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### Entrepreneurship Opportunities on Data-driven Model by using Machine Learning-based Approaches to Environmental Science

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**Abstract.** The fast progress in environmental science and monitoring technologies has headed to a big deal of growth in the quantity and complexity in data generation. The environmental study demands more innovative and powerful computational and data analytical methods. Data analytical focus on having less dependence on previous knowledge. In this context, machine learning (ML) has shown as a promising tool in tackling complex data patterns due to their powerful fitting abilities. Therefore, the past few year has seen a quick development of ML, particularly deep learning (DL). Henceforth, in this communication some research work environmental science related topic by using Artificial Intelligence/Machine Learning (AI/ML) approaches will be introduced. Furthermore, diverse startup,

spin-off, Small and Medium Enterprises (SMEs), and also some Tech companies, etc. are increasing the use of AI-based environmental science.

The fast progress in environmental science and monitoring technologies has headed to a big deal of growth in the quantity and complexity in data generation. The environmental study demands more innovative and powerful computational and data analytical methods. Data analytical focus on having less dependence on previous knowledge. For instance, machine learning (ML) has demonstrated as a promising tool in resolving complex data patterns due to their powerful fitting abilities. Therefore, the past few year has seen a quick development of ML, particularly deep learning (DL). DL is used in image classification and machine translation. These gears are applied in multiple scientific fields, from chemistry,<sup>1</sup> material sciences,<sup>2</sup> and biomedicine,<sup>3</sup> to quantum physics.<sup>4</sup> In addition, environmental science (ES) have also implemented ML actively. It has shown by the rapid growth in the number of publications on the applications of ML in ES.<sup>5</sup> Henceforth, in this communication some research work environmental science related topic by using Artificial Intelligence/Machine Learning (AI/ML) approaches will be introduced. Furthermore, diverse startup, spin-off, Small and Medium Enterprises (SMEs), and also some Tech companies, etc. are increasing the use of AI-based environmental science. At the end of this communication can also be found a list of some startup companies.

Discovering extreme event in huge datasets is a main challenge in climate science research. Up-to-date algorithms for extreme event discovery are created upon human knowledge in describing events focus on subjective thresholds of relevant physical variables. Diverse competing approaches usually obtain vastly different results on the same dataset. A feasible level of characterization accuracy of extreme events in climate simulations and observational data records call attention for better understanding the trend and potential impact of such events in a climate change content. Liu *et al.* presented the first application of DL approach that would help to detect climate extreme events. They developed Deep neural networks that was able to learn high-level representations of a wide class of patterns from labeled data. In addition, they used deep Convolutional Neural Network (CNN) classification system and showed the practicality of DL approach for solving climate pattern detection problems. The result of combined with Bayesian based hyper-parameter optimization scheme, obtained deep CNN system 89%-99% of accuracy in detecting extreme events.<sup>6</sup>

Following to this topic, Rasp *et al.* demonstrated that DL can apply to obtain a lot of advantages of cloud-resolving modeling. They trained a deep neural network to show all atmospheric subgrid processes. This climate model was achieved by learning from a multiscale model in which convection was treated explicitly. The trained neural network then substituted the outdated subgrid parameterizations to a general circulation model. This new method can freely interact with the resolved dynamics and the surface-flux scheme. The predictive multiyear simulations were steady and strictly reproducible. For example, the mean climate of the cloud-resolving simulation and key aspects of variability, containing precipitation extremes and the equatorial wave spectrum. Lastly, the authors showed that the neural network parameterization produced new surface forcing patterns. However, the disadvantages of this method was to cope with temperatures far outside its training manifold. The results demonstrated the possibility of using DL for climate model parameterization.<sup>7</sup>

As last example, Smith *et al.* synthesized diverse methods for ML model interpretation and visualization (MIV) centering on meteorological applications. In recent years, ML has exploded in

popularity in many fields, especially in meteorology. In spite of the fact that ML has been successful in meteorology, it is still not widely accepted due to the perception of this method. ML models are “black boxes,” meaning the ML methods are believed to take inputs and obtain outputs, however, not to provide physically readable information to the user. This research introduced and demonstrated diverse MIV approaches for traditional ML and DL. The MIV allow meteorologists to have a better understanding on what ML models have learned. They also examined the permutation-based predictor importance, forward and backward selection, saliency maps, class-activation maps, backward optimization, and novelty detection. The authors used these methods at multiple spatiotemporal scales to tornado, hail, winter precipitation type, and convective-storm mode.<sup>8</sup>

Moreover, diverse startup, spin-off, Small and Medium Enterprises (SMEs), and also some Tech companies etc. developed AI-based environmental science-related topic. The aim of those enterprises is to help save the planet by using AI. This communication also lists in the Table 1 some selected startups in the area. For more information about startups list, check it out by clicking on the link below. <https://www.eu-startups.com/2022/12/the-european-startups-using-ai-to-tackle-climate-change/>

**Table 1.** AI-driven the European startups to deal with environmental issue.

Startup name	Founder	Funding (€)	Country	Topic
DeepSea	Konstantinos Kyriakopoulos and Roberto Coustas.	5M	UK	It works in the shipping industry, which is a huge part of the supply chain for global trade. They adopts AI to make ships and voyages more efficient.
Vaayu	Namrata Sandhu and Luca Schmid	11M	Germany	AI and ML technology to draw insights from a retailer’s production, sales, and logistics.
7Analytics	Jonas Torland, Werner Svellingen, Helge Jørgensen and Rolf. M. Monsen.	2.5M	Norway	This company utilizes terrain processing, along with multiple data sources, so as to combine flood models. AI and ML are an integral part of 7Analytics’s software solutions.
Greyparrot	Mikela Druckman, Ambarish Mitra, and Nikola Sivacki	10.2	UK	The company uses AI computer vision systems, deployed globally in recycling facilities, to analyze and sort large waste flows at scale.

In conclusion, the first research work they explored DL as a methodology for discovering extreme weather patterns in climate data. They built deep CNN creation for categorizing tropical cyclones, atmospheric rivers and weather fronts. The results showed will be used for quantifying climate extreme events trend in current day and future climate scenarios. It also can be used for investigating the changes in dynamics and thermodynamics of extreme events in global warming contend.<sup>6</sup> In the second study, the author demonstrated that a DL network can represent subgrid processes in climate models from cloud resolving model data.<sup>7</sup> The last research work analyzed ML MIV approaches and showed the application

for diverse meteorological fields. As we can see through the scientific work mentioned above, ML remains to gain popularity in meteorology and further environmental science. It is essential for experts to understand the trade-offs inherent in the models themselves.<sup>8</sup> In the table 1, recent startups company have been performed by using de AI/ML in the environmental issue related topics. Certainly, the prior research work discussed should be considered as a great opportunity for the creation of new startups.

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