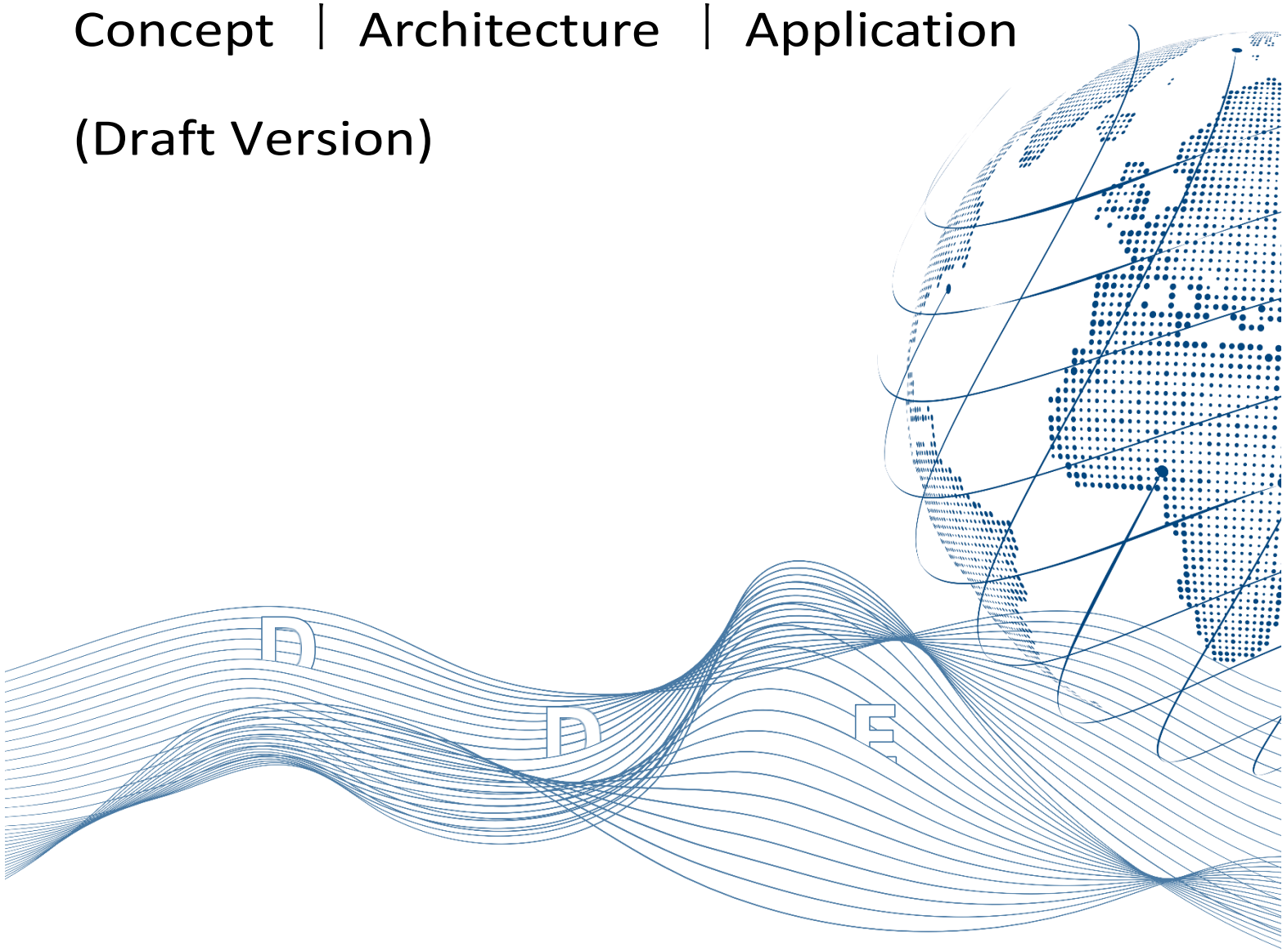
DDE PLATFORM

Concept | Architecture | Application

(Draft Version)



November 2022

DEEP-TIME DIGITAL EARTH (DDE)

International Union of Geological Science's (IUGS) Recognized Big Science Program

Contents

1. Preface

1.1 Objectives

The DDE Platform is a one-stop online geoscience research platform. Its scope is to make global geo-scientists' collaborative innovation and discovery more efficient and intelligent.

As an online platform for interdisciplinary collaborative research, the DDE Platform has created an online workspace to support "data-model-computation" driven research. This document is to provide support for users who are using the DDE Platform and the corresponding products with a description of the mission, scope, goals and constructive contents of the DDE Platform, especially to demonstrate DDE business architecture, application system architecture and technical architecture through the design of the enterprise architecture. This document offers a guide of resource, service capabilities, and disciplinary research provided by DDE. This document also provides DDE participants and partners with a navigation to know and connect with each other.

From the perspective of resource sharing, this document aims at how the DDE Platform collects, aggregates and shares resources, including data, knowledge and models (methods) from various sources. DDE provides standardized expressions and systematic management of these resources in different specifications to help building a long-term joint-contribution and shared-benefits platform.

From the capability support level of the platform, this document is used to provide platform creators and maintainers with a clear platform technical system and operational functions, and to clarify the corresponding functions of each key functional module to explain how the DDE Platform operates.

From the perspective of software development, this document explains the technical architecture, and provides software developers with the extension of the platform function modules (components) and the extensions of the discipline function modules (components) from the technical level, so as to explain how the DDE Platform develops itself and integrates with the discipline.

Finally, in order to provide a better user experience, DDE provides the platform's user management mechanism, security mechanism, multi-language and collaborative communication mechanism to help researchers from different countries quickly participate in the platform.

1.2 Audience

This document that provides the DDE Platform scope, business intelligence, and application capabilities to provide the most basic understanding of the DDE Platform is prepared for

every DDE user, including the following three categories:

1) Users who need to create a theme library under the DDE architecture;
2) Users who need to conduct scientific research using DDE resources and products under the DDE architecture;
3) Users who need to perform custom software development under the DDE architecture.

1.3 Overview

This document is aimed at users who use the DDE Platform and series of products. The DDE architecture and related technical content are described in detail, mainly divided into:

1. Preface, which describes an overview of this document, including target, audience, overview, and reference docs;
2. Key concepts of DDE data and platform, introduction of key concepts of DDE data and large platform;
3. Platform overview, DDE Platform introduction, including the proposed background, mission and scope, platform goals and scope;
4. Architecture, expressing DDE using the enterprise architecture analysis method, including DDE business architecture, DDE data architecture, DDE application system architecture, and DDE technical architecture;
5. Security policy, DDE for security related content, mainly from two levels of exposition, data and service security;
6. Open APIs and services, including user authentication, data, knowledge, model, and visualization;
7. User interface, DDE Platform introduction, mainly including four parts, the access to the platform, linking data to the data network, using the model for calculation and analysis, the visualization based on the platform;
8. Use cases, DDE Platform usage cases, are divided into three categories according to the depth of users' use of the platform: using the platform for scientific research exploration and analysis cases, using the platform for specific scenario analysis cases, and using the platform capabilities to build custom scientific research platform cases;
9. Attachment, DDE-related terms used in this document.

The following will be explained one by one.

2. Key Concepts of DDE Data & Platform

2.1 DDE Platform

It is a digital system to realize the target capability of DDE, also known as the DDE Platform system. The system includes but is not limited to the computing power, network, data, software and services that constitute the platform.

1. Data network: a networked system for DDE data acquisition and sharing, also known as the DDE data platform;
2. Knowledge system: a system to generate and share DDE knowledge, also known as the DDE knowledge platform;
3. Model database: a database supporting geoscience model services;
4. Service engine: a system that provides data, knowledge, models and other service capabilities for DDE customers, also known as the DDE service platform, or Deep-time Engine.

2.2 DDE Architecture

It refers to the organizational structure of the DDE Platform system specified from different viewpoints, including the components of the system decomposition, as well as their relevance, interaction mechanism and guiding principles. It mainly includes the business viewpoint, system function viewpoint, data viewpoint and technical implementation viewpoint, and then forms the DDE business architecture, application system architecture, data architecture and technical architecture. At the same time, the specific architecture (such as application system architecture) formed from a certain viewpoint can be further refined into different levels of application system architecture (such as Level 1 (L1) application system architecture, Level 2 (L2) application system architecture, etc.) under this viewpoint according to the different granularity of the system components.

2.3 DDE Business Architecture

The DDE architecture specified from the viewpoint of DDE business, mainly specifies various roles, systems and their relationships (such as scenarios, services, processes, etc.) in the DDE ecosystem. The DDE business architecture is independent of the implementation technology of the DDE Platform system.

2.4 DDE Application Architecture

The DDE architecture specified from the viewpoint of DDE functions, mainly specifies the

functional entities that make up the DDE Platform system and their relationships. The DDE application architecture is independent of the implementation technology of the DDE Platform system.

2.5 DDE Data Architecture

The DDE architecture specified from the viewpoint of DDE data, mainly specifies the data set required for the system operation of the DDE Platform system, including the data model of the databases and interfaces.

2.6 DDE Technical Architecture

The DDE architecture specified from the viewpoint of technology implementation, mainly specifies the software entities that make up the DDE Platform system and their relationships, as well as their deployment methods on IT facilities, and is related to IT implementation technologies (such as cloud computing, communication pipeline, edge computing, terminal, and so on).

2.7 DDE Services

It refers to various geo data services provided by the DDE Platform system to customers through standardized interfaces and processes, including but not limited to geo basic data sharing, geo knowledge search, computing services based on geo models and algorithms, etc.

DDE services are provided by the Deep time Engine, including but not limited to API access, APP access, open database, etc.

2.8 DDE Application Scenarios

Through the combination of the services provided by the DDE engine, the application system oriented to specific task requirements is formed, such as the application of geoscience resource acquisition (Resource Hub), geoscience visualization (Earth Explorer), address mapping (GlobalLayer), geoscience analysis (Analysis), etc. It can be called DDE application for short.

2.9 DDE Customer

It refers to individuals or groups who meet their own application needs by purchasing (not necessarily paying, but free of charge) DDE services or applications.

2.10 DDE User

Individuals or groups using DDE Platform functions, including DDE customers, DDE Platform operation management personnel, etc.

3. Platform Overview

3.1 Scope, Objectives, Applications

3.1.1 Background

Geosciences encompass all areas of natural science related to the Earth, studying its physical, chemical, and biological properties. Studying geosciences allows us to better understand our planet, improve our control over resources, protect people from natural disasters, improve the environment and the quality of human life, and ensure the prosperity of society.

Today, people and the Earth face intricate and interconnected environmental, social, and economic challenges, growing inequalities and unequal opportunities, and widening gaps in science, technology, and innovation. There is an urgent need to accelerate human progress, promote the building of knowledge societies and leverage the burgeoning information and communication technologies to accelerate global interconnection.

After experiencing the empirical paradigm and the system paradigm, in the era of big data, the research scope of geoscience is changing from a single discipline to a multi-disciplinary earth system science, and a new data-driven scientific research paradigm is emerging. This new research paradigm which regards the "data-model-knowledge" as the core and advocates multi-disciplinary collaboration and mutual penetration needs platform as the base for support.

3.1.2 Vision and Mission

Vision: Enabling and Empowering global geoscientists' collaborative innovation and discoveries
Mission: Building a One-Stop Online Research Platform for Geoscientists

3.1.3 Objectives

- Create a one-stop online deep-time geoscience research platform for scientific research resource global circulation compliance with FAIR
- Make small-scale research better and large-scale research faster, support promoting multi-disciplinary intersection research and multi-layer composite research

3.1.4 Applications

- Build an open global data network covering data production, access, analysis, visualization, sharing and archiving;

- Provide an online collaborative platform for interdisciplinary research;
- Create an online workspace to support "data-model-computing" driven research;
- Contribute to paradigm shift in geoscience research through emerging practices in digital scholarship, data, knowledge and computational management, and open science.

3.2 Description of Conceptual Architecture

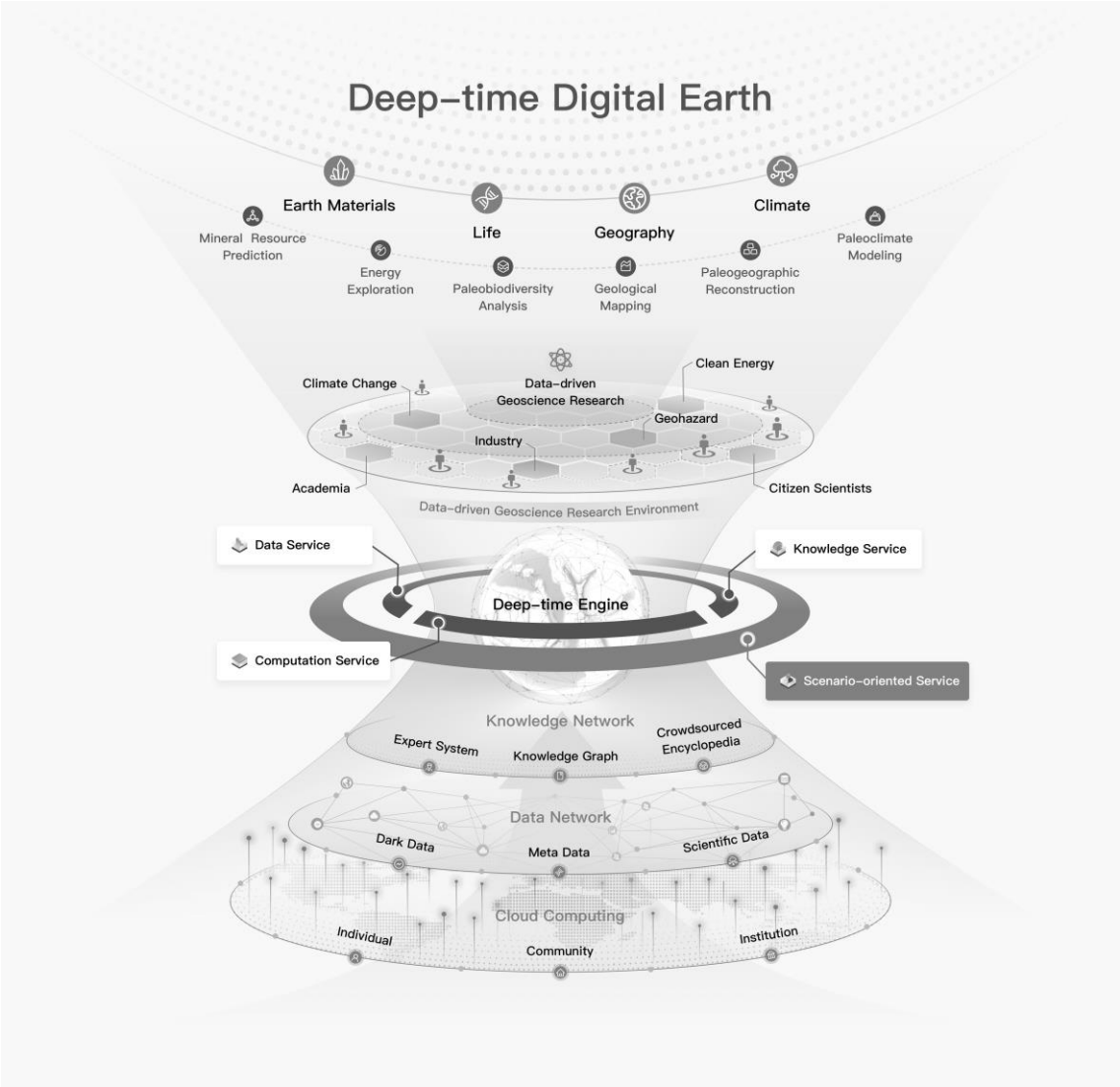


Figure 1 DDE Conceptual Architecture

DDE takes the service capacity building of the four main engines as a grip to form the Deep-time Engine, build a data-driven geological research environment on the cloud and link the global scientists to collaborate online, realize the scientific research exploration support of the evolutionary problems in deep time with a global posture and data-driven research as the core means around the big scientific problems, and take the DDE Platform as a carrier to realize the revolution of geoscience research paradigm.

DDE is conceptually divided into 7 layers:

1. Cloud Computing Layer

The global cloud computing layer composed of individuals, communities, institutions and other computing nodes, as the support of the computing service engine, is used to meet the massive, fast, and efficient computing needs of the processing platform.

2. Data Network Layer

The data layer is built by means of dark data lighting, metadata collection, scientific data acquisition and linking, which provides support for the data service engine and is used to meet the needs of various platform data collection, classification, management, retrieval, etc.

3. Knowledge Network Layer

The knowledge network layer is formed by expert knowledge system, knowledge map construction, crowdsourcing knowledge encyclopedia and other methods to provide support for the knowledge service engine to meet the needs of platform knowledge discovery, modeling, management, application, etc.

4. Deep-time Engine

It is the core of the DDE service platform and consists of four major engines, namely, data service engine, computing service engine, knowledge service engine and scenario service engine, providing users with comprehensive deep time geoscience services.

5. Cloud Service Layer

Based on the DDE service platform, it builds a one-stop on cloud Data-driven Geoscience Research Environment (DDRE) for users, supports the openness and collaboration of global scientists, empowers climate change, clean energy, geological disasters, industry applications and other fields covered by the Sustainable Development Goals (SDGs).

6. Scientific Research and Application Layer

With the support of the DDE Platform, a customized workflow is established for geoscience application scenarios to achieve the convergence of multiple disciplines and support geoscience scenarios such as mineral resource prediction, paleogeographic reconstruction and geological mapping.

7. Evolutionary Research Empowerment Layer

Based on the cloud scientific research infrastructure service capabilities of the DDE Platform, it promotes the development of data-driven earth science paradigm shift, and promotes human exploration of the four major scientific issues of deep-time digital earth: earth material evolution, life evolution, geographical evolution, and climate evolution.

3.3 Deep-time Engine

Taking the service capabilities of four core engines of data, knowledge, calculation and

scenarios as the breakthrough point, DDE builds the Deep-time Engine. Based on the Deep-time Engine, DDE realizes the construction of a global network of scientific research elements, which makes the communication between scientific research elements smooth. At the same time, it supports the construction of an on-cloud data-driven geoscience research environment, links online collaboration of global scientists, and realizes the scientific research exploration of the four evolutions of deep time centering on major scientific issues with data-driven research as the core means. It uses the DDE Platform as a carrier to promote the paradigm revolution of geoscience research.

4. Platform Architecture

4.1 Scope

DDE promotes the transformation of geoscience paradigm for digitalization and the construction of global geoscience ecology through resource sharing and research platform.

Specifically, by integrating global geoscience data and sharing global geoscience knowledge, DDE builds a one-stop online geoscience research platform of "open + co-construction, sharing + collaboration", integrates "data + knowledge + algorithm + computing power", promotes the evolution of data-driven geoscience research paradigm, realizes a geoscience research and exploration platform, and promotes global cooperation among geoscience practitioners through co-construction and sharing.

Therefore, we can understand the overall scope of DDE as four levels: resource sharing, platform co-construction, paradigm evolution, and geoscience ecological construction:

1) Resource sharing: Integrate global geoscience data and share global geoscience knowledge;
2) Platform co-construction: Open + co-construction sharing + collaboration, one-stop online geoscience research platform;
3) Paradigm evolution: Integrate "data + knowledge + algorithm + computing power" to promote data-driven paradigm evolution in geoscience research;
4) Geoscience Ecology: Realize a platform for geoscience research and exploration to jointly build and share and promote global cooperation among geoscience practitioners.

Based on the above goals and scopes, we carry out the top-level design of business architecture, application system architecture, technical architecture and data architecture to realize the technical integration of data model, knowledge model, computing model and software architecture functions, and realize the integration of platform functions and discipline functions.

4.2 Business Structure

4.2.1 Objectives

DDE takes platform construction as its core work, and aims to build a one-stop online geoscience research platform that is "open, co-construction, sharing, and collaboration."

The DDE business architecture is based on a business scope, which describes how to support geologists with data, platforms and discipline knowledge. Therefore, its business capabilities are reflected in seven areas:

1. Resource element management

Realize Internet geoscience data from discovery, access, storage management, shedding light on dark data, and knowledge and algorithm management.

2. Supply of resources and services

It provides geoscience practitioners with data, knowledge, and model methods of geoscience to solve the acquisition needs of data resources, knowledge organization resources, and computational analysis resources in the research process.

3. Capability generation support

It provides a scientific research toolkit for geoscience research, including resource acquisition, geoscience visualization tools, geological mapping tools, geoscience analysis tools, and personal research space toolsets, providing a data science-based work platform for geoscience researchers.

4. Academic research and disciplinary work support

It provides four types of node construction for academic research and 13 discipline work platforms for discipline work, directly supporting various fields of geoscience research.

5. Standard specification

In order to promote the global cooperation of geoscience practitioners, DDE provides basic terminology, software, data, operation and maintenance specifications for the whole process and all fields, so as to promote joint contribution and shared benefits.

6. DDE Platform Ops

DDE has established a platform operation and maintenance team to serve global geoscience researchers in terms of user authorization, resource acquisition, platform use, research analysis, software development, etc., and serve scientists from all over the world through a multilingual mechanism.

7. DDE operation

DDE establishes a platform operation team, which conducts team content operation, we-media operation, community operations for DDE, and provides event planning and compliance for DDE Platform construction on this basis.

4.2.2 Design

Based on the above key points of business capability construction, we divide DDE's business into two parts: core business functions and operation and maintenance support functions. The core business functions are divided into 5 levels, and the operation and maintenance support functions are divided into 3 levels.

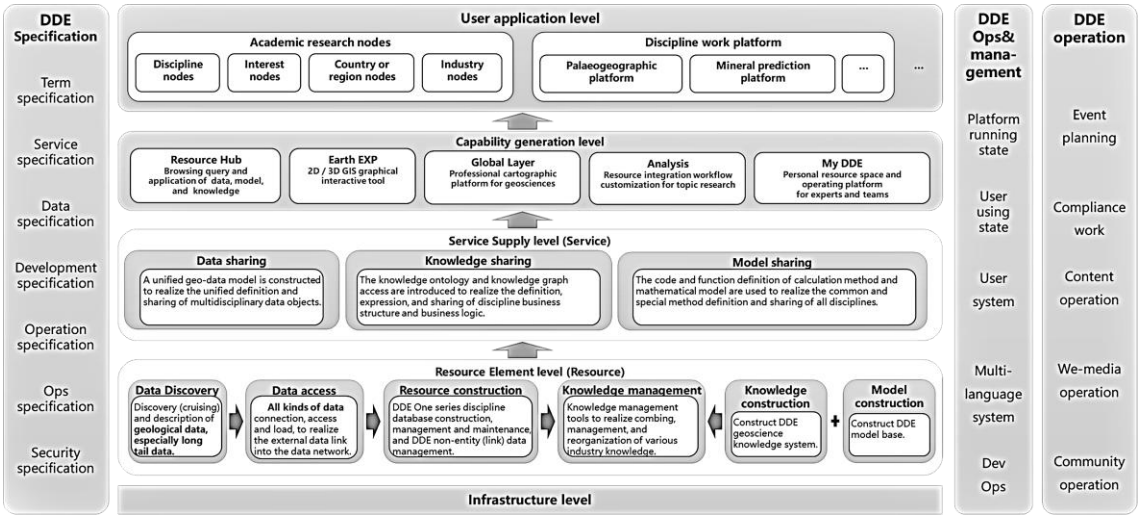


Figure 2 DDE business architecture

The core functionality of DDE is divided into five parts.

1. Infrastructure: Cloud computing infrastructure supply.

DDE adopts a cloud-native architecture to achieve the provision of functions, through the unified cloud infrastructure construction work with partners, to provide software and network environment for DDE operation, and to support the global deployment of DDE.

2. Resource elements: the construction process of resource element layer.

The resources of DDE include data, knowledge and models. They are aimed at the basic data of geoscience, research results and research rules and methods. From the source of various resources to the process of their management, it is the main business task of the resource element layer.

3. Service provisioning: Application-oriented service provisioning.

Provides permission-based APIs in the cloud-native environment, so that geoscience application software can call these resources and share them uniformly.

4. Capability generation: expert-level online research capability generation.

It is aimed at geologists and researchers, and provides capabilities through a platform tool for the process of geoscience research. The platform currently provides five types of instrumental functions, including: resource management, visual analysis, global mapping, geoscience analysis and personal resource management, providing a digital working environment for geoscience researchers.

5. User application: Subject-oriented work environment for discipline experts.

Based on a specific goal or theme, the disciplines and nodes are reasonably organized and divided to form a unique workflow and tool system to provide direct support to the research team and organization.

The DDE Business System also provides a systematic framework consisting of three parts:

1. DDE Specification:

Including language, data, software, operation, maintenance and other related technical specifications and management specifications. Agreed on unified standards in platform and discipline construction.

2. DDE Platform operation and maintenance management:

DDE Platform operation and maintenance has established an operation and maintenance team to serve global geotechnical researchers, and carry out platform operating state awareness, user management, user support, multi-language support system, and DevOps software development on this platform.

3. DDE Platform operation:

DDE relies on the infrastructure provider to establish a platform operation team. This team platform carries out full-cycle management, providing event planning, compliance work, content operation, self-media operation, community operations, etc.

4.2.3 Technology implementation

Taken together, DDE builds an overall business framework based on the above eight business logic parts.

1. Cloud Native Foundation Support Layer

The bottom layer of DDE business architecture is ubiquitous network, heterogeneous integration, flexible and scalable information network, which connects all kinds of geoscience scientific research resources into the network and integrates them into the platform system, classifies and guarantees the direction of various disciplines and the business of interdisciplinary scientific research scenarios, and provides a unified cloud-native basic support for the interconnection of scientific research nodes, the sharing of resources, information circulation and knowledge discovery in the whole process of scientific research.

2. Resource element layer

The resource element layer realizes the mapping from physical space to data space through the standardized modeling and coding of geoscience data, geoscience model, geoscience knowledge and other elements, and forms a discoverable, obtainable, understandable, trustworthy and interoperable DDE scientific research element resource.

3. Service supply layer

The service supply layer builds a DDE resource sharing environment, uniformly accesses various digital resource elements such as data, models, and knowledge related to geoscience scientific research business, supports on-demand and right-based invocation and optimal allocation, provides data resources, knowledge resources, model resource services, and common functional services such as service support, collaborative services, computing services, visualization services, data support, and integration frameworks provided by the

platform.

4. Capability generation layer

According to the needs of DDE geoscience scientific research, according to typical scientific research application scenarios, call the data resource services, knowledge resource services, model resource services, common function services provided by the service supply layer, as well as the core capabilities of various platforms, and form the ability to support interdisciplinary research under the unified scientific research infrastructure environment.

5. User Application Layer

To the global actual users of DDE, through the formation of global collaborative scientific research capabilities of DDE business architecture, support the construction of various discipline website systems, and finally geoscientists through the assistance of various application system platforms, cooperate in research in a completely digital global unified scientific research infrastructure environment, form a scientific research community in the field of geoscience, and support the research on major scientific issues of DDE.

4.3 Data Architecture

4.3.1 Goal

Linking, lighting, and brightening the data of deep-time geoscience within a unified spatio-temporal framework.

To achieve this goal, some important tools, platforms, and systems must be included in the data architecture. As follows:

1. Data discovery tool: discover data sources and help users find large amounts of long-tail data.

2. Data network management platform: build data nodes and link other data nodes on the internet to form a network.

3. Data service system: provide unified data services.

4.3.2 Design

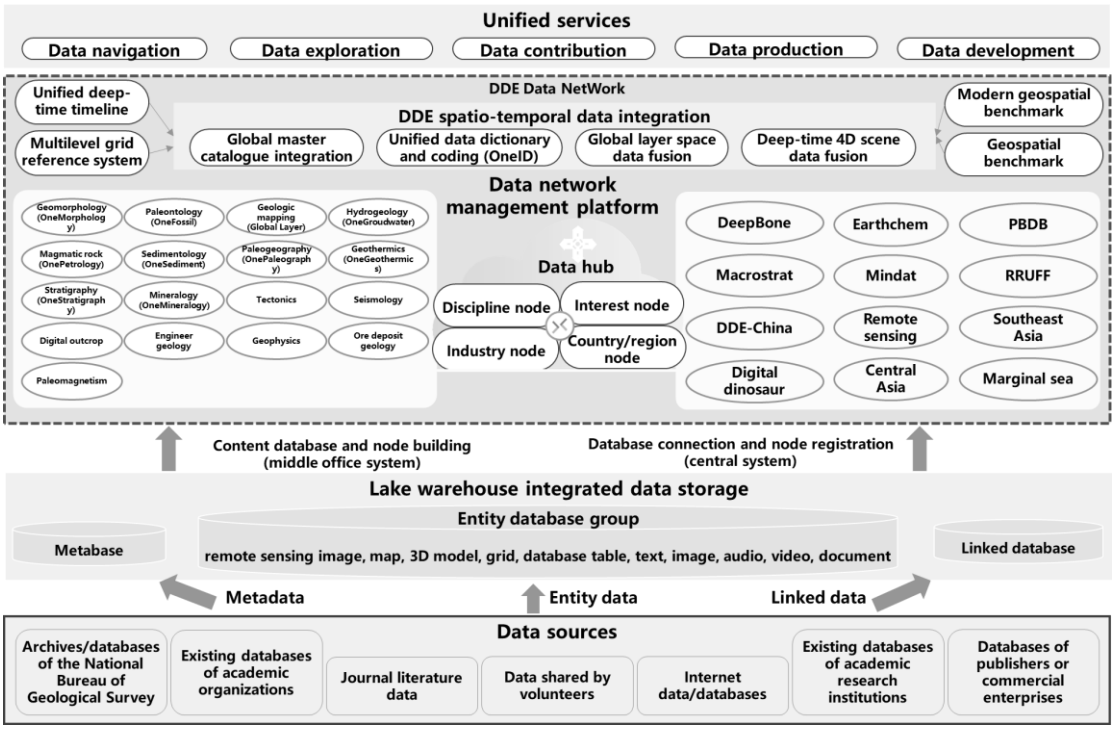


Figure 3 DDE data architecture

1. Data source

7 main data sources: archives/databases of the National Bureau of Geological Survey, existing databases of academic organizations, existing databases of academic research institutions, databases of publishers or commercial enterprises, journal literature data, internet data/databases, and data shared by volunteers.

2. Lake warehouse integrated data storage

The integrated technology of the data lake and warehouse forms the support for the underlying storage of the DDE data network, which includes the meta-database, entity database group, and linked database (the storage and management authority of this kind of data remains with the data owner, and DDE only connects them through linking) constructed from various data sources.

3. DDE data network

DDE data network is one of the many efforts to practice the principle of openness and sharing. Instead of storing all data together, DDE connects all data nodes around the world into a data network through linkage and interoperability protocols and technologies. DDE integrates network data logically under a unified spatio-temporal framework.

4. Unified data service

The unified data service mainly includes data navigation, data exploration, data contribution, data production, and data development. By unifying data services, the DDE Platform and

data nodes around the world can equally obtain services from the network.

4.3.3 Technology implementation

4.3.3.1 Data Model

1. Data types

From the perspective of data format: remote sensing image, map, 3D model, grid, database table, text, image, audio, video, and document.

From the perspective of geology: field survey, mineral exploration, geophysical exploration, geochemical exploration, remote sensing geology, hydrogeological survey, engineering geological survey, environmental geology survey, marine geological survey, etc.

2. Data system

The data system is constructed based on the discipline catalogue.

Table 1 Discipline catalogue system

First level discipline	Second level discipline	Third level discipline
Geology	Paleontology	Paleoecology
		Taphonomy
		Evolutionary paleontology
		Molecular Paleontology
		Paleoanthropology
		Ichnology
		Invertebrate Paleontology
		Geobiology
		Paleobotany
		Vertebrate paleontology
		Micropaleontology
		Palynology
	Stratigraphy	Magnetostratigraphy
		Cyclostratigraphy
		Chronostratigraphy
		Sequence stratigraphy
		Lithotratigraphy
		Biostratigraphy
		Event stratigraphy
		Geologic timescale

First level discipline	Second level discipline	Third level discipline
		Chemostratigraphy
	Sedimentology	Sedimentary rocks
		Sedimentary physical properties
		Sedimentary geochemistry
		Sedimentary process
	Paleogeography	Lithofacies Paleogeography
		Climate Paleogeography
		Tectono-paleogeography
		Paleobiogeography
	Mineralogy	Mineral Properties and its Applications
		Crystallography
		Mineral genesis and Its Occurrence
		Classification and Description
		Chemistry Composition and Crystal Structure
	Igneous petrology	Composition and classification
		Geochemical properties
		Physical properties
		Magmatism and origin
	Metamorphic Petrology	Metamorphic fabrics
		Dynamic Metamorphism
		Impact metamorphism
		Contact Metamorphism
		Metasomatism
		Regional metamorphism
		Ocean-Floor metamorphism
		Burial Metamorphism
		Migmatism
		Metamorphic history
	Economical Geology	Characteristics of ore deposits
		Deposit type
		Ore genesis
		Metallogeny
	Structure Geology	Historical Structure
		Active Structure/Neo-Structure

First level discipline	Second level discipline	Third level discipline
	Tectonics	Plate Tectonics
		Deep Earth Tectonics
		Geodynamics
		Thermochronology
	Geochronology	Radioisotopic dating
		Non-radioisotopic dating
	Mathematical Geosciences	Data Visualization
		Analysis
		Modelling
		Computation
	Geochemistry	Surficial Geochemistry
	Geological Mapping	Geological Survey
		Geological Mapping
		Digital Geological Mapping
Geophysics	Geomagnetism and Paleomagnetism	Paleomagnetic Direction Data
		Paleointensity
		Rock Magnetic Data
		Secular Variation Data
		Magnetic Field Data on Planets and Meteorites
		Oeanic Magnetic Anomaly Data
		Continental Magnetic Anomaly Data
		Biogeomagnetism
		Magnetic Reversal Data
	Geophysic	Magnetic exploration
		Gravity&Gravity exploration
		Geoelectricity&Electrical exploration
		Seismology & Seismic Exploration
		Rock physics
		Integrated geophysics
		Nuclear geophysics
		Geophysical logging
Geography	Geomorphology	Special Geomorphology
		Dynamical Geomorphology
		Regional Geomorphology

First level discipline	Second level discipline	Third level discipline
		Applied Geomorphology
		Experimental Geomorphology
		Geomorphological Mapping
Geological Resources and Geological Engineering	Petroleum geology	Oil and gas resources assessment
		Geological elements
		Petroleum accumulation
	Drilling and Well Logging	Instruments for drilling and well logging
		Coring and core analysis
		Logging data processing and interpretation
	Hydrogeology	Storage of groundwater
		Groundwater flow
		Groundwater quality.
		Geological processes of groundwater
		Groundwater dependent ecosystems
	Geothermics	Theoretical geothermics
		Applied geothermics
	Engineer Geology	Regional Engineering Geology
		Soil Mass Engineering Geology
		Rock Mass Engineering Geology
		Applied Engineering Geology
		Geological Hazards
		Intelligent Engineering Geology
Oceanography	Marine Geology	Submarine Geomorphology
		Marine sedimentation
		Marine sediment dynamics
		Paleoceanography and paleoclimatology
		Marine geochronology
		Marine petrology and geochemistry
		Seafloor tectonics and geodynamics
		Subseafloor biosphere
Atmospheric Science	Meteorology, atmospheric physics and chemistry, climatology	Paleoclimatology
Remote sensing science and technology	Remote Sensing Infrastucture	Sensor and platform
		electromagnetics for remote sensing
		Remote sensing digital image processing

First level discipline	Second level discipline	Third level discipline
	Applied Remote Sensing	Environmental remote sensing
		Resource remote sensing
		agricultural remote sensing
		Planetary remote sensing
	Photogrammetry	
Planetary Geology		

4.3.3.2 Data source

The data sources can be classified as follows according to the processing mode:

- To be the alliance data node of DDE through linking.
  1) Archives/databases of the National Bureau of Geological Survey
  2) Existing databases of academic organizations and research institutions
  3) Databases of publishers or commercial enterprises
- Long tail data discovered and mined by technical means.
  1) Journal literature data
  2) Internet data/databases
- Data contributed by volunteers motivated by technical means and operational strategies.
  1) Data shared by volunteers

4.3.3.3 Data Governance

Data governance covers both entity and linked data. The former provides users with support for database and data node construction, involving data collection, access, cleaning, management, etc. While the latter provides data link services for institutions or individuals intending to share data, making their databases a node of the DDE data network. It involves link data registration, conversion, etc., as well as supports the direct connection and API access of databases.

4.3.3.4 Data Network

A data network is an organic whole formed by linking data nodes together through the central system according to standard protocols. It can link data and guarantee data services upward.

4.3.3.5 Data Service

Data service mainly includes data navigation, data exploration, data contribution, data production, and data development.

4.4 Application Architecture

4.4.1 Objectives

DDE application architecture is derived from the functional realization of business architecture. It clarifies a series of software functions such as platform architecture, functional modules, API interfaces provided by DDE.

These software modules or APIs can meet the full process research work of nodes or subject experts, and at the same time support the daily maintenance of the platform by the operation team.

4.4.2 Design

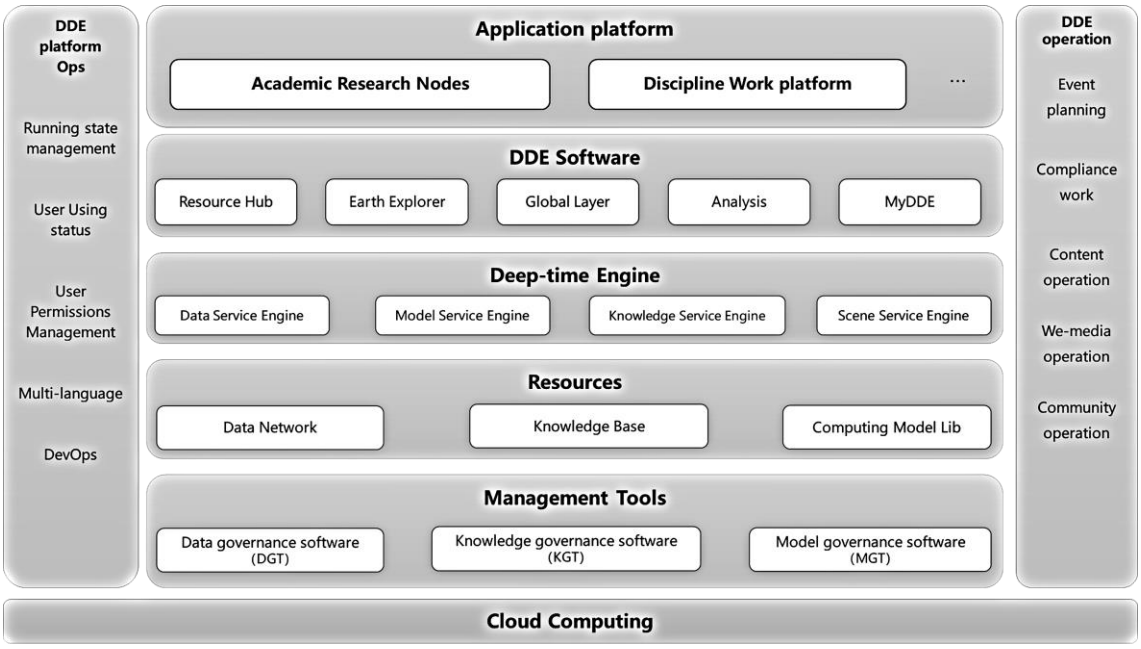


Figure 4 DDE application architecture

1. Cloud Native Information Infrastructure

Cloud computing infrastructure building is part of the DDE Cloud construction, based on open cloud infrastructure, providing 7x24 hours of online cloud computing services for DDE community experts, unified cloud computing technology framework and services for the DDE Platform.

2. "Data-knowledge-model" collation support software

Realize the collection, creation, development and management of resources such as data, knowledge and models.

3. Resource Element Library

It realizes the collection, creation, storage and management of resource elements, and conducts systematic, modeled and standardized management of various resources.

4. Deep-time Engine

Deep-time Engine is a service-oriented API customization for DDE resource sharing, which realizes the unified external sharing interface of various resources.

5. DDE Software Tools

Provide specific scientific research tools for geoscience researchers, and form a working platform with visualization, flow and modeling.

4.4.3 Data Governance

4.4.3.1 Data Governance Software

Data governance software is a comprehensive data access tool integrating geoscience data storage and management. It is mainly for users who want to build databases with the help of DDE's ability.

4.4.3.2 Data Network

Data network includes data nodes, standard protocol and central system.

1. Data node

Data nodes are data sources distributed across the internet environment, providing data that follow FAIR principles (findable, accessible, interoperable, and reusable). According to the construction mode, it can be divided into self-built and non-self-built data nodes.

2. Standard protocol

A standard protocol is a set of rules, standards, or conventions established for the access, transmission, and operation of data in a data network.

3. Central system

The central system is a software that links various data nodes and provides unified data services across nodes based on standard protocols. It realizes address allocation, addressing, routing, etc.

4.4.3.3 Data Engine

1. Elasticsearch

Elasticsearch is the data core engine of Elastic Stack, which undertakes the core functions of storage, query, aggregation, machine learning, etc., and provides nearly real-time search and analysis for all types of data.

2. API Management

The platform provides services of API registration, API modification, and registered API deletion.

4.4.4 Knowledge Governance

4.4.4.1 Knowledge Governance Software

The knowledge management tools consist of the Editor for KGs construction in a “top-down” way using professional experiences, the GAKG HITL for KGs construction in a “bottom-up” way with various academic papers, the GKMS for KGs automatic supplementation, and the GeoOpenKG for KGs share and management.

1. Editor

The Editor is short for Geoscience Knowledge Graph Collaborative Editor, which is a knowledge tool for collecting, editing, and organizing ontologies and instances.

2. HITL

The GAKG human-in-the-loop (HITL) labeling tool offers the annotation service for geology scientists and researchers to label the new entities and relations extracted from the geology discipline literatures.

3. GKMS

Geoscience Knowledge Management System (GKMS) is designed to help all earth science workers to manage and leverage this knowledge. The GKMS is an all-in-one platform for managing geoscience knowledge.

4. GeoOpenKG

GeoOpenKG is a one-stop system for opening and sharing geoscience knowledge graphs. Its goal is to open and share the knowledge accumulated in the DDE program with ordinary users, industrial applications, and scientific researchers in the geosciences field in a simple and orderly way.

4.4.4.2 Knowledge Base

DDE Geoscience knowledge base contains 3 typical core databases: GPKG for collaborating knowledge graphs with professional experts, GAKG for constructing knowledge graphs from vast academic papers, and BO4KG for utilizing basic Geoscience ontologies in different disciplines.

1. GPKG

Geoscience Professional Knowledge Graphs (GPKGs) are co-create high-quality Geoscience knowledge graphs by geo-scientists around the world, which are constructed by a professional platform called Geoscience Knowledge Graph Collaborative Editor. The platform provides a variety of features, such as collaborative creation, editing, and verification of geoscience concepts or instances and their properties, relationships, and rules.By using the global professional platform, 56,319 nodes and 58,729 relationships are built currently.

2. GAKG

Geoscience Academic Knowledge Graph (GAKG), as a multimodal academic knowledge graph of geoscience, is a collection of multi-dimensional graph-text-numerical data in academic papers on geosciences. It takes the paper as the core entity and combines bibliometric information, and at the same time, the knowledge entity and the article are matched based on text mining methods. The current GAKG data contains 150 million triples and more than 2 million entities, including 11 different classes of entity, 19 inter-entity relationships (19 object properties), and 39 data properties.

3. BO4KG

Basic Ontology for Geoscience Knowledge Graph (BO4KG) is to provide basic, essential, and manual ontologies for all disciplines in the Geoscience field, thereby making their basic concepts and attributes consistent in semantic. BO4KG, currently, consists of time, space, morphology, and provenance ontologies, which cover over 6 million RDFs triples.

4.4.4.3 Knowledge Engine

The knowledge engine is a collection of reusable functions and contents API services that are abstracted and encapsulated during the construction of DDE knowledge platforms and software. Based on these services, more complex and flexible applications in the field of geoscience can be built through secondary development. At present, the knowledge engine includes a knowledge navigation service, a knowledge retrieval service, and a knowledge online reference service.

1. Knowledge navigation service

It presents all knowledge graphs and their profile information currently contained in the DDE in a hierarchical structure. With more related services, users can further navigate to the concepts, relationships, attributes, instances, and other contents contained in each

knowledge graph. The detailed information about these contents can also be further browsed by users. Therefore, users can navigate all contents of the knowledge graphs based on this service.

2. Knowledge retrieval service

It supports users to retrieve the knowledge they are interested in by entering keywords or SPARQL query statements as search criteria. The knowledge comes from multiple sources, including BO4GK (Basic Ontology for Geoscience Knowledge Graph), GPKG (Geoscience Professional Knowledge Graphs), and GAKG (Geoscience Academic Knowledge Graph). Based on the search results, users can further view the detailed information about each result item and perform operations such as collection and download.

3. Knowledge online reference service

Based on the service, users can obtain the specific content of knowledge by specifying its URI (Uniform Resource Identifier) which is the globally unique name of the knowledge. These contents can be organized in a format of rdf, ttl, etc. according to the service parameters and then as the return results of the service for further online use by users, so as to achieve online reference of knowledge and simplify the use process of knowledge content in DDE geoscience knowledge graphs.

4.4.5 Model Governance

4.4.5.1 Model Governance Software

1) Model registration: The platform provides model registration services. The platform authorizes users to complete model registration into DDE Platform by filling in and submitting model information, that is, model name, model source, model parameters and model dependency images and other model information.
2) Model deletion: The platform provides the deletion service for the user's registered models. Users can delete self-built models previously.
3) Model update: The platform provides model modification services. The platform authorizes users to modify the model information previously registered by the user, that is, model name, model source, model parameters, model dependency image and other model information, which can complete the modification and update of the model in the platform.
4) Model search and view: The platform provides model search services. Users can quickly retrieve relevant models by keywords or discipline categories to achieve rapid model positioning. Users can view and browse model information by clicking on the model.

4.4.5.2 Model Base

In the process of platform construction, the model base mainly involves the following components:

1) Docker: It is virtualization technology. Using Docker, an open-source application container engine, each model and its corresponding dependencies can run into a portable container.

2) Image registry: a collection of images corresponding to open source products can be Harbor. By storing the packaged model images in the image registry, the model can be stored, managed, and pulled.

4.4.5.3 Computing Engine

The platform model service engine is based on container orchestration technology (Kubernetes) and extends and develops many services such as model invocation service, model workflow calculation, and model search service.

1) Model invocation service: Based on the mirror warehouse, various models support the scheduling of upper-layer services.

2) Airflow calculation: Based on Airflow, we schedule, calculate, and monitor each model according to the directed acyclic graph (DAG) mode and realize the automatic model workflow calculation.

3) Model search service: The platform provides the model search service. Users can quickly retrieve relevant models by keywords or discipline categories to achieve fast positioning of models.

4.5 Technical Architecture

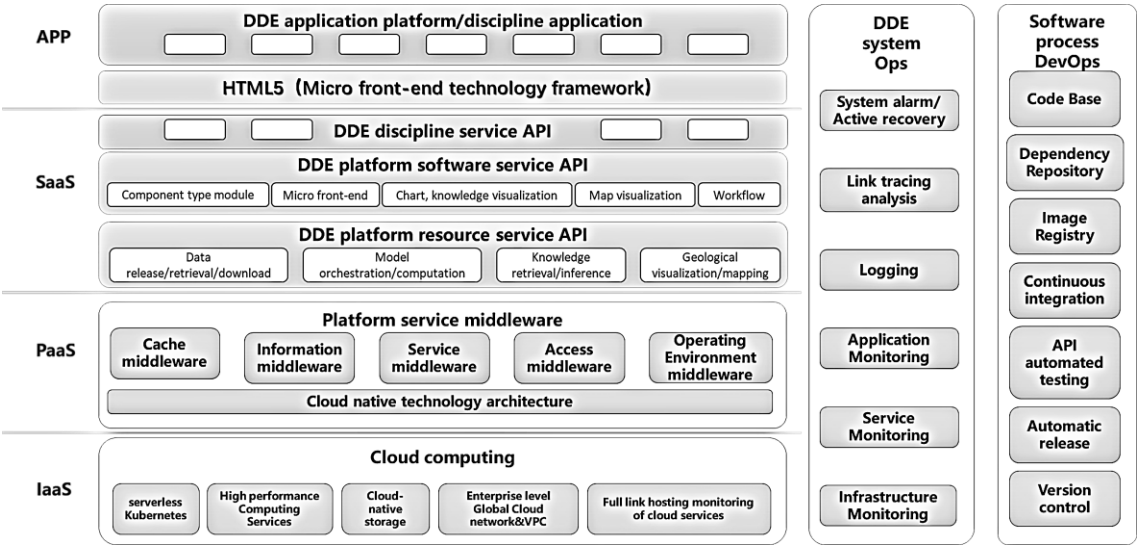


Figure 5 DDE Technical Architecture

The platform is divided into four layers vertically: the infrastructure layer (IaaS), platform service layer (PaaS), software service layer (SaaS), and the top application layer (APP). Horizontally, based on extensive platform functional services, supplemented by DDE system operation and maintenance and software processes, to strengthen the stability of large platforms and the agility of development.

4.5.1 Infrastructure

The infrastructure layer is the operation foundation of the platform. The platform builds the computing, network, and storage resources that are native to the cloud based on the cloud vendor services. It provides high-performance computing, storage, network, and other cloud infrastructure support for the functional operation and capability building of the platform, software, and application layers.

On the computing side, the platform uses container orchestration services and high-performance computing services. With the help of Kubernetes, the platform can manage Docker containers in a more advanced and flexible way. According to the wishes of users and the rules of the whole system, the platform can handle all kinds of relationships between containers automatically. At the same time, the platform also adopts the Spark parallel computing service with complete characteristics according to Kubernetes.

In terms of storage, the platform adopts cloud-native storage to store persistent data of upper-layer services. The primary storage used is object storage and file storage.

In terms of network, the platform uses enterprise-level global cloud networks and VPC to achieve a flexible, reliable, and large-scale cloud network at the global level.

4.5.2 Platform Service

Based on cloud-native technology architecture and infrastructure, platform service provides platform service middleware to the software service layer upwards and complete functions, including caching, resource storage, message communication, service management, authority control, and operating environment configuration.

Resource storage is mainly for three types of resources: data, models, and knowledge.

The platform guarantees the mutual invocation of platform microservices through message communication middleware.

Ensure the registration and release of services through service management.

Complete the hierarchical cutting of data and functions through permission control.

4.5.3 Software Service

Software service can improve their professional and business logic by calling platform services and providing them to the application layer in the form of APIs. Based on the application architecture of DDE, software services can be divided into DDE Platform resource service API, DDE Platform software service API, and DDE subject service API.

4.5.3.1 DDE Platform Resource Service API

DDE resource service consists of four primary services: data, model, knowledge, and geological visualization mapping.

1. Data Service

The DDE Platform resource service API provides data publishing, retrieval, and download services.

2. Model Service

Model Service facilitates users' use of platform tools and helps users use platform data to realize real-time online calculation, modeling, scene application, and other functions.

3. Knowledge Service

In order to facilitate users to obtain knowledge information in a specific aspect, the platform provides knowledge analysis and import, knowledge retrieval, and knowledge reasoning.

4. Geological Visualization and Mapping

According to the geological data category, it can help users to complete the visualization of geological data, and provide high-quality mapping services.

4.5.3.2 DDE Platform Software Service API

DDE Platform Software Service API is committed to creating a unified and agile frontend visualization software service, which provides component model, micro frontend, graph, knowledge visualization, and map visualization in the form of API.

1. Component-based module

Modularity refers to isolating a set of functions that can be run independently and managed independently. The advantages of component modules are high development and debugging efficiency, strong maintainability, avoidance of blocking, and more accessible version management.

2. Micro frontend

Micro frontend draws on the architectural concept of microservices, splitting a huge frontend application into multiple independent and small flexible applications; each application can be independently developed, run independently, deployed independently, and then combined these small applications into a complete application.

3. Map Visualization

Map visualization is the most critical form of spatial information visualization. Graphics and text are commonly used on computers to represent spatial information. The emergence and development of multimedia technology have brought spatial information visualization into a new era.

4. Diagrams, knowledge visualization

Graphs and knowledge visualization to visualize data and knowledge in the form of charts and graphs. It can more intuitively support the presentation of the results of the DDE Platform, which helps users to analyze, research, and further research the results obtained.

4.5.3.3 DDE Discipline Service API

According to the characteristics of the discipline, build professional service APIs, such as paleogeography reconstruction service API, paleo-latitude calculator API, and mineral resource prediction service API.

4.5.4 Application Layer

According to the business process, three categories of services in the software service layer are invoked, and various DDE application platforms and discipline applications are built through the front-end technical framework.

4.5.5 DevOps Technology

Implement agile development with DevOps and form a systematic engineering CI/CD based on the codebase, dependency repository, image registry, API automated testing and automated publishing. This helps the DDE family of products to iterate quickly while significantly increasing the fault tolerance of new feature development.

4.5.6 Security and Operation Technology

Based on the characteristics of the overall product cloud biochemistry, the health status monitoring and security guarantee of all links are realized through link tracking analysis, log service, and monitoring at all levels, and the full-link analysis capability is provided for the operation.

4.5.7 Deployment Architecture for Reference

The technical architecture of the DDE Platform is designed to work with a variety of cloud infrastructures. Here is a list of four recommended deployment solutions for Deep-time.org on the cloud.

1. The Open-Source Software based Deployment Architecture

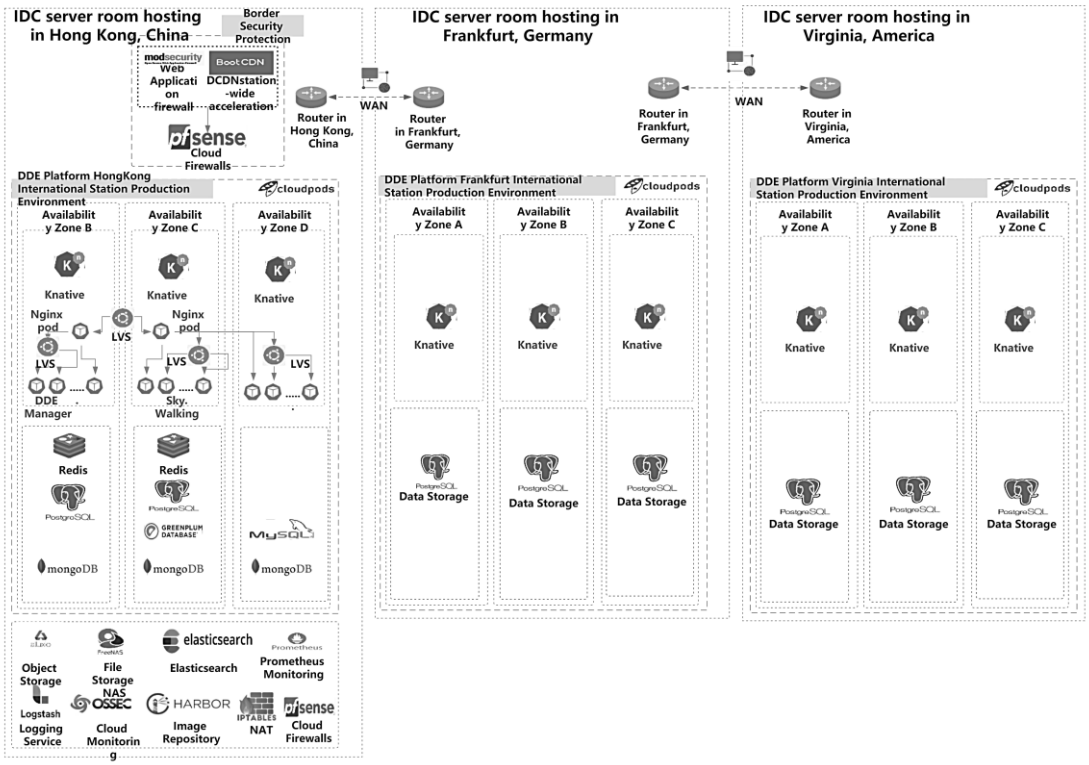


Figure 6 Basic architecture of DDE globally multi-regional deployment (Open Source)

Table 2 Products of DDE globally multi-regional deployment (Open Source)

Product Name of Open Source	Product Version of Open Source
PostgreSQL	12
Apache MySQL	8
Greenplum	6.21.3
Redis	5.0.0
Mongodb	4.2
Alluxio	1.4.0
FreeNAS	12
Knative	1
Logstash	8.4.3
Prometheus	2.39.1
Harbor	2
LVS	1.4.21
No Global Elastic IP	
Linux iptables	1.1.19
FreeSSL	/
Hurricane Electric Free DNS	/
PfSense	2.5.2
OSSEC	3.7.0
No Open Source Global Traffic Management	
ModSecurity	2
BootCDN	/
No Open Source Global Acceleration Products	
Gatekeeper	/

2. The Amazon Web Services (AWS) based Deployment Architecture

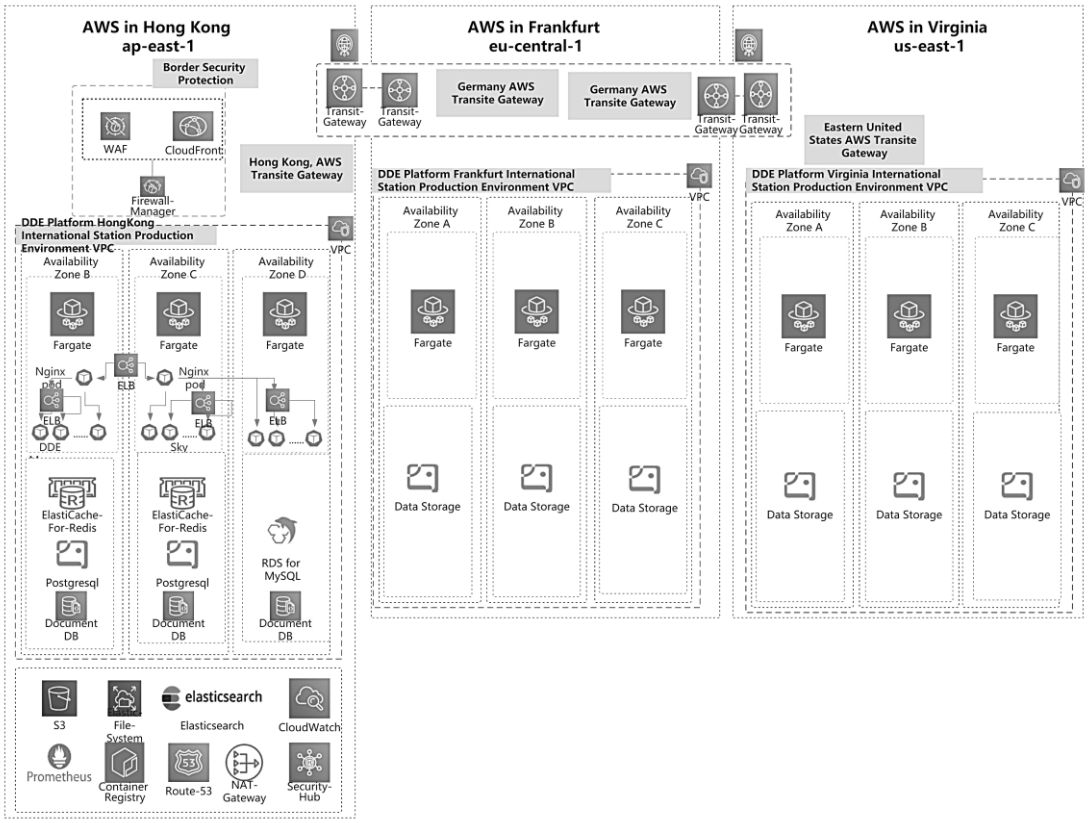


Figure 7 Basic architecture of DDE globally multi-regional deployment (AWS)

Table 3 Products of DDE globally multi-regional deployment (AWS)

Product Name of AWS	Product Version of AWS	Remarks
RDS For PG	12	
RDS For MySQL	8	
Redshift	1.0(based on greenpulm 5.0)	Alibaba Cloud AnalyticDB for PostgreSQL Latest Version 6.0 based on PostgreSQL 9.4， Redshift based on PostgreSQL 8.2
ElastiCache	5	
No Corresponding Cloud Database Mongodb Product		Amazon DocumentDB 4.0.0（MongoDB）,compatibility rate 95%.Instructions are different; codes need being modified; Recommended to self-build Mongodb 4.2 database on AWS
S3	/	
Elastic File System (EFS)	/	
AWS Fargate	1.4.0	
Cloudwatch	/	
Amazon Managed Service for Prometheus	/	
Elastic Container Registry(ECR)	/	
Elastic Load Balancing(ELB)	/	
EIP	/	
NAT GATEWAY	/	
AWS Certificate Manager(ACM)	/	
Amazon Route 53	/	
AWS Network Firewall	/	
AWS Security Hub	/	
Amazon Route 53	/	
AWS WAF	/	
Amazon Cloud Front	/	
AWS Global Accelerator	/	
AWS Shield - Advanced	/	

3. The Azure based Deployment Architecture

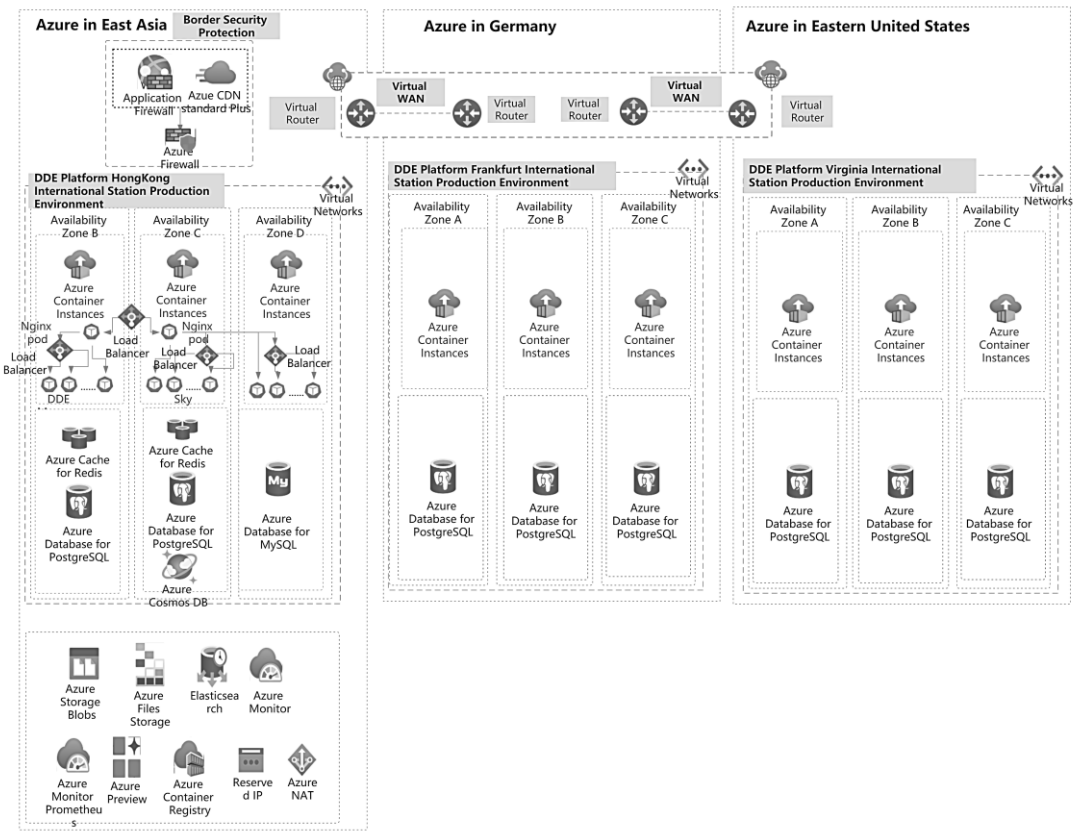


Figure 8 Basic architecture of DDE globally multi-regional deployment (Azure)

Table 4 Products of DDE globally multi-regional deployment (Azure)

Product Name of Azure	Product Version of Azure	Remarks
Azure Database for PostgreSQL	12	
Azure Database for MySQL	8	
No corresponding product for PostgreSQL, but Azure has the enterprise analysis service product of Azure Synapse		Azure Synapse for SQL Server, Cosmos and Azure SQL DB
Azure Cache for Redis	4 or latest 6	
Azure Cosmos DB	4.2	
Azure Storage Blobs	/	
Azure Files Storage	/	
Azure Container Instances	/	
Azure Monitor	/	
Azure Monitor Prometheus	/	
Azure Container Registry	/	
Load Balancer	/	
Reserved IP	/	
Azure Virtual Net	/	
Azure App Service and SSL Certificate	/	
Azure DNS(International) and Azure Traffic Manager	/	
Azure Firewall	/	
Security Center	/	
Taffice Manager Profile	/	
Web Application Firewall	/	
Azue CDN Standard Plus	/	
No global acceleration products		
Azure DDoS Protection	/	

4. The Apsara based Deployment Architecture

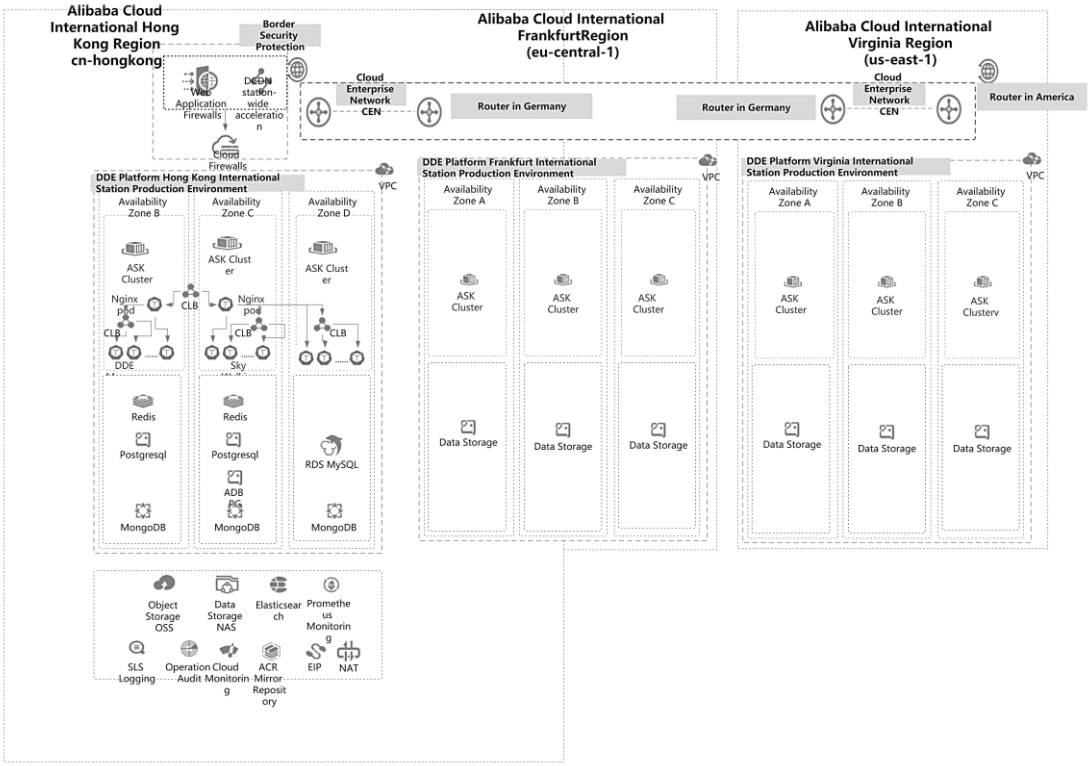


Figure 9 Basic architecture of DDE globally multi-regional deployment (Apsara)

Table 5 Products of DDE globally multi-regional deployment (Apsara)

Product Name of Apsara	Product Version of Apsara
RDS For PG	12
RDS For MySQL	8
AnalyticDB For PostgreSQL	6.0(v6.3.9.1)
Redis	5
Cloud Database Mongodb	4.2
OSS	/
NAS	/
ASK Container Service	1.22.10
SLS	Matched with ASK
Prometheus	Matched with ASK
ACR Container Image Service	/
SLB	/
EIP	/
NAT	/
SSL	/
DNS	/
Cloud Firewall	Enterprise Edition
Cloud Security Center	Enterprise Edition
Global Traffic Management	Ultimate Edition
WAF	/
DCDN	/
GA	Medium II
DDOS Advanced Defense (International)	Insurance Protection

Currently, there are two service regions deployed globally based on Apsara: Hong Kong in China, Frankfurt in Germany. With the globally evolvement of DDE projects, the number of service regions will be further increased, the global service capacity will be improved, and the deployment mode will be flexibly selected according to user requirements as well.

5. Security Policy

5.1 Security Concepts

The information security of the DDE Platform is maintained by multiple roles using multiple strategies. The following first introduces five related roles and explains their roles in information security maintenance.

5.1.1 Platform operator

Platform operators correspond directly to the owner of the system and the entity ultimately responsible for it. In a data ecosystem, there are many actors with the people responsible for collecting, selling, processing, and transforming data. Any of these organizations may operate one or more instances of the platform.

5.1.2 Platform Developer

This role is critical to the security and permission granting of data in the system. Platform functions must be expressive enough to meet the security needs of platform developers. The platform must provide platform developers with control over platform data. If the platform developer has used the platform correctly, his behavior must be safe and predictable.

5.1.3 Infrastructure Provider

Infrastructure providers provide physical security for systems and data. They are also responsible for security maintenance while providing basic security services. This role is generally responsible for network connectivity including edge platforms and platform operator facilities. In a cloud environment, they are jointly responsible for the overall security of data with the platform operator.

Platform operators negotiate data security protocols with cloud providers based on the confidentiality, integrity and availability of their services. Depending on the platform operator chosen in the offering, various security responsibilities fall on different infrastructure providers or platform operators.

5.1.4 Application Provider

Application developers build applications that run on top of a data platform and use its features. These applications determine the actions they allow, the permissions they require, and the applications and logging they provide. For example, an application that allows all authenticated users to perform all application actions may be inappropriate in some contexts (e.g., generating a map from data), while in others it may be perfectly reasonable (e.g., searching for matching data). Application developers choose their safety classifier based on different scenarios, and how the functionality of the application is managed in that model.

In addition, platform operators can build their own applications to manage data. In this case, they will play the role of application developers.

5.1.5 Service Providers

Service providers enable platform operators to operate underlying technologies (such as storage) or services. A platform operator may correspond to multiple platform service providers.

5.2 Service Security

Service providers enable platform operators to operate underlying technologies (such as storage) or services. A platform operator may correspond to multiple platform service providers.

5.2.1 API access authentication

5.2.1.1 API Access Credentials Overview

When using services such as platform data and computing resources, users need to perform user authentication through access credentials (rzpj) after login, and only after successful user authentication can they enjoy the corresponding operation rights within the scope allowed by the platform.

5.2.1.2 Get user login credentials

The user identity access credential rzpj requires the user to log in to obtain it. The basic steps for obtaining it are:

1) Register platform users and improve relevant information;
2) Get the user's rzpj through the user login interface.

5.2.2 Organization Isolation

The platform ensures logical isolation between organizations. In order to follow the principle of independence over avoidance of duplication, the platform utilizes the local functions of each user environment as much as possible to avoid introducing loopholes. As designed, sharing data between organizations is more difficult than sharing data within organizations.

5.2.3 Platform development strategy

5.2.3.1 Security Awareness and Training

All people involved in the development lifecycle should understand the concept of security and their roles and responsibilities related to secure code development.

5.2.3.2 Security Code Review

A security code review is a specialized task that includes manual or automated reviews of an application's source code to help developers understand problems. This task involves authentication, authorization, session management, error handling, auditing and logging, encryption, the principle of least privilege, and key management. Code reviews are performed by the submitter before submission to the master branch.

5.2.3.3 Security testing

A security code review is a specialized task that includes manual or automated reviews of an application's source code to help developers understand problems. This task involves authentication, authorization, session management, error handling, auditing and logging, encryption, the principle of least privilege, and secret management. Code reviews are performed by the submitter before submission to the master branch.

5.2.3.4 Secret Management

Secrets are connected to data storage resources during development. For database secrets, Cloud as a Service secrets, and object storage secrets, the platform uses cloud vendor secret management services to manage the secrets throughout their lifecycle, generating, disabling, enabling, delaying, or automatically rotating secrets according to the actual situation. The secrets are generated by a random number generation algorithm based on a secure, high system entropy seed in the cipher machine, which protects the secrets from being copied by attackers. The secret is protected by a hardware security mechanism. The plain text of the secret is only used for cryptography operations inside the cipher machine and will not leave the security boundary of the cipher machine hardware. The secret is written to disk in full

log, and the usage can be tracked at any time.

6. Platform Services Interface

6.1 Authentication and Authorization

The DDE Platform and series products adopt a unified user management method, which requires user information verification and permission acquisition through the API interface. The specific API contents are as follows:

DDE Software Development Specification.

6.2 Data Services

6.2.1 Data services

DDE realizes unified definition and interdisciplinary sharing of data objects by building a unified geoscience data service model. The platform provides users with the functions of browsing, accessing, searching and using data nodes in the data network through DataHub. These functions can be directly called through API interface. The specific API contents are as follows:

DDE Software Development Specification.

6.2.2 Data Sharing Services

DDE data service includes five main parts: data navigation, data exploration, data contribution, data production and data development.

6.3 Knowledge Services

DDE realizes the interoperability of knowledge-related functions and contents through knowledge APIs. Based on these APIs, users can build more complex and flexible related applications. The knowledge APIs can be divided into knowledge directory navigation service, knowledge retrieval service, and knowledge online reference services according to functions. The specific API contents are as follows:

DDE Software Development Specification.

6.4 Model Services

DDE provides three types of models: geoscience analysis model, big data calculation model, and machine learning model. DDE also provides two forms of workflow organization and online JupyterLab coding to assemble and use the model. These capabilities can be directly

called through the API interface. The specific API content is as follows:

DDE Software Development Specification.

6.5 Visualization APIs

DDE provides four-dimensional earth visualization and interactive analysis capabilities based on the unified deep-time spatiotemporal system, as well as intelligent chart analysis visualization capabilities for structured data. The visualization service provides custom software development capabilities through Iframe. When calling, you need to set Iframe components and calling functions. The specific interface content is as follows:

DDE Software Development Specification.

7. Getting Started

7.1 Get Access to Platform

Users can access the platform directly through Deep-time.org and browse open resources on the platform without registration.

Users can register as platform users directly via email, and after registration, they will have a personal research space, MyDDE, which can obtain a series of cloud-based resource operation capabilities provided by the platform, and after registering as a platform user, they will be able to access and use DDE application system.

At the same time, the DDE Platform has opened the user authentication API, and users can directly register to obtain user authentication through the API for subsequent operations. See 6.1 for details.

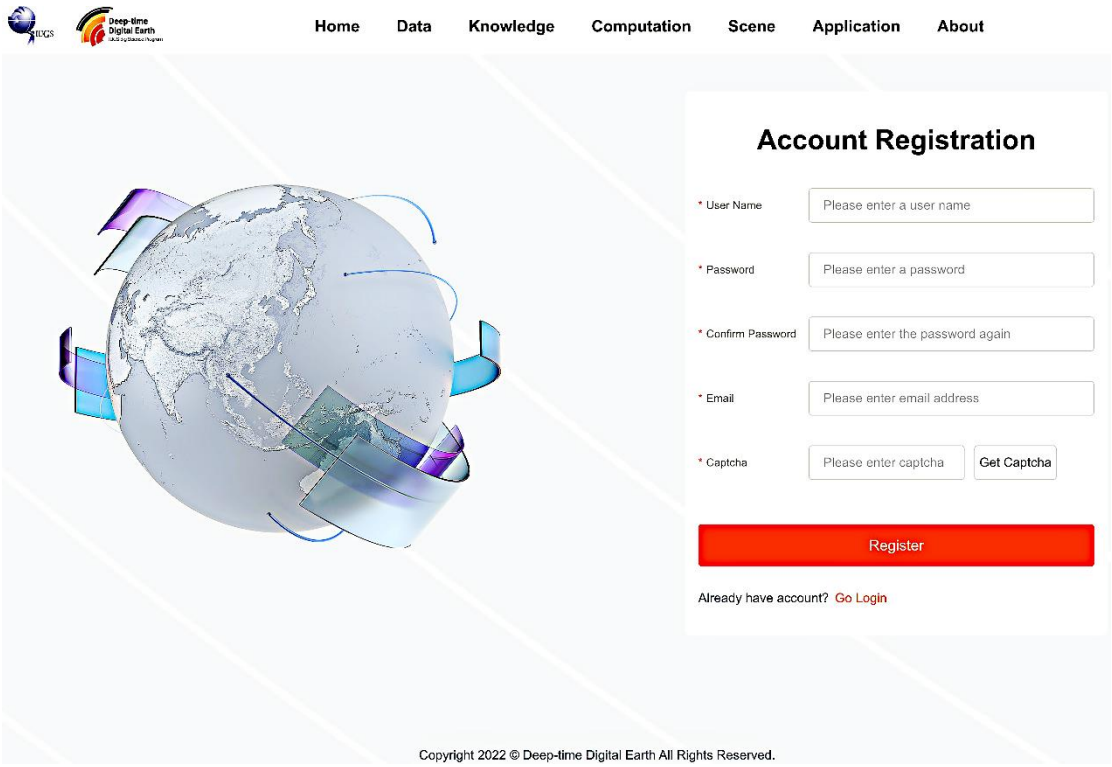


Figure 10 Deep-time.org User Login

7.2 Publish Data to Data Network

After registering as a platform user, the user can link the user's personal data to the data network in the data management - DataAtom column of the personal scientific research space MyDDE, user resources. Click the "New" button and fill in the metadata information form as required to link the user's personal data to the data network, that is, publish it as a DataAtom.

For the high-frequency needs of individual users to organize data through files, the platform supports one-click linking of files to data networks, which can be achieved through the data linker tool in MyDDE.

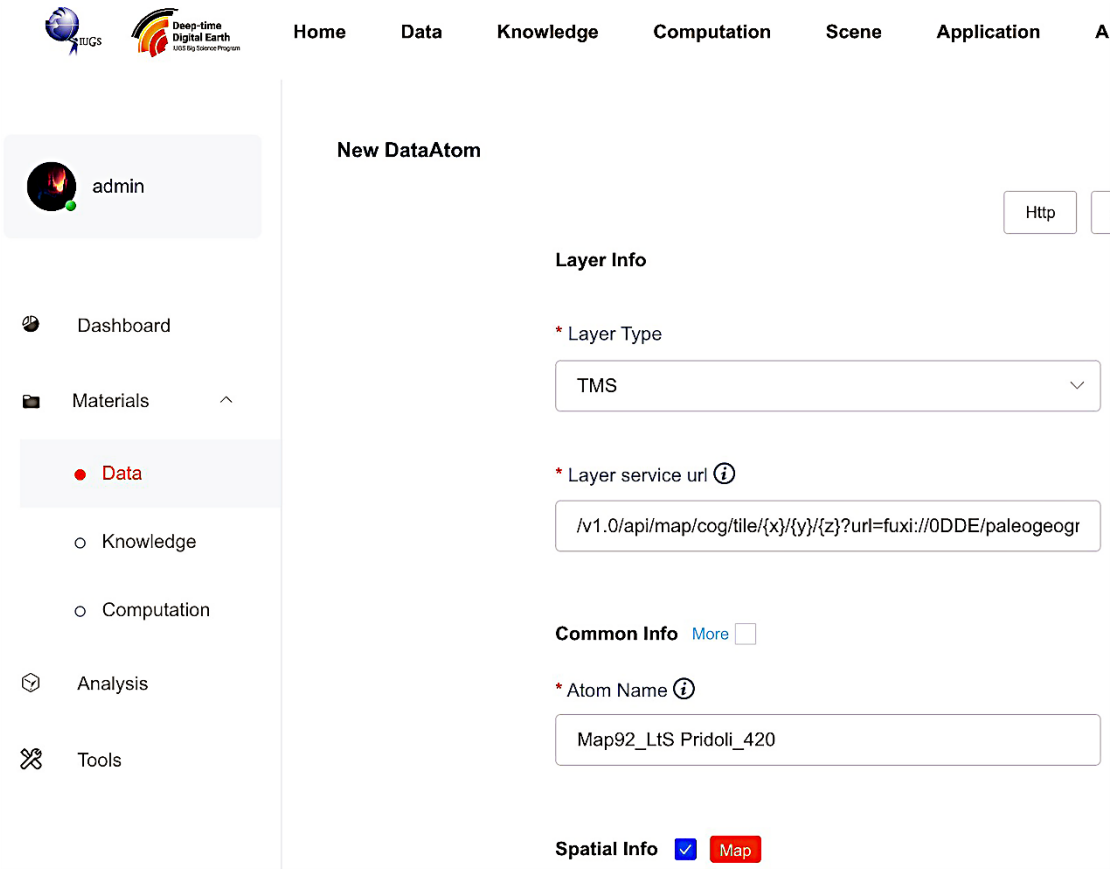


Figure 11 Linking data to the data network

Detailed graphic operation process see doc:

https://deep-time.org/#/about/UserManual/UsemanualModules.

7.3 Use Model to Analyze

Users can browse the model library and workflow in the computing resource square in the computing module. At the same time, users can access and use the model by using the geoscience Analysis module. The platform provides two forms of workflow arrangement and online coding space for users to use.

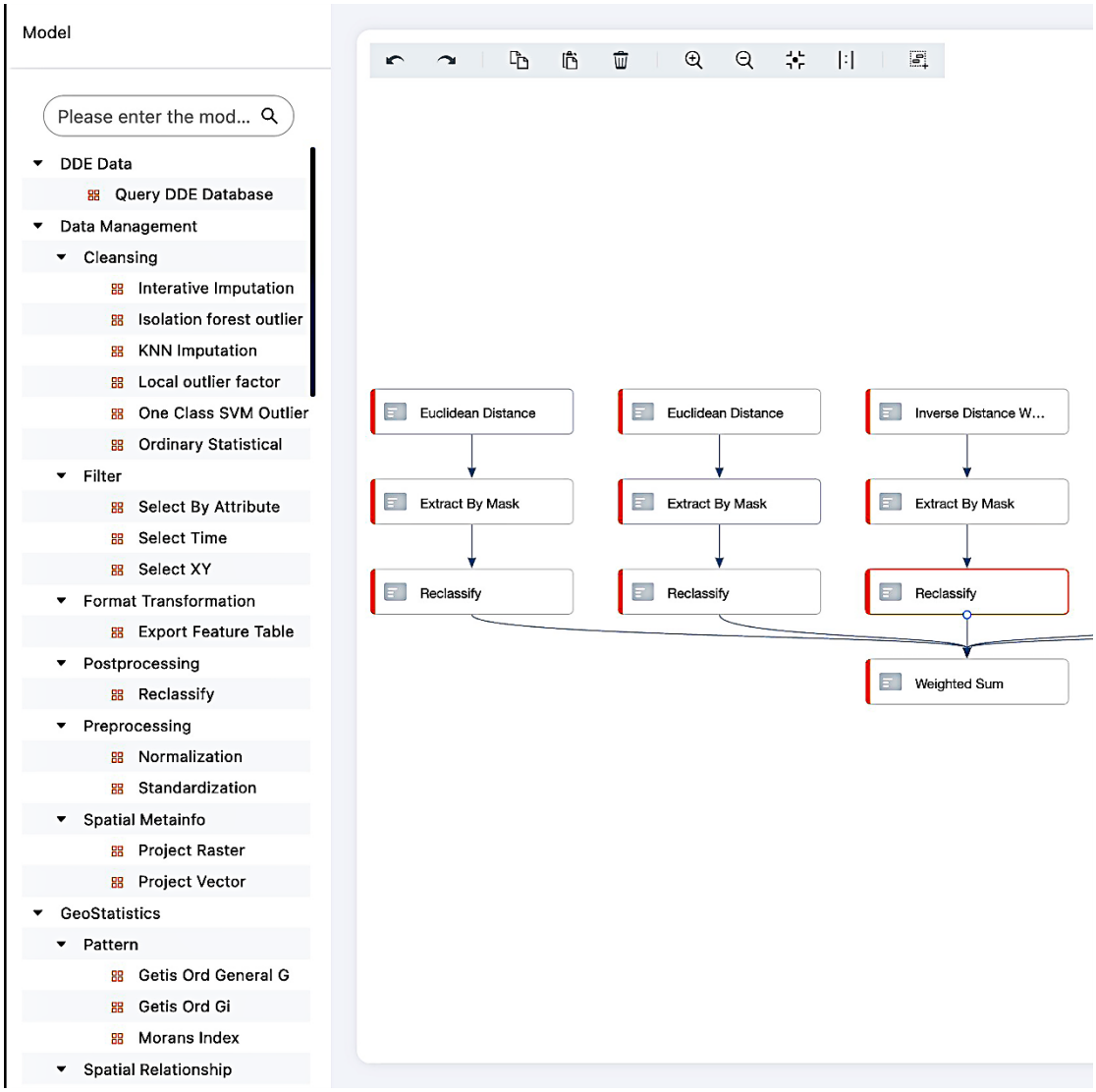


Figure 12 Organization of workflow orchestration

Detailed graphic operation process see doc:

https://deep-time.org/#/about/UserManual/UsemanualModules.

7.4 Visualize Data on Platform

For data with spatiotemporal information, users can use the deep-time visualization Earth Explorer module to load various types of data as layers on the earth for visual display; for structured data, users can generate interactive common analysis charts through the smart chart tool under MyDDE.

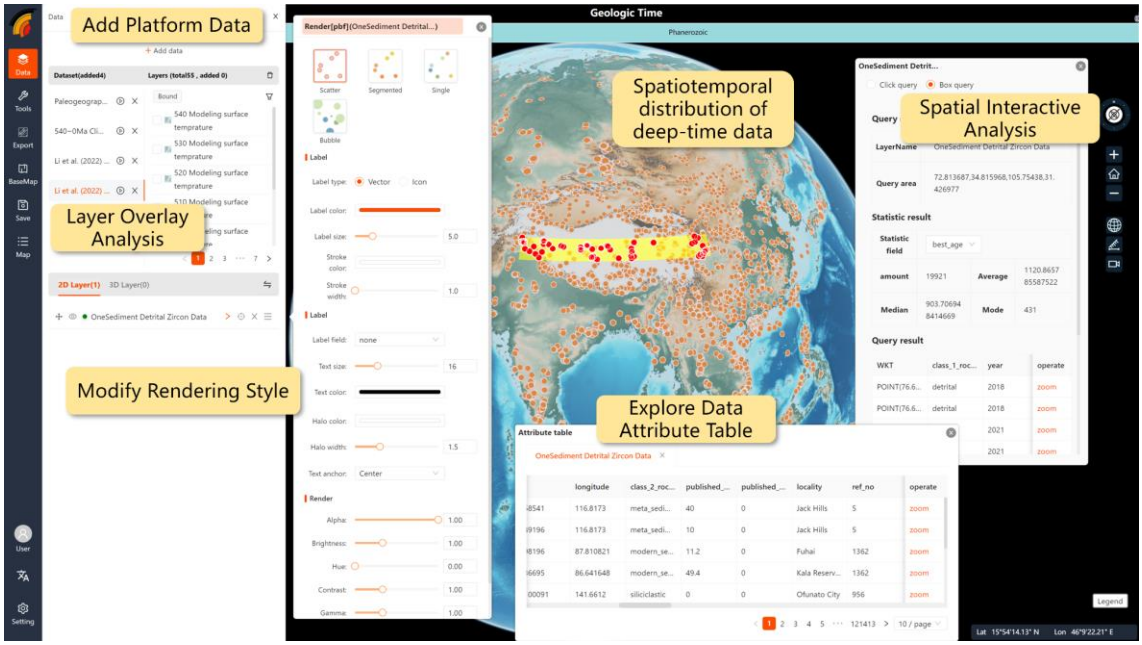


Figure 13 Visualizing spatiotemporal data Deep-time.org

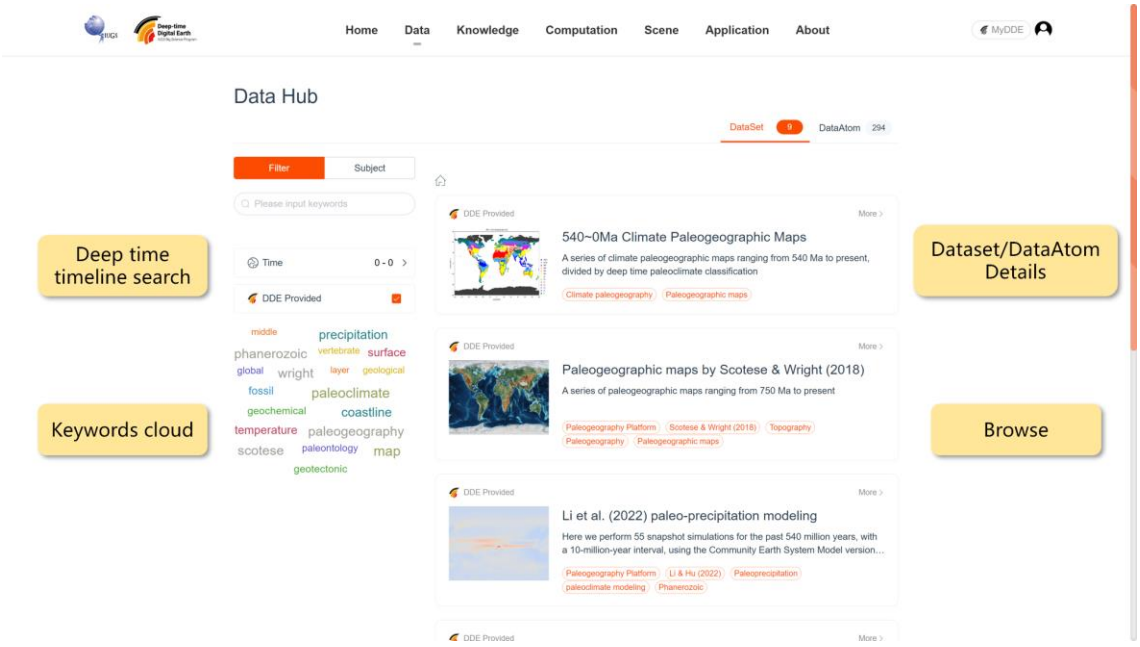
Detailed graphic operation process see doc:

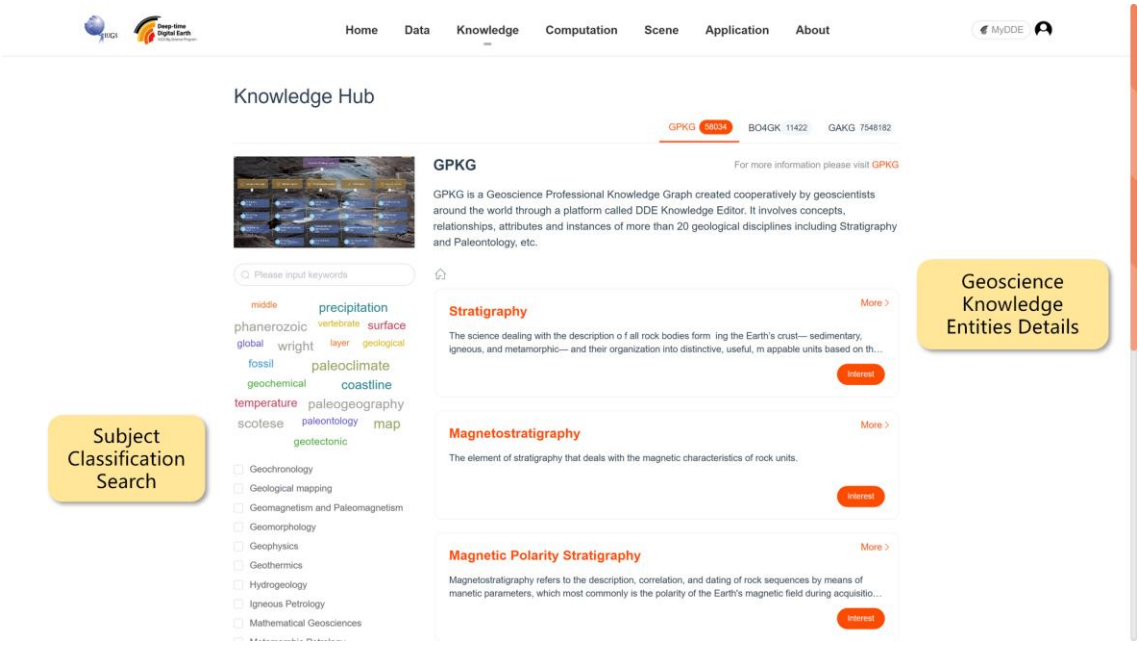
https://deep-time.org/#/about/UserManual/UsemanualModules.

8. Use Cases

8.1 Using platform for research

Users can browse the data, knowledge, and model resources provided by DDE by visiting the Resource Hub. After becoming a registered user, they can use the various products and capabilities provided by the DDE Platform to operate and analyze the resources. By exploring the platform resources and capabilities, users can gradually become familiar with the use of the platform and find new scientific sparks in the multidisciplinary intersection of deep-time digital earth resources.





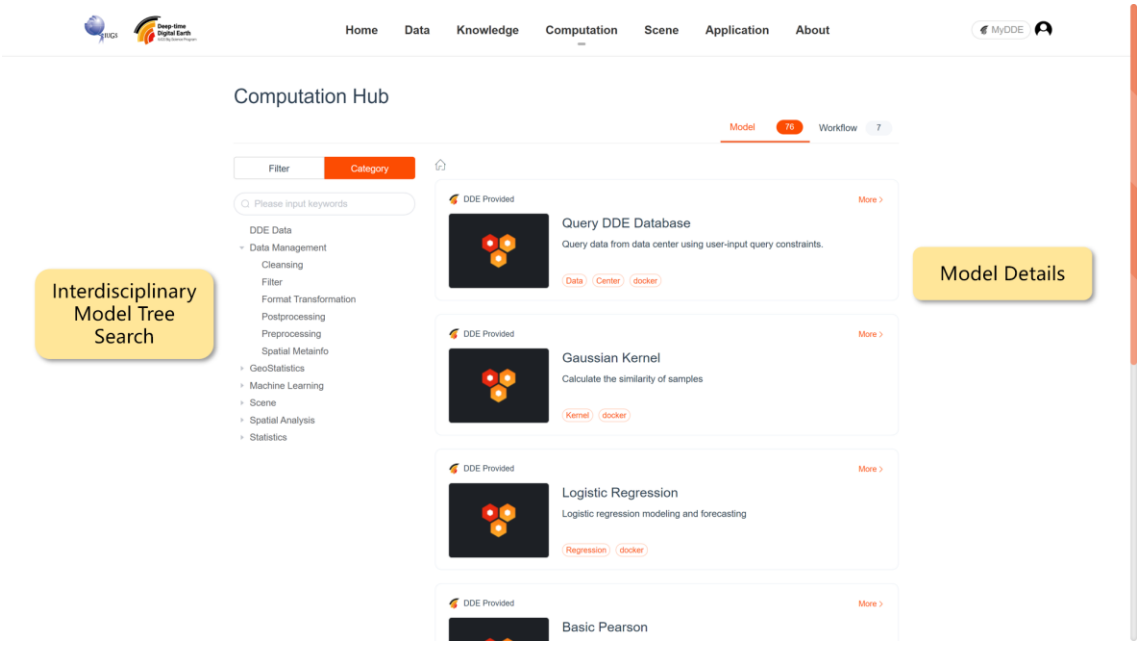


Figure 14 Browse data, knowledge, model resources in deep-time.org

For more features, please contact the following links:

https://deep-time.org/#/about/UserManual/UsemanualModules.

8.2 Using scientific research platform for specific analysis

Considering that users will use the DDE Platform for specific disciplinary or scenario analysis needs, requiring the organization of a specific form of platform capability, the platform has built a series of scenario analysis workflows or disciplinary platforms to support users' scenario-based needs.

In the scenario analysis process, the platform provides users with the process steps that need to be executed on the platform to complete a specific scenario analysis, and users can directly refer to the process to achieve the analysis task. At the same time, some mature scenarios have been developed into professional discipline platforms through which users can experience more discipline platform capabilities.

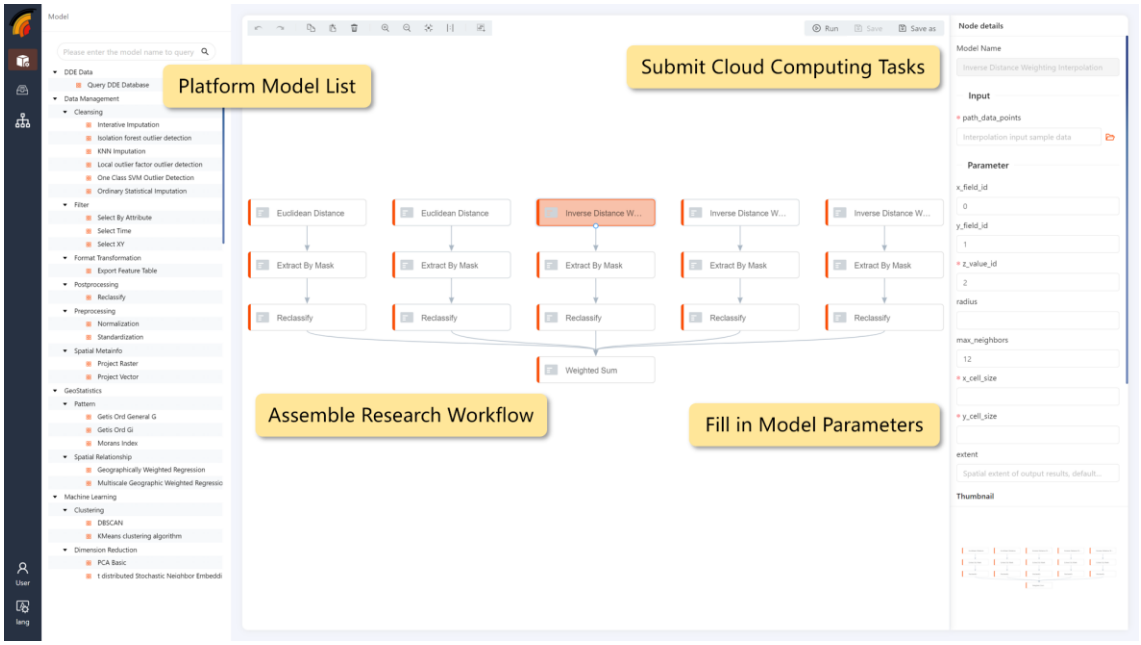


Figure 15 The research workflows supported by deep-time.org

For more usage details, please visit the following links:

https://deep-time.org/#/about/UserTutorials.

8.3 Building your own scientific research platform

All the DDE services and capabilities of the platform are open to the public in the form of standard API interfaces. If users have more mature Research & Development (R&D) capabilities, they can build more customized scientific research platforms by using open APIs of the platform. At present, the platform has supported the construction of several DDE disciplinary platforms, such as Paleogeographic Reconstruction Platform and Mineral Potential Mapping Platform. At the same time, we encourage users to use the unified DDE user management system and incorporate the built platforms into the DDE application system to practice the concept of joint contribution and shared benefits.

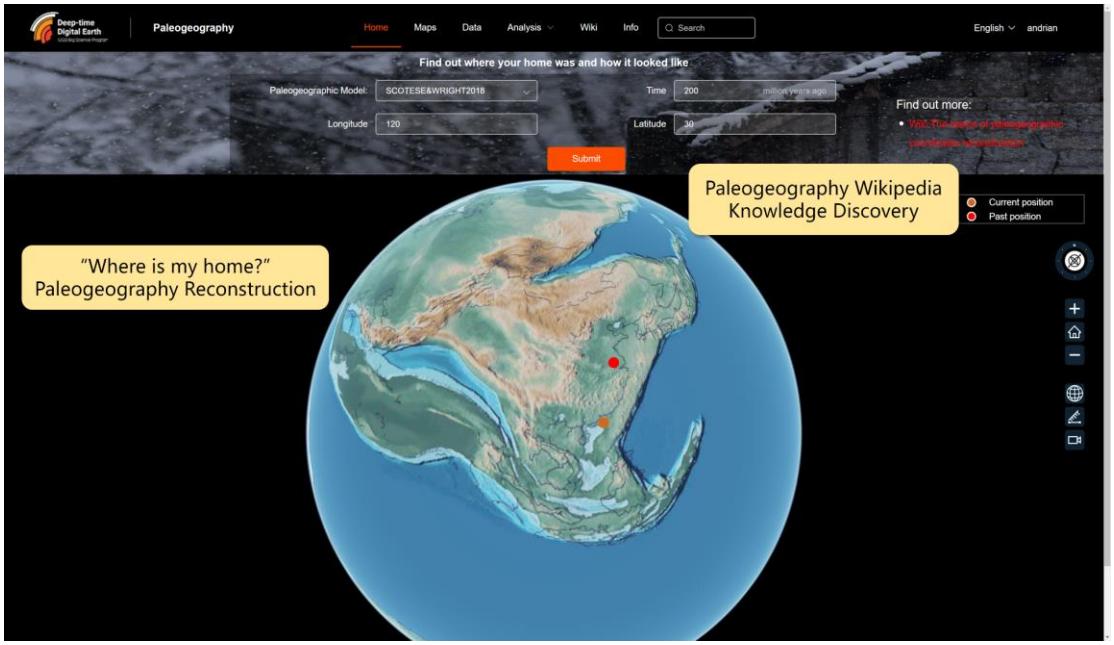


Figure 16 The Paleogeography Reconstruction Platform fueled by deep-time.org

For the complete API doc, please refer to the following link:

https://deep-time.org/#/about/API_Docs/UserApi.

9. Data and Intellectual Property

9.1 Data and IP Principles Initiative

DDE puts forward the principles of “openness, sharing, traceability and non-discrimination”. Under the premise of legality, it is encouraged to improve information disclosure and data sharing across the platform, ensure data traceability, and establi
sh an open, inclusive and non-discriminatory operating mechanism. By concretizing these principles into specific platform governance norms and agreed terms, DDE will effectively realize its projected goal of making global geoscientists’ collaborative innovation and exploration more efficient and intelligent.

9.2 Data and IP Legal Compliance Safeguards

Compliance with data and IP laws and regulations is the basic guarantee for the sustainable development of DDE. Participants and users shall clearly indicate the source and IP condition of data and related materials. And they should respect IP rights of the original right holders when conducting secondary use, development, and dissemination of existing data and related materials. Moreover, it is required to comply with corresponding international and local laws and regulations regarding IP and data when collecting, storing, using processing, transmitting, providing and disclosing data and related materials (such as explanatory documents, technical manuals, etc.) derived from official databases, scientific literature, scientific experiments and other channels at home and abroad.

Meanwhile, the DDE Platform as well as its participants and users enjoy legal IP rights and data interests on the original and improved results produced thereby. The DDE Platform formulates necessary data and IP norms in accordance with the law, by which to prevent and govern data and IP risks. By professional data and IP consultation, exchange and training, etc., it will explore the path to establishing an operational mechanism of fully respecting and utilizing data and IP in big science projects.