NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography

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NSF AI Institutes

In 2019, the National Science Foundation (NSF) launched a new national investment in Artificial Intelligence (AI) to create a network of national AI institutes. Each institute will serve as a nexus of collaboration to create next-generation theory and applications of AI and to work synergistically with academia and industry. In the fall of 2020, NSF announced 5 new NSF AI institutes and 2 additional institutes funded by the United States Department of Agriculture (USDA) and the National Institute of Food and Agriculture (NIFA). Each institute is funded for approximately $20M over 5 years to make significant advances in foundational and applied AI research.

The inaugural institutes are:

- NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography
- NSF AI Institute for Foundations of Machine Learning
- NSF AI Institute for Student-AI Teaming
- NSF AI Institute for Molecular Discovery
- NSF AI Institute for Artificial Intelligence and Fundamental Interactions
- USDA-NIFA AI Institute for Next Generation Food Systems
- USDA-NIFA AI Institute for Future Agricultural Resilience, Management, and Sustainability

Trustworthy AI for Environmental Sciences

The vision of the NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography (AI2ES, Figure 1) is to create trustworthy Artificial Intelligence (AI) methods for diverse environmental science (ES) users that will revolutionize our understanding and prediction of high-impact atmospheric and ocean science phenomena and create new educational pathways to develop a more diverse AI and environmental science workforce. We are a convergent center with leading experts from AI, atmospheric and ocean science, risk communication, and education all working synergistically to develop and test trustworthy AI methods that will transform our understanding and prediction of the environment.

AI2ES has three main research foci: 1) foundational research on trustworthy AI/ML; 2) use-inspired ES research where an integrated effort tests trustworthy AI techniques in both atmospheric and ocean sciences; and 3) foundational RC research on trustworthy AI in ES, to understand user thinking, information needs, and effective communication approaches. The three research components are tightly integrated (Figure 2). To develop meaningful and novel approaches to trustwor-
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Figure 2: AI2ES foundational research in trustworthy AI, environmental science, and risk communication form a virtuous cycle.

For trustworthy AI for ES, it is necessary for scientists to have a deep understanding of the nature of AI and ES [2, 12, 3, 13]. They must also have a deep appreciation for the nature of ES user trust and risk perceptions, information processing, and decision making. This integrated convergent approach will enable the development of trustworthy AI systems and risk communication techniques that foster appropriate levels of trust by ES decision makers.

AI2ES trustworthy AI methods will directly address the major scientific challenges that ES data poses [4]. For example, when predicting a tornado, it is critical that the AI method correctly handle heterogeneous, multi-scale, spatiotemporal data. Most AI methods assume that samples are independent and identically distributed, yet this is not true for ES data. Fundamental fields, such as pressure, temperature, or wind, are highly spatio-temporally autocorrelated. A tornado requires multi-scale spatio-temporal factors to coalesce [6, 1, 11]. Additionally, multi-scale factors can influence the background probability of a severe storm and the intensity of the tornado, such as the position of the jet stream affecting the probability of a large-scale tornado outbreak [10, 8, 5]. Weather is also non-linear and chaotic [7], providing another challenge for AI. Training AI for high-impact weather can also be difficult due to the small number of reliable labeled examples, stemming from the rarity of events, such as tornadoes, or from the lack of humans in less populated areas to report hazards [14]. In addition, although humans reason about weather phenomena using object-level concepts such as “rear-flank downdrafts” [9], it is difficult to precisely define such objects for automated identification. Finally, as our climate changes, the fundamental driving forces behind the examples are non-stationary. All of these challenges make standard AI approaches infeasible.

Trust is a social phenomenon, and our integration of risk communication research across AI2ES activities provides an empirical foundation for developing user-informed, trustworthy AI by engaging and partnering with key environmental decision makers from communities that will be using the techniques developed. Our partnership of multiple academic institutions, NCAR, NOAA, and private industry spans the full cycle of fundamental research into trustworthy AI and enables rapid integration of trustworthy AI for increased societal impact. Environmental science provides a perfect testbed to advance trustworthy AI given its grounding in nature’s physical laws and conservation principles as well as the broad range of stakeholder feedback and high societal impact.

AI2ES also introduces novel broadening participation and workforce development activities fully integrate with AI2ES research on trustworthy AI, environmental science and risk communication. In coordination with two Hispanic (HSI) and Minority Serving (MSI) institutions, we are creating and piloting test a novel community college certificate in AI for the environmental sciences. This certificate will significantly enhance the diversity of the STEM workforce. AI2ES is also developing AI/ES training for all levels of students, including K-12 outreach and modules, and online education modules that leverage our private industry’s existing educational resources and networks. These will all be available on our website https://www.ai2es.org.

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References


Amy McGovern is a Lloyd G. and Joyce Austin Presidential Professor in the School of Computer Science and School of Meteorology at the University of Oklahoma. She is also the Director of the NSF AI Institute for Research on Trustworthy AI in Weather, Climate, and Coastal Oceanography.