Chapter 17
Application of Machine Learning Techniques in the Study of the Relevance of Environmental Factors in Prediction of Tropospheric Ozone

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ABSTRACT

This work presents a new approach for one of the main problems in the analysis of atmospheric phenomena, the prediction of atmospheric concentrations of different elements. The proposed methodology is more efficient than other classical approaches and is used in this work to predict tropospheric ozone concentration. The relevance of this problem stems from the fact that excessive ozone concentrations may cause several problems related to public health. Previous research by the authors of this work has shown that the classical approach to this problem (linear models) does not achieve satisfactory results in tropospheric ozone concentration prediction. The authors' approach is based on Machine Learning

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(ML) techniques, which include algorithms related to neural networks, fuzzy systems and advanced statistical techniques for data processing. In this work, the authors focus on one of the main ML techniques, namely, neural networks. These models demonstrate their suitability for this problem both in terms of prediction accuracy and information extraction.

INTRODUCTION

The atmosphere provides protection and support for humans and other species without which we could not survive. It protects because its composition prevents the passage of harmful radiation to humans such as ionizing and ultraviolet radiation, and it is a medium because it contains chemical elements without which there would be no life on Earth. Therefore, models are needed to help predict the evolution of these chemical elements over time so that if trends are not desirable, control elements can be implemented to avoid problems (Corani, 2005; Hooybergh s et al., 2005). Tropospheric ozone is one component of the atmosphere that can cause severe problems. There are many research studies that demonstrate the effects of this pollutant on human health (Kinney et al., 1996; Larsen et al., 1991; Spekton et al., 1991). Moreover, humans are not the only species affected by high concentrations; adverse effects on agriculture have also been well documented (Krupa et al., 1994; Legge et al., 1995). In the European Community, these effects have been estimated to cost over one billion euros per year (Krupa et al., 1994). For example, in Europe, there has been an annual increase of tropospheric ozone concentration of between 1% and 2% over the past twenty years, with indications that this trend will continue (Stockwell et al., 1997). Harmful effects on public health, crop yields and agricultural ecology have led the governments of the EU and the USA to pass laws to reduce the concentration of this pollutant. The development and update of this legislation requires legislators to have a scientific understanding of the following:

- A rigorous and detailed knowledge of the tropospheric ozone concentration. This requires the establishment of a network to monitor the environmental air quality and subsequent numerical analysis of the data (advanced statistics).
- Predictions for the short, medium, and long term. Reliable predictions would help authorities to comply with legal regulations corresponding to advance notice to the public when tropospheric ozone concentrations reach levels that are harmful to the health of vulnerable groups (children, seniors, etc.). Long-term forecasts would also allow the species of agricultural crops that are best suited to the presence of tropospheric ozone to be selected.
- The importance of atmospheric variables and atmospheric pollutants on tropospheric ozone concentration. With this knowledge, the best decisions can be made with regard to the control of various environmental contaminants that play an important role in the formation of tropospheric ozone.

Tropospheric ozone is considered to be a secondary pollutant and is made up of complex and non-linear photochemical reactions. Its precursors (NO_x and Hydrocarbons) interact photochemically with the atmosphere to create tropospheric ozone, while tropospheric ozone is destroyed by oxidation. In a laboratory, tropospheric ozone concentrations would be easily predictable since all the conditions and concentrations of all the gases involved in their composition would be known and controlled. However, the prediction

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