# The Earth Science Gateway as Introduction to the Causes Distribution, And Consequences of Earth's Natural Hazards and Disasters

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**Abstract**
The science gateway is an important part of many large-scale scientific projects in the fields of Earth, astronomy, the environment and natural disasters. The development of science portals and gateways covers the requirements of large-scale sciences such as earth sciences, astronomy, and all sciences that use the latest version of high-performance computing infrastructure platforms, such as grid, and cloud, or cluster computing. Many research projects are dedicated to this problem. One of the current topics of our research is the application of artificial intelligence in the analysis and classification of hyperspectral imaging data. The article describes the creation, and use of a tool to 3D visualize the results of simulations of this research. The paper describes the use of artificial intelligence methods to create models for detecting and classifying tree species, using hyperspectral images and LiDAR data in the aerial photography of energy line structures and using such methods in the field of Earth's natural hazards and disasters.
Keywords: Earth Science gateway, hyperspectral imaging data, natural hazards, natural Disasters, visualization service.

## 1. INTRODUCTION

The development of science gateways is subject to the new modern requirements of scientific disciplines such as earth sciences, astronomy, chemistry, physics, and all areas of science that use the latest already perfect high-performance computing platforms such as cloud and grid infrastructure. The Earth Science Gateway serves mainly for the distribution and cooperation of scientific areas that are interested in Earth's problems.

To solve these problems, various information systems and scientific gateways have been created. One of them is the frequent The Earth Science Gateway is becoming the most important one in the process of saving the Earth as an input and output source of data and tools for many large-scale projects that address the negative impacts of natural disasters, as well as their consequences, such as chemical and physical changes on the Earth. For the prevention, the information system "Territori Aperti" [1]. This system is often used because it solves how to correctly evaluate and manage natural disasters by using new scientific pieces of knowledge that are concentrated in Earth science gateway.

During the solution to natural disasters, the main points of the solution chosen, such are:

- *The origin and prevention of natural disasters.*
- *The correct management, and management of natural disasters.*
- *The correct evaluation of the consequences of the disaster.*
- *The creation of innovative processes for the restoration of destroyed parts.*

New systems and scientific gateways are updated and supplemented with new knowledge of individual relevant scientific disciplines. Most often these are chemical, astronomical, and physical sciences. Last but not least in this process is the use of new HPC platforms and especially the use of new modern tools concentrated in the Earth Science Gateway.

Recently, the number of natural disasters has increased enormously, threatening primarily the lives and livelihoods of people and all animals, changing the chemistry and climate on Earth. Humanity will long recover from billions of dollars in damage to Earth. The causes of these natural disasters are varied. Scientists and scientific projects must be targeted, the results must be linked to each other. Scientists and scientific projects should solve the most serious problems of the Earth. This is mainly done through science gateways as well as datasets from which they draw data for their targeted research. Such is the Geocoded Disaster Data Set. This set (GDIS) [2] of data is widely used because it provides spatial geometry in the form of GIS polygons and coordinates of centroid latitude and longitude for each subject observed. This subject is evaluated in the EM-DAT database as a disaster subject. The current GDIS contains spatial information on major disasters around the world. Again, the Earth science gateway serves to concentrate and distribute important data.

The Centre for Research on Disaster Epidemiology (CRED) at the Catholic University of Louvain, Belgium administers the developed catalog EM-DAT [3]. EM-DAT is a practical and easy-to-use catalog of a large number of natural disasters. In the EM-DAT catalog, all disasters are country-level-coded. Its practicality is that catastrophes are coded and recorded in one line with a unique observation for each disaster event and affected landscape. The necessary information about the subnational location is recorded in the catalog in the form of the string variable "Location". The string variable contains the names of the affected areas of each event. "Latitude" and "Longitude" are part of the range for locating disaster-stricken sites.

New knowledge, computing platforms, catalogs, and databases integrated into the Earth Science Gateway help us eliminate the consequences of natural disasters that humanity has to deal with in order to survive and for our children to live.

The main topic of our article is a description of tools, platforms, and methods by which we have enriched the Earth Science gateway in the field of natural disaster prevention, especially by analyzing their consequences.

## 2. 3D GEO-VISUALIZATION SERVICE FOR THE GRID AND CLOUD-ORIENTED APPLICATIONS OF NATURAL DISASTERS

### A. The Grid and Cloud platform

Within the framework of natural disasters, we have also solved a lot with some natural disaster projects. One of the areas was a 3D geo-visualization service for grid-oriented applications of natural disasters [5]. Our basic goal is to design, improve, and complement a framework suitable for a unified way of collaboration between grid and cloud visualization applications and visualization clients. We gradually switched from grid infrastructure to cloud infrastructure and in visualization from 3D imaging through virtual reality and augmented reality to mixed reality.

The framework consists of many tools that are innovated with new knowledge. As an example, we describe one of the innovative tools included in the framework and it is a tool for 3D Geo-visualization of running Grid applications up to the rendering of their intermediate or final results in the client application. Its advantage is that it displays intermediate results specified by the client and is capable of repairing and restarting applications.

The subject of our current interest is the large Forest fire in our country which damaged vegetation and chemically destroyed the entire forest [4]. The main goal of the fire solution was to calculate the point of fire origin, how the fire spread, what mistakes firefighters made when extinguishing, and why several volunteer firefighters died there. Then calculate general rules for a procedure that would eliminate errors and which would be a guide for firefighters on how to proceed in extinguishing a fire. The topic of a lot of projects is how to prevent such disasters. Our research group is oriented toward high-performance computing. In natural disaster applications we start with grid infrastructure and recently we solved problems with natural disasters through cloud infrastructure. Many grid and cloud applications oriented on natural disasters utilize grid computing and within the grid, solutions raise the requirement of visualization service of research results and also for their presentation. When we started we used the data from grown maps as the input data. The development of new Geo methods has brought us to use hyperspectral images and Lidar data to solve a lot of problems with natural disasters. Such data we use for example to create models for the classification and CAVE visualization of Tree Species. For creating concrete forests we used the Sibyla forest generator. Sibyla system is the best forest generator that is possible to use for our research and is the best for students and researchers.

## 3. HYBRID MODEL SIBYLA AS FOREST GENERATOR

To generate the required forest parameters, we used and currently still use a sophisticated hybrid model "SIBYLA" developed and innovated by forest faculty in Zvolen, Slovakia [6]. For solving the origin and spread of fire, as well as for solving other natural disasters, the generation of terrain and environment is the starting basis. For calculating the parameters of trees, terrain, and the entire forest, the Sibyla system is suitable because it contains a hybrid model, process, and empirical structural modeling principles. The input data for generating trees in the forest are usually the crown parameter, the position of the tree and the type of tree, and the height and diameter of the trunk of the given tree. The SIBYLA system can generate a forest structure even if a parameter is missing, and even the SIBYLA system can add these parameters from its database. See Fig. 1.

**Fig 1:** Example of forest structure generator Sibyla

The output data from the SIBYLA system is then used as input data for our designed augmented reality visualization tool. See fig. 2 and 3. We are also using the system CAVE in forest faculty in Zvolen [6].

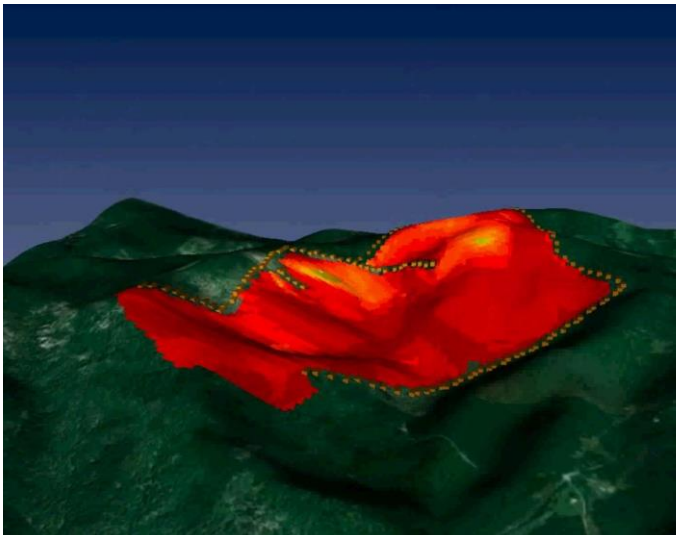

**Fig 2:** Example of part of forest fire, visualization by forest generator Sibyla

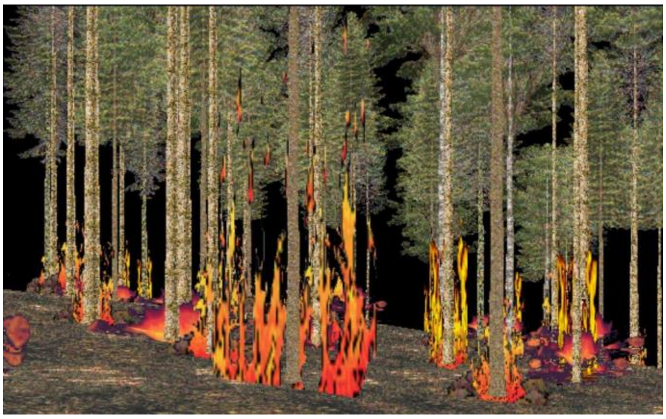

**Fig 3:** Example of part of forest fire, visualization by forest generator Sibyla

At the beginning of our research, we start with the „in-VRs" framework. The framework was innovated because it depend also on input data.

The article describes the use of artificial intelligence methods to create models for detecting and classifying tree species, using hyperspectral images and LiDAR data in the aerial photography of energy line structures. The most important output is a validated model with cloud infrastructure support for detecting and classifying objects of interest at the TRL 5 level, which is also exceptional on a global scale. The outputs of the research are also a geodatabase of reference tree characteristics, a library of spectral curves, a database of simulation of tree growth, but also a cloud infrastructure to support the development of classification models and data storage. An important output will be the visualization of the results of simulations in the "CAVE" environment

## 4. NEW METHODS OF CLASSIFICATION OF WOODY PLANTS

### A. Classification of Individual Types of Woody Plants by Different Machine Learning Methods

The classification of individual types of woody plants can be realized by different methods of machine learning [4]. Consistently based on the basic mathematical models of machine learning [5], the classification task is one of the simplest derivable models - the Support Vector Machine. Other models such as Decision Trees, Random Forest, rule-based, or many others usually provide a higher degree of accuracy of classification. In order to further increase accuracy, it is possible to group several models into one using ensemble learning methods, with individual sub-models suitably complementing and eliminating weaknesses with each other. Merged models usually use Voting or Weighting techniques. In the case of large-scale data, special methods, algorithms, and classification approaches are available that do not simultaneously require the availability of all data in memory, as well as significantly reduce the time required for training.

The deployment of deep learning methods significantly reduces the need for preprocessing inputs, as the first layers of deep neural networks carry out preprocessing directly in the neural network. Determining the appropriate method of preprocessing images is thus part of the training process The wide range of available neural network structures (e.g. Convolutional Neural Networks, Long-Short memory) from specialized to universal structures for various tasks provides a great starting position for successful modeling of tree types. Different types of input data (Lidar data, hyperspectral data), together with augmentation methods, will provide a sufficiently representative training set, which should largely counteract the impact of overfitting. Deploying more-advanced domain-forestry models will also allow subsequent determination of the range of the crown of the stand, determination of the position of the tree trunk (relative to the relevant classified object), estimation of the diameter of the trunk, and so on. Due to the availability of 3D input data, it is also possible to approximate the height of the tree crown. See Fig.4. and Fig 5.

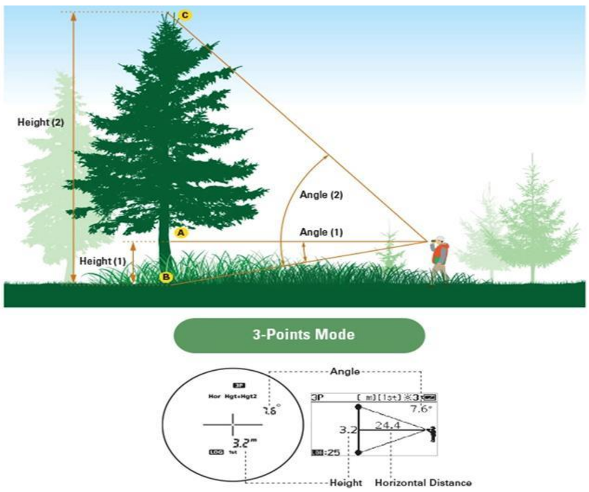


**Fig. 4.** Spatial identification of crown projections of tree crowns

| IDPlot | ID | X_m | Y_m | Specie | Qualit | DBH_m | Crown Base_d |
|---|---|---|---|---|---|---|---|
| 2 | 1 | 0,235 | -2,547 | SM | 2 | 355 | 109 |
| 2 | 2 | -0,058 | -15,859 | SM | 2 | 99 | 12 |
| 2 | 3 | 1,235 | -19,16 | SM | 3 | 144 | 60 |
| 2 | 4 | 1,438 | -19,74 | BK | 2 | 105 | 49 |
| 2 | 5 | 2,113 | -24,224 | BK | 2 | 125 | 13 |
| 2 | 6 | 2,302 | -24,415 | BK | 2 | 111 | 44 |
| 2 | 7 | 3,759 | -34,72 | BO | 1 | 265 | 104 |
| 2 | 8 | 3,374 | -35,81 | BK | 1 | 108 | 5 |
| 2 | 9 | -0,164 | -34,909 | BO | 1 | 346 | 83 |
| 2 | 10 | 0,227 | -32,712 | BK | 1 | 130 | 22 |
| 2 | 11 | 0,664 | -33,073 | BK | 1 | 159 | 22 |
| 2 | 12 | 2,205 | -32,715 | BK | 1 | 179 | 17 |
| 2 | 13 | 1,529 | -31,783 | BO | 1 | 326 | 85 |
| 2 | 14 | 1,245 | -31,012 | SM | 2 | 121 | 18 |
| 2 | 15 | -0,928 | -30,337 | SM | 2 | 69 | 15 |
| 2 | 16 | -4,58 | -31,49 | BK | 1 | 78 | 16 |
| 2 | 17 | -5,535 | -33,122 | BK | 2 | 137 | 17 |
| 2 | 18 | -5,902 | -33,782 | BK | 1 | 133 | 14 |
| 2 | 19 | -4,827 | -34,675 | BO | 1 | 370 | 92 |
| 2 | 20 | -10,549 | -31,379 | MU | 2 | 83 | 22 |

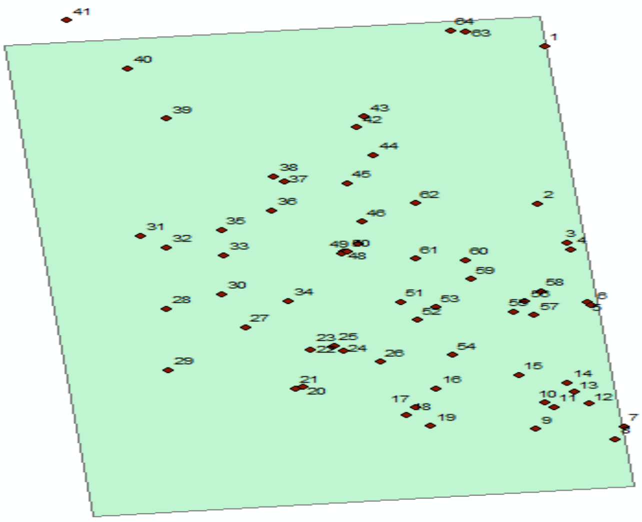

**Fig. 5.** Output data of spatial identification of projections of tree crowns.

### B. Visualization service

Our research continued with the application of artificial intelligence means in the analysis and classification of hyperspectral imaging data. The project aims to use artificial intelligence methods to create the model. New, modern software solutions, formed based on research needs and requirements, have created the requirement to connect the CAVE system with the SIBYLA growth simulator, a unique tool worldwide. This tool makes a significant contribution to science, education, and public relations through the popularization of forestry science [6].

## 5. CONCLUSION

The Earth Scientific gateway groups the latest methods and cooperation between research projects. Therefore new validated model with cloud infrastructure support for detecting and classifying objects of interest at the TRL 5 level, is also exceptional on a global scale. The outputs of the research are also a geodatabase of reference tree characteristics, a library of spectral curves, a database of simulation of tree growth, but also a cloud infrastructure to support the development of classification models and data storage. An important output will be the visualization of the results of simulations in the "CAVE" environment.

Research on the application of artificial intelligence means in the analysis and classification of hyperspectral imaging data within the framework of effective cooperation combines the activities of independent research and development provided by the Technical University in Zvolen and the Institute of Informatics of the Slovak Academy of Sciences, with industrial research provided by VUJE, as. Within the framework of the project, engineering, research, and development work will be carried out, including the implementation of repeated aerial photography of selected sections of electrical leadership, using the cutting-edge technology of individual partners. The excellence of the research is supported not only by a top team, which includes 4 guarantors from different fields but also by focusing the project on current research trends, which it combines for the needs of applications in the field of energy of the Slovak Republic. The results of this research fulfill and form the Earth science gateway. The Earth Science Gateway as Introduction to the Causes Distribution, And Consequences of Earth's Natural Hazards and Disasters. Work is in progress.

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