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Asian Black Carbon Influence on East Asian Summer Monsoons

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Since the black carbon (BC) emission in East and South Asia has increased significantly during the last decades of the 20th century, there is an ever growing concern about its impact on Asian monsoon. In this study we provide an in-depth analysis of the influence by performing several ensemble sensitive experiments with or without historical BC concentrations over East Asia, South Asia, and the combined East and South Asia in an atmospheric general circulation model, GFDL AM2.1. The results show that: (a) The East Asian summer climate is sensitive to the East Asian BC (EABC) concentrations in a sense that EABC contributes significantly to the frequently occurring north-drought and south-flood patterns in Eastern China. In detail, the large scale precipitation anomalies induced by EABC characterize more rainfalls over central/south China, East China Sea and southern Japan and less rainfall over northern China and the west Pacific region between 10[U+F0B0] to 20[U+F0B0]N. These anomalous precipitation patterns are mainly attributed to the EABC induced large scale circulation changes including the weakened Western Pacific Subtropical High (WPSH), anomalous ascent motions over central-southern China (centering over the Yangtze River valley (YRV)) and the subsequent descent motions over northern China and the South China Sea. These modeled results suggest that the EABC experiment reproduces the climate shift event of eastern China during the late 1970s, including intensified rainfall in the YRV and the weakened summer monsoonal circulation. (b) The anomalous results of South Asian BC (SABC) experiment signify a tri-polar precipitation response over East Asia, with a reduction from the YRV to East China Sea and southern Japan sandwiched with increases over a northern domain from northern China/ Korea to northern Japan and over southern China. As for southern China, particularly the YRV, the impact of SABC is to offset a fraction of intensified rainfall induced by local BC of East Asia. Mechanistically, the remote effect of SABC over East Asian climate is realized through a propagating wave train along the Asian upper jet that disperses the South Asian local atmospheric signals downstream and causes an intensified subtropical high over the western Pacific and thus less moisture supply from the Bay of Bengal to reach the Yangtze River basin. (c) The combined East and South Asian BC (ABC) also results in reduced precipitation anomalies over eastern China and the South China Sea extending to Japan while enhanced precipitation over central and northern China. This implies that ABC has a tendency to shift the meiyu rain belt northward consistent with the previous conclusions for absorbing aerosols. Based on above mentioned model results we argue that the East Asian summer climate is highly sensitive to the BC concentrations over the local or over South Asia, and the latter might have contributed to the weakening of East Asian monsoon during the last two decades of the 20th century.