

# Outline of the Earth Simulator Project

## 1. Mission and Basic Principles of the Earth Simulator

The Earth Simulator was developed for the following aims. The first aim is to ensure a bright future for human beings by accurately predicting variable global environment. The second is to contribute to the development of science and technology in the 21st century. Based on these aims, the principles listed below are established for the projects of the Earth Simulator.

- 1) Each project should be open to researches in each research field and to the public, rather than it is confined within the limited research society.
- 2) In principle, the research achievements obtained by using the Earth Simulator should be promptly published and returned to the public.
- 3) Each project should be carried out for peaceful purposes only.

## 2. Earth Simulator Research Project

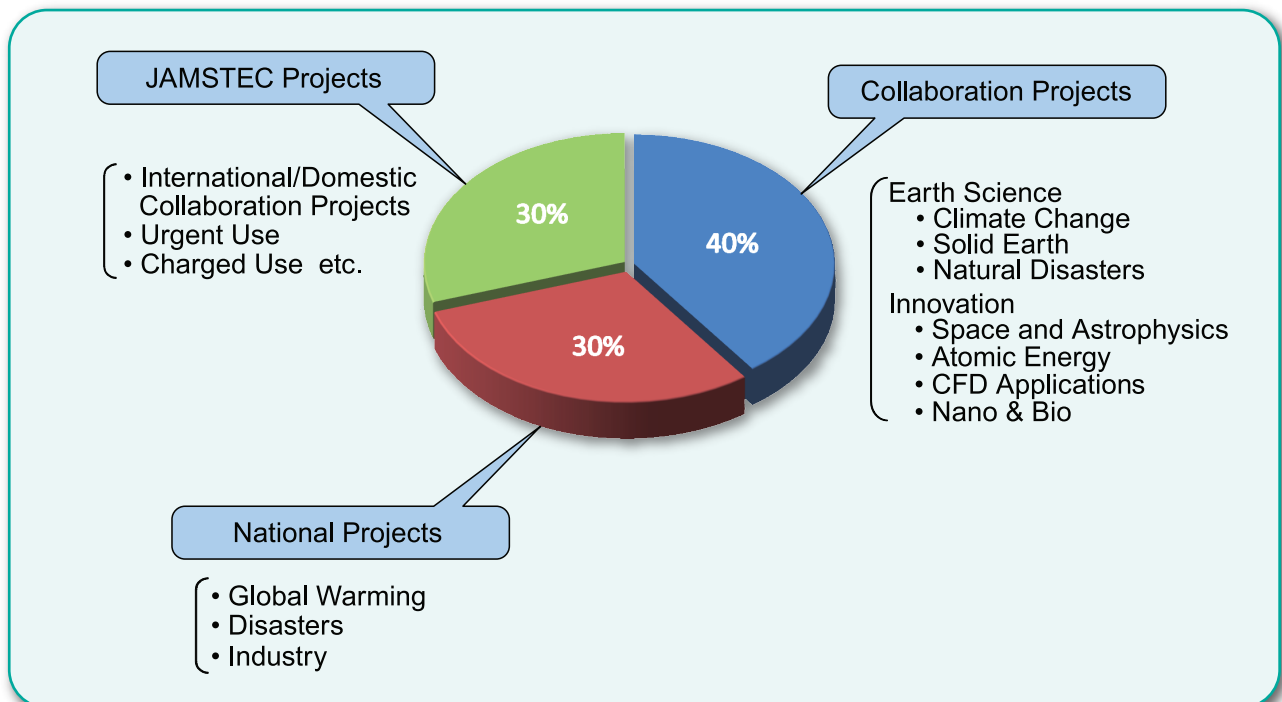
There are two fields of Earth Simulator Research Projects, as follows:

- Earth Science
- Epoch-making Simulation

The allocation of Earth Simulator resources for each research field in FY2010 was decided to be as shown in following graph.

Public project recruitment for Earth Simulator Research Projects in FY2010 was held in February 2010, and 31 research projects were selected by the Selection Committee.

**The Allocation of Resources of the Earth Simulator in FY2010**



## Authorized Projects in FY2010

### Earth Science (19 projects)

	Title	Project leader	Affiliation of project leader
1	Understanding Roles of Oceanic Fine Structures in Climate and its Variability	Wataru Ofuchi	ESC, JAMSTEC
2	Simulations of Adaptation-Oriented Strategy for Climate Variability	Keiko Takahashi	ESC, JAMSTEC
3	Development of a High-quality Climate Model for Global Warming Projection Study	Akira Noda	RIGC, JAMSTEC
4	Simulations of Atmospheric General Circulations of Earth-like Planets by AFES	Yoshiyuki Hayashi	Graduate School of Science, Kobe University
5	Study on the Diagnostics and Projection of Ecosystem Change Associated with Global Change	Michio Kishi	RIGC, JAMSTEC
6	Development of a Numerical Model of Urban Heat Island	Yasunobu Ashie	National Institute for Land and Infrastructure Management
7	Study of Cloud and Precipitation Processes using a Global Cloud-system Resolving Model	Masaki Sato	RIGC, JAMSTEC/Atmosphere and Ocean Research Institute, The University of Tokyo
8	Study on Predictability of Climate Variations and Their Mechanisms	Yukio Masumoto	RIGC, JAMSTEC
9	Simulation and Verification of Tropical Deep Convective Clouds using Eddy-permitting Regional Atmospheric Models	Kozo Nakamura	RIGC, JAMSTEC
10	Atmospheric Composition Change and its Climate Effect Studies by a Chemical Transport Model	Masayuki Takigawa	RIGC, JAMSTEC
11	Ocean State Estimation for the Recent Decade and Adjoint Sensitivity Analysis for the Optimal Observing System, by using a 4D-VAR Ocean Data Assimilation Model	Shuhei Masuda	RIGC, JAMSTEC
12	High-frequency Global Ocean Modeling with the 1-km Spatial Resolution	Ryota Hino	Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University
13	Global Elastic Response Simulation	Seiji Tsuboi	IFREE/DrC, JAMSTEC
14	Simulation Study on the Dynamics of the Mantle and Core in Earth-like Conditions	Yozo Hamano	IFREE, JAMSTEC
15	Predictive Simulation for Crustal Activity in and around Japan	Chihiro Hashimoto	Graduate School of Environmental Studies, Nagoya University
16	Numerical Simulation of Seismic Wave Propagation and Strong Ground Motions in 3-D Heterogeneous Media	Takashi Furumura	Center for Integrated Disaster Information Research, Interfaculty Initiative in Information Studies, The University of Tokyo/Earthquake Research Institute, The University of Tokyo
17	Development of Advanced Simulation Tools for Solid Earth Sciences	Akira Kageyama	Graduate School of System Informatics, Kobe University
18	Numerical Simulations of the Dynamics of Volcanic Phenomena	Takehiro Koyaguchi	Earthquake Research Institute, The University of Tokyo
19	Space and Earth System Modeling	Kanya Kusano	IFREE, JAMSTEC

**Epoch-making Simulation (12 projects)**

	Title	Project leader	Affiliation of project leader
20	Development of General Purpose Numerical Software Infrastructure for Large Scale Scientific Computing	Akira Nishida	Research Institute for Information Technology, Kyushu University
21	Large-scale Simulation on the Properties of Carbon-nanotube	Syogo Tejima	Research Organization for Information Science & Technology
22	Development of the Next-generation Computational Fracture Mechanics Simulator for Constructing Safe and Sustainable Society	Ryuji Shioya	Faculty of Information Sciences and Arts, Toyo University
23	Large-scale Simulation for a Terahertz Resonance Superconductors Device	Mikio Iizuka	Research Organization for Information Science & Technology
24	Direct Numerical Simulations of Fundamental Turbulent Flows with the World's Largest Number of Grid-points and Application to Modeling of Engineering Turbulent Flows	Yukio Kaneda	Graduate School of Engineering, Nagoya University
25	A Large-scale Post-genome Analysis using Self-Organizing Map for All Genome and Protein Sequences	Toshimichi Ikemura	Nagahama Institute of Bio-Science and Technology
26	First Principles Calculation on Hydrogen Diffusion Behavior in Iron Containing a Dislocation and Grain Boundary	Hideo Kaburaki	Japan Atomic Energy Agency
27	Development of a Fluid Simulation Approach by Massively Parallel Bits-operations with a New Viscosity Control Method	Hiroshi Matsuoka	Research Institute of Electrical Communication, Tohoku University
28	Development of Adaptive High Accuracy Libraries	Hidehiko Hasegawa	Graduate School of Library, Information and Media Studies, University of Tsukuba
29	Developments of Sophisticated Simulation Analysis Method of Actual Reinforced Concrete Building by Shaking Table Test	Yoshiyuki Kasai	Department of Urban Environment and Information Science, Graduate School, Maebashi Institute of Technology
30	Numerical Studies of Droplet Impacts (Splashes)	Feng Xiao	Interdisciplinary Graduate School of Science and Engineering, Tokyo Institute of Technology
31	Theoretical Study of Drug Resistance Mechanism Based on the Fragment Molecular Orbital Method	Shigenori Tanaka	Graduate School of System Informatics, Kobe University

JAMSTEC : Japan Agency for Marine-Earth Science and Technology

IFREE : Institute for Research on Earth Evolution

ESC : Earth Simulator Center

RIGC : Research Institute for Global Change

DrC : Data Research Center for Marine-Earth Sciences

### 3. Collaboration Projects

#### Collaboration Projects in FY2010

<ul style="list-style-type: none"><li>• Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER), Département d'Océanographie Physique et Spatiale, France</li></ul>
<ul style="list-style-type: none"><li>• Ernest Orlando Lawrence Berkeley National Laboratory, University of California (LBNL), USA</li></ul>
<ul style="list-style-type: none"><li>• Korean Ocean Research &amp; Development Institute (KORDI), Korea</li></ul>
<ul style="list-style-type: none"><li>• The National Oceanography Centre, Southampton (NOCS), UK</li></ul>
<ul style="list-style-type: none"><li>• The large-scale numerical simulation of the weather/oceanographic phenomena for international maritime transportation : Kobe University</li></ul>
<ul style="list-style-type: none"><li>• Research and development for MSSG calculation performance optimization in the next-generation supercomputer system : RIKEN</li></ul>
<ul style="list-style-type: none"><li>• Collaborative research on the sophistication of the computational simulation software toward constructing the platform for the leading industrial research and development : Institute of Industrial Science, the University of Tokyo</li></ul>
<ul style="list-style-type: none"><li>• Numerical study on rheophysical behavior of viscoelastic fluids and their mechanisms using Digital Ink Laboratory (DIL) System : DNP Fine Chemicals Fukushima Co., Ltd</li></ul>

### 4. System Configuration of the Earth Simulator

#### The Earth Simulator

#### - New Earth Simulator System of Ultra High-speed Vector Parallel Super Computer -

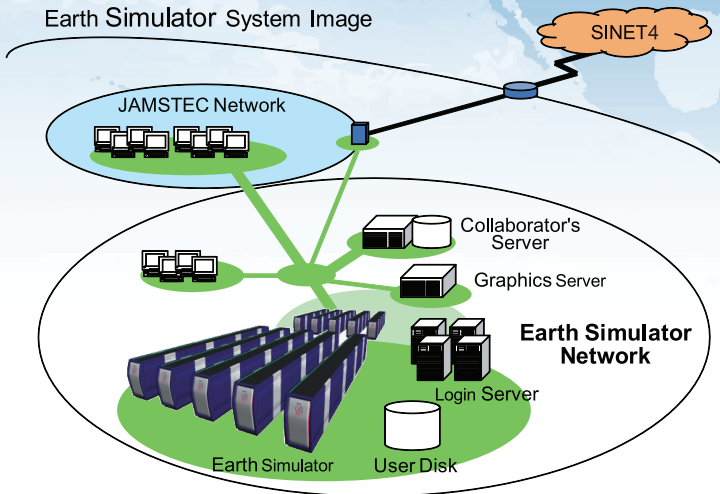
The Earth Simulator is the upgraded system of the previous Earth Simulator, which has significantly contributed to the development of a simulation culture in the area of earth science and related technical fields, and introduces new features to bring accurate and

high-speed analysis and projections of global-scale environmental phenomena. The ES is also used to produce numerical simulations for advanced research fields that are beyond the scope of other computing systems.

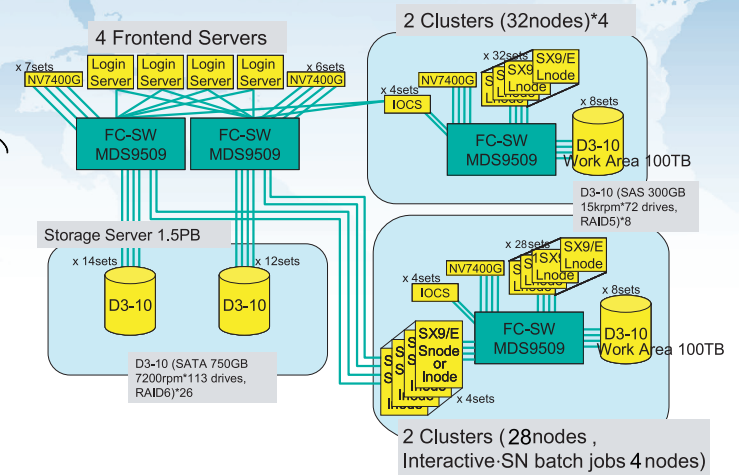




## ES System Outline



## Storage System



### Features of the Earth Simulator for operation and control

- (1) Clustering of nodes to control the system (transparent for users) .  
A cluster consists of 32 nodes,  
Most of them are for batch jobs (batch clusters).
- (2) Providing special nodes for TSS and small batch jobs.
- (3) Configuration of the TSS cluster.
  1. TSS nodes [2 nodes],
  2. Nodes for SN (Single Node) batch jobs [2 nodes],
- (4) Configuration of the batch cluster.
  1. Nodes for MN (Multi-Nodes) batch jobs,
  2. System disks for user-file staging,
- (5) Storage of user files for batch jobs on a mass-storage system.  
Automated file recall (Stage-In) and migration (Stage-Out).
- (6) Connection of all the clusters to a mass-storage system

### Real Applications Benchmark Performance

Application	ES (# of CPUs)	New ES (# of CPUs)	Speed up
PHASE	135.3 sec (4096)	62.2 sec (1024)	2.18
NICAM-K	214.7 sec (2560)	109.3 sec (640)	1.97
MSSG	173.9 sec (4096)	86.5 sec (1024)	2.01
SpecFEM3D	96.3 sec (4056)	45.5 sec (1014)	2.12
Seism3D	48.8 sec (4096)	15.6 sec (1024)	3.13

Harmonic Mean of Speed up Ratio : 2.22