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Monsoon abrupt change and its dominant factors

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Abrupt changes of monsoon are apparent in the geological record of climate over various timescales. During Holocene and last glacial period, rainfall in India and China has undergone strong and abrupt changes. In this context, we regard monsoon as dissipative system, which has many characteristic times, to contrive various factors and corresponding mechanism dominated in monsoon's abrupt change. The abrupt change of monsoon over inter-decadal to century timescales may be resulting from different fluctuation's competition, which impose on the inner basic physic processes. In order to find out the key factors which control the monsoon's abrupt change, starting from the seminar works by Leith, who proposed to employ the Fluctuation-dissipation Response theory(FDR) to study the response of climatic systems to changes in the external forcing, many authors applied this relation to different geophysical problems, ranging from simplified models to general circulation models and to the covariance of satellite radiance spectra. The FDR has been originally developed in the framework of statistical mechanics of Hamiltonian systems, nevertheless a generalized FDR holds under rather general hypotheses, regardless of the Hamiltonian, or equilibrium nature of the system. Our work verify the FDR theory' applicability in monsoon systems, which demonstrates that it can reveal clear and fundamental factors that control monsoon's abrupt change. By making use of FDR theory, combined with observational data analysis, we have already seen how monsoon systems with many characteristics times, different correlation functions behave differently and a variety of timescales emerges, which correspond to the different decay times of the correlation functions.

Via theoretical and data analysis, it is suggested that each monsoon system has experienced several significant abrupt changes in 20th century. The global main monsoon rainfall has undergone an obvious abrupt jump in the mid- and late 1970s. This precipitation regime shift is in good coincidence with a significant abrupt climate change which has been extensively observed in other regions over the world as well as for other variables. The East Asia summer monsoon's abrupt change mainly result from the SST forcing which derive from pacific ocean and mid-latitude atmospheric circulation pattern's distribution. The abrupt change in late 1990s may be induced by vegetation cover change caused by the anthropogenic activity. Through analysis about Indian summer monsoon, it displays that SST forcing derived from North Atlantic Ocean plays an important role in the abrupt change or regime shift, and further research suggests that although the forcing signals are fairly weak, certain internal feedback in monsoon dynamics may have amplified the weak external forcing. On the other hand, West Africa summer monsoon has also undergone obvious abrupt change, especially in late 1960s, characterised by lasting precipitation decreasing in Sahel region approximately for 30 years. The dominant factors are the vegetation cover change and SST forcing derived from Atlantic Ocean.