ASPECTS REGARDING SEVERE WEATHER AND THE INFLUENCE ON AGRICULTURE IN A CHANGING CLIMATE

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Abstract. *Agriculture is the one of the most important priorities and economic activities in developing countries. Climate change, which is already affecting the society at a global level, has an impact on the increase in magnitude and frequency of severe weather events. As such, both agriculture and industry are affected by climate change and their revenues decrease, thus affecting the entire economic cycle. The aim of this paper is to present theoretical considerations regarding climate change induced severe weather events and to highlight some practical techniques used in operational meteorology in order to improve the forecast of severe weather events. By analysing the morphology and dynamics of thunderstorms, by applying the correct parametrization in weather forecast models, nowcasting and by issuing on time weather alerts, financial losses may be limited. Throughout this paper, the parametrization of convective cells will be described, operational forecasting techniques will be presented and the application of ingredient-based forecasting methodology will be discussed. Severe weather associated hazards like hail, heavy rainfall, damaging winds and even frost will be analysed in order to establish a local climatology of these phenomena. With the aid of Weather Surveillance Doppler Radar (WSDR) and by associating some instability convection indices with synoptic charts, the agriculture-related severe weather events can be identified and their formation pattern can be established. Further on, by establishing an analysis methodology and by compelling all available data, weather-related hazard maps are to be compelled and are to be used by agrometeorology forecasters in order to seek viable solutions. The Western part of Romania is characterized as having a moderate-continental climate, with hot influences from the Southern part of Europe and with humid advections from the South-Western part of Europe. In combination with cold advections from the Northern Europe, both summer as well as winter specific agriculture-related severe weather events are present.*

Keywords: *agriculture, severe weather events, climate change, operational forecasting, sustainable development*

INTRODUCTION

Severe weather events impose a high risk upon human society and general well-being. Adaptation to such changes in magnitude of weather has been researched for a long time. Climate change has affected not only agriculture, but also the entire industry. BUSUIOC (2010) stated that climate change has an impact on both frequency and magnitude of severe weather, as such severe weather events will be more frequent and thus will produce more damage.

The Western part of Romania is exposed to moderate humidity (MIRCOV, 2018). During the summer months, most of the rainfalls occurs from local or regional convective situations

(MIRCOV, 2017). During the autumn and winter months, the majority of the rainfalls occur from warm fronts, especially from nimbostratus clouds.

DOSWELL (2001) classifies severe convective storms as those systems which produce heavy rainfall (more that 25mm/h), sustained wind with speed exceeding 25 m/s, hail size larger than 2 cm, and in extreme cases, even supercell mesocyclones, which are capable of developing tornadoes. In order for such events to form, there is the need for a high degree of atmospheric instability, the presence of cold and dry air at 700 hPa or 500 hPa, condensation nuclei, vertical and horizontal windshear and a lifting mechanism.

MATERIALS AND METHODS

This paper, which shall be regarded as a hybrid between both theory and practice in operational forecasting, points out some of the most important weather-related variables, which are taken into consideration when agriculture-related severe weather is forecasted.

The most important air masses which make up the topoclimatology of the Western part of Romania were described by ŞERBAN (2010). The general atmospheric circulation affects the Western part of Romania through cold air advection. The cold air originates from the North and North Western part of Europe. This happens due to the Azores Anticyclonic activity. Cold and humid air masses mix with hot and dry air masses especially during the summer, thus being able to initiate convective activity in the central and eastern part of Hungary as well as in the Western part of Romania. During the winter, the Azores Anticyclone, depending on its position, may cause late blizzards, as it was the case in March 2018. Freezing temperatures from that blizzard had a negative impact on the growth of crops and on the entire industrial flow in the Western part of Romania.

One of the conditions for severe weather to form is the mixing of hot and humid air with cold and dry air. The presence of dry air at 700hPa level or even at 500hPa level has led to the formation of severe thunderstorm clusters, mesoscale convective systems (MCS) and even supercells. It is at this level where hail embryos may form and develop. Under some circumstances, as for example strong updrafts, hail may reach important dimensions, which can, in some cases, damage not only crops, but also destroy buildings, cars and even produce harm to humans. The Carpathian dam (ION-BORDEI, 1983) acts like a wall and prevents much of the storm systems to pass beyond the Western part of Romania. The orographic convection, which takes place in the vicinity of the Carpathian Mountains, still may produce important storm cells and further affect other regions. The Mediterranean cyclones, which are active all time during the year, do influence the formation of blizzards over the Western part of Romania, especially during the late winter months (TOPOR ET STOICA, 1965).

Severe weather, especially convections, arise during the hot season. SANDU (2010) suggests that the time scale for such type of weather events is between May and September.

Over the last century an impressive quantity of observational data about thunderstorms over land has been gathered. Because if the need to recognize the conditions in which thunderstorms develop, and in particular to those in which they may become severe, simple theories were constructed to relate the like hood of afternoon storms to conditions aloft observed during soundings made the previous morning.

An important theory is based on the assumption that at least in the interior of thunderclouds air ascends adiabatically, loosing any condensed water vapor, after beginning its rise in the state anticipated to be produced by the sunshine near the ground.
There are mainly three types of thunderstorms which may occur. This classification is based on the type of cell from which the thunderstorm is formed.

1. Single cell thunderstorms

Usually, all convection is based on sufficient instability. If the vertical wind shear is less than 10 m/s, then there is a greater probability of a single cell thunderstorm. Usually, single cells have a life cycle of maximum 30 minutes from the first towering cumulus until the dissipation stage. The towering cumulus causes great gradients in the atmosphere. The precipitation starts at the moment when the towering cumulus reaches the subfreezing layer. The most important and well-developed part of a single cell thunderstorm is situated at the -10°C up to -20°C layers. Around 25 minutes after the initiation the updraft begins to weaken and the outflow begins to stabilize. Usually, these types of thunderstorms are around 6 km in diameter. They usually are not a threat for humans. The updraft contains warm, moist air originating from storm inflow that is buoyant and rises rapidly. This is considered in operational forecasting as an appearance of a rapidly-building thunderstorm.
The downdraft is caused by precipitation particles accumulating at the top of the storm. These particles coalesce while others evaporate. The downward motion quickly begins occurring, forming the downdraft. It can fall directly back into the updraft, or in the case of stronger storms, just downwind of the updraft. The downdraft as it sinks, causes the cloud droplets to evaporate, appears visually as clear, bright air but may be filled with rain and hail, and thus darkened.

2. Multi cell thunderstorms

Multi cell storms are a common occurrence when deep, moist convection is organized mostly into clusters or areas. Multi cells are defined as a group of cells in close proximity and they share a common cold pool and precipitation area. This type of thunderstorms is very similar to the single cell one because the main difference is the diameter of the storm and the affected area. Multi cell thunderstorms usually form when the terrain has different thermal properties and they couple into a larger storm system. The only common element to other storms in a multi cell system is the wind and the inflow of hot and humid air.

The multicell cluster, as it is determined with the help of Doppler radar scans, is the most common type of storm in a multicell environment.

3. Supercell thunderstorms

The multi cell thunderstorm may produce severe weather but the supercell almost always produces one or more extreme weather phenomena. The supercell can occur in almost any latitudes and in the mid latitude location especially in spring time. It requires extreme instability and a special combination of boundary level and high wind conditions. The supercell usually forms in the following conditions:

- Warm and very moist air at low level;
- A shallow capping inversion at the 850-800 hPa level;

- Cold dry aloft accompanied by extreme instability;
- Severe wind shear which increases with height.

The severe wind shear tilts and twists the thunderstorm with such height that the updraft core is severely displaced from the downdraft core. The capping inversion prevents small cells from forming and when the convective turbulence is strong enough to penetrate the inversion, the warm moist air shoots upward with great speed and a large storm quickly develops (FABRY, 2015).

The strong updraft is not broken by any downdraft action and slants upward and overshoots by several thousand feet into the stratosphere above the storm anvil. The precipitation downdraft is offset and the gust front travels ahead of the storm. There are two important differences between the structure of a single cell thunderstorm and a super cell thunderstorm:

1. The supercell is much larger;
2. Updrafts and downdrafts are being separated in a supercell;

Because of this separation, severe turbulence and wind shear occur in the cell. The rain free base is located at the rear edge of the storm and a tornadic cloud or even a tornado is before it.

The tornadic cloud, also known as wall cloud is a low-level cloud which signals a high level of rotation within the thunderstorm. This appears approximatively 5 km before the tornado outline and is usually a precipitation free area. The Doppler radar usually registers the speed of a tornado within a supercell because of the formation of a mesocyclone within the storm.

RESULTS AND DISCUSSION

The operational meteorology focuses on the forecasting of severe weather and its impact on industry and agriculture. The most important negative impact of severe weather on agriculture is produced by hail, flash floods and squalls. These types of events are forecasted with the help of state-of-the-art technology, mainly numerical weather prediction (NWP) and with the use of Weather Surveillance Radar.

Small scale convection is also called cumulus convection, from the small heap clouds that commonly form in it. The individual clouds are several kilometers apart and have dimensions of up to a kilometer or two, usually insufficient for shower formation. These fair-weather cumulus clouds are produced by the heating of the air, which is in contact with the warm land and land. They occupy vast areas in great populations, especially over the oceans in the tropical regions (MĂHARĂ, 2001) and where cool air in higher latitudes flows towards warmer water, and also overland during sunshine. Individual clouds are short-lived; thus, the population only contains a small number of clouds.

The cumulonimbus convection is initiated by those type of clouds, which produce precipitation. Most of them in the Western part of Romania are produced due to orographic lifting, from the weight of condensed water or release of latent heat of fusion during its freezing, the buoyancy, vigor and size of cumulus towers are often greatly enhanced, and the clouds become cumulonimbus (MĂRĂZAN ET ALL, 2021).

Ordinary multicell thunderstorms are characterized by the successive formation of more or less easily resolvable new cells, usually on the right flank of the storm. DENNIS ET AL (1971) suggest that these new cells appear as cumulus clouds, sometimes arranged in lines, extending up to 30-40 km (MĂRĂZAN, 2018) in front of the mature cell. They often develop out of a shallow cumuliform shelf cloud on the right flank of the storm and grow rapidly as they approach the main cumulonimbus cloud mass, merging within 10 to 30 minutes of their formation. A first radar echo, associated with the initial development of precipitation, usually appears in these clouds just before they merge with the main cloud mass, and the merger tends to be followed by a burst of heavy rain or hail reaching the ground.

In contrast with individual ordinary cells, which to a first approximation can be considered closed systems drifting with the mean winds, a supercell behaves as an open system that propagates continuously either to the left or to the right of the mean winds with a velocity that permits it to maintain a continuous circulation. As the air approaches the updraft initially beneath the echo overhang before rising within the vault. Part of this forward overhang contains particles several millimeters in diameter, some of which are believed to be destined to become hailstone embryos, and so it has been named embryo curtains (BROWNING ET FOOTE, 1976). Depending upon the degree of water loading and evaporative cooling below cloud base, the updraft then may or may not break down. It might, as well, revert to an impulsively propagating multicell storm (VASQUEZ, 2011). As such, more research is needed to clarify the interaction of the storm dynamics with the three-dimensional precipitation trajectories. Because of their more nearly steady organization, it will be easier to carry out such studies for supercells than for multicell systems.

Among the modern techniques of observation that are providing greatly improved and more detailed information on thunderstorm structure are aircraft reconnaissance (mainly for outside of clouds operations) and, especially, use of pairs of Doppler radars to map the form of airflow in regions containing precipitation and radar echo. The latter depends upon the approach of storms within convenient range. Thus, the data are of unparalleled abundance and resolution and thus provide unrivaled insight of the three-dimensional airflow and on the generation of rotation responsible for tornadoes, mainly for supercell generated mesocyclones.

Within this abundance of information and recognition that storms have an evolution in time as well as an essentially three-dimensional structure in space, the analytical theory of thunderstorm structure has become confined to suggesting the most economical and significant ways in which numerical models can be used to simulate and explore storm structures. Because of their dynamical complexity, these models habe necessarily to rely on some simple parametrizations of processes on space scales of less than 1 km, including microphysical processes of the formation, freezing, aggregation, shattering, and melting of the cloud particles. Examination of the generation and separation of electrical charge that accompanies these processes has also to be postponed, although it is their effectiveness which has given thunderstorm its name.

CONCLUSIONS

Severe weather events still impose a high degree of risk on agriculture. By correctly analyzing the conceptual models of convective cells, by integrating the numerical weather prediction together with nowcasting technologies, the damages produced by weather can be limited. The need for new forecasting technologies is crucial in order to ensure that the Western part of Romania remains competitive with regard to agricultural and industrial development. The state-of-the-art cloud seeding equipment, which was installed in the vicinity of Recaş winery, is one of the needed adaptation measures in order to ensure that the magnitude of severe weather events is limited. But this is not yet enough, as the forecasters need to have enough data in order to acknowledge cloud seeding prior the arrival of a thunderstorm. Parameters like hail detection algorithm, vertical integrated liquid, cloud height and reflectivity are to be known in order to ensure the correctness of nowcasting. As such, the implementation of dual polarization weather radar would be a major update for the National Weather Service as well as for aviation forecasters. Therefore, a cooperation between forecasters from the National Weather Service and aviation forecasters from ROMATSA S.A. would be benefic in order to ensure the safety for both agriculture and terminal navigation.

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