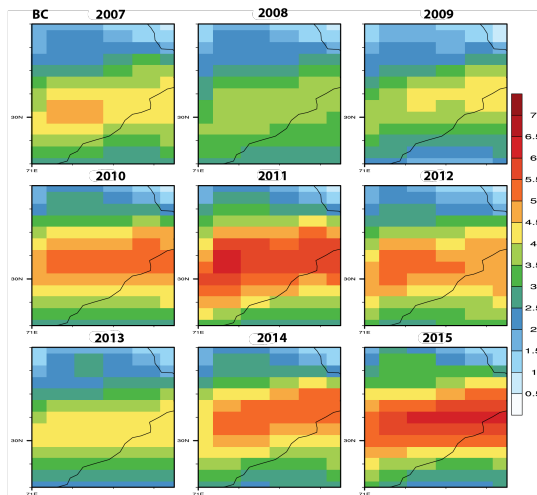


## Case Study of Air Quality during Winter Season over Northeastern Pakistan during 2007 to 2015

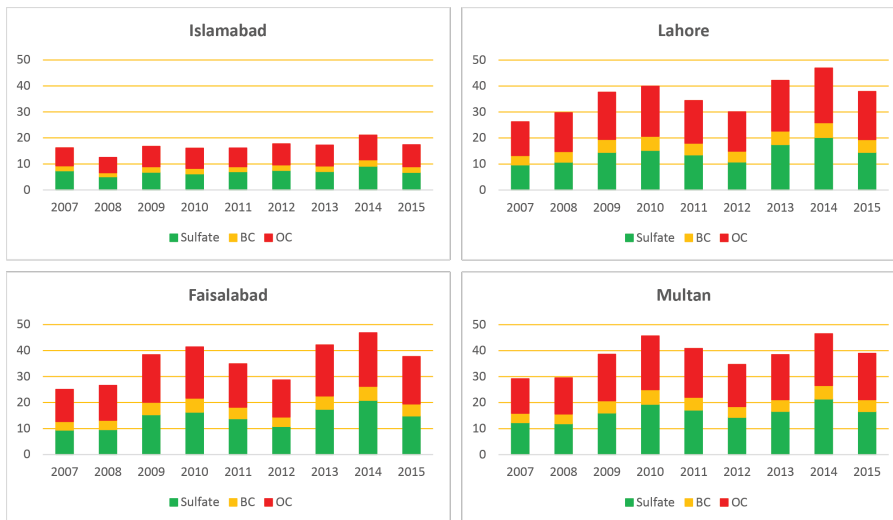
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Air pollution during winters over northeastern (NE) Pakistan (28–34 °N, 71–74.5 °E) is a serious challenge that affects human health, climate, and daily life. We use the Modern-Era Retrospective analysis for Research and Applications, V. 2 (MERRA-2) and satellite observations to quantify the last decade trend and interannual variation of aerosol during wintertime over NE Pakistan. Aerosols [sulfate, black carbon (BC), and organic carbon (OC)] are retrieved from MERRA-2 during 2007 to 2015. This study provided a unique opportunity to reveal temporal and spatial air pollution levels in mega cities in NE Pakistan. This study analysed the air pollution characteristics during winter, 2007 to 2015 in four mega cities including national and provincial capital cities in NE Pakistan. Averaged over winters from 2007 to 2015, over the four mega cities, Islamabad, Lahore, Faisalabad and Multan, the concentrations of sulfate were 5.06, 14.09, 14.29, 16.22  $\mu\text{g m}^{-3}$ ; BC were 1.5, 4.69, 4.46 4.52  $\mu\text{g m}^{-3}$ ; and OC were, 5.85, 17.32, 16.99  $\mu\text{g m}^{-3}$  and 17.29, respectively. Aerosol concentrations during wintertime over NE Pakistan showed an increasing trend of aerosol optical depth and increased up to 0.5–0.8 over the past decade.



**Figure 1.** Concentration of BC ( $\mu\text{g m}^{-3}$ ) over northeastern Pakistan (28–34 °N, 71–74 °E) during winter (average over December, January, February), 2007 to 2015.



**Figure 2.** Aerosol conc. (average over December, January, February) over Islamabad, Lahore, Faisalabad and Multan during 2007 to 2015.