NASA SBIR 2022 Phase I Solicitation

S17.04 Application of Artificial Intelligence for Science Modeling and Instrumentation

Lead Center: GSFC

Participating Center(s): ARC, JPL, LaRC

Scope Title

Accelerating NASA Science and Engineering Through the Application of Artificial Intelligence to Data Assimilation

Scope Description

NASA, the National Oceanic and Atmospheric Administration (NOAA), and other Federal Agencies maintain extensive Earth observation networks and are continuously developing the next-generation remote-sensing platforms. The data from these observations are used in a wide variety of ways, including as input to scientific data analysis and physics-based computer models to make a wide range of forecasts. Most forecast models are driven by data from observing systems; these data contain artifacts of the observing system, such as noise, sparsity of observations, and anomalies that do not affect the overall forecast. Since the quality of the forecast is directly related to the estimation of the initialization state of the physical system, these improvements cannot be achieved without better estimates of state of the system. Data assimilation is a technique for integrating observational data about a physical system with modeling that reflects the understanding of the physical processes in it. It fills the gaps in observations and provides both an estimate of the state of the system as well as the uncertainty in that estimate. Current methods are computationally expensive and as data volumes increase, may not be able to meet the performance needed for timely forecasts.

NASA is looking for proposals that apply artificial intelligence (AI), computer vision (CV), machine learning (ML), and/or deep learning (DL) to data assimilation to improve efficiency and accuracy of model forecast products, driven by remote sensing and, when appropriate, in situ data sources. The result will lead to a better forecast of future states and an understanding of risk for localized extreme atmospheric weather, space weather, and water events and lead to earlier warnings, which will save lives and reduce property damage. As an alternative to traditional data assimilation, the application of AI/CV/ML/DL methods, such as pattern recognition, feature extraction, super resolution, gap filling, and more, have the potential to result in a more complete state of the natural system.

Proposals MUST specify and be in alignment with existing and/or future NASA/NOAA programs. Research proposed to this subtopic should demonstrate technical feasibility during Phase I, and in partnership with scientists and/or engineers, show a path toward a Phase II prototype demonstration, with significant communication with missions and programs to later plan a potential Phase III infusion. It is highly desirable that the proposed projects lead to solutions that will be infused into government programs and projects.

Expected TRL or TRL Range at completion of the Project

4 to 6
Primary Technology Taxonomy

Level 1

TX 11 Software, Modeling, Simulation, and Information Processing

Level 2

TX 11.2 Modeling

Desired Deliverables of Phase I and Phase II

- Prototype
- Software
- Research

Desired Deliverables Description

Data products developed under this subtopic may be developed for broad public dissemination or used within a narrow scientific community. It is expected that the labeled training data sets, models, and resulting data assimilation products will be publicly accessible.

In general, the desired outcomes for this subtopic include, but are not limited to, the following:

- New methods and approaches for science data assimilation.
- New/improved data assimilation products that can be used and infused into NASA science projects.
- Labeled training data sets and trained models specific to a given problem but that can also be used as a basis for furthering other science and engineering research and development.

More specifically:

- Phase I should be used to establish a proof of concept with deliverables including a final report, any software developed, training sets, etc.
- Phase II will expand on this proof of concept to a full prototype with a very similar set of deliverables, including a final report, software, training sets, etc.

State of the Art and Critical Gaps

NASA, along with other Federal Agencies and commercial and foreign research organizations that perform science and engineering, is making large strides in the use of artificial intelligence (AI) technologies (which includes computer vision, machine learning, and deep learning). This subtopic is looking to improve this by providing trained models that have the possibility of creating a better initial state of the physical system (i.e., Earth, solar wind, etc.) prior to being used as input for scientific data analysis and as input into physics-based simulations to improve forecasts.

In addition, emerging computational platforms now provide significant improvements in computing capabilities to enable AI to be applied to a wide variety of applications in science and engineering. These emerging computational capabilities have the potential to dramatically speed up AI calculations, and these systems are even being used as the reference architecture for exascale high-performance computing systems.

Relevance / Science Traceability

Broad applicability across throughout the decadal surveys and satellite development requirements to improve the quality and granularity of system forecasts:
• Improved measurements of the Earth system could provide better gap analysis for future mission requirements.
• Global Modeling and Assimilation Office (GMAO) assimilation: Augment data assimilation to improve computational performance or data quality.
• Carbon Cycle Ecosystems Office (CCOE): Wide variety of applications given the diversity of data sets from sparse in-situ to global satellite measurements.
• Earth Science Technology Office/Advanced Information Systems Technology (ESTO/AIST): New technology and services to exploit NASA and non-NASA data leading to digital twins of physical systems.
• Computational and Information Sciences and Technology Office (CISTO - Code 606): Computational, analytic, and visualization technologies used for new data science.
• NASA Center for Climate Simulation (NCCS - Code 606.2): Building applications toward exascale computing.

References

• 2017-2027 Decadal Survey for Earth Science and Applications from Space: https://science.nasa.gov/about-us/science-strategy/decadal-surveys
• 2013-2022 Decadal Survey in Solar and Space Physics
• Global Modeling and Assimilation Office: https://gmao.gsfc.nasa.gov/
• NASA Goddard Institute for Space Studies: https://www.giss.nasa.gov/
• NASA Earth Science Data: https://earthdata.nasa.gov/
• NASA Center for Climate Simulation: https://www.nccs.nasa.gov/
• NASA High-End Computing (HEC) Program: https://www.hec.nasa.gov/
• PUBLIC LAW 115–25—APR. 18, 2017 – Weather Research and Forecasting Innovation Act of 2017
• 2019 OSTP/OMB memo: Fiscal Year 2021 Administration Research and Development Budget Priorities

In addition, proposers are encouraged to search the NASA Technical Report Server (NTRS) for additional information to help guide potential solutions: https://ntrs.nasa.gov/