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MEDIUM-RANGE OSCILLATION OF METEOROLOGICAL ELEMENTS AT GREAT WALL STATION, ANTARCTICA

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Abstract A method of multi-spectral analysis is used to study the spectral characteristics of surface and upper-level meteorological elements over the Great Wall Station (62°12'S, 58°57'W), Antarctica and their phasecorrelation, propagation of mean oscillation at 500hPa level in the Southern Hemisphere and their corresponding synoptic sense. the results are summed up as follows: 1. Over the sub-Antatctic zone, as in the Northern Hemisphere there generally exist quasi-weekly oscillation and quasi-biweekly oscillation. In different seasons the oscillations of meteorological elements are different: in winter season quasi-biweekly oscillation is dominant, while in summer season quasi-weekly oscillation is dominant. 2. From the Earth's surface to the lower stratosphere there is a distinct quasi-weekly oscillation at each isobaric surface, but the most intense oscillation appears at 200—300hPa, and the oscillations of height and temperature are propagated downward. 3. Both in winter and summer seasons the quasi-biweekly oscillation are propagated from west to east, and the mean velocity of its propagation is about 7—17 longtitude / day. 4. The quasi-biweekly oscillation and the quasi-weekly oscillation over the sub - Antarctic zone are closely related to the activity and intensity variation of polar vortex at 500hPa, while at 1000hPa they reflect an interaction between the circumpolar depression and the sub-tropical high. The quasi-biweekly oscillation may be a reflection of inherent oscillation of the polar vortex, where as the quasi-weekly oscillation is a result of forced oscillation by external disturbance.

A large number of calculations and analysis made reveals the features of medium-range oscillation over the sub-Antarctic zone. The results are of significance for understanding the behaviour of synoptic dynamics and making the weather forecast.

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Key words Antarctic Great Wall Station, Meteorological elements, Multi-spectral analysis method, Medium-range oscillation, Polar vortex.

1. Introduction

The spectrum characteristic of meteorological elements is one of the most important topics in modern synoptic study and many meteorologists have done a lot of research in this field in recent years. Krishnamurti *et al* (1979) made a research on monsoon system in northern hemisphere with the method of spectrum analysis, and discussed mainly the quasi 2-week oscillation of the monsoon system. Yasunari (1979) did a study of the low-frequency oscillation of the Asian monsoon which has a periodic length of about 40 days. Lu Longhua *et al* (1986) discussed the medium-range oscillation of characteristic value of the general circulation over the Qinghai-Xizang Plateau in the summer of 1979, and made a research on the interannual change of medium-range oscillation characteristics and its synoptic sense as well. In Van Loon's study (1972) of the meteorology in southern hemisphere only the annual wave, the semi-annual wave and 2 years cycle of the meteorological elements in southern hemisphere were discussed. The method he used was a method of harmonic analysis.

In this paper, with the method of multi-spectrum analysis, we study the spectrum characteristics of the surface meteorological elements obtained over the Great Wall Station (GWS).

the sounding data over Frei station (July-October, 1985) which is 2.5 km away from GWS, isobaric surface height field of 500hPa in southern hemisphere (1986), and the vertical structure spatial distribution and the propagation characteristics of the medium-range oscillation in this area, and we also primarily discussed the synoptic sense of the quasi 1-week oscillation and the quasi 2-week oscillation.

The method used is just similar to those used by Jenkins, Watts (1968) and Lu Longhua (1984). The characteristics of auto-oscillation for multi-time series and their correlationship are described with auto-spectrum, phase-spectrum and coherence. In order to eliminate the effects of perturbation, the data are treated with a method of 5 days smoothing mean processing, and a difference treatment is applied to the data with distinct tendency. When the convariance is being calculated, the sum only refers to the points where the data have been obtained, the maximum lag is taken to be one third of the total length of the series, using the method of Jenkinsv and Watts (1968), we intensified the frequency points that are used to calculate the spectrum-estimate value. The Zangvil method (1977) is used to determine various dominant oscillation scale and the spectrum characteristics are indicated by the products of power and frequency. The oscillation intensity within a certain cyclic range is indicated with the total variance percentage of this oscillation. The significance of oscillation can be examed with the non-dominant scale.

2. The Main Oscillation Cycle of the Surface Meteorological Elements of GWS

The auto-spectrum characteristics of the station pressure, temperature, humidity and wind velocity at GWS (Jan, 1985—Dec, 1987) are given in Fig. 1. As the data are available only for 3 years, therefore the data are not treated with the difference scheme and only the perturbation is removed from them with 5-day smoothing mean. In Fig. 1, the solid lines indicate the auto-spectrum of various elements while the dotted and dashed lines indicate non-dominant scale cycle hypothesis of 0.05 significance (Zangvil, 1977) and the examing line of red noise. respectively. Fig. 1 shows that like the data from northern hemisphere in general, the surface meteorological elements also have quasi 1-week, 2-week and 3—4 week oscillations. Moreover, with the non-smoothing mean series we've found that these elements also have a distinct 3—5 day cycle of oscillation. In this paper we focus our discussion on the quasi 1-week oscillation as well as quasi 2-week oscillation at GWS.

The phase relationship of the dominant oscillation for station pressure and other elements is given in Table. 1. It shows that in case of quasi 1-week, 2-week and 3—4 week oscillations, the relevant oscillation coherence between pressure and other elements is much higher and there exists a closer relationship, the phases of various oscillations for pressure all have a lead with respect to those of temperature and humidity oscillations. Among them in general, the phase difference of quasi 3—4 week and 2—week oscillations all have a lead of about 7 days with respect to those of the temperature and humidity oscillations, while the phase of quasi 1-week oscillation for pressure has a lead of about 2 days with respect to those of temperature and humidity oscillation, the phase correlationship of oscillations for pressure and wind is connected with periodic length. Among them the phase of quasi 3-4 week and 1-week oscillations for pressure has a lead of about 4 days with respect to that of the oscillation for wind velocity, while for the quasi 2-week oscillation of pressure has a lead of about

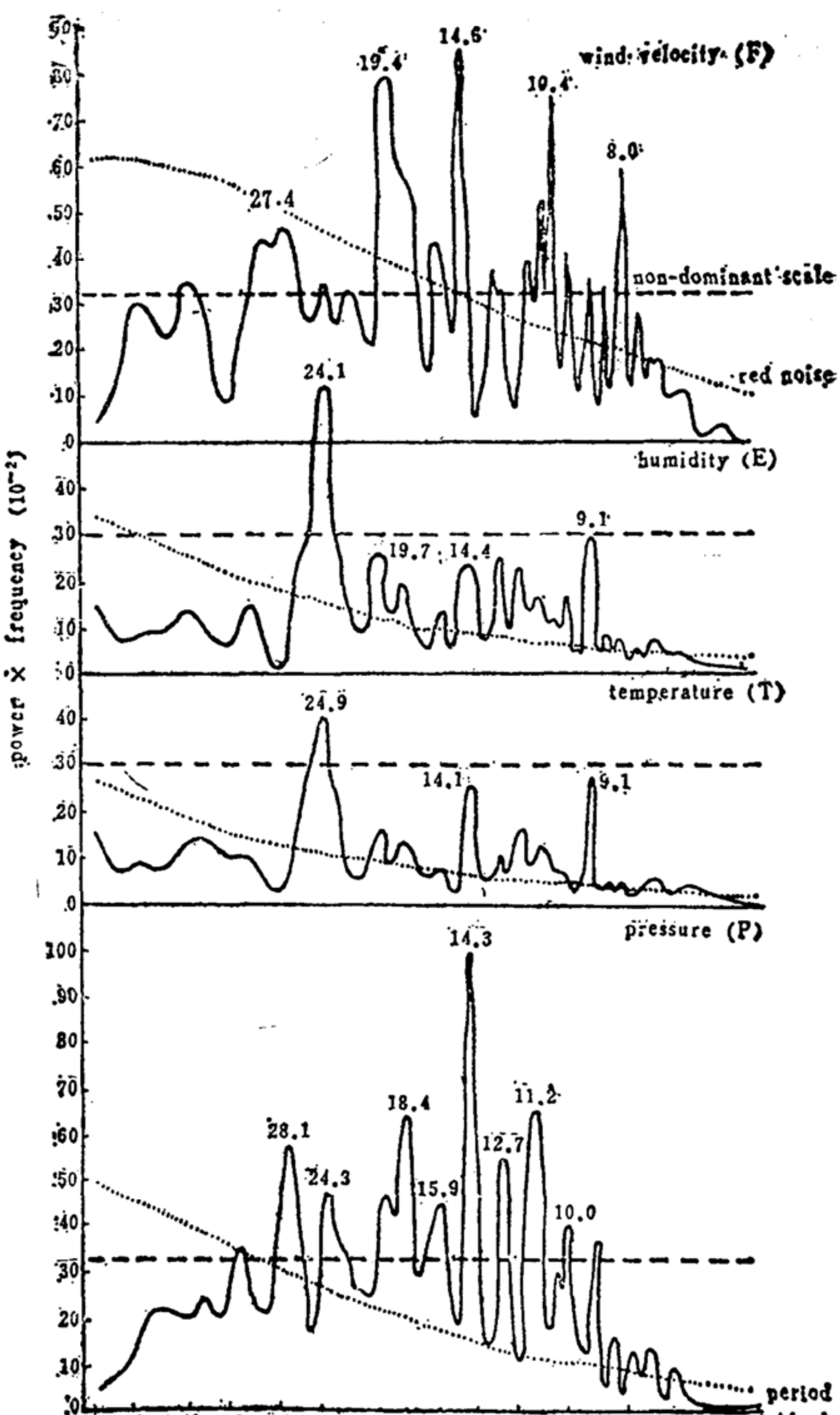


Fig. 1 The auto-spectrum characteristics of the pressure, temperature, humidity and wind velocity (PTEF) at GWS.

2.7 days with respect to that of the wind velocity oscillation.

In different season the characteristics of oscillations for various elements are different. The medium-range oscillation characteristics for surface meteorological elements at GwS in

Table 1. The phase-relationship of main oscillation between surface pressure and other elements at GWS.

surface meteorological element		pressure	temperature	humidity	wind velocity
3—4 weeks (21.5—28.1 days)	phase difference (day)	0	7.5	6.8	—4.0
	coherence (%)	100	57	70	57
2 weeks (13.5—15.5 days)	phase difference (day)	0	7.2	6.8	2.7
	coherence (%)	100	47	63	52
1 week (8.5—9.5 days)	phase difference (day)	0	1.9	2.3	—4.4
	coherence (%)	100	72	77	54

the winter and summer of 1987 are shown in Fig. 2. The characteristics of 1–week and 2–week oscillations over GWS can be seen clear in Fig. 2. From this fig, we can also see clearly that in the winter and summer of 1987, various elements had quasi 1–week and 2–week oscillations and the intensity of quasi 2–week oscillation was stronger than that of quasi 1–week oscillation. In the summer of 1987, quasi 2–week oscillation did not occur and the case is just similar in other years. In the summer season though there did occur 2–week oscillation, its intensity would be weaker than that of 1–week oscillation, therefore, we can say that the characteristics of the medium-range oscillation is of mainly 2–week scale in the winter, while in the summer is of mainly 1–week scale.

3. The Vertical Structure of Medium-Range Oscillation Characteristics

In this paper the vertical structure of medium-range oscillation characteristics over the area of King George island are discussed with the sounding data (July-Oct, 1985) at Frei station. We have not conducted upper level sounding over GWS.

The vertical structure and the phase relationship of the oscillations of contour height and temperature are given in Fig. 3 and Fig. 4 respectively. From them we could see that in this area from the surface to the mid-and lower stratosphere, for the isobaric surface height at each layer exists quasi 2–week oscillation and length of the dominant scale changes a little while the oscillations at 200–300hPa level are maximum. Between each layers below 150hPa, the phases of quasi 2–week oscillation for heights are the same, the phase differences are within one day. Above the 150hPa level, on each layer, the phase of oscillation at the upper level has a lead with respect to that at the low level. At the 30hPa level the 10–day oscillation phase of contour height has a lead of 1.8 days with respect to that at 250hPa level, and the quasi 2–week oscillation for isobaric surface height is propagated downward. The vertical structure of temperature oscillation for isobaric surface height is quite complicated. Below 500hPa level and above 50hPa level there is mainly 1–week oscillation. Below 500hPa level the phase

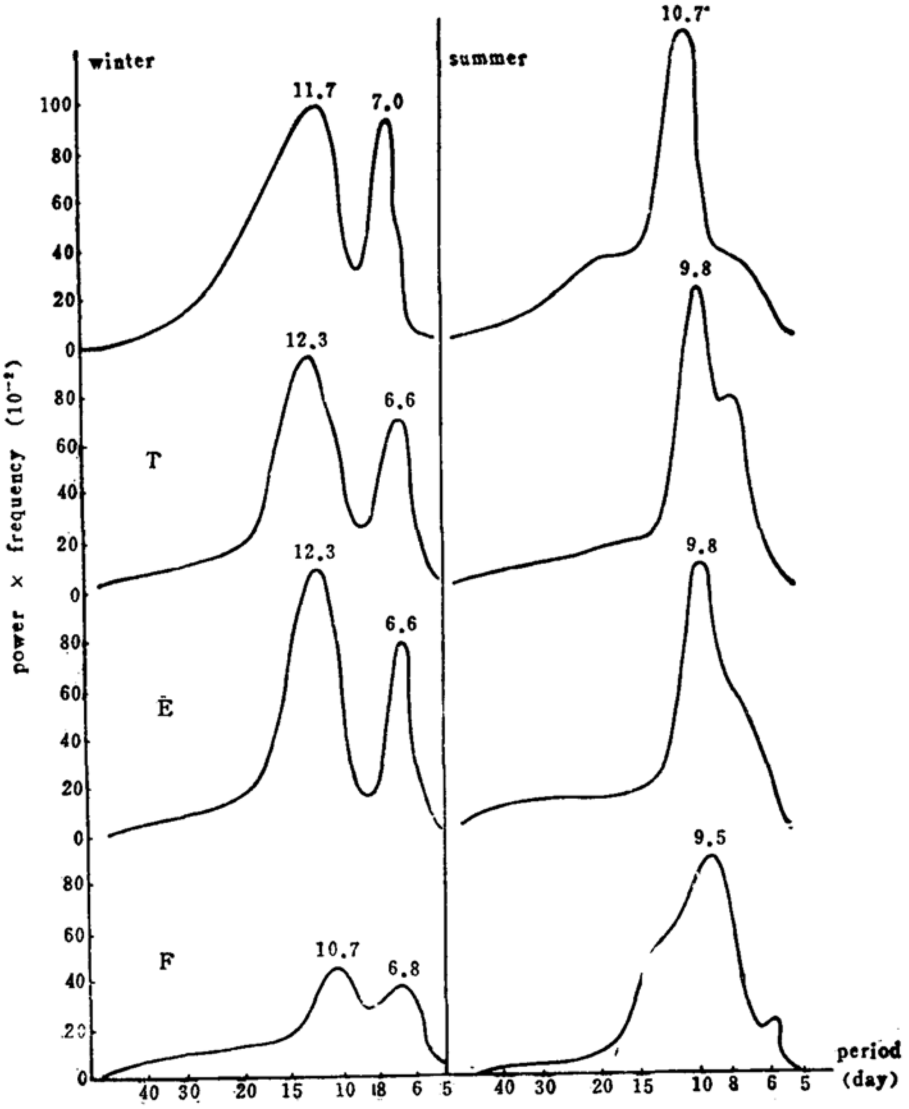


Fig. 2 Characteristics of medium-range oscillation for various meteorological elements at GWS in the winter and summer of 1987.

difference of quasi 1–week oscillation for temperature at each layer is smaller, while above 50hPa level, the phase of oscillation at the low level has a lead with respect to that at the upper level. The phase of 1–week oscillation at 850hPa level has a lead of three days with respect to that at 30hPa level. From 300hPa to 70hPa level, the temperature oscillation at the constant pressure surface are dominated by the quasi 2–week oscillation. The phase of quasi 1–week oscillation at 700hPa level has a lead of about 2.7 days with respect to that at 200hPa level.

4. Spatial Distribution and Propagational Characteristics of the Medium-Range Oscillation

The spatial distribution and propagational characteristics of the quasi 2–week and 1–week oscillations are discussed with the selected data of isobaric surface height at 500hPa in southern hemisphere in the winter half year and the summer half year of 1986 due to the different oscillation characteristics of various meteorological elements in different season.

The spatial distribution of intensity for quasi 1–week oscillation in the summer season

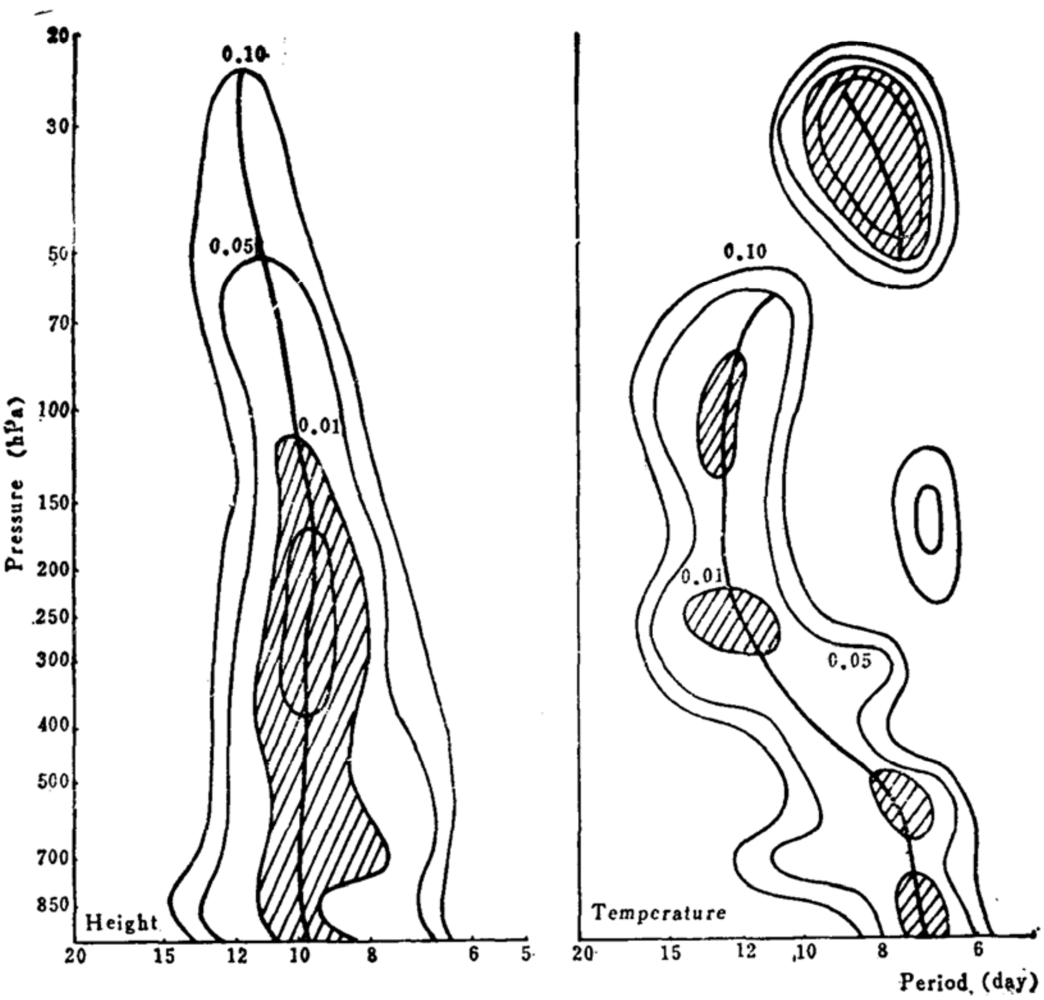


Fig. 3 The vertical structure of contour height and temperature oscillations at the Frei station (The solid line indicates the isoexam of significance for non-dominant scale hypothesis, the shade line area indicates an area where the significance >0.01).

(Sep.-Jan.) of 1986 and of quasi 2-week oscillation in the winter season (May-Aug.) of 1986 is given in Fig. 5.

Here the intensity of quasi 1-week and 2-week oscillations is presented with the percentage of total variance which are respectively made up of the 7.7 — 9.8 days and 11.7 — 16.4 days oscillations. In Fig. 5, the solid line indicates the isoexam of significance for non-dominant scale hypothesis, the shade line area indicates an area where significance > 0.01. From Fig. 5 we can see that the areas of high value for the intensity of 2-week and quasi 1-week oscillations in southern hemisphere occur in a shape of sheets. The spatial distribution of the high value area is closely related to the situation of the circulation at 500hPa level at the same period. For example, over the 60°S parallel near GWS, intensity of the quasi 2-week oscillation in the winter of 1986 occurs in a form of 4-wave distribution in general, while for that of the quasi 1-week oscillation in the summer of 1986 is of 2-wave form. In the same period at 500hPa level over the area of high latitude distributions also occur in the form of 4 waves and 2 waves.

In Fig. 6, the relationship between the difference of the longitude or the latitude and the

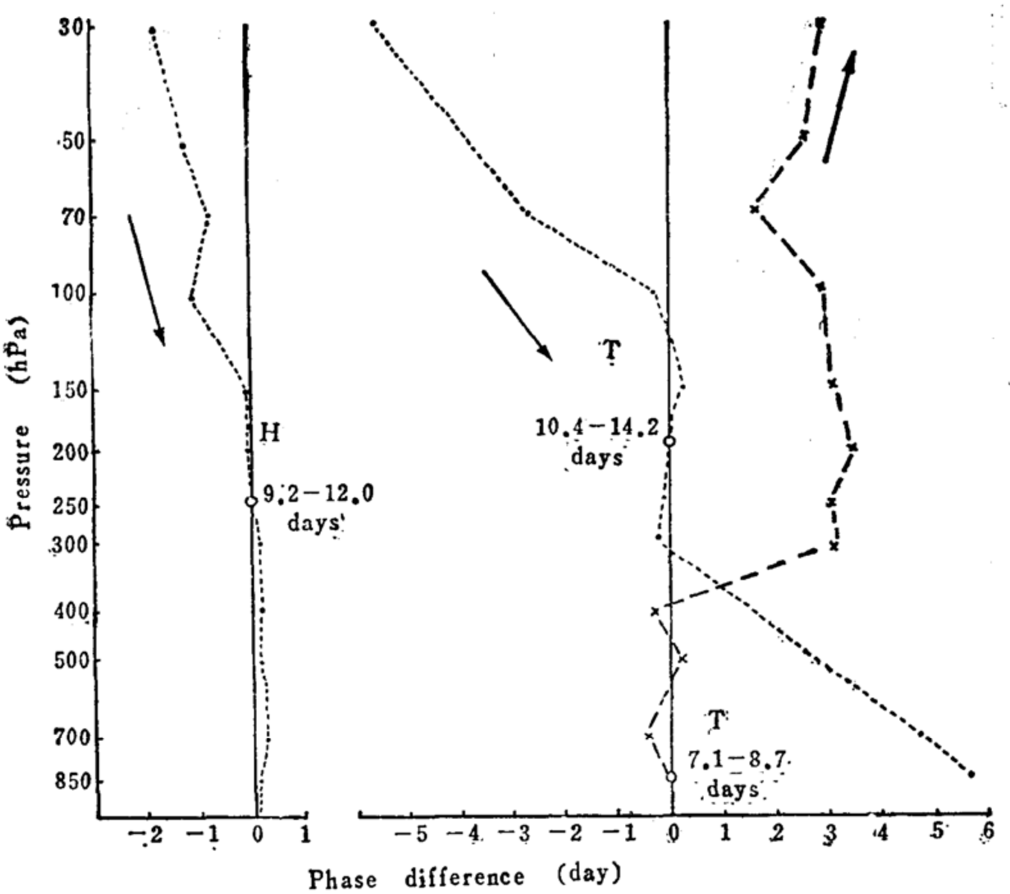
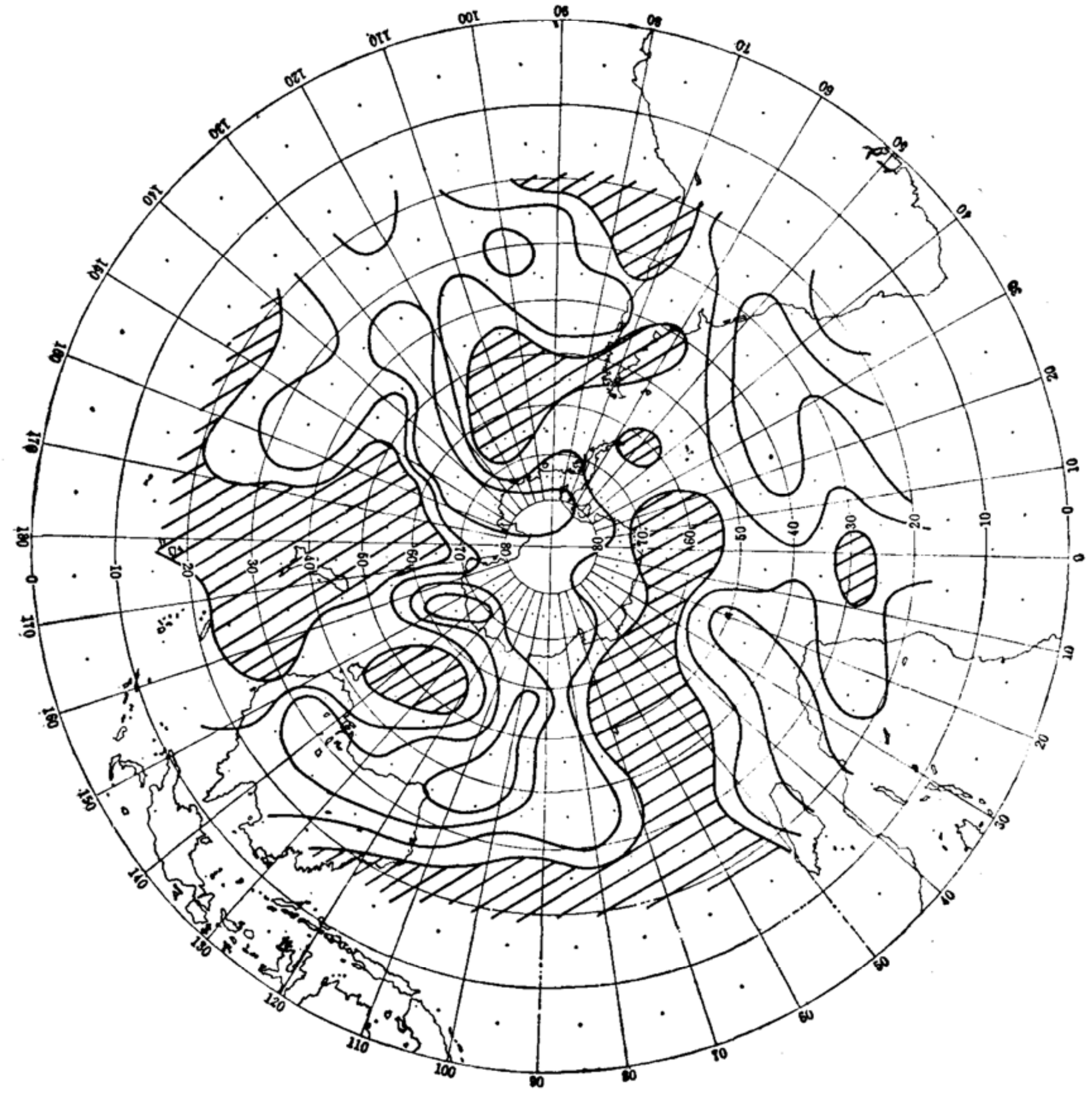


Fig. 4 The phase relationship of the oscillation for contour height and temperature (selected only the points where the coherence is not smaller than 40%).

relevant phase-difference of medium-range oscillation is given at the point of 60° W, 60° S near GWS. Thus the horizontal propagation characteristics of the 1–2week and 2–week oscillations in different season can be determined according to this relationship. In Fig. 6 the propagational direction of oscillation is represented by arrows, L indicates the spatial wave length of oscillation and V indicates the propagational velocity of turbulence.

In Fig. 6 we could see that also in winter or in summer just near GWS, the quasi 1–week and 2–week oscillations all propagate from west to east, while the mean propagational velocity of turbulence is of 7—17 longitudes per day. In winter the propagational velocity and the spatial scale of the quasi 2–week oscillation propagating eastward are all smaller than those of the quasi 1–week oscillation. But in the summer season it is just the other way round. The propagational velocity and the spatial scale for the quasi 2–week oscillation propagating eastward are all larger than those of the quasi 1–week oscillation. In the summer season, the propagational velocity and the spatial scale for the quasi 2–week oscillation propagating eastward are all 2—3 times larger than those in the winter season. Compared with the winter season, in the summer season the propagational velocity and the spatial scale for the quasi 1–week oscillation are all smaller than those in the winter. Their changes are not as big as those of the quasi 2–week oscillation.



(a)

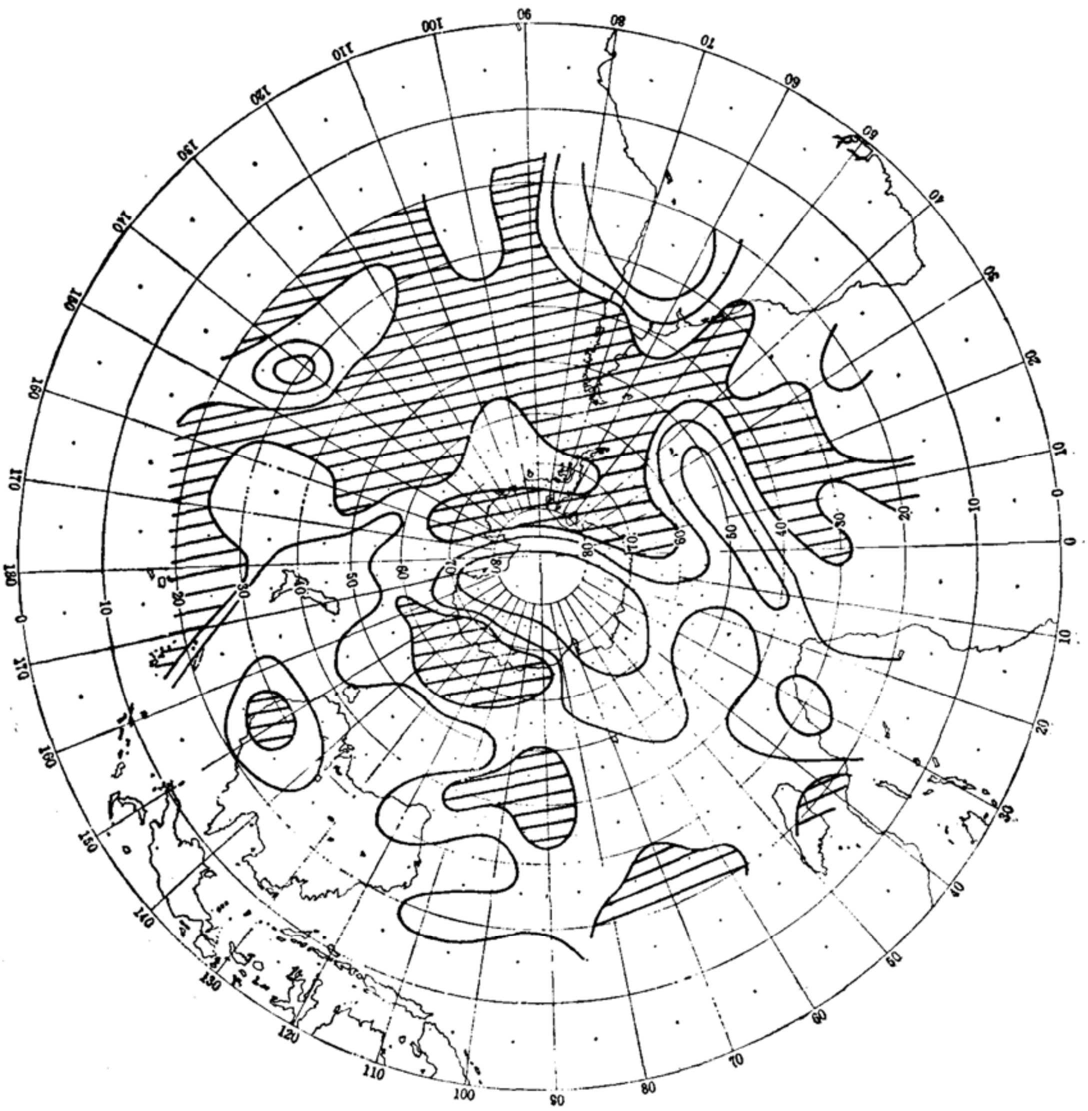
Fig. 5 The spatial distribution of intensity for medium-range oscillation at 500hPa in southern hemisphere, a. Quasi 2-week oscillation in winter;

Near GWS, the longitudinal propagation characteristics for the quasi 2–week and 1–week oscillations are quite complicated due to the existence of both the Antarctic Peninsula and the continent of south America. The quasi 2–week oscillation in the winter and the quasi 1–week oscillation in the summer all propagate northward and their mean velocity of propagation is about 11–12 latitudes per day. The dominant propagating direction of the quasi 2–week oscillation in the summer and the quasi 1–week oscillation in the winter is southward, but there also exist some northward cases. In summer the area of GWS is a sink for quasi 2–week oscillation and the oscillation is affected by turbulences both formed at the high latitude and low latitudes. In winter, the area of GWS is a source and the oscillation propagates to high latitudes and low latitudes. No matter in which direction it propagates, the propagational velocity of the quasi 2-wcek oscillation in summer is about a half of that of the quasi 1-week oscillation in winter.

The propagational characteristics of the quasi 2-week and 1-week oscillations in different seasons given in Fig. 6 coincide with the spatial distribution of various oscillations given in Fig. 5. For example, the spatial scale of the quasi 2-week oscillation in winter is 156° latitudes — 96° longitudes. In Fig. 5a, this scale is represented by 60° W longitude at GWS. There are two zones of high value and three of low value in southern hemisphere. On the whole globe, there are about 2—3 waves. At the 60° S latitude where GWS is situated, there are about 4 waves, the mean wave length is about 90°. All these facts suggest that the characteristics of medium-range oscillation over GWS area are closely related with those of circulations in southern hemisphere.

5. The Synoptic Sense of the Medium-Range Oscillation

In the discussion on the oscillation of a monsoon system Krishnamurti (1976) suggested



(b)

b. Quasi 1-week oscillation in summer.

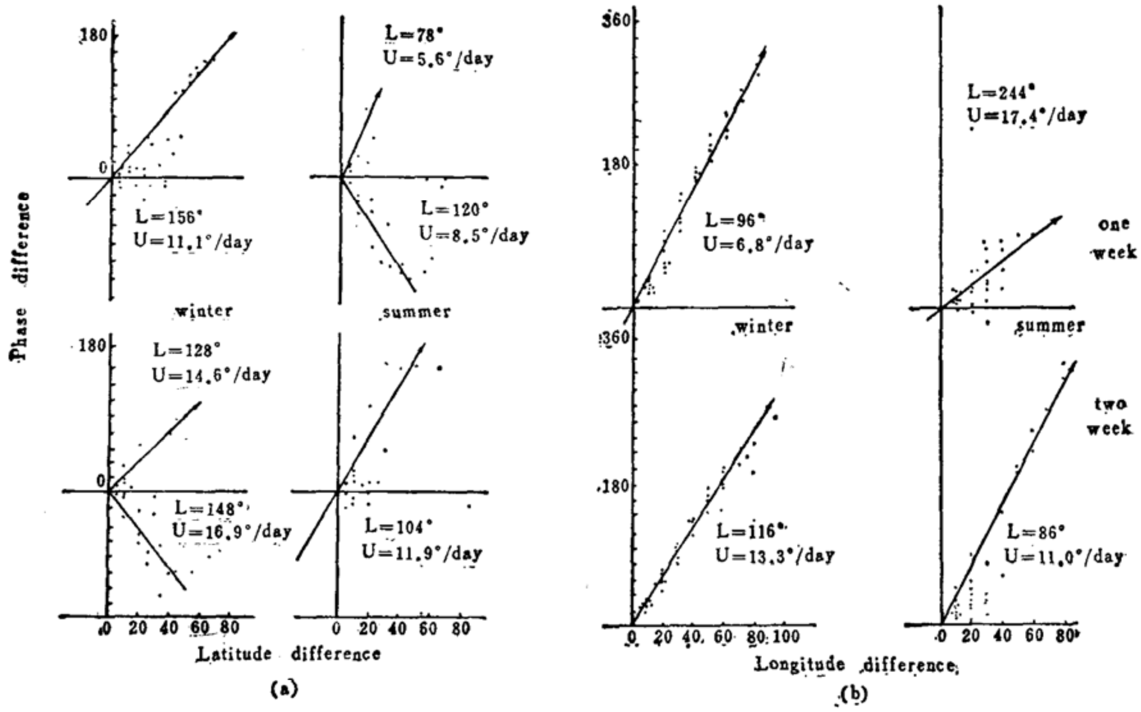
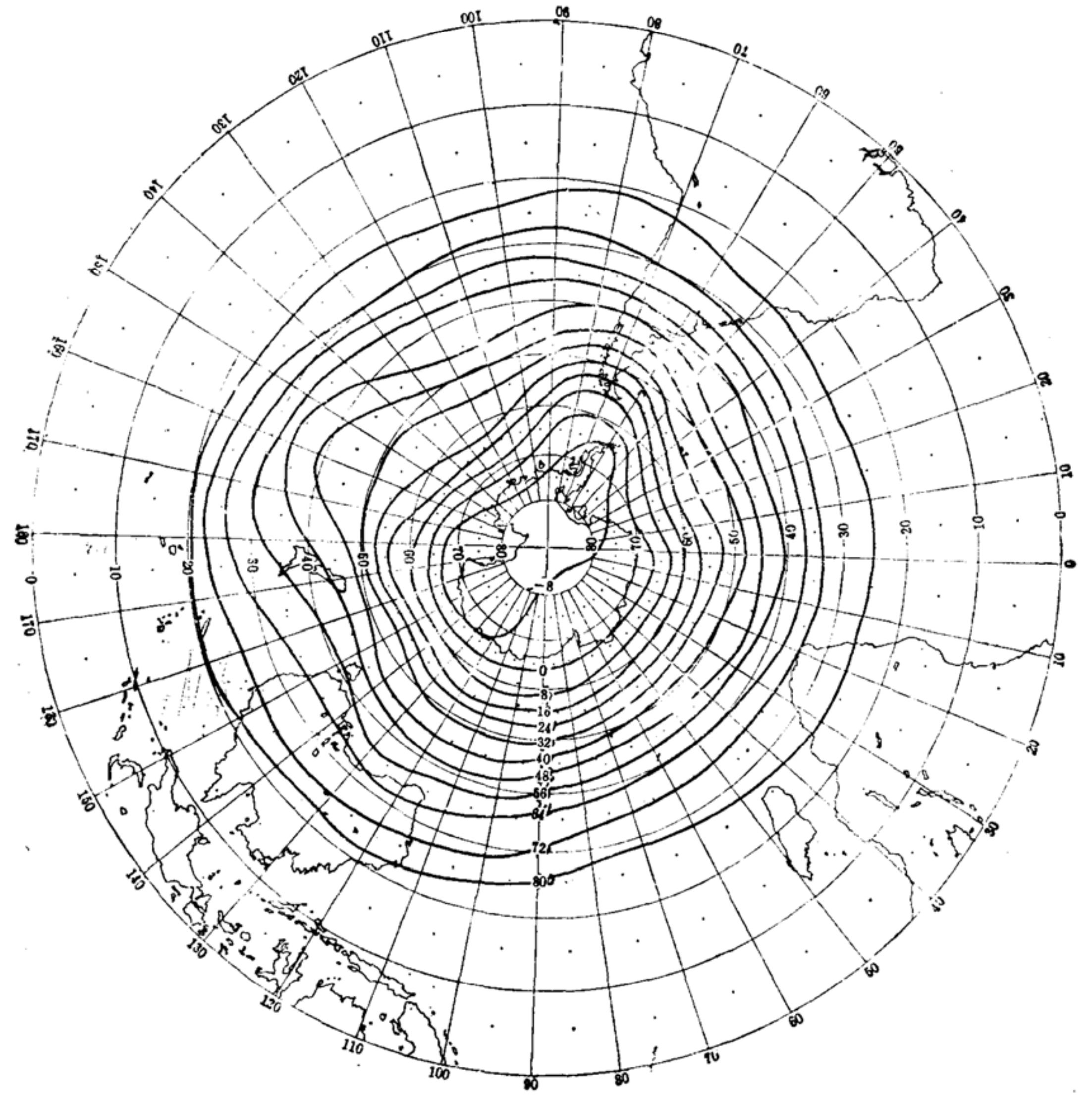


Fig. 6 The horizontal propagation characteristics of quasi 2-week and 1-week oscillations on the cross section of 60° S and 60° W in 1986. a. Along the 60° W cross section; b. Along the 60° S cross section.

that the quasi 2–week oscillation was an intrinsic oscillation produced by the process of large-scale monsoon system, while the quasi 1–week oscillation might be a reflection of the passage of local instability disturbances. In the discussion on medium-range oscillation over the Qinghai-Xizang plateau in summer, Lu Longhua (1986) suggested that the quasi 2–week oscillation might be a reflection of intrinsic oscillation in south Asia while the quasi 1–week oscillation might be a reflection of the forced oscillation of the turbulence of the westerly belt. Characteristics of the medium-range oscillation over GWS area are closely related to the polar vortex in southern hemisphere.

In the winter and summer of 1986, the 500hPa circulation situations were roughly the same when there occurred different phases for the quasi 2–week oscillation over GWS area. The polar vortex was stronger when there occurred low phase and then GWS was located in the area of trough of polar vortex. When there occurred the high phase, the polar vortex would be weaker and then GWS would be located in the area of ridge of the polar vortex.

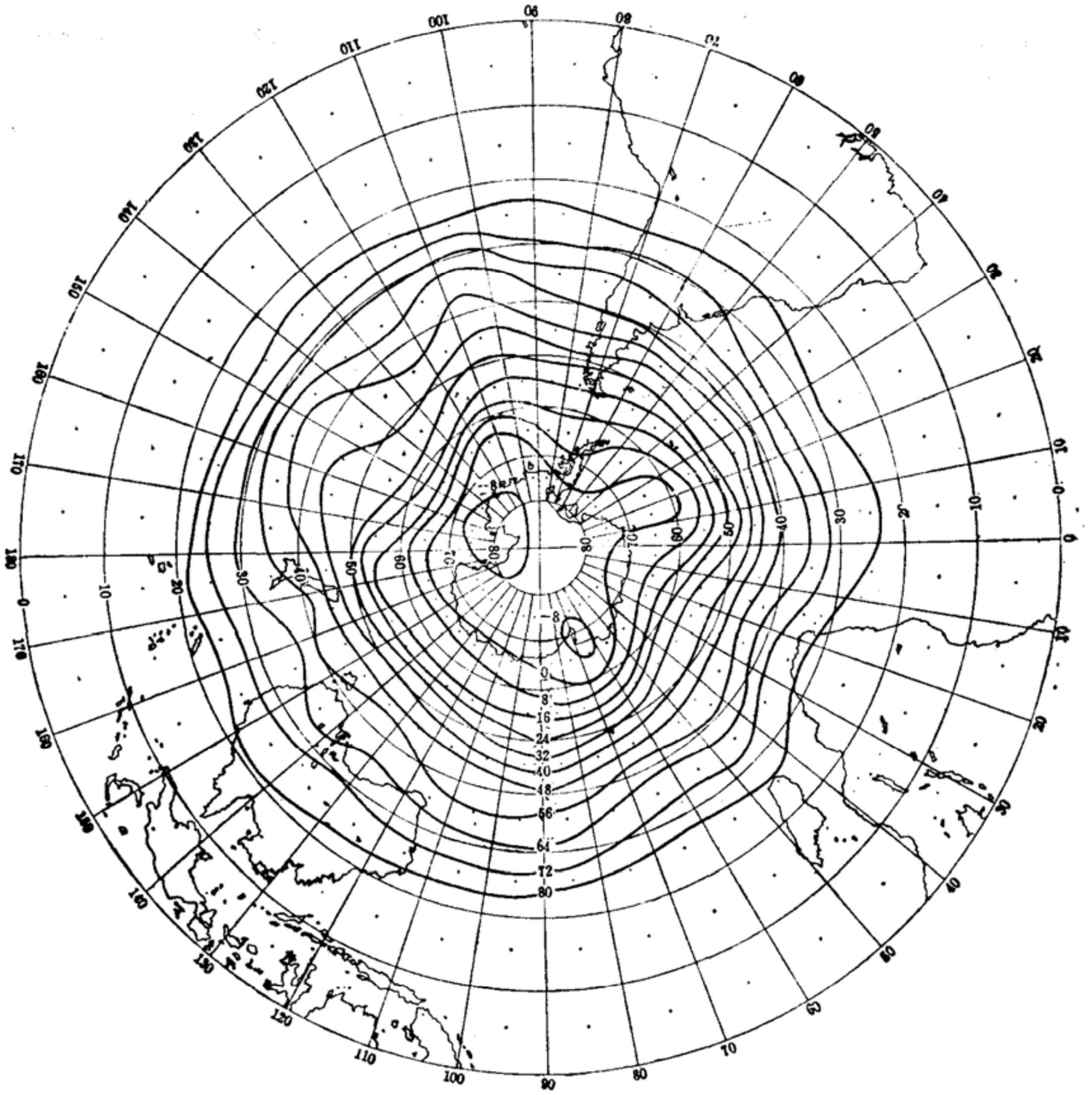
Taking Fig. 7 as an example, the relationship between the 500hPa circulation patten and the different phases of medium-range oscillation over GWS area is given, from Fig. 7 we can see that when there occurs the low phase of the quasi 2–week oscillation over GWS area, the station is generally located at the trough area of the polar vortex, and the polar vortex is stronger, while GWS is controlled by the circumpolar low pressure at 1000hPa level. When there occurs high phase of the quasi 2–week oscillation over GWS area, the station is located in the



(a)

Fig. 7 The composite chart of 500hPa when there occurred the different phases for the quasi 2-week oscillation over GWS in the winter of 1986. a. low phase;

ridge area of the polar vortex, and the polar vortex is weaker. At 1000hPa level, GWS is controlled by a high pressure system which is originated by the southward extension from the western of south Aemrican continent of the sub-tropical ridge, or by the high pressure area between two cells of circumpolar low pressure. From 1985 to 1987, although there existed quasi 2-week and 1-week oscillations over GWS both in winter and summer, in winter quasi 2-week oscillations were relatively stronger, when 500hPpa polar vortex was strong, and while in summer, when 500hPpa polar vortex was weak, there would be a domination of the quasi 1-week oscillation, this suggests that both two oscillatory characteristics are related to the intensity of the polar vortex and it is possible that polar vortex is a reflection of an intrinsic oscillation, while the quasi 1-week oscillation may be a reflection of the turbulence-forcing oscillation from outside.



(b)

b. high phase.

6. Conclusions

With the method of multi-spectrum analysis the study of the characteristics of the medium-range oscillation for meteorological elements over the area of GWS is conducted, the results are as follows.

(1) Like the situation in northern hemisphere, over the Antarctic there exist generally 3–5 day, quasi 1-week and 2-week oscillations. The characteristics of oscillations for various meteorological elements in different seasons are different. In winter it is dominated by the quasi 2-week oscillation, while in summer it is dominated by the quasi 1-week oscillation.

(2) Over the area of the King George Island where GWS is located, there existed a distinct quasi 2-week oscillation at the isobaric surface height of each layer from surface to stratosphere through July to October, 1985. The dominant scale of this oscillation changed a little. The intensity of the oscillation at 200–300hPa level was maximum. The temperature oscillation at the constant pressure surface was complicated. In the low troposphere and the

mid-stratosphere it was dominated by the quasi 1-week oscillation, while at the upper troposphere and the low stratosphere (300–70 hPa) it was dominated by the quasi 2-week oscillation. The height oscillation and the quasi 2-week oscillation for temperature were both propagated downward.

(3) In both winter and summer, near GWS, the quasi 2-week oscillation propagating from west to east and the mean propagational velocity is about 7–17 longtitudes per day. While the quasi 2-week oscillation in the winter and quasi 1-week oscillation in the summer propagating from south to north and their mean propagational velocity is about 11–12 latitudes per day. The quasi 2-week oscillation in the summer and the quasi 1-week oscillation in the winter are complicated; though the dominant propagational direction is southward, there are also some cases of northward propagational direction. The south-north propagational direction is connected with the length of oscillation.

(4) The 2-week and 1-week oscillations over GWS are closely related to the activity of trough and ridge for 500hPa polar vortex and the variations of their intensity. At the same time, at 1000hPa level, they reflect the influence of the activities of circumpolar low and subtropical high. Over the Antarctic area the quasi 2-week oscillation might be a reflection of polar vortex, while the quasi 1-week oscillation might be a reflection of turbulent forcing oscillation from outside.

A large number of calculations and analysis have revealed the characteristics of the medium-range oscillation over GWS. The results are of significance to the understanding of the behaviour of synoptic dynamics and the making of weather forecast. Further studies for the synoptic sense and the transmission mechanism are required with longer data series.

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