www.simiode.org
SIMIODE
A SYSTEMIC INITIATIVE FOR MODELING INVESTIGATIONS & OPPORTUNITIES WITH DIFFERENTIAL EQUATIONS

STUDENT VERSION

Airshed Sulfur

Brian Winkel, Director SIMIODE
Chardon OH 44024 USA
BrianWinkel@simiode.org

Abstract: Temperature inversions and low wind speeds can trap air pollutants in a mountain valley for an extended period of time. Gaseous sulfur compounds are often a significant air pollution problem. We offer a model for analysis to predict long-term levels of pollutants and present additional issues.

SCENARIO DESCRIPTION

Temperature inversions and low wind speeds can trap air pollutants in a mountain valley for an extended period of time. Gaseous sulfur compounds are often a significant air pollution problem, but their study is complicated by their rapid oxidation. Hydrogen sulfide, H_2S, oxidizes into sulfur dioxide, SO_2, which turns into a sulfate. The following model has been proposed for determining the concentration $x(t)$ and $y(t)$ of H_2S and SO_2, respectively, in a fixed air shed.

Let

$$\begin{aligned} x'(t) &= -\alpha x + \gamma \\ y'(t) &= \alpha x - \beta y + \delta\,. \end{aligned}$$

where the constants α and β are the conversion rates of H_2S into SO_2 and SO_2 into sulfate, respectively, and γ and δ are the production rates of H_2S into SO_2 and SO_2 into sulfate, respectively.

a) Solve the equations and estimate the concentration levels that could be reached under prolonged air pollution.

b) What effect does this model show if we were to reduce, δ, the production rate of SO_2?

c) Does the original amount of either compound effect the long-term amount of the respective compound?

d) Suppose we stopped producing SO_2 altogether. How would the resulting long-term level of SO_2 compare to the original long-term level of SO_2. say if we assumed $\gamma = 0.5$ and $\delta = 0.4$?