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Original Contribution

CLASSIFICATION AND APPLICATION OF GNSS METHODS AND TOOLS IN THE STUDY OF NATURAL DISASTERS

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ABSTRACT: *Global Navigation Satellite System (GNSS) is an umbrella term that refers to any satellite navigation system with global coverage. GNSS devices and receivers use geolocation information obtained from satellites to determine the current location of an object.*

KEY WORDS: *Natural disasters, Ecodisaster, Location, GNSS.*

1. Introduction

Since the dawn of civilization, man has tried to combat natural disasters. He strives above all to know and study the elements, to understand the causes that cause them, to guess where and when they will manifest themselves, and to eliminate the damage caused as quickly as possible.

Thanks to its rapid development in recent years, space science and technology are very effective tools for studying the Earth and the surrounding space. Along with other phenomena and processes studied by many sciences, this is especially true of environmental catastrophes, and today, in the face of aerospace methods and technical means, humanity has an extremely powerful and promising weapon for studying and combating eco-catastrophes [5].

2. Classification and basic guidelines in the use of GNSS methods and tools in the fight against environmental disasters

Global Navigation Satellite System (GNSS) is a generic name for all satellite navigation systems with global coverage that provide real-time and high-precision location, speed and time information. Examples of such systems include the American GPS, the European Galileo, the Russian GLONASS and the Chinese BeiDou.

GNSS technology plays a key role in modern strategies for the prevention and management of environmental disasters and accidents. GNSS receivers can track the movement of the earth's surface, deformations of the earth's crust, landslide movements, rises in river and sea wave levels, as well as the spread of pollutants. This makes GNSS an extremely useful tool for:

• Early warning of natural disasters – such as earthquakes, landslides and floods;

• Monitoring of risk areas – areas with active seismicity or a high risk of erosion; An example of such an area is the Alpine regions of Northern Italy, which are at high risk of landslides due to steep terrain, heavy rainfall and earthquake activity, where permanent GNSS stations have been installed in critical areas of the slopes, which track with millimeter accuracy the horizontal and vertical movements of the earth's surface in real time;

• Assisting emergency services – through accurate positioning of affected areas, transport routes and coordination of rescue operations;

• Post-disaster impact assessment – by comparing GNSS data before and after the incident.

GNSS systems are often integrated with other technologies, such as Remote Sensing, Geographic Information Systems (GIS), and the Internet (IoT), to provide a comprehensive and timely picture of the risk and evolution of environmental threats.

The main GNSS methods used in practice are:

➢ **Static Method (Static GNSS)**

• **Description:** In this method, the receivers remain at a fixed point for an extended period (several hours).

• **Applications:** Geodesy, construction of geodetic networks, monitoring of movements of the earth's crust.

• **Accuracy:** Very high (millimeter to centimeter order).

➢ **Kinematic Method (Kinematic GNSS)**

• **Description:** The receiver moves during measurements. Processing can be in real time or after the fact.

• **Applications:** Topographic surveys, mobile mapping, transportation.

• **Accuracy:** Centimeter when using RTK.

➢ **RTK – Real-Time Kinematic**

• **Description:** Provides real-time positioning through a connection between a movable and base receiver.

• **Applications:** Precision agriculture, construction, drones.

• **Accuracy:** 1–2 cm in real time.

➢ **PPP – Precise Point Positioning**

• **Description:** Uses global patches from satellites or servers, without the need for a local base station.

• **Applications:** Oceanography, air navigation, scientific research.

• **Accuracy:** Centimeter, but with a longer initialization time (up to 30 minutes).

➢ **DGPS – Differential GNSS correction**

• **Description:** Works with base stations that broadcast corrections to mobile receivers.

• **Applications:** Marine navigation, agriculture, hydrography.

• **Accuracy:** Meter to decimeter.

Table 1 Relative table of GNSS methods

Method	**Work**	**Accuracy**	**Resources**	**Applications (incl. for disasters)**
Static GNSS	Fixed receiver for a long period	mm – cm	2+ receivers, post-processing	Monitoring of earth movements, tectonics, landslides
Kinematic GNSS	Receiver on the move	cm – dm	RTK/PPP or post-processing	Topography, mobile mapping, quick analysis of affected areas
RTK (Real-Time)	Real-time base-rover connection	1–2 cm	RTK equipment, communication connection	Construction, precision agriculture, drones, disaster response
PPP	Position calculations with global adjustments	cm - dm	One receiver, access to correction data	Remote Area Automatic Stations, Oceanography, Disaster Prediction
DGPS	Local fixes via base station	dm - m	Receiver + Access to Patches	Maritime navigation, agriculture, river level monitoring
Postprocessing	Data is processed after measurements	mm – cm (depending on the method)	Software, database data/ephemeris	Deformation analysis, retrospective disaster analysis

The classification of ecological disasters can be made according to several different criteria: origin, periodicity and scale of damage.

According to their origin, they are divided into two groups: natural and anthropogenic.

Natural catastrophes can also be defined as extreme geophysical events, in which the geophysical parameters, i.e. the physico-chemical parameters of the surrounding natural environment, change and acquire extreme values [7].

Natural disasters occur on Earth without human participation and intervention. So is climate change, which leads to more frequent and more extreme weather changes. The frequency and severity of dangerous phenomena such as hail, floods, tornadoes and lightning is increasing worldwide.

Forecasts made on the basis of numerical models in different scenarios for climate change, natural disasters and eco-catastrophes confirm this increase in the future. One of the geographical areas where a significant increase in extreme cases is predicted is Southeast Europe. Here, first of all, we note the frequent cases of supercells.

When the word supercell is mentioned, the perception of a concept from the world of biology, physics or mathematics arises, but in practice it is a natural phenomenon. It is called a supercell, and along with it the concept of mesocyclone is used, which makes it more understandable for a wide range of people.

The essence of the supercell is a huge cloud, often with a diameter of more than 30 kilometers, and its volume is also colossal and can reach up to 500 cubic kilometers and more.

Supercells require specific atmospheric conditions to form, which makes them relatively rare but extremely dangerous and give rise to collateral disasters. Four main factors are needed for their formation:

- **Instability:** The lower atmosphere should be unstable, with warm, moist air near the surface covering cooler, drier air from above. This contrast of temperature and humidity allows warm air to rise quickly.
- **Wind cut:** This is the change in wind speed and direction with the change in altitude. For a supercell to develop, there must be a significant cut of wind to start spinning and maintain the mesocyclone.

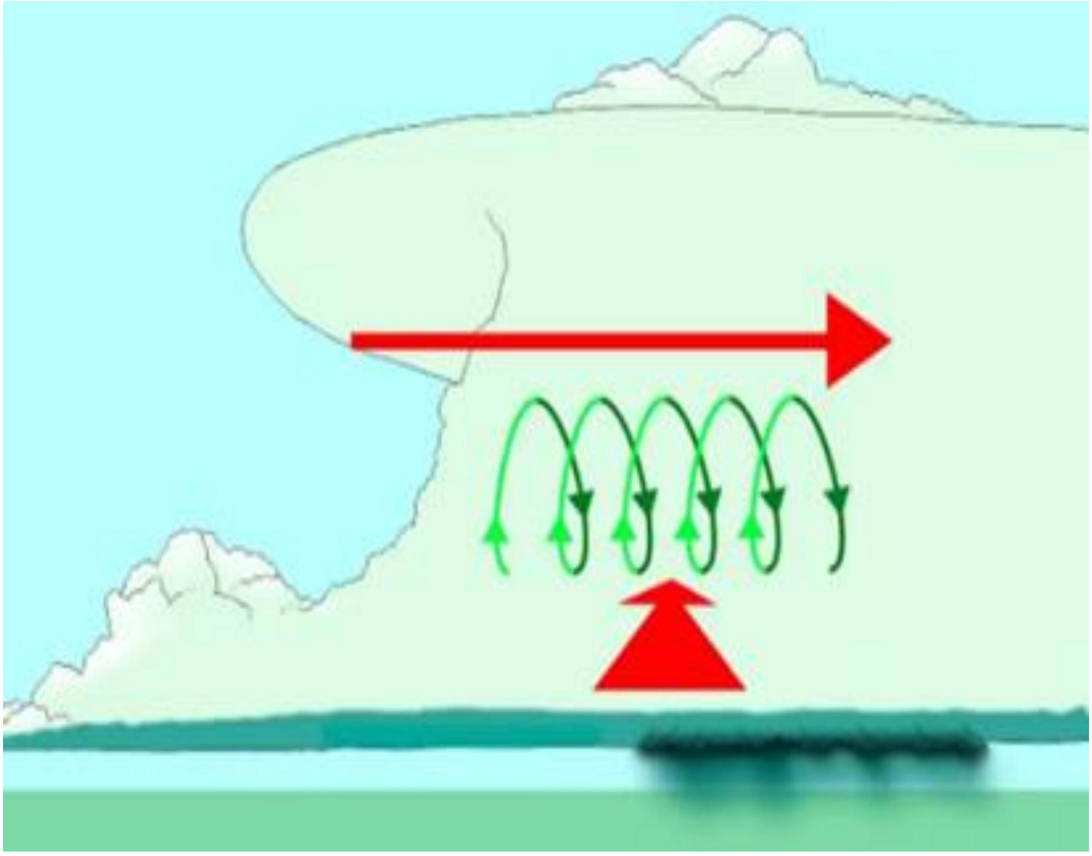

Fig. 1. The change in wind speed and direction

➢ **Lifting mechanism:** The mechanism for initiating the initial upward current is vital. It can be provided by factors such as frontal borders, dry lines, or borders from previous storms.

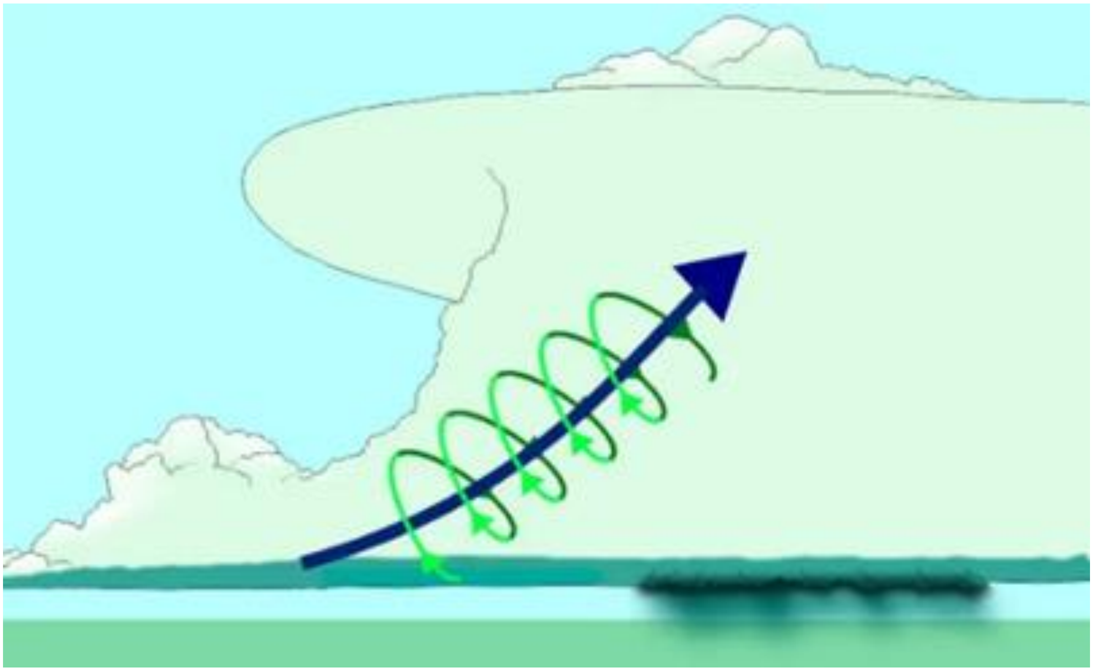

Fig. 2. Device of the upward current

➢ **Triggering:** Often, supercells are triggered by the convergence of different air masses or by the lifting effect of mountains.

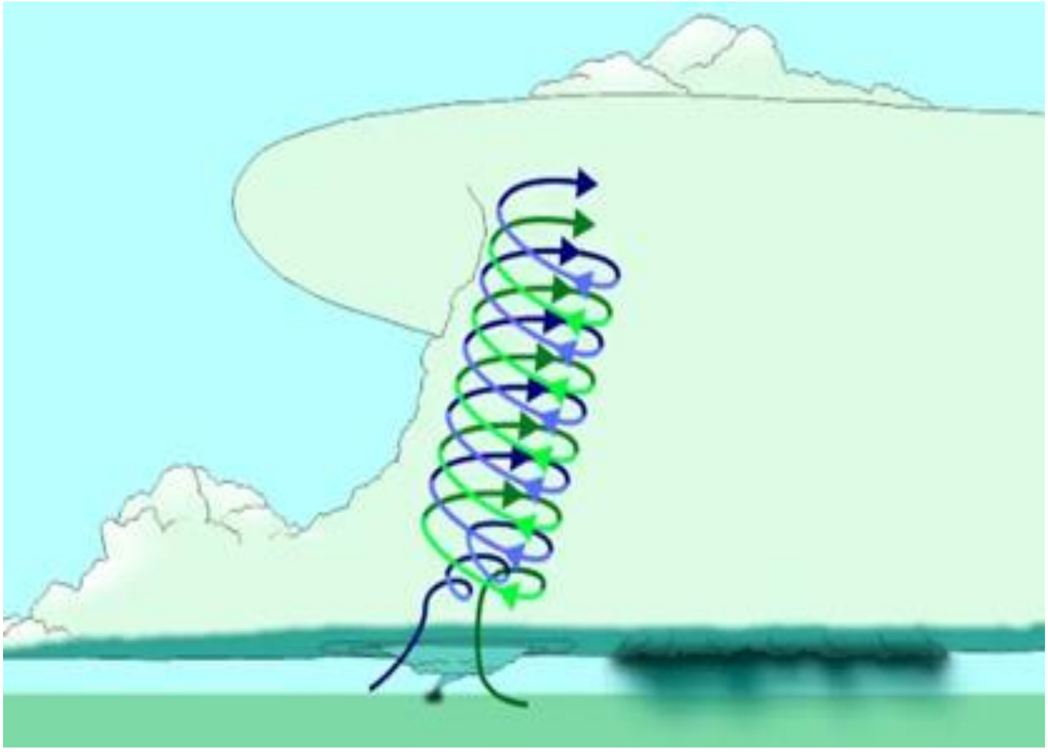

Fig. 3. Unification of different air masses

All supercells produce harsh weather conditions and are one of the most dangerous weather phenomena due to their potential for significant destruction. The main dangers they can lead to include:

- **Tornado**: Supercells are responsible for most strong and violent tornadoes, which can cause great damage and loss of lives.
- **Hail**: Large grains of hail can destroy crops, properties, and vehicles, posing a threat to human safety.
- **Flash floods**: Supercells can unleash heavy amounts of rainfall in a short time, resulting in flash floods that flood low-lying areas.
- **Lightning:** Supercells generate intense lightning that can cause wildfires and pose a risk to outdoor people, such as heavy rains, storms, floods, and hailstorms, but only 30 percent of them produce tornado.

Supercells are the most easily visible and recognizable from space. In a satellite satellite image, even a non-specialist can easily distinguish an emerging or already mature mesocyclone.

The operability required both for regular weather forecasting and for forecasting and monitoring of meteorological environmental disasters requires the use of satellite images.

The information obtained through them about the state of the atmosphere over the oceans is extremely valuable. On the one hand, there are not many ground-based weather stations in these territories, and on the other hand, it is above them that some of the most terrible environmental catastrophes arise and develop [3].

Predicting an eco-catastrophe is the most important and decisive direction. It is done on the basis of collecting and processing information to change the parameters of natural objects, processes and phenomena in which the disaster originates. Sometimes these objects occupy spaces of thousands of square kilometers, and in other cases several objects must be tracked at the same time thousands of kilometers apart. All this enormous volume and complex activity with great reliability, accuracy and speed can only be carried out by using space methods and means.

Timely and correct forecasting, as well as the rapid control of the relevant alarm, provide opportunities to realize with much greater efficiency all other directions of the fight against environmental catastrophes.

Fig.1 Basic guidelines in the use of aerospace methods and means in the fight against environmental catastrophes.

What does it really mean to predict an environmental disaster? This means answering the question: **where**, **when** and with **what force** it will manifest itself.

The purpose of active intervention, on the other hand, is to reduce the intensity of the catastrophe, while monitoring the process should provide express and current information about its development, which allows for prompt decision-making for active intervention and rescue operations.

Serious eco-catastrophes stimulated the creation and use of remote monitoring systems through remote sensing as a result of GNSS. The constant increase in the technological and technical-operational level of the measuring equipment leads to the receipt of more and more information. Particularly promising in the study of modern geodynamics are the global satellite systems for determining the location of points on the Earth's surface, where this information is used as a control and a priori for identifying the type and condition of the studied objects and phenomena.

The characteristics of natural phenomena and their possible impacts can be synthesized from different sources and put on a future map. Although hazard mapping has been improved through the wider use of geographic information systems (GIS) and Global Navigation Satellite System (GNSS), the inclusion of social, economic and environmental variables in the mapped areas remains a major challenge. Attention is drawn to hazards that may cause others (such as earthquakes or volcanic eruptions cause landslides) or worsen their effects, providing a more accurate picture of the impact of natural phenomena on a particular area.

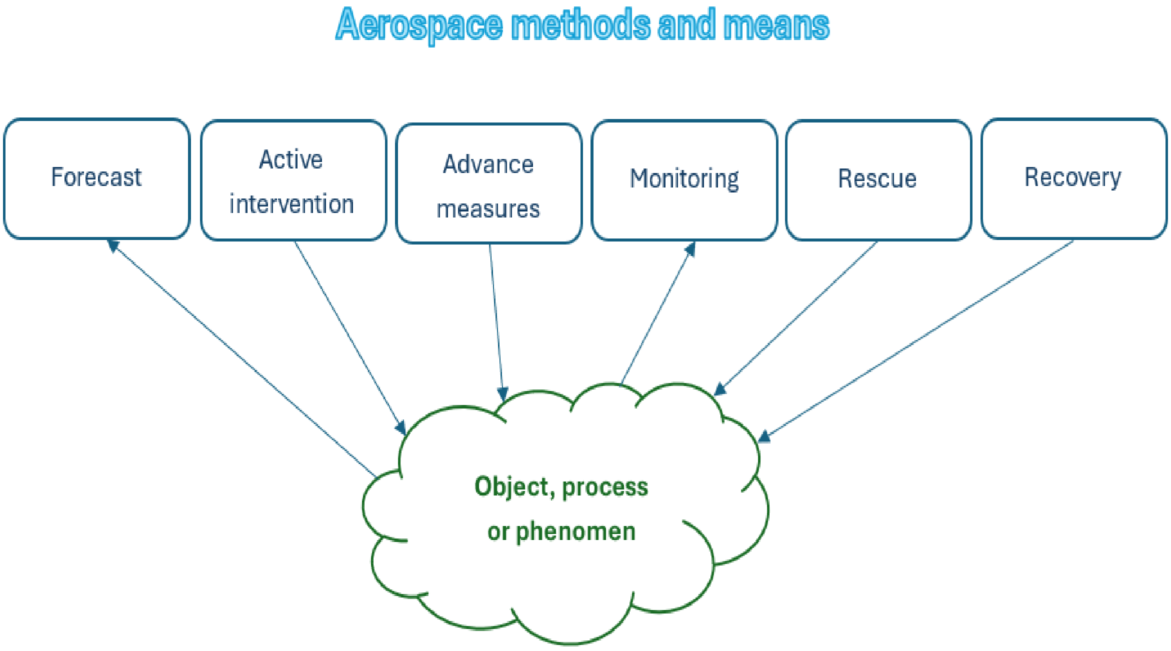

Fig. 4. Basic guidelines in the use of aerospace methods and means in the fight against environmental catastrophes

An important task when conducting high-precision geodetic GNSS measurements for disaster monitoring is to select a suitable receiver for ground-based measurements. Receivers can use five types of signals to determine coordinates: C/A code, P(Y) code with two frequencies, and carrier phase with two frequencies. Millimeter accuracy can only be ensured by carrier phase measurements, code measurements can provide accuracy up to a meter. The main disadvantage of single-frequency measurements is the inability to accurately read the ionospheric delay [8].

3. Measures to combat climate change

Management to natural disasters is a reflection and function of the current state of personal and general material, social, economic and environmental conditions, which are constantly changing under the influence of ways of thinking, by behavioral, cultural, socio-economic and political influences on individuals, families, teams, communities and countries.

Natural disaster risk management should be at the centre of strategic management at all levels of government, due to the threat of colossal loss and damage.

Bulgaria falls into one of the regions with increased warming trends and an increase in the frequency of extreme weather and climatic phenomena - droughts, cases of heavy rainfall, thunderstorms and hail.

In order to reduce the risk of extreme weather, it is necessary to limit greenhouse gas emissions both in Bulgaria and globally, because they are the main cause of climate change. And Bulgaria is still lagging behind in terms of introducing a climate neutrality goal, which should also be included in the Climate Change Mitigation Act. At the national level, it is also necessary to make a connection with a strategy for the restoration and preservation of the Bulgarian forest. Forest protection is critical for flood prevention and should become a state and public priority!

On the other hand, it is also important to take measures to adapt to climate change, an example in this regard would be the creation of an early warning system for possible floods due to heavy rains. If such systems work, the public will be able to receive messages that intense rainfall is coming and there is a danger of flooding in advance on their phones, and thus social and financial consequences and damage could be reduced.

The integration of GNSS as an additional component into traditional systems increases their effectiveness by providing invaluable, global and cost-effective data for monitoring and assessing various threats. Realizing this potential requires interdisciplinary, multilateral, and international cooperation, as the complexity and global nature of the natural hazards posed by climate change require collective efforts and diverse experiences to effectively address these challenges.

4. Conclusion

As long as the planet Earth exists, natural phenomena and processes of a catastrophic nature will inevitably occur on it. Humanity is tasked with minimizing negative impacts through prevention, timely response, and sustainable risk management.

In modern conditions, the adoption of optimal solutions in all spheres of human activity is based on up-to-date and high-quality information. This is especially important in the field of environmental disaster management, where information technologies play a key role.

One of the current areas for the application of information technologies is in the study of environmental disasters, where GNSS technologies, geographic information systems, etc. are used, which provide operational access to a large set of digital data that allows for operational control over their relevance and quality, and various tasks are solved with them.

GNSS methods and technical means in the fight against environmental disasters are the most valuable, most effective and most promising in predicting and monitoring environmental disasters and climate change.

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