Vol. 18 No. 5 Advances in Atmospheric Sciences September 2001

EAWM–Related Air–Sea–Land Interaction and the Asian Summer Monsoon Circulation①

Bueh Cholaw (布和朝鲁), Ji Liren (纪立人) and Sun Shuqing (孙淑清)
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029
Cui Maochang (崔茂常)
Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071

(Received September 1, 2000)

ABSTRACT

Based on the data analysis, this study further explores the characteristics of East Asian winter monsoon (hereafter, EAWM, for brevity) as well as the related air–sea–land system, and illustrates how and to what degree anomalous signals of the subsequent Asian summer monsoon are rooted in the preceding EAWM activity. We identified an important air–sea coupled mode, i.e., the EAWM mode illustrated in Section 3. In cold seasons, strong EAWM–related air–sea two–way interaction is responsible for the development and persistence of the SSTA pattern of EAWM mode. As a consequence, the key regions, i.e., the western Pacific and South China Sea (hereafter, SCS, for brevity), are dominated by such an SSTA pattern from the winter to the following summer. In the strong EAWM years, the deficient snow cover dominates eastern Tibetan Plateau in winter, and in spring, this anomaly pattern is further strengthened and extended to the northwestern side of Tibetan Plateau. Thus, the combined effect of strong EAWM–related SSTA and Tibetan snow cover constitutes an important factor in modulating the Asian monsoon circulation. The active role of the EAWM activity as well as the related air–sea–land interaction would, in the subsequent seasons, lead to: 1) the enhancement of SCS monsoon and related stronger rainfall; 2) the northward displacement of subtropical high during Meiyu period and the related deficient rainfall over Meiyu rainband; 3) above–normal precipitation over the regions from northern Japan to northeastern China in summer; 4) more rainfall over the Arabian Sea and Northeast India, while less rainfall over southwest India and the Bay of Bengal. The strong EAWM–related air–sea interaction shows, to some degree, precursory signals to the following Asian summer monsoon. However, the mechanism for the variability of Indian summer monsoon subsequent to the strong EAWM years remains uncertain.

Key words: EAWM, Air–sea–land interaction, Interannual variability, Asian summer monsoon

1. Introduction

The monsoon–related air–sea and air–land interactions have long been the subject of observational and theoretical studies. In general, there are two dominant ideas for the interannual variation of Asian monsoon circulation: first, the boundary forcing (SST and land surface process) is the important factor in governing the interannual variability of Asian monsoon system; second, the Asian monsoon circulation itself plays a very active role in the variation of air–sea–land coupled climate system and thus its anomalous activity might well

---

①This work was jointly supported by Key Project of Chinese Academy of Sciences (KZCX2–203), National Natural Science Foundation of China (Grant No. 49875020) and National Key Programme for Developing Basic Sciences (G1998040904).

be the precursory signal to the monsoon circulation in the subsequent seasons.

Numerical experiments with GCMs suggested that the tropical Pacific SSTA is responsible for the variation of Asian monsoon circulation. More specifically, during the past few years, coupled Ocean–Atmosphere models have also been used to study the relationship between Asian summer monsoon and SST anomalies (e.g., Latif et al., 1994). They all reached the conclusion that the warming of the central–eastern Pacific Ocean is generally accompanied by a weaker–than–normal Asian monsoon. Most studies in this area emphasized the important role of tropical SST anomalies in modulating the interannual variability of Asian monsoon system.

The influences of land surface process on the Asian monsoon circulation have also been studied extensively with observational data and GCMs (Yeh et al., 1984; Yasunari et al., 1991; Yang and Lau, 1998; among others). However, owing to the lack of adequate data, the interannual variability of Eurasian snow cover, soil moisture content and their related physical processes have not yet been clarified so far. As for the snow cover anomalies, for example, most studies take the Eurasian snow cover as a whole regardless of the fact that the snow covers anomalies are tend to be of opposite signs for the high and mid–latitude area of the continent.

The Asian monsoon circulation is an important component of global general circulation and plays an active, rather than passive, role in the climate system. Yasunari et al. (1991) proposed that anomalous Indian summer monsoon could lead to the occurrence of a chain of event in the air–sea–land system and posed a concept of "monsoon year". Li et al. (1988) also suggested that the frequent outburst of the cold wave over East Asia is responsible for the initiation of El Niño event. More recently, Ji et al. (1997) and Bueh and Ji (1999) put forward a concept of the Ocean–Atmosphere coupled regime (i.e., EAWM regime), and highlighted the active role played by the EAWM activity in the development and persistence of self–sustained regime behavior in the air–sea coupled system. They also suggested that such a coupled regime would dominate during whole cold seasons, and thus bring, to some degree, predictable signals to the following Asian summer monsoon. The land surface process, however, has not been taken into account and hence the related air–land interaction is not involved in their studies.

As is well known so far, the ENSO mode and its related air–sea–land interaction have been extensively studied in the monsoon–related subject, but little attention has been paid to other coupled modes. In addition to ENSO mode, Bueh and Ji (1999) identified an important coupled mode, i.e., EAWM mode, and emphasized, as mentioned above, its importance in the coupled climate as well as the interseasonally persistent characteristics related.

In the present study, based on the data analysis, we further explore the characteristics of EAWM–related air–sea–land system, and illustrate how the signals of anomalous Asian summer monsoon are rooted in the preceding anomalous EAWM activity.

This paper is organized as follows. The data set used is described in Section 2. The characteristics of the anomalous EAWM–related air–sea–land interaction are presented in Section 3. Section 4 will discuss interseasonal persistence of the anomaly signals associated with EAWM activity. The conclusion and discussion are presented in the final section.

2. The data set

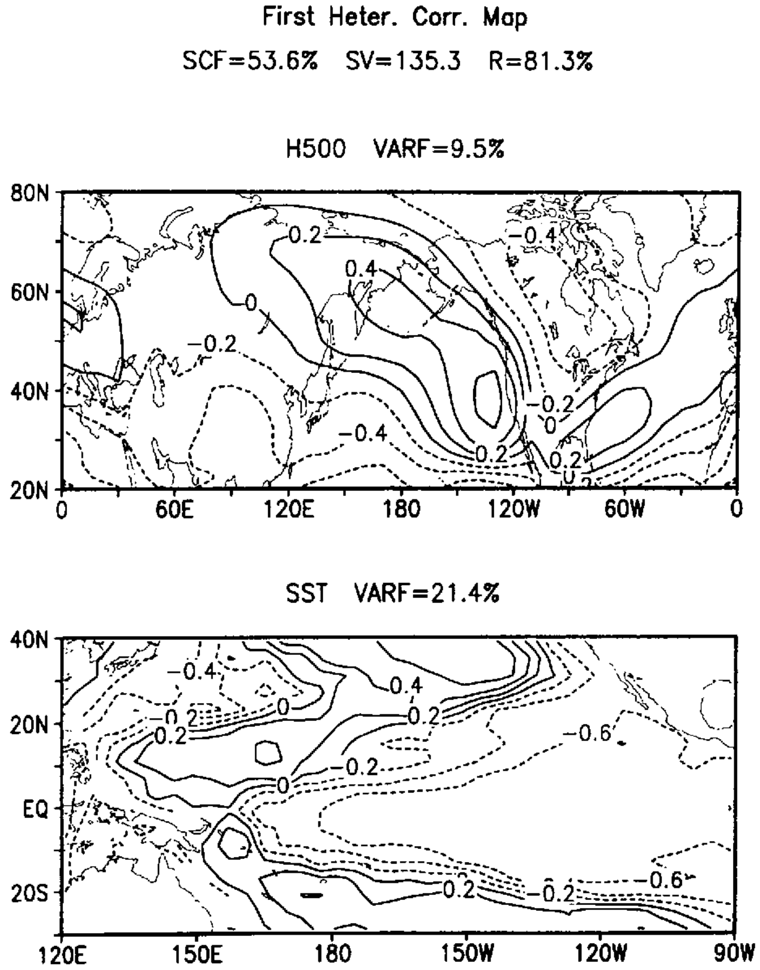
The data used in this study are monthly mean wind and SST from NCEP / NCAR reanalysis data (1958. 1–1992. 12), Xie and Arkin's precipitation data (1979. 1–1993. 12), as well as snow depth data of ECMWF reanalysis (1979.1–1993.12).

3. Characteristics of EAWM–related air–sea–land interaction

It has long been recognized that the East Asian trough at 500 hPa level in the strong EAWM years strengthens and extends southward significantly and, meanwhile, the corresponding two ridges over the Ural area and the western coast of North America are well developed and they often merge into the well established polar high. In the strong EAWM year, thus, the middle troposphere flow over high and middle latitudes is characterized by the apparent stretch of East Asian major trough. The reverse is also true for the weak monsoon year. How is then the anomalous EAWM activity coupled with the tropical Pacific SST?

Figures 1 and 2 display the first and second SVD modes of two fields, i.e., northern extratropical 500 hPa height and the tropical Pacific SST. The strength of coupling between these two fields is indicated by three measures, namely, the fraction of total squared covariance between the two fields (SCF), the temporal correlation coefficient between the two expansion coefficients (R) as well as the singular value (SV) for SVD mode in question. A useful measure of the significance of the heterogeneous correlation patterns themselves is given by the fraction of domain–integrated variance of the pattern (VARF) explained by the expansion coefficient of the other pattern as shown at the upper right corner of each panel. The interested readers are referred for further details to the work of Bretherton et al. (1992) and Bueh and Ji (1999). The heterogeneous correlation patterns for the first mode, displayed in Fig. 1 exhibit a notable projection on the coupling between PNA patterns (positive or negative), documented by Wallace and Gutzler (1981), and the SST patterns of ENSO episodes. This pair of patterns are basically identical to the leading mode of Lau and Nath (1990). Such a relationship has been extensively investigated (e.g., VanLoon and Madden 1981; Horel and Wallace 1981; among others) and is not the main subject of this paper.

The heterogeneous correlation patterns for the second mode, shown in Fig. 2, clearly show the relation between anomalous EAWM activity and the tropical Pacific SST. Hereafter, this SVD mode is called EAWM mode, for brevity. In this mode, SCF, SV and R reached about 20.0%, 86.5% and 80%, respectively, also meeting significance requirement. It is noteworthy that the singular value of this mode is equivalent to two thirds of its counterpart of the first SVD mode. Also noticeable is that the domain–integrated variance (VARF) of 500 hPa height explained by the expansion coefficients of SST field in this mode is 10.5%, and larger than that of the first mode. So it is suggested that the anomalous winter monsoon activities over East Asia must be closely connected with such a pattern of SST field. On the positive polarity of its expansion coefficients, particularly, the North–South dipole structure of this pattern is reminiscent of the flow pattern of 500 hPa height during the periods of strong (or frequent) winter monsoon activities over East Asia. The SST field of this mode differs significantly from that of the first mode. It can be seen that the SST anomaly of the Nino3 area is very weak and less extensive than that of ENSO mode. On the other hand, the positive (warm) anomaly bands, from the western Pacific to subtropical areas near the western coast of North America and South America, are well–organized and quite different from the circumstance of La Niña event. Such an SST pattern, as suggested by Bueh and Ji(1999), could lead to the enhancement of EAWM activity, which is, in turn, also favorable to the development and maintenance of the SSTA pattern of this SVD mode. The two–way interaction, thus, would lead to a positive feedback process and then form a self–sustained coupling regime, and we may call it EAWM regime.


First Heter. Corr. Map

SCF=53.6% SV=135.3 R=81.3%

H500 VARF=9.5%

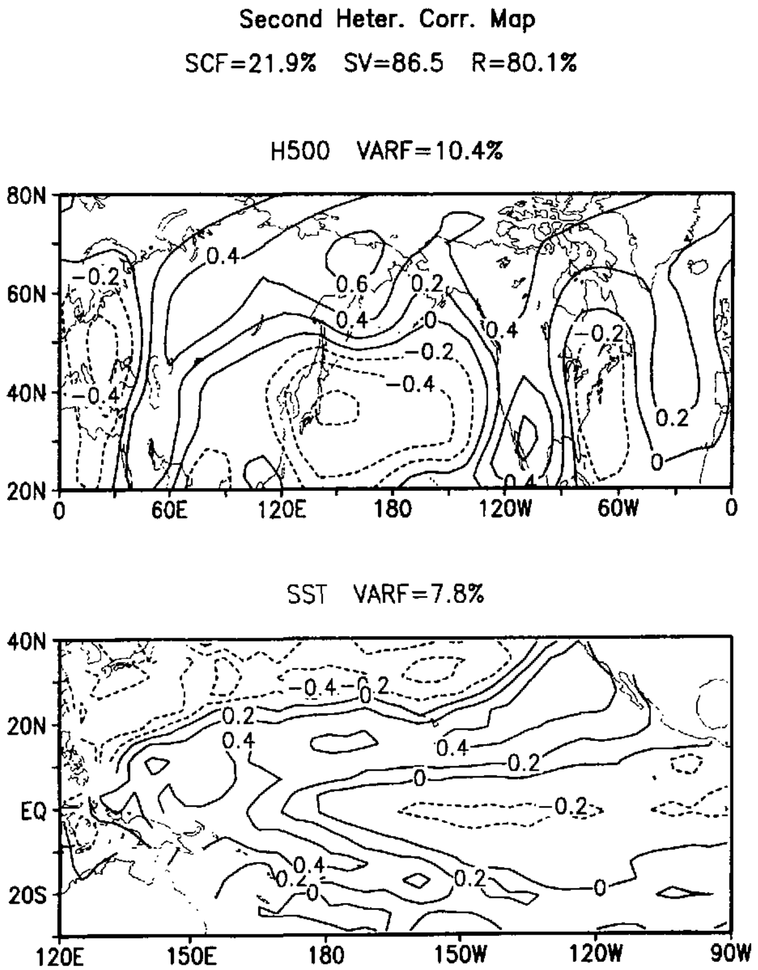
SST VARF=21.4%

Fig. 1. Heterogeneous correlation patterns for the first SVD mode of (a) the extratropical 500 hPa height field of the Northern Hemisphere and (b) the tropical Pacific SST field, in winter (DJF).

To help better understand the prominent features of EAWM–related air–sea–land system, we defined a normalized EAWM index (hereafter, EAWMI), which is the combination of two normalized indices I_v and I_H, where I_v is the area mean V component of 1000 hPa wind velocity for coastal eastern Asia (115°–130°E, 10°–30°N) while I_H represents the meridional extension of 500 hPa flow in winter (DJF). The latter is defined as follows:

$$I_H = 0.5(H_U + H_P) - H_E, \tag{1}$$

in which, H_U, H_P and H_E stand for the normalized area mean 500 hPa height over Ural ridge area (55°–65°E, 50°–60°N), North Pacific ridge area (150°–120°W, 60°–70°N) and East Asian trough region (120°–140°E, 35°–50°N), respectively.



Second Heter. Corr. Map

SCF=21.9% SV=86.5 R=80.1%

H500 VARF=10.4%

SST VARF=7.8%

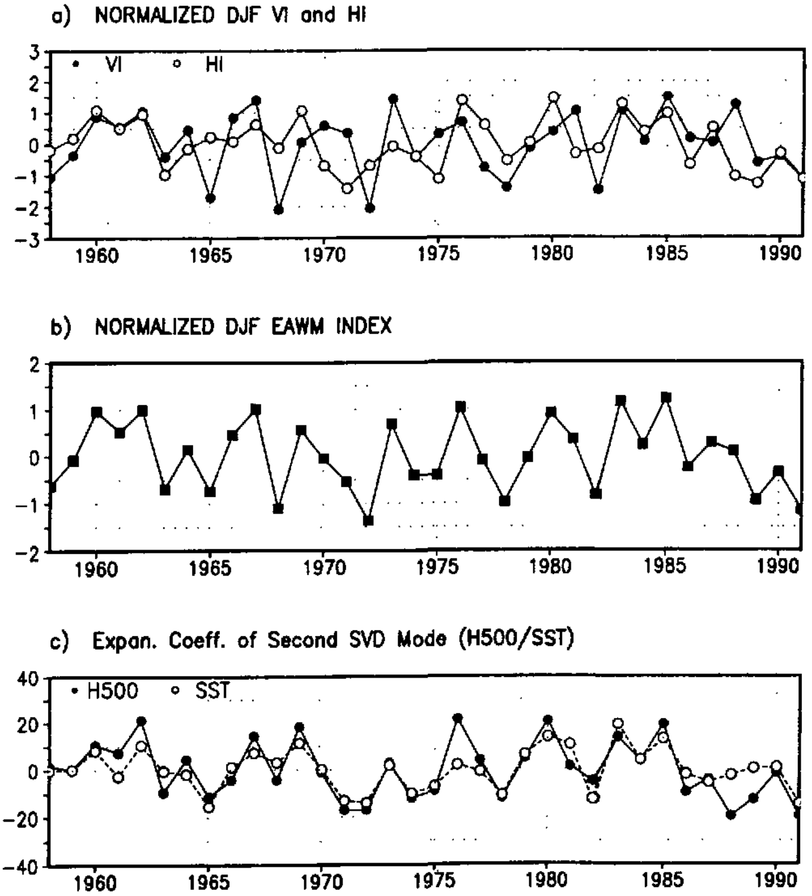
Fig. 2. As in Fig. 1 but for the second SVD mode.

And the EAWMI (I_{EAWM}) is defined as

$$I_{\mathrm{EAWM}} = 0.5(I_{\mathrm{V}} + I_{\mathrm{H}}). \tag{2}$$

From the comparison of Fig. 3b and Fig. 3c, one can see that the second SVD mode discussed above clearly illustrates the intimate relationship between the anomalous EAWM activity and the tropical Pacific SSTA pattern different from that of ENSO phenomenon.

In terms of the EAWMI, we may define the strong ($I_{\mathrm{EAWM}} > 1.0$) and weak ($I_{\mathrm{EAWM}} < -1.0$) monsoon years. Figure 4a shows the winter SSTA pattern of strong EAWM composite. It is clear that most features, e.g., positive anomalies over the central and middle Pacific as well as over the subtropical area near the coast of North and South America, and negative anomalies over the eastern Pacific are essentially identical to the result of SVD analysis. Also notable are the significant negative anomalies over the SCS and the northwestern



a) NORMALIZED DJF VI and HI

b) NORMALIZED DJF EAWM INDEX

c) Expan. Coeff. of Second SVD Mode (H500/SST)

Fig. 3. The EAWM–related indices, (a) I_V and I_H, (b) EAWM index, and (c) the expansion coefficient of 500 hPa height field for the EAWM mode.

Pacific as well as the North Pacific region. Observational studies found the SST in the above–mentioned regions is very sensitive to the strong EAWM activity, in particular, at the SCS and the northwestern Pacific region. The SSTA pattern of weak composite, in Fig. 5a, is basically out of phase with that of strong composite. It is very similar to the El Niño phase and consistent with the fact that the majority of weak EAWM years are concurrent with El Niño years. So, our discussion in the following sections will be mainly focused on the strong EAWM composite.

According to the basic mechanism of monsoon, i.e., land–sea thermal contrast, the land surface anomaly over Eurasia must be very important in modulating the Asian monsoon. As extensively investigated, the snow cover anomaly is an important factor in the sense of land–air interaction during cold seasons. The snow depth anomalies of strong EAWM composite in winter and spring are shown in Fig. 6a and Fig. 6b, respectively. Over Eurasian

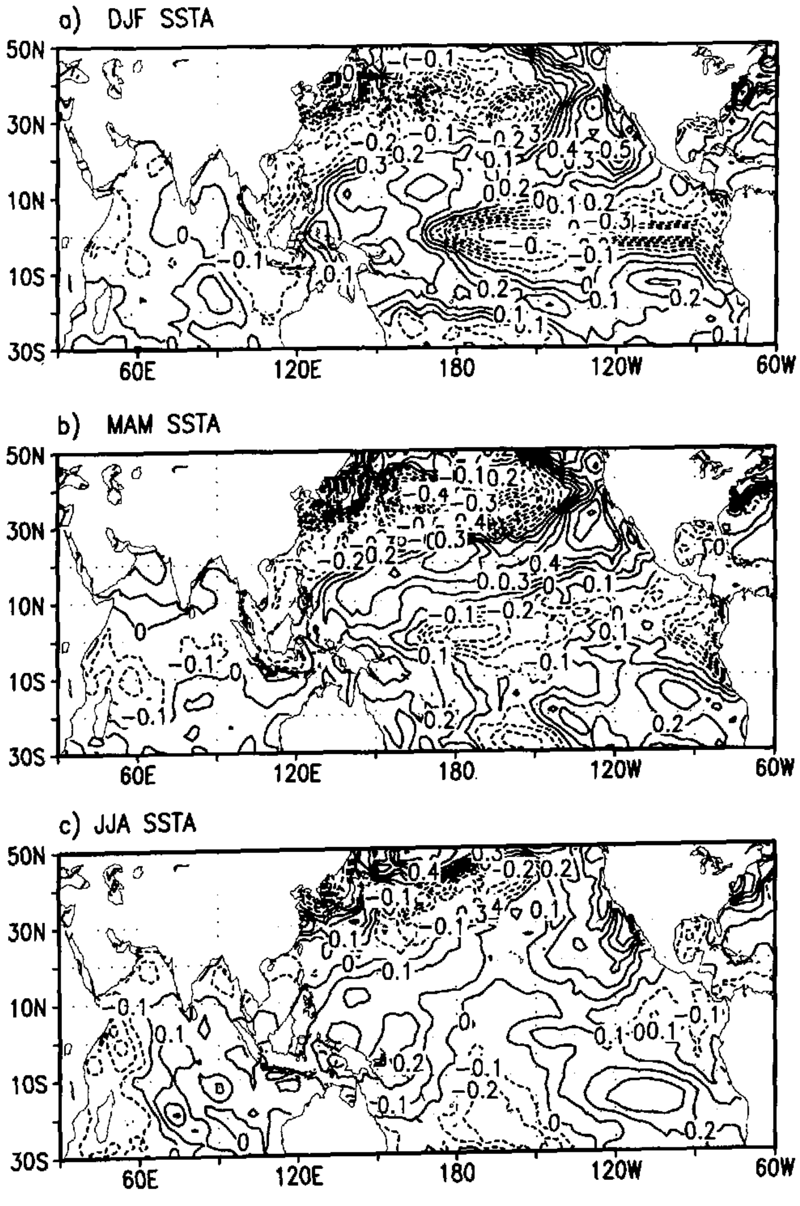


Fig. 4. The tropical Pacific SSTA fields for strong EAWM composite, (a) in winter, (b) in spring, and (c) in summer.

continent, the snow depth anomalies in these two seasons look a little bit different. In winter, most areas of Eurasian continent except the latitude band about 40°–55°N is dominated by deficient snow cover, particularly over eastern Tibetan Plateau. In spring, however, the negative anomaly over the Tibetan Plateau extends to its northwest side and the positive and

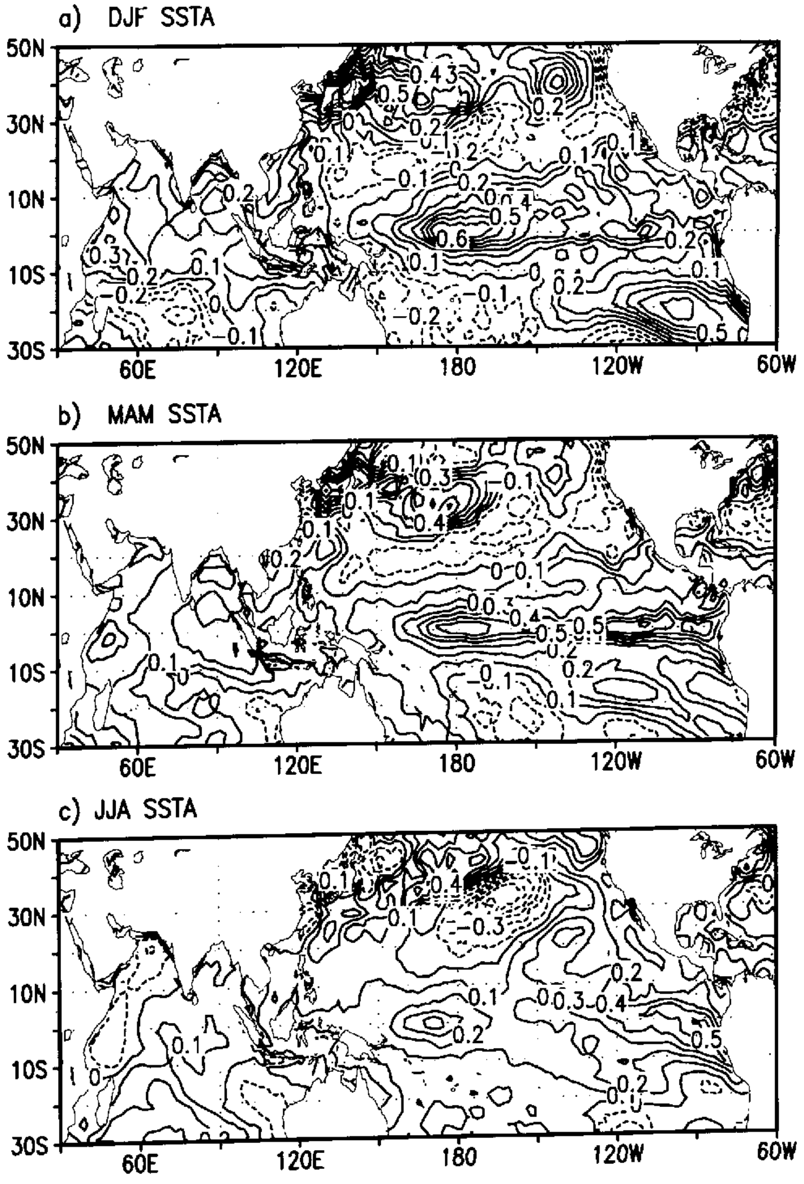


Fig. 5. As in Fig. 4 but for the weak EAWM composite.

negative anomalies over middle and high latitude bands are strengthened extensively. In weak composite, as displayed in Fig. 6c and Fig. 6d, the reverse is basically true, especially over Tibetan plateau. Numerical studies with GCMs (e.g., Vernekar et al., 1995; Shen, 1996) stress the important impact of Tibetan snow cover anomaly on the Asian summer monsoon. Thus, it is naturally suggested that the snow anomaly associated with anomalous EAWM activity

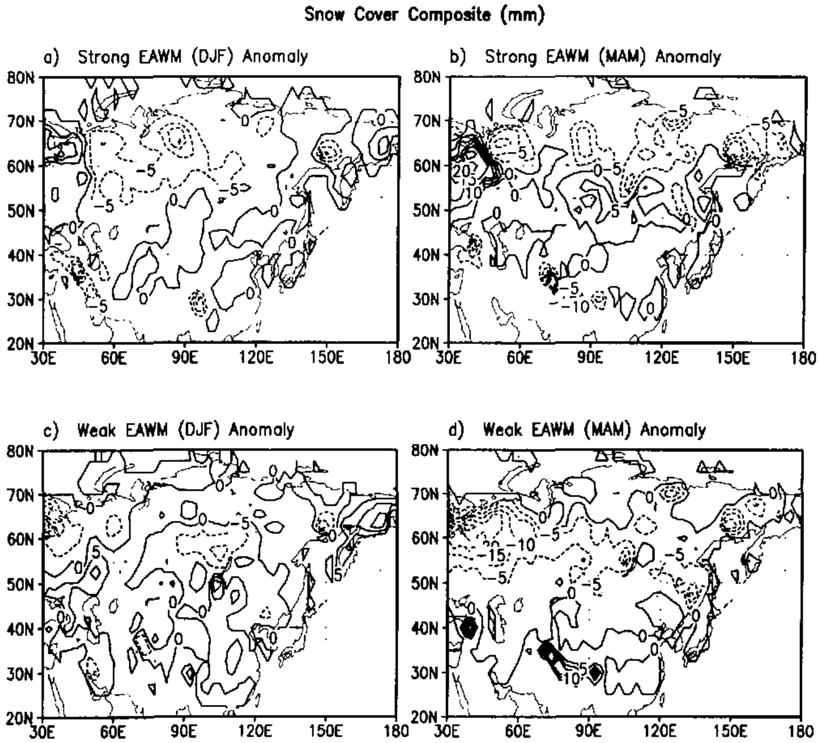


Fig. 6. Composite anomalies of the snow depth over Eurasian continent, (a) for strong EAWM in winter, (b) as in (a) but for spring, (c) for weak EAWM in winter, (d) as in (c) but for spring.

has a significant influence on the Asian monsoon circulation. The further discussion on this subject will be given in the following section.

4. Interseasonal persistence of the anomaly signals in EAWM– related air–sea–land system

In Section 3, the characteristics of EAWM–related air–sea–land coupled patterns are discussed mainly in winter season. The question following is how the associated SST and land surface anomalies persist and further interact with the subsequent Asian monsoon circulation.

Figure 7 shows the 1000 hPa anomaly wind streamlines of the strong EAWM composite. In winter, given in Fig. 7a, the three branches of monsoon circulation respectively in East Asia, Indian peninsula and East Africa are all well strengthened. In particular, extra northerly over East Asian sector stretches across the equator, indicating the enhancement of the Australian summer monsoon circulation. The extra cyclone centered at the southern tip of Indian peninsula seems also indicative of the influence of strong EAWM activity. The most prominent features are the cyclonic convergence anomalies over the western Pacific and northeastern Pacific areas. Such anomalous circulation is consistent with the enhancement of

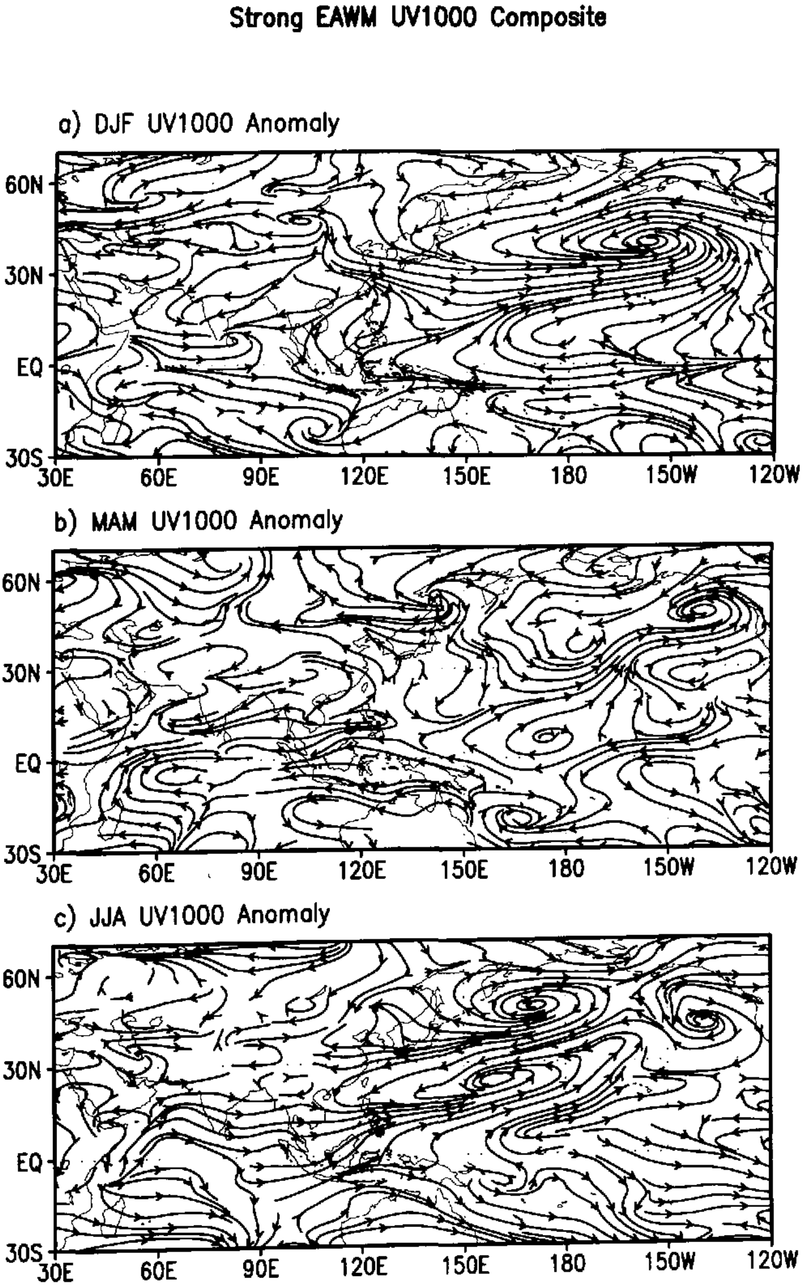


Fig. 7. As in Fig. 4 but for the streamline fields of 1000 hPa level.

the convection, hence the precipitation, over these areas, particularly over the western Pacific, the area of maximum precipitation in the winter hemisphere. In Fig. 7b and Fig. 7c, one can also see that this cyclonic anomaly is also maintained in spring and its western Pacific part remains conspicuous even in summer. We speculate that such an interseasonal persistence of the circulation anomaly must be closely associated with the EAWM–related tropical Pacific SSTA pattern (see Fig. 4). In the prior autumn season, the corresponding SSTA pattern (not shown) is much less organized and different from that in winter. In cold seasons, strong EAWM–related air–sea interaction, illustrated by a self–sustained coupled regime (Bueh and Ji, 1999), is responsible for the development and persistence of such an SSTA pattern. As a consequence, the key regions, i.e., the western Pacific and SCS, are dominated consistently by the EAWM–type SSTA pattern from the winter to the following summer, whereas that of other domain is significantly changed.

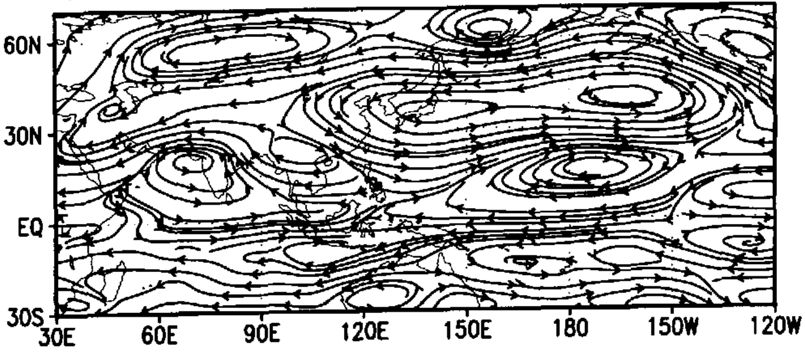
As is well known, the SCS monsoon breaks out in the late spring prior to the outburst of Indian summer monsoon in the same year (Wu and Zhang, 1998). In the following spring of strong EAWM composite, southerly anomaly wind (Fig. 7b) and above–normal precipitation (Fig. 9b) occur over the region from SCS to South China, showing a deeper SCS monsoon trough. The SCS SST and Tibetan snow cover are two important factors in governing the interannual variability of SCS monsoon (Chen and Wu, 1998; Sun and Chen, 2000). It is clearly seen in Fig. 4b and Fig. 6b that all SCS basin in spring is covered by cold SSTA while the Tibetan snow cover is significantly deficient, implying a stronger land–sea thermal contrast, hence a stronger SCS monsoon. So, the strong EAWM activity, to some degree, leads to a strong subsequent SCS monsoon circulation, keeping in mind that the active role of the strong EAWM is responsible for the corresponding springtime SST and snow cover anomalies.

Huang and Sun (1992) proposed that above–normal convection over maritime continent is unfavorable to the residence of the subtropical high in its climatological position during the Meiyu period, thus leading to deficient rainfall over Meiyu band. It is clear that the cyclonic anomaly flow over the western Pacific and anticyclonic anomaly flow over the sea of Okhotsk as well as its southern flank, as shown in Fig. 7c and Fig. 8c, are essentially unfavorable to the residence of the subtropical high in the position associated with Meiyu band. Rather, it would be suggestive of the northward displacement of the subtropical high. Also seen is the cyclonic anomaly to the south of Lake Baigal, implying the cold air activity from the high–latitude region. Obviously, such a circulation pattern is closely related to deficient rainfall over Meiyu rainband and abundant rainfall over northeastern China as well as its neibouring part of North China. The summer rainfall pattern of the strong EAWM composite, displayed in Fig. 9c, is just in line with the above–mentioned East Asian summer monsoon circulation. However, it is noteworthy that Meiyu period is mainly in June and early July. So the above discussion based on the June–July–August (JJA) mean anomaly seems not appropriate. But we have found that the anomalous circulation pattern of JJA mean is still robust in June, July and August, respectively (not shown).

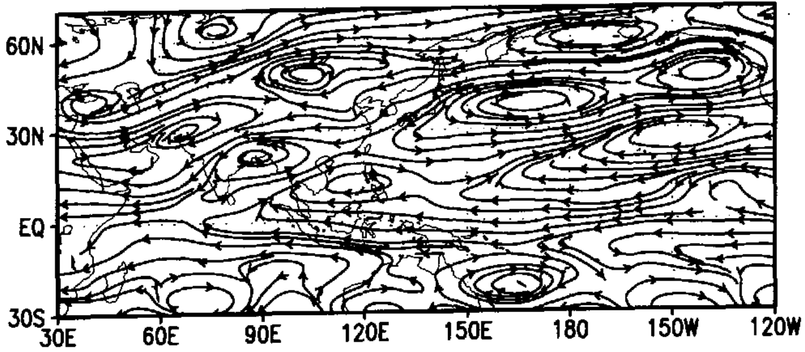
It is also seen in Fig. 7c that the monsoon flow over the Arabian Sea and the Northeast India is strengthened, whereas Southwest India is dominated by anomalous northwesterly, indicative of the weak monsoon trough there. It is even more evident in Fig. 9c that, in the Indian monsoon region, the rainfall distribution is mainly characterized by a wave–like (+ – +) pattern over the Arabian Sea, Southwest India and Northeast India, respectively. Also notable is the deficient rainfall over the Bay of Bengal where extra northwesterly dominates

Strong EAWM UV500 Composite

a) DJF UV500 Anomaly



b) MAM UV500 Anomaly



c) JJA UV500 Anomaly

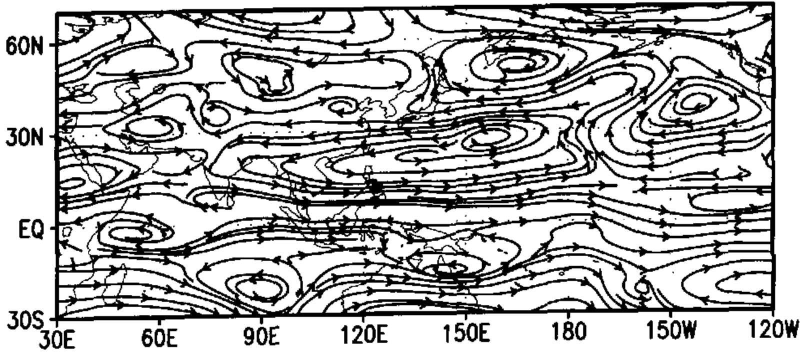
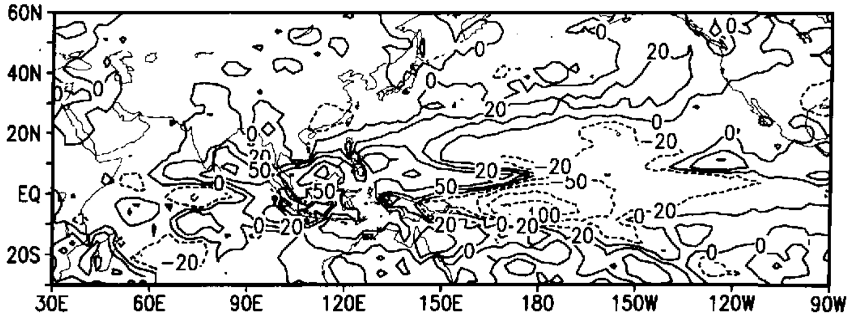
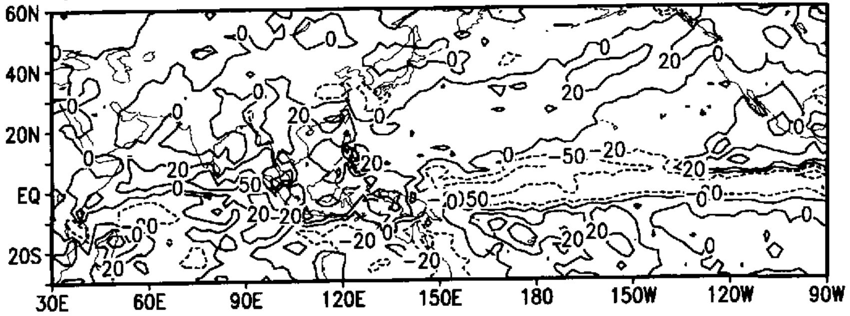


Fig. 8. As in Fig. 7 but for 500 hPa level.

a) DJF Anomaly of Strong EAWM



b) MAM Anomaly of Strong EAWM



c) JJA Anomaly of Strong EAWM

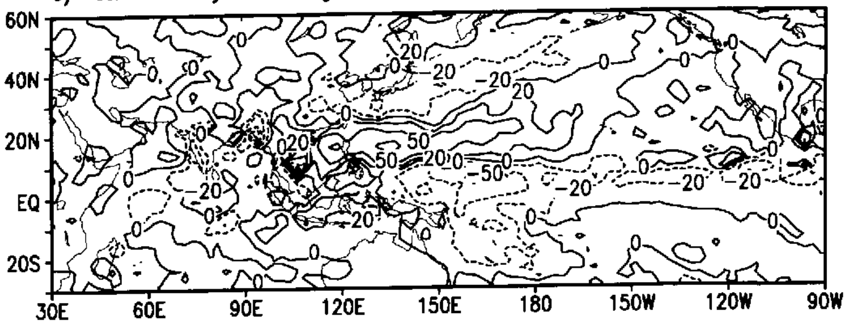


Fig. 9. Rainfall anomaly fields for the strong EAWM composite, (a) in winter, (b) in spring, (c) in summer.

and reduces the monsoon precipitation. It might be suggested that the deficient snow cover of Tibetan Plateau is responsible for the abundant rainfall over the Arabian Sea and Northeast India. As for the deficient rainfall over Southwest India and the Bay of Bengal, the mechanism remains uncertain.

5. Concluding remarks

The ENSO mode and its related air–sea–land interaction is extensively studied in the monsoon–related subject while other coupling modes, if any, have received much less attention. In addition to ENSO mode, in this paper and our previous work (Bueh and Ji, 1999), we have identified an important air–sea coupled mode, i.e., the EAWM mode illustrated in Section 3. In cold seasons, strong EAWM–related air–sea two–way interaction is responsible for the development and persistence of the SSTA pattern of EAWM mode. As a consequence, the key regions, i.e., the western Pacific and SCS, are dominated consistently by such an SSTA pattern from the winter to the following summer. In the strong EAWM years, less snow cover tends to occur at eastern Tibetan Plateau in winter, and in spring, this anomaly pattern strengthens further and extends to the northwestern side of the plateau. Thus, the combined effect of the two, the strong EAWM–related SSTA and less snow cover over Tibetan Plateau, constitutes an important factor in modulating the Asian monsoon circulation.

The active role of the EAWM activity associated with air–sea–land interaction would, in the subsequent seasons, lead to: 1) the enhancement of SCS monsoon and related stronger rainfall; 2) the northward displacement of subtropical high during the Meiyu period and related deficient rainfall over the Meiyu rainband; 3) above–normal precipitation over the regions from northern Japan to northeastern China in summer; 4) more rainfall over the Arabian Sea and Northeast India, and deficient rainfall over Southwest India and the Bay of Bengal. The strong EAWM–related air–sea–interaction shows, to some degree, precursory signals to the following Asian summer monsoon. However, the mechanism for the variability of Indian summer monsoon subsequent to the strong EAWM years remains uncertain.

REFERENCES

Bretherton, C. S., C. Smith, and J. M. Wallace, 1992: An intercomparison of method for finding coupled patterns in climate data. *J. Climate*, **5**, 354–369.

Bueh Cholaw and Ji Liren, 1999: The ocean–atmosphere coupled regimes and East Asian winter monsoon (EAWM) activity. *Advances in Atmospheric Sciences*, **16(1)**, 91–106.

Bueh Cholaw and Ji Liren, 1999: Anomalous activity of East Asian winter monsoon and the tropical Pacific SSTA. *Chinese Science Bulletin*, **44(10)**, 890–898.

Chen Lieting and Wu Renguang, 1998: Interannual and decadal variations of snow cover over Qinghai–Xizang Plateau and their relationships to summer monsoon rainfall in China. *East Asian Monsoon and Torrential Rain in China*, China Meteorological Press, 230–239.

Horel, J.D., and J.M.Wallace, 1981: Planetary scale atmospheric phenomena associated with the Southern Oscillation. *Mon. Wea. Rev.*, **109**, 813–829.

Huang, Ronghui, and Sun Fengying, 1992: Impacts of the tropical western Pacific on the East Asian summer monsoon. *J. Meteor. Soc. Japan*, **70(1B)**, 243–256.

Ji Liren, Sun Shuqing, Klaus Arpe, and Lennart Bengtsson, 1997: Model study of the interannual variability of Asian winter monsoon and its influences. *Advances in Atmospheric Sciences*, **14(1)**, 1–22.

Latif, M., A. Sterl, M. Assenbaum, M. M. Junge, and E. Maier–Reimer, 1994: Climate variability in a coupled GCM. Part II: The Indian Ocean and monsoon. *J. Climate*, **7**, 1449–1462.

Lau, N.-C., and M.J.Nath, 1990: A general circulation model study of the atmospheric response to equatorial SST anomalies observed in 1950–79. *J. Climate*, **3**, 965–989.

Li Chongyin, Chen Yuxiang, and Yuan Chongguang, 1988: An important causative factor of El Niño event —frequent activities of the strong cold waves in eastern Asia. *Scientia Atmospherica Sinica* (Special issue), 125–132 (in Chinese).

Sun Shuqing, and Chen Jun, 2000: Influences of Anomalous East Asian Winter Monsoon on the Wind and Thermal fields of the South China Sea Monsoon. *Climate and Environmental Research*, **5(4)**, 400–417 (in Chinese).

VanLoon, and R. A. Madden, 1981: The Southern Oscillation. Part I: Global associations with pressure and temperature in Northern winter. *Mon. Wea. Rev.*, **109**, 1150–1162.

Wallace, J. M., and D. S. Gutzler, 1981: Teleconnections in the geopotential height field during the Northern Hemisphere winter. *Mon. Wea. Rev.*, **109**, 784–812.

Wallace, J. M., C. Smith, and C. S. Bretherton, 1992: Singular value decomposition of wintertime sea surface temperature and 500–mb height anomalies. *J. Climate*, **5**, 561–576 .

Wu Guoxiong and Zhang Yongsheng, 1998: Tibetan Plateau forcing and monsoon onset in South Asia and southern China sea. *Mon. Wea. Rev.*, **126(4)**, 913–927.

Yang, S., and K. –M. Lau., 1998: Influences of sea surface temperature and ground wetness on Asian summer monsoon. *J. Climate*, **11**, 3230–3246.

Yasunari, T., A. Kitoh, and T. Tokioka, 1991: Local and remote responses to excessive snow mass over Eurasia appearing in the northern spring and summer climate — A study with the MRI GCM. *J. Meteor. Soc. Japan*, **69**, 473–487.

Yeh, T. C., R. T. Wetherald, and S. Manabe, 1984: The effect of soil moisture on the short–term climate change and hydrology change —A numerical experiment. *Mon. Wea. Rev.*, **112**, 474–490.

与 EAWM 相关的海陆气相互作用及亚洲夏季风

布和朝鲁　　纪立人　　孙淑清　　崔茂常

摘　要

基于观测资料分析，本文讨论了与东亚冬季风(EAWM)异常活动相联系的海–陆–气系统的特征，指出它往往是随后亚洲夏季风异常的一个信号．我们分析并确定了一类重要的海气耦合模态，即 EAWM．它所包含的海–气双向相互作用，使该模态的 SSTA 分布得以发展和持续。特别是在西太平洋和南海等关键地区，SSTA 异常将从冬季维持到夏季。在强冬季风年，青藏高原积雪冬季在其东部出现负距平区，春季则延伸到高原西北部．SSTA 及高原积雪分布，共同构成调制亚洲季风环流的重要因子，它将有助于 1)随后南海季风和季风降水的增强；2)梅雨期西太平洋副高偏北，长江流域少雨；3)夏季我国东北和日本多雨；4)阿拉伯海和印度东北多雨，而印度西南部及孟加拉湾少雨．总之，强 EAWM 及相联的海气相互作用，一定程度上，预示着亚洲夏季风的活动特征．

关键词：EAWM，海–陆–气相互作用，年际变化，亚洲夏季风