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Response of East Asian summer monsoon to external forcing over the last millennium

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The centennial-millennial variation of the East Asian summer monsoon (EASM) precipitation over the past 1000 years was investigated through the analysis of a millennium simulation of the coupled climate model ECHO-G. The model reproduces reasonably realistic present-day EASM climatology. The simulated variation of precipitation in East Asia over the last millennium compares favorably with the observed and reconstructed data. The model results indicate that the centennial-millennial variation of the EASM is essentially a forced response to the external radiative forcing (insolation, volcanic aerosol, and greenhouse gases). The strength of the response depends on latitude. The spatial structure of the centennial-millennial variation differs from the interannual variability that arises primarily from the internal feedback processes within the climate system. On millennial time scale, the extratropical and subtropical precipitation was generally strong during Medieval Warm Period (MWP) and weak during Little Ice Age (LIA). The tropical rainfall is insensitive to the effective solar radiation forcing (insolation plus radiative effect of volcanic aerosols) but significantly responds to the modern anthropogenic radiative forcing. On centennial time scale, the variation of the extratropical and subtropical rainfall also tends to follow the effective solar radiation forcing closely. The forced response features in-phase rainfall variability between the extratropics and subtropics, which is in contrast to the anti-correlation on the interannual time scale. Further, the behavior of the interannual-decadal variation in the extratropics is effectively modulated by change of the mean states on the millennial time scale, suggesting that the structure of the internal mode may vary with significant changes in the external forcing. These findings imply that on the millennial time scale, (a) the proxy data in the extratropical EA may more sensitively reflect the EASM rainfall variations, and (b) the Meiyu and the northern China rainfall provide a consistent measure for the EASM strength.