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Long-term impacts of sulfur and nitrogen deposition on the South Korean forest ecosystems by long-range transport and local emissions

Jae-Myun Shim and Soon-Ung Park
School of Earth and Environmental Sciences, Seoul National University

Exceedances of sulfur and nitrogen critical loads in South Korean forest ecosystems caused by long-range transport and local emissions of sulfur and nitrogen have been estimated using the maximum critical load of sulfur and the critical load of nutrient nitrogen. The long-term averaged deposition of sulfur and nitrogen is estimated with a simplified chemical model and the K-mean clustering technique. The three consecutive days of gridded daily mean National Center for Environmental Protection (NCEP) reanalyzed 850 hPa geopotential height fields with and without precipitation on the last day over South Korea are used for clustering of synoptic patterns for the period of 1994-1998. Two emission conditions are simulated for each cluster to estimate long-term averaged depositions of sulfur and nitrogen by long-range transport and local emissions over South Korea. One condition takes all emissions within the simulated domain into account as a base case and the other condition excludes all South Korean emissions but including all of the other emissions, as a control case. The results of the present study indicate that the contribution of long-range transport to the annual total deposition over South Korea is found to be about 34% (500 eq ha^{-1} yr^{-1}) for sulfur and 58% (680 eq ha^{-1} yr^{-1}) for nitrogen, of which 53% for sulfur and 67% for nitrogen are contributed by wet deposition. This suggests the importance of wet deposition through the transformed acidic precursors for long-range transport to South Koreas total deposition of sulfur and nitrogen. The estimated exceedance for South Korean forest ecosystems indicates that the current estimate of total sulfur deposition affects about 45% of the South Korean forest ecosystems adversely, of which 23% is attributed to South Korean source only and the rest of 22% is attributed to long-range transport together with South Korean source. Long-range transport of sulfur itself does not exceed the maximum critical load of sulfur. On the other hand, the current estimate of total nitrogen deposition is found to affect all South Korean ecosystems adversely. About 38% and 18% of the South Korean forest ecosystems are respectively found to be affected adversely by South Korean nitrogen emissions and by long-range transport, suggesting that the reduction of nitrogen deposition from both South Korean sources and long-range transport is a prerequisite to ensure South Korean forest ecosystems sustainable