SEASONAL CLIMATE SUMMARY

The Global Climate for December 1986–February 1987: El Niño Returns to the Tropical Pacific

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1. Introduction

A major highlight during December 1986–February 1987 (DJF) was the occurrence of anomalously warm sea surface temperatures in the equatorial Pacific associated with the warm phase of the Southern Oscillation. After a period in early 1986, characterized by slight positive sea surface temperature (SST) anomalies in the eastern equatorial Pacific and inconsistent tropical indices (Arkin and Janowiak, 1987), conditions in the equatorial Pacific remained near normal until the middle of the year. Sea surface temperature anomalies then began to increase in the western and central equatorial Pacific and the warmest water began to shift eastward towards the date line. At the same time, equatorial easterly anomalies decreased and were replaced by westerly anomalies. By September, it was evident that a mid-Pacific warming was in progress (Climate Analysis Center, 1986). Positive SST anomalies continued to spread eastward during October and November while enhanced equatorial convection became established near the date line. This phase of the developing ENSO episode is described by Bergman (1987). During DJF, SST anomalies increased along the west coast of South America and classical El Niño conditions developed in this region.

In many respects, the evolution of the 1986/87 warm episode has been similar to that of the 1982/83 El Niño/Southern Oscillation (ENSO) episode. In both cases the mid-Pacific warming preceded the appearance of classical El Niño conditions along the west coast of South America. Anomaly patterns of SST, rainfall and atmospheric circulation in the tropics and subtropics during DJF were remarkably similar to those observed during the mature phase of previous ENSO episodes (Rasmusson and Carpenter, 1982; Ropelewski and Halpert, 1987; Arkin, 1982), but were much weaker than those observed during 1982/83 (Quiroz, 1983).

2. The tropics

a. The equatorial Pacific indices

The values of indices used to monitor oceanic and atmospheric conditions in the equatorial Pacific are shown in Table 1. The equatorial Pacific SST indices increased since mid-1986 (Fig. 1) in the Niño 3 and Niño 1+2 regions, while in the Niño 4 region values dropped slightly since October 1986. The outgoing longwave radiation (OLR) index (negative values indicate enhanced equatorial convection in the central Pacific) decreased abruptly in September and continued to decrease through February to more than two standard deviations below normal (Table 1 and Fig. 2). For the period November 1986–February 1987, sea level pressure was consistently higher than normal at Darwin, Australia, and lower than normal at Tahiti. As a result, the Southern Oscillation Index (SOI) was negative throughout DJF and, for the period October 1986–February 1987, had a mean value of −1 (Table 1 and Fig. 3). The equatorial 850 mb zonal wind indices were near zero in the central and eastern Pacific, but were generally negative (indicating westerly anomalies) in the western Pacific. For all three index regions the values during DJF were substantially lower than those observed in early 1986 (Fig. 4).

b. Sea surface temperatures

The DJF mean and anomalous SST are shown in Fig. 5. In comparison to the December 1985–February 1986 period (Arkin and Janowiak, 1987), there was a substantial weakening of the tongue of cold water along the equator in the eastern Pacific (Fig. 5a). Also, the region with SST greater than 29°C shifted from the western Pacific eastward so that it was centered on the date line during DJF.

A large portion of the equatorial central and eastern Pacific had SST anomalies of greater than +1.0°C (Fig. 5b). Anomalies in the rest of the tropical belt were generally within 1.0°C of normal. The growth and eastward spread of positive SST anomalies in the equatorial Pacific since mid-1986 are readily seen in Fig. 6.

c. Outgoing longwave radiation in the tropics

The tropical patterns of mean and anomalous OLR (Fig. 7) are typical of ENSO episodes. The lowest values
of OLR for the entire tropics were found near the date line along the equator (Fig. 7a). Negative anomalies in this region were as low as ~50 W m$^{-2}$. Negative anomalies also occurred along the South Pacific convergence zone, throughout the tropical Indian Ocean, in a northwest–southeast band through South America and in the northern Gulf of Mexico. Positive anomalies prevailed in the Philippines, northeast Australia, and in northern and southern Africa. The development and eastward shift in the OLR anomalies in the central Pacific is readily apparent in the time-longitude section shown in Fig. 8.

### d. Tropical circulation features

1) **The 850 mb circulation**

The seasonal mean and anomalous 850 mb vector wind are shown in Fig. 9. Easterlies were stronger than normal throughout the subtropical North Pacific (Fig. 9b). Easterlies were also stronger than normal in the tropical Atlantic, eastern subtropical South Pacific and along the equator between 120°W and 160°W. Westerly anomalies prevailed in the equatorial central Pacific. Anomalous cyclonic circulation occurred at low latitudes in both hemispheres near and to the west of the date line.

The transition from large easterly anomalies in early 1986 to westerly anomalies in the equatorial central Pacific is shown in Fig. 10. Also evident is the eastward shift in the region of anomalous zonal convergence from the far western Pacific (near 160°E) in early 1986 to the central Pacific (near 160°W) during DJF 1986–87.

2) **The 200 mb circulation**

Anomalous equatorial 200 mb easterlies occurred in the equatorial Pacific in the region of anomalous atmospheric convection and warmest sea surface temperatures (Fig. 11b). An anticyclonic anomaly couplet dominated the subtropics of the central Pacific in both hemispheres. Poleward of each anticyclonic circulation center, the midlatitude westerlies (Fig. 11a) were stronger than normal (Fig. 11b) and, in the case of the Northern Hemisphere, they extended farther eastward than normal. Equatorial westerly anomalies were confined mainly to the region of the Atlantic.

### 3. The Southern Hemisphere extratropics

a. **Seasonal atmospheric circulation**

The tropospheric (500 mb) geopotential height anomalies in the Southern Hemisphere during DJF (Fig. 12) display an out-of-phase pattern between middle and high latitudes throughout the Pacific/Australian sector. Between 120°E and 160°W positive anomalies occurred at high latitudes, while negative anomalies occurred at midlatitudes, which is suggestive of block-

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**Table 1. Atmospheric and sea surface temperature (SST) indices for the tropical Pacific. Atmospheric indices are mean values of departures from long-term averages divided by the standard deviation of the respective time-series. SST indices are mean values of departures from long-term averages divided by the standard deviation of the respective time-series.**

<table>
<thead>
<tr>
<th>Pacific SST</th>
<th>SLP anomalies</th>
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<tbody>
<tr>
<td>5°N-5°S, 160°E-150°W</td>
<td>Tahiti minus Darwin SOI</td>
</tr>
<tr>
<td>Niño 1+2</td>
<td>0°-10°S, 90°W-150°W</td>
</tr>
<tr>
<td>Niño 2+3</td>
<td>5°N-5°S, 180°E-150°W</td>
</tr>
<tr>
<td>Niño 3</td>
<td>0°-10°S, 150°W-90°W</td>
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<tr>
<td>Pacific 200 mb</td>
<td>Outgoing longwave radiation index</td>
</tr>
<tr>
<td>5°S-5°N, 150°W-120°W</td>
<td>15°S-15°N, 160°E-120°W</td>
</tr>
<tr>
<td>135°E-140°W</td>
<td>175°W-155°W</td>
</tr>
<tr>
<td>Tahiti-Darwin SOI</td>
<td>133°E-180°</td>
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</table>

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FIG. 1. 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).

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.
ing activity in this region. In the eastern Pacific sector the pattern of anomalies reversed relative to that observed farther west. The anomaly pattern in the Atlantic and Indian Ocean sectors was relatively weak.

b. Significant climate anomalies

Many continental areas of the Southern Hemisphere observed above normal temperatures during DJF (Fig. 13). Some of these, such as southern Africa, central Argentina and eastern Australia, were at or above the 90th percentile. Only relatively small portions of the west and south coasts of Australia and the area near New Caledonia experienced temperatures at or below the 30th percentile. Conditions were generally wetter than normal (>70th percentile) along the south coast of Australia and at low latitudes of Africa and South America and drier than normal (<30th percentile) in eastern Australia, New Caledonia, New Zealand, central Chile and coastal sections of southeast Africa (Fig. 14).

4. The Northern Hemisphere extratropics

a. Seasonal atmospheric circulation

The Northern Hemisphere 700 mb mean geopotential height and anomaly fields are shown in Fig. 15. Negative anomalies dominated the north-central Pacific and the north-central Soviet Union. Negative anomalies also occurred in the Atlantic and west of Greenland. Positive height anomalies prevailed over North America and throughout most of the sub tropics. The pattern of negative anomalies in the central and eastern Pacific and positive anomalies over Canada was highly persistent throughout the season and contributed to the abnormally warm temperatures observed over the western two-thirds of Canada, Alaska and the northern Plains of the United States (Fig. 16). Many stations in this region experienced record or near record warm temperatures for DJF. Warmer than normal conditions also prevailed over China and the southern Soviet Union. Colder than normal temperatures were observed throughout much of Europe and the northwestern Soviet Union. Record cold temperatures were experienced at many stations in this region during early January.

Precipitation was generally above normal from the southwestern United States eastward along the Gulf Coast states to the middle Atlantic states (Fig. 17). Wetter than normal conditions also were observed in the central Soviet Union, Alaska and extreme northern Canada. It was drier than normal in the northwestern United States and southwestern Canada eastward to northern New England.

b. Monthly circulation and climate anomalies

1) December 1986

The 700 mb geopotential height anomaly pattern for December (Fig. 18) was remarkably similar to that for DJF. Large negative anomalies prevailed in the Aleutians with weaker negative anomaly centers near Greenland and over the north-central Soviet Union. Positive anomalies covered most of Canada and the United States, as well as the subtropics.

Warmer than normal temperatures were observed throughout the northern United States east of the Rocky Mountains (Fig. 19a). Colder than normal conditions were restricted to the northern Rocky Mountains and portions of Texas and Louisiana (Fig. 19b). Precipitation was above normal in southern New Mexico, most of Texas and in several areas along the East Coast from central New England southward to Florida. It was generally drier than normal over the northwest and north-central states with very dry con-
FIG. 4. Five-month running mean of the standardized 850 mb easterly wind anomaly in the latitude belt 5°N–5°S for (a) 135°E–180°W, (b) 175°W–140°W and (c) 135°W–120°W. The “O’s” indicate actual westerlies.
Fig. 5. (a) Sea surface temperature, DJF 1986/87 (blended analysis), on a 2.5° grid. Contour interval is 2°C. Temperatures > 20°C are contoured every degree with odd contours dashed. (b) Sea surface temperature anomalies, DJF 1986/87. Anomalies are computed departures from the COADS/ICE climatology (Reynolds, 1987). Contour interval is 1°C with negative anomalies dashed.

Fig. 6. Time-longitude section of monthly sea surface temperature anomalies for 5°N-5°S. Contour interval is 0.5°C. Values less than -0.5°C are shaded. Values greater than 0.5°C are stippled. A 1-2-1 filter in time is used on all points prior to the current month. Anomalies are computed based on the COADS/ICE climatology (Reynolds, 1987).
Fig. 7. (a) Mean outgoing longwave radiation, DJF 1986/87 (NOAA 9 AVHRR IR window channel measurements by NESDIS/ESL). Contour interval is 20 W m$^{-2}$ and contours > 280 W m$^{-2}$ are dashed. (b) Outgoing longwave radiation anomalies, DJF 1986/87. Anomalies are computed as departures from the CAC climatology (Janowiak et al., 1985). Contour interval is 10 W m$^{-2}$. Positive anomalies are dashed.

Fig. 8. Time–longitude section of monthly outgoing longwave radiation anomalies for 5°N–5°S. Contour interval is 10 W m$^{-2}$. Negative values are shaded. Smoothing as in Fig. 6.
FIG. 9. (a) Mean 850 mb vector wind, DJF 1986/87, and (b) anomalies. Anomalies are departures from the 1980–83 DJF mean. Contour interval for isotachs is 5 m s\(^{-1}\).

FIG. 10. Time-longitude cross section of 850 mb zonal wind anomalies averaged over 5\(^\circ\)N-5\(^\circ\)S. Contour interval is 1 m s\(^{-1}\). Positive anomalies (anomalous westerlies) are shaded.
ditions (at or below the 10th percentile) over many sections of the Great Basin and northern Plains.

2) January 1987

The 700 mb geopotential height anomaly pattern for January was similar to that for December in the Pacific–North American sector (Fig. 20). However, there was a dramatic reversal in the anomaly pattern, from December to January, over the Mediterranean northward to the Norwegian Sea. During January, a strong positive anomaly center was found near Iceland, which resulted from very strong blocking in the first half of the month. This blocking episode contributed to some of the coldest temperatures ever recorded over portions of Europe and the western Soviet Union.

In the United States, much above normal temperatures (at or above the 90th percentile) were observed from Montana eastward to Minnesota and southward to Nebraska (Fig. 21a). Only small areas in the West and Southwest observed temperatures below the 30th percentile. The precipitation anomaly pattern was quite similar to that observed in December. Drier than normal conditions occurred in the northern Rocky Mountains eastward to the Great Lakes, while wetter than normal conditions were found along the East
FIG. 12. (a) Southern Hemisphere (SH) mean 500 mb height and (b) anomalies for DJF 1986/87. Mean (anomaly) interval is 8 dam (2 dam).
Fig. 13. Mean SH surface air temperature for DJF 1986/87 expressed as percentiles of the normal (Gaussian) distribution fit to the 1951–80 base period data. Hatched area < 30%; stippled area is > 70%. Station locations are denoted by small “plus” symbols.

Fig. 14. Percentiles of SH precipitation for DJF 1986/87 based on a gamma distribution fit to the 1951–80 base period data. Hatched area < 30%; stippled area is > 70%. Station locations are denoted by small “plus” symbols.
Coast and part of the Gulf Coast. Drier than normal conditions also appeared in the Ohio Valley.

3) February 1987

There was a substantial weakening of the negative anomaly center in the region of the Aleutians during February (Fig. 22). Positive height anomalies persisted over nearly all of Canada and the northern half of the United States. Large negative height anomalies were found in the Atlantic. Positive anomalies prevailed in most of the subtropics.

The February temperature anomaly pattern in the United States is similar to that observed in January, with generally near normal or above normal temperatures prevailing over the entire country (Fig. 23a). Only extreme eastern Maine experienced temperatures below the 30th percentile. Near record warmth (greater than the 90th percentile) continued in the area from eastern Montana eastward to Wisconsin and southward through Iowa and northeast Nebraska.

Drier than normal conditions prevailed over much of the Northeast and the northern Rocky Mountain states during February (Fig. 23b). All of New England, most of New York and parts of Pennsylvania, Ohio and Michigan experienced precipitation at or below the 10th percentile. Wetter than normal conditions were observed from the Dakotas south-southwestward to Arizona then eastward throughout the southern states except for central and southern Florida.
Fig. 18. As in Fig. 15, except for December 1986.

Fig. 19. Percentiles of (a) temperature and (b) precipitation for the contiguous United States.
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REFERENCES


