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INNOVATIVE CONCEPTION OF USING GEOSPATIAL ARTIFICIAL INTELLIGENCE FOR OPERATIONAL RISKS ASSESSMENT OF COMPOUND CLIMATE EXTREME EVENTS

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Abstract: Continued pressure on agricultural land, food insecurity, and required adaptation to climate change have made integrated assessment and modelling of future agro-ecosystems development increasingly important. Compound climate extreme events (CEs) can pose significant threats to societies, economies, and ecosystems around the world. When modelling past and future occurrences of CEs, the most suitable tools can result from the interconnectivity of growth models, economic models, and climate models using Geospatial artificial intelligence. Such information, in the form of geographical maps, can be effectively used as climate and weather risk assessment and integrated into future risk analyses, since they will improve the understanding of how CEs respond to near-term climate. GeoAI will also help users deal with regional crop production problems and issues related to CEs and cropping system management under climate change. Cropping system models offer the potential for integrating the physiological understanding of crop characteristics and for examining how potential growth and major limitations to production might vary in different environments and with different management scenarios. GeoAI, crop models, and decision support systems can be useful tools for researchers, teachers, scientists, extension personnel, policymakers, and planners to help and support the application and evaluation of sustainable and long-term alternative management practices.

Keywords: Compound climate extreme events, Geospatial artificial intelligence, drought,

The conception of using Geospatial artificial intelligence to modelling Compound events

Biodiversity loss and ecosystem degradation are critical risks for every region due to climate change. Adapting to these changes for sustainable crop production is an urgent challenge for those who manage the environment. Moreover, compound climate extreme events can pose significant threats to societies, economies, and ecosystems around the world, especially when amplified by anthropogenic climate change. Compounding climate/weather extreme events (CEs) are based on the joint impact of several natural drivers that negatively affect the overall agriculture production system. They can be defined as the co-occurrence in time and space of two or more natural hazards and/or their drivers [1]. An example would be the occurrence of two or more high-risk weather events during the growing season, and it is their joint interaction that causes the highest yield loss. Concurrent extremes of drought and heat cause problems for crop growers across Europe [2, 3]. Given these potentially severe impacts, it is important to anticipate CEs future changes within the next 20-30 years, so that suitable adaptation strategies can be implemented. However, to quantify CEs' use of a very large quantity of climate data (terabytes of multi-model ensembles) and therefore, we can use Geospatial artificial intelligence (GeoAI). The main benefit of Geospatial artificial intelligence to the modelling of CEs is that it fully considers the underlying to quantify the joint impacts on agriculture systems, from local to global scales. Such information, in the form of geographical maps, can be effectively used as hazard assessment and integrated into future risk analyses, since they will improve the understanding of how CEs respond to near-term climate.

Geospatial artificial intelligence is an innovative tool with the application of artificial intelligence (AI) using geospatial data to accelerate real-world understanding of environmental impacts, and operational risks of climate change on agriculture. New geospatial models are designed to convert satellite data into high-resolution maps of floods, fires, and other landscape changes to reveal the ecosystem's past and hint at their future. GeoAI elaborates scenarios of real-world problems helping to generate solutions for real cases. This innovative conception introduces the latest information technologies and their applications in agriculture, including decision support systems, crop simulation models, and computer climate models [4,5,6].

In the case of climate modelling, GeoAI can analyze large volumes of geospatial climate data, such as temperature, precipitation, and atmospheric conditions, to identify patterns, trends, and anomalies, it can help in predicting extreme weather/climate events, such drought, heat waves, fires spring and autumn frosts, and excess rainfall, by analyzing historical climate data and incorporating real-time observations. Moreover, GeoAI can assist in climate change impact assessment by modelling the effects of climate change on ecosystems, water resources, and urban areas.

What is a crop model?

The crop models calculate expected growth and development based on equations that describe how a crop, as a community of plants, responds to soil and weather conditions. Computer simulation models of the soil-plant-atmosphere system can make a valuable contribution to improving crop performance and predicting environmental impacts in different management scenarios [7]. Dynamic crop simulation models can be a useful tool to simulate the wide-ranging effects of CEs on crop production where impacts depend on multiple dependent weather-soil variables and crop management. The last two decades have witnessed the development of numerous crop-growth and yield simulation models describing the dynamics of the soil-plant-atmosphere system.

Integration GeoAI in crop models

GeoAI will help users deal with regional crop production problems and issues related to CEs and cropping system management under climate change. The innovative concept summarizes basic information on simulations of crop production, water and nutrient management, climate risks, and environmental sustainability. The practical application of the dynamic crop models aims to understand the synergies of weather, climate change, soil, water, crops, and agrotechnology in the context of adaptation and mitigation to future climate changes to ensure the potential sustainability of landscapes concerning ecosystems, biodiversity, and human communities at global and regional scales. It provides possible sceanarius of crop adaptation measures and assesses the effectiveness of adaptation processes at the farm, district, and county levels. The integration of GeoAI and artificial intelligence into crop models can enhance its capabilities in data integration, crop monitoring, yield prediction, disease and pest management, precision agriculture, decision optimization, and climate change adaptation. These technologies can provide farmers and agronomists with valuable insights and support in making informed decisions, improving productivity, and ensuring sustainable agricultural practices.

Integrating AI technologies in crop models can improve crop monitoring, AI algorithms can analyze satellite imagery and other remote sensing data to monitor crop health, growth patterns, and yield potential. By integrating this information into crop models, farmers and agronomists can receive real-time updates on crop conditions, identify areas of concern, and make informed decisions regarding irrigation, fertilization, and pest management [4,5,6].

Linking climate models with crop models

One of the big challenges for scientists is creating climate models that display the Earth in high resolution. Higher-resolution models will allow scientists to zoom in on certain regions. The biggest problem scientists face is finding enough computing power to run higher-resolution models. Integration of climate models with growth models is a tool to evaluate climate and weather production conditions during the growing season. Their basic applications include decision support or optimisation of cultivation practices, but they are also of great importance in the context of assessing the impact of ongoing climate change on agriculture and the environment. They are used to quantify the impacts of a changing climate at present and for different future scenarios, as well as to look for possible adaptation measures. The form of virtual experiments (i.e., simulated by computer) allows us to efficiently deal with both within-season analyses with a very high number of variants and long-term simulations, which would be extremely challenging, if not unrealistic, in the case of field experiments. With the progressive development of computer technology, AI, and the models themselves, their potential is increasing. At the same time, it is important to recognise that growth models cannot replace field experiments and that the potential of combining them is necessary. These practices are applied both in the field of science and research and in the educational process, where they offer a range of opportunities for increased attractiveness and efficiency. Applying growth models during learning processes will allow students and researchers to simulate the soil-plant-atmosphere system dynamics. The audiences will be able to independently propose new possibilities for the application of green infrastructure in the context of the landscape planning process, taking into account landscape characteristics such as topography, vegetation, soil, water resources, agrotechnology, crop zoning under new climatic conditions, as well as to offer intelligent solutions to reduce the adverse impacts of meteorological extremes on crop production and the environment. The growth model simulates several scenarios that can illustrate how the food system will respond to combined cases of climate extremes.

Crop-livestock integration modelling

The direct and indirect effects of global warming, combined with the increasing frequency of weather extremes, are also serious issues for livestock production. The dual concept of crop losses and CEs has been suggested as an approach to understanding extreme impacts and reducing farmers' exposure to weather-related financial risks. Sustainable fodder production for livestock is exposed to an ensemble of CEs whose impacts are complex and difficult to assess. CEs can contribute to increased water stress on fodder production, which will not keep the optimum demand for the livestock sector. In that case, vulnerability assessment of optimum water resources for livestock, estimation of the meteorological aspects of climate change, and adaptation strategies can be analyzed using a business-as-usual production model and a comprehensive economic model [3, 7, 8], and such an assessment should be focused in-terms of multiple explicit scales from the local to the global level. Crop-livestock integration modelling can account multiple variables including crops, animals, economics, residue, products, labour, nutrition, feed, water and greenhouse gases.

Conclusion

When modeling past and future occurrences of CEs, the most suitable tools result from the interconnectivity of growth models, economic models, and climate models using Geospatial artificial intelligence. GeoAI leverages AI techniques like machine learning, deep learning, and computer vision to process and analyze geospatial CEs. It helps in extracting meaningful insights, improving decision-making processes, and developing more accurate and efficient models for climate, crops, and economic systems. Using AI geospatial models with climate models, crop models and economic models can help large consumer goods companies to better understand macro trends like climate change, CEs or geopolitical risk that impact where they are currently buying their raw materials from and where they might want to consider purchasing those resources in the future. It can also help a large agribusiness to better measure, track and mitigate the impact of their farming practices on the local environments and surrounding communities by better understanding soil degradation, water conservation activities, or how to reduce pollution caused by run-off from fields to local bodies of water. By using Geo AI with crop models, users can analyze geospatial data related to soil properties, weather conditions, topography, and land use to develop accurate crop growth models, can help in optimizing irrigation schedules, fertilizer application, and pest management by providing real-time information about crop health, water stress, and nutrient deficiencies, also GeoAI can support precision agriculture by enabling farmers to make data-driven decisions regarding planting, harvesting, and yield estimation.

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