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Seasonal climate summary southern hemisphere (summer 2004/05): a neutral ENSO situation with a cooling Pacific. Hot and dry over the western half of Australia

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Southern hemisphere circulation patterns and associated anomalies for the austral summer 2004/05 are reviewed, with emphasis given to the Pacific Basin climate indicators and Australian rainfall and temperature patterns.

Neutral ENSO conditions persisted during the summer of 2004/05. Near-equatorial Pacific surface temperatures were generally warmer than average, but most anomalies decreased by around 0.4°C during the course of the season. February was a particularly anomalous month; it was characterised by a large fall in the Southern Oscillation Index, strongly enhanced convection around the date-line, strong westerly wind anomalies in the western to central tropical Pacific and numerous tropical cyclones over the central Pacific.

Australian summer rainfall totals were well below average in a band extending from northwest WA to the far western border areas of NSW and Queensland. It was also much hotter than average over the western half of the country, particularly in the Pilbara of WA where mean maximum and minimum temperatures were the highest on record.

Introduction

The borderline warm El Niño-Southern Oscillation (ENSO) conditions of spring 2004 (Bettio and Watkins 2005) persisted through summer, but with some weakening as positive SST anomalies reduced. There was a brief ENSO-like coupling of the ocean and atmosphere in February, accompanied by a sharp drop in the Southern Oscillation Index (SOI), the development of a quasi-stationary mass of convection near the date-line and strong westerly wind anomalies over the western to central tropical Pacific. Numerous tropical cyclones also formed over the central Pacific in February, some of them reaching category 5, the most intense. Tropical cyclone *Olaf* made a direct hit on American Samoa's Manu'a Islands, which were declared a major disaster area by the USA.

Averaged over Australia, it was the driest summer since 1989/90, ranking 16th driest out of the past 105 summers. Rainfall was particularly suppressed across subtropical parts of the country with several patches registering record low falls. In contrast, conditions

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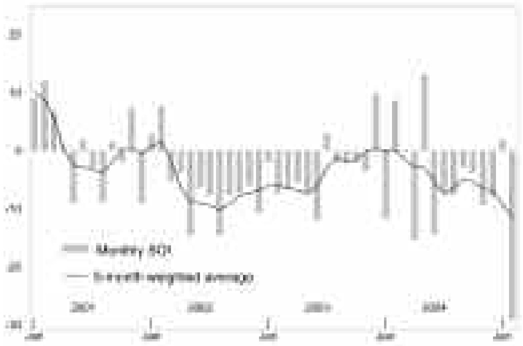
were wetter than average in the southeast of the mainland, although a substantial fraction of the rainfall occurred during a 48-hour period in early February.

In area-average terms, Australian maximum temperatures were the third highest on record since 1950. It was a particularly hot summer over much of WA and western parts of the NT, with record high mean maxima and minima in the Pilbara.

This summary reviews the southern hemisphere and equatorial climate patterns for summer 2004/05, with particular attention given to the Australasian and Pacific Regions. The main sources of information for this report are the *Climate Monitoring Bulletin - Australia* (Bureau of Meteorology, Australia), the *Darwin Tropical Diagnostic Statement* (Bureau of Meteorology, Australia) and the *Climate Diagnostics Bulletin* (Climate Prediction Center, Washington). Further details regarding sources of data are given in the Appendix.

Fig. 1 **Southern Oscillation Index, from January 2001 to February 2005. Means and standard deviations used in the computation of the SOI are based on the period 1933-1992.**



Pacific Basin climate indices

The Troup Southern Oscillation Index*

The sequence of weakly negative Southern Oscillation Index (SOI) values that occurred during spring (Bettio and Watkins 2005) continued only as far as the first month of summer with a December reading of –8.0. Thereafter the SOI (Fig. 1) was more volatile rising to +1.8 for January before plunging to a value of –29.1 for February, the lowest value for any month since February 1983 (–33.3). The seasonal mean of –11.8 indicated that, on the whole, the Walker Circulation was weaker than average across the western Pacific during summer, a situation that was consistent with other indicators that showed borderline warm ENSO conditions.

Darwin's mean sea-level pressure (MSLP) mostly fluctuated within 2-3 hPa of average during December and January, with some of the lowest values of the season occurring at the end of December and start of January, in association with the onset of the monsoon over northern Australia. The monthly anomalies were 0.0 and +0.1 hPa respectively for these two months. During February however, the MSLP anomalies at Darwin became consistently positive as the Australian monsoon weakened and convection became anchored around, and to the east of, the date-line. Darwin's February MSLP anomaly was a substantial +2.4 hPa. Tahiti's MSLP was more variable than Darwin's with anomalies of –1.6 hPa, +0.4 hPa and –3.8 hPa respectively for the three summer months, the February value establishing a new record for the month. In fact, Tahiti's February mean MSLP of 1007.3 hPa was the equal lowest of any month: December 1883 and January 1998 also had the same mean. The anomalously low February pressure over French Polynesia was consistent with a period of sustained convection in the vicinity of the date-line.

The November/December, December/January and January/February values of the Climate Diagnostics Center (CDC) Multivariate ENSO Index (MEI) (Wolter and Timlin 1993, 1998) were +0.679, +0.298 and +0.742 respectively. These values were marginally lower than those recorded during spring and indicate a persistence of borderline warm ENSO conditions over the Pacific basin. The MEI is derived from a number of atmospheric and oceanic indicators, and typically shows positive values in excess of +0.8 during warm ENSO (El Niño) events.

Outgoing long wave radiation

Figure 2, adapted from the Climate Prediction Center (CPC), Washington (CPC 2005), shows the standardised monthly anomaly of outgoing long wave radiation (OLR) from January 2001 to February 2005, together with a three-month moving average. These data, compiled by the CPC, are a measure of the amount of long wave radiation emitted from an equatorial region centred about the date-line (5ºS to 5ºN and 160ºE to 160ºW). Tropical deep convection in this region is particularly sensitive to changes in the phase of the Southern Oscillation. During warm (El Niño) ENSO events, convection is generally more

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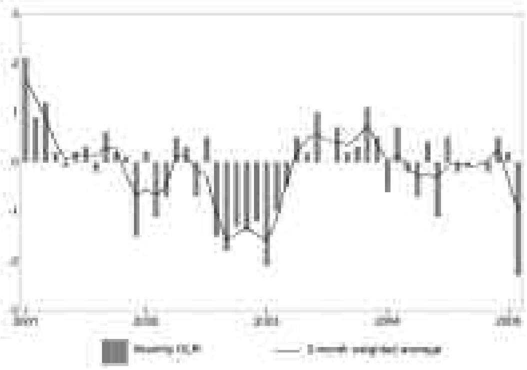
*The Troup Southern Oscillation Index (SOI) used in this article is ten times the standardised monthly anomaly of the difference in mean sea-level pressure between Tahiti and Darwin. The calculation is based on a sixty-year climatology (1933-1992).

Fig. 2 **Standardised anomaly of monthly outgoing long wave radiation averaged over the area 5ºS to 5ºN and 160ºE to 160ºW, from January 2001 to February 2005. Negative (positive) anomalies indicate enhanced (reduced) convection and rainfall in the area. Anomalies are based on the 1979-1995 base period. After CPC (2005).**



prevalent resulting in a reduction in OLR. This reduction is due to the lower effective black-body temperature and is associated with increased high cloud and deep convection. The reverse applies in cold (La Niña) events, with less convection expected in the vicinity of the date-line.

The December and January values of this index (+0.5 and +0.2 respectively) were indicative of close to, or slightly reduced, tropical convective activity around the international date-line. However, in February the index had a value of –2.3, the lowest value since the 1997/98 El Niño, as a result of a sustained period of increased convection in this region. The low OLR and SOI values in February, together with the persistence of above average sea-surface temperatures and reduced trade wind strength (see below), were characteristic of a genuine ocean-atmosphere coupling that occurs during warm ENSO events, albeit briefly in this instance. It was the short duration of this coupling, and the complete lack of it during 2004, that resulted in the Australian Bureau of Meteorology refraining from declaring an El Niño event for this most recent period of excess heat in the Pacific.

There were two clearly defined pulses of increased convective activity associated with the Madden-Julian Oscillation (MJO) during summer. The MJO is characterised by waves of enhanced or suppressed convective activity propagating eastward across the Indian Ocean and northern Australian tropics to the western, or sometimes central, Pacific (Wheeler and Weickman 2001). It usually has a clear signal in the OLR field. The first pulse occurred from late December to late January as a wave of enhanced convection propagated across the Maritime Continent and western Pacific Ocean. It was associated with the onset of the monsoon over northern Australia at the end of December and early January. Pulse number two developed during the last two days of January in the western Pacific, and propagated slowly to the east for a fortnight before losing the characteristics of an eastward moving wave. At about this time, convection became quasi-stationary around the date-line indicating ENSO-like coupling between the ocean and atmosphere, albeit for a brief period.

Oceanic patterns

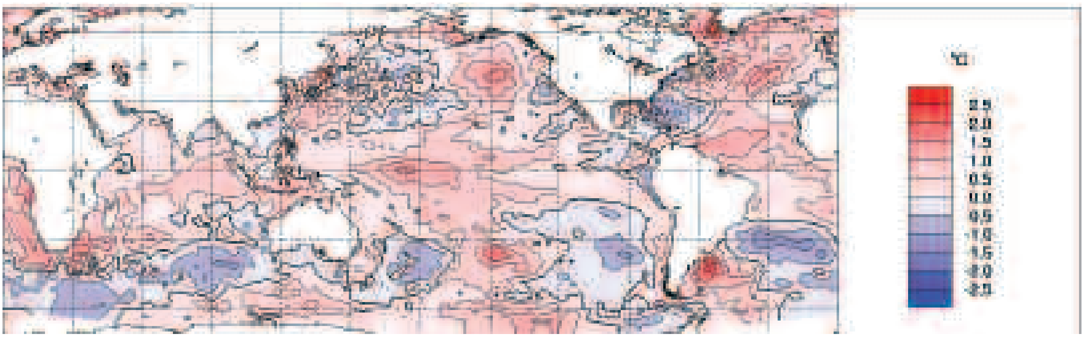
Sea-surface temperatures

Figure 3 shows summer 2004/05 sea-surface temperature (SST) anomalies in degrees Celsius (°C), obtained from the NOAA optimum interpolation analyses (Reynolds et al. 2002). The contour interval is 0.5°C. Positive anomalies are shown in pink and red shades, while negative anomalies are shown in blue shades.

Seasonally averaged positive anomalies were evident across the tropical Pacific Ocean, with the exception of the far east, as well as over the Coral Sea, northern Australian waters and much of the tropical Indian Ocean. In the Pacific, near-equatorial anomalies exceeded +1.0°C between about 160°E and 160°W and peaked at +1.5 to +2.0°C just to the west of the date-line. The area of anomalies over +1.0°C around the equatorial date-line changed only slightly from December to January, but there was a marked decline in its spatial coverage in February; a month characterised by strongly enhanced convection (and hence reduced solar insolation) in this region. As further evidence of this sharp cooling trend, the NINO4 index had monthly values of +1.04°C, +1.01°C and +0.75°C for the three summer months respectively.

The NINO3.4 index, representing the central tropical Pacific, showed a similar trend with monthly values of +0.78°C, +0.68°C and +0.37°C, while in NINO3, representing the central to eastern tropical Pacific, the cooling trend was more consistent over the season with December to February monthly values of +0.70°C, +0.47°C and +0.04°C. Anomalies became negative in the NINO1 and 2 areas of the far eastern Pacific in February, and this is consistent with the negative anomalies shown in Fig. 3 near the South American coast.

Fig. 3 Anomalies of sea-surface temperature for summer (December, January, February) 2004/05 (ºC). The contour interval is 0.5°C.



The general cooling over the tropical Pacific during summer was indicative of a modest relaxation of the warmer than average conditions that had prevailed over the basin during the second half of 2004.

Subsurface patterns

Figure 4 shows a time-longitude diagram of the anomaly in metres of the depth of the 20°C isotherm along the equatorial Pacific Ocean between January 2001 and February 2005, as calculated by the Bureau of Meteorology Research Centre (BMRC). The 20°C isotherm is generally situated close to the equatorial ocean thermocline, the region of greatest vertical temperature gradient with respect to depth. The thermocline can also be regarded as the boundary between the upper ocean warm water and the deeper ocean cold water. An abnormally shallow thermocline in the eastern Pacific Ocean is characteristic of La Niña events. Positive anomalies correspond to the 20°C isotherm being deeper than average, and negative anomalies to it being shallower than average.

The main feature of Fig. 4 is the series of coloured bands that slope slightly upwards from left to right (west to east); these generally represent Kelvin waves with downwelling shown by warm colours and upwelling by cool. Bettio and Watkins (2005) described a series of downwelling waves that warmed the eastern Pacific during spring. During summer however, the main Kelvin wave was upwelling in nature; that is, it cooled the subsurface by raising the thermocline, with its origin near 170°E at the end of December and start of January. By the end of February, the 20°C isotherm was about 30 m shallower than average (i.e., a negative anomaly) in the eastern Pacific. In contrast, the 20°C isotherm anomaly reached around +30 to +40 m, or even a little higher, in the span from 180° to 150°W during February, in association with the quasi-stationary convection which occurred in this region during the month. Persistent westerly wind anomalies near, and to the west of, the convection produced a strong downwelling signature on the thermocline.

Fig. 4 Time-longitude section of the monthly anomalous depth of the 20°C isotherm at the equator from January 2001 to February 2005. The contour interval is 10 m.

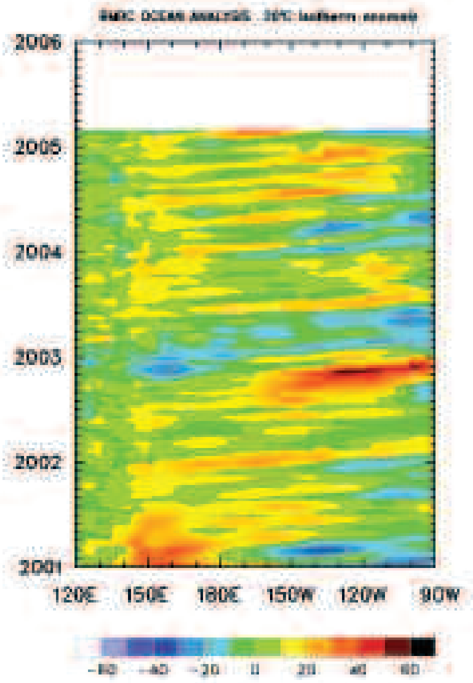


Figure 5 shows a sequence of equatorial Pacific vertical temperature anomaly profiles for the four months ending February 2005, also obtained from the BMRC. In the figure, red (blue) shades indicate subsurface waters which are warmer (cooler) than average. These diagrams show the gradual intensification of negative subsurface temperature anomalies in the eastern Pacific in response to the upwelling Kelvin wave described in the previous paragraph. From November 2004 to January 2005 there was a general decline in the strength and extent (both zonally and vertically) of positive anomalies between about 160°E and 140°W. However, this trend was strongly reversed in February due to the persistent westerly wind anomalies mentioned above.

Atmospheric patterns

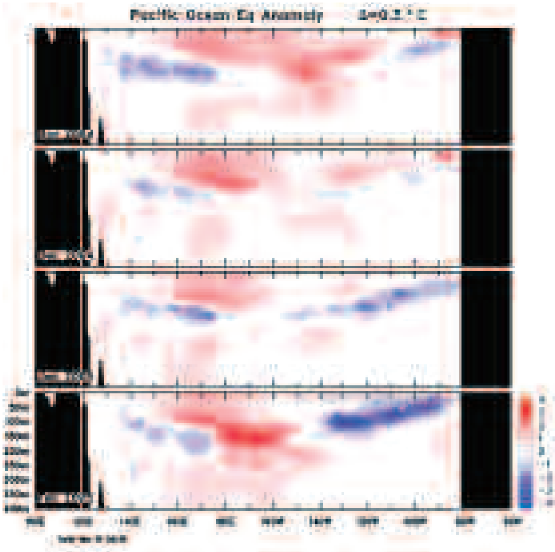
Surface analyses

The summer 2004/05 mean sea-level pressure (MSLP) across the southern hemisphere is shown in Fig. 6, with the associated anomalies shown in Fig. 7. These anomalies are the departures from a twenty-two year (1979-2000) climatology obtained from the United States of America's National Centers for Environmental Prediction (NCEP). The MSLP analysis itself has been computed using data obtained from the Bureau of Meteorology's Global Assimilation and Prediction (GASP) model daily 0000 UTC analyses.

The mean and anomalous hemispheric MSLP patterns were, on the whole, unremarkable. In the middle to high latitudes the circumpolar flow was largely zonal but with a strong wavenumber two character; one trough was situated near 110°W (east Pacific) and a broad trough dominated the Indian Ocean sector, although at about 50°S there was a weak trough near 30°E and a stronger one near 100°E.

The MSLP anomalies did not exceed 5 hPa in magnitude in any location, with the exception of a small part of the Antarctic Peninsula. Atmospheric pressure was above average over Indonesia, much of the Indian Ocean and Australia, with an anomalous ridge extending south to southeast from the Great Australian Bight to the Antarctic coast and then eastwards along it to 120°W. Local maxima occurred at the head of the Great Australian Bight near the Western Australia – South Australia border (+2.7 hPa), at 150°E just off the Antarctic coast (+4.6 hPa) and on the coast of Antarctica at 150°W (+2.4 hPa). Positive anomalies also covered most of the southern Atlantic Basin as well as the southeast Pacific between about 25°S and 40°S and east of 140°W.

Fig. 5 **Four-month November 2004 to February 2005 sequence of vertical temperature anomalies at the equator for the Pacific Ocean. The contour interval is 0.5°C.**



Negative MSLP anomalies were evident over much of the Pacific as well as areas between 60°S and the coast of Antarctica, between longitudes 120°W and 120°E (going clockwise). The strongest anomalies occurred at the southern end of the Antarctic Peninsula where a –5 hPa isopleth was analysed, implying a value marginally lower than this in its centre. Anomalies below –2.5 hPa occurred in a band extending east-southeast from New Zealand with minima of –4.1 hPa and –4.9 hPa. There were also small centres with anomalies below –2.5 hPa off the Antarctic coast near 30°E and between 60°E and 110°E, the latter containing a minimum of –4.8 hPa.

Tropical cyclones

There were only four tropical cyclones that crossed or threatened the Australian coast during the summer of 2004/05. Tropical cyclone *Raymond* formed in the Timor Sea on 2 January and crossed the Kimberley coast the following day, with heavy rain falling over northern WA and the northwest of the NT until 4 January. Tropical cyclone *Kerry* was first analysed on 3 January as a low centred northeast of New Caledonia. The system drifted slowly to the southeast for much of its life, with tropical cyclone status being attained on 6 January and severe tropical cyclone intensity being reached on 8 January. *Kerry* eventually decayed off the southeast Queensland coast on 15 January. A low that initially formed in the Gulf of Carpentaria on 3 February intensified into tropical

Fig. 6 **Summer 2004/05 mean sea-level pressure (hPa). The contour interval is 5 hPa.**

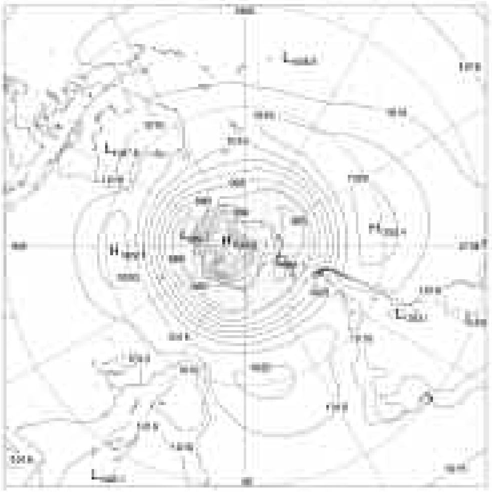
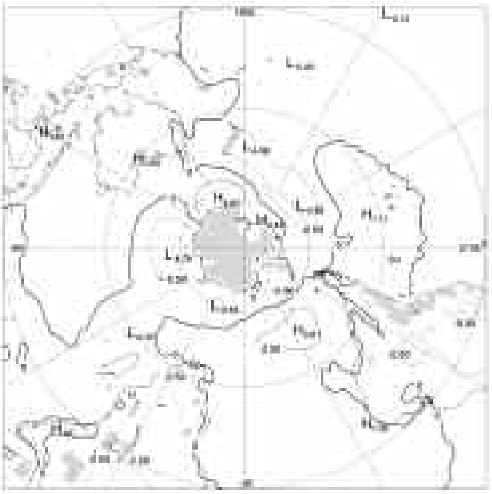


Fig. 7 **Summer 2004/05 mean sea-level pressure anomaly (hPa). The contour interval is 2.5 hPa.**



cyclone *Harvey* by 6 February. There was further rapid intensification to a severe tropical cyclone on 7 February before *Harvey* made landfall about 30 km west of the Queensland/Northern Territory border, a remote area with only a few settlements affected. Short-lived tropical cyclone *Vivienne* initially formed as a low in the monsoon trough north of Port Hedland on 4 February. The system reached tropical cyclone intensity on 8 February but weakened early on 9 February.

Several intense tropical cyclones formed over the south Pacific, well to the east of Australia. Late January to the end of February was a particularly active period in association with the steep fall in the SOI and strongly enhanced convection in the vicinity of the date-line. Tropical cyclone *Lola* passed near Tonga on 31 January before heading south-southwest, with only minor damage reported. Cyclone *Meena* was active from 3 to 7 February and reached category 4 strength. This storm formed east of American Samoa and then tracked southeast to the Cook Islands. Though it failed to make a direct hit on any of the Cook Islands, it caused widespread flooding and some building damage. Cyclone *Nancy* was active from 13 to 16 February and reached category 3 at its maximum intensity. *Nancy* passed the southern Cook Islands of Rarotonga and Aitutaki on 16 February. Tropical cyclone *Olaf* developed on 13 February and made a direct hit on American Samoa's Manu'a Islands, which were declared a major disaster area by the USA with many of the villages suffering severe damage. *Olaf* then approached the Southern Cook Islands as a category 4/5 storm before eventually moving into the Southern Ocean around 19 February. The southern Cook Island of Rarotonga was affected by a storm surge, with damage to residences and some resorts on the west coast. In the wake of cyclone *Olaf*, the south Pacific braced for another powerful storm – tropical cyclone *Percy*, which developed on 25 February. Cyclone *Percy* caused considerable and widespread damage on Tokelau's three atolls and on the Northern Cook Islands of Pukapuka and Nassau, including widespread damage to major infrastructure.

Mid-tropospheric analyses

The mean 500 hPa geopotential height patterns for summer 2004/05 are shown in Fig. 8, with anomalies shown in Fig. 9. Broadly speaking, 500 hPa heights were above average over Antarctica, below average in the vicinity of the circumpolar trough and southern mid-latitudes, and above average in the latitudes of the subtropical ridge. The one exception was in the south Atlantic where ridging extended well into the subpolar regions. Over Australia, 500 hPa heights were slightly below normal over South Australia, New South Wales, Victoria and Tasmania, and above average in northern and western areas, with a local maximum of +14 m over northwest WA.

Long wave troughs were situated near 110°E and 120°W, with a weaker trough situated near 20°E. A weak split in the mean zonal flow occurred in the

Fig. 8 **Summer 2004/05 500 hPa mean geopotential height (gpm). The contour interval is 100 gpm.**

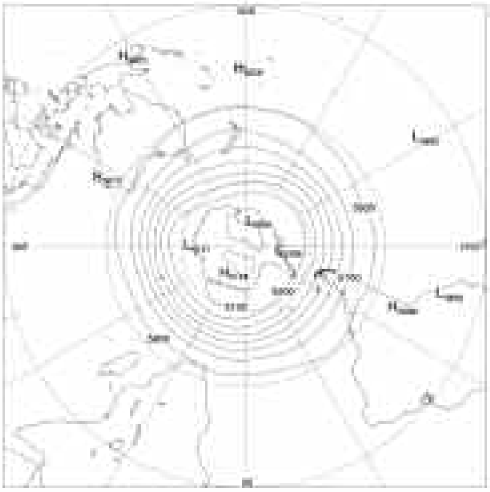
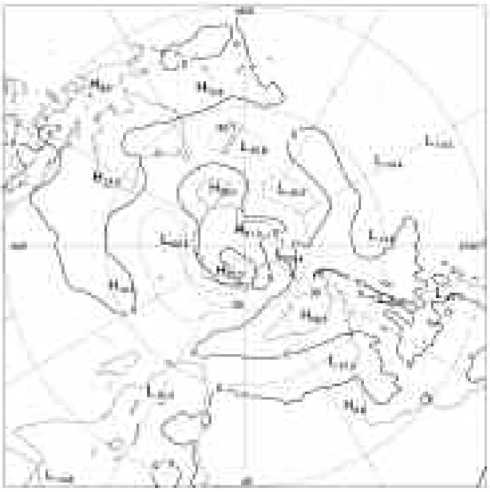


Fig. 9 **Summer 2004/05 500 hPa mean geopotential height anomaly (gpm). The contour interval is 30 gpm.**



eastern Australian/Tasman Sea region, and was associated with a height anomaly of –46 m, essentially above one of the aforementioned MSLP anomalies. A cyclonic anomaly with a centre of –44 m was located further to the southeast, also in association with a negative MSLP anomaly. The strongest height anomaly of –63 m, located near 50°S, 90°E, was associated with the long wave trough immediately to the west of Australia.

Blocking

Figure 10 is a time-longitude section of the daily southern hemisphere mid-level Blocking Index,

$$BI=1/2[(u_{25}+u_{30}) - (u_{40}+2u_{45}+u_{50}) + (u_{55}+u_{60})] .$$

Here, u_λ indicates the 500 hPa level zonal wind component at λ degrees of southern hemisphere latitude ranging from 0° at the equator to +90°S at the South Pole. The blocking index measures the strength of the 500 hPa flow at the mid-latitudes (40°S to 50°S) relative to that at subtropical (25°S to 30°S) and high (55°S to 60°S) latitudes.

Taken across the entire season in the form of a seasonal mean (Fig. 11), blocking was generally quite close to the climatological distribution. The largest positive departures occurred in the South American and Atlantic sectors, while the strongest negative anomalies (i.e., increased zonal flow) were observed in the Indian Ocean sector. These are consistent with the 500 hPa height anomalies discussed earlier.

The highest value of the BI for summer was over +60 m s^{-1} (and probably close to +80 m s^{-1}) near 145°E in early February (day 64), while other maxima over +60 m s^{-1} were observed near 165°E at the end of December (day 30) and at 10°E at the end of January (day 60). There were two periods when blocking was most persistent; the first occurred during late December and early January between about 150°E and the date-line, while the second was observed in late January to early February from around 150°E to 160°W.

Winds

Low-level (850 hPa) and upper-level (200 hPa) wind anomalies for summer 2004/05 are shown in Figs 12 and 13 respectively. Isotach contours are at 5 m s^{-1} intervals, and in Fig. 12 the regions of the globe where the land rises above the 850 hPa height are shaded grey. The low-level pattern across the Pacific shows somewhat weakened easterly trade winds (i.e. westerly anomalies) extending from the Maritime Continent to about 150°W. This situation is consistent with the continued warmth of the Pacific and the mainly negative SOI values observed during the season. However, the seasonal average masks the intraseasonal variability; trade winds were generally close to average near the equator in December and January, but strong westerly wind anomalies peaking at over 10 m s^{-1} developed in February. February's anomalous westerlies were associated with the markedly enhanced convection around the date-line and were an indicator of a short-lived coupled ENSO-mode.

In the Australian region the 850 hPa anomalies closely reflected the MSLP anomalies, with cyclonic

Fig. 10 Summer 2004/05 daily blocking index (m s^{-1}): time-longitude section. The horizontal axis measures degrees of longitude east of the Greenwich meridian. Day one is 1 December.

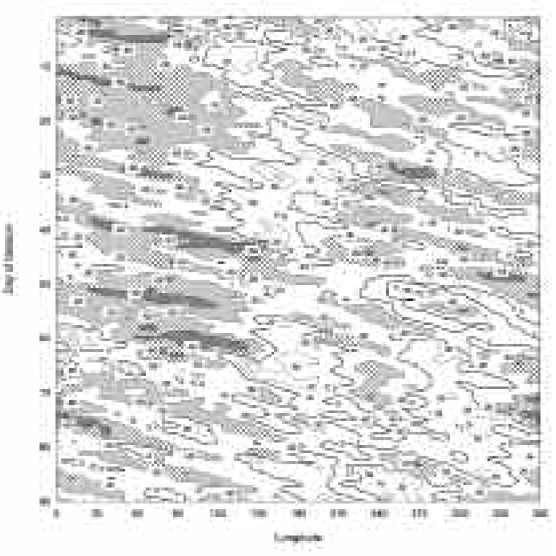
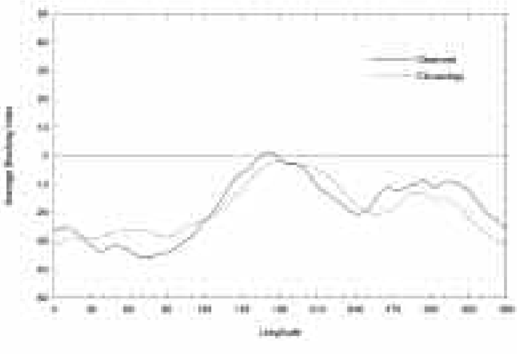


Fig. 11 Mean southern hemisphere blocking index (m s^{-1}) for summer 2004/05 (solid line). The dashed line shows the corresponding long-term average. The horizontal axis shows degrees east of the Greenwich meridian.



circulation anomalies being centred over New Zealand and over the Southern Ocean well to the southwest of WA. A zonally aligned trough over northern Australia resulted in easterly anomalies across the far northern fringes of the continent and west to northwesterly anomalies across subtropical areas.

The upper levels of the tropical Pacific were characterised by weak anomalies over the western half of the basin, northeast to southeasterly anomalies from about 150°W to 120°W, and moderate to strong westerly anomalies in the southern hemisphere from around 120°W to the South American coast. The combination of upper-level and low-level wind pattern anomalies indicated a modestly weaker than average Walker Circulation. The westerly anomalies just south of the equator in the far eastern Pacific were particularly prominent in January and February, and were associated with a persistent cyclonic anomaly in the southeast Pacific to the west of Chile.

In the Australian region, an anomalous elongated upper trough extended southeast from central Australia to Victoria and then eastward over the Tasman Sea to New Zealand. Anomalous west to northwesterly flow occurred on the northern flank of this trough with a local maximum over Queensland, while anomalous south to southeasterlies were observed on the trough's southern flank.

Australian region

Rainfall

Figure 14 shows the summer rainfall totals for Australia, while Fig. 15 shows the summer rainfall deciles, where the deciles are calculated with respect to gridded rainfall data for all summers from 1900/01 to 2003/04.

Summer rainfall was predominantly below average to very much below average across Western Australia and in a broad band extending over the western and southern NT, northern and western SA to the far southwest of Queensland and adjacent areas of far western New South Wales (Fig. 15). Patches with record low summer totals occurred in each of these States and Territories, and averaged over Western Australia it was the fourth driest December to February period since 1900/01 (see Table 1). In contrast, seasonal rainfall totals were above to very much above average across Victoria, parts of southeast SA, the southern fringes of NSW and in districts on and just west of the Dividing Range in NSW.

The enhanced totals in the southeast of the country were due in large part to 48 hours of heavy rain resulting from intense cyclogenesis in early February. Many Victorian and some southern NSW localities set new daily rainfall records for February, with several, including Melbourne, setting all-time records on either the second or third of the month. The 48-hour total averaged over the Central district of Victoria was the third highest since 1900. Furthermore, Victoria's area-averaged February total was the highest for the month since 1973, and the first month in decile 10

Fig. 12 Summer 2004/05 850 hPa vector wind anomalies (m s^{-1}).

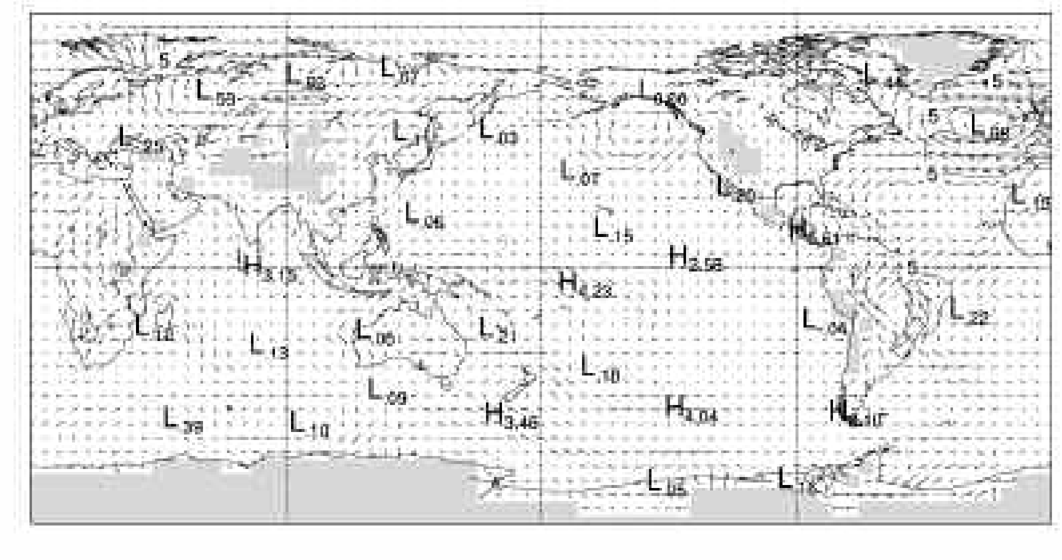
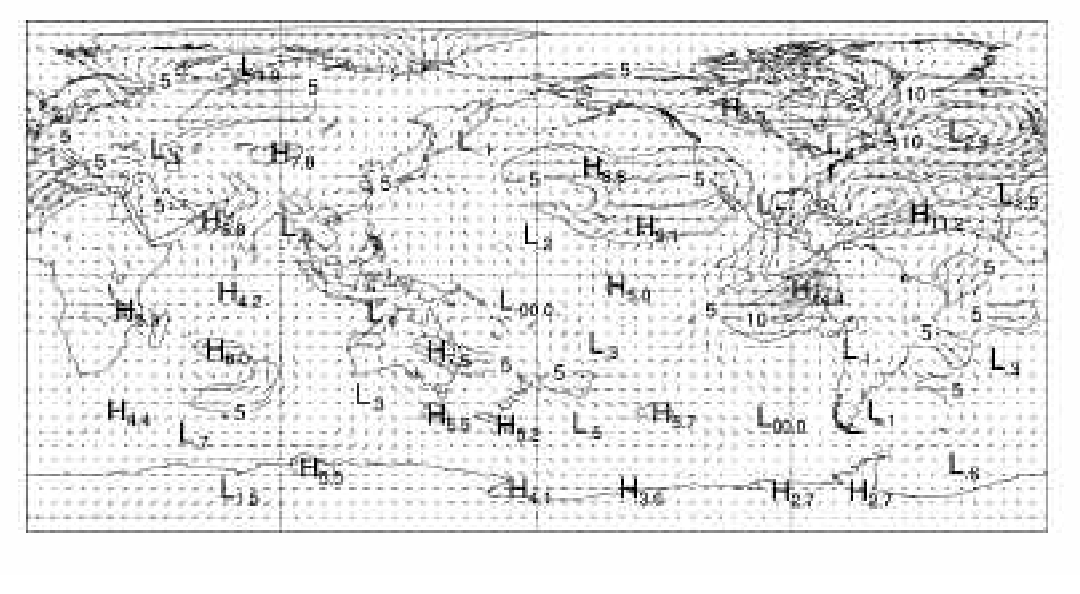


Fig. 13 Summer 2004/05 200 hPa vector wind anomalies (m s^{-1}).



(i.e., wettest 10% of the historical record) for the State since July 1995, nearly ten years prior. By definition, the monthly State area-average should reach decile 10 about 12 times in 10 years.

Average to above average summer rainfall totals occurred in a broad zone extending from the north of the NT to the northern parts of the Wide Bay and Burnett districts of southeast Queensland. These areas were generally to the north and east of the upper trough mentioned in the previous section.

In relative terms December, with a rank of 64 out of 105, was the wettest month of the season over the country, with large parts of eastern and far northern Australia registering above to very much above average monthly rainfall. In terms of a ranked spatial mean, summer became progressively drier with

Fig. 14 **Summer 2004/05 rainfall totals (mm) in Australia.**

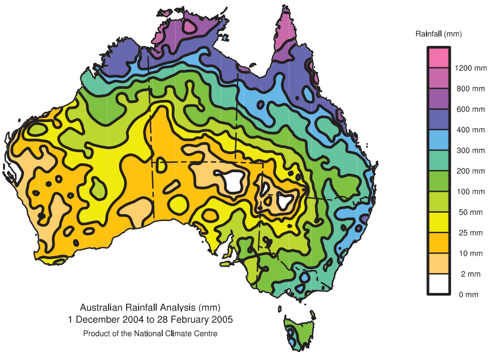


Fig. 15 **Summer 2004/05 rainfall for Australia: decile range values based on grid-point values over the summers 1900/01 to 2004/05.**

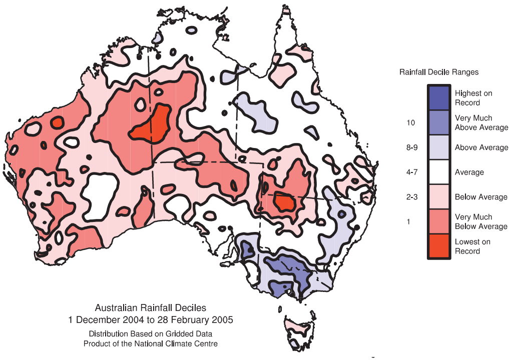


Table 1. **Seasonal rainfall ranks and extremes on a national and State basis for summer 2004/05.**

	Highest seasonal total (mm)	*Lowest seasonal total (mm)*	*Highest 24-hour fall (mm)*	*Area-averaged rainfall (aar) (mm)*	*Rank of aar**
Australia	1503 at Bellenden Ker Top Station (QLD)	Zero at several locations	424 at Kuttabul (Qld), 24 January	159	16
WA	603 at Mount Hart Station	Zero at several locations	163 at Ord River, 2 January	73	4
NT	1088 at Manton Dam	Zero at Palmer Valley	212 at Port Keats, 1 January	243	27
SA	202 at Mannum	Zero at several locations	62 at Cockburn, 9 December	28	21
QLD	1503 at Bellenden Ker Top Station	Zero at several locations	424 at Kuttabul, 24 January	292	40
NSW	776 at Bretti	Zero at several locations	209 at Tweed Heads, 8 December	155	57
VIC	513 at Balook	48 at Pirlta	190 at Haines Junction, 3 February	190	97
TAS	652 at Mount Read	56 at Northdown	130 at Longley, 4 February	188	36

* The ranks range from 1 (lowest) to 105 (highest) and is calculated over the summers 1900/01 to 2004/05 inclusive.

January ranked 40th of 106 and February 10th of 106, with 86.5% of the country recording a total below the February median. Furthermore, 70.4% of Australia recorded a February rainfall total in the driest one-third of the historical record, that is, the lowest tercile.

Temperature

Figures 16 and 17 show the maximum and minimum temperature anomalies respectively for summer 2004/05. The anomalies have been calculated with respect to the 1961-1990 period.

Fig. 16 **Summer 2004/05 maximum temperature anomalies (°C) for Australia based on a 1961-1990 mean.**

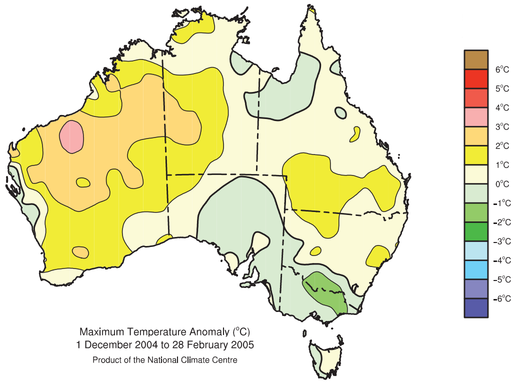
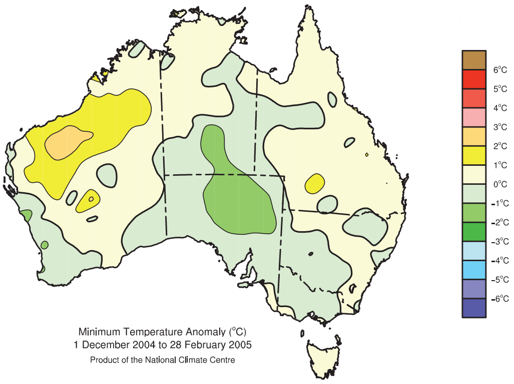


Fig. 17 **Summer 2004/05 minimum temperature anomalies (°C) for Australia based on a 1961-1990 mean.**



Not only were rainfall totals very low, but it was an extremely hot summer in the northern half of Western Australia and western parts of the Northern Territory. Maximum temperatures were two to three degrees above the long-term seasonal mean over a very large expanse of country, peaking in the +3 to +4°C range near Marble Bar in the Pilbara. Many centres in the Pilbara and neighbouring districts broke their record mean maximum temperatures for the month of January. Nyang averaged 44.8°C, the hottest January ever recorded anywhere in Australia. This figure also equalled the Australian record for any month, previously set in February 1998, also at Nyang. Western Australia as a whole recorded its third hottest summer mean maximum temperature in the post-1950 period (see Table 2), with parts of the Pilbara and western interior districts having record high summer means.

Maximum temperature anomalies were between +1 and +2°C over most remaining parts of WA, the western half of the NT, far northwest SA, much of southern Queensland and in patches across NSW. Negative anomalies occurred over Victoria, western Tasmania, much of eastern SA, far western coastal WA and in districts surrounding the Gulf of Carpentaria. The lowest anomalies of –1°C to –2°C occurred in a band from the East Gippsland coast through northeast Victoria to the southern border areas of NSW.

The strong cyclogenesis in southeastern Australia during early February produced not only very heavy rainfall, but also very low daily maximum temperatures, especially on 3 February over northern Victoria and southern New South Wales. A new Australian record low maximum temperature for February of –0.2°C was set at Mount Hotham on this day, breaking the previous record of 1.0°C set at Mount Baw Baw on 16 February 1998. With a reading of 0.3°C, a NSW State record also occurred at Thredbo Top Station, eclipsing the previous record of 2.0°C at the same location on 22 February 1993.

Positive maximum temperature anomalies became progressively more widespread and intense as the season progressed, with +2 to +4°C departures being widespread in February over western, central and northeastern Australia. A large area in the interior of WA recorded anomalies in excess of +4°C for the month, and in area-average terms it was the third hottest February for the State in the post-1950 era. In Queensland it was the second hottest.

Summer minimum temperatures (Fig. 17) were not as extreme as the maxima, with an area-averaged anomaly of +0.06°C and a rank of 32 of 55 (Table 3). A large band of negative anomalies covered most of Victoria, a large fraction of western NSW, all but the far southeast of SA, southeast WA, southern and eastern areas of the NT and parts of far western Queensland. The strongest anomalies of –1 to –2°C were observed over northern and central SA and southern NT. In northern SA the average summer minimum temperatures were low enough to be ranked in the first decile, that is, the coolest 10% of the historical record (since 1950). Seasonal minima were also below normal in a band covering parts of western and southern WA, with a few spots of –1 to –2°C anomalies near the west coast. The district surrounding Geraldton recorded minima in decile 1.

Table 2. Seasonal maximum temperature ranks and extremes on a national and State basis for summer 2004/05.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily recording (°C)*	*Lowest daily recording (°C)*	*Anomaly of area-averaged (aam) mean (°C)*	*Rank of aam**
Aust	43.4 at Marble Bar (WA)	12.7 at Mount Read (TAS)	48.2 at Mandora (WA), 19 December	–0.2 at Mt Hotham (Vic), 3 February	+0.84	53
WA	43.4 at Marble Bar	22.3 at Albany	48.2 at Mandora, 19 December	17.0 at Shannon, 21 February	+1.43	53
NT	40.3 at Walungurru	32.0 at McCluer Island	46.3 at Rabbit Flat, 6 December	24.0 at Kulgera, 1 and 8 December, and at Territory Grape Farm, 3 January	+0.99	49
SA	36.8 at Oodnadatta	20.1 at Mount Lofty	46.5 at Marree, 14 January	10.8 at Mount Lofty, 2 February	+0.19	32
QLD	39.2 at Windorah	26.7 at Applethorpe	45.3 at Thargomindah, 8 February	18.0 at Applethorpe, 4 December	+0.66	41
NSW	36.4 at Bourke	14.2 at Thredbo Top Station	46.3 at White Cliffs, 14 January	0.3 at Thredbo Top Station, 3 February	+0.46	37
VIC	31.0 at Mildura	13.7 at Mt Hotham	43.4 at Hopetoun, 11 January	–0.2 at Mt Hotham, 3 February	–0.63	16
TAS	23.9 at Ouse	12.7 at Mount Read	36.8 at Bushy Park, 26 January	1.6 at Mount Read, 27 December	+0.12	28

* The temperature ranks range from 1 (lowest) to 55 (highest) and are calculated over the summers 1950/51 to 2004/05 inclusive.

Table 3. Seasonal minimum temperature ranks and extremes on a national and State basis for summer 2004/05.

	Highest seasonal mean (°C)	*Lowest seasonal mean (°C)*	*Highest daily recording (°C)*	*Lowest daily recording (°C)*	*Anomaly of area-averaged (aam) mean (°C)*	*Rank of aam**
Aust	27.9 at Marble Bar (WA)	4.3 at Liawenee (TAS)	33.4 at Marble Bar (WA), 20 December	–5.2 at Charlotte Pass (NSW), 14 February	+0.06	32
WA	27.9 at Marble Bar	11.5 at Jarrahwood	33.4 at Marble Bar, 20 December	1.2 at Bridgetown, 1 December	+0.50	49
NT	27.1 at Centre Island	19.4 at Alice Springs	31.0 at Walungurru, 16 and 17 February	9.5 at Arltunga, 4 February	–0.03	27
SA	22.0 at Moomba	10.9 at Naracoorte	31.8 at Oodnadatta, 2 January	3.0 at Naracoorte, 3 December	–0.65	14
QLD	26.9 at Sweers Island	14.7 at Applethorpe	32.6 at Ballera, 2 January	5.0 at Applethorpe, 29 December	+0.05	31
NSW	21.5 at Tibooburra	5.3 at Thredbo Top Station	29.9 at Tibooburra, 15 January	–5.2 at Charlotte Pass, 14 February	–0.14	23
VIC	15.5 at Gabo Island	6.0 at Mt Hotham	24.3 at Hamilton, 26 January	–4.3 at Mount Hotham, 28 December	–0.43	19
TAS	14.0 at Swan Island	4.3 at Liawenee	20.0 at Flinders Island, 26 January	–2.4 at Mount Wellington, 28 December	+0.22	34

* The temperature ranks range from 1 (lowest) to 55 (highest) and are calculated over the summers 1950/51 to 2004/05 inclusive.

Minimum temperatures were above average over most of northern and central WA, much of the northern half of the NT, most of Queensland and the eastern half of New South Wales, and Tasmania. The peak anomalies of +1 to +3°C occurred over northern and northwest WA with the Pilbara the focus of the warmth. Most of the region with anomalies over +1°C had seasonal means in the top decile, with record high values (since 1950) covering the Pilbara.

In contrast to the maximum temperatures, mean monthly minimum temperatures became progressively cooler, in relative terms, as the season progressed. The national area-averaged minimum temperature anomalies were +0.34°C, +0.10°C and –0.25°C for December, January and February respectively.

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Appendix

Data sources used for this review were:

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- National Climate Centre, Climate Monitoring Bulletin - Australia. Obtainable from the National Climate Centre, Australian Bureau of Meteorology, GPO Box 1289, Melbourne, Vic. 3001, Australia.
- National Climate Centre, South Pacific Seasonal Outlook Reference Material. Obtainable from the National Climate Centre, Australian Bureau of Meteorology, GPO Box 1289, Melbourne, Vic. 3001, Australia.
- Bureau of Meteorology, Monthly Significant Weather Summaries. Obtainable from: http://www.bom.gov.au/inside/services_policy/public/sigwxsum/sigwmenu.shtml
- Climate Prediction Center (CPC), Climate Diagnostics Bulletin. Obtainable from the Climate Prediction Center (CPC), National Weather Service, Washington D.C., 20233, USA and also from: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/CDB_archive.html