地理学报(英文版) 2003年第13卷第3期

The relationship between ENSO cycle and temperature, precipitation and runoff in the Qilian mountain area

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El Nino and La Nina are the events concerned internationally. The corresponding relationship between El Nino events, temperature, precipitation and runoff in the Qilian mountain area are analyzed according to the date from the weathe r and the hydrometric stations in the area, the results show that effects of El Nino events to temperature, precipita tion and runoff are different in the different time and zones. When El Nino occurs, temperature rises, but precipitat ion and runoff decrease in the whole Qilian mountain area, especially in the east and middle parts of the area. Tempe rature rises, precipitation and runoff still decrease in the eastern Qilian mountain area in the next year El Nino oc curring, but decrease extent is fewer. There are not obvious relationship between temperature, precipitation and runo ff with El Nino events in the western Qilian mountain area.

The relationship between ENSO cycle and temperature, precipitation and runoff in the Qilian mountain area LAN Yongcha o, DING Yongjian, KANG Ersi, ZHANG Jishi (Cold and Arid Regions Environmental and Engineering Research Institute, CA S, Lanzhou 730000, China) 1 Introduction El Nino and La Nina are the events that temperature rise or descend singular ly of seawater in Equator Eastern Pacific Ocean area. Alternant occurring of El Nino and La Nina is an interactional process between ocean and atmosphere, which indicates the cycles of seawater from cold to warm and from warm to cold in Equator Eastern Pacific Ocean area. El Nino event and Southern Oscillation phenomenon are called jointly as ENSO. ENSO is not only an event, but also a cycle yet because it commonly possesses a quasi-period for 2-7 a (Jin and Tao, 1999). El Nino and La Nina are the states of two contrary arguments. Corresponding circumfluence system is different along with the dissimilarity of position and intensity of calefaction area (Ni et al., 2000). Chinese scientists hav e made sure that exceptional SST at Equator Eastern Pacific Ocean area also affected badly climates and weather of va st area of China (Dong and Liu, 2000; Li and Li, 2000; Zhu and Teng, 2000). The research on cause of formation of ENS O cycle and its mechanism as well as affecting process to climate have gained some advances, but the occurring time s, the intensity and the sustaining times of El Nino and La Nina events still cannot be forecasted exactly until no w. So analyzing reciprocity between ocean and atmosphere, ocean and land, it is an effective method for analyzing th e corresponding relations between ENSO cycle and air temperature, precipitation and mountainous runoff in the Qilian Mts. area by use of statistics laws. 2 General situations of the study area Qilian mountain area, located in the nort heastern part of the Qinghai-Tibet Plateau, lies between 93o30′-103o00′E and 36o30′-39o30′N (Figure 1), about 850 km long and 200-300 km wide. It is snowcapped all the year round with modern glaciers reaching a height of over 4,000 m and great vertical variations in climate. Affected mostly by southeastern warm and damp current from the Pacific and Indian oceans, precipitation reaches 400-700 mm and runoff depth, 100-500 mm. Part of precipitation is stored in soli d form and becomes natural solid reservoir because of lower temperature. So the Qilian Mts. area is the cradle of th e rivers in the Hexi Inland Arid Region in Gansu Province of Northwest China. Rivers runoff in Hexi all originates fr om the northern foot of the Qilian Mts., and changes in the mountainous runoff resulted from global warming will brin g an important effect to the socioeconomic development in Hexi. Under the control of Mongolia High Pressure, winter w eather in the Qilian Mts. area is quite cold and dry, accompanied with sufficient sunshine, lower temperature and sca rce precipitation. Precipitation from November to February only occupies 5% of yearly total. The sky over the Bay of Bengal and Qinghai-Tibet Plateau is heat source region from May to August (Tang and Xu, 1984; Long and Li, 1999). Bec ause of the warming of sensible heat, Land Hot Low Pressure grows and Mongolia High Pressure declines, which makes th

e Qilian Mts. area to be controlled by Land Hot Low Pressure, thereby the vapors on the Indian Ocean and the Bay of B
engal can be transported to the Hexi Corridor area by southwest current (Ni et al., 2000). While extending to west o
f the Pacific Ocean subtropical high lead southwest current to transport to west. Southeast and southwest monsoons ca
n affect furthest the Heihe drainage system located in the middle part of the Hexi Corridor, and the areas west to th
e Heihe River are affected mainly by westerly current. Four weather stations of Wushaoling, Qilian, Yeniugou and Tuol
e are set from east to west in the Qilian mountain area, which began to observe basically from the metaphase of the 1
950s and has accumulated data for about 50 years. The Hexi region situated between 37o17´-42o18´N, 92o23´-104o12´E an
d with a total area of 215×105 km2 belongs to the arid and semi-arid climate region. The rivers in the region respec
tively belong to three major drainage systems, i.e., Shiyanghe, Heihe and Shulehe. There are 57 big and small inland
rivers altogether, of which 23 rivers have had hydrometric stations set up (8 rivers in the Shiyanghe drainage basi
n, 9 in the Heihe drainage basin and 6 in the Shulehe drainage basin), most of them have the measured records for mor
e than 40 years, these records are the basis for accurate calculation of water resources in the region. For reasons o
f terrain, precipitation and underlying surface of catchments, the course of most of the above mentioned rivers is ve
ry short and the water quantity of them is very small. There are just 10 rivers with water quantity being more than 1
×108 m3 and 3 rivers, more than 5×108 m3. The three largest are the mainstreams of the Heihe River in the Heihe dra
inage system, the Taonaihe River in the Heihe drainage system, and the Changmahe River in the Shulehe drainage syste
m (Ni et al., 2000; Luo, 2000). Wushaoling, Qilian and Tuole weather stations are selected respectively as the repres
entative weather stations at the east, middle and west sections of Qilian Mountains, and the Jiutiaoling Hydrologic S
tation on the Xiyinhe River and the Zamusi Hydrologic Station on the Zamuhe River of the Shiyanghe drainage system, t
he Yingluoxia Hydrologic Station on the mainstreams of the Heihe River, the Liyuanpu Hydrologic Station on the Liyuan
he River and the Binggao Hydrologic Station on the Taolaihe River of the Heihe drainage system, and the Changmapu Hyd
rologic Station on the Changmahe River and the Dangchengwan Hydrologic Station on the Danghe River of the Shulehe dra
inage system are selected respectively as the representative hydrologic stations at the east, middle and west of the
Hexi Corridor region, which are all located at the outlet of the mountain basins of the rivers. 3 ENSO cycle and its
effect on the weather of the fringe regions of the Qinghai-Tibet Plateau West Pacific Subtropical High and typhoon ar
e the important synoptic systems affecting summer climate in China. Studies show that El Nino events possess consangu
inity with intensity, extending position and movement law of West Pacific Subtropical High. Position of secondary hig
h ridge located at the West Pacific in all the months (June to October) of flood season, especially in August to Octo
ber, is south (north) bias when ocean temperature of Prophase Equator Eastern Pacific is higher (lower). Position of
586 line located at the south side of Western Pacific in July to October is south (north) bias, and Subtropical High
Tropic and Easterlies current located at Eastern Asia and Western Pacific Ocean extend to south (north) when the move
ment of Prophase Southern Oscillation in winter and spring is weaker (stronger), Typhoon forming at Western Pacific a
nd landing at China in this year is fewer (more), and that is reverse in the La Nina events occurrence. Western Pacif
ic Subtropical High in summer is weaker (stronger) when Prophase Southern Oscillation in winter and spring is weaker
(stronger) (Li, 1985). With regard to the relationship between El Nino events and Western Pacific Subtropical High an
d Typhoon, Wang et al. present a connection model as follows. The lower (higher) ocean temperature of Equator Mid an
d East → the stronger (weaker) Southern Oscillation → the stronger (weaker) Walker current → the Hadely current ea
st to which is weaker (stronger) and west is stronger (weaker) → the active (fallow) Typhoon located at Western Paci
fic Ocean in summer and autumn. Tropic current is affected directly through coupling action between ocean and atmosph
ere after El Nino events occurrence. The natural process of weather fluctuation of the Qinghai-Tibet Plateau decides
the dynamic change on climate of the Qilian mountain area to a great extent, and the process changes constantly alon
g with energy exchanges between Land and Atmosphere, and Ocean and Atmosphere, and again the exceptional atmosphere c
urrents will affect plateau monsoon, leading to consequently more changes in space and time distribution of precipita
tion in the Qilian mountain area (Ni et al., 2000), that is, stronger (weaker) Walker and Hadley Currents will bring
in Hot Low located at the Qinghai-Tibet Plateau to strengthen (weaken), and that will bring in precipitation, which v
apor is transported through summer monsoon, in the eastern Qilian mountain area to increase (decrease) (Lai, 1992).Th
ere is an atmosphere movement center all whether summer or winter (Cold High in winter and Hot Low in summer), which
is strongly or weakly related directly to Plateau monsoon, that is, the positive departure centre in winter and sprin
g expresses the strong plateau monsoon, and that in summer and autumn expresses the weak plateau monsoon; the negativ
e departure centre just expresses the reversed case. If dividing the plateau into two parts, east and west by the lin
e at 90oE, well then it can be observed from precipitation departure charts in the plateau flood season (April to Sep
tember) in the concerned years that the precipitation in the east is greater than the west in the stronger summer mon

soon years and vice versa. Analysis shows there is a good corresponding relation between summer runoff and ground sen sible heat in the last winter (especially late winter) in the Qinghai-Tibet Plateau. For example, the snowfall was ex ceptionally great on the plateau in the winter of 1997, which brought in exceptionally greater precipitation in the m iddle and lower Yueguzolie River basins and the areas to the south of the Yueguzolie River in summer in 1998 and tha t exceptionally fewer precipitation in the Qinghai-Tibet Plateau and the areas north to the plateau. If El Nino event s occur, the perturbance of the south branch of the westerlies on the Qinghai-Tibet Plateau on the 500 hPa upper air chart in the El Nino is weaker than the general years, and the upper air on the plateau is often controlled by the ho rizontal and the vertical westerly currents. The Wolaer high-pressure ridge is weaker, the position of the sub-tropi c high-pressure ridge is south bias, and the East Asia trough is deeper, the precipitation in east is greater than i n west in China in this year. If La Nina events occur, the snow in winter in the Qinghai-Tibet Plateau is few. Deep t rough often occurs in the Qinghai-Tibet Plateau on the 500 hPa upper air chart of the Northern Hemisphere in summer, and that longitudinal circumfluence is very strong and sometimes the south and north branch of deep trough will link each other to form a new deep trough of the running-through south-north direction along the western part of the Qingh ai-Tibet Plateau to form a position combined with strong high ridge in the east of the plateau, that is, there is a s trong high ridge at the east and a weaker high ridge at the west, but the positions of the trough and the ridge on th e north branch of the current are almost adverse with the mean. The middle scale low-pressure system often occurs at the northeast of the plateau and the northward south bias current is stronger, which both transports the plentiful o f vapor to the plateau and offers the advantageous power condition to the precipitation on the plateau. So the runof f in the Qilian area located at the Qinghai-Tibet Plateau in the La Nina events occurring years is higher than the no rmal years. Of course, climate of the Qinghai-Tibet Plateau mutually is affected by South Asia monsoon, East Asia su b-tropic high pressure monsoon, and the effects of heat condition of the Qinghai-Tibet Plateau itself at one time. E l Nino events are only one of the stronger signals of the factors affecting climate of the Qinghai-Tibet Plateau (Ma and Zhu, 2000). 4 Relationship between ENSO cycle and temperature, precipitation and ous runoff in the Qilian mountai n area An analysis of observation data series of the relational hydrologic and weather stations shows temperature, pr ecipitation and mountainous runoff in the Qilian mountain area have a characteristic of 3-5 years quasi-period surge too, which tally with that of El Nino events. It is presumed hereby that there are certain relations possibly betwee n ENSO cycle with the temperature, precipitation and mountainous runoff in the Qilian mountain area. Temperature, pre cipitation and mountainous runoff in the Qilian mountain area can be classified into three types according to their d epartures, that is, + (the higher years, departures > 0); 0 (the normal years, departures = 0), - (the lower years, t he departures < 0. All the above data together with corresponding El Nino and La Nina occurring years are listed in T ables 1-3. 5 Analysis and discussion of results Various corresponding relationships between El Nino events with tempe rature, precipitation and mountainous runoff in the east, middle and west part of the Qilian mountain area are prelim inarily analyzed and discussed hereinbefore. The results show that because of the little difference on ocean temperat ure between Equator Eastern and Western Pacific in the typical El Nino years, Walker current is weaker (low index), a nd summer subtropical high located at Western Pacific is weaker or the ridge line position is southern bias; contrari wise Walker current is stronger (high index), and summer subtropical high located at Western Pacific is stronger or t he ridge line position is northern bias in the years of La Nina events (Zhu and Li, 1989; 1992). In the years subtrop ical high is weaker or the ridge line position is south bias, the Qilian mountain area located at the northwestern si de of the Qinghai-Tibet Plateau is under the control of the northwest bias current, which brings in dry air and scarc e precipitation. So the summer precipitation in most parts of the Qilian mountain area is very little and the mountai nous runoff is lower in the years of El Nino events; and that the summer precipitation in the part of the Qilian moun tain area is very plentiful and the mountainous runoff is higher in the years of La Nina occurrence. Consequently, w e can consider there is certain relationship between ENSO cycle and temperature, precipitation and runoff in the Qili an mountain area. But the effects of ENSO cycle on temperature, precipitation and runoff in the east, the middle and the west sections of the Qilian mountain area, the through atmosphere current are various because of the differences in geography and physiognomic status, and the influence of different atmosphere current systems. It can be found tha t the characteristics of corresponding relations between ENSO cycle and temperature, precipitation and runoff in the Qilian mountain area are as follows. (1) Corresponding relations between ENSO cycle and temperature, precipitation an d runoff in the east section of the Qilian mountain area are more remarkable than the middle and the west. The temper ature and runoff markedly rise, the precipitation decreases in the area, and the probability that the yearly mean tem perature is positive departure, and the yearly precipitation and yearly runoff are negative departure make up more th an 2/3 in the El Nino years; the temperature is still higher and the probability that the yearly mean temperature is

positive departure is still greater in the whole Qilian mountain area, precipitation and runoff continuously decrease in the next years of El Nino occurrence, but the decreasing extent is fewer than that in the El Nino years. (2) There are certain corresponding relations between ENSO cycle and temperature in the middle and west sections, but the corresponding relations between ENSO cycle and precipitation and runoff are not very marked, especially at the west section. The probability that the yearly mean temperature is positive departure is still greater in the years and the next years of El Nino events.

关键词： ENSO cycle; El Nino events; runoff; Qilian mountain area

