SEASONAL CLIMATE SUMMARY

The Global Climate for December 1987–February 1988: A Return towards Normal in the Tropical Pacific

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The format of this seasonal climate review article is substantially revised from those which have appeared over the past 6 years in the Monthly Weather Review and the Journal of Climate. Our goal in these articles, as in the past, will be to provide a prompt, high quality summary of the climatic events of the most recent three-month season. Our changes are intended to allow us to reduce the lag between the end of the season and publication as much as possible. To achieve this, we have defined a standard set of figures that will be included in all seasonal climate summaries. This set will be supplemented periodically with depictions of the Northern Hemisphere snow cover, global sea ice and stratospheric parameters. The text has been reduced considerably by eliminating general discussion of the standard figures. The text that remains is intended to clarify interrelationships and point out temporal continuity from previous seasons when these are not obvious from inspection of the figures. We hope that this new format and the improved timeliness will be helpful to those readers who have found the seasonal review articles useful.

The El Niño/Southern Oscillation (ENSO) warm event that began during late 1986 (Bergman 1987) reached its mature phase during the March–May 1987 season (Wagner 1988) and continued in its mature phase through June–August 1987 (Arkin 1988) and September–November 1987 (O'Lenic 1988) before beginning to subside during this December–February period. Equatorial Pacific sea surface temperature anomalies, the feature of the atmosphere–ocean system most closely identified with ENSO, decreased substantially from the previous season (Fig. 7). The SST anomaly pattern for February shows that conditions in the equatorial Pacific have continued to return towards normal. The SST anomalies, however, remained greater than +0.5°C in the central Pacific region (Niño 4; Fig. 6b) and negative outgoing longwave radiation (OLR) anomalies continued to be observed in the equatorial region west of the date line (Figs. 8b and 9). The band of negative OLR anomalies extending from this region southeastward is indicative of an enhanced South Pacific convergence zone.

The 850 mb zonal wind anomalies in the central Pacific became easterly during December and strengthened during January and February. This is the first occurrence of easterly anomalies in this area since before the beginning of the current warm episode (Fig. 11). During most of 1987, upper tropospheric (200 mb) easterly anomalies were observed over much of the equatorial belt. In February 1988, easterly anomalies were virtually absent along the equator and westerly anomalies generally prevailed. Over the Pacific basin, seasonal 200 mb vector wind anomalies were mainly meridional (Fig. 12b), the result of easterly anomalies during December and January and strong westerly anomalies during February. The return of easterly anomalies at 850 mb and westerly anomalies at 200 mb indicate that the conditions typically found in the troposphere during Pacific warm events have abated.

The 500 mb height anomaly field for the DJF season in the Southern Hemisphere was notable due to a lack of any well-defined anomalous features (Fig. 13b). Temperatures were again above normal, however, throughout most of the hemisphere (Fig. 15); temperatures throughout large parts of the Southern Hemisphere have been above normal for the past six seasons. While this occurred during an ENSO warm episode, with above normal sea surface temperatures in many parts of the Southern Hemisphere oceans, past warm events have not been shown to be associated with general warmth throughout the entire Southern Hemisphere. Horel and Wallace (1981), however, note a tendency for warmer than normal conditions in the tropical troposphere during ENSO.

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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 standard deviation of the appropriate monthly mean. Crosses denote individual monthly means.

Fig. 2. 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 standard deviation of the appropriate monthly mean; crosses are individual monthly means.

Fig. 3. Five-month running mean of the standardized 850 mb easterly wind anomaly in the latitude belt 5°N–5°S for 175°–140°W. Crosses are the monthly anomalies; “O” indicates that the mean wind was westerly during the month.
The most notable precipitation anomaly during the Southern Hemisphere summer season was the relative drought in northern Australia during the monsoon season (Fig. 16). While precipitation was near or slightly above normal during December, conditions became very dry during January and some dryness persisted into February. Dry conditions during a warm event are common during this season over eastern and northern Australia (Ropelewski and Halpert 1987). Since positive SST anomalies and enhanced convection in the central Pacific have persisted into 1988, the dry conditions that have affected these parts of Australia this year as well as last are probably related more to the enhanced convection than to the phase of the ENSO. Other significant precipitation anomalies included heavy February rainfall in southeast Brazil and areas of South Africa, Botswana and Zimbabwe.

The seasonal height anomaly pattern for the Northern Hemisphere (Fig. 17b) contains the only anomalies in either hemisphere which exhibited strong month to

<table>
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<tr>
<th>Date (1987-88)</th>
<th>Tahiti</th>
<th>Darwin</th>
<th>Pacific 85 kPa zonal wind indices</th>
<th>Outgoing longwave radiation index</th>
<th>Pacific 20 kPa zonal wind index</th>
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<th>Niño 3</th>
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* Preliminary.
** Revised.
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, 1987).

month persistence. The negative height anomaly center over the Bering Sea and the positive anomalies over northwestern Canada were present during all three months of the season, much as they were during last winter (Kousky 1987). Associated with this height anomaly pattern, warmer than normal conditions were found from Alaska extending into the western half of Canada (Fig. 19). The anomalies, however, were not

(text continued on p. 644)
Fig. 6. (a) Mean sea surface temperature, DJF 1987/88 (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, DJF 1987/88. Anomalies are computed as departures from the COADS/ICE climatology (Reynolds 1987). Contour interval is 1°C, with negative anomalies dashed.
FIG. 7. Time-longitude section of monthly sea surface temperature anomalies for 5°N–5°S. A 1–2–1 smoothing filter in time is used on all internal points of the diagram. Contours in tenths °C at an interval of 0.5°C. Dashed lines indicate negative anomalies.
Fig. 8. (a) Outgoing longwave radiation, DJF 1987/88 (NOAA AVHRR IR window channel measurements by NESDIS/ESL). Data are accumulated and averaged over 2.5° areas and interpolated to a 5° Mercator grid for display. Contour interval 20 W m⁻², with contours of 280 W m⁻² and above dashed. (b) Outgoing longwave radiation anomaly, DJF 1987/88. Anomalies are computed as departures from the 1974–1983 base period mean (1978 missing). Contour interval 10 W m⁻², with positive anomalies dashed.
Fig. 9. 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 a 1974–83 base period mean (1978 missing).
FIG. 10. (a) Mean 850 mb vector wind, DJF 1987/88, (NMC final analysis). Winds are analyzed on a 2.5° grid and interpolated to a 5° Mercator grid for display. Vector length of 5° longitude represents wind speed of 6.25 m s\(^{-1}\). Contour interval for isotachs is 5 m s\(^{-1}\). (b) As in (a) except for wind anomalies. Vector length of 5° longitude represents anomalous wind speed of 3.125 m s\(^{-1}\), and anomalies are computed as departures from 1980-83 base period monthly means.
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. Anomaly is departure from monthly mean averages calculated from a Mar 80–Feb 84 base period.
Fig. 12. (a) Mean 200 mb vector winds. DJF 1987/88, and (b) anomalies. Anomaly is departure from 1988-89 mean. Contour interval for mean (anomalies) is 10 m s\(^{-1}\) (5 m s\(^{-1}\)). Vector length of 5° longitude represents wind speed of 20 m s\(^{-1}\) (6.25 m s\(^{-1}\)) for mean (anomalies).
Fig. 13. (a) Mean Southern Hemisphere 500 mb height for DJF 1987/88. Contour interval 8 dam. (b) Height anomaly (departure from the 1978-83 mean), contour interval 2 dam, with negative anomalies dashed.
Fig. 14. (a) Mean Southern Hemisphere 290 mb vector wind, DJF 1987/88, and (b) anomalies. Anomaly is departure from 1978–83 mean.

Contour interval for mean (anomalies) is 10 m s⁻¹ (5 m s⁻¹).
Fig. 15. Mean Southern Hemisphere surface air temperature for DJF 1987/88 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. Hatched area < 30 percentile, stippled area > 70 percentile. Station locations are denoted by small '+'; no analysis done in areas with insufficient data.

Fig. 16. Southern Hemisphere precipitation percentiles for DJF 1987/88 based on a Gamma distribution fit to the 1951–80 base period data, displayed as in Fig. 15.
Fig. 17. As in Fig. 13 except for the Northern Hemisphere.
Fig. 18. As in Fig. 14 except for the Northern Hemisphere.
as great as those associated with the record or near record warmth which affected many stations in this region last year (Kousky 1987). As was the case in the Southern Hemisphere, temperatures during the December–February period averaged above normal for large parts of the Northern Hemisphere. The greatest temperature anomalies occurred in January, when record-breaking temperatures were common over large areas of Europe and Japan.

Since January 1973 Arctic and Antarctic sea ice extent have been analyzed weekly by the Joint NOAA/NAVY Ice Center. These analyses are based on interpretation of satellite imagery supplemented by aircraft and surface observations. Monthly estimates of sea-ice areas are derived at CAC (see Ropelewski 1983 for details) to update time series of sea-ice area (Fig. 27). Sea-ice variability is dominated by long term fluctuations that are especially evident in the first half of each series. Over the previous two years there has been relatively more Arctic sea ice in the northern winter but the sea-ice area returned to near the 16-yr mean in February 1988. Conversely, Antarctic sea-ice area has
been near or below its period mean during the past two austral winters, but during these austral summer months more than normal sea-ice prevailed.

Daily values during October 1987 to February 1988 of the zonal mean wind and temperature at 2 mb (approximately 42 km) shown in Figs. 28 and 29 give an overall view of the important stratospheric winter events. The outstanding event for this Northern Hemisphere winter was a major stratospheric warming which culminated in a polar circulation reversal from below the 10 mb level throughout the middle and upper stratosphere. The early December occurrence for this event is the earliest on record for a major stratospheric warming. Figure 28 traces the gradual increase in polar westerly wind during the winter, with a minor decrease in mid-November and the change to polar easterlies in early December. Strong wintertime westerlies associated with the cold polar vortex became reestablished thereafter and reached maximum strength in mid-February. The temperature traces in Fig. 29 show the associated reversal in temperature gradient from high to low latitudes during the stratospheric warming.
Figure 23. As in Fig. 21 except for February 1988.

Figure 30 for Balboa (9°N, 80°W) traces the departure of each monthly value of the mean 30 mb zonal wind from its respective long term monthly average.

By February 1988, the tropical quasi-biennial oscillation was in the decreasing westerly phase.

(References on p. 652)
FIG. 24. (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 1951–80 base period and for December 1987.
Fig. 25. As in Fig. 24 except for January 1988.
FIG. 26. As in Fig. 24 except for February 1988.
Fig. 27. Time series of sea ice area for a) the Arctic and b) the Antarctic. Monthly sea ice areas are standardized by the 1973 to 1988 base period means and standard deviations. The solid line represents a 3 month running mean except for the last point. The (+) represents the unsmoothed standardized sea ice value for February of each year.
2-MB ZONAL WIND AT 60 DEG N LAT (10/87 - 2/88)

Fig. 28. Zonal geostrophic wind (m s⁻¹, westerly positive) averaged around 60°N for 2 mb (Gelman et al. 1986).

2-MB ZONAL MEAN TEMP AT 10, 60, AND 80 DEG N LAT (10/87 - 2/88)

Fig. 29. Temperature (°C) averaged around 80°N, 60°N and 10°N for 2 mb.

Fig. 30. Monthly mean departures from long-term (1951-88) average for 30 mb Balboa zonal wind (m s⁻¹) (Angell 1986).
REFERENCES


