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## **BMRC Research Report No. 7**

**THE AUSTRALIAN SOUTHERN HEMISPHERE  
CLIMATOLOGY DATA TAPE**

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THE AUSTRALIAN SOUTHERN HEMISPHERE  
CLIMATOLOGY DATA TAPE

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ABSTRACT

This report describes the contents and format of the Australian southern hemisphere (ASH) climatology data tape. This climatology has been prepared from ten years (September 1972 to August 1982) of daily numerical analyses of the southern hemisphere atmospheric circulation prepared in the Australian Bureau of Meteorology. Details of the analysis system and the data base available for the analyses as well as the derivation of the climatology from the daily analyses are described. The climatology includes ten-year mean fields, daily transient eddy statistics and inter-annual variability statistics.

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## INTRODUCTION

From May 1972, the World Meteorological Centre (WMC) Melbourne in the Australian Bureau of Meteorology has produced daily numerical analyses of the southern hemisphere atmospheric circulation which have described the broadscale features. These analyses are of widespread interest and have already been the basis of a considerable number of studies, e.g. Howarth (1983), Le Marshall and Kelly (1981), Physick (1981), Swanson and Trenberth (1981a, b), Stretten and Pike (1980), Trenberth (1979, 1981, 1982), Van Loon (1980) and many others. The first ten years of these daily analyses (September 1972 to August 1982) have been used to derive a climatology for the southern hemisphere.

There were several reasons for the production of this climatology. It provided a means for gauging some aspects of analysis quality and a basis for estimating the impact of changes in the analysis system and the data base on the analyses. It also gave an opportunity to estimate the differences between the WMC Melbourne data and those from earlier studies of the southern hemisphere, in particular the climatology of Taljaard et al. (1969), as well as the chance to examine differences within the ten-year period itself. Some aspects of the WMC Melbourne's southern hemisphere analyses have been described by Trenberth and his colleagues in a series of papers (Trenberth 1979, 1981, 1982; Swanson and Trenberth 1981a, b) using a shorter time period of analyses.

This report describes the contents and format of the Australian southern hemisphere (ASH) climatology data tape, which contains the data from the ten-year climatology in a form which can be read easily by computer. Details of the analysis system and the data base available for the daily analyses, as well as the derivation of the climatology from the daily analyses are also described.

The climatology includes statistics for each calendar month for the ten-year mean monthly-mean fields and the daily and monthly standard deviation fields, which have been computed about the individual monthly means and the mean of the ten-monthly means, respectively. The variables included in the climatology are mean sea level pressure, temperature, geopotential height, zonal and meridional wind and water vapour mixing ratio. In addition, statistics on the mean meridional transport of heat, water vapour and momentum by the transient eddies are included.

An atlas (Karoly et al. 1986) containing diagrams and microfiche of selected fields from the climatology may be used in conjunction with the data tape. This atlas contains additional statistics on the radiosonde station data available for the daily analyses and verification of the ASH climatology with a climatology of radiosonde data for the same period.

No attempt has been made in this report to describe the features of the climatic fields or to compare them with other southern hemisphere climatologies. Two papers, Le Marshall et al. (1985) and

Karoly (1985), have been published which describe the main features. Their conclusions about the quality of the climatic fields are presented in the concluding remarks.

## THE DAILY ANALYSES

### Analysis methodology

Within WMC Melbourne, the operational analyses which form the basis of this climatology are held on a 47 x 47 polar stereographic grid on the hemisphere, giving an effective resolution of about 500 km. Geopotential height, wind and temperature are held at seven pressure levels (1000, 850, 700, 500, 300, 200 and 100 hPa), water vapour mixing ratio is held at the lowest four pressure levels and mean sea level pressure is also recorded. Since 1976, daily analyses at the 250 hPa level have been prepared by interpolation between the 300 and 200 hPa levels. This level was not included in the climatology. The basic southern hemisphere analysis-forecast system was outlined by Gauntlett et al. (1972). The analysis component of the system, which remained unchanged over the ten years, is further described below.

The analyses relied on initial specification of the mean sea level pressure (MSLP) and 1000 to 500 hPa thickness fields by manual analysis methods. These methods made use of all available conventional data and also cloud picture interpretation (Guymer 1978), which gave the deviations of these two fields from the climatology of Taljaard et al. (1969) and extended the data base into data-void regions.

The conventional data base used in the analyses was that arriving at WMC Melbourne within seven hours of the analysis time. The coverage of these observations was often incomplete with, for instance, upper air observations from some South American and African stations and Easter Island not usually being included in the analysis. Details of the data base are given in the next sections.

In the analysis scheme, manually analysed fields of MSLP and 1000 to 500 hPa thickness were gridded to provide pseudo-observations which were used to modify or replace first guess fields. The successive correction method analyses (Cressman 1959) used objective data rejection criteria which ensured that the features of the manual analyses were retained. Pseudo-observations from the manually analysed 1000 to 500 hPa thickness were also broken down according to climatology to provide inter-level thickness pseudo-observations below 500 hPa. All pseudo-observations had a high weight in the successive correction method analyses.

A complete hemispheric coverage of pseudo-observations was usually provided at 00 Z. After 1976 at 12 Z, the coverage of pseudo-observations was more limited and variable, with the 1000-500 hPa thickness in particular usually being specified only in the sector from 90 to 180° east.

MSLP and 1000 hPa height were analysed first using all available conventional observations and the pseudo-observations. Over Antarctica, station data are reduced to give MSLP assuming a linear relationship between the intermediate layer thicknesses and the 1000 to 500 hPa thickness. For example, at the South Pole, the algorithm used for calculating 1000 to 500 hPa thickness is:

1000 to 500 hPa thickness = 2 x (700 to 500 hPa thickness) + 30 dam.

The MSLP is then calculated from the 1000 hPa geopotential height hydrostatically. The analyses were built up from the 1000 hPa level to each successive higher level using the following procedure. The inter-level thickness field was analysed first. The first guess thickness fields between 1000 and 500 hPa were 12-hour prognoses. Before 1976, these were provided by a filtered baroclinic model and subsequent to this by a hemispheric version of the spectral model of Bourke et al. (1977). However, because of the pseudo-observation coverage (see above), these guess fields had little effect below 500 hPa in the 00.Z analyses. The geopotential height at each level was diagnosed from the analysed inter-level thickness and the lower-level height field. A first guess for the wind field was obtained using a combined geostrophic-gradient wind relation from the height field with a relaxation to the Taljaard climatology in low latitudes. All wind observations were then analysed. A first guess for the temperature field at each level was obtained using a statistical relationship from the analysed inter-level thickness field and prescribed lapse rates. All temperature observations were then analysed.

Above 500 hPa, the first guess thickness fields were a combination of 12-hour prognosis fields, and fields based on correlations between lower and upper tropospheric variables, generated by using predictors and predictands which were deviations from climatology (Seaman 1972). No pseudo-observations were used above 500 hPa. Otherwise the analysis procedure above 500 hPa was the same as for the lower levels.

The water vapour mixing ratio was analysed from very sparse observations using as a first guess a combination of the 12-hour prognosis and the Taljaard climatology. A check was performed during the analysis to prevent supersaturation.

#### **Analysis data base**

The conventional data base used in the analyses consisted mainly of ship and surface synoptic observations, radiosonde and rawinsonde data, drifting ocean-buoy data mainly during 1979 and 1980, and lower-level cloud winds when available. In addition, these data have been supplemented since 1976 between 20°S and 60°S by Vertical Temperature Profile Radiometer (VTPR) data, in part locally reduced (Kelly et al. 1976). From 1979, second-generation sounding data from the Tiros N/NOAA A-G series satellites have been incorporated into the analyses. These arrived in Melbourne via the Global Telecommunication System from NESS/NESDIS and were at approximately 5° horizontal

resolution. Deployment of the second-generation sounders resulted in a significant improvement in sounding data quality from 1979 onwards, and, with two satellites from July 1979, asynoptic problems were overcome (full hemispheric coverage four times per day).

The satellite imagery available to augment the data base during analysis came from USA polar-orbiting satellites (Automatic Picture Transmission (APT) and Weather Facsimile (WEFAX) data) and since January 1977 from the GOES-E and GOES-W geostationary satellites. From 1978, imagery from the Japanese Geostationary Meteorological Satellite (GMS) has augmented this data base and, on occasion, imagery from the Meteor series of satellites and Meteosat has also been used.

The coverage of upper-air observations received at the WMC Melbourne was often incomplete. An indication of the typical coverage of reporting radiosonde stations included in the 00 Z analyses is shown in Fig. 1. On this map for January, the number of years out of ten and the average number of days in the month for which 00 Z observations of 500 hPa height were received (in brackets) are plotted at the station positions. A good coverage was maintained over the ten-year period from stations in Australasia, the western Pacific Ocean and Antarctica. Much poorer coverage was obtained from stations in Africa and South America, where reports from some stations were received in one year only, the FGGE year. In addition, there was a very low station density in many oceanic areas of the southern hemisphere due to the absence of island stations and weather ships. However, this station coverage is as good as that available for the Taljaard climatology and is better than that used in the recent station climatology of Gort (1983) in the southern hemisphere.

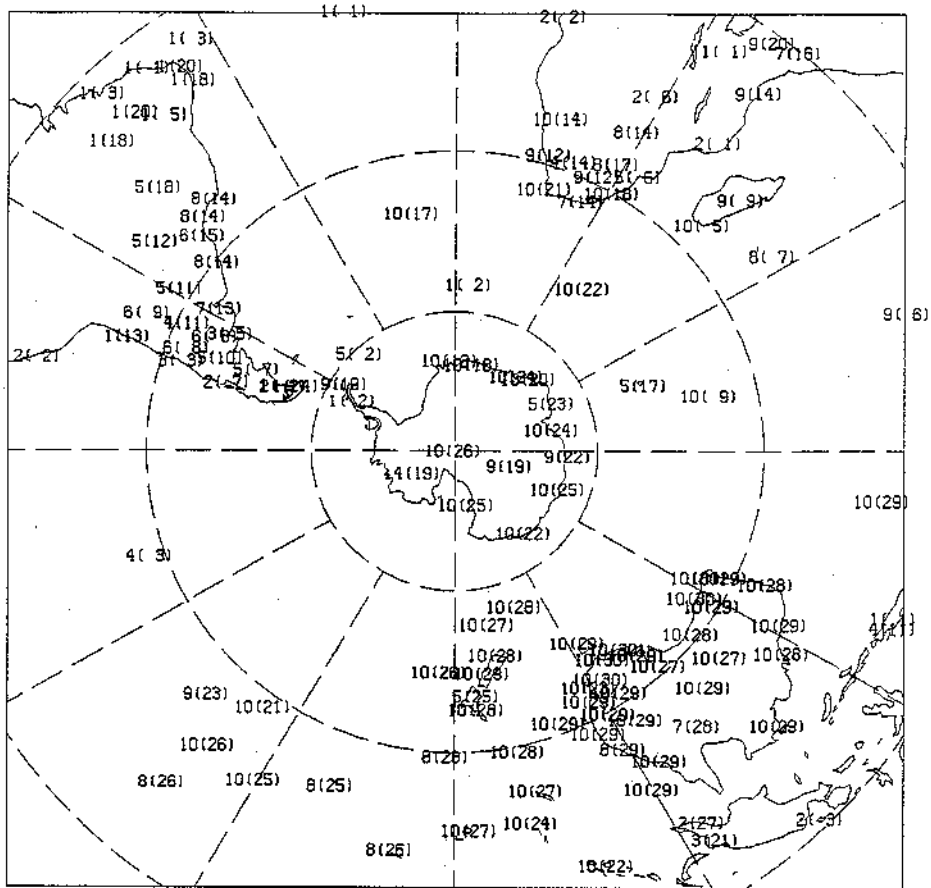
#### DATA ANALYSIS FOR THE CLIMATOLOGY

The daily hemispheric analyses at 00 Z from September 1972 until August 1982 were used for the climatology. The first few months of the daily analyses before September 1972 were not used in the

climatology because of initial problems with the daily analysis system and the large number of missing analyses. During the ten-year period, less than 2 per cent of analyses were missing and the longest continuous sequence of missing analyses was nine in May 1979, which resulted from problems with the operational archiving process. No attempt was made to correct for missing analyses in the climatology. Analyses at 00 Z were used because they usually had a more complete coverage of pseudo-observations than at 12 Z.

All variables available in the daily analyses have been included in the climatology: MSLP, geopotential height, temperature, zonal and meridional wind and water vapour mixing ratio. The same horizontal and vertical resolution as in the daily analyses was used. Monthly means and daily standard deviations of the grid-point data about the individual monthly means were computed for each month:

$$\text{monthly mean } \bar{x} = \frac{1}{N} \sum x,$$



JAN STN REPORTS YY(DD)

Fig. 1 Coverage of upper-air observations in January used in the daily analyses. Shown at each station location is the number of months out of ten (YY) and the average number of days in the month (DD, in brackets) for which 00 Z observations of 500 hPa height in January were received at WMC Melbourne during the period 1973-1982.

where  $x$  represents the daily grid-point value,

$$\text{daily standard deviation } \sqrt{x'^2} = \sqrt{\frac{1}{N-1} \sum (x - \bar{x})^2} \dots$$

Ten-year means of the monthly means and daily standard deviations were computed for each calendar month:

$$\text{10-year mean monthly mean } \bar{\bar{x}} = \frac{1}{10} \sum \bar{x},$$

$$\text{10-year mean daily standard deviation } \sqrt{\overline{x'^2}} = \frac{1}{10} \sum \sqrt{x'^2}.$$

The monthly standard deviations of the monthly means about their ten-year mean were calculated for each calendar month:

$$\text{monthly standard deviation } \sigma(\bar{x}) = \sqrt{\frac{1}{9} \sum (\bar{x} - \bar{\bar{x}})^2}.$$

Meridional fluxes of heat, moisture and momentum by the transient eddies were computed using the covariances of daily departures from the individual monthly means of the meridional wind with temperature, water vapour mixing ratio and zonal wind, respectively:

$$\text{monthly mean meridional flux } \overline{v'x'} = \frac{1}{N} \sum (v - \bar{v})(x - \bar{x}),$$

$$\text{10-year mean meridional flux } \overline{\overline{v'x'}} = \frac{1}{10} \sum \overline{v'x'}.$$

#### DATA TAPE CONTENTS AND FORMAT

The data tape contains the fields from the ASH climatology interpolated onto a  $5^\circ \times 5^\circ$  latitude-longitude grid from  $10^\circ\text{S}$  to the South Pole. These fields have been written as character records on the magnetic tape. Each record contains the data for a single latitude circle, level, month and climatological parameter. There are four sets of parameters in the climatology each in a separate file; the ten-year mean monthly means, the ten-year mean daily standard deviations, the monthly standard deviations and the transient eddy fluxes. The parameters in each file and the names used for them on the tape are listed in Table 1. The data are available at the seven pressure levels given in Table 2 for all the parameters, except that parameters involving water vapour mixing ratio are available at the lowest four levels only and parameters involving mean sea level pressure are available at a single level only.

To achieve greater accuracy and to save space, the data at each level have been multiplied by a scale factor. The same scale factor is used at all latitudes for a single level and parameter. In addition, the ten-year mean monthly mean sea level pressure and geopotential height fields have had constants which are given in Table 2 subtracted from them to improve the accuracy of the numbers written on the tape.

Each horizontal field, (A(72,17)), can be read from a tape unit (ITAPE) using FORTRAN code similar to the following:

```
CHARACTER LABEL*20, NAME*4
DIMENSION A(72,17), IN(72)
100 FORMAT (A20, A4, 4I4, 72I5)
READ (ITAPE,100) LABEL, NAME, MONTH, LEVEL, LATIT, ISCALE,
*(IN(I),I=1,72)
J=LATIT/5 - 1.
DO 10 I=1,72
A(I,J) = FLOAT(IN(I))* 10.0** ISCALE.
10 CONTINUE
```

where LABEL = Label described the set of climatology parameters (see Table 1)

NAME = name of parameter from Table 1

MONTH = month number (1 = January, 2=February, 12= December)

LEVEL = level from Table 2

LATIT = latitude in degrees south of equator (LATIT>0)

ISCALE = scaling factor used to obtain parameter

IN = integer array used to hold scaled data along one latitude circle at 5° longitude intervals from 0° to 355°E  
i.e. I=1 corresponds to 0°  
I=2 corresponds to 5°E  
I=72 corresponds to 355°E

In each file, the data records are written in order of increasing latitude from 10°S to 90°S, then in order of increasing level from the lowest level to the highest (see Table 2), then in order of the parameters in each set (see Table 1), then in calendar month order from January to December.

The data has been written onto an unlabelled tape in EBCDIC code, with record length = 400 and blocksize = 4000. There are 4 files on the tape, corresponding with the 4 sets of parameters in Table 1.

The ASH climatology data tape is available on request from the National Climate Centre, Bureau of Meteorology, GPO Box 1289K, Melbourne, Vic 3001, Australia.

Table 1. File 1 Ten-year mean monthly mean fields

Label: ASH TEN YEAR MEAN

Parameter	NAME	No. of Levels	Units	Comments
$\bar{p} - 1000$	MSLP	1	hPa	biased mean sea level pressure
$\bar{z} - z_{SA}$	HGHT	7	gpm	biased height
$\bar{T}$	TEMP	7	°C	temperature
$\bar{q}$	MIXR	4	g/kg	water vapour mixing ratio
$\bar{u}$	UZON	7	m/s	zonal wind
$\bar{v}$	VMER	7	m/s	meridional wind

File 2 Ten-year mean daily standard deviation fields

Label: ASH 10 YR DLY SD

Parameter	NAME	No. of Levels	Units	Comments
$\sqrt{\overline{p'^2}}$	SDP'	1	hPa	
$\sqrt{\overline{z'^2}}$	SDZ'	7	gpm	
$\sqrt{\overline{T'^2}}$	SDT'	7	°C	
$\sqrt{\overline{q'^2}}$	SDQ'	4	g/kg	
$\sqrt{\overline{u'^2}}$	SDU'	7	m/s	
$\sqrt{\overline{v'^2}}$	SDV'	7	m/s	

File 3 Monthly standard deviation fields

Label: ASH 10YR MONTHLY SD

Parameter	Name	No. of Levels	Units	Comments
$\sigma(\bar{p})$	SIGP	1	hPa	
$\sigma(\bar{z})$	SIGZ	7	gpm	
$\sigma(\bar{T})$	SIGT	7	°C	
$\sigma(\bar{q})$	SIGQ	4	g/kg	
$\sigma(\bar{u})$	SIGU	7	m/s	
$\sigma(\bar{v})$	SIGV	7	m/s	

File 4 Meridional flux by transient eddies

Label: ASH 10YR MERID FLUX

Parameter	Name	No. of Levels	Units	Comments
$\overline{v'T'}$	V'T'	7	°Cm/s	
$\overline{v'q'}$	V'Q'	4	(m/s)x(g/kg)	
$\overline{v'u'}$	V'U'	7	m <sup>2</sup> /s <sup>2</sup>	

Table 2. List of Levels.

Level	Z <sub>SA</sub> , Constant subtracted from ten-year mean height
1000 hPa	113 gpm
850 hPa	1,457 gpm
700 hPa	3,011 gpm
500 hPa	5,572 gpm
300 hPa	9,159 gpm
200 hPa	11,784 gpm
100 hPa	16,206 gpm
mean sea level, 1013 hPa	1,000 hPa subtracted from ten-year mean sea level pressure

#### CONCLUDING REMARKS

This report describes the contents and format of a data tape containing a ten-year climatology of daily numerical analyses of the southern hemisphere. No attempt has been made here to describe features in the climatology or compare this climatology with other southern hemisphere climatologies. Two papers, Le Marshall et al. (1985) and Karoly (1985), have been published which describe these features. Their main conclusions about the quality of the numerical analysis climatology are presented below.

In using the WMC Melbourne analyses, certain characteristics of the analysis scheme need to be borne in mind. There is an in-built bias towards the Taljaard climatology as a result of the analysis scheme. The operational data 'cut-off' set at seven hours after the analysis time has resulted in the omission of data from the analyses. Geopotential height, wind and temperature have been diagnosed from MSLP and 1000 to 500 hPa thickness determined from cloud picture analysis in data-sparse regions.

Several deficiencies in the analyses, generally related to the data base, can be identified from the climatology. The water vapour mixing ratio has been analysed from sparse data and may be unreliable. The low-latitude wind field, which has been analysed using a geostrophic-gradient wind assumption for the first guess, was too weak in low latitudes. The first guess for the 1000 hPa temperature field was obtained from the 1000 to 850 hPa thickness using a statistical relationship. This relationship was often not a good approximation and did not take into account differences in the underlying surface. There was not a good coverage of observed 1000 hPa temperatures so the analysed 1000 hPa temperatures were unreliable. Differences between

this climatology and that of Taljaard et al. (1969) for the mean 1000 hPa temperature were greater than 6°C over some continental regions. Higher-level temperature analyses in the ten-year climatology were much better because of the more reliable relationship between inter-level thickness and temperature.

In the upper troposphere, however, it appears the temperature analyses may be influenced by the data distribution. The daily temperature variability in the upper troposphere in the analyses appears to be reduced away from conventional observation points.

As a result, the temperature analyses at the 1000 hPa level and at levels above 300 hPa should be used with appropriate reservations. Temperature analyses in the middle troposphere and geopotential height and wind analyses from the 1000 hPa level to about the tropopause level were reliable. Verification of the analysis climatology against a climatology of radiosonde station observation indicated that most of the mean analysed fields and their daily and monthly variability agreed well with observations.

More recently, an extensive comparison (Karoly and Oort 1987) has been made between southern hemisphere circulation statistics from the numerical analysis-based ASH climatology described here and the station-based GFDL climatology described by Oort (1983). This comparison has confirmed the above results and assessed the quality of the meridional transport statistics. In general, there is reasonable agreement between the two climatologies for the meridional transports in the middle troposphere. For the heat transport, the differences are larger close to the surface and in the upper levels, indicating the likely errors in the ASH transports at these levels. This is in agreement with earlier assessment of the reliability of the ASH temperature analyses at these levels.

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