Chapter 1

Classification Techniques for Thunderstorms and Lightning Prediction: A Survey

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ABSTRACT

Environmental disasters affect the economy, biodiversity, human life, and living organisms. Thunderstorms are one of such environmental disaster. By using proper methodology of forecasting thunderstorms, the adverse effects can be reduced. The prediction of thunderstorms is the most difficult task in weather forecasting due to their temporal and spatial extension either physically or dynamically. Lightning is associated with thunderstorms, which causes wildfires, kills people and other living organisms. Heavy rain from thunderstorms causes flash flooding. In this regard, several researchers have proposed different methodology such as statistical, numerical mode, data mining, soft computing, and machine learning for forecasting of severe weather to reduce the damages. This chapter focuses existing classification methods on thunderstorms and lightning prediction. This chapter includes suggestions on the future research directions.

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INTRODUCTION

A thunderstorm is a series of sudden electrical discharge resulting from atmospheric conditions. Electric discharged result in sudden flashes of light and rumbling sound wave, commonly known as thunder and lightning. The thunderstorm is a weather sensational phenomenon with few kilometers to 100 kilometers and time varying from an hour to several hours which occurs seasonally. A severe thunderstorm is a natural phenomenon that causes lots of damages to life, properties, animal and crops. Forecasting of severe thunderstorm and lightning is a challenge for researcher and scientists in world because such highly nonlinear and disorder phenomena may acquire significant consequences on the huge part of agricultural productivity.

Moisture, unstable air and lifting mechanism are playing important role in the formation of thunderstorm. There are many causes that lead to uplifting of warm and humid air such as air-solar heating, two different air streams meet, vicinage of the low pressure channel, etc. When humid air is lifted upward and cooled then the moisture in the air is condensed and form clouds. Due to further lifting of humid air, the cloud would be extended larger and water droplets continue growing in the cloud and further freezes to form ice crystals. As soon as the water droplets are become so heavy, they are falling as hail. The hail acquires the negative charge due to rubbing against the ice crystals in clouds. Thus the negative charges are collected at the base of the cloud and positive charges are created at the top of the cloud. These negative charges are attracted by some other clouds, objects and earth. When the attraction extent to large, negative and positive charges are either discharge or come together to form lightning. Lightning is further heating and expanded the air, which produced the thunder. Thunderstorms are categorized on the basis of physical characteristic. Actually, thunderstorm type is a regular spectrum, but these can be broadly classified into four types- single cell storms, multicell cluster storms, multicell line storms and supercell storms. Single cell storms are not strong to produce dreadful weather and its life is 20-30 minutes. Due to poorly organized and occurred at arbitrary locations and time, it is challenging to forecast accurately where and when will happen. The multicell cluster storms are the most general type of thunderstorms. A group of cells and moving along as one unit can be considered as multicell cluster storms. Multicell cluster storms have stayed for several hours, but its cellular life is 20 minutes. It produces moderate size hail, downbursts heavy rain and occasionally weak tornadoes. Multicell cluster storm are more dangers than single cell storms, but less intense than supercell storms. The multicell line storms are also known as a squall line. Squall line consists of a long line of storms and well developed gust. It produces hail, heavy rainfall and weak tornadoes. Supercell storms are generally highly organized thunderstorm and poses high threat to life and properties. It consists of one main updraft and produces giant hail and strong to violent tornadoes. Every thunderstorm poses lightning. Lightning is generally classified into four broad categories: Inter-cloud, cloud to cloud, cloud to ground, cloud to air. Cloud to ground is more dangerous than the other types of lightning.

In the last two decades, the prediction of thunderstorm and lightning is an active area of research. Yet it is still a challenging work for researcher and forecasters due to its spatial and temporal extension. United Nation has stated that the lightning disasters are the most serious of ten natural disasters. According to the China Electrotechnical Commission, lightning disasters are major public hazardous in an electronic era. NCRB report of India reported 1, 95,745 total deaths in 45 years due to five major calamities. Out of which 39% were due to lightning, which is the most fatalities than other calamities. This leads to a lot of research work for prediction and forecasting of thunderstorm and lightning. Without electronic products,