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CLIMATOLOGICAL VARIATION OF GLOBAL CROSS-EQUATORIAL FLOWS FOR THE PERIOD 1948 – 2004

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Abstract: By using monthly NCEP/NCAR meridional gridpoint wind data at the levels of 1000, 850, 700, 600, 500, 400, 300, 200, 150 and 100 hPa from 1948 to 2004, the intensity of global cross-equatorial flows is calculated. The spatial and temporal variation of global cross-equatorial flows at the 850-hPa level are shown and discussed. The results show that the strength of the 850-hPa global cross-equatorial flows represent obvious long-term variation and interdecadal change during the period. Evidence suggests that the cross-equatorial flow of the passages at 45 – 50 °E in June to August, 105 – 115 °E in May to September, 130 – 140 °E in May to September and May to November and 20 – 25 °E in February to April intensified and that the cross-equatorial flow of the passages at 50 – 35 °W in June to August weaken in the past 57 years，with an increase of 0.25m/s/10a for summer Somali Jet and increase of 0.32 m/s/10a for cross-equatorial flow at 130 – 140 °E in May to September The results of Singular Spectrum Analysis (SSA) for the time series indicate that for the cross-equatorial flow at 850 hPa, the interdecadal and long-term trend changes are 35% – 45%, and the interannual variation is no more than 30%, in variance contribution. The results also reveal that the interannual variation of intensity of the summer cross-equatorial flows in the Pacific is significantly correlated with Southern Oscillation. With weak Southern Oscillation, strong cross-equatorial flows in Pacific will happen, though the summer Somali Jet is only a little positively correlated with North Atlantic Oscillation (NAO).

Key words: cross-equatorial flow; climatic change; tendency change; Singular Spectrum Analysis; Southern Oscillation

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1 INTRODUCTION

Cross-equatorial flows are linked with atmospheric circulation globally, especially at the middle and low latitudes, and influence the weather change and climate across the globe and China [1 - 6]. It is our opinion that it is very necessary to study the variation of the cross-equatorial flow with long data series. Is there any change in the intensity of global cross-equatorial flows in response to the significant interdecadal change in the general circulation in the background of substantial global warming from the end of 1970s? How does it change? There has not been any documentation on it. With 10-layer global monthly mean meridional winds on yearly basis since 1948, which is compiled using the NCEP / NCAR dataset, the current work studies in detail the cross-equatorial flow on 850 hPa over the 57 years, including the passages, tendency change and interdecadal variation. The Singular Spectrum Analysis (SSA) is used to determine the periodic characteristics and the temporal series and variation contribution of the intensity of the flows.

2 DATA AND METHODS

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The reanalysis wind field data by NCEP / NCAR and global wind field data for January 1948 – December 2004 are used to determine the passages and annual variation of the global cross-equatorial flows on the monthly basis. When V for the equator is positive (negative), it indicates the presence of cross-equatorial flows from the Southern (Northern) Hemispheres to the Northern (Southern) Hemispheres. To have quantitative analysis of the long-term intensity change, the time series is worked on for a tendency coefficient of r_{xt}[7].

3 MAIN CHARACTERISTICS OF GLOBAL CROSS-EQUATORIAL FLOWS (1948 – 2004)

Fig.1 gives the longitude – altitude cross section of the 10-layer meridional wind for January and July averaged over the 57 years from 1948 to 2004.

It is know from the figure that the cross-equatorial flow is stronger in the Eastern Hemisphere than in the Western Hemisphere for either January or July Some of the strongest flows can reach as high as up to 850 hPa or above. Fig.2 gives the monthly variation of the global 850-hPa cross-equatorial flows averaged over the 57 years. It is found that they vary monthly. There are five zones of longitude through which the cross-equatorial flows travel in January four of them in the Eastern and one of them in the Western Hemispheres, with the maximum wind speed between – 3.21 m/s and – 4.87 m/s. They are the main global passages to transport air to the south. As shown in Fig.2, however, the four passages in Eastern Hemisphere can last as late as February – March, and the more westward the passage locates, the shorter it can persist. The passage in the Western Hemisphere persists until April to May. Then, passages transporting air northward begin to appear at 20°E in March and spread eastward. The speed of southerly wind increases with time, with the highest in summer. There are five longitude zones in summer being larger than 2 m/s in average, four of them in the Eastern Hemisphere. The highest wind appears around 45°E, which is the well-known Somali Jet. It is as strong as 10.39 m/s at 850 hPa in average in July and still 3 m/s at 600 hPa.

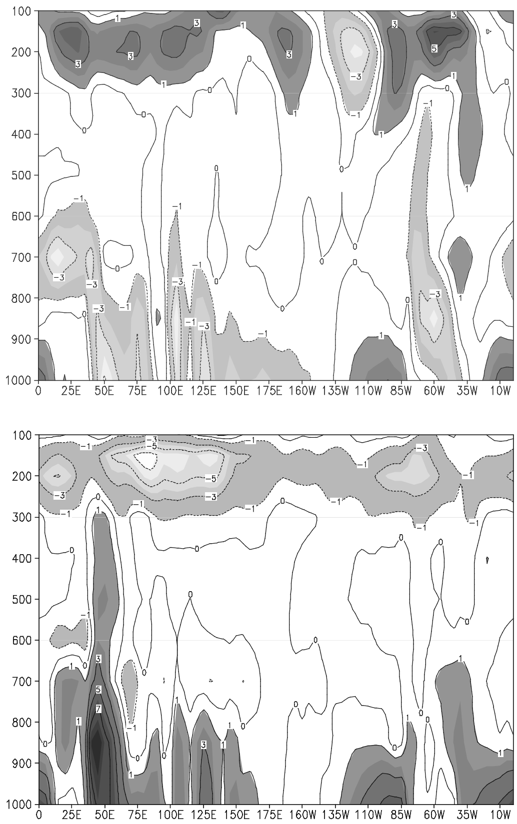

Fig.1 Global cross-equatorial flows for January and July. Unit: m/s. The ordinate is for the layer and the abscissa for the longitude. The V on the dashed line is negative.

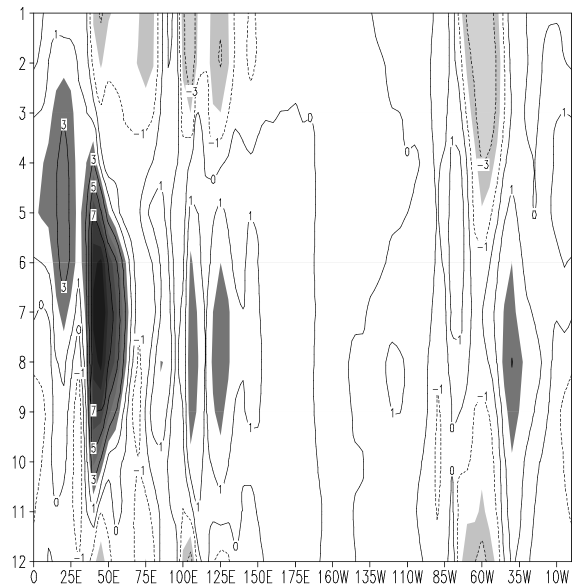

Fig.2 Annual variation of global cross-equatorial flows at 850-hPa. The ordinate is the month and the abscissa is the longitude. The shaded area indicates the northerly and southerly winds with absolute values larger than 2 m/s and the V values on the dashed lines are negative.

4 TENDENCY AND INTERDECADAL VARIATION OF GLOBAL CROSS-EQUATORIAL FLOWS

4.1 *Long-term tendency*

Fig.3 gives the tendency coefficients of the 850-hPa cross-equatorial flows across the globe[7]. It is seen that their long-term variation is shown by four strengthening flows in the Eastern Hemisphere and one weakening flow in the Western Hemisphere. It shows that the cross-equatorial flow at 130°E – 140°E has very strong positive tendency from May to September, with a coefficient of 0.76, or a mean increasing rate of 0.32 m/s every 10 years. The regional cross-equatorial flows are just moderate, averaging at 1.14 m/s, followed by the one at 105°E. It has a tendency coefficient of 0.68, strengthening by an average of 0.26 m/s every 10 years. On the contrast, the Somali Jet at 45°E – 50°E is the strongest of all, with a tendency coefficient of 0.54, strengthening by an average of 0.25 m/s every 10 years. In contrast, in June – August, the cross-equatorial flow is 1.82 m/s in average between 50°W and 35°W in the Western Hemisphere, with a tendency coefficient of –0.22, decreasing by 0.07 m/s every 10 years.

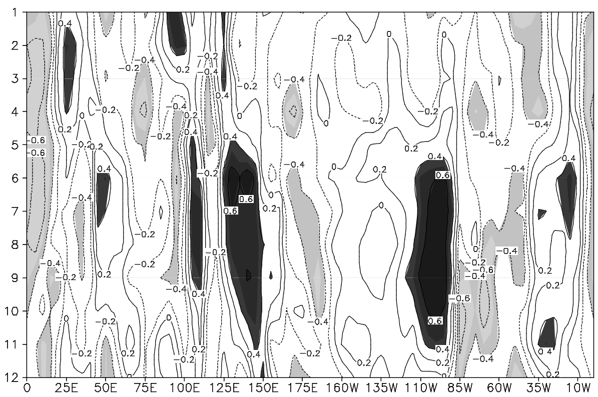

Fig.3 Tendency coefficients of global cross-equatorial flows at 850 hPa. The ordinate is the month and the abscissa is the longitude. The shaded area is where the absolute values are larger than 0.4 and surpass the 0.01 significance test.

4.2 *Interdecadal and abrupt changes of climatological variation of global cross-equatorial flows*

In addition to long-term tendency variation, part of the global cross-equatorial flows are also marked with significant interdecadal and abrupt changes. As shown in our computation, the cross-equatorial flows at 45°E – 50°E (June – August) and 130°E – 140°E (May – September) significantly strengthened after 1980 (Fig.4). As shown in the *t* statistical test, they reach the reliability of 0.001. Additionally, the former cross-equatorial flow also varies at the interdecadal scale in June – August. It was much weaker in early 1950s than the middle and late stages of the decade. The Somali Jet was very weak from the beginning of 1960s to mid-1970s. It began strengthening in mid-1970s and has maintained at high levels of intensity ever since. It shows that the significant interdecadal abrupt change in the middle and late stages of the 1970s taking place in the atmospheric circulation is also evident in the cross-equatorial flows.

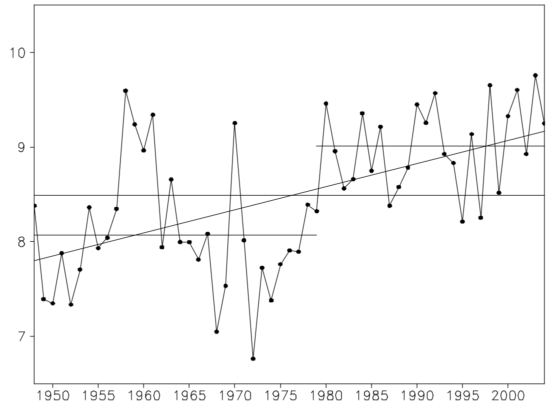

Fig.4 Temporal variation of the 45°E – 50°E cross-equatorial flows for June – August, 1948 – 2004. The straight line is the regression and the horizontal straight line stands for the mean of different sections of time. The ordinate is the wind speed in the unit of m/s.

4.3 *Singular Spectrum analysis (SSA) of cross-equatorial flows*

With the method of SSA and by taking a backward extension of M = 12 years, it is determined that the variance contribution reaches 37.7% for the tendency variation of the Somali Jet in summer, in addition to a quasi-20-year interdecadal variation. For its counterpart in the western Pacific, it is 45%, plus oscillatory periods of 10-11 years and 20 years. They all have periods of 2 to 4 years but with variance contribution less than 30%. It shows that the cross-equatorial flows are marked with large tendency variation and interdecadal variation while the variance contribution is usually less than 1/3 for the interannual oscillation within 10 years.

For analyses of other aspects, refer to the Chinese edition of the journal.

5 CONCLUSIONS

(1) In either January or July, the cross-equatorial flows are stronger in the Eastern Hemisphere than in the Western Hemisphere. They vary with the month on 850 hPa. There are five zones of longitude through which flows are transported southward across the equator in January.

(2) Significant positive tendency is found in the

cross-equatorial flows at 45°E – 50°E (June – August), 105°E – 115°E (May – September), 130°E – 140°E (May – November) and 20°E – 25°E (February – April). There is negative tendency in the cross-equatorial flow in summer at 50°W – 35°W, which decreases at 0.07 m/s every 10 years. From May to September, the cross-equatorial flow at 130°E – 140°E increases at 0.32 m/s every 10 years.

(3) After 1980, the cross-equatorial flow over Somali and at 130°E – 140°E increased significantly while the one at 105°E – 115°E strengthened substantially in early 1970s.

(4) For the variation of cross-equatorial flows in the Eastern Hemisphere, about 45% of the variance are made up of long-term tendency variation and interdecadal variation, with the latter taking up 30%.

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