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Study of the climatic teleconnection between the Siberian high and maritime continent warm pool

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Abstract This paper attempts to establish a method for analysing the relationship between the polar and equatorial climate of the Northern Hemisphere. The Arctic Oscillation (AO) is known to have no direct relationship with the monsoon over the Maritime Continent (MC). Thus, an index called the Siberian High(SH)–Maritime Continent(MC) Index (SHMCI) is developed to represent the mean sea level pressure difference between the SH and the warm pool over the MC. This index indicates a strong link with the monsoon circulation. A positive (strong) value of the SHMCI is associated with strong meridional winds and intense and frequent cold surge events over the South China Sea. The correlation between the AO index and the SHMCI is -0.39, which is medium but statistically significant; however, it is not sufficiently conclusive to infer direct correlation. Nevertheless, the SHMCI can be used as a tool to relate the AO with the monsoon over the MC because of the influence demonstrated by the AO towards the SH. Further analysis on the convergence and divergence anomalies over the MC reveals an impact discernible only from the SHMCI. This implies that the SHMCI manifests clearly the relationship between the Arctic and equatorial climate.

Keywords **polar to equatorial climatic teleconnection, Arctic Oscillation, Asian Winter Monsoon, Siberian High-Maritime Continent index, convergence and divergence**

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1 Introduction

This paper investigates the effect of the Arctic climate on the climate of the near equatorial region over the Northern Hemisphere, focusing on the Maritime Continent (MC). This is achieved by analysing its impact on both the Siberian High (SH) and the Asian Winter Monsoon (AWM). In an earlier study, Lin et al.[1] reveal that the winter Arctic Oscillation (AO) and tropical forcing are correlated on the inter-annual variability time scale. This is based on the linear regression between the global vertically-averaged thermal forcing and the time series of the observed and simulated AO indices, when a belt of heating is observed along the global tropics with a maximum south of the equator. In another study by L'Heureux and Higgins[2], the relationship between the AO and the Madden-Julian Oscillation (MJO) during winter over the equatorial region shows an association in the progression of the eastward movement of the active MJO and the signal of the AO. The AO and the MJO also share several similar features. For example, during the western hemisphere shift of the MJO, the anomalous patterns of the 500-hPa geopotential height, zonal winds and surface temperature resemble those that occur during the negative phase of the AO. Thus, the AO is considered one of the principal keys for studying the teleconnection between the polar (Arctic) and equatorial climates. The AO, first studied by Thompson and Wallace[3], is a mode of atmospheric variability in which the atmospheric pressure over the Arctic regions varies contrarily with that over the mid-latitudes (about 45°N) on time scales ranging from weeks to decades[4].

The AO has a strong effect on the variability of the SH and as a principal component of the AWM, the SH was used to study the teleconnection between the Arctic and equatorial climates. It was believed that the air movement between the mid-latitudes and the polar region is affected by the AO[3]. During the positive phase, the polar vortex is

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stronger, isolating the air over the polar region and preventing the cold air in the Arctic from moving equatorward and thus, the mid-latitudes experience warmer temperatures. In Siberia and East Asia, the most recognised effect of the AO is reflected in the temperature. The correlation between the AO Index (AOI) and the temperature over Eurasia was 0.55[3]. The warmer air also causes a weaker SH, which has an effect on the weather around it, especially in East Asia[5]. Park et al.[6] noted that the variability of precipitation and snowfall over East China, Korea and Japan can be associated with the different phases of the AO. A positive AO causes a weaker SH, resulting in a milder monsoon season over East Asia and below-average snowfall and precipitation. During the negative AO phase, the movement of the cold Arctic air dips further towards Siberia, resulting in a stronger SH. The winter season becomes intense with higher precipitation recorded in East Asia[6].

Gong et al.[7] observed that the East Asian Winter monsoon is affected by the AO via the variability of the SH. In their study, correlating the AO and the SH, an index representing the intensity of the SH based on the mean sea-level pressure (MSLP) average over the region 70°E–120°E and 40°N–60°N was created. The correlation between the AO index and the SH index was –0.48, which is statistically significant at above the 5% level. The negative values indicate an anti-correlation, implying that a weaker SH is associated with positive AO and vice versa. The effects of the AO on the development of the SH are related to the modulation of the surface temperature over Eurasia and the circulation above the Siberian-Mongolian plateau. A warmer Siberian-Mongolian region induces a weaker SH and at the same time, weaker convergence aloft results in a weaker SH. Although the relationship between the AO and the surface temperature over China is weak, it is believed that the SH is important in connecting the AO and the surface temperature variability over China[8].

The high pressure of the SH contributes to the eastward and southward movement of surface air and as it moves southward, the return flow from the equator in the upper levels completes the Hadley circulation[9]. The southward movement of the cold air, combined with the warm and moist easterly from the tropical Pacific in the MC, causes intense convective systems over the region with prolonged thunderstorms and showers[10]. The surges of cold air occur intermittently, causing a temperature fall, frost, freezing rain and heavy snowfall over East Asia[11-12]. The cold surges can be observed throughout the entire region affected by the winter monsoon. Chang et al.[13] explained the cold-surge events as outbreaks of cold air that occur a few times per month as a result of the strengthening and the propagation of the SH to the southeast. This leads to the acceleration in the movement of the northwesterly air and a fall in temperature over East Asia. The cold surges are also affected by the East Asian Trough. Wu and Wang[14] discussed the effects of the East Asian Trough on the AWM, in which a weak East Asian Trough at the 500-hPa level was associated with a weak East Asian Winter Monsoon. This is also related to the strong zonal steering aloft, causing a weaker meridional wind component in the lower troposphere. Another study by Park et al.[6] stated that the modulation of the cold-surge activity over East Asia is related to the phase of the AO. A negative AO phase results in a stronger cold surge due to the strong cyclone-anticyclone couplet. Conversely, a positive AO phase results in weaker surges. As promising as it may sound, the relationship between the AO and the AWM is still weak, whereas the relationship between the AO and the SH is stronger[14].

Lau and Boyle[15] defined the cold surge via a number of criteria, including a surface temperature drop of more than or equal to 5℃ in Hong Kong, a sea-level pressure difference between coastal and central China of more than or equal to 5 hPa and a prevailing northerly wind of more than or equal to 5 $\mathrm{m\cdot s^{-1}}$ in the northern part of the South China Sea (SCS), within a 24–48 h period. The surges can occur as early as October but, on average, most occur from November to March[16]. The maximum surge frequency is in November and the minimum surge frequency is in February. Zhang et al.[16] also mentioned that most of the strong cold surges occur during very cold months, which implies the importance of a strong meridional pressure gradient that results in a strong meridional wind over the SCS. Zhang et al.[16] defined a few extra characteristics of cold surges to relate the events to the El Niño–Southern Oscillation (ENSO). This a quasi-periodic oscillation with an average of period of 2 to 5 years, which affects the climate pattern of the Pacific basin, the MC and the monsoon. The additional characteristics of the cold surges are that the centre of the SH must be more than or equal to 1 035 hPa, the temperature drop over central China must be more than or equal to 9℃ and the surface temperature drop over southern China must be more than or equal to 6℃. The study of the relationship between the cold-surge events and ENSO has resulted in a significant relationship between the cold-surge activities and the SO index. Fewer surges over the SCS occur when the SO index is negative and vice versa. Another definition of the cold surges, which focuses on the activity of the surges over the southern part of the SCS, was proposed by Chang et al.[13] in which the cold surges are said to occur over the area of 110°E–117.50°E along 15°N, when the meridional wind exceeds 8 $\mathrm{m\cdot s^{-1}}$. The study focuses more on the Borneo Vortex and the impacts due to the MJO. For this study, the definition of the cold surge will be the same as that defined by Chang et al.[13], because it relates to the surge events over the MC.

This paper investigates the teleconnection between the Arctic to equatorial climates by looking at the relationship of the AO with the AWM over the MC. The study focuses on an investigation on the wind circulation, which is the principal component of the monsoon. This also includes the cold surges, which are the principal signature of the northeast monsoon. The relationship between the AO and the AWM over Malaysia will be investigated through the Siberian High-Maritime Continent Index (SHMCI). The index represents the mean sea-level pressure difference between the SH and the warm pool region of the MC. The findings from this study can be used as a method for studying and predicting both the intensity of the monsoon over the SCS and the relationship between the Arctic and equatorial climates. After introducing the data and methodology, the analysed results are discussed and the final section concludes with the use of the SHMCI to link the Arctic climate to that of the equatorial region.

2 Data and methodology

Daily and monthly MSLP, u- and v-component winds and vertical velocities from the National Centers for Environmental Prediction/National Center for Atmospheric Research reanalysis data are used. The data are 2.5°×2.5° in resolution and cover a period from 1948 to 2010. The AOI for 40 winter seasons (November to March from 1970 to 2010) is obtained from the National Oceanic and Atmospheric Administration's Climate Prediction Center website[17]. The latest climatological base period used is 1971–2000.

Based on the AOI, the positive and negative phases are characterised and the variations of MSLP of the SH, as well as the wind components (lower and upper levels) over the Northern Hemisphere (0–90°N and 0–360°) are observed. Correlation analyses between the AOI and MSLP over the SH region and between the AOI and the 925-hPa air temperature are performed.

The SHMCI is defined as the MSLP difference between the SH area (80°E–120°E, 40°N–60°N) and the MC warm pool (10°S–10°N, 100°E–140°E). The index is calculated by subtracting the seasonal average MSLP over the SH and MC areas and the values are then normalised with respective standard deviations. The selection of the SH region is based on the centre of action of the SH and that of the MC region is based on the region of low MSLP over the equator. The MSLP difference between the SH and the MC is calculated as:

$$Z = \mathrm{MSLP}_{\mathrm{SH}} - \mathrm{MSLP}_{\mathrm{MC}}$$

where $\mathrm{MSLP}_{\mathrm{SH}}$ is the MSLP of the SH in a particular month of a particular year and $\mathrm{MSLP}_{\mathrm{MC}}$ is the MSLP of the MC for the same month and year. The index is given by:

$$\mathrm{SHMCI}_n = \frac{Z_{n,m} - \bar{Z}_m}{\sigma_m}$$

where $Z_{n,m}$ is a value of the SLP difference for month (m) in year (n), $\bar{Z}_m$ is a climatological average (from 1971–2000) of the MSLP difference for month (m) and σ_m is a climatological standard deviation (from 1971–2000) of the MSLP difference for month (m).

Positive values indicate a high difference of MSLP between the SH and MC and negative values represent a low difference of MSLP between the two regions. In this study, in referring to a specific season of a year, for example, winter 1970, we include the months of November and December 1970 and January, February and March 1971.

Anomalies of the 925-hPa wind components in response to the different phases of the SHMCI and spatial correlation charts are prepared. In studying the frequency of cold surges over the defined wind surge area, a cold surge is said to occur when the meridional wind is equal to or more than 8 $\mathrm{m \cdot s^{-1}}$ in the area 110°E–117.5°E along 15°N[18]. This frequency is calculated from the six-hourly meridional wind components and the total frequency of the cold-surge events is obtained from November to March for each season. A pressure-latitude cross sections of the Hadley circulation with respect to the positive and negative phases of the SHMCI is performed by averaging over 100°E–130°E. Anomalies of the zonal and meridional components over the same cross-section region are also obtained.

Average and anomalous velocity potential analyses at the 925- and 200-hPa levels over the Asian Pacific area, as well as phases analyses of the convergence and divergence during the AO and SHMCI phases in comparison with the SO phases are performed to evaluate the impact of ENSO.

3 Results and discussion

The AO has no direct relationship with the 925-hPa winds and cold surges during the winter monsoon season over a seasonal time scale. When comparing the anomalies of the 925-hPa wind components with the AO phases, the anomalies are at a minimum over the MC. The spatial correlations between the AOI and the 925-hPa wind components (Figure 1) show no significant correlation over the MC. However, the AO has significant impact on the SH, which is the principal component in the AWM. Hence, indirectly, the AO has an effect on the monsoon circulation over the MC. Previous studies have shown a relationship between the AO and the SH, which affects the AWM over East China. Although these studies have demonstrated the significant impact on the monsoon over East Asia, they have not revealed an impact on the wind circulation over the MC, especially over Malaysia. Seasonal correlation studies show that the correlations between the SH and the 925-hPa wind components are significant over East Asia and parts of the SCS (Figures 2a and 2b).

Based on general circulation theory, the pressure difference between the equatorial and the mid-latitude regions induces the southward air movement that results in the Hadley cell circulation. The pressure difference between the subtropical ridge and the warm pool of the MC (equatorial trough) is one of the principal components of the monsoon wind circulation; the higher the pressure difference, the stronger the winds and thus, the stronger the monsoon. This theory is used in developing an index that can indicate the strength of the wind circulation over the East Asian winter monsoon region. This study also investigates the reliability of the SHMCI for studying the monsoon circulation and cold surges. The SHMCI represents the sea-level pressure difference between the SH and the MC. The SHMCI is controlled mainly by the SH; the correlation coefficient between the SHMCI and the SH is 0.81. The correlation coefficient between the SHMCI and the MSLP of the MC is –0.54. The SHMCI seasonal values, shown in Figure 3, indicate the seasonal average signal (positive (strong) or negative (weak)), together with the seasonal MSLP of the SH and the warm pool region. Of the 40 winter seasons studied, 21 are weak seasons and the remaining 19 are strong. During these 40 winter monsoon seasons (1970–2009), a negative value of the SHMCI occurs mostly in the weak seasons (21 seasons).

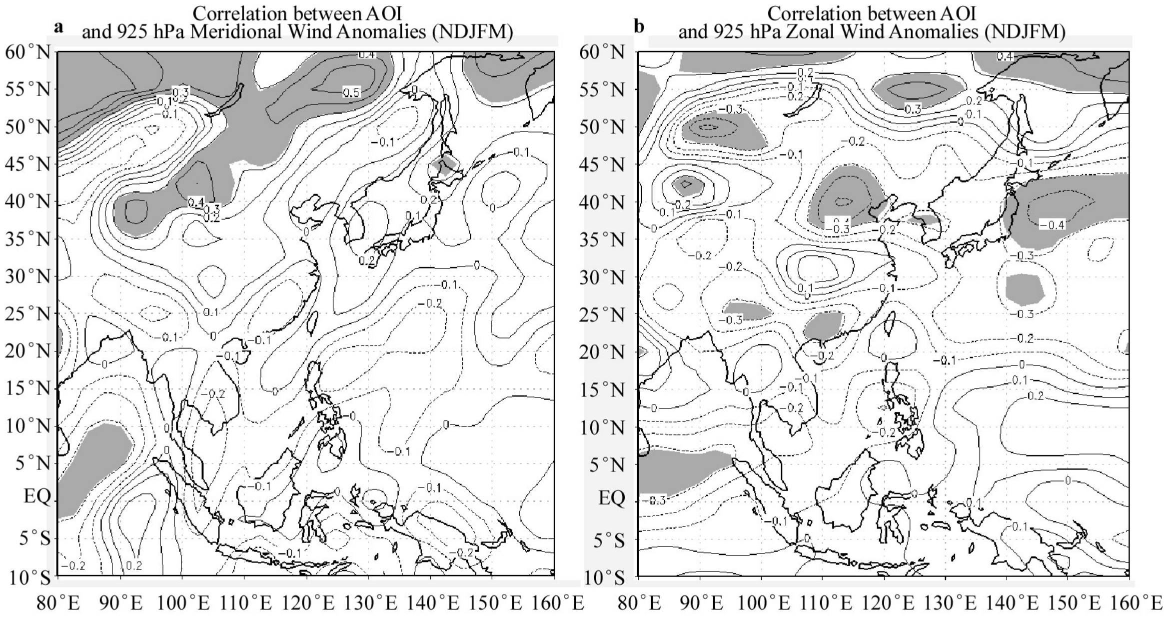

Figure 1 Spatial correlation between the AOI and the 925-hPa meridional (**a**) and zonal (**b**) wind component anomalies. Shaded regions show where the correlation is statistically significant.

The barotropic characteristics of the SCS region motivate this study to focus only on the wind circulation. Based on the 925-hPa wind anomaly studies (not shown), the zonal component is stronger over the SCS region (stronger easterly over the northern part of the SCS and stronger westerly over the southern part) during a positive SHMCI phase and vice versa. For the 925-hPa meridional wind component, a stronger northerly is observed over the SCS region during the positive (strong) SHMCI seasons and a weaker northerly is noted over the SCS region during negative (weak) SHMCI seasons. Stronger wind components over the SCS region indicate a steep sea-level pressure gradient between the mid-latitude and equatorial regions, inducing stronger wind circulations. The spatial correlation maps (Figures 2c and 2d) show that the correlation of the SHMCI and the 925-hPa wind components are significant over the SCS, especially for the meridional component. The grey areas indicate those regions where the correlations are statistically significant.

In the cold-surge study, as shown in Figure 4a, the value of the correlation coefficient between the SHMCI and the average seasonal cold-surge intensity (average values of meridional component) is –0.62. The value of the correlation coefficient between the SHMCI and the frequency of the cold surges during the monsoon season (Nov–Mar), as shown in Figure 4b, is 0.57; both values are statistically significant. On a seasonal time scale, these correlation values are considered relevant and this index reveals the relationship between the MSLP difference between the SH and the MC with the cold-surge activity over the SCS and South East Asia.

The signal of the AO with regard to the monsoon is investigated using the velocity potential to represent the convergence and divergence over the MC at the 925- and 200-hPa levels, to observe the flow patterns of the upper and lower level circulations. The convergence and divergence over the MC are influenced predominantly by the ENSO phenomenon; thus, the influence of other phenomena might be overshadowed. To detect the role of the AO on the MC, phases analyses were performed. These analyses were compared with the Southern Oscillation Index (SOI), which is one of the most significant phenomena over the MC. The analysis examines how strongly the AO affects the convergence and divergence over the MC. Figures 5 and 6 present the composite images of the 925-hPa convergence and 200-hPa divergence over the MC, respectively, through the velocity potential over the 925- and 200-hPa levels, which are mapped in an in-phase and out-of-phase manner (positive AO with positive SO, positive AO with negative SO, negative AO with positive AO and negative AO with negative SO).

In the AO-SO case, the positive AO associated with the weaker AWM should result in weaker convergence over the MC, whereas negative AO should result in stronger convergence over the MC. Figures 5b and 5c are in phase, in which the positive AO and negative SO are associated with weaker convergence over the MC and negative AO and positive SO are associated with stronger convergence over the MC. Figures 5a and 5d indicate that the SO has a dominant effect on the convergence over the MC, which is associated with the El Niño/La Niña phenomena. Figure 5a shows stronger convergence over the MC. This stronger convergence is associated more with the SO rather than the AO. A positive SO results in stronger convergence over the MC, whereas a positive AO should result in a weaker monsoon (weaker convergence) over East Asia (and MC). The same results are shown in the 200-hPa divergence (Figure 6); the divergence over the MC is stronger, reflecting the behaviour of the SO over the MC. Weaker convergence and divergence during the negative AO and SO phases, also signify the strong influence of the SO, because the negative AO is associated with a stronger SH and thus, the monsoon circulation. While the results show no proof of the influence of the AO on the convergence and divergence over the MC, this study compares the SHMCI with the SOI phases to see whether there are differences in the signals regarding the convergence and divergence behaviour over the MC.

In Figure 7a, the negative anomalies during the positive SHMCI and SOI (La Niña) indicate that the 925-hPa level convergence is stronger and in Figure 7d, the positive anomalies indicate a weaker 925-hPa level convergence during negative SHMCI and SOI (El Niño). The centre of the convergence region is closer to the MC during the positive SHMCI and SOI (La Niña) and further from the MC

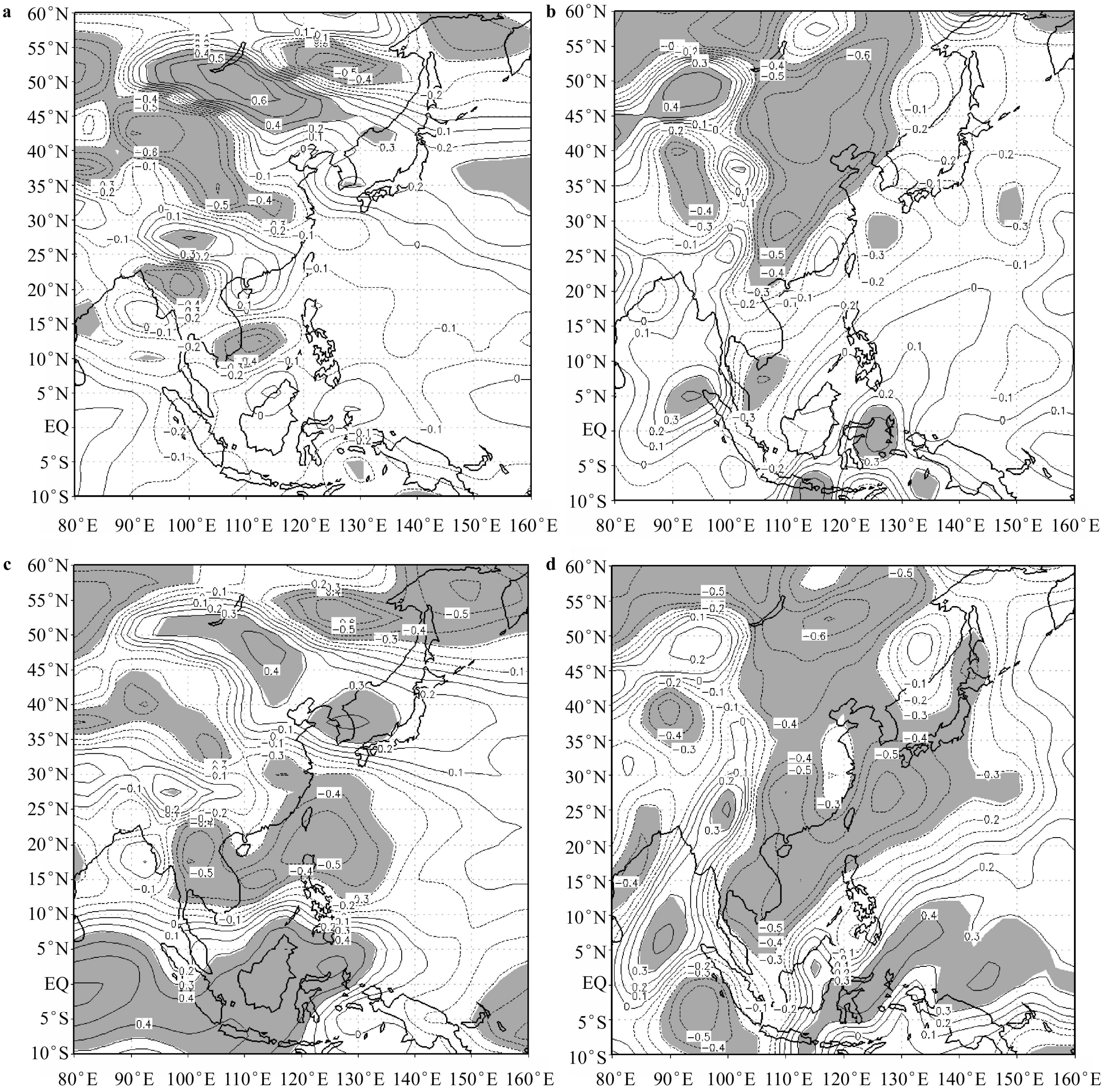

Figure 2 Spatial correlation between the SH MSLP and the 925-hPa meridional (**a**) and zonal (**b**) wind component anomalies. Shaded regions show where the correlation is statistically significant. Spatial correlation between the SHMCI and the 925-hPa meridional (**c**) and zonal (**d**) wind component anomalies. Shaded regions show where the correlation is statistically significant.

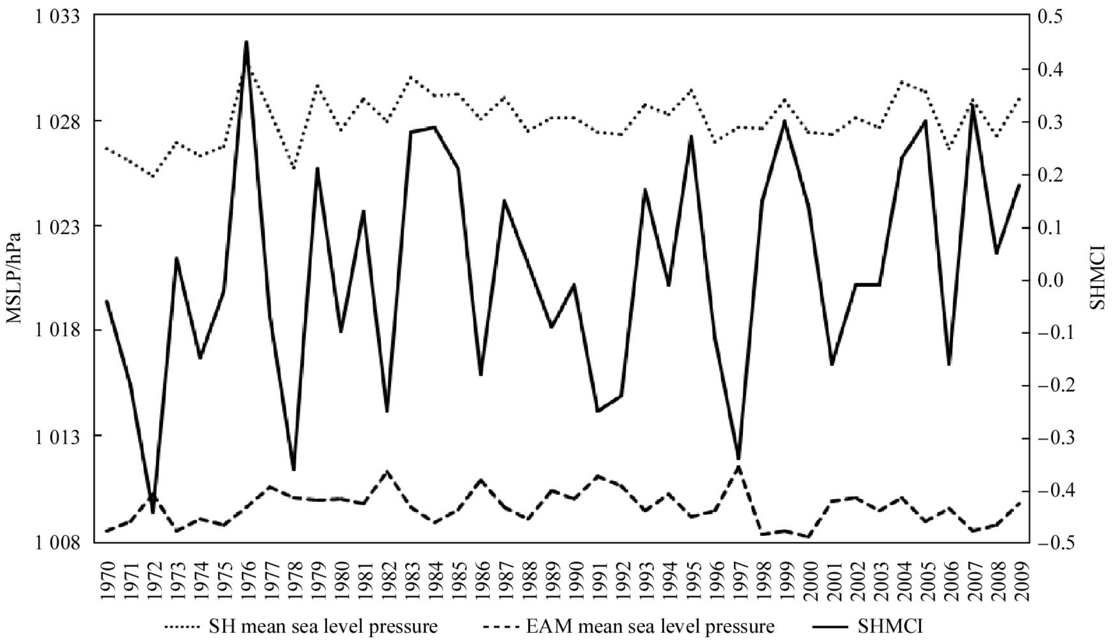

Figure 3 Seasonal value of the Siberian High-Maritime Continent Index, Siberian High and warm pool region over Maritime Continent (NDJFM averaged).

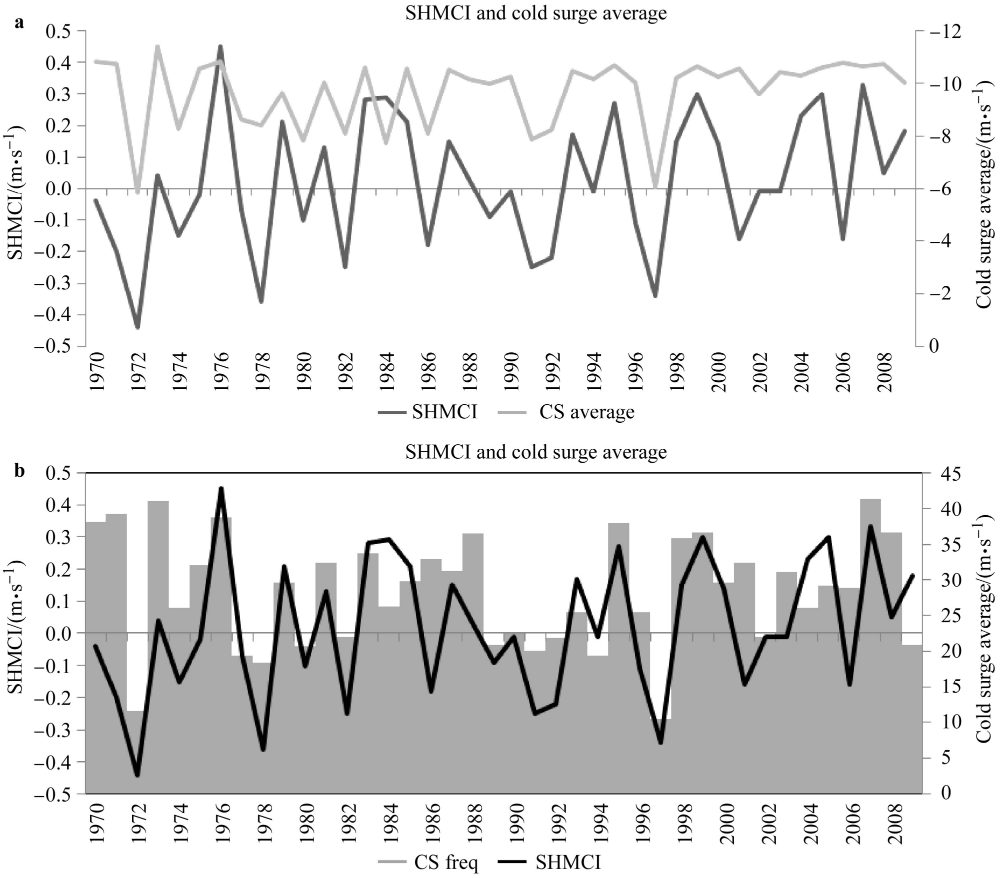

Figure 4 Correlation between SHMCI and cold surge average values in m·s^{-1} (**a**), cold surge frequencies (**b**, both within the NDJFM season). Correlation between SHMCI and the cold surge average is −0.62. Correlation between SHMCI and the cold surge frequency is 0.57. These results indicate a significant relationship between SHMCI and the cold surge strength. Positive SHMCI is associated with stronger and more frequent cold-surge events.

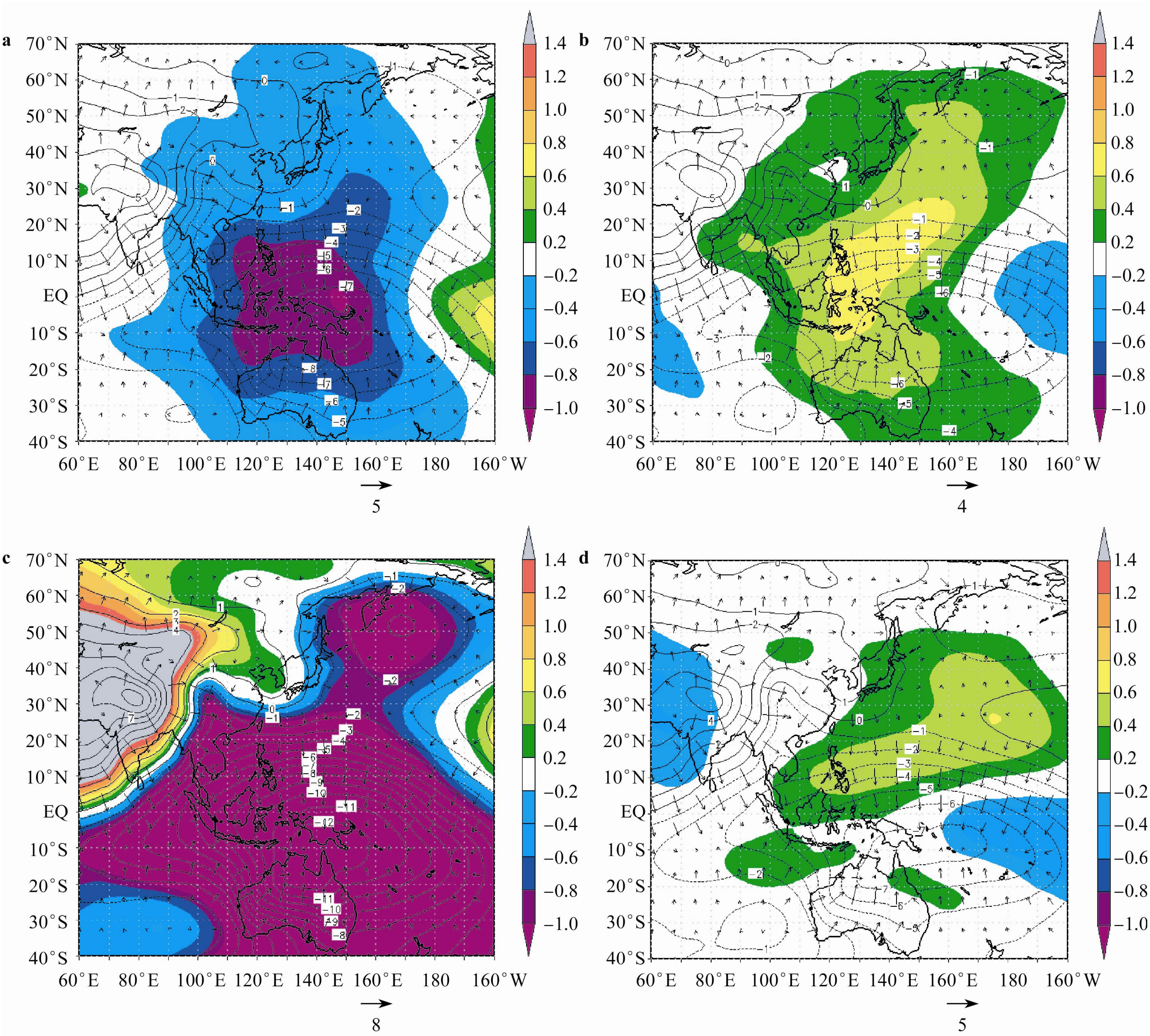

Figure 5 Phases analysis. These images show the average values of velocity potential (contour, in 10^6 $m^2 \cdot s^{-1}$), its anomalies (shaded) and wind convergence (vectors) at 925 hPa (NDJFM averaged), which represent the convergence over Asia. **a**, AO+ and SO+ phase; **b**, AO+ and SO− phase; **c**, AO− and SO+ phase; **d**, AO− and SO− phase. AO+ is associated with a weaker monsoon and vice versa. SO+ is associated with La Niña and SO− is associated with El Niño.

during the negative SHMCI and SOI (El Niño). Figures 7b and 7d shows the conditions during the out-of-phase seasons. In Figure 7c, during the negative SHMCI and positive SOI (La Niña), stronger 925-hPa level convergence is observed with almost the same intensity as during the case of positive SHMCI and SOI; however, the convergence core is more towards the Pacific rather than the MC. In Figure 7b, during the positive SHMCI and negative SOI (El Niño), a stronger 925-hPa level convergence zone is observed over the west of the MC and a weaker convergence zone observed over the northern Pacific. Figure 8 shows the phases analysis for the 200-hPa velocity potential. Strong divergence is observed during the positive SHMCI and SOI (La Niña) in Figure 8a and weak divergence is observed during the negative SHMCI and SOI (El Niño) in Figure 8d. In Figure 8c, strong divergence is observed over the centre of the divergence region, east of the MC and the Pacific. Figure 8b shows a stronger divergence over the west MC and near the centre of the divergence core and a weak divergence over the east MC.

In general, during the positive SHMCI, whether it is La Niña or El Niño, the convergence and divergence zones are slightly closer to the MC. The greater difference in MSLP between the SH and the MC is believed to cause the zones of convergence and divergence to be closer towards the MC and the Asian Continent. The opposite condition is shown during negative SHMCI phases, in which the convergence and divergence zones are slightly eastwards towards the Pacific Ocean. The same patterns are also shown in the 200-hPa divergence analysis, in term of the locations of the anomalies and the divergence centre. While the AO has no direct connection with the convergence and divergence over the MC, it has a relationship with the SH via the SHMCI. Therefore, the climate variability between the Arctic and equatorial regions can possibly be determined by examining the positions of the zones of convergence and divergence, as well as their strengths, using the anomaly analysis.

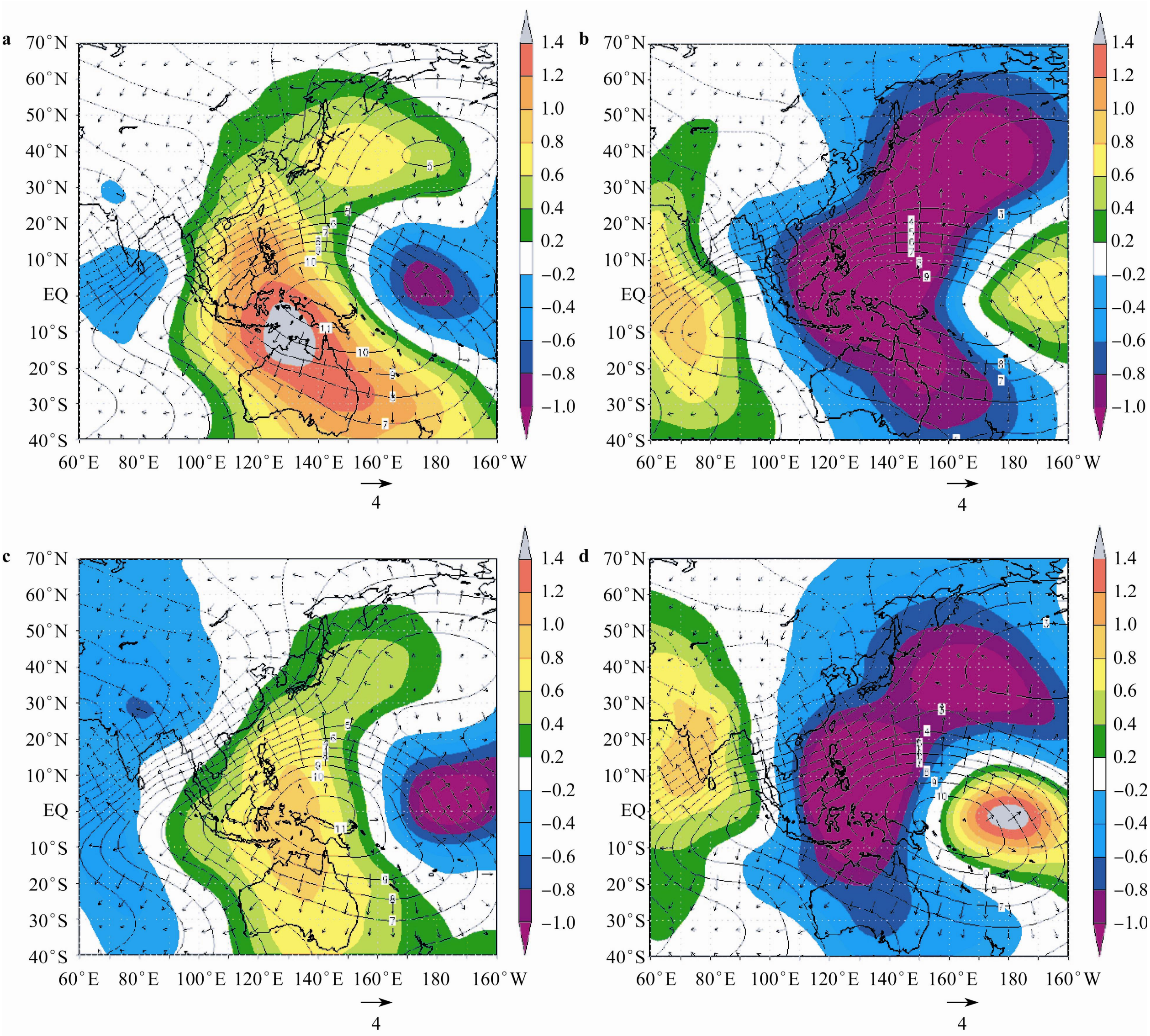

Figure 6 Phases analysis. These images show the average values of velocity potential (contour, in 10^6 $m^2 \cdot s^{-1}$), its anomalies (shaded) and wind divergence (vectors) at 200 hPa (NDJFM averaged), which represent the divergence over Asia. **a**, AO+ and SO+ phase; **b**, AO+ and SO− phase; **c**, AO− and SO+ phase; **d**, AO− and SO− phase. AO+ is associated with a weaker monsoon and vice versa. SO+ is associated with La Niña and SO− is associated with El Niño.

4 Conclusion

This study investigates the teleconnection between the Arctic and equatorial climate through the SHMCI. It employs the AOI to investigate the relationship during the AWM. However, the AO has no direct impact on the 925-hPa wind components over the MC, as revealed in the anomaly and spatial correlation analyses. Therefore, as the AO has a significant effect on the SH (the principal component in the AWM), the investigation uses the SHMCI to represent the pressure difference between the SH and the warm pool of the MC. The warm pool is the principal element of the monsoonal wind circulation over the MC. Thus, the effect of the AO on the SH may also affect the SHMCI, as well as the monsoon wind circulation. The SHMCI acts ideally in the monsoon analysis. The anomaly analysis shows that positive SHMCI phases indicate stronger northerly and easterly components and vice versa. The spatial correlation analyses between the 925-hPa winds components and the SHMCI show significant correlation over a large area of South East Asia. These results suggest that the northerly

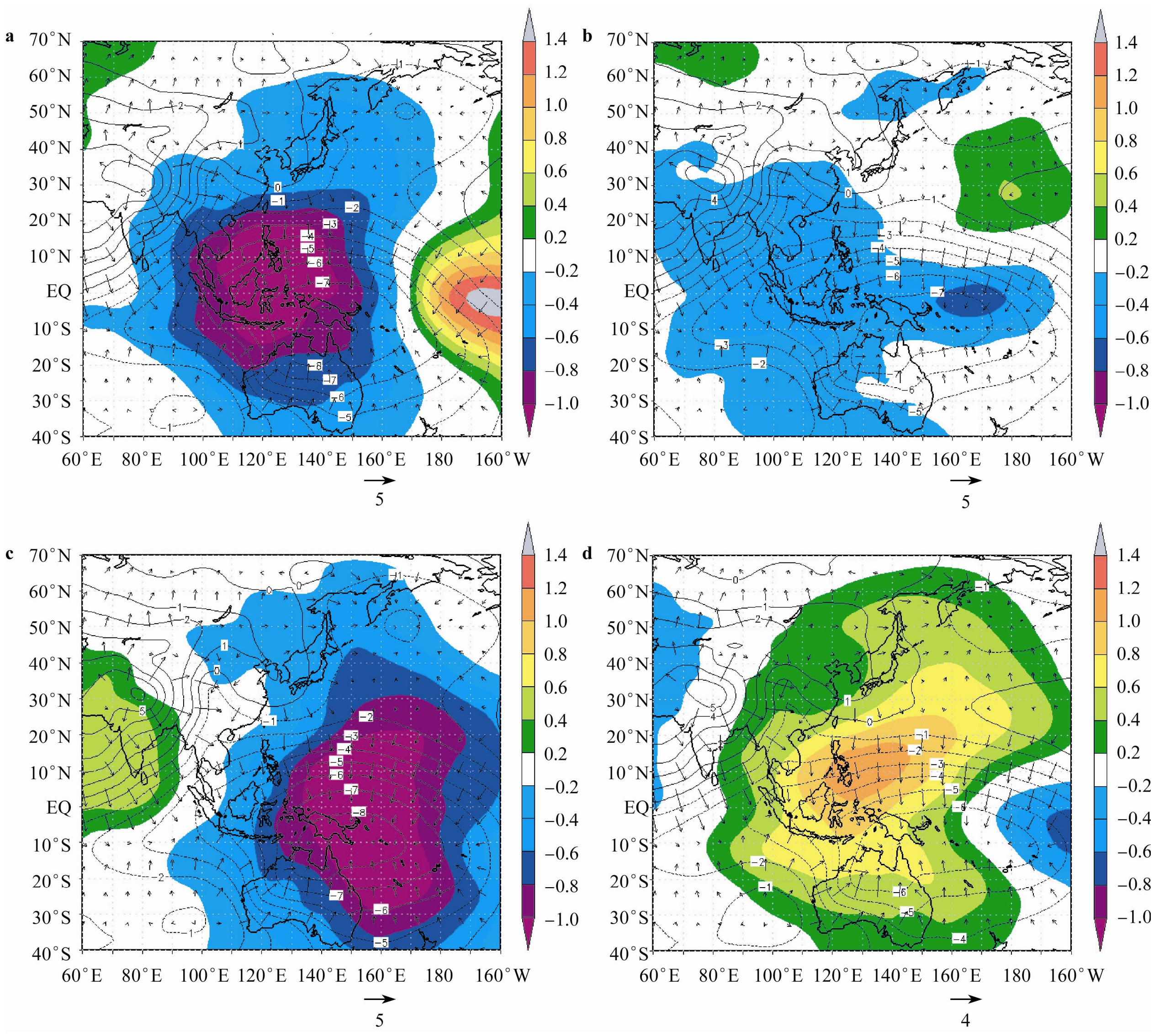

Figure 7 Phases analysis. These images show the average values of velocity potential (contour, in 10^6 $m^2 \cdot s^{-1}$), its anomalies (shaded) and wind convergence (vectors) at 925 hPa (NDJFM averaged), which represent the convergence over Asia. **a**, SHMC+ and SO+ phase; **b**, SHMC+ and SO− phase; **c**, SHMC− and SO+ phase; **d**, SHMC− and SO− phase. SMCHI+ is associated with a stronger monsoon and vice versa. SO+ is associated with La Niña and SO− is associated with El Niño.

and easterly winds are stronger during positive SHMCI phases and vice versa. The correlation coefficients of the SHMCI and the average cold-surge intensity and its frequency are high (–0.62 and 0.57, respectively), which implies that the cold surges are more intense in terms of wind speed and frequency during positive SHMCI phases and vice versa.

The correlation coefficient between the seasonal AOI and SHMCI is –0.39. This could explain the indirect correlation, which is significant at above the 5% level. The result can still be presumed to indicate a large MSLP difference, which is observed during most of the negative AO phases, because of its effect on the SH. In the convergence and divergence analysis, the phases tests assess the influence of the AO and SHMCI on the convergence zone. The AO has no significant impact on the convergence and divergence over the MC. Although the convergence region is influenced mostly by ENSO, the SHMCI shows slight influence on the spatial location of convergence and divergence zones. For the case of negative SOI and positive SHMCI, the convergence and divergence areas are closer to the MC. For the case of positive SOI and negative SHMCI, the convergence zone is further towards the middle of the Pacific Ocean. As we are looking for the relationship between the Arctic and equatorial climates, this comparative analysis suggests that the role of the AO in modulating the East Asian Winter Monsoon is via the SH-MC pressure gradient.

We conclude that there is a relationship between the AO and the AWM over Malaysia. The correlation analysis shows that the AO has a strong effect on the SH but that its

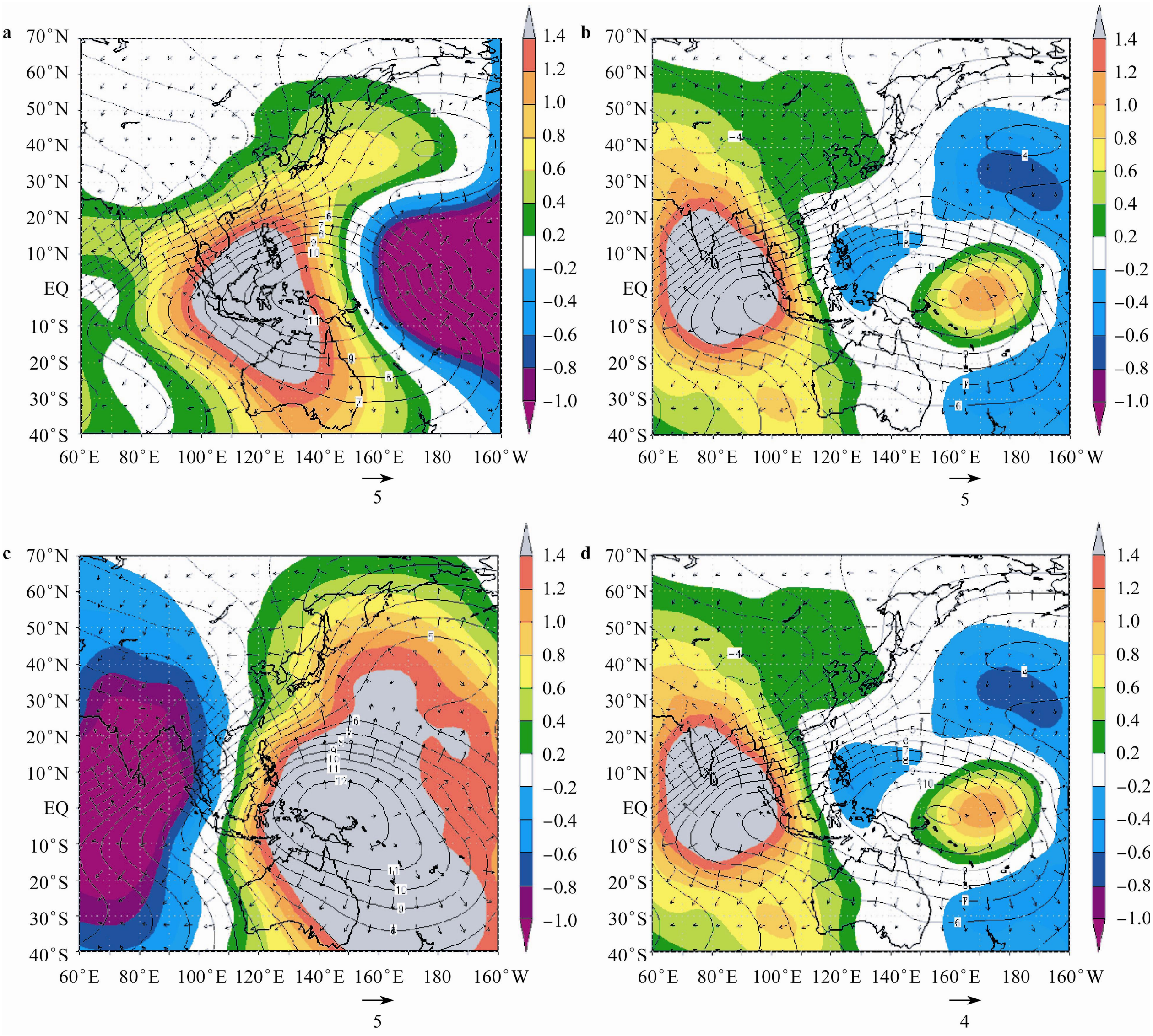

Figure 8 Phases analysis. These images show the average values of velocity potential (contour, in 10^6 $m^2 \cdot s^{-1}$), its anomalies (shaded) and wind divergence (vectors) at 200 hPa (NDJFM averaged), which represent the divergence over Asia. **a**, SHMC+ and SO+ phase; **b**, SHMC+ and SO− phase; **c**, SHMC− and SO+ phase; **d**, SHMC− and SO− phase. SHMCI+ is associated with a stronger monsoon and vice versa. SO+ is associated with La Niña and SO− is associated with El Niño.

effect is weaker on the AWM over Malaysia and the MC. However, as the AO has a close relationship with the SH, based on the SHMCI, the relationship between the AO and the monsoon over the MC can be inferred. The comparison of the effect of the SHMCI and SOI on atmospheric convergence and divergence over the MC, illustrates the possible role of the AO in affecting the AWM over the MC through the SHMCI by shifting the location of the convergence core and affecting its strength. Further studies are needed to investigate the teleconnection between the Arctic and equatorial climates through the SHMCI and lead-lag analysis, for daily, monthly and seasonal time scales.

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