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DARWIN TROPICAL DIAGNOSTIC STATEMENT

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DARWIN TROPICAL DIAGNOSTIC STATEMENT

March 2009

ISSUED BY DARWIN RSMC

SUMMARY
The ENSO features for the month of March lean towards neutral conditions, though some La Niña-like characteristics have been evident in atmospheric conditions during the past several months. Low-level easterly wind anomalies over the western Pacific Ocean, the SOI being more than one standard deviation above the long-term mean since August and the Maritime Continent being the broad scale focus of convection for several months, reinforced the seasons La Niña-like appearance. Nonetheless not all of the typical La Niña indicators have been in place. In particular the low-level winds of the near-equatorial eastern Pacific Ocean have been near-normal. The near-equatorial central and eastern Pacific Ocean sea surface temperatures remained cooler than average, but not at the levels typically associated with La Niña events. The MSLP anomalies were close to neutral. Enhanced convection that developed in the central Indian Ocean during late February propagated eastwards towards the Maritime Continent in the first half of March. Four cyclones were analysed in the RSMC area during March, one of those forming on the last day of February.

INDICES

Troup's Southern Oscillation Index (SOI) for March 2009	Zero
5-month mean (centred upon January)	+ 11
Darwin mean MSL pressure for March 2009	1008.5 hPa
Pressure anomaly (1933 – 1992 mean)	+ 0.9 hPa
Tahiti mean MSL pressure for March 2009	1012.5 hPa
Pressure anomaly (1933 – 1992 mean)	+ 0.9 hPa

Time series of Troup's SOI:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	- 7	- 3	- 1	- 3	- 3	+ 5	- 4	+ 3	+ 2	+ 5	+ 10	+ 14
2008	+ 14	+ 21	+ 12	+ 4	- 4	+ 5	+ 2	+ 9	+ 14	+ 13	+ 17	+ 13
2009	+ 9	+ 15	0									

The above table presents monthly values of the SOI from 2007. Fig.1 shows the monthly SOI and its five month running mean for the past ten years. The SOI has mostly been positive since August 2007. The main contributor to the higher SOI values has been Tahiti's pressures which remained higher than the long-term mean during the period. The five month mean SOI centred upon January was +11.

TROPICAL CYCLONES

[Fig. 2]

Four tropical storms were analysed in the RSMC southern hemisphere area during March. One of those, Tropical Cyclone Gabrielle, formed on the last day of February and continued into March. Two of the cyclones reached typhoon intensity. The comparative long-term means for tropical cyclone formation during March are 0.4 tropical storms (0.2 typhoons) for the north-western Pacific Ocean and 4.7 tropical cyclones for the South Pacific and southern Indian Oceans combined. Tropical cyclone formation is rare in the northern Indian Ocean, including the Bay of Bengal, during March.

Tropical Cyclone Gabrielle

(The system developed in February and continued into March)

A tropical depression southwest of Jakarta within the monsoon trough developed into a tropical cyclone on 28 February. The short-lived system tracked to the southeast on 1 March, and had weakened into a tropical depression by 2 March.

Severe Tropical Cyclone Hamish

Forming from a low in the monsoon trough in the Coral Sea on the 5th, Tropical Cyclone Hamish tracked southeast parallel to the northeast coast of Australia. It strengthened further to Severe TC intensity on the 7th continuing to move parallel to the coast. Unfavourable upper-level windshear and changes in the steering flow turned the cyclone back towards the north-northwest. It weakened below hurricane intensity early on the 11th and decayed into a low later on the same day.

Severe Tropical Cyclone Ilsa

Tropical Cyclone Ilsa formed in the Timor Sea from a low that had been lingering in the monsoon trough for several days. The system tracked east-southeast, under favourable upper-level outflow and weak vertical windshear, which helped the system to intensify. It reached hurricane intensity on the 19th. As it moved further south, cooler sea surface temperatures and strong vertical wind shear weakened the system to tropical cyclone intensity on the 23rd and to a tropical low on the 24th.

Tropical Cyclone Jasper

A tropical low in the monsoon trough in the Southwest Pacific Ocean developed into Tropical Cyclone Jasper on the 24th, which tracked southeast towards New Caledonia. As it moved south, the cooler sea surface temperatures and unfavourable upper winds weakened the system into a tropical low on the 26th.

SEA SURFACE TEMPERATURE (SST)

[Figs. 3a, 3b]

Warm SSTs dominated the tropical western Pacific Ocean in a ‘warm V’, with patches of +2 to +3 anomalies in the East China Sea and Sea of Japan. The ‘cool tongue’ persisted in the central equatorial Pacific Ocean close to the South American coast. The SSTs in the north Indian Ocean including the Arabian Sea and the Bay of Bengal were mostly above average for the month. Waters off the northwest coast of Australia, including the Timor Sea and waters in the SPCZ in the southwestern Pacific Ocean remained warmer then usual for March and consistent with the cyclogenesis areas of the month.

MEAN SEA LEVEL PRESSURE (MSLP)

[Figs. 4a, 4b]

Negative MSLP anomalies prevailed in the tropical Indian Ocean west of 100°E and near the dateline in the equatorial western Pacific Ocean. MSLPs were higher than normal over the rest of the RSMC area including the Australian continent. However the anomalies remained weak, consistent with the neutral ENSO conditions. A persistent long-wave ridge over the Tasman Sea contributed to higher than normal pressures in the area.

850 hPa FLOW

[Figs. 5a, 5b]

The monsoon trough in the southern hemisphere remained well organised in the wind analysis, though not much weather was associated with it. Westerlies remained stronger than normal in the southern equatorial Indian Ocean with some patches of above 5 ms^{-1}. Easterlies were close to normal strength in the equatorial western Pacific Ocean near the dateline. They were stronger in the southern tropics and weaker in the northwestern low latitude Pacific Ocean close to the dateline, consistent with less than normal convection in the area.

200 hPa FLOW

[Figs 6a, 6b]

Weak easterly upper level flow prevailed to the east of 160°E in the lower latitudes, contributing to westerly anomalies of greater than 10 ms^{-1} near the dateline. The subtropical ridge in the northern hemisphere remained weaker to the east of 140°E. Greater than 20 ms^{-1} anomalies appeared in the northern extratropical regions close to the dateline. In the southern extratropical regions, the STR flow was more meridional than the long term mean, giving rise to circulations in the anomalies near the west coast of Australia and in the Coral Sea.

VELOCITY POTENTIAL

[Figs 7a, 7b]

The axis of low level convergence was well aligned with the axis of upper level divergence and the monsoon trough in the southern hemisphere. The Maritime Continent and far western Pacific Ocean remained the areas of strongest low-level convergence and upper-level divergence during the month, which was consistent with the OLR pattern.

OUT-GOING LONG-WAVE RADIATION (OLR)

[Figs 8a, 8b]

Convection was greater than normal over much of the northern tropics between 90°E and 160°E. The remainder of the tropics (the western half of the Indian Ocean and areas east of 160°E) had below average convection for the month, consistent with the pressure and wind patterns. Below average convection prevailed over Australia. Convection was also below average over parts of Java, Sumatra and the adjacent south-eastern Indian Ocean during the month, in spite of two cyclones forming in the region. However, convection over the SPCZ area remained active and above average. Negative OLR anomalies coincided with the axes of maxima in the 850 hPa and 200 hPa velocity potential.

CROSS-EQUATORIAL INTERACTION

[Fig. 9]

The low-level northerly flow was close to normal above the 850 hPa level but greater than normal below the 850 hPa level at all longitudes. This was complimented by the southerly flow at the upper levels and consistent with the persistent monsoon trough in the area. The cross equatorial flow was stronger than normal in the Indian Ocean and the Maritime continent, contributing to a stronger than normal Hadley circulation in the area and consistent with the OLR pattern. The cross equatorial flow near the date line was weaker than normal and consistent with the suppressed convection in the area.

850 hPa WIND COMPONENTS AND RAINFALL AT DARWIN

[Figs. 10a, 10b]

Over central longitudes of Australia the monsoon trough remained close to the north coast and was fairly week for most of the month. Low-level winds at Darwin remained northwesterly during the first three weeks of the month, consistent with a persistent monsoon trough in close proximity. Winds turned north-easterly for about three days after the 25th before turning back to the northwest. Good rainfall was recorded between the 11th and the 18th, along with some isolated showers at the beginning of the month. Though the number of rainy days for the month was 16, compared with the long term mean of 19.6 days, rainfall at Darwin was much below normal. The monthly rainfall total was 120.0 mm, the long term mean is 323.8 mm.

INTRA-SEASONAL VARIATIONS

[Figs. 11, 12, 13]

The first broadscale region of active convection in the southern hemisphere's summer monsoon season developed in the central Indian Ocean around mid-November. This was just 30 days after the previous active Madden-Julian Oscillation [MJO]. This became the renewed active MJO event and moved eastward to be focussed over the Maritime Continent region [including longitudes of northern Australia] from the middle to latter part of November. During the middle of December tropical convective activity picked up over the western Indonesian archipelago and extended eastward to northern Australia, without significant activity first being seen further west in the tropical Indian Ocean. Active convection then persisted around the Maritime Continent region until the middle of January, seemingly in response to the broader atmospheric tropical circulation [and La Nina type conditions], with little apparent MJO modulation.

Around mid-January the central Indian Ocean picked up in activity while the near-equatorial regions of the Maritime Continent became relatively suppressed, indicative of renewed modulation by the MJO. The active convection subsequently traversed eastward to return its focus to the Maritime Continent and enhanced tropical weather was seen over northern Australia for much of the first half of February. The Maritime Continent region returned to a relatively suppressed MJO phase for the remainder of February.

A period of enhanced tropical convection in the southern Indian Ocean developed near the end of February before western areas of the Maritime Continent saw increased levels of convection in early to mid March. During this period, tropical convection remained focused around tropical cyclones that formed either side of the Australian continent, and most of Australia's tropical north missed out on any enhanced rainfall during this active phase of the MJO.

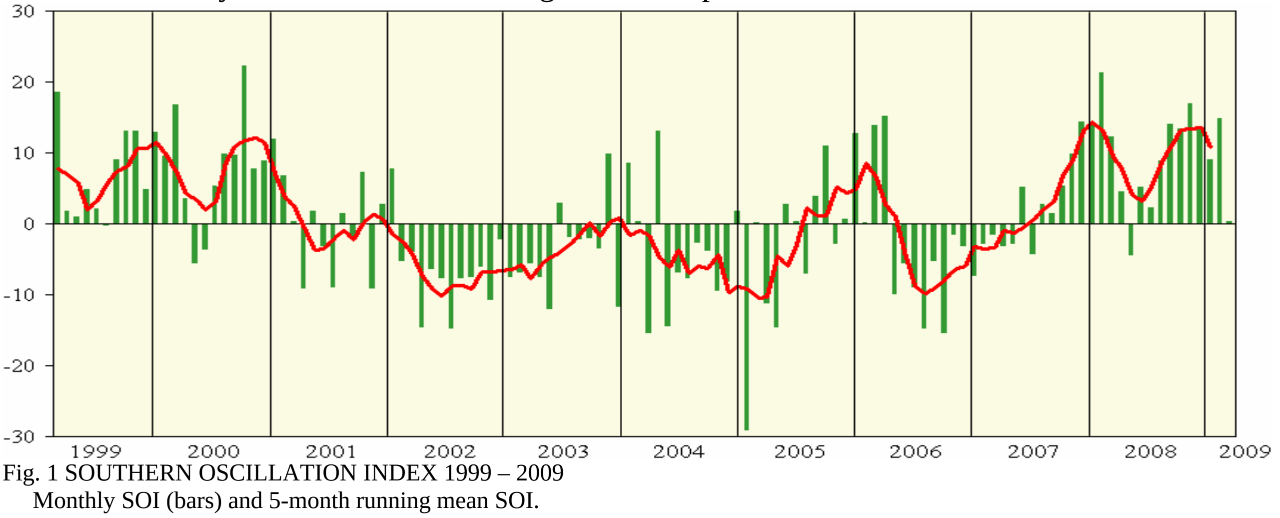

Fig. 1 SOUTHERN OSCILLATION INDEX 1999 – 2009
Monthly SOI (bars) and 5-month running mean SOI.

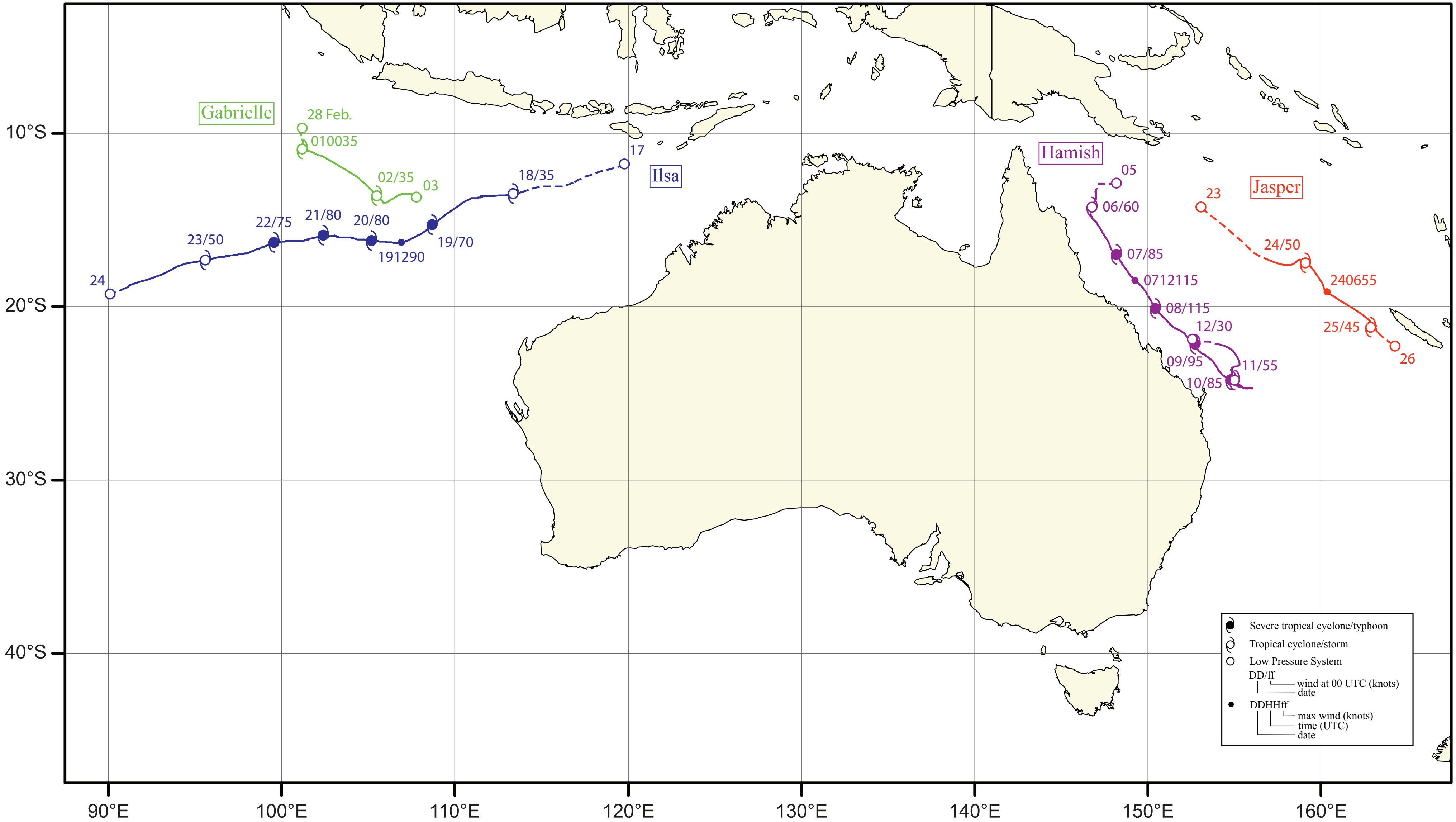

Fig. 2 OPERATIONAL TRACKS OF CYCLONES; GABRIELLE, HAMISH, ILSA AND JASPER FOR MARCH 2009.

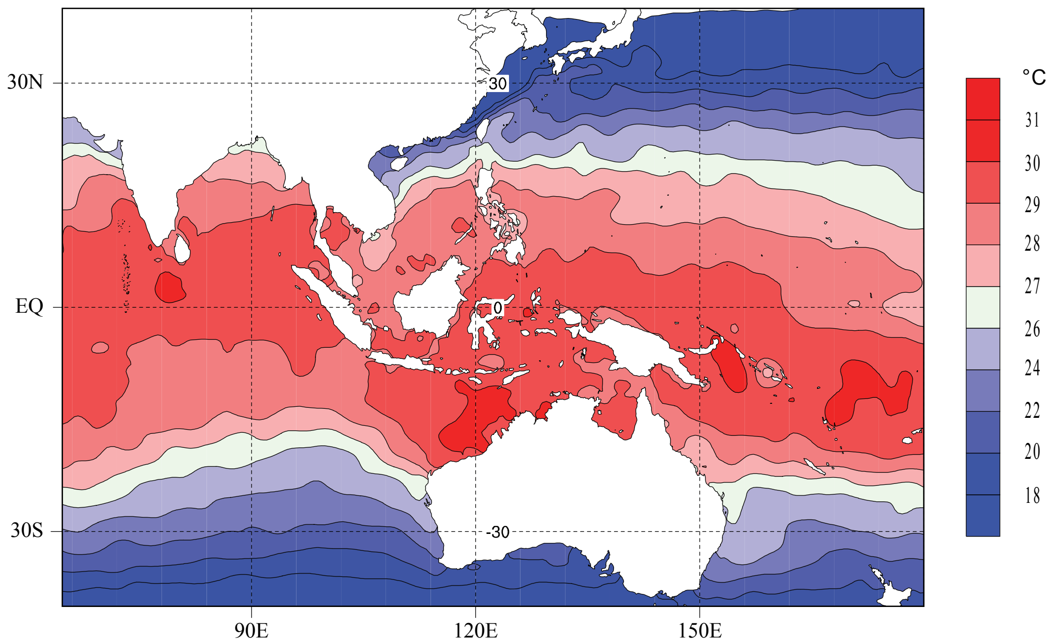

Fig.3(a) SEA SURFACE TEMPERATURE, March 2009.

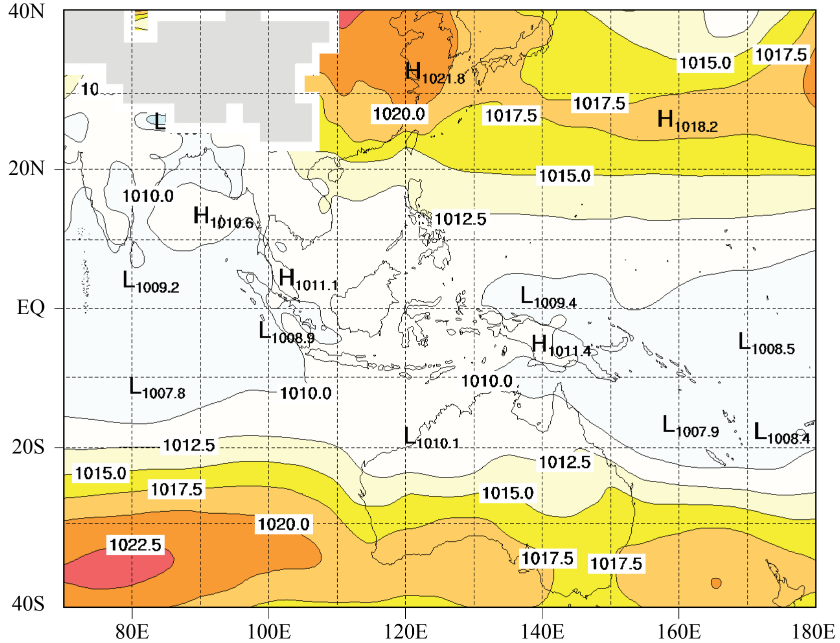

Fig.4(a) MEAN SEA LEVEL PRESSURE, March 2009.
Isobar interval 2.5 hPa

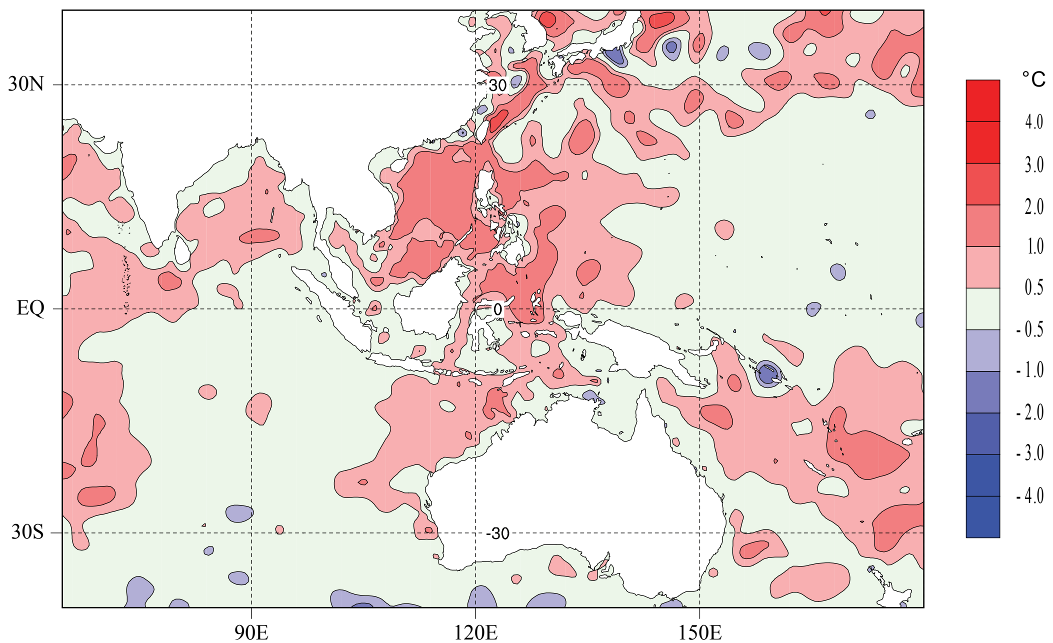

Fig.3(b) SEA SURFACE TEMPERATURE ANOMALY, March 2009.

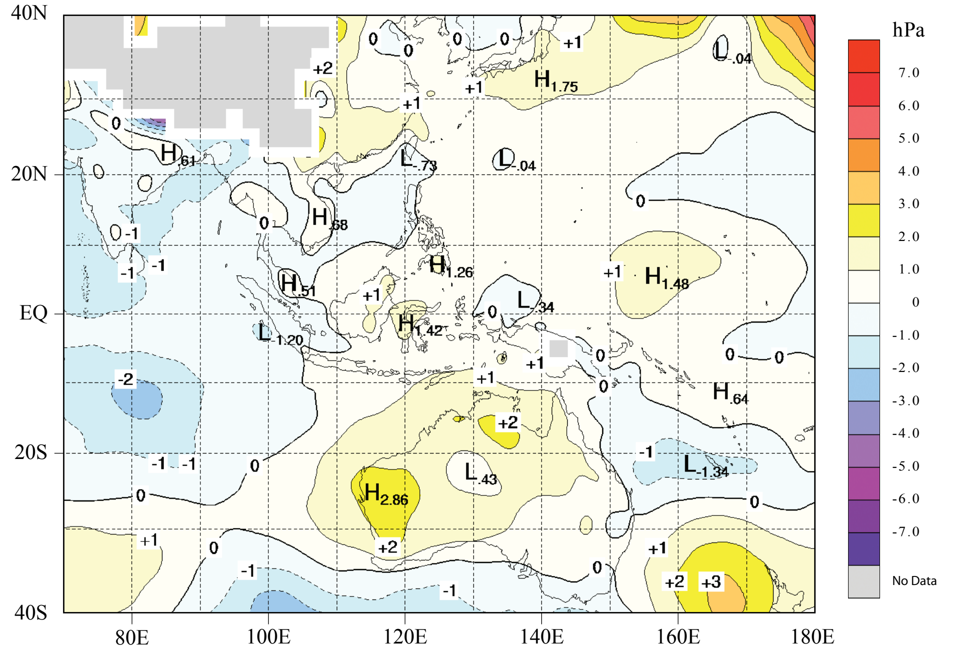

Fig.4(b) MEAN SEA LEVEL PRESSURE ANOMALY, March 2009.
Contour interval 1 hPa. Heavy line represents zero anomaly.

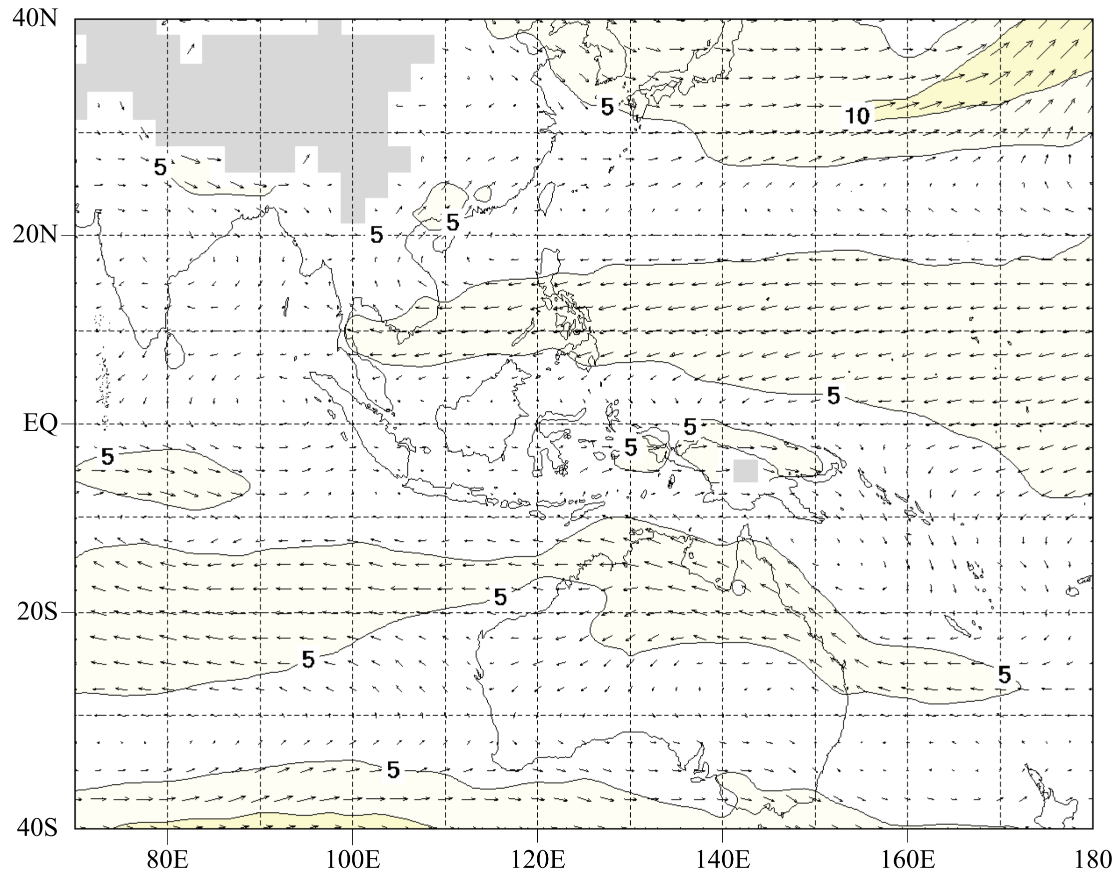

Fig.5(a) 850 hPa VECTOR WIND ANALYSIS, March 2009.
Arrow length indicates relative magnitude. Isotachs at 5ms^{-1} intervals are shaded.

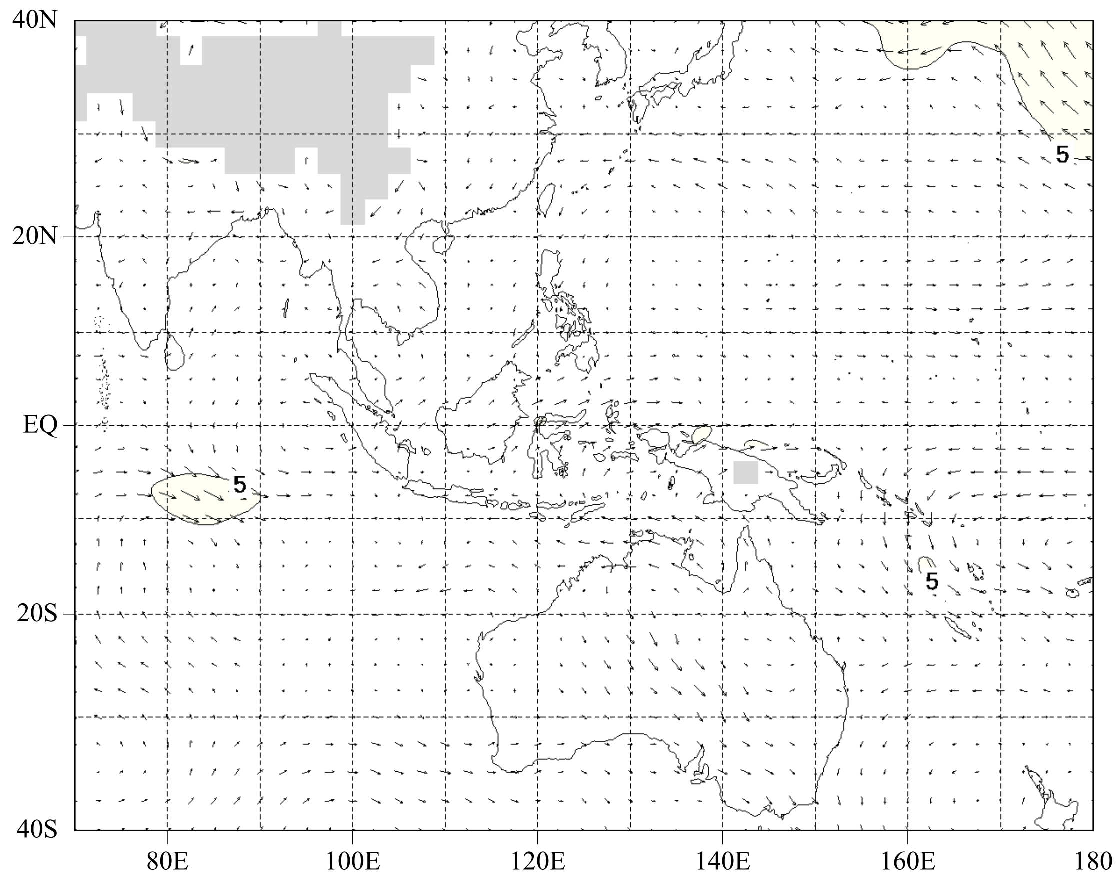

Fig.5(b) 850 hPa WIND ANOMALY, March 2009.
Arrow length indicates relative magnitude. Anomalies > 5 ms^{-1} are shaded.

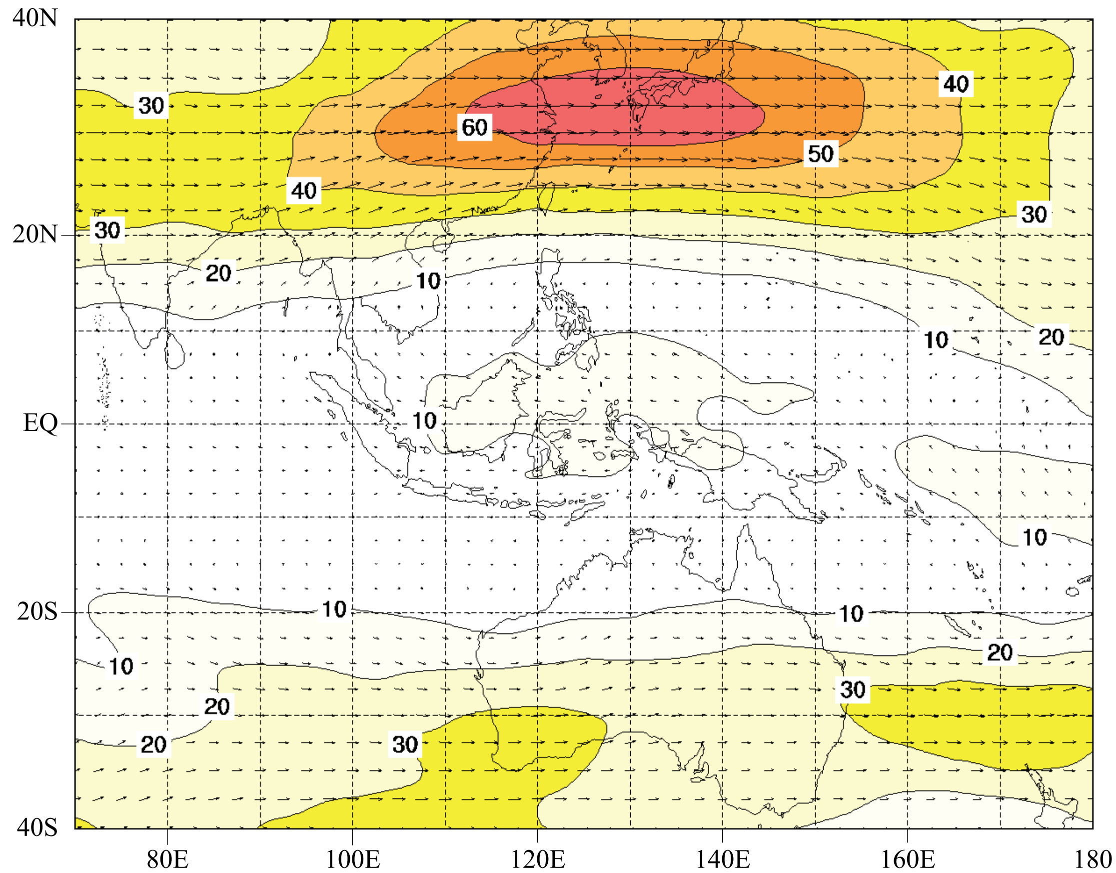

Fig.6(a) 200 hPa VECTOR WIND ANALYSIS, March 2009.
Arrow length indicates relative magnitude. Isotachs at 10ms-1 intervals are shaded.

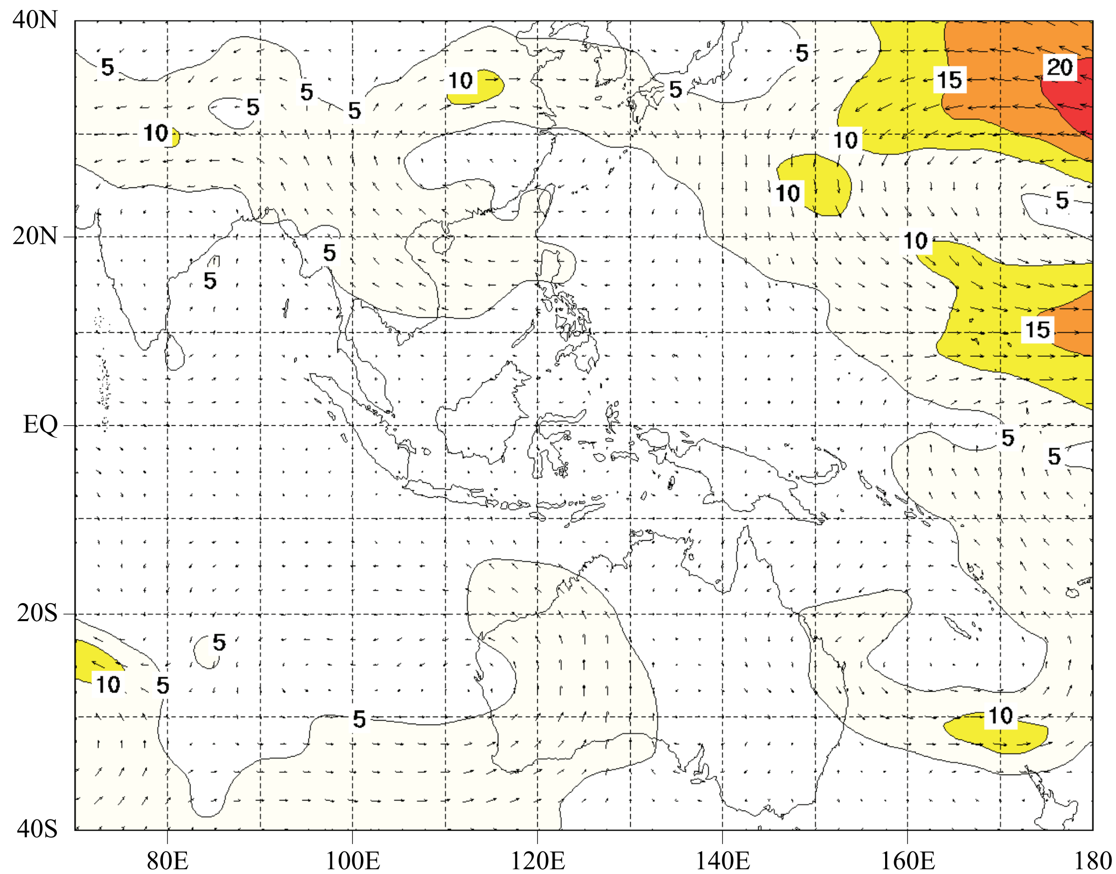

Fig.6(b) 200 hPa WIND ANOMALY, March 2009.
Arrow length indicates relative magnitude. Anomalies > 5 ms-1 are shaded.

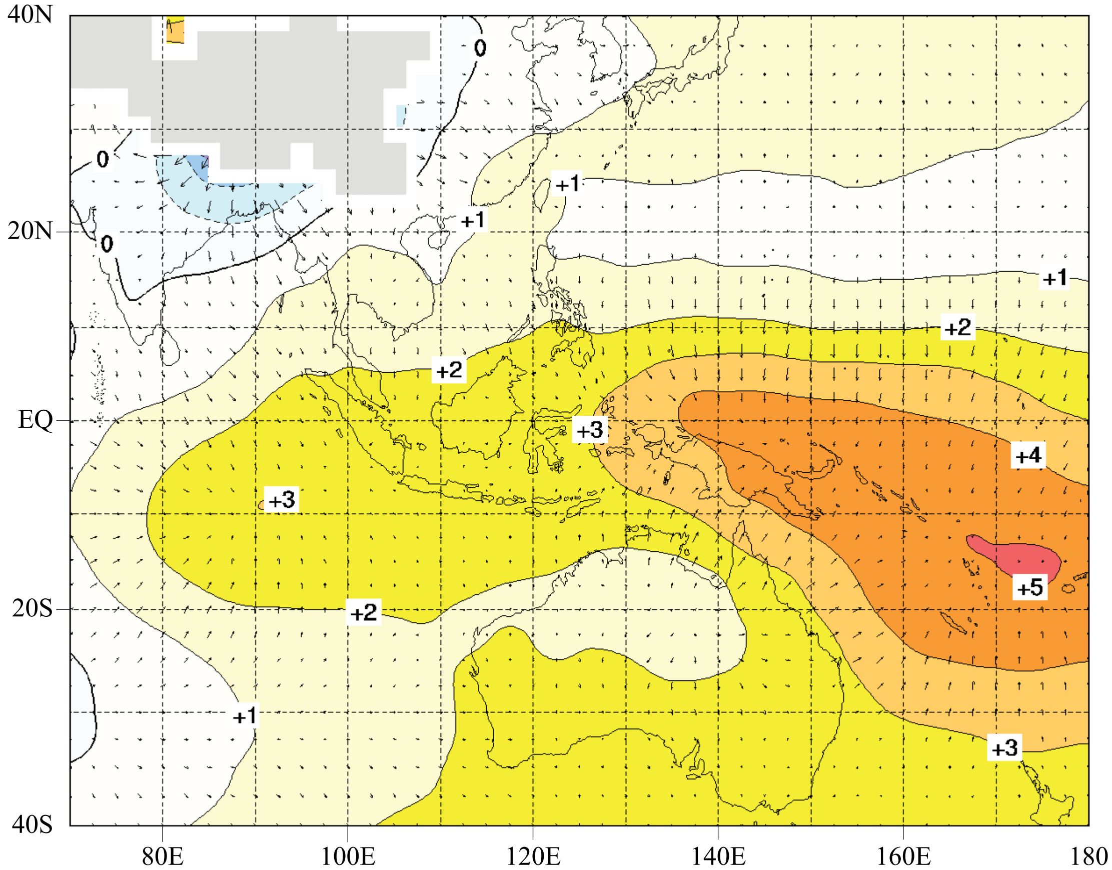

Fig.7(a) 850 hPa VELOCITY POTENTIAL (x $10^6 m^2 s^{-1}$) and DIVERGENT WIND, March 2009.

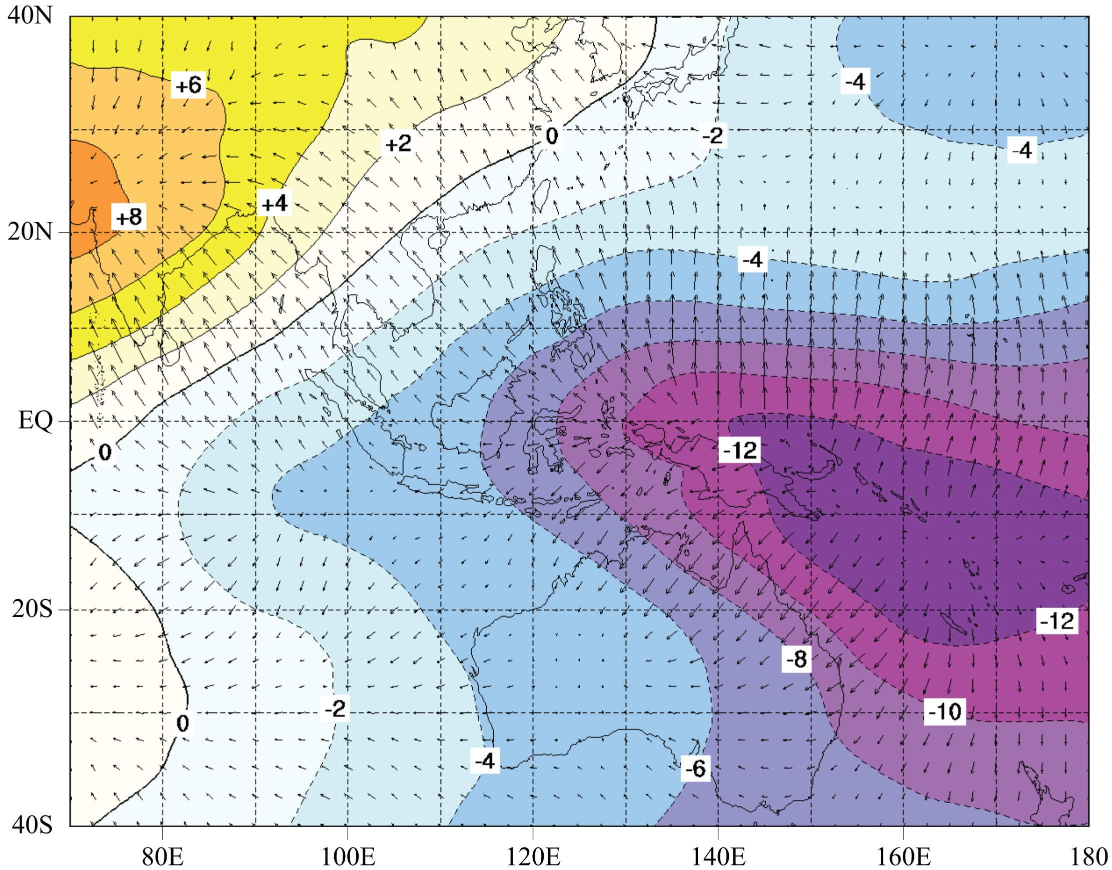

Fig.7(b) 200 hPa VELOCITY POTENTIAL (x $10^6 m^2 s^{-1}$) and DIVERGENT WIND, March 2009.

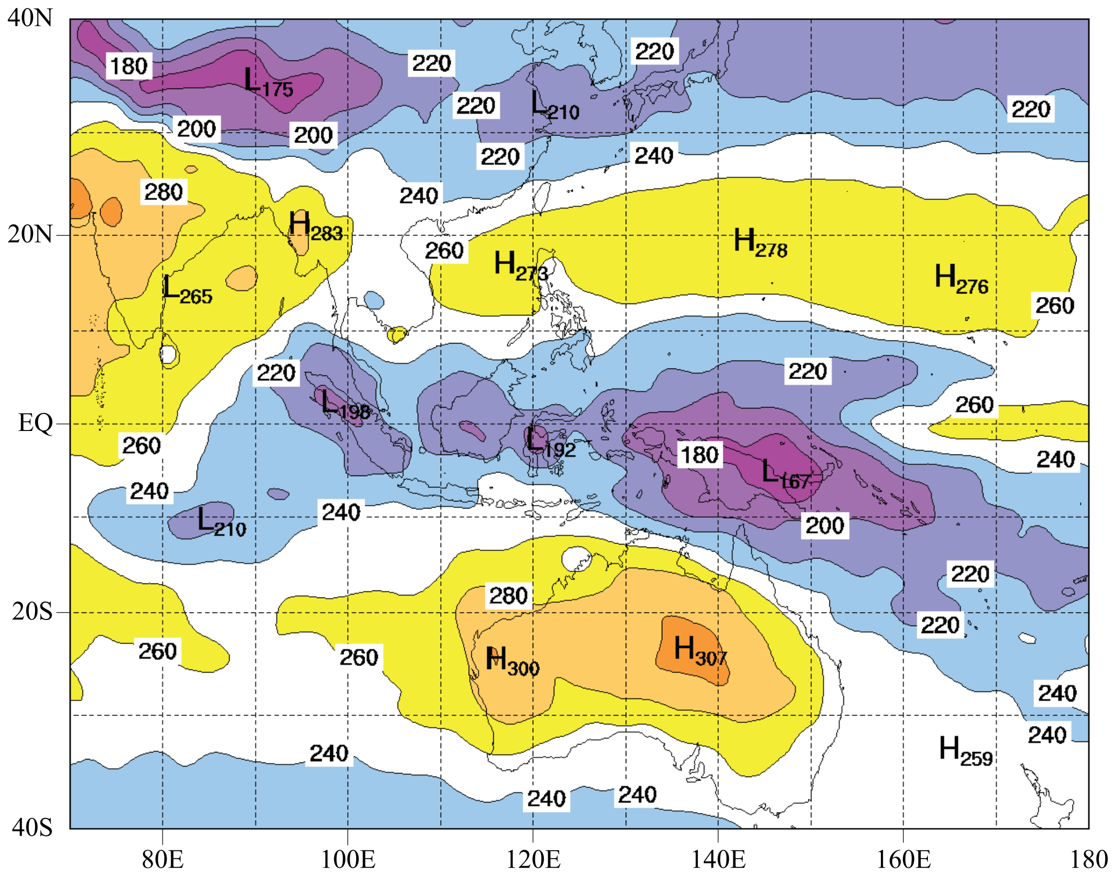

Fig.8(a) OUTGOING LONG WAVE RADIATION, March 2009.
Contour interval 20 watt m^{-2}.

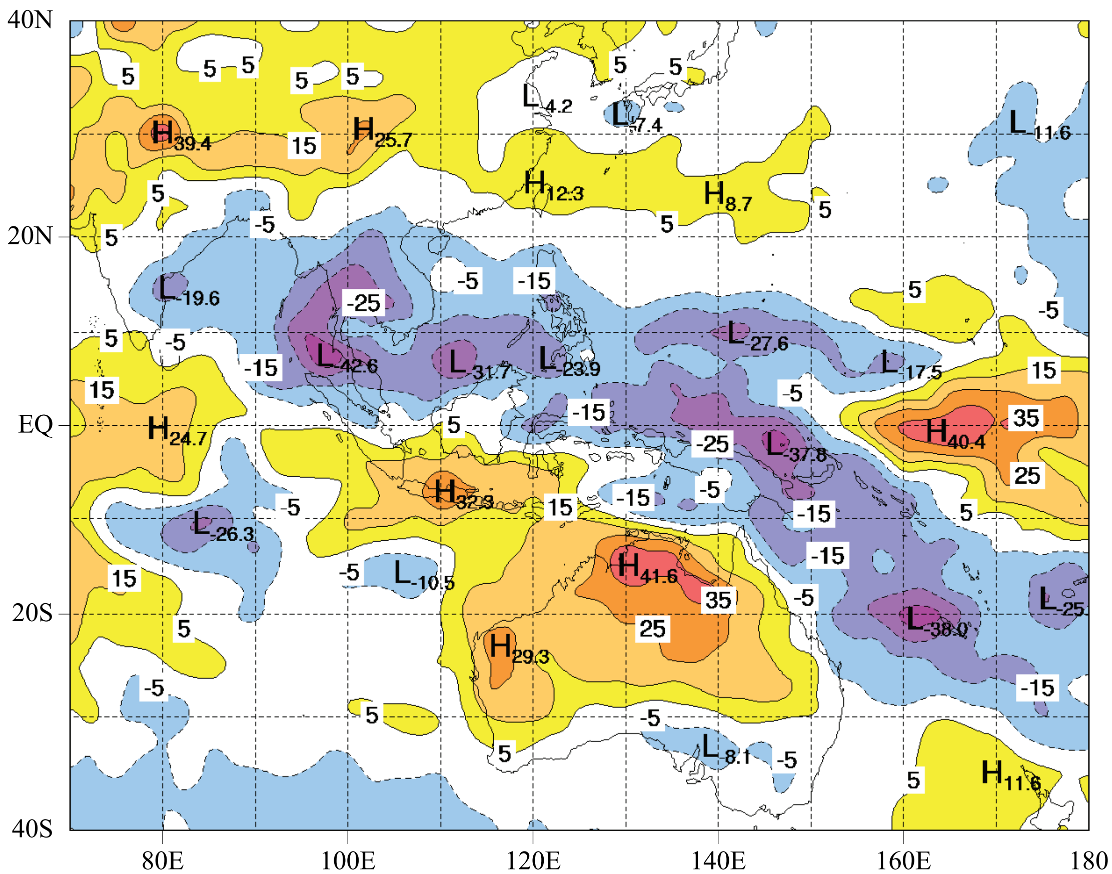

Fig.8(b) OUTGOING LONG WAVE RADIATION ANOMALY, March 2009.
Contour interval 10 watt m^{-2}.

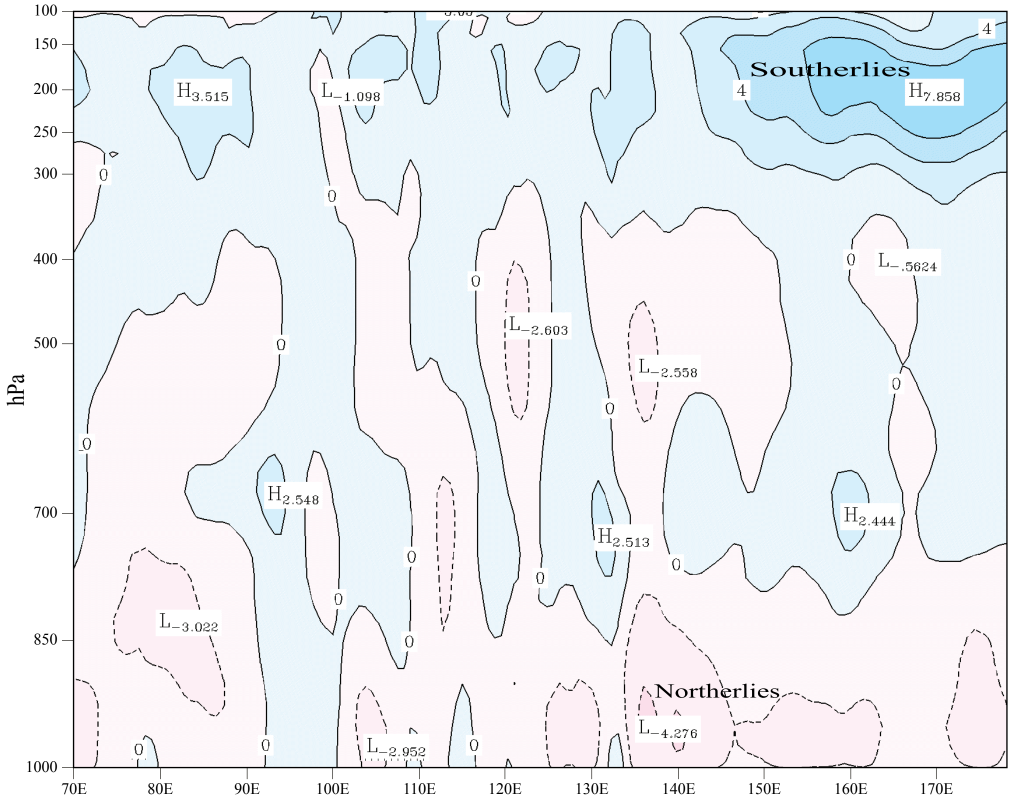

Fig.9 EQUATORIAL CROSS SECTION OF MERIDIONAL WIND, March 2009. Isotachs at $2ms^{-1}$ intervals.

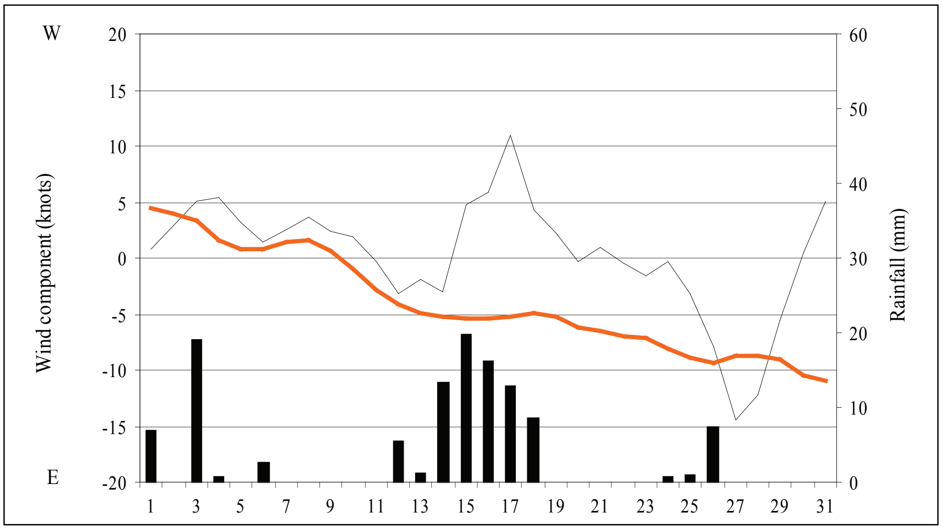

Fig.10(a) DARWIN 850 hPa MEAN ZONAL WIND, March 2009. Columns represent rainfall. Black line represents 3-day running mean. Orange line represents the mean seasonal wind.

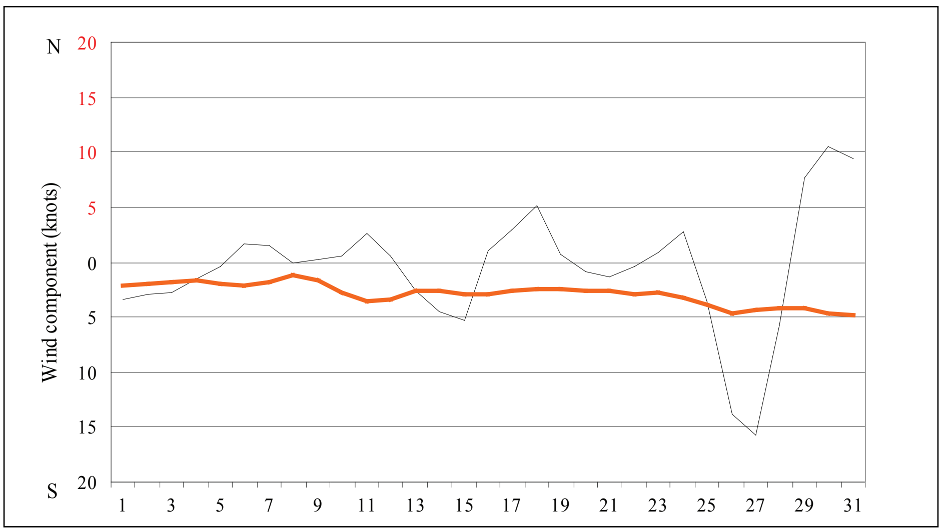

Fig.10(b) DARWIN 850 hPa MEAN MERIDIONAL WIND, March 2009. Black line represents 3-day running mean. Orange line represents the mean seasonal wind.

Time/longitude cross section, southern series.
5 day running mean, averaged over 15°S to 5°S

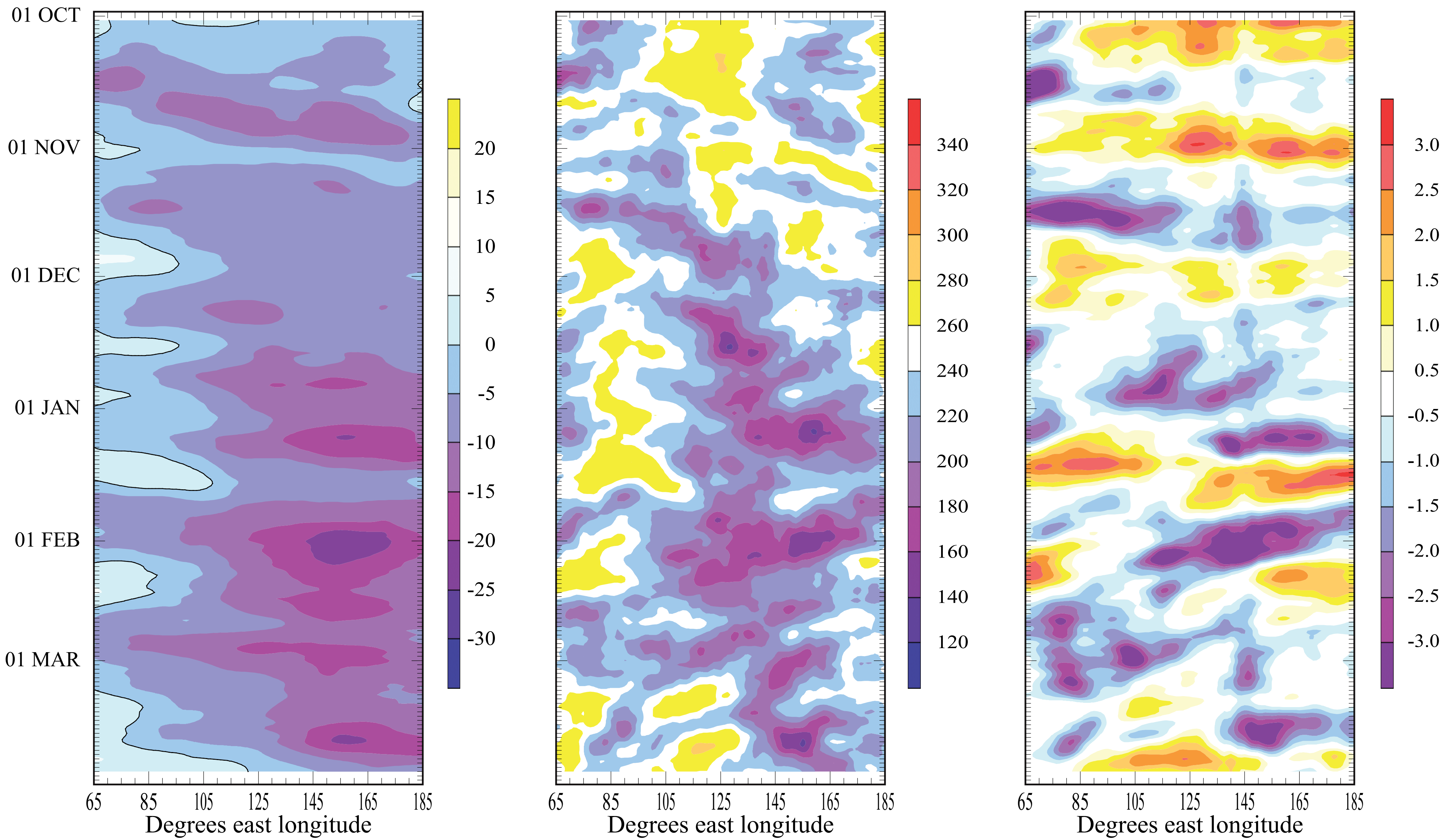

Fig. 11(a) 200hPa velocity potential based on GASP ($10^6 m^2 s^{-1}$)

Fig.11(b) Outgoing long wave radiation (watt m^{-2})

Fig. 11(c) Mean sea-level pressure anomaly (hPa)

Time/longitude cross section, equatorial series.
5 day running mean, averaged over 5°S to 5°N

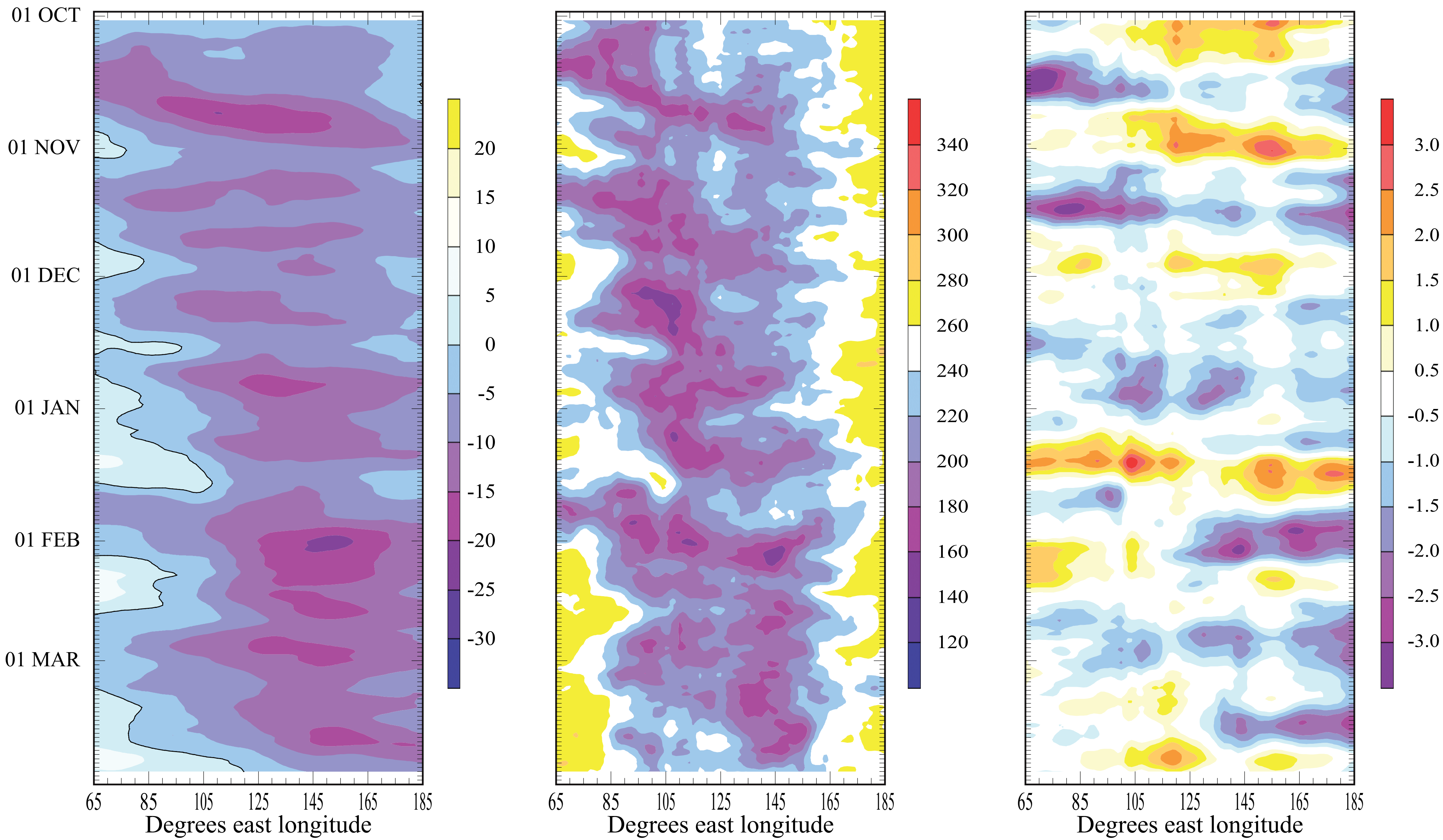

Fig. 12(a) 200hPa velocity potential based on GASP ($10^6 m^2 s^{-1}$)

Fig.12(b) Outgoing long wave radiation (watt m^{-2})

Fig. 12(c) Mean sea-level pressure anomaly (hPa)

Time/longitude cross section, northern series.
5 day running mean, averaged over 5°N to 15°N

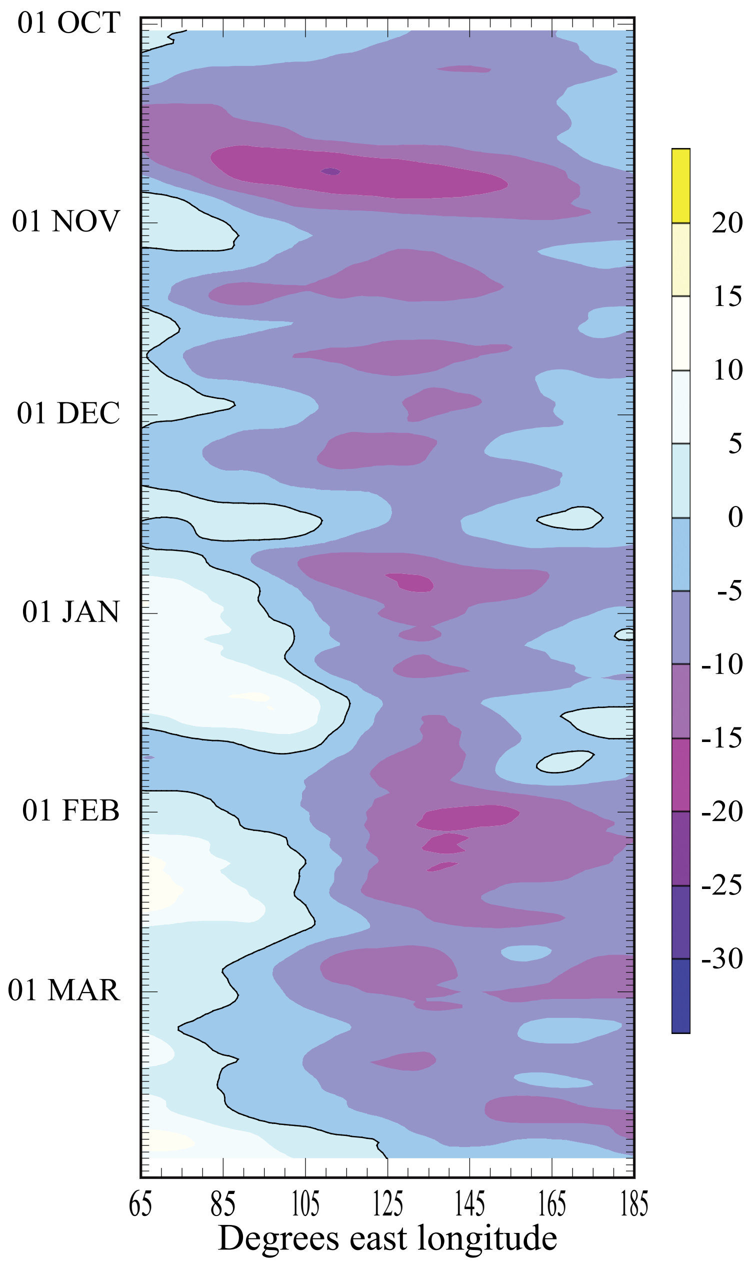

Fig. 13(a) 200hPa velocity potential based on GASP ($10^6 m^2 s^{-1}$)

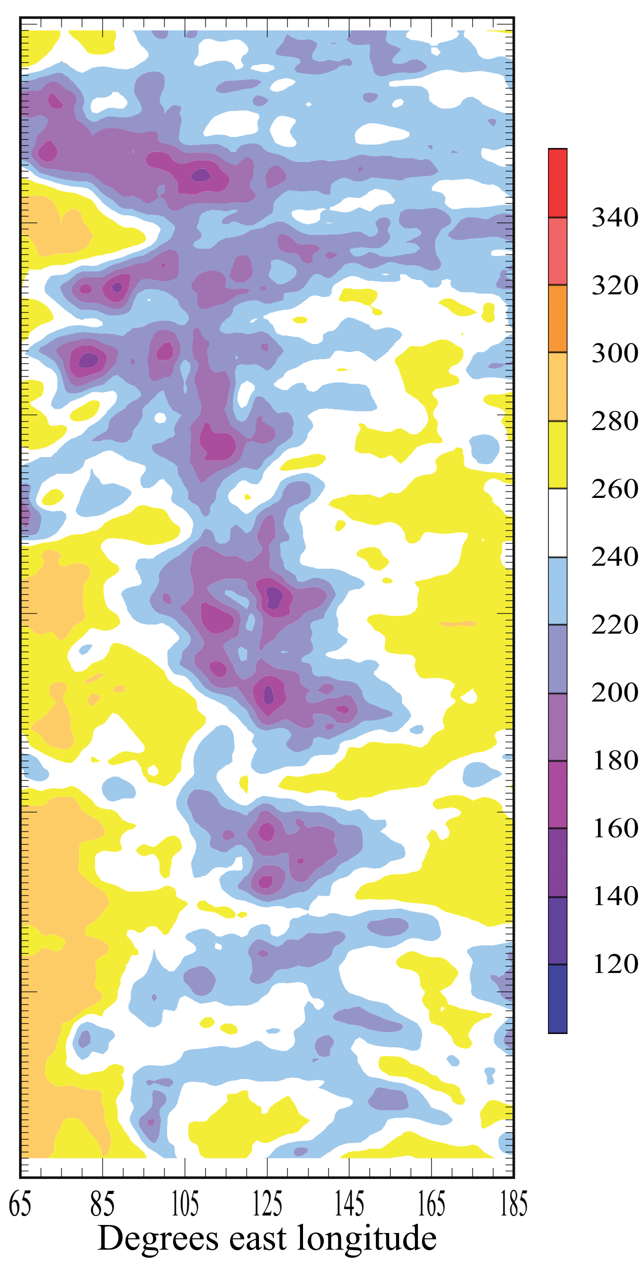

Fig.13(b) Outgoing long wave radiation (watt m^{-2})

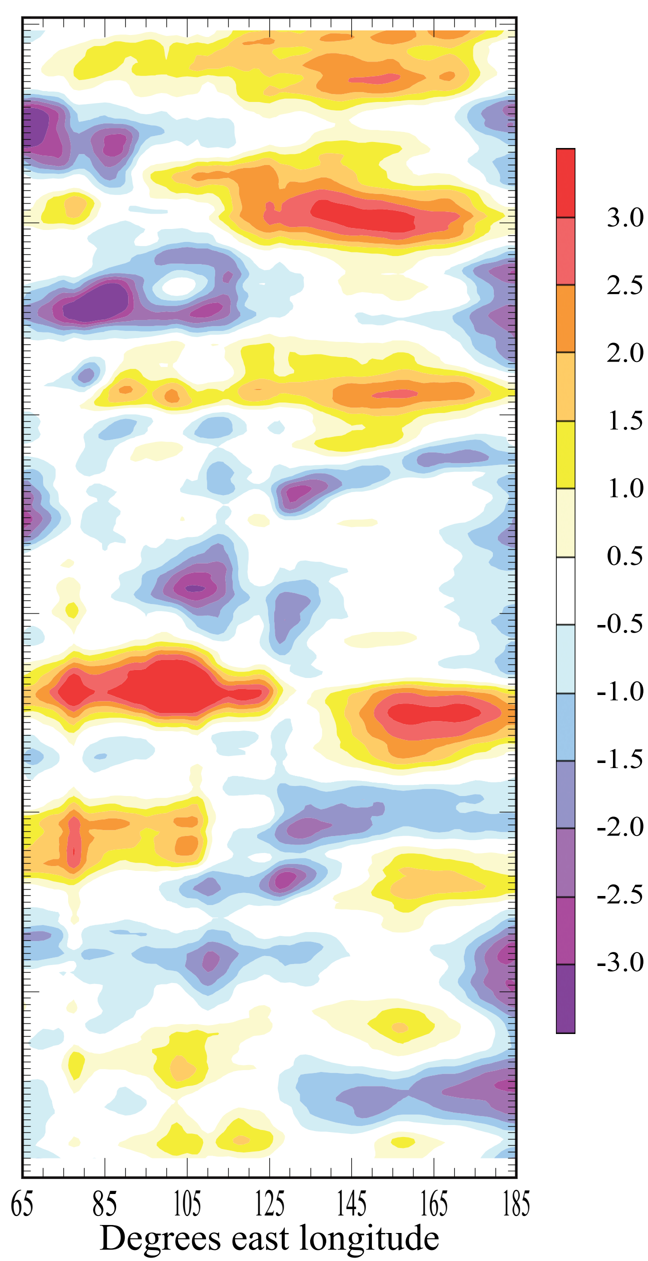

Fig. 13(c) Mean sea-level pressure anomaly (hPa)

Explanatory Notes

1. **Darwin Tropical Diagnostic Statement** is a near real-time monthly diagnostic summary of the major tropical circulations within the Darwin Regional Specialised Meteorological Centre (RSMC) area of analysis responsibility, which covers 40ºN-40ºS, 70ºE-180º.

2. **Features** discussed generally include:

- El Niño - Southern Oscillation (ENSO) aspects
- Tropical cyclone (TC) occurrence
- Sea surface temperature (SST)
- Mean sea level pressure (MSLP).
- Lower and upper level wind
- Up-motion and convection
- Intra-seasonal variability

3. **Data sources**:

(i) $SOI = 10 \times (\Delta P_{TAH} - \Delta P_{DAR}) / \sigma$

where ΔP_{TAH} =Tahiti (91938) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 3-hourly observations)

ΔP_{DAR} = Darwin (94120) monthly pressure anomaly (monthly mean minus 1933-1992 mean, averaging 0900, 1500LT observations)

σ = monthly deviation of the difference.

(ii) Operational tropical cyclone tracks based upon Darwin RSMC manual operational analyses. A tropical cyclone or cyclonic storm is defined as having mean wind ≥ 17 ms^{-1} (34 kn) or a named system. Standard practice is to accept intensity and position as promulgated by the responsible warning agency, whenever possible. This may cause apparent discontinuities in intensity or track when cyclones cross warning area boundaries. Limited post analysis may sometimes be performed when warranted. A severe TC (equivalent to typhoon or hurricane) or very severe cyclonic storm is defined as having mean wind ≥ 32 m s^{-1} (63 Kn).

(iii) Tropical cyclone climatology for the northwest Pacific and the south Indian and Pacific Oceans is based on *2004 Annual Tropical Cyclone Report*, by Atangan, J.F. and Preble, A., (2004), US Naval Pacific Meteorology and Oceanography Center/ Joint Typhoon Warning Center, Pearl Harbour, Hawaii, USA, (available at https://metoc.npmoc.navy.mil/jtwc/atcr/2004atcr/), which contains a climatology of 59 years. North Indian Ocean records are taken from WMO *Technical Document No. 430, Tropical Cyclone Report No.TCP-28* (Mandal, 1991), which contains a 99 year climatology.

(iv) SST analysis based on Darwin RSMC automated operational analyses (RSMC subset of the Australian National Meteorological and Oceanographic Centre (NMOC) global analysis: blended *in situ* and satellite data, 1ºC resolution). The 1ºx 1º global SST climatology from the US National Centers for Environmental Prediction (Reynolds and Smith 1995). A high resolution global sea surface temperature climatology, *J. Clim., 8*, 1571-1583 is used for the calculation of anomalies and as the default field for the analysis first guess.

(v) Mean MSLP, upper wind data, anomalies and velocity potential data from the Bureau of Meteorology's Global Assimilation and Prediction System (GASP - refer Bourke et al 1990. The BMRC global assimilation and prediction system. *ECMWF Seminar proceedings: Ten years of medium-range weather forecasting*, Sep 89) and NCEP2 22 year climatology, 1979-2000. MSLP anomaly analysis modified using CLIMAT messages.
Equatorial cross section of meridional wind field was derived from the Bureau of Meteorology's operational Tropical region Extended Limited Area Prediction System (TXLAPS_PT375n) model. (Refer- *Analysis and Prediction Operations Bulletin No 59*. Bur. Met., Australia.)
A full web version available at: http://www.bom.gov.au/nmoc/bulletins/nmc_bulletin.shtml).

(vi) The mean seasonal cycles for the Darwin 850 hPa wind components were constructed by averaging daily values over 39 years (1950 to 1988), each curve smoothed with 600 passes of a three day running mean weighted 1-2-1.

(vii) OLR time longitude plots and maps derived from the US National Oceanic and Atmospheric Administration.

4. **Some commonly-used acronyms**:

CS	Cyclonic storm	SCS	South China Sea
ISO	Intra-seasonal oscillation	SOI	Southern Oscillation Index
JMA	Japan Meteorological Agency	SPCZ	South Pacific convergence zone
JTWC	Joint Typhoon Warning Center, Pearl Harbour	SST	Sea Surface Temperature
MJO	Madden-Julian Oscillation	STC	Severe tropical cyclone
MSLP	Mean Sea Level Pressure	STR	Subtropical ridge
MT	Monsoon trough	TC	Tropical cyclone (see note 3(ii))
NET	Near-equatorial trough	TD	Tropical depression
OLR	Out-going long-wave radiation	TXLAPS	Tropical region Extended Limited Area Prediction Scheme
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services	TS	Tropical storm (generally used for TC in northern Hemisphere sector)
PNG	Papua New Guinea	TUTT	Tropical upper tropospheric trough
RSMC	Darwin Regional Specialised Meteorological Centre (see note 1)	VSCS	Very severe cyclonic storm

5. **Subscription rates**: All costs in $AUSTRALIAN:

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95.50 (86.80 ex GST)	12.00 (Australia)	107.50
	16.44 (Asia/Pacific)	103.24
	24.36 (Rest of the world)	111.16

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