DREAM: Distributed Resources for the Earth System Grid Federation (ESGF) Advanced Management

2015 AGU Fall Meeting

(INS52A) Exploiting Big Earth Data: Computation, Testing, and CyberGIS III

Friday, December 18, 2015

Dean N. Williams (PI)
On behalf of the DREAM site PIs

Overview

Motivation

Approach

Architecture

Requirements

Motivating Use Cases

Motivation

- Distributed Resources for the Earth System Grid Federation (ESGF) Advanced Management (DREAM) provides a new way to access large data sets across multiple DOE, NASA, and NOAA compute facilities
- DREAM is focused on providing services for dynamic management of resources held at diverse and scattered U.S. sites. Some of the present issues that we seek to address include how to:
  - **Publish** dynamic resources into a virtual organization;
  - **Discover** distributed resources and services through an intuitive, yet powerful query syntax;
  - **Link** together various phases of a scientific execution;
  - **Monitor and expose** the dynamic storage and computational resources, throughout the federation;
  - **Execute** parallel distributed analytics across DOE, NASA, and NOAA data centers; and
  - **Explore, analyze, and visualize** large-scale data remotely using commodity hardware.

Approach

Our approach generalizes the current operational infrastructure used by the ESGF into a template architecture that hides each implementation layer behind a well-defined Application Programming Interface (API), so that different communities may decide to adopt or swap any single part. The deployable software stack will include the following modules:

- **Publishing services** (reference implementation based on ESGF publishing software);
- **Search services** (reference implementation based on Solr-Cloud and ESGF Search API);
- **Transfer services** (reference implementation based on Globus/GridFTP);
- **Computation services** (reference implementation based on Ultrascale Visualization Climate Data Analysis Tools (UV-CDAT) and ESGF Computing API);
- **Resource monitoring and allocation** (to be developed from scratch);
- **Security services** (reference implementation based on open standards and ESGF security infrastructure);
- **User interface** (reference implementation based on CoG web knowledge environment); and
- **Exploration services** (remote analysis and visualization based on streaming, multi-resolution data)

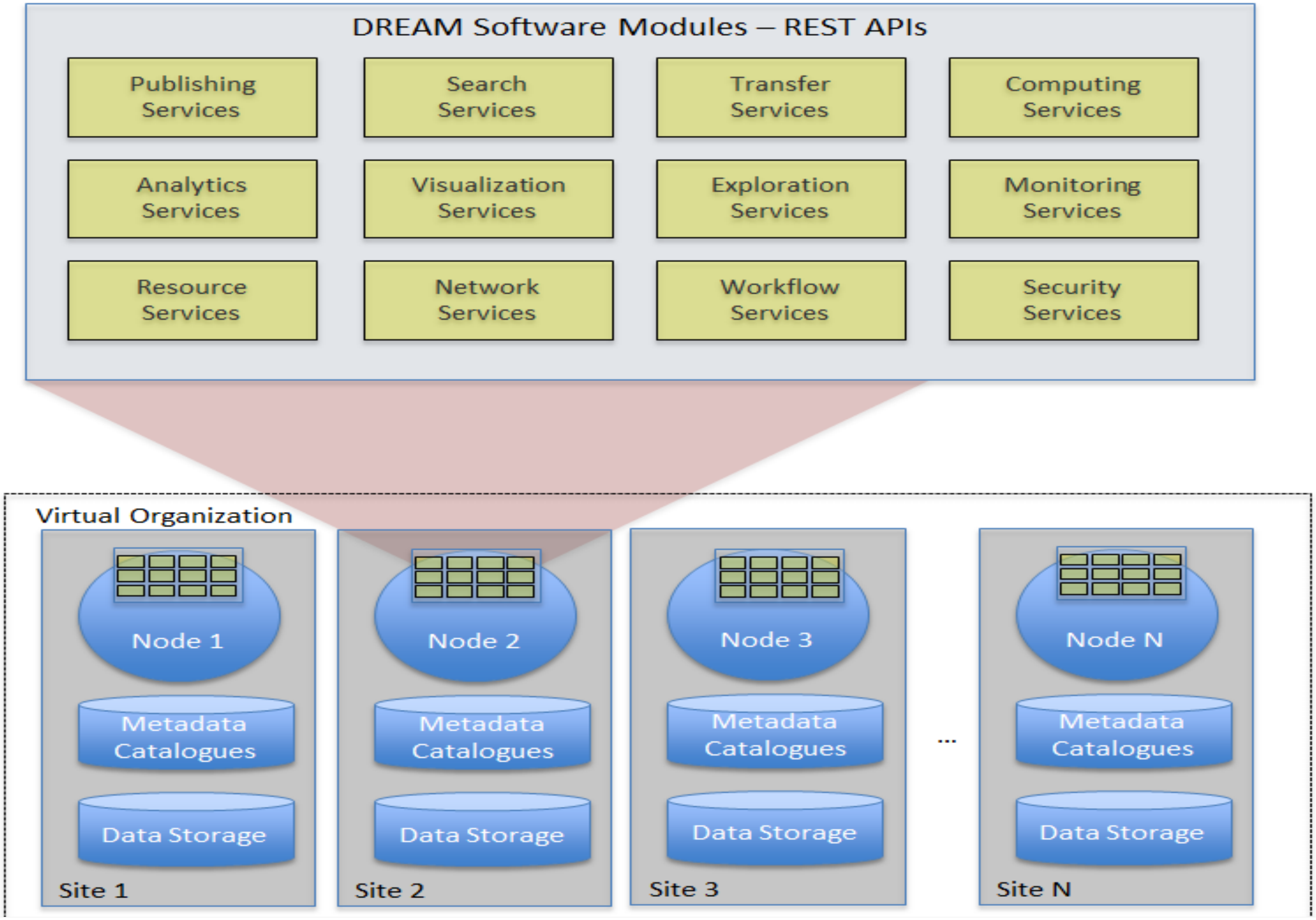
Architecture

The two basic principles behind the DREAM design are "**modularity**" and "**abstraction**". Modularity means that DREAM will be structured not as a single monolithic system, but rather as a composition of interacting software services, which are packaged and can be installed individually and independently

The functionality of each service will be abstracted in a well-defined API, so that each service can be easily invoked by other services and clients without worrying about the underlying implementation details. All service APIs will be defined to conform to the Representational State Transfer (REST) web service paradigm, which will allow simple invocation by standard web-enabled clients

In general, software systems that are both modular and abstract have an intrinsic longer longevity, because each service can be evolved or replaced individually, without affecting the backward compatibility with other parts of the systems, or its clients.

Architecture



DREAM Software Modules – REST APIs

Publishing Services

Search Services

Transfer Services

Computing Services

Analytics Services

Visualization Services

Exploration Services

Monitoring Services

Resource Services

Network Services

Workflow Services

Security Services

Virtual Organization

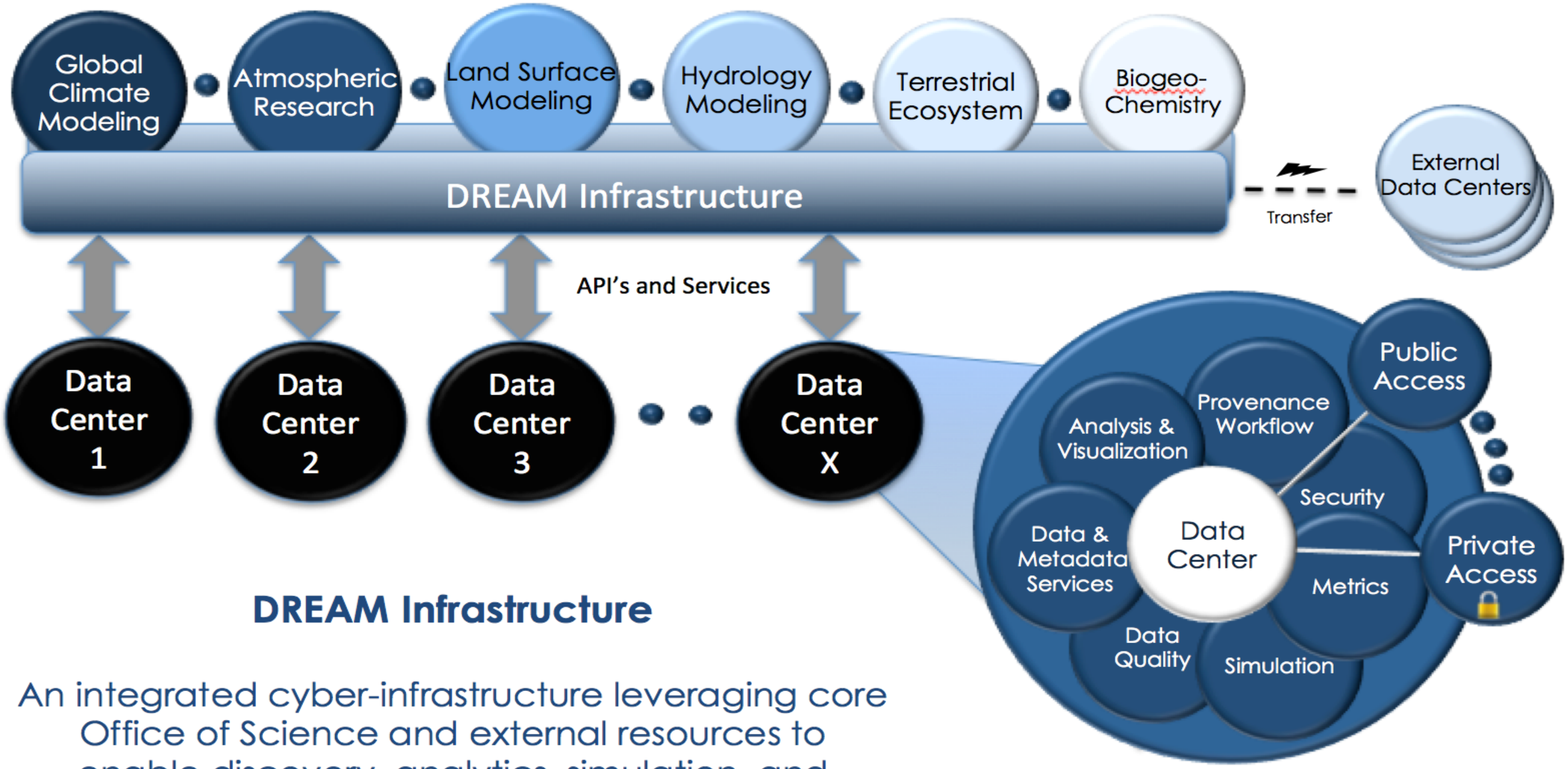
Requirements

- **Distributed**: DREAM will support a system composed of geographically distributed nodes, each with its own set of data resources, metadata catalogs, and software services. The DREAM protocols and services will unite all nodes in a single federation, so that a client will be able to discover, search, download and execute resources independent of their physical location, as if they were held and run on a single server.
- **Dynamic**: the DREAM architecture will be designed to support a highly dynamic system, which will expose with minimum delay all data and services that are available at that time throughout the federation. For example, data collections produced by a model run, data streams originating from the real-time processing of a field instrument, or new derived products produced by a scientist running their processing code, could all be published into the system and immediately returned as results of federation-wide searches. Additionally, the system will continually provide an up-to-date report on the state of its components and will be able to automatically direct client requests where resources are available.
- **Scalable**: the DREAM architecture will be able to scale to the "Big Data" volumes that are expected in several scientific fields (climate, astronomy, genomics, etc.) in the next 5-10 years. Scalability will be achieved through a two-fold approach. First, each service will be implemented through a high-performance technology that is inherently able to handle large volumes of data, in a distributed environment. Second, the DREAM modular architecture will allow each service to be instantiate multiple times.

Requirements

- **Resiliency and Fault Tolerance**: The DREAM architecture will be designed to include redundant components for all critical services (such as search, authentication, authorization, data download and visualization), and to execute automatic failover in case any component becomes unavailable. When backup services are not available, we will ensure that DREAM produces meaningful error responses to human and machine clients.
- **Secure**: DREAM will support a distributed and federated security model, whereby each node will maintain complete control over the policies for accessing its local data and computational resources, while federation-wide authentication and authorization services will be responsible for enforcing these policies homogenously through the system. Single-sign-on and federated access control will allow users to register and authenticate only once, and then propagate their identity

Requirements

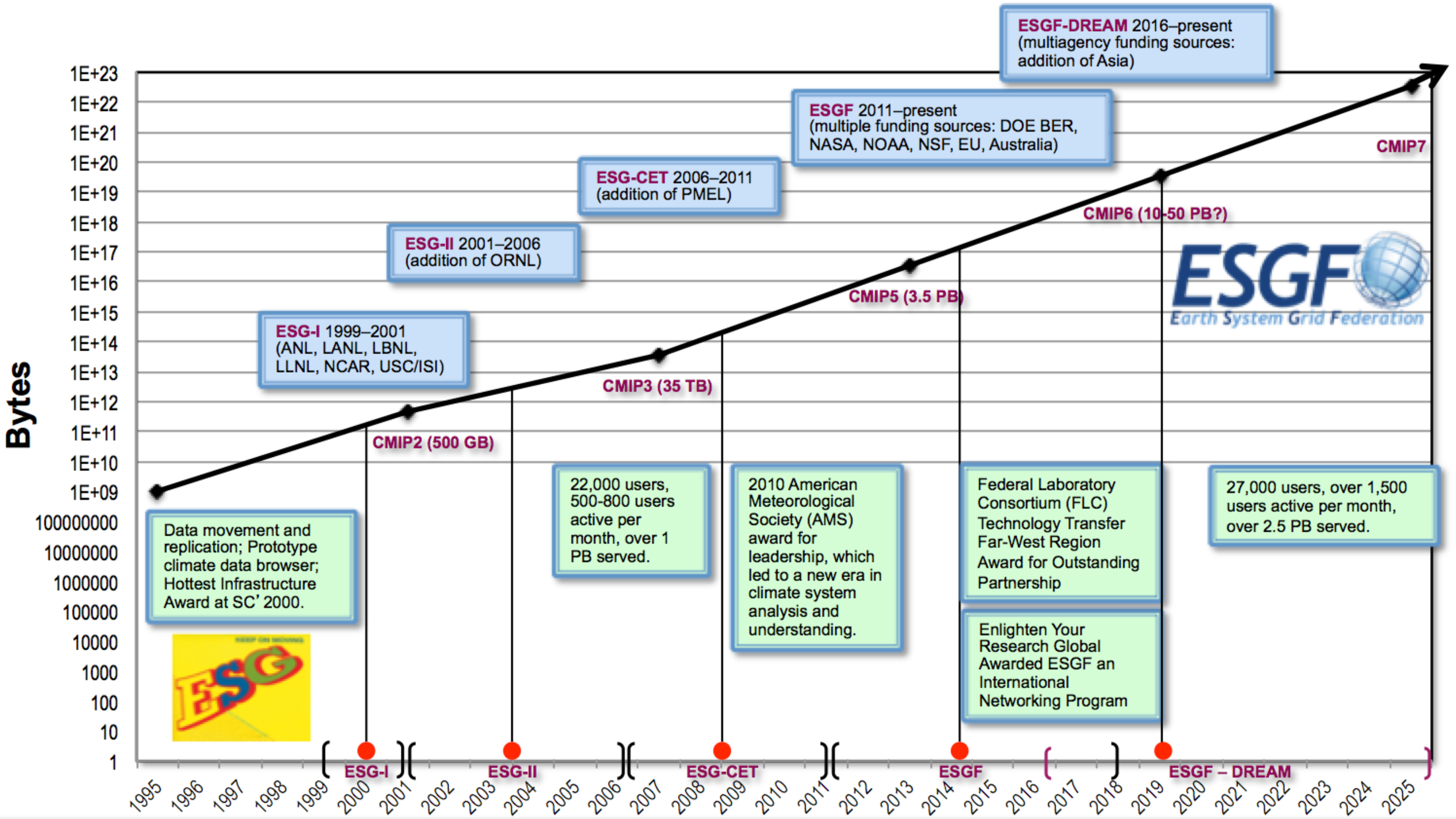


DREAM Infrastructure

An integrated cyber-infrastructure leveraging core Office of Science and external resources to enable discovery, analytics, simulation, and knowledge innovation

Data Center & Interoperable Services

Motivating Use Case



ESG-I 1999–2001 (ANL, LANL, LBNL, LLNL, NCAR, USC/ISI)

ESG-II 2001–2006 (addition of ORNL)

ESG-CET 2006–2011 (addition of PMEL)

ESGF 2011–present (multiple funding sources: DOE BER, NASA, NOAA, NSF, EU, Australia)

ESGF-DREAM 2016–present (multiagency funding sources: addition of Asia)

Data movement and replication; Prototype climate data browser; Hottest Infrastructure Award at SC' 2000.

22,000 users, 500-800 users active per month, over 1 PB served.

2010 American Meteorological Society (AMS) award for leadership, which led to a new era in climate system analysis and understanding.

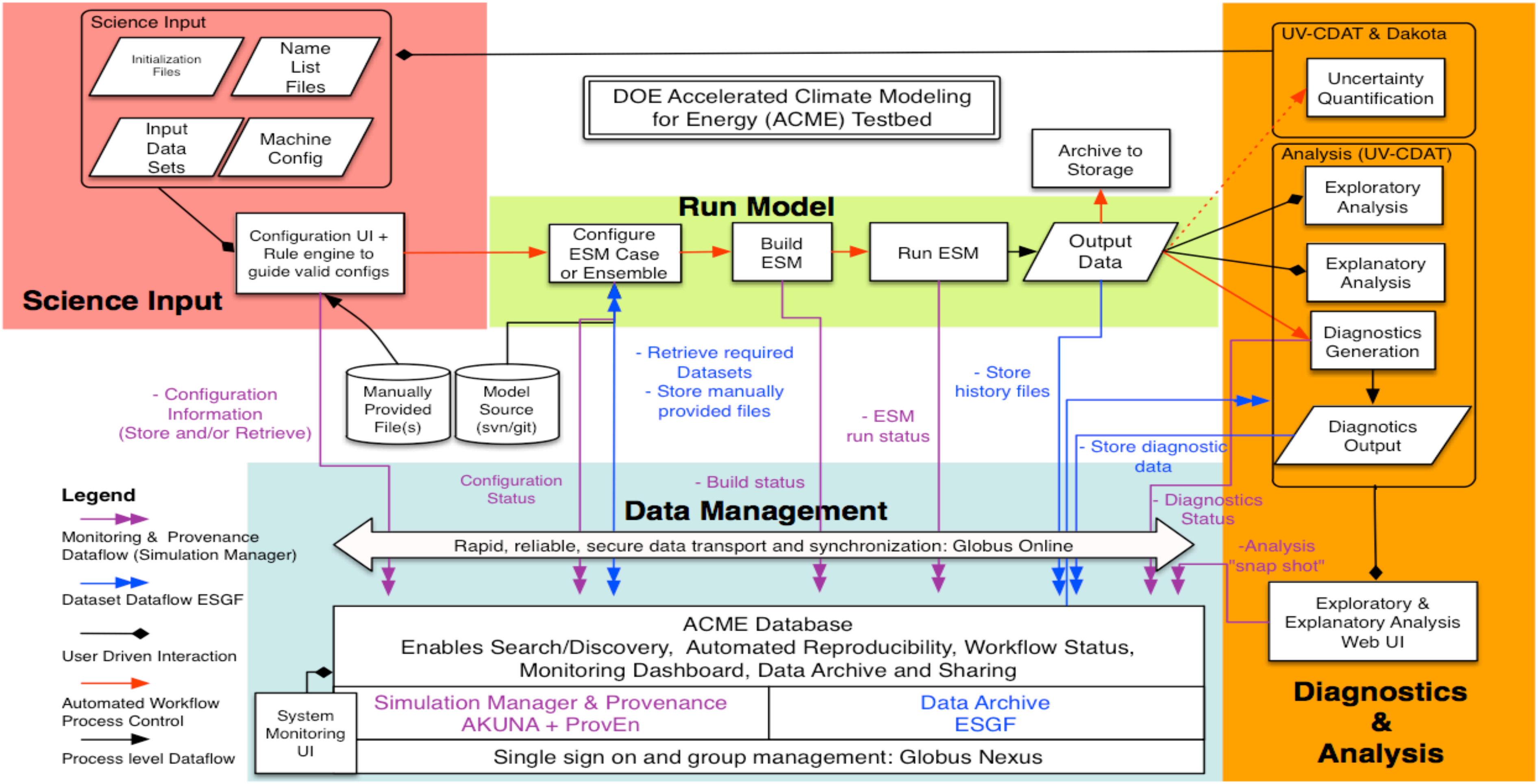
Federal Laboratory Consortium (FLC) Technology Transfer Far-West Region Award for Outstanding Partnership

Enlighten Your Research Global Awarded ESGF an International Networking Program

27,000 users, over 1,500 users active per month, over 2.5 PB served.

We recognizes that data management, stewardship and curation is an ongoing and long-lived function that requires a strategy that is resilient to continuing evolution in hardware and software.

Motivating Use Case



Science Input

Initialization Files

Name List Files

Input Data Sets

Machine Config

Configuration UI + Rule engine to guide valid configs

Science Input

DOE Accelerated Climate Modeling for Energy (ACME) Testbed

Run Model

Configure ESM Case or Ensemble

Build ESM

Run ESM

Output Data

Archive to Storage

UV-CDAT & Dakota

Uncertainty Quantification

Analysis (UV-CDAT)

Exploratory Analysis

Explanatory Analysis

Diagnostics Generation

Diagnotics Output

Manually Provided File(s)

Model Source (svn/git)

- Configuration Information (Store and/or Retrieve)

- Retrieve required Datasets

- Store manually provided files

- ESM run status

- Store history files

- Store diagnostic data

Configuration Status

- Build status

- Diagnostics Status

-Analysis "snap shot"

Data Management

Rapid, reliable, secure data transport and synchronization: Globus Online

ACME Database

Enables Search/Discovery, Automated Reproducibility, Workflow Status, Monitoring Dashboard, Data Archive and Sharing

Simulation Manager & Provenance AKUNA + ProvEn

Data Archive ESGF

Single sign on and group management: Globus Nexus

System Monitoring UI

Exploratory & Explanatory Analysis Web UI

Diagnostics & Analysis

Legend

Monitoring & Provenance Dataflow (Simulation Manager)

Dataset Dataflow ESGF

User Driven Interaction

Automated Workflow Process Control

Process level Dataflow

ESGF
Earth System Grid Federation

esgf.llnl.gov; ESGF public website

UVCDAT

uvcdat.llnl.gov; UV-CDAT public website

CoG

www.earthsystemcog.org/; CoG public website