9 DEC 2021

AI4ESP

BERAC UPDATE

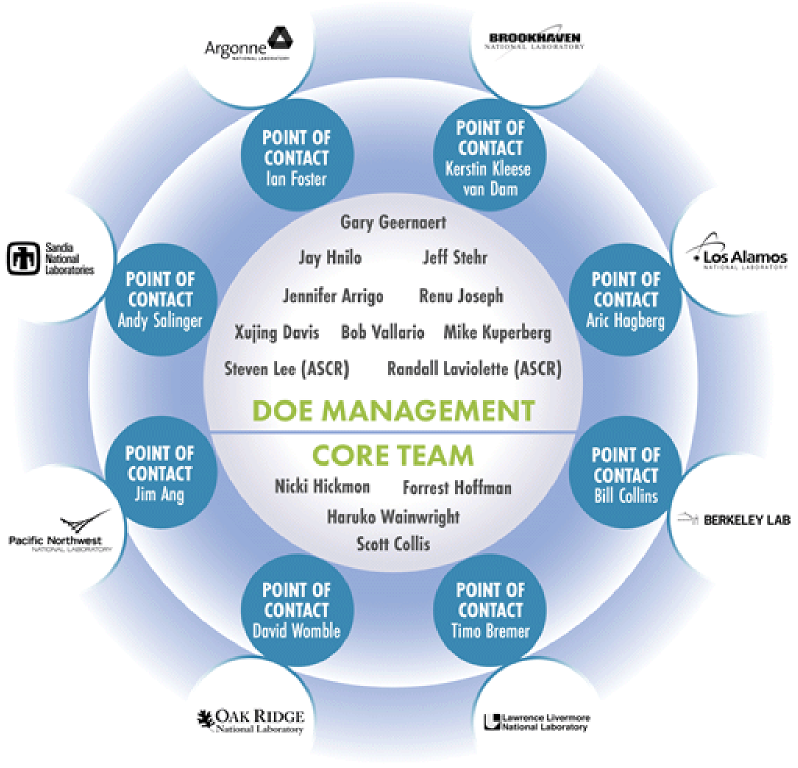
Nicki Hickmon[1] Forrest Hoffman[2] Haruko Wainwright[3] Scott Collis[1]

1 Argonne National Laboratory
2 Oak Ridge National Laboratory
3 Lawrence Berkeley National Laboratory

U.S. DEPARTMENT OF ENERGY

WHAT IS AI4ESP

AI4ESP is a BER-ASCR planning project to create a paradigm shift in the science of predictability and prediction, based on the co-design of artificial intelligence methodologies with physics-based observing, data assimilation, modeling, and prediction. It directly supports the DOE strategy to advance climate science and capabilities.

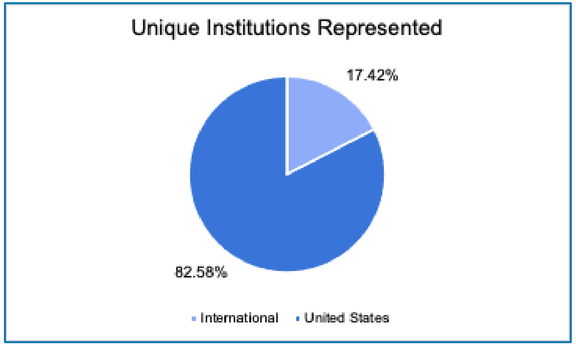


2021 AI4ESP WORKSHOP

- Spring ‘21: Community delivered 156 white papers on concepts that combined AI with climate science to inform the design of a game-changing workshop

- Oct-Dec ‘21: AI4ESP workshop held to further refine concepts towards a community strategy in support of the goals of DOE
  - Goal: How can we combine AI and machine learning with the traditional physics-based approach to prediction research, in order to reduce uncertainties for climate predictions of complex extreme phenomena in high gradient environments
  - Sessions:
    - Atmospheric Modeling
    - Land Modeling
    - Data Acquisition to Distribution
    - Human Systems & Dynamics
    - Hydrology
    - Watershed Science
    - Neural Networks
    - Ecohydrology
    - Surrogate Models & Emulators
    - Aerosols & Clouds
    - Knowledge-Informed Machine Learning
    - Coastal Dynamics, Oceans & Ice
    - Knowledge Discovery & Statistical Learning
    - Climate Variability & Extremes
    - Explainable/Interpretable/Trustworthy AI
    - Hybrid Modeling
    - AI Architecture Co-Design

- Feb ‘22 through June ‘22: Brief DOE plus other federal and international agencies on workshop results

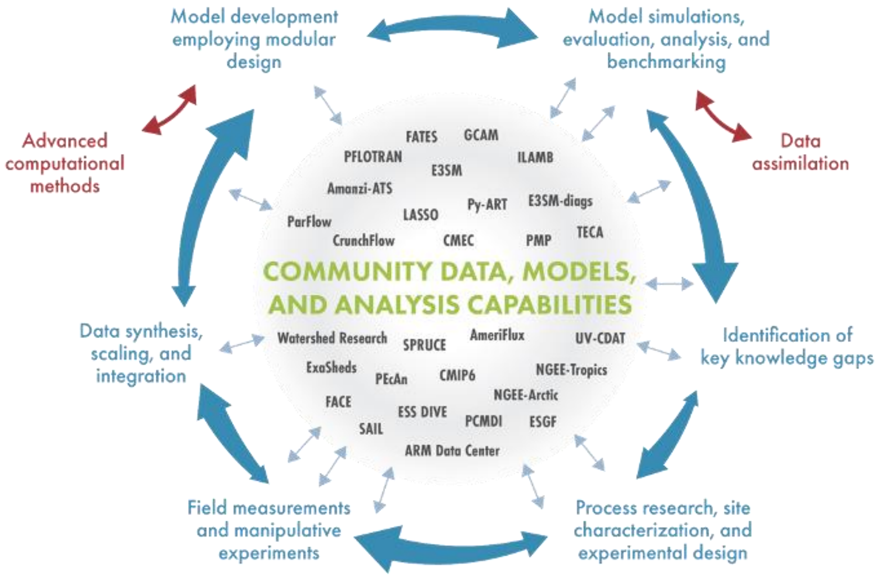


- 740+ participants
- 178 institutions
- 17 sessions, 10 days, 5 weeks

AI4ESP WORKSHOP HIGHLIGHTS

Grand Challenge Groupings

- Application Challenges
- Uncertainty Quantification Challenges
- Data Challenges
- Human Systems Drivers & Stakeholders
- Research Cultural Challenges

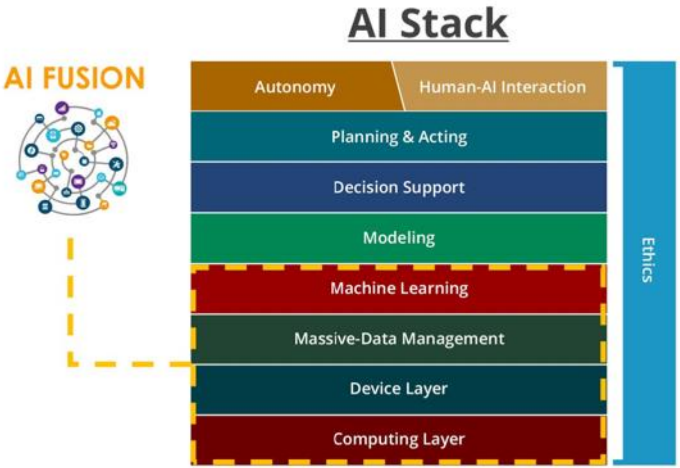


AI4ESP WORKSHOP HIGHLIGHTS

Codesign Is Critical

Codesign advanced computing, software, hybrid ML/physical models, observations and future Earth system modeling capabilities

- Common/consistent language & format
- Merged products (standardization, interoperability)
- Adaptive data & parameter selection
- Computation using large datasets without moving
- Specialized AI/ML code & architecture
- Training and benchmarking datasets and hybrid model design

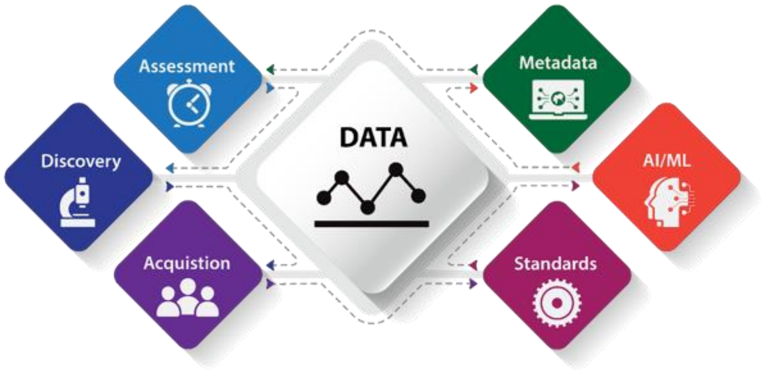


College of Engineering, Carnegie Mellon University

AI4ESP WORKSHOP HIGHLIGHTS

Cultural Change Is Compulsory

- Communities excited to work together
  – need combined purpose and early success
- Existing & upcoming workforce development
- Common terminology across groups & scales in AI4ESP space
- Transfer learning for different domains & scales
- Achieve & maintain FAIR, equitable data access
- Open science community effort pulling in an ultimately singular direction
- Environmental justice throughout the system



Modular Data Ecosystem to enable data interoperability for AI. Courtesy of Prakash & Serbin

AI4ESP WORKSHOP HIGHLIGHTS

Infrastructure Investment Is Imperative

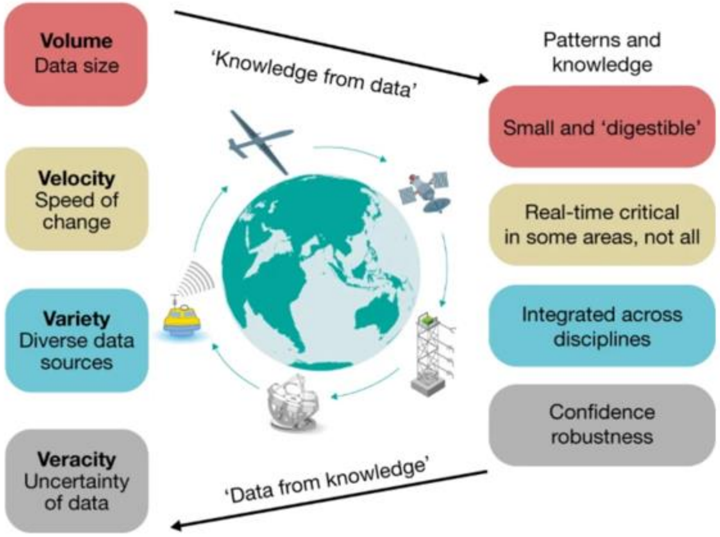
- Workforce development
- Multi-agency/institution coordination, cooperation, collaboration
- Codesign, creation, implementation & maintenance
  - Computational resources
  - Training, benchmarking, & combined datasets
  - AI methodology development
  - Interoperable frameworks for data & hybrid modeling
- FAIR/Equitable data & software practices
- Observations covering normal & capturing rare & extreme events
- Adaptive observatories, data assimilation, & modeling

image from technologynetworks.com

AI4ESP WORKSHOP HIGHLIGHTS

Uncertainty Quantification & Propagation Is Underlying

- Digital twin mindset
- Common understanding of uncertainty
- Defined uncertainty
- Capture beginning with instrument/sensor calibration/operation
- Propagation requires formatting and transfer standards
- Assimilation, parameterization, surrogate, emulator, hybrid modeling

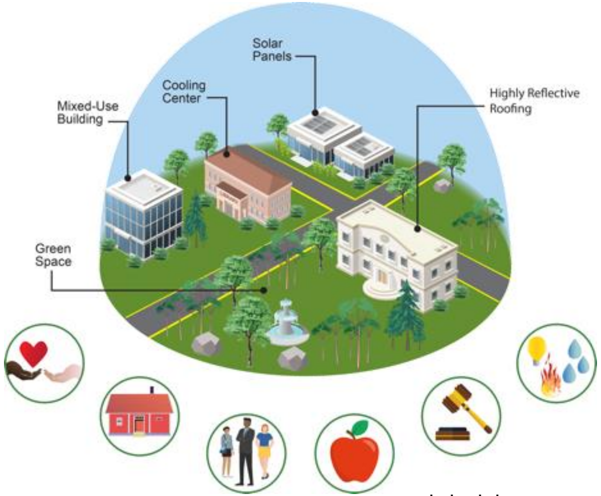


Data challenges in the earth sciences: different data sources, small data / big data challenges, and uncertainty in the data. Figure taken from (Reichstein, M. et al. 2019)

AI4ESP WORKSHOP HIGHLIGHTS

Human System Integration Is Significant

- Inclusion of complex human processes & decisions
- Capture complex feedbacks between all components
- Build decision-relevant process models
- Ethically sensitive data synthesis and gap filling
- Representation of human systems and dynamics in models
- Results must be robust, explainable, & trustworthy
- Results must be shared efficiently (both positive & negative)



globalchange.gov

AI4ESP WORKSHOP HIGHLIGHTS

Advancements Must Accelerate

- Build unified framework(s) across Earth system predictability space
  - Codesigned
  - Domain interoperability
  - Open, community contributed
  - Impactful, trusted & explainable results
- AI initiatives beyond DOE
- DOE uniquely positioned

Workshop Special Thanks:

Harriet Kung

Gary Geernaert

Barbara Helland

BERAC MEETING FEEDBACK (HELP US IMPROVE THE MESSAGE):

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AI4ESP@ANL.GOV

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DOE BER AI Webpage: https://science.osti.gov/ber/research/artificial-intelligence-ai

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