Earth System Digital Twins (ESDT) Workshop

Lightning Talk

An Analytic Collaborative Framework for the Earth System Observatory

da Silva, Arlindo
Global Modeling and Assimilation Office, NASA/GSFC

October 27, 2022

Project Objectives

Science and Technology Objectives

- UseCloud-optimized representative datasets for the ESO missions and the PoR for prototyping an *Analytic Collaborative Framework*
- An *Algorithm Workbench* for enabling experimentation and exploration of synergistic algorithms involving the AOS, SBG and the PoR
- Science demonstrations: use of synthetic data to demonstrate capability of new observing system
  - SBG atmospheric correction
  - Evaluate lidar-polarimeter retrievals
  - Explore synergistic algorithms

Application Objectives

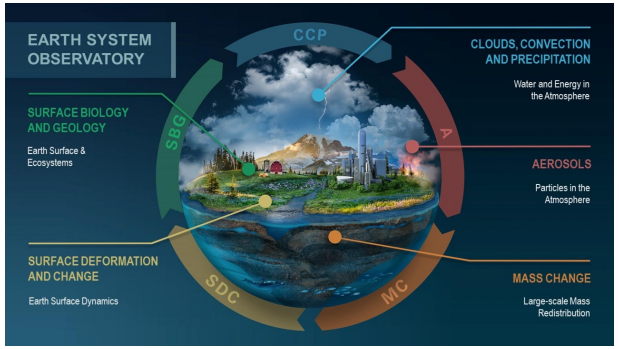
- Concrete Open-source Science demonstrations including use cases that span science discovery and end user applications with direct societal impact.
  - Hazardous Plumes
  - Solar energy application
  - Bio-diversity application

Benefits to Earth Science

- Bridges the gap between advanced earth system modeling and realistic simulation of future observing systems
- Early development of new concepts in model-data fusion enabling science investigations aimed at elucidating physical processes and their representation in models.

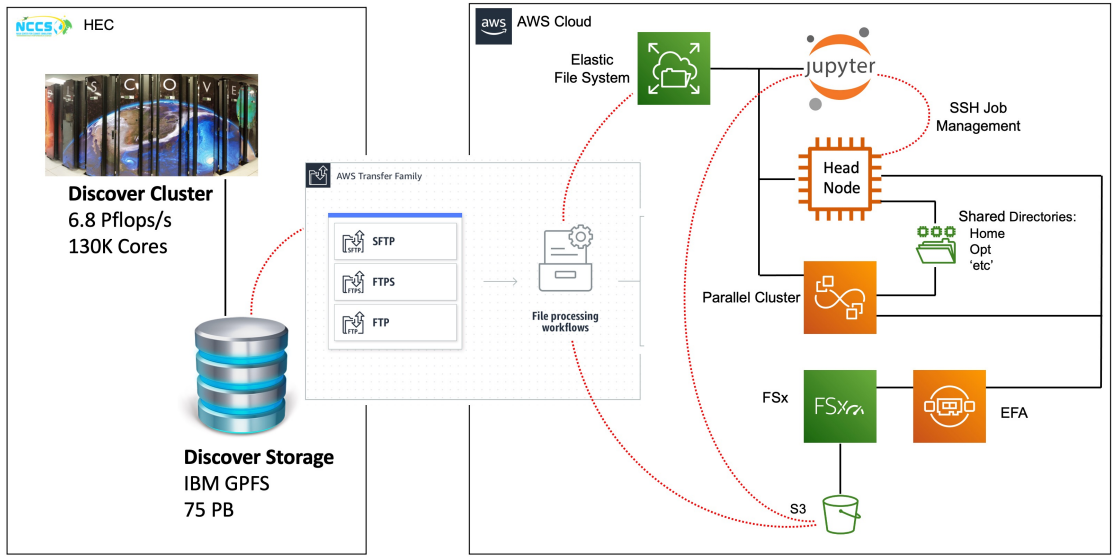
Relationship to ES Digital Twins

- Develops a **Digital Replica** of the future ESO observing system based on realistic, high-resolution Earth system model simulations
- Provide a framework for observing system simulations and tools to conduct *what-if* investigations and trade studies for the benefit of NASA missions in development.

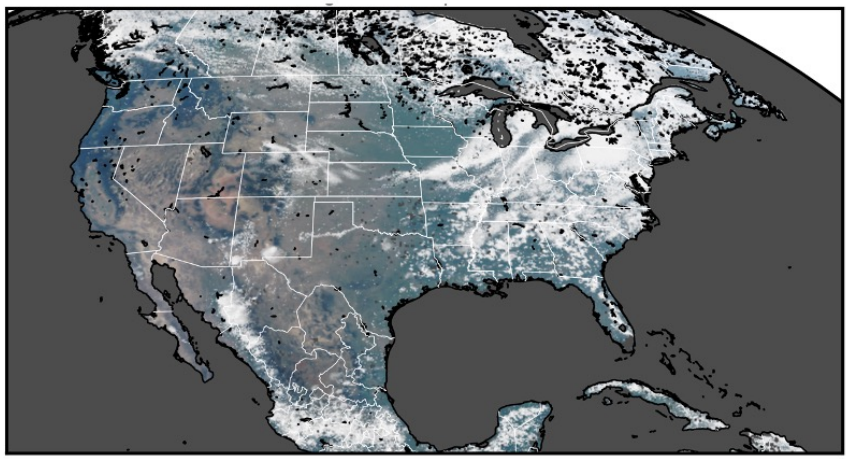


Technology Approach

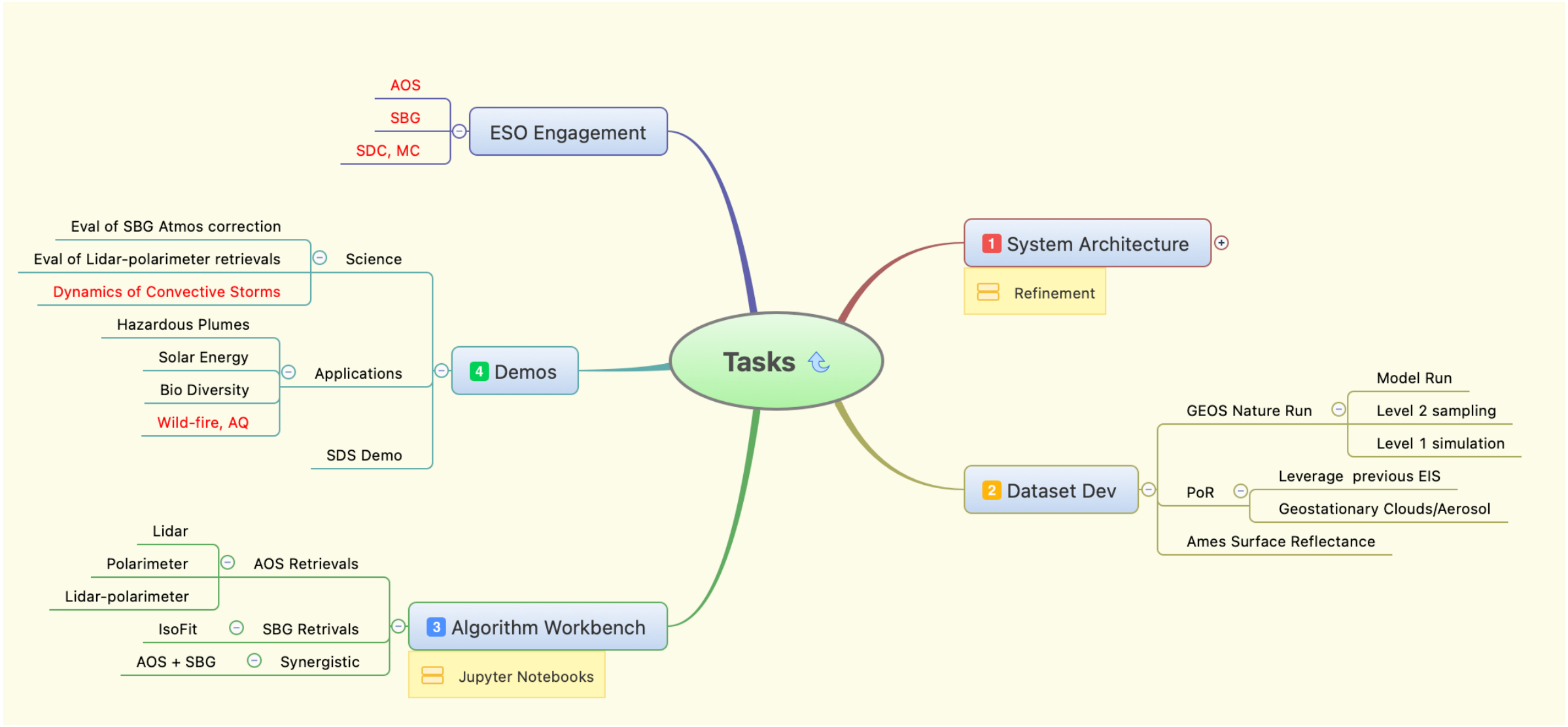
- Based on a global storm resolving GEOS Nature Run, simulate the AOS observing system
- Based on the Ames synthetic surface reflectances and AOS atmosphere simulate SBG reflectances at TOA
- Implement an Algorithm Workbench on AWS for developing testing and evaluating AOS, SBG and synergistic AOS+SBG retrievals
- Open-source Science demonstrations by exploring advanced data analysis and easy access to cloud-optimized (simulated) datasets.



Simulated TEMPO RGB Image

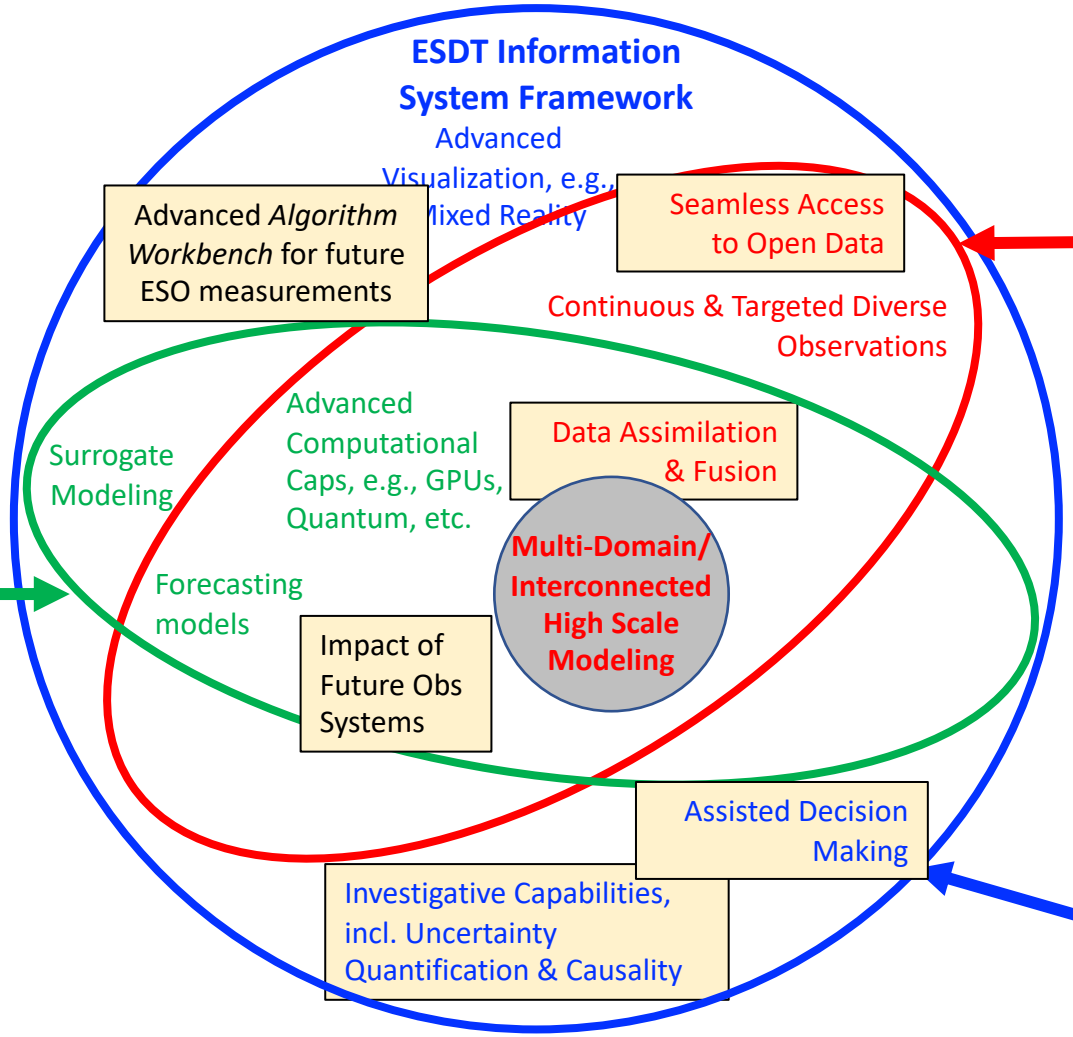


Technology Approach



Earth System Digital Twins (ESDT) Mapping

ESDT 2022
OCTOBER 26–28, 2022



(1) Up-to-Date *Digital Replica* of Past and Current States of Earth System
(Simulated AOS, SBG and PoR Observations)

(2) Real-Time (RT) or Near-RT *Forecasting* of Future States of Earth System

(3) Impact Assessment by running What-If Scenarios for Hypothetical Future States of Earth System
(Explores Future Observing Systems)


ESDT
2022
OCTOBER 26–28, 2022
NASA

Appendix: AIST ESDT Description

Towards understanding the evolution and interactions of Earth's most complicated systems

ESDT 2022
OCTOBER 26–28, 2022

AIST leads NASA's Earth System Digital Twins (ESDT) efforts, developing novel technologies for integrating diverse Earth and human activity models, continuous observations and information system capabilities to provide unified, comprehensive representations and predictions that can be utilized for monitoring as well as for developing actionable information and supporting decision making. Using insights generated from its Novel Observing Strategies (NOS) and Analytic Collaborative Frameworks (ACF) efforts, AIST pioneers ESDTs that could be used to help researchers better understand the fundamental Earth systems that impact everything from wildfires to climate change.

Organized around interconnected, multi-domain, high-scale modeling capabilities, the three major components of an ESDT are a continuously updated **Digital Replica** of the Earth System of interest, dynamic **Forecasting** models and **Impact Assessment** capabilities.

The ***Digital Replica*** is fed by continuous and targeted diverse observations, powered by Data Assimilation and Fusion, and provides an accurate representation of the *current state of the system*.

Forecasting is facilitated by advanced computational capabilities, Machine Learning (ML) and Surrogate Modeling, and provides real-time or near-real-time prediction of *future states of the system*.

Finally, ***Impact Assessment*** uses the Digital Replica and forecasting capabilities with ML, causality, uncertainty quantification and advanced computation and visualization capabilities for running large amounts of simulated predictions quickly and at various spatial and temporal scales, opening the door to investigating "what-if" scenarios. These will allow to understand better the impact of one system on another one, and better predict Earth Science events, e.g., severe weather events. This third component provides *hypothetical future states of the system*.

The latest AIST project solicitation requested technologies dedicated to furthering AIST's three strategic ESDT goals, which are:

1. To develop information system frameworks that provide continuous and accurate representations of systems as they change over time.
2. To mirror various Earth Science systems and utilize the combination of Data Analytics, Artificial Intelligence, Digital Thread and state-of-the-art models to help predict the Earth's response to various phenomena.
3. To provide the tools to conduct "what-if" investigations that can result in actionable predictions.

These goals will allow future Earth System Digital Twins to better represent, predict, and investigate complex Earth system phenomena. In total, AIST selected thirteen projects to further develop its ESDT efforts according to these strategic principles. These projects will explore technologies for better ESDT infrastructure, ML-surrogate modeling for ESDT applications, ACF for ESDT applications, and fully-functioning ESDT prototypes.

A complete list of selected AIST-21 projects can be found here.