SEASONAL CLIMATE SUMMARY

The Global Climate of March–May 1990: An Abnormally Warm Season in both Hemispheres

Vernon E. Kousky and Michael S. Halpert
Climate Analysis Center National Meteorological Center, NWS/NOAA Washington, D.C.
27 July 1990 and 9 October 1990

1. Introduction

Amid fading atmospheric signs of a developing warm episode in the tropical Pacific, sea surface temperatures continued to increase along the equator near the date line. The 28°C isotherm has steadily shifted eastward in the equatorial Pacific during the last year associated with an increase in sea surface temperature anomalies of about 1°C in that region. However, the warm episode-like conditions that occurred during December 1989–February 1990 faded away during March–May (MAM) 1990 and most atmospheric indices indicated a return to near normal conditions. The future course of events may well depend on the evolution of the pool of warmest water (greater than 29.5°C) located east of New Guinea near the equator.

Once again the extratropics featured abnormal warmth in many regions of both hemispheres. Nearly 70% of the Northern Hemisphere stations were above the 70th percentile (30% would be expected) for MAM 1990, which is the highest percentage for a MAM period since 1951. Many of the highest percentages for MAM during the last forty years occurred during the last decade. The abnormal warmth during MAM 1990 was associated with a poleward shift in the westerlies and cooler than normal tropospheric temperatures throughout the tropical belt.

Section 2 focuses on recent events in the tropical belt and their evolution. In section 3 features of the extratropics are discussed.

2. Tropics

Signs of a developing warm episode in the tropical Pacific, which appeared during December 1989–February 1990 (Janowiak 1990), became less coherent during March–May (MAM) 1990. Sea surface temperature (SST) anomalies remained near 0.5°C in the Niño 4 (central equatorial Pacific) region, and increased to near 0.5°C in both the Niño 3 and Niño 1 + 2 regions by the end of the season (Table 1 and Fig. 5). These anomalies are about 1°C higher than those observed during MAM 1989 (Fig. 15). The Southern Oscillation index (SOI) rose sharply throughout the season and ended with a positive value (Table 1 and Fig. 1). The 850-mb zonal wind index in the western Pacific, as well as the outgoing longwave radiation (OLR) index, also trended towards zero (normal) during MAM (Table 1).

Since early 1989, sea surface temperatures have steadily increased in the central Pacific (Fig. 10). The 28°C isotherm, considered to be the threshold temperature for the initiation of deep convection (Gadgil et al. 1984), has steadily shifted eastward reaching 150°W by May 1990. Since the central Pacific shows virtually no annual cycle in SST (Halpert and Ropelewski 1989, their Fig. 154a), the slowly varying trends in sea surface temperature associated with the Southern Oscillation are readily apparent in this region. By May 1990 the 28°C isotherm was farther east than at any time since the latter stages of the 1986–87 warm episode and SST anomalies (Fig. 10b) were near 0.5°C.

Thus, through May 1990, SST in the central equatorial Pacific continued to evolve towards a warm episode. However, the warmest sea surface temperatures along the equator remained in the far western Pacific near 150°E. During the 1986–87 warm episode, the warmest SSTs moved to the vicinity of the date line. This allowed for anomalously strong convection to develop in this region and for persistent westerly winds to form to the west of the date line. The future course of events in upcoming seasons may well depend on the evolution of this pool of near 30°C water in the western equatorial Pacific.

Despite the rather weak SST anomalies, substantial subsurface changes occurred in recent months along the equator in the depth of the oceanic thermocline, as represented by the depth of the 20°C isotherm (Fig. 11).
<table>
<thead>
<tr>
<th>Date</th>
<th>Tahiti-Darwin SOI</th>
<th>Pacific 850-mb zonal wind indices</th>
<th>Outgoing longwave radiation index</th>
<th>Pacific 200-mb zonal wind index</th>
<th>Niño 1 + 2</th>
<th>Pacific SST Niño 3</th>
<th>Niño 4</th>
<th>SLP anomalies Tahiti</th>
<th>SLP anomalies Darwin</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 90</td>
<td>1.1</td>
<td>0.0</td>
<td>-0.1</td>
<td>0.1</td>
<td>0.0</td>
<td>0.5</td>
<td>24.6</td>
<td>0.6</td>
<td>27.4</td>
</tr>
<tr>
<td>Apr 90</td>
<td>0.0</td>
<td>0.0</td>
<td>0.4</td>
<td>-0.9</td>
<td>1.0</td>
<td>-0.2</td>
<td>25.3</td>
<td>0.5</td>
<td>27.7</td>
</tr>
<tr>
<td>Mar 90</td>
<td>-1.2</td>
<td>-1.1</td>
<td>0.4</td>
<td>1.3</td>
<td>-1.2</td>
<td>1.8</td>
<td>26.4</td>
<td>0.2</td>
<td>27.1</td>
</tr>
<tr>
<td>Feb 90</td>
<td>-2.4</td>
<td>-1.2</td>
<td>-0.8</td>
<td>0.6</td>
<td>-1.0</td>
<td>-0.3</td>
<td>25.9</td>
<td>0.3</td>
<td>26.5</td>
</tr>
<tr>
<td>Jan 90</td>
<td>-0.2</td>
<td>-0.1</td>
<td>0.4</td>
<td>0.9</td>
<td>-0.8</td>
<td>2.2</td>
<td>24.6</td>
<td>-0.1</td>
<td>25.3</td>
</tr>
<tr>
<td>Dec 89</td>
<td>-0.7</td>
<td>-0.4</td>
<td>-0.7</td>
<td>-0.5</td>
<td>0.3</td>
<td>0.3</td>
<td>22.9</td>
<td>0.2</td>
<td>24.9</td>
</tr>
<tr>
<td>Nov 89</td>
<td>-0.4</td>
<td>-0.9</td>
<td>0.3</td>
<td>0.5</td>
<td>-0.2</td>
<td>2.1</td>
<td>-0.1</td>
<td>0.2</td>
<td>24.7</td>
</tr>
<tr>
<td>Oct 89</td>
<td>0.6</td>
<td>0.5</td>
<td>0.8</td>
<td>0.7</td>
<td>0.9</td>
<td>-0.2</td>
<td>20.6</td>
<td>0.3</td>
<td>24.5</td>
</tr>
<tr>
<td>Sep 89</td>
<td>0.6</td>
<td>0.7</td>
<td>-0.2</td>
<td>-0.8</td>
<td>1.0</td>
<td>-1.4</td>
<td>20.1</td>
<td>-0.1</td>
<td>24.6</td>
</tr>
<tr>
<td>Aug 89</td>
<td>-0.8</td>
<td>0.8</td>
<td>0.2</td>
<td>0.1</td>
<td>0.9</td>
<td>-0.2</td>
<td>-0.1</td>
<td>0.4</td>
<td>24.6</td>
</tr>
<tr>
<td>Jul 89</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>0.9</td>
<td>-0.1</td>
<td>21.6</td>
<td>-0.2</td>
<td>25.4</td>
</tr>
<tr>
<td>Jun 89</td>
<td>0.5</td>
<td>0.3</td>
<td>-0.1</td>
<td>0.7</td>
<td>1.2</td>
<td>-0.6</td>
<td>22.3</td>
<td>0.2</td>
<td>26.2</td>
</tr>
<tr>
<td>May 89</td>
<td>1.2</td>
<td>0.3</td>
<td>0.8</td>
<td>0.8</td>
<td>1.2</td>
<td>-0.6</td>
<td>23.5</td>
<td>0.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Apr 89</td>
<td>1.6</td>
<td>0.6</td>
<td>1.0</td>
<td>1.5</td>
<td>0.9</td>
<td>1.9</td>
<td>-0.1</td>
<td>25.4</td>
<td>26.8</td>
</tr>
<tr>
<td>Mar 89</td>
<td>0.6</td>
<td>1.0</td>
<td>1.0</td>
<td>0.6</td>
<td>1.1</td>
<td>0.3</td>
<td>26.4</td>
<td>-0.6</td>
<td>26.3</td>
</tr>
<tr>
<td>Feb 89</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
<td>-0.1</td>
<td>1.9</td>
<td>2.8</td>
<td>25.8</td>
<td>-0.7</td>
<td>25.5</td>
</tr>
<tr>
<td>Jan 89</td>
<td>1.7</td>
<td>1.5</td>
<td>1.4</td>
<td>0.1</td>
<td>2.1</td>
<td>2.0</td>
<td>-0.4</td>
<td>24.0</td>
<td>-1.1</td>
</tr>
<tr>
<td>Dec 88</td>
<td>1.3</td>
<td>1.0</td>
<td>1.2</td>
<td>0.7</td>
<td>1.9</td>
<td>2.1</td>
<td>-0.1</td>
<td>22.5</td>
<td>-1.6</td>
</tr>
<tr>
<td>Nov 88</td>
<td>1.9</td>
<td>1.8</td>
<td>1.2</td>
<td>0.6</td>
<td>1.6</td>
<td>2.0</td>
<td>-0.3</td>
<td>21.2</td>
<td>-1.4</td>
</tr>
<tr>
<td>Oct 88</td>
<td>1.4</td>
<td>0.9</td>
<td>1.5</td>
<td>1.0</td>
<td>1.3</td>
<td>1.9</td>
<td>-0.6</td>
<td>20.2</td>
<td>-1.6</td>
</tr>
<tr>
<td>Sep 88</td>
<td>2.1</td>
<td>1.6</td>
<td>1.0</td>
<td>0.2</td>
<td>1.5</td>
<td>1.1</td>
<td>-1.1</td>
<td>19.5</td>
<td>-0.8</td>
</tr>
<tr>
<td>Aug 88</td>
<td>1.4</td>
<td>1.5</td>
<td>0.5</td>
<td>-0.1</td>
<td>1.4</td>
<td>-0.5</td>
<td>-1.3</td>
<td>19.7</td>
<td>-1.2</td>
</tr>
<tr>
<td>Jul 88</td>
<td>1.1</td>
<td>1.2</td>
<td>0.9</td>
<td>1.3</td>
<td>1.5</td>
<td>0.7</td>
<td>-1.2</td>
<td>20.4</td>
<td>-1.8</td>
</tr>
<tr>
<td>Jun 88</td>
<td>-0.2</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
<td>1.3</td>
<td>0.0</td>
<td>-1.5</td>
<td>21.4</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

TABLE 1. Atmospheric and SST index values for the most recent 24 months. Atmospheric indices are standardized by the mean annual standard deviation (1979–1988) except for the Tahiti and Darwin SLP anomalies that are in millibars (mb). SST indices (anomalies and means) are in Celsius (°C). Note that positive (negative) values of the 200-mb zonal wind index imply westerly (easterly) anomalies; positive (negative) values of the 850-mb zonal wind indices imply easterly (westerly) anomalies.
The 20°C isotherm shoaled (became less deep) west of 140°W and deepened east of 110°W. This represents a decrease in the east–west slope of the thermocline. The series of depth–longitude sections of ocean temperature along the equator for the period December 1989–May 1990 (Fig. 13) graphically illustrates the recent changes in subsurface thermal structure. The only other example of a similar change in thermocline slope during the last five years occurred during the last warm episode in late 1986 (Fig. 9). However, the changes that occurred in 1986 were substantially larger than those observed thus far in 1990.

The time–longitude section of the anomalous depth of the 20°C isotherm (Fig. 9b) clearly shows the major swings associated with recent extremes in the Southern Oscillation. The relatively short base period (1985–1989) used to compute the anomalies nearly coincides with the period shown in Fig. 9. Thus, the time-averaged anomaly at each longitude is approximately zero. Prior to the 1986–87 warm episode, positive depth anomalies developed in the central and western equatorial Pacific beginning in mid-1985. This deepening of the thermocline is equivalent to a buildup in the equatorial heat content of the upper ocean. Positive depth anomalies propagated eastward and amplified during 1986. (A similar event occurred in late 1989 and early 1990.) By late 1986 negative depth anomalies developed in the western Pacific as positive anomalies reached their maximum in the eastern portion of the basin. (This is not unlike the evolution in thermocline anomalies that has been observed during the first half of 1990.) The thermocline became abnormally flat by late 1987 with negative depth anomalies throughout the basin. Consequently, the development of stronger than normal easterlies in early 1988 (Fig. 11) resulted in the upwelling of anomalously cold subsurface water and a rapid swing from positive to negative SST anomalies and the development of cold-episode conditions (Janowiak 1988; Ropelewski 1988).

During the 1988–1989 cold episode the tropical troposphere cooled. The zonally averaged 500-mb temperature for the latitude band 20°N–20°S dropped 1.5°C from late 1987 to early 1989 (Fig. 7). Comparing the 500-mb temperature anomaly time series (Fig. 7) with the central equatorial Pacific SST anomaly time series (Fig. 6) reveals that the midtropospheric temperature anomalies lag the SST anomalies by 3–5 months. SSTs returned to near normal in the equatorial central Pacific in late 1989 (Fig. 6), but only recently, during March–May 1990, have the tropical midtropospheric temperatures returned to near normal (Fig. 7).

By the end of May 1990 it was unclear whether the events in the tropical Pacific from late 1989 through early 1990 constituted a weak warm episode in its entirety or whether there would be further evolution during the upcoming seasons. Most atmospheric indices indicated near normal conditions while sea surface temperatures remained slightly positive throughout the equatorial Pacific. Also, experimental prediction models (Barnett et al. 1988) generally indicated continued warming for the next two seasons, but with SST departures not significantly different from zero.

3. Extratropics

The pattern of warmth in the Northern Hemisphere extratropics that was observed in January and February (Janowiak 1990) continued and intensified in March. Nearly all of North America, Europe, and the Soviet Union experienced temperatures above the 70th percentile. Some regions, such as Siberia, northwestern North America and western Africa experienced abnormally warm temperatures throughout the March–May (MAM) 1990 season (Fig. 25). Western Europe, on the other hand, experienced temperatures much above normal during March and May, but near normal in April.

A striking feature of the seasonal temperature percentile analysis for the Northern Hemisphere (Fig. 25) is the predominance of stations with temperature anomalies above the 70th percentile. The percentage of stations reporting temperatures above the 70th percentile for all seasons during 1951–1990 is shown in Fig. 33. (The percentages average near 30 for the climatological base period 1951–1980.) For the Northern Hemisphere, MAM 1990 had the highest percentage (more than 70%) of stations above the 70th percentile during the entire period. Similarly, MAM 1990 featured the highest percentage of Northern Hemisphere stations reporting temperatures above the 90th percentile during the last 40 years (Fig. 34a). A breakdown by season for percentage of stations above the 90th percentile for the period 1951–1990 (Fig. 35) shows that in the Southern Hemisphere the percentages for all seasons have been at their highest levels during the last decade. In the Northern Hemisphere, MAM stands out as the only season with percentages substantially higher during the last ten years compared with the rest of the record, although both JJA and DJF have a number of recent years with high percentages.

It is interesting to note that the December–February seasons of 1988–89 and 1989–90 and the March–May seasons of 1989 and 1990 were characterized by generally similar 500-mb geopotential height anomaly patterns in the Northern Hemisphere and also to some degree in the Southern Hemisphere (Arkin 1989; Mo 1989; Janowiak 1990; Figs. 19 and 23). Positive 500-mb geopotential height anomalies dominated the midlatitudes (30°–45°), while negative anomalies prevailed at high latitudes. Thus, the lower midlatitudes experienced weaker than normal westerlies, while poleward of 45° latitude stronger than normal westerlies were observed. This represents a poleward shift of the jet stream, which is consistent with a cooler than normal tropical midtroposphere (Fig. 7). This anomaly
pattern is opposite to that observed during a warm episode when the global tropics are warmer than normal and the lower midlatitudes experience stronger than normal westerlies. The poleward displacement of the jet stream in both hemispheres, during 1988–1990, was accompanied by exceptional warmth throughout the midlatitudes, not only during DJF (Arkin 1989; Janowiak 1990), but also during the following MAM (see Mo 1989 and Figs. 21 and 25).

March was warmer than normal throughout most of the United States (Fig. 28a), which is consistent with above normal 700-mb heights over the United States eastward through Europe (Fig. 27). A very strong height gradient was observed over the northeast Atlantic and North Sea.

The height anomaly pattern in April (Fig. 29) was similar to that of March, although the region of strong 700-mb height gradient in the Atlantic was displaced 20° to 40° of longitude to the west from its position in March. Abnormal warmth continued over the western and northeastern United States, but below normal temperatures affected the mid-Mississippi Valley and the Southeast (Fig. 30a). Precipitation was below normal in April (Fig. 30b) in many sections of the Midwest, which was in marked contrast to the heavy precipitation observed in that region in March (Fig. 28b).

In May, heavier than normal precipitation returned to the Midwest contributing to a wetter then normal MAM in most locations. After a very dry DJF (Janowiak 1990), California continued drier than normal during March–April (Figs. 28b and 30b), but received unseasonably heavy rains in May (Fig. 32b). However, for the season as a whole (Fig. 36) California was near or drier than normal.

(see References on p. 105)
Fig. 1. Five-month running mean of the difference between the standardized sea level pressure anomalies of Tahiti and Darwin (Tahiti-Darwin). Values are standardized by the mean annual standard deviation. Crosses denote individual monthly means.

Fig. 2. Five-month running mean of the standardized 850-mb easterly wind anomaly in the latitude belt 5°N-5°S for 175°W-140°W. Values are standardized by the mean annual standard deviation (1979-1988). Crosses are the monthly anomalies; "O" indicates that the mean wind was westerly during the month.

Fig. 3. Five-month running mean of the standardized monthly 200-mb westerly wind anomaly averaged over the area 5°N-5°S for the longitudes 165°W-110°W. Values are standardized by the mean annual standard deviation (1979-1988); crosses are individual monthly means.
**Fig. 4.** Departures of the mean monthly 30-mb zonal wind (m s\(^{-1}\)) from its respective long-term (1964-1980) monthly average for Singapore, Malaysia (1°N, 104°E).

**Fig. 5.** Equatorial Pacific sea surface temperature anomaly indices (°C) for the areas indicated at the bottom of the figure. Niño 1+2 is the average over the Niño 1 and Niño 2 areas. Anomalies are computed with respect to the COADS/ICE climatology (Reynolds 1988).
Fig. 6. Time series plot of standardized sea surface temperature anomalies for the equatorial portion of a ship track that runs between Fiji and Hawaii (equatorial crossing near 170°W). Monthly anomalies were computed from the 1950–79 base period and standardized by dividing by the mean annual standard deviation (1951–1980).

Fig. 7. Zonally averaged 500-mb temperature anomaly for the latitude band 20°N–20°S. The anomalies are calculated by subtracting the 1979–1988 monthly mean temperatures for this latitude band from each of the monthly mean averaged temperatures. The "x"s indicate individual monthly values. The solid line is the five-month running mean for the anomalies.

Fig. 8. Five-month running mean of the standardized monthly anomaly in outgoing longwave radiation over the area 5°N–5°S, 160°E–160°W. Values are standardized by the mean annual standard deviation (1979–1988); crosses are individual monthly means.
Fig. 9. (a) Depth and (b) anomalous depth of the 20°C isotherm along the equator in the Pacific Ocean. The contour interval is 10 m. Values less than 50 m and greater than 150 m are shaded in (a). Dark (light) shading in (b) for values greater (less) than 10 m (−10 m). Anomalies in (b) are computed with respect to the 1985–1989 base period means.
Fig. 10. Time-longitude section of monthly (a) mean and (b) anomalous sea surface temperatures for 5°N–5°S. A 1–2–1 smoothing filter in time is used on all internal points of the diagram. Contour interval is 1°C and 0.5°C, respectively. SST values greater than 28°C and anomalies less than –0.5°C are shaded. Stippled areas indicate anomaly values greater than 0.5°C. Anomalies are computed with respect to the COADS/ICE climatology (Reynolds 1988).

Fig. 11. Time-longitude section of monthly 850-mb zonal wind anomalies for 5°N–5°S. A 1–2–1 smoothing filter in time is used on all internal points of the diagram. Contour interval is 1 m s⁻¹, and dashed contours indicate easterly anomalies. Anomalies are departures from the 1979–1988 base period means.

Fig. 12. Time-longitude section of monthly outgoing longwave radiation anomalies for 5°N–5°S. Contour interval is 10 W m⁻² with dashed contours indicating negative anomalies. A 1–2–1 smoothing filter in time is used on all internal points of the diagram. Anomalies are computed as departures from the 1979–1988 base period means.
Fig. 13. Equatorial depth-longitude sections of ocean temperature for the weeks centered on (a) 20 December 1989, (b) 21 February 1990, (c) 28 March 1990, and (d) 23 May 1990. Contour interval is 1°C. Temperatures less than 20°C are shaded. Heavy lines indicate the 15°, 20°, 25°, and 30°C isotherms.
Fig. 14. (a) Mean sea surface temperature, MAM 1990 (blended analysis) on a 2.5° grid. Contour interval 2°C. Temperatures > 20°C are contoured every degree with odd contours dashed. (b) Sea surface temperature anomalies, MAM 1990. Anomalies are computed as departures from the COADS/ICE climatology (Reynolds 1988). Contour interval is 1°C, with negative anomalies dashed.
Fig. 15. Difference in SST (MAM 1990-MAM 1989). Contours are at 0.5°C. Negative values are indicated by dashed lines. Values less than –1°C are shaded. Values greater than 1°C are stippled.
Fig. 16. (a, b) Mean 850 mb vector wind, MAM 1980 (NMC final analysis). Winds are analyzed on a 2.5° grid and interpolated to a 5° Mercator grid for display. In (a), the length of the vector represents wind speed of 6.25 m s⁻¹; contour interval for isotachs is 5 m s⁻¹. In (b), as in (a) except for 1979-1988 base period monthly means.
FIG. 17. (a) Mean 200-mb vector wind, MAM 1990, and (b) anomalies. Anomaly is departure from 1979-1988 mean. Contour interval for mean (anomalies) is 10 m s\(^{-1}\). Vector length of 5\(^\circ\) longitude represents wind speed of 20 m s\(^{-1}\).
Fig. 18. (a) Ongoing longwave radiation, MAM 1990 (NOAA AVHRR IR window channel measurements). Data are accumulated and averaged over 2.5° areas, and interpolated to 0.5° Mercator grid for display. Contour interval 20 W m⁻². (b) Ongoing longwave radiation anomaly, MAM 1990. Anomalies are computed as departures from the 1974-1986 base period mean. Contour interval 10 W m⁻², with positive anomalies dashed.
Fig. 20. (a) Mean Southern Hemisphere 250-mb vector wind, MAM 1990, and (b) anomalies. Anomaly is departure from 1979-1988 mean; isotach contour interval for mean (anomalies) is 10 m s$^{-1}$ (5 m s$^{-1}$).
Fig. 21. Mean Southern Hemisphere surface air temperature for MAM 1990 expressed as percentiles of the normal (Gaussian) distribution fit to the 1951–80 base period data, contoured at the 10th, 30th, 70th, and 90th percentiles (Ropelewski et al. 1985). Hatched area < 30th percentile, stippled area > 70th percentile. Station locations are denoted by small “+”; no analysis done in areas with insufficient data.

Fig. 22. Southern Hemisphere precipitation percentiles for MAM 1990 based on a Gamma distribution fit (Ropelewski et al. 1985) to the 1951–80 base period data, displayed as in Fig. 21.
Fig. 25. As in Fig. 21, except for the Northern Hemisphere.

Fig. 26. As in Fig. 22, except for the Northern Hemisphere.
Fig. 27. Mean Northern Hemisphere 300-mb height (shaded lines, at intervals of 6 m) and departure from 1951-80 base period mean (dotted lines, at intervals of 15 m) for March 1990.

Fig. 28. (a) Mean United States surface air temperature expressed as percentiles of the normal (Gaussian) distribution and (b) precipitation as percentiles of the Gamma, both fit to the 1951-1990 base period and for March 1990.
Fig. 30. As in Fig. 28, except for April 1990.

Fig. 29. As in Fig. 27, except for April 1990.
Fig. 33. Percentage of stations with observed temperatures above the 70th percentile based on a Gaussian distribution for the (a) Northern Hemisphere and (b) Southern Hemisphere. Standard seasons have been used and all seasons are included in the figure.

Fig. 34. As in Fig. 33, except for observed temperatures above the 90th percentile.
FIG. 35. Percentage of stations with observed temperatures above the 90th percentile based on a Gaussian distribution for each season and hemisphere. Northern Hemisphere data is shown on the left and Southern Hemisphere data on the right. Seasons are (top to bottom) March–May (MAM), June–August (JJA), September–November (SON), and December–February (DJF).

REFERENCES