Sulfur Wet Deposition

This EnviroAtlas national map portrays annual wet deposition of sulfur dioxide (SO_2) and particulate sulfate (SO_4) (kilograms of sulfur per hectare) within each subwatershed (12-digit HUC) for the year 2006. The map is based on data from the Community Multiscale Air Quality modeling system (CMAQ).

Why is sulfur deposition important?

Sulfur deposition occurs when sulfur in the atmosphere is transferred to the earth's surface through wet deposition or dry deposition. Total sulfur deposition includes the wet and dry deposition of sulfur dioxide (SO_2) and particulate sulfate (SO_4). The main source of sulfur emissions is the burning of fossil fuels, although some come from natural sources such as volcanoes.

Atmospheric deposition of sulfur and nitrogen plays an important role in terrestrial, freshwater aquatic, and marine ecosystem functioning and degradation.[3,7] Soils have an inherent buffering capacity. When acidic atmospheric deposition overwhelms this capacity, numerous harmful effects can occur.[10,6,9] For example, deposition can cause slower plant growth, the loss of soil fertility, the injury or death of forest vegetation, and the localized extinction of fish and other aquatic species.[1,2,4] Acidification of lakes and streams due to deposition can cause the loss of species diversity and extinction of fish and other aquatic species.[2,4,6]

Sulfur deposition can also cause microbes to produce more methane, a greenhouse gas (GHG), and change mercury into an extremely toxic chemical called methyl mercury that can more easily enter the food chain and build up in human and animal tissue.[5]

How can I use this information?

The map, Sulfur Wet Deposition, provides information from the CMAQ model showing how exposure to sulfur deposition varies across space due to complex emissions patterns and their transport and transformation. This map provides spatially continuous values of concentration and deposition that can be used as input to ecological assessments and ecosystem management strategies. Having data on sulfur deposition will help in determining the extent to which an ecosystem will recover and the timeline for recovery.[8]

This map also provides important input to critical loads analyses. Critical loads can be defined on the basis of species diversity, soil chemistry, tree growth, and many other indicators. Comparison of total sulfur deposition to critical load values allows users to identify areas where critical loads are likely to be exceeded and attention is potentially needed to avoid or mitigate damage.

How were the data for this map created?

This map was created using output from the CMAQ Modeling System v 5.0.2. Meteorology data was processed for 2006 using the Weather Research Forecast model v3.4 with the Pleim-Xu land surface model. Emissions are based on the National Emissions Inventory (NEI) 2006 platform. The output was corrected for errors in wet deposition using PRISM data and for bias in the rainwater concentrations of sulfate using National Atmospheric Deposition Program (NADP) data. Model predicted values of dry deposition were not adjusted. Finally, the gridded data were summarized by 12-digit HUC, using the 2011 Watershed Boundary Dataset.

Air quality models are an important tool for translating emissions data into information about ecological exposure. This is because deposition in a watershed can come from a large geographic area. Airsheds are very large in comparison to the watershed and include emissions from multi-state regions. Local deposition is caused by a mix of airshed and distant emissions. This makes it difficult to predict the exposure that results from emissions without the use of a regional air quality model.

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For detailed information on the processes through which this data was generated, see the metadata.

What are the limitations of these data?

All national data layers are inherently imperfect; they are an estimation of the truth based on the best available science. Calculations based on these data are therefore also estimations. The user should be aware that the mapped data are not perfect and should be used to inform further investigation. Periodic updates to EnviroAtlas will reflect improvements to nationally available data.

Atmospheric deposition varies across the U.S. due to differences in climate and land surface. The National Trends Network (NTN), a part of the NADP, provides wet deposition data at numerous sites across the U.S. While monitoring data are useful, estimates of deposition between monitoring locations can miss changes in value due to the distribution of emissions and variations in the land surface. The CMAQ modeling system accounts for the complex chemistry of the atmosphere and interactions between chemicals.

The CMAQ modeling system is based on the best available science. Still, the chemistry and physics of the atmosphere are very complicated, and there are uncertainties in the model representations and inputs that result in uncertainties in the predicted concentrations and deposition fluxes. The data have been summarized based on HUCs, but actual atmospheric deposition will vary within the HUC.

For more technical details about the limitations of these data, refer to the metadata. Accuracy information for the source data sets can be found on their respective web sites.

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded.

Where can I get more information?

There are numerous resources on sulfur deposition; a selection of these resources is below. To ask specific questions about this data layer, please contact the EnviroAtlas Team. Information about the models used can be found at their respective websites.

Acknowledgements

The data for this map were generated by Jesse Bash, Ellen Cooter, George Pouliot, Rob Gilliam, and Kristen Foley, EPA. This fact sheet was created by Donna Schwede, Robin Dennis, Ellen Cooter, and Jesse Bash, EPA.

Selected Publications

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[2]Dennis, R., R. Haeuber, T. Blett, et al. 2007. Sulfur and nitrogen deposition on ecosystems in the United States. EM December 2007:12-17.

[3]Driscoll, C. T., Y.-J. Han, C. Y. Chen, et al. 2007. Mercury contamination in forest and freshwater ecosystems in the Northeastern United States. BioScience 57:17-28.

[4]Driscoll, C. T., G. B. Lawrence, A. J. Bulger, et al. 2001. Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies. BioScience 51:180-198.

[5]Greaver, T. L., T. J. Sullivan, J. D. Herrick, et al. 2012. Ecological effects of nitrogen and sulfur air pollution in the US: what do we know? Frontiers in Ecology and the Environment 10:365-372.

[6]Lawrence, G., J. Sutherland, C. Boylen, et al. 2007. Acid rain effects on aluminum mobilization clarified by inclusion of strong organic acids. Environmental Science & Technology 41:93-98.

[7]Lovett, G. M., T. H. Tear. 2008. Threats from Above: Air Pollution Impacts on Ecosystems and Biological Diversity in the Eastern United States. Nature Conservancy.

[8]Mitchell, M., G. Lovett, S. Bailey, et al. 2010. Comparisons of watershed sulfur budgets in Southeast Canada and northeast US: new approaches and implications. Biogeochemistry, Online First 19 May 2010.

[9]Sullivan, T. J., B. J. Cosby, J. R. Webb, et al. 2008. Streamwater acid-base chemistry and critical loads of atmospheric sulfur deposition in Shenandoah National Park, Virginia. Environmental Monitoring and Assessment 137:85-99.

[10]Sullivan, T. J., I. J. Fernandez, A. T. Herlihy, et al. 2006. Acid-base characteristics of soils in the Adirondack Mountains, New York. Soil Science Society of America Journal 70:141-152.