THE ROLE OF ASIA IN GLOBAL CHANGE

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Long extended abstract

Asia has two kinds of unique features, namely the social features and natural features, which all play important role in the global change. The most important social features are its high population and its high rate of economic development. These social features will result in large emission of greenhouse gases into the atmosphere and large rate of change in land cover. In natural features the first to be named is Tibetan Plateau, the role of which in general circulation and climate is definite. The second to be named is the loess plateau which can provide rich records of paleoclimate. This together with the rich proxy climate data from the historical written documents make good contributions to PAGES. The climatic natural feature in Asia are quite a few. But this paper will single out the Asian monsoon which has intimate connections with the circulation or climate in various far remote regions of the world.

I. Social aspect of the role of Asia in global change

(1) The emission of greenhouse gases and aerosols

The most significant social features of Asia are its high population and high rate of economic development. At present Asia has about three billions of people, the half of that of the world. This population raises the large requirement to foods and industrial products. Economic development bring about a great advance in urbanization and energy resource industry. All of these play important role in global change in many aspects, especially landuse/land cover changes and the emission of greenhouse gases.

The greenhouse gases involve mainly carbon dioxide(CO_2), methane(CH_4), nitrous oxide(N_2O) as well as hydroflourocarbons (HFCs), PFCs and SF6. According to current estimations of emission of greenhouse gases in China, the emissions of CO_2 are 2218.9 MT(million tone) in 1990 and 2287.9 MT in 1994 in China, to be equal to 625.1 Mtc and 760.3 MtC respectively, which account to 10.2 and 12.7 per cent of the total global emission. The maximum emission source in China is fossil fuel burning, accounting to more 90 per cent of the total emission. With the economic development in China the production and consumption of fossil fuel will still be the maximum emission source of greenhouse gases in the future(Wang et al. 1998).

Asia possesses the maximum areas of rice paddy in the world. Rice paddy is an important natural source of methane. The seeding areas in Asia and China are 98.22 Mha and 30.17 Mha, accounting to 90.0 and 20.5 per cent of the total global areas. The emission of methane in China in 1994 is about 32.91 Tg (10^{10} g)(6.1 per cent of global emission), in which each of emissions from rice paddy and coal mining make up about one third of the total amount. In recent years areas of rice paddy is slightly reduced due to urbanization, but industrial sources of methane still increase, therefore, the total emissions of CH_4 is increasing continuously.

The emission of nitrous oxide in China is about 0.66 Mt(equal to 0.418 Tg N), accounting to 5.3 per cent of the total global amount. The natural and anthropogenic sources (mainly farmland) are each about one half of the total, i.e. 0.206 Tg N and 0.212 TgN respectively. According to recent estimations (1995), the emission of HCFCs in China is 2244 T, only 0.9 % of the global emissions, because of the low rate of replacement of CFCs. The emissions of PFCs and SF6 in China in 1995 are respectively 2541.2 T and 215 T.

In contract with global warming due to the increase of concentration of greenhouse gases in the atmosphere, the increase of aerosol concentration in the atmosphere leads to the cooling in its response areas. In addition to the transfers of dust and particles from soil and vegetation to the atmosphere, the particles and powder dust are also emitted from industrial productions. In the aerosols, the cooling effect of sulphate in the atmosphere is significant. At present, there are three high concentration areas of sulphate aerosol in the world, i.e. eastern part of North America, Europe and eastern Asia. The emission of sulphate dioxide in China in 1993 is around 1830GgS, and it will increase gradually in the next 20-30 years. From the simulations of climate model, the increase of sulphate aerosol causes the cooling effect in a large area in eastern Asia, the strongest cooling area (about -1.5 C)is in central China (Sizhung province).(Wang, et al. 1998)

(2) The landuse/landcover change

The change in land cover not only affects local climate and environment, but also in very large scale. In history, with the increase of population the farmland extended continuously. About 3ka BP, cultivation areas were limited to the central and lower reaches of Yellow River, and extended to northern China and the south of Yangtze River at about 2ka BP, around 14-19 century(Ming and Qing Dynasty) the farmland reached almost to current state.

Around mid-Holocene (6 ka BP) climate was considerable warmer than the present due to the change of orbital parameters, and at that time landcover was basically natural vegetation because human activities was little to extent. The differences between the simulated climate with reconstructed vegetation cover in mid-Holocene and the today's landcover in China show that the effects of change in landcover is significant.(Wang, 1998)

The most rapid change of land cover occurs in recent half century. Since the past half century, the population in Asia has increased quickly, reaching to 3 billion people, about the half of the total world population. In China population also increased from 0.54 billion to 1.2 billion. Such population stress bring about a great change in land use and land cover. Overall, forest land increased slightly, grassland decreased considerably and farmland changed from 97.88 Mha in 1949 to 139.67 Mha in 1985(Taiwan not included), mainly due to a large scale of increase of cultivations in northeastern and northwestern China. In recent twenty years, because of high economic development, urbanization and transportation occupy a large amount of farmland in eastern and central China, but on the other hand, further cultivation has been carried out in west part and marginal regions of China, thus totally, the farmland has a little change, being 137.2 Mha in 1995. But with the westward shift of farmland the quality of ecosystem environment fell down.

An important aspect of changes of landuse pattern is urbanization, especially in economic developing areas in eastern China. For example, in Yangtze river delta, as monitored by satellite remote sensing in the past 15 years from 1980 to 1994 the vegetated areas as large as 162.9 Kha (including 149 Kha farmland) became townareas. The rapid urbanization in regions of Lake Tai is given as an example.(Tong, et al. 1998)

II. The natural aspects of the role of Asia in global change

After discussing the role of social features of Asia in global change, we now turn to the natural features of Asia in global change.

(1) The role of Tibetan Plateau

The role of Tibetan plateau in the formation of global circulation have long been discussed. Its role in forming the semi-permanent long-wave troughs and ridges is well-known. The splitting of the westerlies over the Plateau into two branches which then merge into one forming the strongest jet stream in northern hemisphere near the Asian coast is also motorous. The role of these long-wave troughs and ridges and this jet stream in global circulation is definite.

In summer besides the dynamic effect, the heat source of the plateau also has a strong thermal influence on the global circulation and climate. The strong surface heating makes the air stratification very unstable and produces strong near surface (actually in middle troposphere) convergence and positive vorticity and upper layer divergence and negative vorticity. Intense convective activities generated thereby not only maintains very particular large-scale circulation over the plateau and its surroundings, but also transport large amounts of sensible heat, moisture, chemical pollutants, as well as air with low ozone concentration from near surface layers to upper layers. A minimum center of low ozone concentration(Zhou, 1995) and a huge upper-layer anticyclone with warm and moist core are thus observed over the plateau region in summer(Ye and Kao, 1979). The strong divergent flow and anticyclonic vorticity source of the upper atmosphere have strong influence on the general circulation over the world via meridional as well as longitudinal circulation, and energy dispersion on spherical surface(Ye and Wu, 1998).

Resulting from the numerous convective cells, there forms a large amount of rising air over the plateau. This ascending air flows southward from the plateau in upper troposphere across the equator and merges with the upper branch of the southern hemispheric Hadley cell. Further to the north the ascending air over the plateau flows northward and descends between 40°N and 47°N where The Takla Makan and Dzungaria Desert are located. The ascending air over the plateau also flows eastward descending east of 170°E, constituting an intense E-W circulation as noted by Krishmurti, and westward descending over Afghanistan, Iran and Sandi Arabia, leading to the formation of dry climate there(Ye and Yang, 1979).

(2) The paleoclimate derived from loess core of the loess plateau.

Loess is another unique natural feature in Asia which can provide rich records of paleoclimates up to 2.5 myr ago.

Magnetic susceptibility of loess and paleosol can be used as a proxy index for summer monsoon intensity whereas the median diameter of quartz isolated from the loess and paleosols can serve as a proxy index of the intensity of winter monsoon . Together with these proxy indices are the fossil snails and the hardwood the pollen assemblage in the loess which may also be used for the paleo-climate studies.

Variations in the magnetic susceptibility of loess-paleosol sequence suggest that over past 2.5myr, the East Asian monsoon exhibited a cyclic variation with periods of 100000,41000 and 21000 years which are the periods of the variations of the earth's eccentricity, obliquity, and precession, respectively. Studies also show that both the pattern and timing the grain-size variations in loess plateau bear a strong resemblance of paleoclimate proxy records from North Atlantic region that span the last glacial cycle. This means that the Heinrich events denoted by cold North Atlantic sea temperatures had left their signature in Chinese loess records.

Examples of the variations the intensity Asian monsoon during the periods 10-80 kyr, 430-550kyr, and 780-840kyr are given.(Liu, An and et al., 1985,1990 and 1997)

(3) The variation of Asian monsoon in relation with the climate variations in other parts of the world.

Climatically, Asia has quite a number of the natural features which are important for global change. Asian monsoon is such an important member. How it is related to its surrounding climate, will be discussed. Generally speaking, each monsoon system has its own seasonal and interannual variations. However, it is found that over Afro-Asian continents the simultaneous fluctuations in different monsoon regions happened in history on different time scales.

In the middle of 1960's, the summer precipitation pattern suffers an abrupt change(Yan, Ji and Ye, 1990). The summer rainfall regions in a long belt of African and Asian arid/semiarid zones from Salara, Mid-East, northern India to North China decreased abruptly. On the two sides of this zone were two belts of increasing rainfall. This pattern corresponds to the period from strong to weak Afro-Asian monsoon (AAM).

The alternation of wet-dry climate pattern of AAM also occurred since the last 140 ka. The synthetic analysis of proxy data from different sources shows the simultaneous occurrence of dry and wet periods along the belt of arid/semiarid areas over African Asian continents from North China, SE Tibet, NW India, Arabian Peninsula and south Sahara-Sahel(Yan and Petit Marie).