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RECENT CHANGES IN THUNDERSTORM ACTIVITY IN VASLUI

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Abstract. A thunderstorm (also called an electrical storm) is a form of weather characterized by the presence of lightning and its attendant thunder, produced from a cumulonimbus cloud. Thunderstorms form when significant condensation (resulting in the production of a wide range of water droplets and ice crystals) occurs in an atmosphere that is unstable and supports deep, rapid upward motion. This appears in the presence of three conditions: sufficient moisture accumulated in the lower atmosphere, reflected by high temperatures; a significant fall in air temperature with increasing height (steep adiabatic lapse rate); and a force such as mechanical convergence along a cold front to focus the lift. The process to initiate vertical lifting can be caused by: (1) unequal warming of the surface of the Earth, (2) orographic lifting due to topographic obstruction of airflow, and (3) dynamic lifting created by the presence of a frontal zone. As an intricate part of the global climatic system, thunderstorms pattern and activity are highly susceptible to anthropogenic climate change, and recent observation concerning thunderstorms in Vaslui seems to support this connection. But even if this is only a temporary period of anomaly, a cyclic variation or the beginning of a trend prone to continue in the future, the period spanning more than 22 years analyzed in this paper (1985-2006), deserve some more in depth research, because of the significant and rapid developments in thunderstorm activity, and also considering the background: this interval contains the top 17 hottest years ever recorded in the instrumental meteorology era. In addition, the fact that the changes in thunderstorm activity can be clearly linked to the significant changes in the way precipitations fall in the warm season, opens a new way in which the ferocity and destructive force of recent extreme weather phenomena can be explained, and ultimately predicted .

Introduction

The climate of the town of Vaslui is a direct consequence of its geographical location at the intersection between the 46°39" North latitude parallel and the 27°44' East longitude meridian, and by the presence to the west of the Carpathian Mountains and large opening of this territory to the large expanses of Eastern

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Europe, which place this urban center in a temperate climate with an added shade of excessiveness. In addition, the location of this town in the central parts of Bârladului Plateau at the contact between the Central Moldavian Plateau and the Tutova Hills, in a clearly defined depression, gives a local flavor to the characteristics of the regional climate.

The average annual temperature is 9.2 °C, the average temperatures of the coldest and the hottest months (January and July) are -3.5 °C and 20.9 °C. The extreme temperatures are -32.0 °C the minimum, and 39.5 °C the maximum (almost surpassed in July 2000).

A closer look on the characteristics of the warm season (when thunderstorms occur) shows that: the average number of summer days in Vaslui is 97.3; the average of the maximum temperatures is 34.8 °C while the number of tropical days is 18.3.

The annual average precipitations are of 526.2 mm; the monthly averages are lower in the winter, spring and autumn months, while summer months are those in which precipitations are more abundant (May 77.9 mm, June 83.3 mm August 61.8 mm), the majority of those being of convective origin, usually heavy rain. (Larion, 2004)

1. Factors that influence thunderstorm activity in Vaslui

Even if thunderstorms are just a form of whether, their pattern and activity seem to be influenced by factors that go beyond the characteristics of the local climate.

The general factors can be attributed to:

a. the solar activity and its periodic variations that influence both the "solar forcing" and the properties of the solar wind.

b. Changes in the state of the terrestrial magnetosphere and ionosphere.

c. The general circulation of the atmosphere, with its seasonal and year-by-year variations.

d. The human induced changes to the atmosphere and their impact on the heat transfer processes.

On the local level, the way in which thunderstorms manifest is highly influenced by the geographic location and the characteristics of the local geomorphology, soil, vegetation, hydrology and land use.

2. The main parameters that define thunderstorm activity in Vaslui

The start of the thunderstorm season:

a. Earliest date: *17 III*; latest date *28 V*.
b. Averaged date *19 VI*.

The end of the thunderstorm season:

a. Earliest date: *22 VIII*; latest date *4 XII*.
b. Averaged date *26 IX*.

The average length of the thunderstorm season:

a. Minimum length: *99 days*; maximum: *264 days,*
b. Average length: *161 days.*

The annual number of thunderstorms: minimum: 24; average: 39.25; maximum: 64. The annual duration of thunderstorms: minimum: 39.4 hours; average: 151.1 hours; maximum: 78.9 hours.

The thunderstorm activity in Vaslui can be characterized as being specific to what would be expected considering the town's position in the eastern part of Romania (Central Moldavian Plateau). The late date on which the season starts and its early end, create a thunderstorm season shorter than in western Romanian, with fewer thunderstorms but with a higher risk of extreme weather events like: torrential rain, large hail and severe winds especially in the months of May and August.

3. Recent trends in thunderstorm activity in Vaslui

Human activity has a big impact in Earth's radiation balance. The emission of greenhouse gases and the dispersion of aerosols have significantly modified the radiative heat transfer processes in the atmosphere.

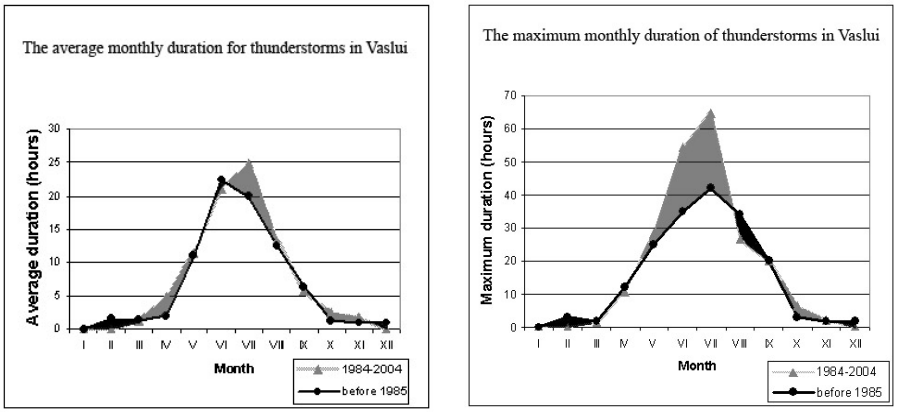

Fig. 1 - The average and the maximum monthly duration of thunderstorms in Vaslui

Empirical evidence and some mathematic models suggest that the excess of energy captured in the Earth's atmosphere by the greenhouse gases is transferred ultimately through convective and latent processes (which serve as the "fuel" that drives the formation and development of thunderstorms cells in the atmosphere). The increased frequency of thunderstorms (detected through cloud pattern analysis

and the global detection of lightning strikes) seems to support these suppositions (D. Francis -1998).

This paper tries to demonstrate that climate change may also have other influences in thunderstorm activity and ultimately in all the extreme phenomena associated. It seems that within extremely warm years, thunderstorm temporal distribution and duration suffers a radical transformation. Data collected before 1985, suggested an almost even distribution of thunderstorms between the two most active months of the season (June and July, with a slight advantage for June) but this whole thing changed from the beginning of the 90's when the frequency and the duration of thunderstorms increased spectacularly in July. This process became strikingly visible after 1995, and resulted in successive record-breaking monthly thunderstorm activity for July.

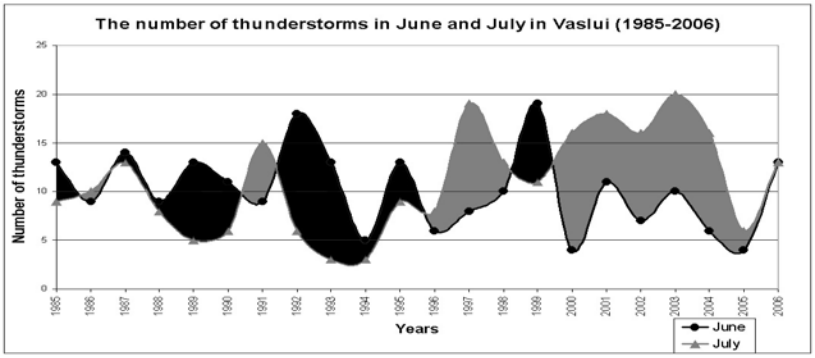

Fig. 2 - The number of thunderstorms (June and July) in Vaslui between 1985 and 2006

On the other hand, the storm activity in June remained fairly constant and ultimately entered in a declining trend. Nevertheless, the surge recorded for the month of July since 1995 was not matched by an equally spectacular rise in thunderstorm activity for the whole seasons (with only limited increases compared to the average).

As seen in picture one, the average monthly duration for thunderstorms in Vaslui has not changed significantly compared to the climatological norm, with the exception of the two incriminated months (June and July), which saw their roles reverted as the peak months of the thunderstorm season. In picture two, we can observe the extent of the increase in duration of thunderstorms recorded between 1997 and 2004, which included the absolute record for frequency and duration for the month of June in 1999, same record for the month of July in 2004 (picture three).

We can also see that the span between 1997 and 2004 was characterized by sustained thunderstorm activity for the peak of the season. The increased frequency of thunderstorms in June and July during those years is also important because it happened in a series of consecutive years that create the rather strange impression of block unity and therefore can be considered quite anomalous.

Coincidence or not, the same period was that of the long but moderated "solar maxima" (centered in 2001) that characterized the solar cycle which begun in May 1996 and ended in March 2007. And as an added bonus, these eight years of extraordinary thunderstorm activity were all considered as being part of the top ten list comprising the warmest years (globally) in the instrumental temperature record. This may indicate that unusual cosmic and global temperature conditions may sometimes override regional or local climate patterns.

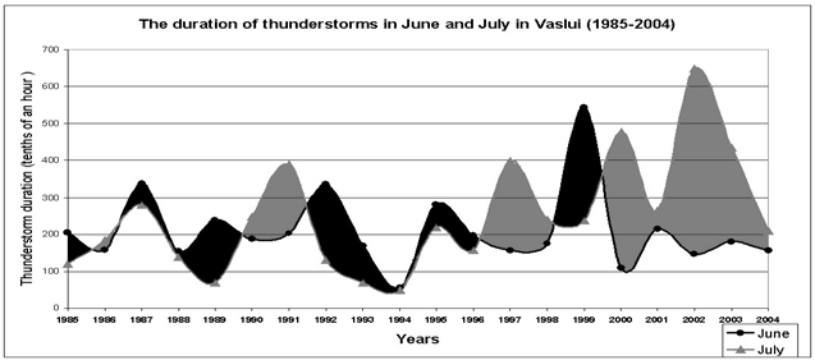

Fig. 3 - The duration of thunderstorms (June and July) in Vaslui between 1985 and 2004

Even so, the graph displaying the duration of thunderstorms for the same period shows that it depends less on those general factors previously described. This is because of extraordinary favorable circulation patterns (which continuously feed warm and moist air) that create the conditions for extremely long weather events characterized by lightning and thunder (e.g. the 11 hrs. and 40 min. thunderstorm that lasted the entire night between the 23 and 24 of June 1999, or the 14 hrs. and 17 minutes thunderstorm of 21-22 of July 2002). It seems that only in some years these kind of favorable conditions occur, creating the condition for one or more ultra-long thunderstorms. In addition, the fact that this kind of storms happen during the night proves that they are generated exclusively by frontal activity.

4. The effects of changes in thunderstorm pattern on precipitations

The connection between precipitation and thunderstorms is not a direct one as the area on which lightning and thunder can be observed is much larger than the one affected by the various precipitations generated by the same convective cell (which also fall with diminishing intensity as we go further away from the torrential core) and by the fact that thunderstorms yield different quantities of precipitations in different air masses and synoptic situations.

Nevertheless, the fact that the majority of thunderstorms producing significant amounts of precipitation, evolve in a multicellular or squall line behavior, sweeping large areas, creates the premises for a possible statistical link between the number and duration of thunderstorms and the quantity of precipitations recorded in summer months.

It becomes apparent from picture 5 that the quantities of rain recorded in Vaslui in the interval of time studied in this paper tend to follow the evolution of thunderstorm related parameters described earlier. We can clearly observe the apparent increase of precipitations occurring in July and the reverse phenomenon occurring for the month of June. Surprisingly, even the "block" of anomalous years spanning between 1997 and 2004 is clearly visible, and also the extreme June of 1999 and July of 2002 have their own correspondent in the precipitations chart.

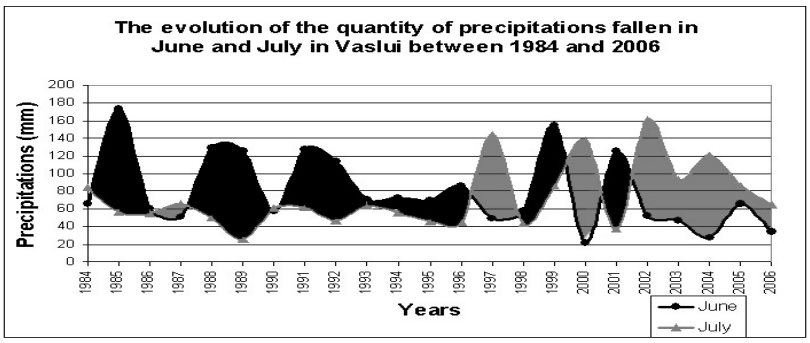

Fig. 4 - The precipitations recorded in June and July in Vaslui, between 1984 and 2006

However, even more impressive is the fact that after 1996, July becomes the wettest month of the year by a huge margin. This seems to suggest that the switch between June and July in both thunderstorm activity and precipitations has a common cause: changes in the atmospheric circulation patterns, which now tend to favor frontal activity and incursions of maritime air masses outside the classical

15th of June – 15th of July, of the so called "Romanian monsoon", with even more surprising quantities of rain recorded for the month of August.

Conclusions

Climate change is slowly starting to become something more palpable than speculation and computer modelling. Its first visible manifestations are the frequent appearance of events and phenomena that were once considered very rare, and also the sensation that what used to be called abnormal weather, tends to become lately the "norm" of the day.

Even though the meteorological records for Vaslui show that many years have been characterized by a July with intense convective whether, the fact that this happened in the late 90's in consecutive years closely packed in a small span of time and that this transformation created a significant gap towards June (which is well documented as the peak month for the thunderstorm season) can be considered a sign that the weather patterns are changing as we speak.

As shown in this paper, the causes of these recent changes are multiple, and each cause tends to have a more significant influence upon a very specific weather parameter. Factors like solar activity and forcing, global change and modifications in atmospheric circulation patterns have been shown to have significant influence in the transformation of thunderstorm activity observed in recent years.

The importance of these findings stand from the fact that changes in thunderstorm activity will certainly result in changes to the summer quantities of precipitations and in the distribution both spatial and temporal and extreme weather events, considering that those modifications are directly linked to thunderstorms or have common generating factors.

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