Outline of the Earth Simulator Project

1. Mission and Basic Principles of the Earth Simulator

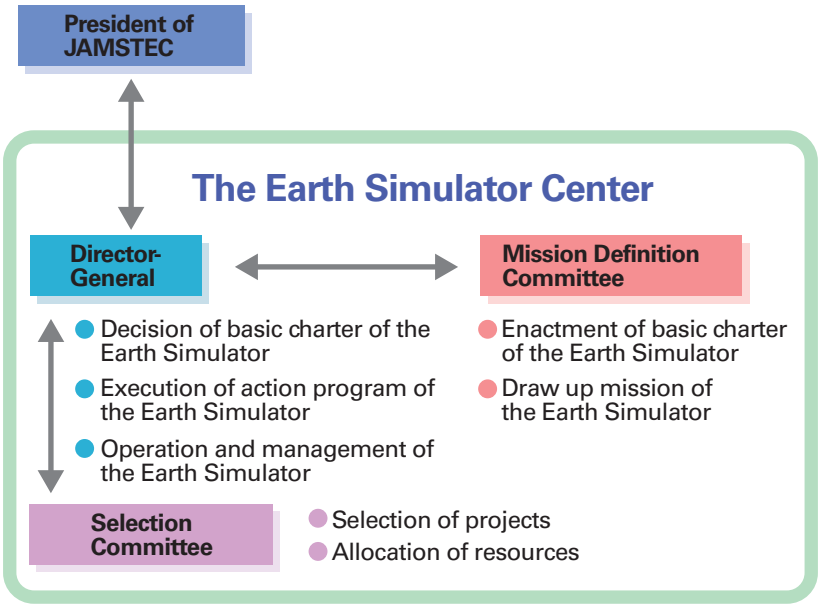
The Earth Simulator was developed for the following aims. The first aim is to ensure a bright future for human beings by accurately predicting variable global environment. The second is to contribute to the development of science and technology in the 21st century. Based on these aims, four principles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

1) Each project should be open to researches in each research filed 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) The Mission Definition Committee will examine the research achievements and encourage effective operations.
4) Each project should be carried out for peaceful purposes only.

2. Managing System for the Earth Simulator Project

The Earth Simulator Project is managed under policy which is decided by the Mission Definition Committee and the Selection Committee. The Mission Definition Committee enacts the basic charter of the Earth Simulator and draws up its mission. Research projects using the Earth Simulator are selected by the Selection Committee every year.

Fig. 1 Managing System for Projects in FY2005



3. Earth Simulator Research Project

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

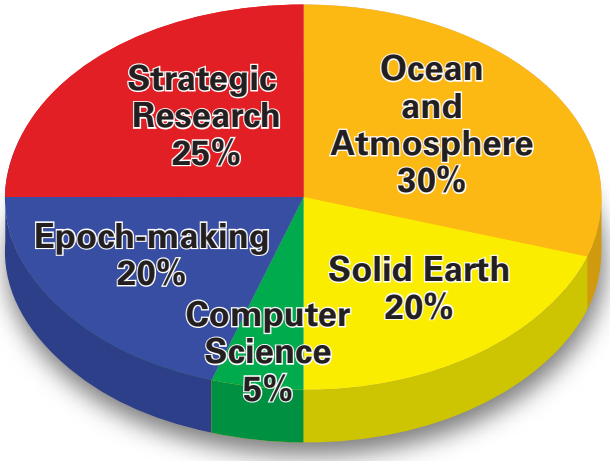
- Atmospheric and Oceanic Simulation
- Solid Earth Simulation
- Computer Science
- Epoch-making Simulation

Allocation of the Earth Simulator resources is planned by the Mission Definition Committee each fiscal year. The allocation of resources for each research field in FY2005 was decided to be as shown in following graph (Fig. 2).

Public project recruitment for Earth Simulator Research Projects in FY2005 was held in February 2005, and 44 research projects were selected by the Selection Committee. The allocation of resources for each project was also decided by the Selection Committee.

International Collaboration Projects were carried out under the allocation of "Strategic Research".

Fig. 2 The Allocation of Resources of the Earth Simulator in FY2005



Authorized Projects in FY2005

Atmospheric & Oceanic Simulation (12 projects)

	Title	Project leader	Affiliation of project leader
1	Future Climate Change Projection using a High-Resolution Coupled Ocean-Atmosphere Climate Model	Akimasa Sumi	Center for Climate System Research, The University of Tokyo
2	Development of Integrated Earth System Model for Global Change Prediction	Taro Matsuno	FRCGC, JAMSTEC
3	Advanced Parameterization of Physical Processes	Toshiyuki Hibiya	Graduate School of Science, The University of Tokyo
4	Development of Super High Resolution Global and Regional Climate Models	Akira Noda	Meteorological Research Institute
5	Research Development of 4-dimensional Data Assimilation System using a Coupled Climate Model and Construction of Reanalysis Datasets for Initialization	Toshiyuki Awaji	FRCGC, JAMSTEC

6	Sustainable Coexistence of Human Nature and the Earth Advanced Prediction System and Counter Measures of Regional-and Meso-scale Water Cycle	Hiromasa Ueda	Acid Deposition and Oxidant Research Center
7	Atmospheric Composition Change and its Climate Effect Studied by Chemical Transport Models	Hajime Akimoto	FRCGC, JAMSTEC
8	Understanding and Forecasting High-Impact Phenomena in the Atmosphere and Ocean	Wataru Ofuchi	ESC, JAMSTEC
9	Multi-scale Weather/Climate Simulations with Coupled Non-hydrostatic Ocean-Atmosphere GCM on the Earth Simulator	Keiko Takahashi	ESC, JAMSTEC
10	Study on the Mechanism of Climate and Ocean Variability and Their Predictability	Toshio Yamagata	FRCGC, JAMSTEC
11	Development of a Numerical Model of Urban Heat Island	Yasunobu Ashie	Building Research Institute
12	Development of a Coupled Atmosphere-Ocean-Land General Circulation Model (GCM) at the Frontier Research Center for Global Change	Tatsushi Tokioka	FRCGC, JAMSTEC

Solid Earth Simulation (9 projects)

	Title	Project leader	Affiliation of project leader
13	Global Elastic Response Simulation	Seiji Tsuboi	IFREE, JAMSTEC
14	Simulation Study on the Generation and Distortion Process of the Geomagnetic Field in Earth-like Conditions	Yozo Hamano	IFREE, JAMSTEC/ Graduate School of Science, The University of Tokyo
15	Numerical Simulation of the Mantle Convection	Yoshio Fukao	IFREE, JAMSTEC
16	Predictive Simulation for Crustal Activity in and around Japan	Mitsuhiro Matsu'ura	Graduate School of Science, The University of Tokyo
17	Numerical Simulation of Seismic Wave Propagation and Strong Ground Motions in 3-D Heterogeneous Media	Takashi Furumura	Earthquake Research Institute, University of Tokyo
18	Simulation of Earthquake Generation Process in a Complex System of Faults	Kazuro Hirahara	Graduate School of Science, Kyoto University
19	Development of Solid Earth Simulation Platform	Kengo Nakajima	Graduate School of Science, The University of Tokyo
20	Dynamics of the Core-Mantle Coupled System	Akira Kageyama	ESC, JAMSTEC
21	Numerical Simulation of Physical Properties of Earth's Materials	Mitsuhiro Toriumi	Graduate School of Frontier Science, The University of Tokyo

Computer Science (1 project)

	Title	Project leader	Affiliation of project leader
22	Development of Micro-Macro Interaction Simulation Algorithm	Kanya Kusano	ESC, JAMSTEC

Epoch-making Simulation (22 projects)

	Title	Project leader	Affiliation of project leader
23	Numerical Simulation of Rocket Engine Internal Flows	Kozo Fujii	Japan Aerospace Exploration Agency
24	Large-scale Simulation on the Properties of Carbon-nanotube	Kazuo Minami	Research Organization for Information Science & Technology
25	Development of the Next-generation Computational Solid Mechanics Simulator for a Virtual Demonstration Test	Ryuji Shioya	Graduate School of Engineering, Kyushu University
26	Study of the Standard Model of Elementary Particles on the Lattice with the Earth Simulator	Akira Ukawa	Center for Computational Sciences, University of Tsukuba
27	Large-scale Simulation for a Terahertz Resonance Superconductors Device	Masashi Tachiki	Research Organization for Information Science & Technology
28	Geospace Environment Simulator - Evaluation of the Plasma Environment around a Spacecraft using Electric Propulsion -	Yoshiharu Omura	Research Institute for Sustainable Humanosphere, Kyoto University
29	Particle Modeling for Complex Multi-phase System with Internal Structures using DEM	Hide Sakaguchi	IFREE, JAMSTEC
30	Development of Transferable Materials Information and Knowledge Base for Computational Materials Science	Shuhei Ohnishi	CAMP (Collaborative Activities for Materials Science Programs) Group
31	Cosmic Structure Formation and Dynamics	Ryoji Matsumoto	Faculty of Science, Chiba University
32	Direct Numerical Simulations of Fundamental Turbulent Flows with the Largest Grid Numbers in the World and its Application of Modelling for Engineering Turbulent Flows	Chuichi Arakawa	Interfaculty Initiative in Information Studies, Graduate School of Interdisciplinary Information Studies, The University of Tokyo
33	Biosimulation	Toshikazu Takada	Forum on the Bio-Simulation
34	Large-scale Softmaterial Simulation on Drug Delivery System	Atsushi Miyauchi	Research Organization for Information Science & Technology
35	Nano-simulation of Electrode Reaction in Fuel Cells	Tamio Ikeshoji	Research Institute for Computational Sciences, National Institute of Advanced Industrial Science and Technology
36	Synergetic Simulation Study on Cross-hierarchy Complex Physics in High-temperature Plasmas	Takaya Hayashi	Theory and Data Analysis Division, National Institute for Fusion Science
37	Study on Numerical Predictions of Complicated Thermal-Hydraulic Dynamics in Nuclear Reactors by Large-Scale Simulations	Kazuyuki Takase	JAEA
38	First Principles Molecular Dynamics Simulation of Solution	Masaru Hirata	JAEA

39	Numerical Studies for Novel Superconducting Properties and Neutron Detector Applications by Superconductor Nano-fabrication Techniques	Masahiko Machida	JAEA
40	Electronic and Atomistic Simulations on the Irradiation Induced Property Changes and Fracture in Materials	Hideo Kaburaki	JAEA
41	Large-Scale Simulation of Groundwater Flow and Radioactive Nuclide Transportation	Hiroshi Okuda	Research into Artifacts, Center for Engineering, The University of Tokyo
42	First-principles Molecular Dynamics Simulation of Oxide Layers for Radiation-tolerant SiC Devices	Atumi Miyashita	JAEA
43	Direct Numerical Simulation of Turbulent Flows in Subchannels of a Tight Lattice Bundle	Hisashi Ninokata	Graduate School of Engineering, Tokyo Institute of Technology
44	Frontier Simulation Software for Industrial Science	Chisachi Kato	Institute of Industrial Science, The University of Tokyo

JAMSTEC : Japan Agency for Marine-Earth Science and Technology
FRCGC : Frontier Research Center for Global Change
IFREE : Institute for Research on Earth Evolution
JAEA : Japan Atomic Energy Agency
ESC: The Earth Simulator Center

4. International Collaboration Projects

We place special emphasis on elevating the worldwide power of simulation science and technology. As one way to achieve this task, we are doing our best to promote international collaboration based on institution-to-institution agreement.

Table 1 International Collaboration Projects as of March 2006

Scripps Institution of Oceanography, USA
Hadley Centre for Climate Prediction and Research, The Met Office, UK
Centre for Global Atmospheric Modelling, Centres for Atmospheric Science, UK
Italian Aerospace Research Center, Italy
Numerical Prediction Research Division, Environment Canada Meteorological Service of Canada, Canada
National Energy Research Scientific Computing Center, USA
Center for Computational Visualization, Department of Computer Sciences and Institute for Computational Engineering and Sciences, The University of Texas, USA
French National Centre for Scientific Research, France
French Research Institute for Exploitation of the Sea, France
Department of Geology & Geophysics, University of Minnesota, USA
International Arctic Research Center, University of Alaska Fairbanks, USA

5. Domestic Collaboration Projects

In addition to three domestic collaboration projects, we newly started the project with the Inctec Inc. regarding the behavior of the ink in the rotary press. We will continue to promote coopration with industries more strongly.

Table 2 Domestic Collaboration Projects as of March 2005

Automobile Simulation: Japan Automobile Manufacturers Association
Economic Simulation: Institute of Economic Research, Hitotsubashi University
Aerodynamic Simulation: School of Engineering, Tohoku University Japan Aerospace Exploration Agency Mitsubishi Heavy Industries, Ltd.
Ink & Printing Simulation: The Inctec Inc. Institute for Research on Earth Evolution, JAMSTEC

6. The Program for Strategic Use of Advanced Large Research Facilities

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) promotes a broad range of high-quality research and development carried out by researchers qualified to get the most out of advanced large-scale research facilities.

In particular, MEXT promotes the "Program for Strategic Use of Advanced Large-scale Research Facilities", which aims to create new technologies and industries.

This program has been entrusted by MEXT to the Earth Simulator Center, which has developed a structure within which researchers can exploit the Earth Simulator with the assistance of full-time staff able to advise on simulation techniques.

Projects within this program have been using the Earth Simulator since July 2005.

Title	Organization
Research for Method of Protein Structure Analyzing using X-ray by using Drug Design System on Computer	Fundamental and Environmental Research Laboratories, NEC Corporation
Simulation of Organic Materials for Optical Properties	Tsukuba Research Laboratory, Sumitomo Chemical Co. Ltd.,
Development of Ecological High-Performance Tire by Modeling of Nano-Particle Network Structure in Rubber	SRI Research & Development Ltd.
Development of Environment Symbiosis Urban Planning Method with Whole Building Environment Simulation.	Technology Center, Taisei Co. Ltd
Large-scale Simulation for Designing the Structure and Property of Novel Nano-material	Honda R&D Co., Ltd.

7. JST (Japan Science Technology Agency) Basic Research Programs, CREST (Core Research for Evolutional Science and Technology)

CREST (Core Research for Evolutional Science and Technology) that JST (Japan Science and Technology Agency) promotes is one of the basic research programs which are categorized as Competitive Research Funds. The objective of CREST is to promote leading, creative and internationally high level basic studies in an attempt to achieve strategic goals set by the government. It also aims at producing a significant impact on the development of future science and technology and creating innovative technological seeds that contribute to creation of new industries in the future.

Research Supervisors in charge of Research Areas coordinate researchers spreading across different institutions and run the Research Areas as "Virtual Institutes". A Research Director organizes an appropriate Research Team (group of researchers, research assistants, etc., formed for the purpose of conducting studies) in the Research Area by selecting members from industry, government and academia, and implements the Research Themes.

A part of the Research Themes selected in FY2005 have started their research activities using the Earth Simulator since October of 2005.

Title	Project leader	Affiliation of project leader
Global Cloud Resolving Model Simulations toward Numerical Weather Forecasting in the Tropics	Masaki Satoh	Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology
High Performance Simulation for Disaster Prediction	Keiko Takahashi	The Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology
Integrated Predictive Simulation System for Earthquake and Tsunami Disaster	Mitsuhiro Matsu'ura	Graduate School of Science, The University of Tokyo

8. System Configuration of the Earth Simulator

The Earth Simulator is a highly parallel vector supercomputer system of the distributed-memory type, consisting of 640 processor nodes (PNs) connected by 640x640 single-stage crossbar switches. Each PN is a system with a shared memory, consisting of 8 vector-type arithmetic processors (APs), a 16 GB main memory system (MS), a remote access control unit (RCU), and an I/O processor. The peak performance of each AP is 8 Gflops. Thus, the ES as a whole consists of 5120 APs with 10 TB of main memory and theoretical performance of 40 Tflops.

Table 3 Specifications of the Earth Simulator

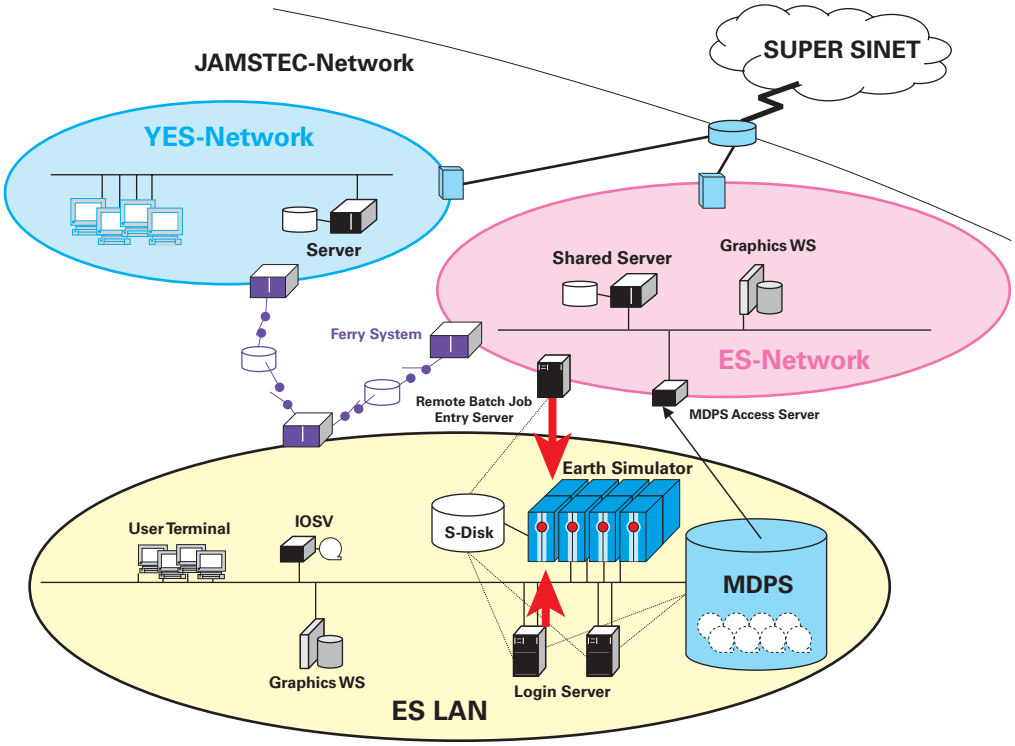
Peak performance/AP	8 Gflops	Total number of APs	5120
Peak performance/PN	64 Gflops	Total number of PNs	640
Shared memory/PN	16 GB	Total peak performance	40 Tflops
		Total main memory	10 TB

From October 2003, an MDPS (Mass Data Processing System) was installed as a new data storage system, which renews the archive system. It consists of four file service processors, 250 TB disks, and a currently used 1.8 PB cartridge tapes library (CTL). The MDPS was adopted in order to improve manageability for data transmission performance and access.

In October 2004, the Earth Simulator Center/JAMSTEC was connected with the Super SINET(*) with four lines of 1Gbps. It is expected to contribute to effective use of data obtained from the Earth Simulator.

(*) The Super SINET is an ultra-high-speed network operated by the National Institute of Informatics.

Fig. 3 Network Composition around the Earth Simulator



9. History and Event Calendar

Year 2001

Apr. 1	The Earth Simulator Center established as part of Japan Marine Science and Technology Center.
Dec. 1	Prof. Tetsuya Sato became director of the Earth Simulator Center.
Dec. 7	1st Advisory Committee

Year 2002

Jan. 28	2nd Advisory Committee
Mar. 1	Operation of the Earth Simulator
Mar. 6	1st Orientation for users
Mar. 11	2nd Orientation for users
Mar. 15	Opening Ceremony at the Earth Simulator Center
Apr. 18	Earth Simulator achieved 35.61 Tflops using Linpack HPC, registered as No.1 in the Linpack report dated April 17, 2002. (Press release by JAMSTEC)
Jun. 5	1st meeting of the Mission Definition Committee
Jun. 20	Earth Simulator certified as the world's fastest supercomputer, with performance of 35.86 Tflops, in the TOP500 list of June 2002.
Jun. 21-30	Public project recruitment of FY2002
Jul. 10	1st Selection Committee
Jul. 16	Start of the authorized projects of FY2002
Sep. 28	1st Earth Simulator Center Symposium at Pacifico Yokohama "Harmonious Relationship between the Earth and Mankind"
Oct 23	2nd Mission Definition Committee
Nov. 1-30	Additional public project recruitment of FY2002
Nov. 20	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of November 2002.
Nov. 21	Gordon Bell Awards at SC2002 in US; • "A 26.58 Tflops Global Atmospheric Simulation with the Spectral Transform Method on the Earth Simulator" (Award for Peak Performance) • "14.9 Tflops Three-dimensional Fluid Simulation for Fusion Science with HPF on the Earth Simulator" (Award for Language) • "16.4 Tflops Direct Numerical Simulation of Turbulence by a Fourier Spectral Method on the Earth Simulator" (Awards for special accomplishment)
Dec. 13	2nd Selection Committee
Dec. 24	Start of the additional authorized projects of FY2002

Year 2003

Feb. 1-2	Annual Meeting for research projects in FY2002
Feb. 28	3rd Advisory Committee
Mar. 5	3rd Mission Definition Committee
Mar. 12-30	Public project recruitment of FY2003
Apr. 10	3rd Selection Committee
Apr. 19	Open House of Yokohama Institute for Earth Sciences
Jun. 3	Won the 2003 Computerworld Honors 21st - Century Achievement Awards in the Environment, Energy & Agriculture category

Jun. 19	2nd Earth Simulator Center Symposium at NATIONAL MUSEUM OF EMERGING SCIENCE AND INNOVATION (TOKYO) "Harmonious Relationship between the Earth and Mankind~A message from another Earth"
Jun. 25	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of June 2003.
Aug. 21	4th Mission Definition Committee
Nov. 16	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of November 2003.
Nov. 20	Won the Gordon Bell Award at SC2003 in U.S.; • "A 14.6 Billion Degrees of Freedom, 5 Teraflop/s, 2.5 Terabyte Earthquake Simulation on the Earth Simulator" (Award for Peak Performance)

Year 2004

Jan. 10-11	Annual Meeting for research projects in FY2003
Jan. 21	4th Advisory Committee
Jan. 22	5th Mission Definition Committee
Feb. 2-29	Public project recruitment of FY2004
Mar. 11	4th Selection Committee
Mar. 19	Won the Tokyo Creation Award 2003
Apr. 1	Start of the authorized project of FY2004
Apr. 17	Open House of Yokohama Institute for Earth Sciences
May. 20	Won the IPSJ Industrial Achievement Award
Jun. 16	ESC made a contract with the Japan Automobile Manufacturers Association for collaborative research.
Jun. 23	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of June 2004.
Sep. 15	1st meeting of the reorganized Mission Definition Committee
Oct. 13	3rd Earth Simulator Center Symposium at Iino Hall (Tokyo) "A Harmonious Relationship between the Earth and Mankind ~ the Earth is changing this way"
Oct. 25	ESC made a contract with the Institute of Economic Research of Hitotsubashi University for collaborative research.
Nov. 8	Earth Simulator certified as the 3rd fastest supercomputer, in the TOP500 list of November 2004.
Nov. 11	Won the Gordon Bell Award at SC2004 conference in U.S.; • "A 15.2 TFlops Simulation of Geodynamo on the Earth Simulator" (Award for Peak Performance)
Nov. 29	Mid-term Evaluating Committee starts evaluating the research activities associated with the Earth Simulator.

Year 2005

Jan. 7-8	Annual Meeting for research projects in FY2004
Jan. 13	2nd Mission Definition Committee
Jan. 19	Initiation of international collaborative research with Hadley Centre for Climate Prediction and Research
Feb. 2-28	Public project recruitment of FY2005
Mar. 10	5th Selection Committee
Mar. 25-Spt. 25	EXPO 2005 AICHI JAPAN was held in Aichi Prefecture and the visual contents associated with the Earth Simulator were displayed.
Apr. 1	Start of the authorized project of FY2005
Apr. 16	Open House of the Yokohama Institute for Earth Sciences
May. 16	"The Program for Strategic Use of Advanced Large Research Facilities" project recruitment of FY2005
Jun. 13	3rd Mission Definition Committee
Jun. 20	Earth Simulator certified as the 4th fastest supercomputer, in the TOP500 list of June 2005.

Jul. 1	Starting "The Remote Batch Job Entry for Earth Simulator", for all users using the Earth Simulator inside and outside the country
Jul. 8	Start of the authorized "The Program for Strategic Use of Advanced Large Research Facilities" projects of FY2005
Jul. 12-15	Prof. Tetsuya Sato, the Director-General of the Earth Simulator Center, received the second John Dawson Prize at ICNSP&APPTC joint international conference.
Jul. 14	4th Earth Simulator Center Symposium at Chiyoda Uchi-Saiwai-cho Hall "Harmonious Relationship between the Earth and Mankind~ The front of simulation science"
Sep. 1	Won "Global 100 Eco-Tech Awards", in EXPO 2005 AICHI JAPAN
Sep. 22	4th Mission Definition Committee
Oct. 1	Start of the authorized "Core Research for Evolutional Science and Technology" projects of FY2005
Nov. 2	Dr. Sumi's project of "The Kyosei Project" (supported by MEXT) won "Nikkei Global Environmental Technology Award"
Nov. 19	Earth Simulator certified as the 7th fastest supercomputer, in the TOP500 list of November 2005.
Dec. 15-Jan. 31	"The Program for Strategic Use of Advanced Large Research Facilities" project recruitment of FY2006

Year 2006

Jan. 6-8	Annual Meeting for research projects in FY2005
Jan. 8	5th Mission Definition Committee
Jan. 20-Feb. 20	Public project recruitment of FY2006
Feb. 2	Dr. Kageyama, a project leader of Solid Earth Science research field, received JSPS (Japan Society for the Promotion Science) prize.
Mar. 8	6th Selection Committee