7 days.

For 'Rise' category, May (29 events) is least consistent for less number of days and more consistent for more number of days (12 events) in May while June has the reverse trend as compared to the month of June for maximum temperature departure. The 'Rise' category has the more tendencies to remain more consistent (23 events of 11 days) among 'No/Little change', 'Rise' and 'Fall'. For 'Fall', the more consistent month is that of April and highest consistency occurs in May (5 events of 11 days).

'No/ Little Change', 'Rise' and 'Fall' acquired seasonal percentage that ranges from zero to 37, 43 and 42 respectively. For spell 1 to 2, 'Rise' and 'Fall' are found closer while after spell three, 'No Change' and 'Fall' are closer. The number of occurrence three shows the farthest points with the values of 4.9, 2.2 and 7.5.

The maximum and minimum values for above said categories are 26.10, 14.60 and 9.7 and 0, 0.4 and 1.2 percent respectively. Diurnal maximum temperature variations are found less than departure variations.

Future outlook of this study suggests the heat wave analysis in order to explore and understand more variations in the behavior of diurnal maximum temperatures.

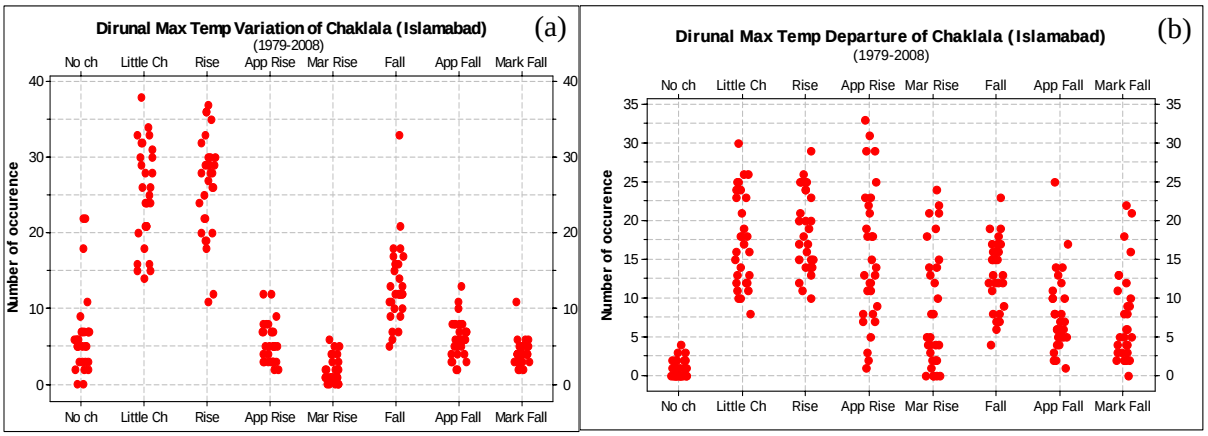

Figure 1: (a) Defined Categories verses frequency for daily variations for April, May and June (1979-2008)
(b) Defined Categories verses frequency for departure variations for April, May and June (1979-2008)

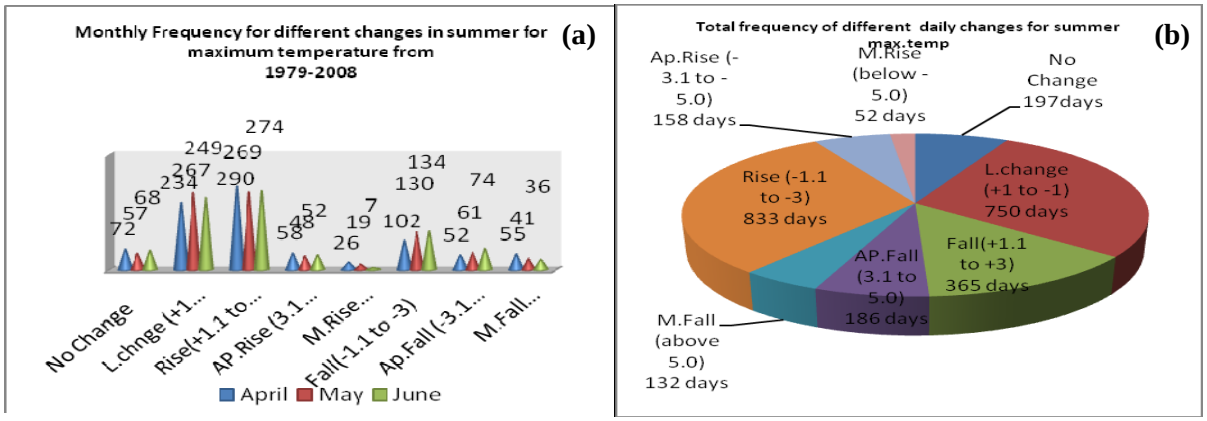

Figure 2: (a) Occurrences/month for diurnal variations (1979-2008) **(b)** Total frequency for diurnal variations (1979-2008)

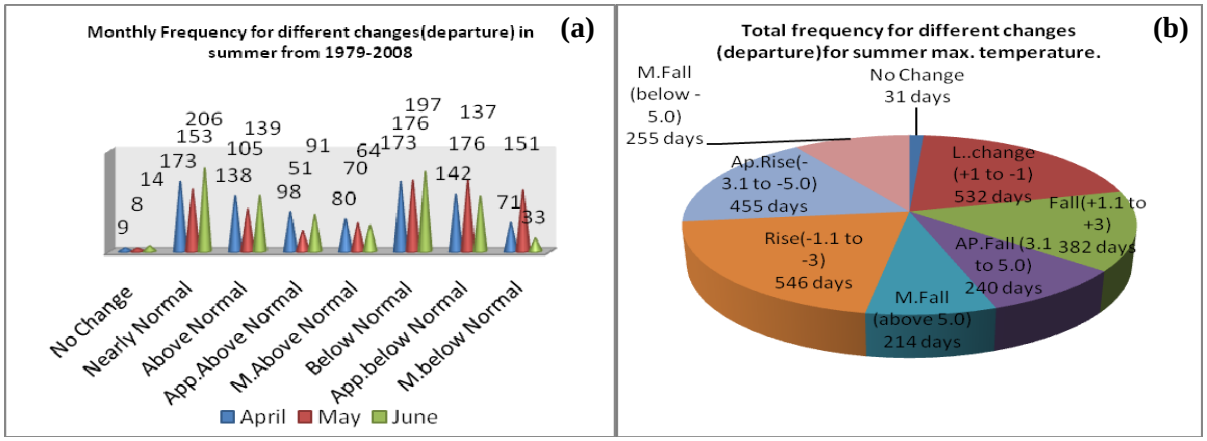

Figure 3: (a) Occurrences/month for departure variations (1979-2008)
(b) Total frequency for departure variations (1979-2008)

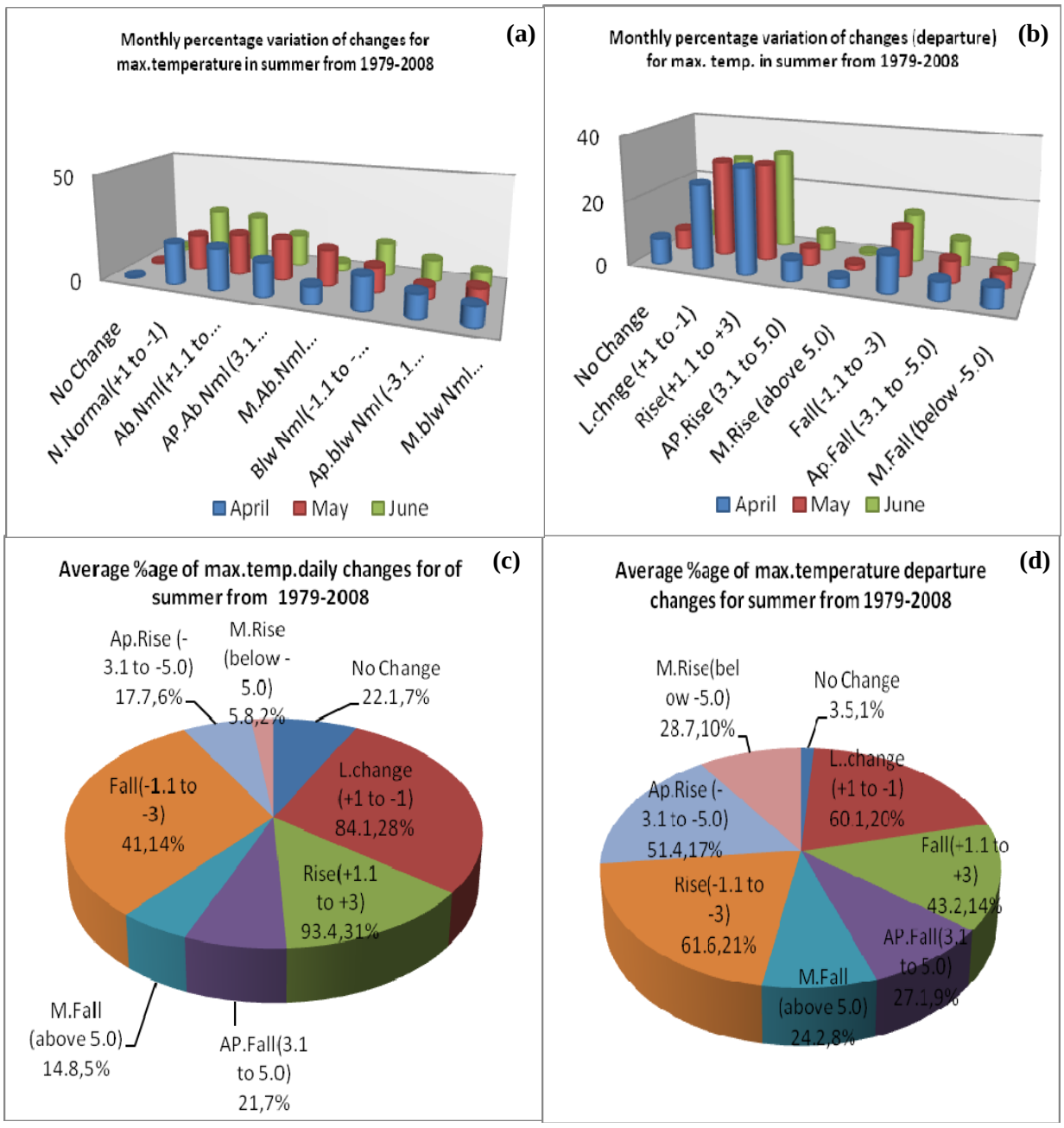

Figure 4: (a) percentage for diurnal variations (1979-2008) **(b)** percentage for departure variations (1979-2008) **(c)** Average percentages for diurnal variations (1979-2008) **(d)** Average percentages for departure variations (1979-2008)

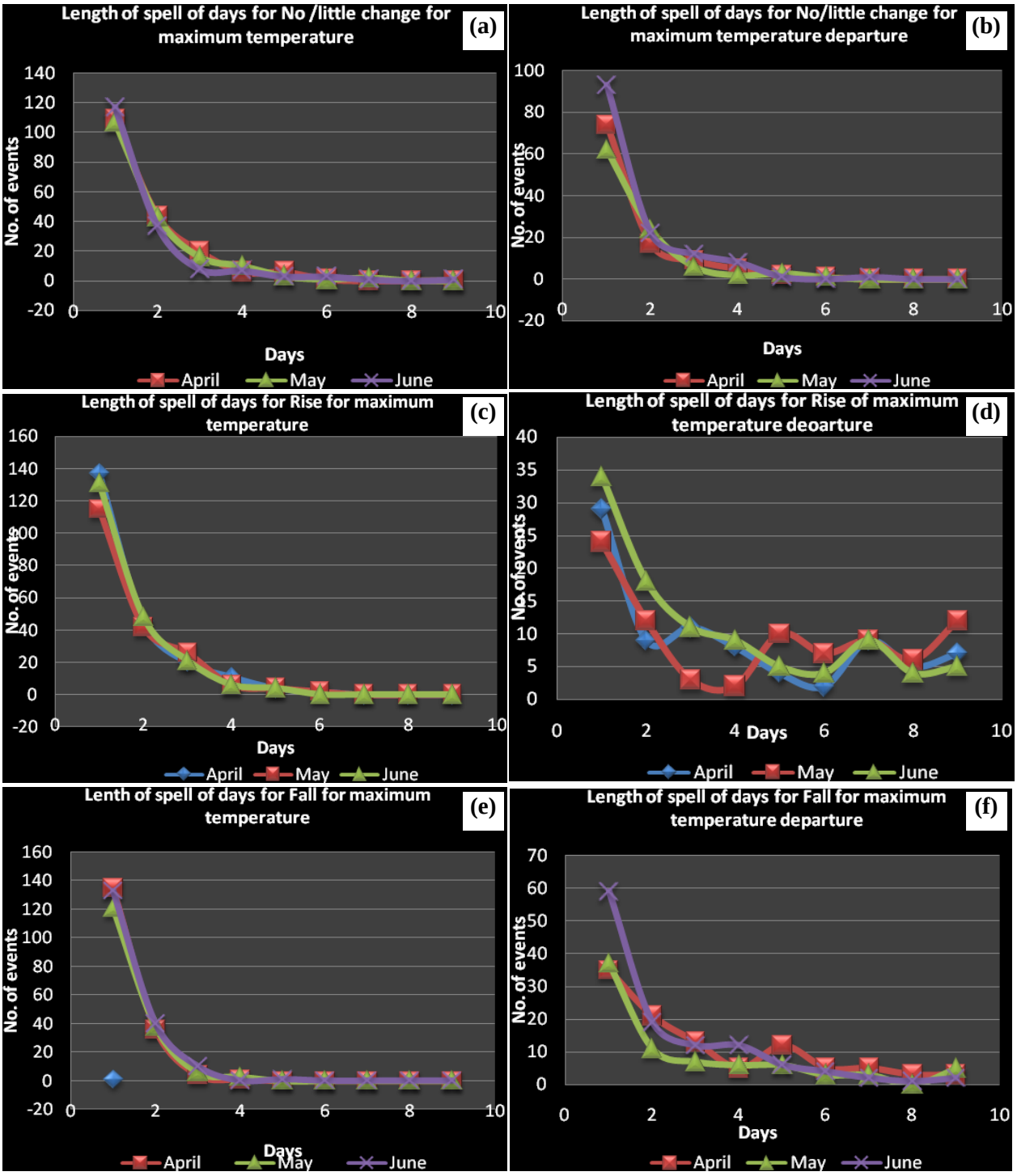

Figure 5: (a-f) Diurnal Length of Spells of 'No/Little change', 'Rise' and Fall Categories (1979 - 2008)

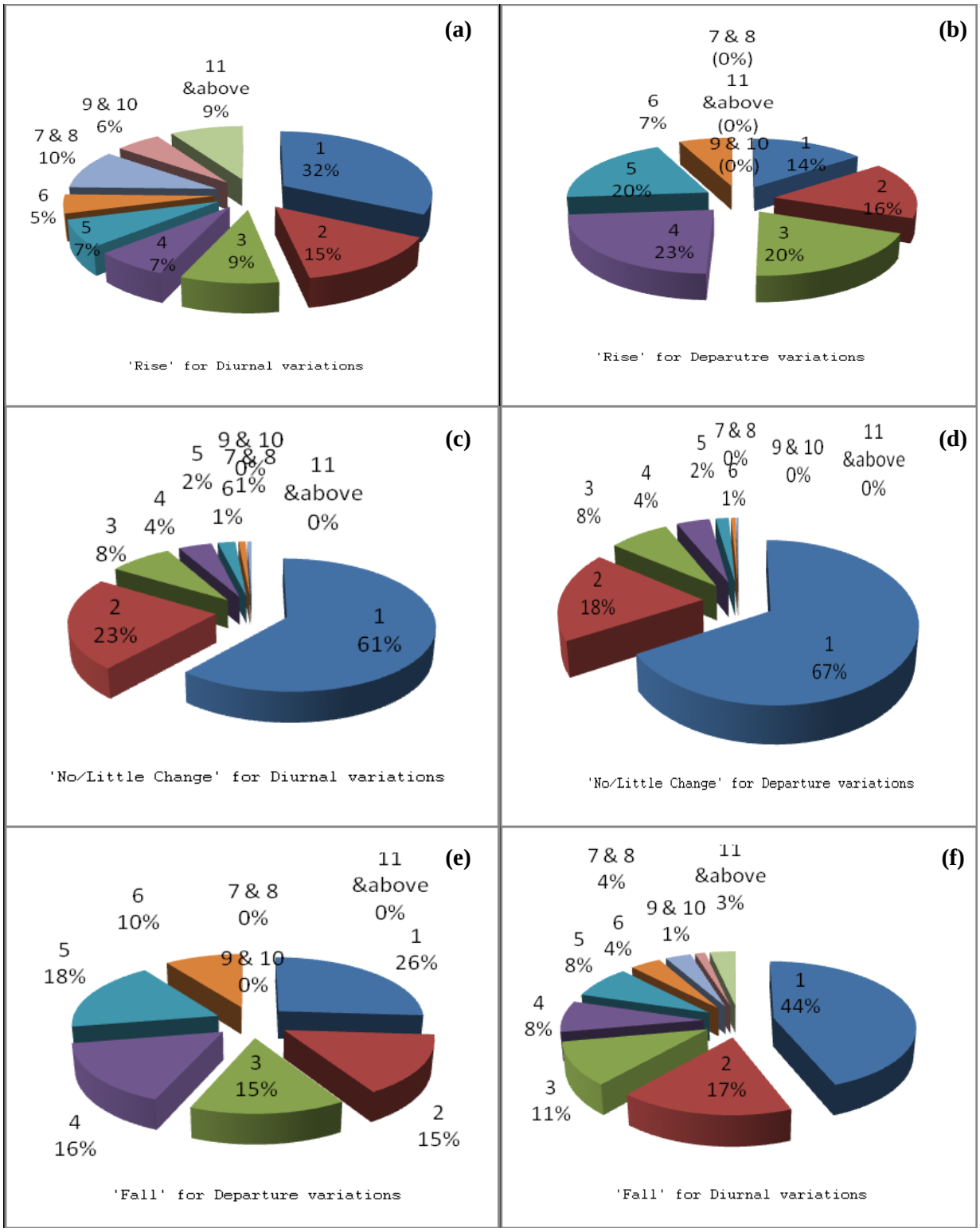

Figure 6: (a-f) Diurnal & Departure variations for 'No/Little change', 'Rise' and Fall categories (1979-2008)

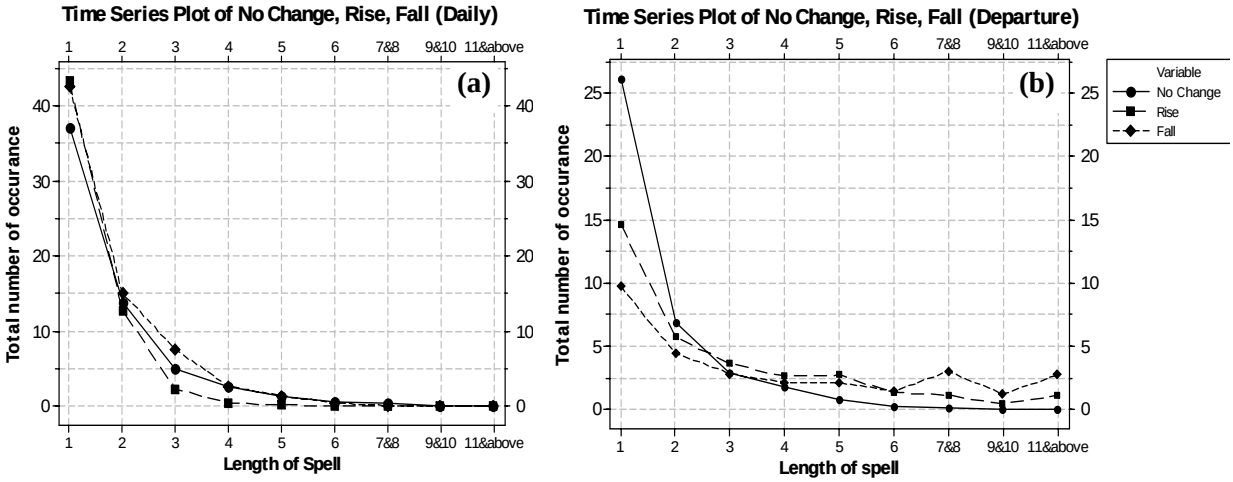

Figure 7: (a) Frequencies of three defined categories for diurnal variations (1979-2008)
(b) Frequencies of three defined categories for departure variations (1979-2008)

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