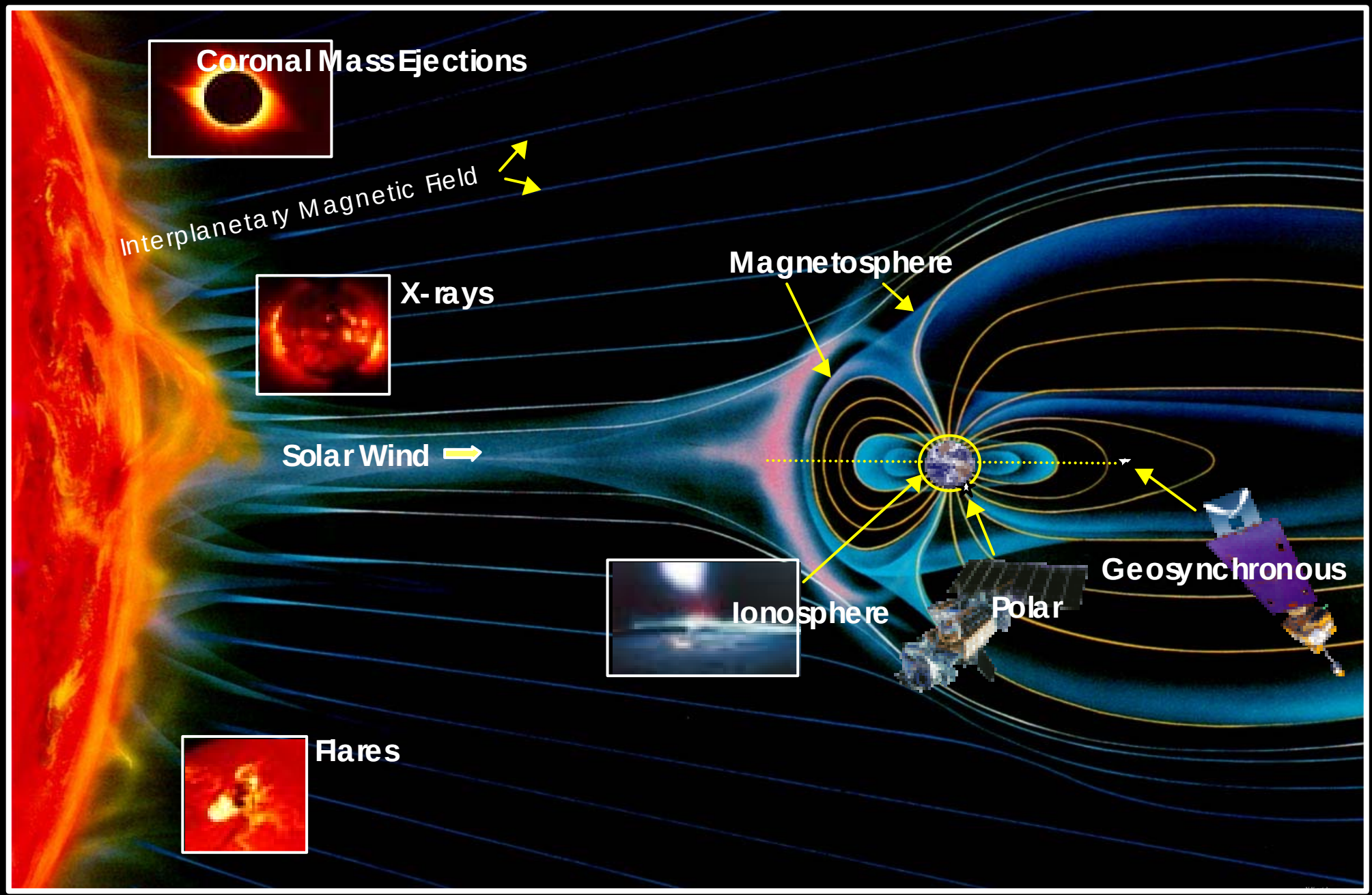
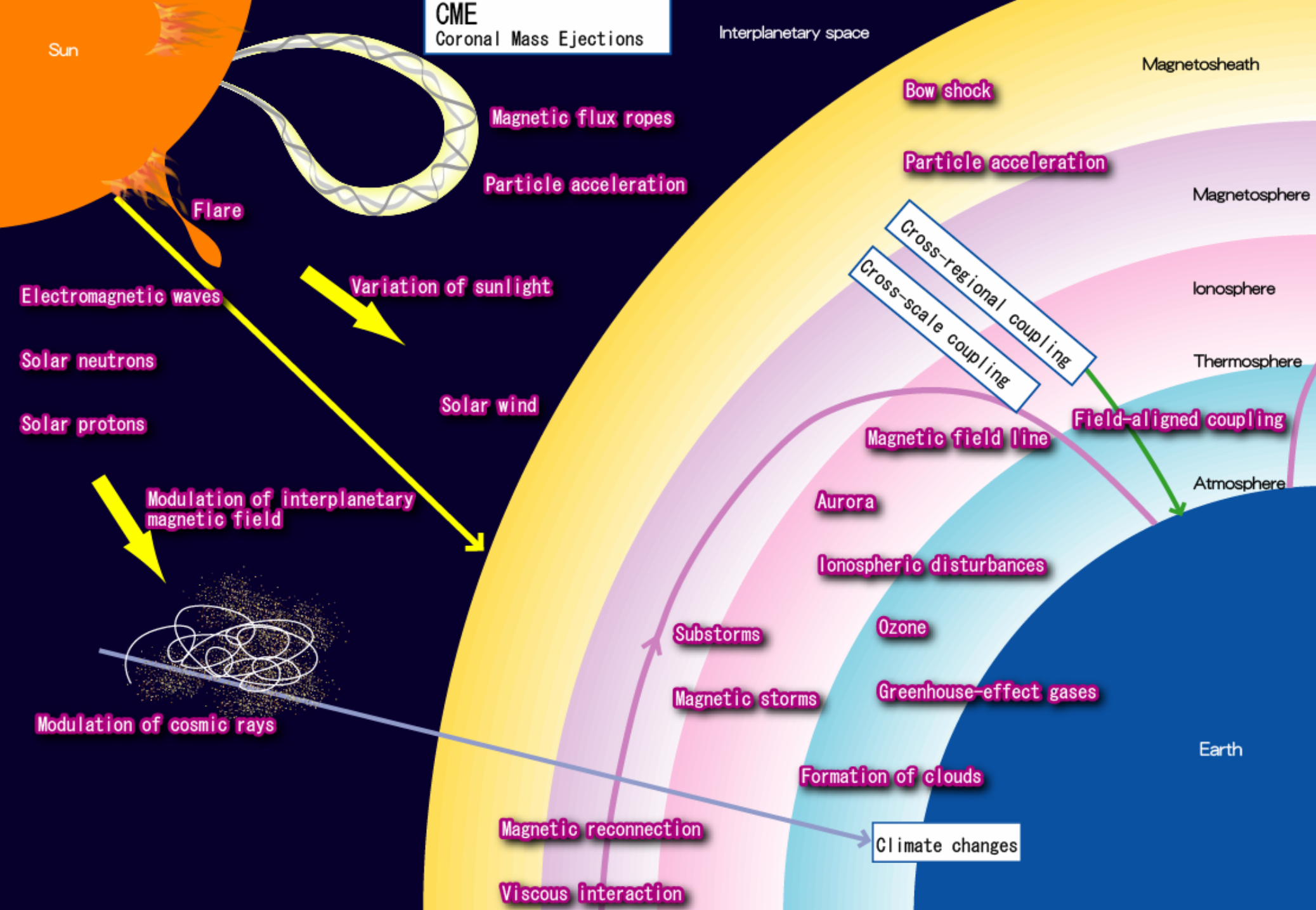
CODATA-20 Beijing, Oct 23-25, 2006

Virtual Observatory in the Geospace Environment Studies

Tatsuki Ogino and STEL Members
Solar-Terrestrial Environment Laboratory,
Nagoya University
and
Group for Creative Research Project

Solar-Terrestrial Environment




Sun
CME
Coronal Mass Ejections
Interplanetary space
Magnetosheath
Bow shock
Magnetic flux ropes
Particle acceleration
Particle acceleration
Magnetosphere
Flare
Cross-regional coupling
Cross-scale coupling
Ionosphere
Electromagnetic waves
Variation of sunlight
Thermosphere
Solar neutrons
Solar wind
Field-aligned coupling
Solar protons
Magnetic field line
Atmosphere
Modulation of interplanetary magnetic field
Aurora
Ionospheric disturbances
Ozone
Substorms
Magnetic storms
Greenhouse-effect gases
Modulation of cosmic rays
Earth
Formation of clouds
Magnetic reconnection
Climate changes
Viscous interaction

Regional Coupling in Sun-Earth System

1. From solar surface to interplanetary space

Solar flare to CME (Coronal Mass Ejection)

2. Solar wind-magnetosphere-ionosphere interaction
Coupling between the CME and magnetosphere

3. Interstellar wind-heliosphere interaction
Long term variation and solar cycle

Physical Model of Regional Coupling

Solar Physics

Flare to CME

Solar wind-magnetosphere interaction

GSFC/NASA
NRL, UCLA, Michigan
Nagoya, NICT, Kyusyu

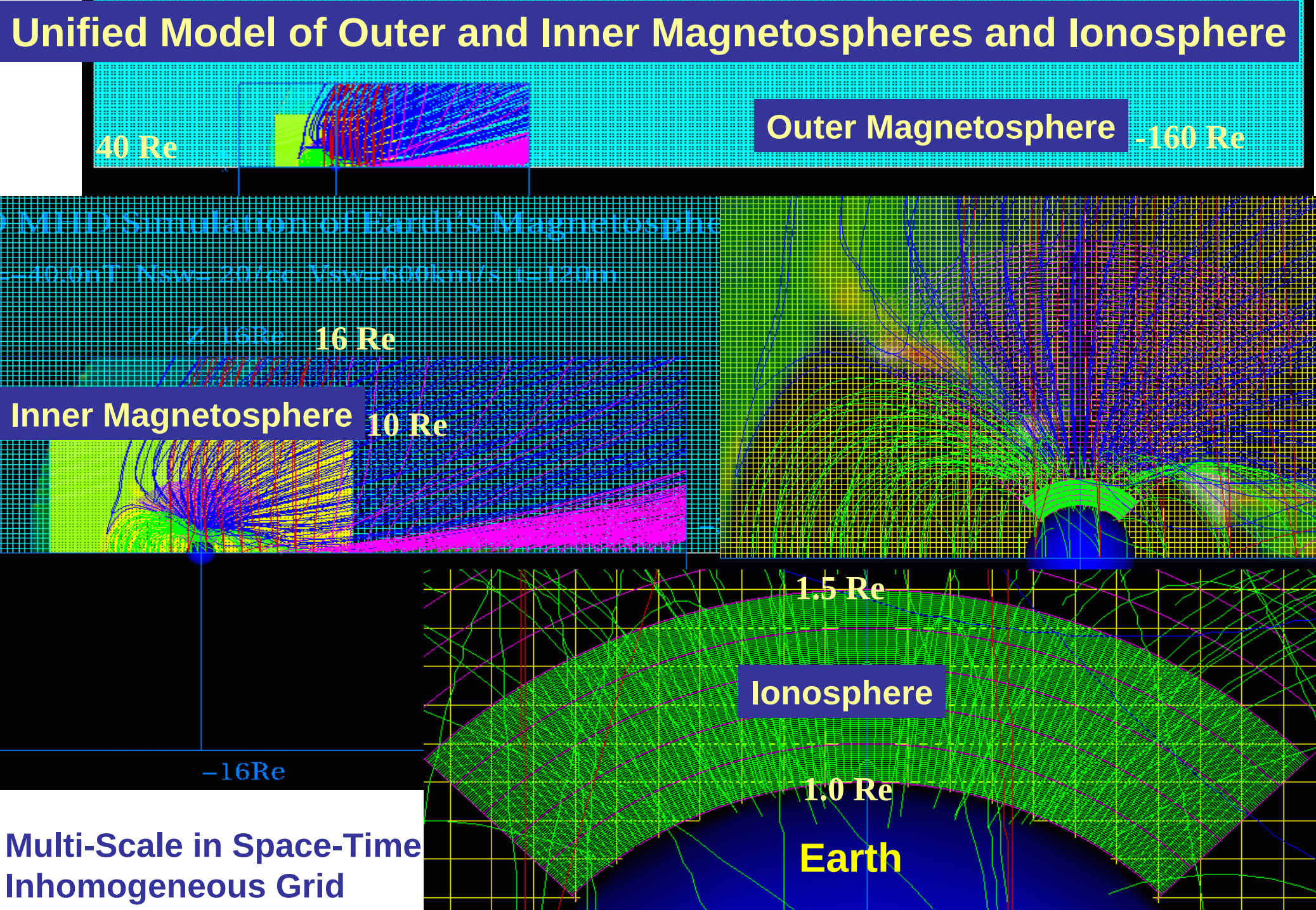
CME to Earth

M-I Coupling (KRM, AMIE)

Thermosphere Model (NCAR et al)

Solar wind-magnetosphere-ionosphere-thermosphere interaction

Unified Model of Outer and Inner Magnetospheres and Ionosphere



Multi-Scale in Space-Time
Inhomogeneous Grid

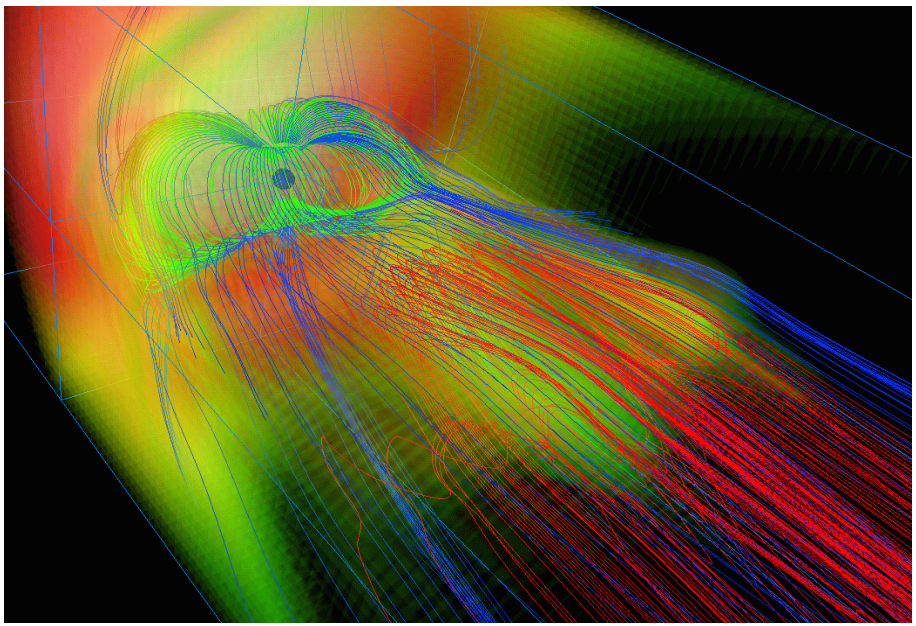
Cross-Scale Coupling in Sun-Earth System

(macro-, meso-, micro-scale coupling)

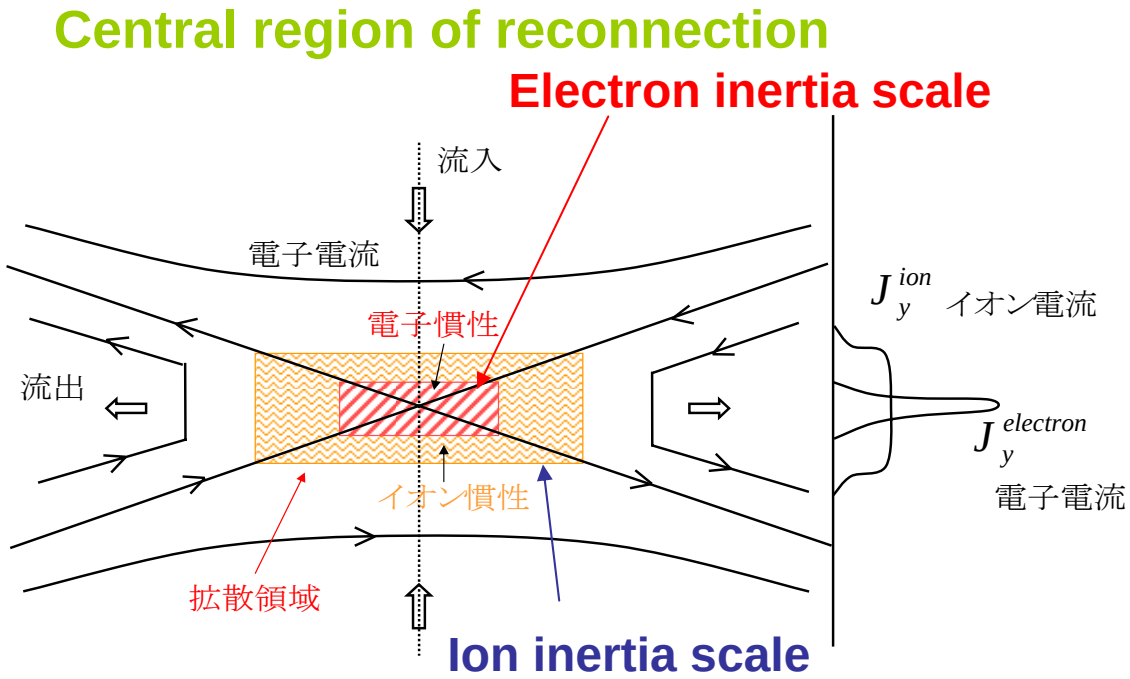
1. **Structure of magnetic reconnection (separation of Ion-electron inertia scales) and particle acceleration**
2. **Dynamics of the high energy ring current particles**
3. **Variation of high energy particles in radiation belts**
4. **Particle acceleration/precipitation in aurora region**

Magnetosphere: Cross scale coupling

Importance of magnetic reconnection for energy budget
Coupling between ion and electron inertia scales?



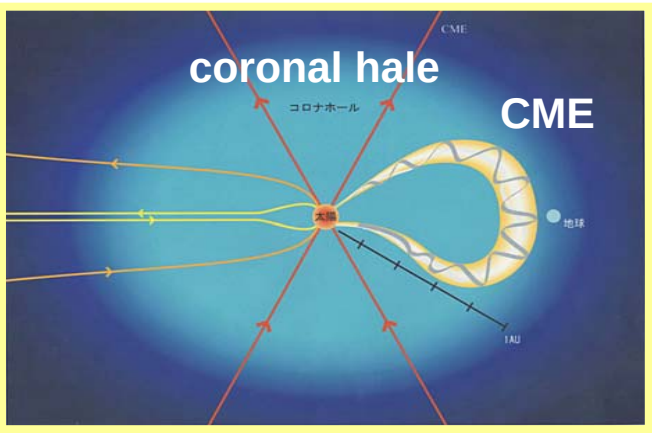
Structure of the magnetosphere and magnetic reconnection in the tail

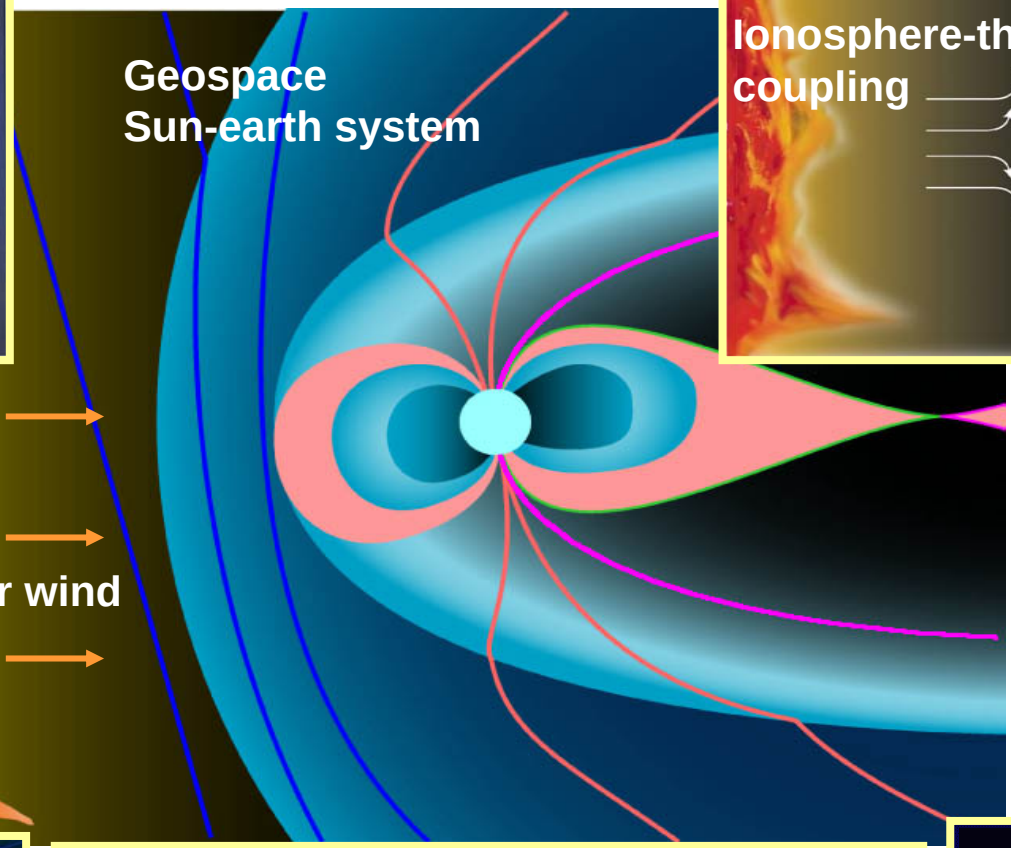


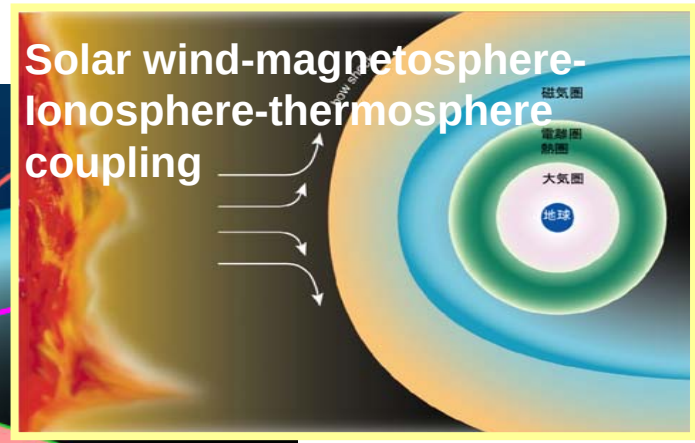
Schematic diagram of the cross scale coupling between ions and electrons in the region of tail reconnection

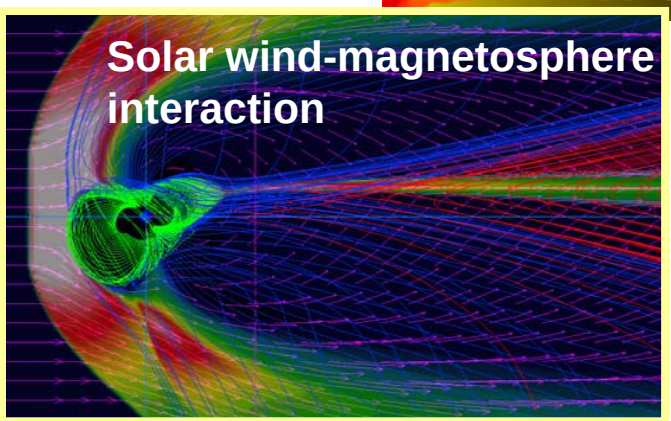
Space Weather Map

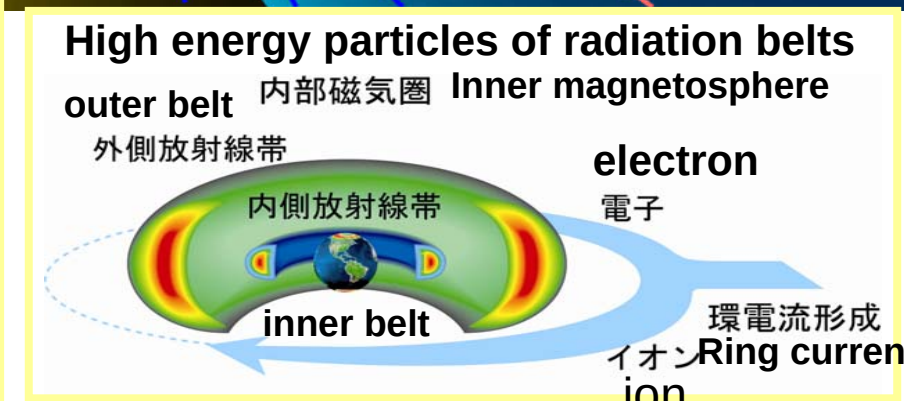
Geospace Study

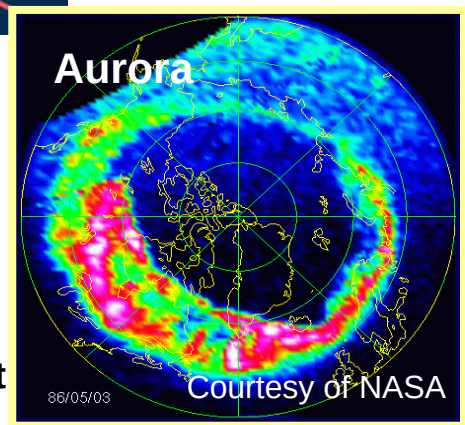












Objectives of Virtual Laboratory

1. Real time accumulation of observation data and their mutual utilization
2. Produce new simulation/modeling data by physical model using observation data as input
3. Produce animation and 3D visualization (VRML, VR) data
4. Comparison and assimilation of simulation/modeling data with observations
5. Sharing of VR function through high speed network

Supercomputing

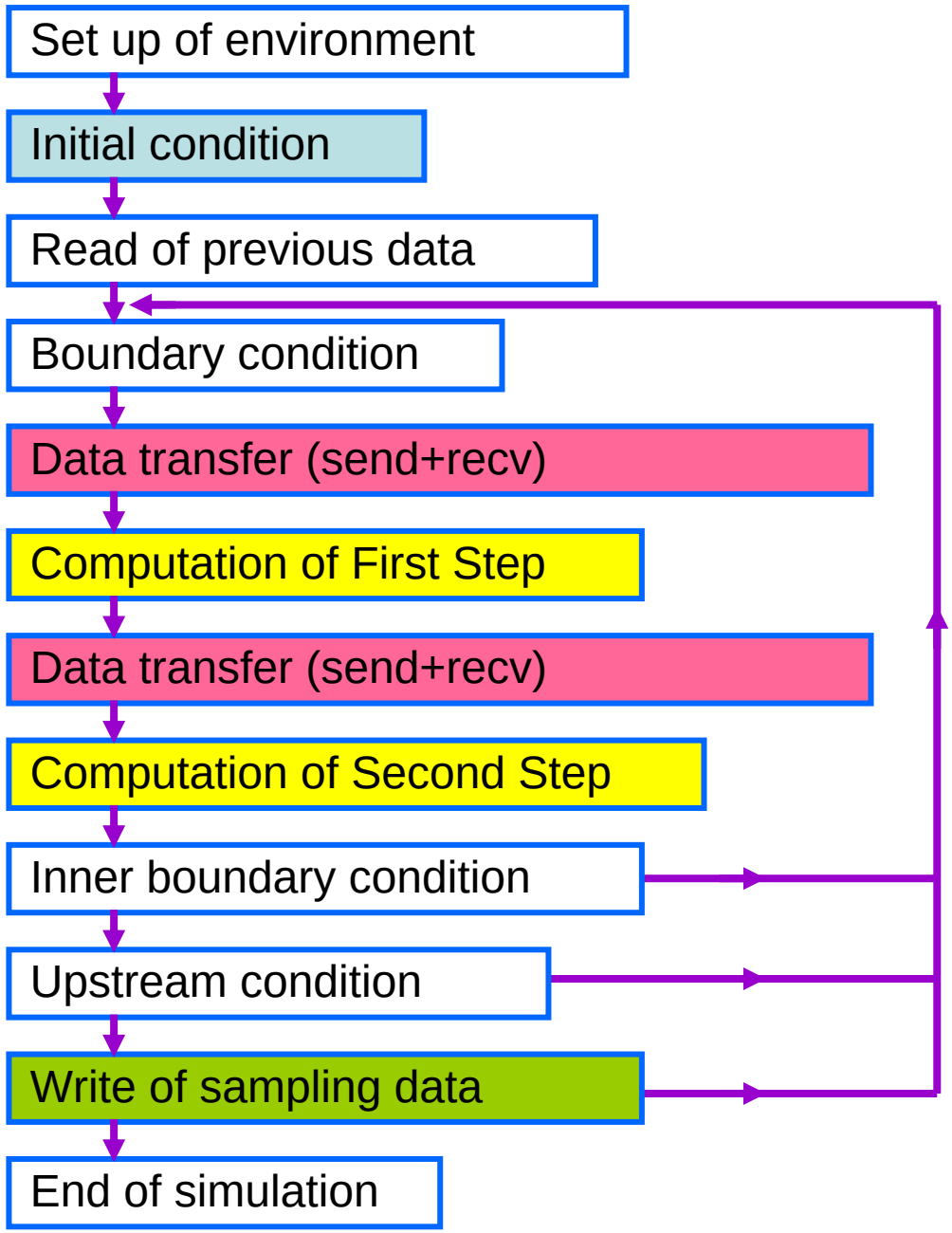
- From vector-parallel machine to scalar-parallel machine
- For high performance computation by scalar-parallel machine

Increase of the number of cpu in parallel computation
Decrease of the amount of communication
Increase of hit rate of cache

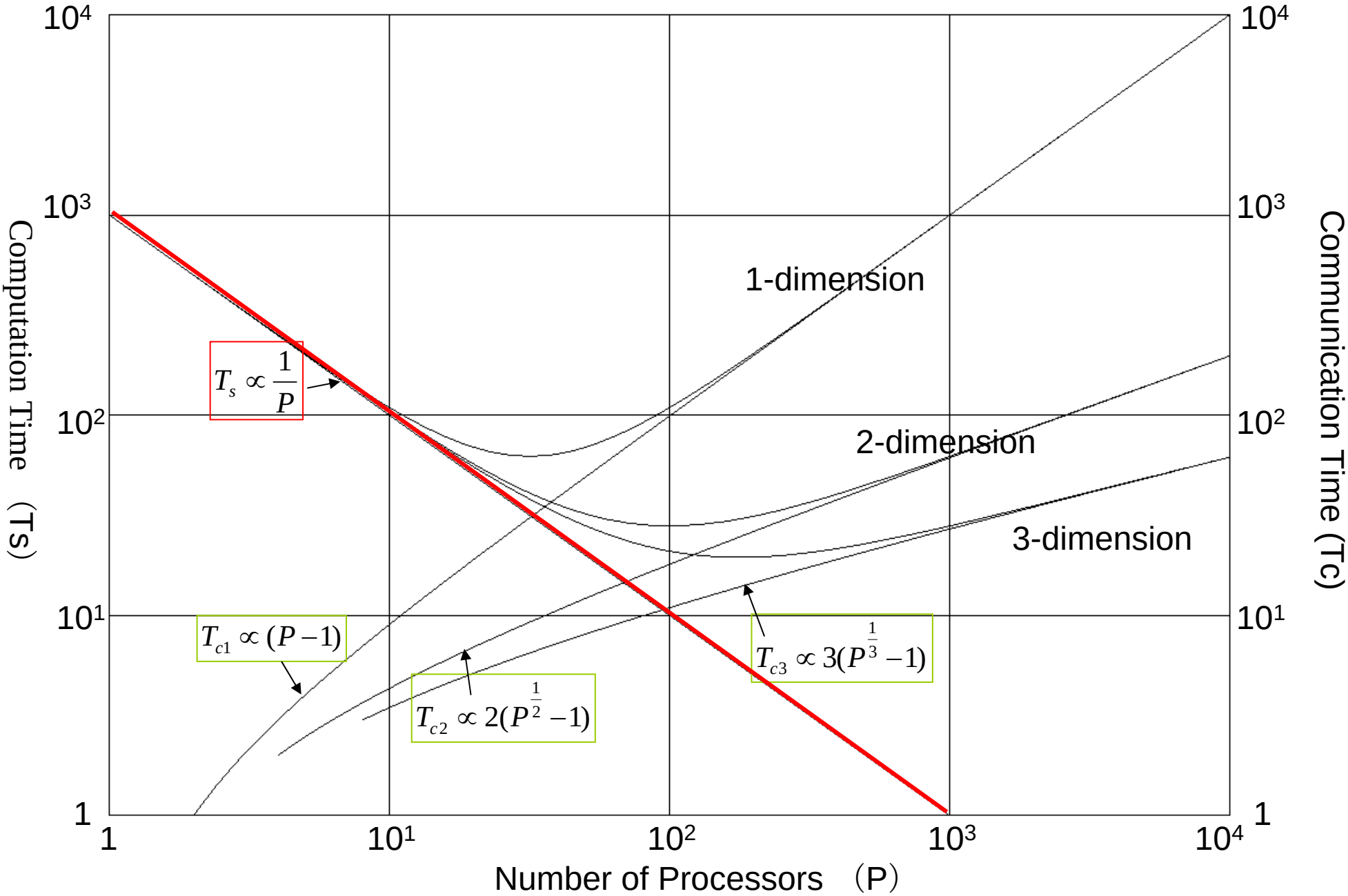
- **Parallelization of 3D MHD code**

3D array of (Nx,Ny,Nz)=(N,N,N)
3D decomposition, (Px,Py,Pz)
Number of cpu, P=Px*Py*Pz

3. New Development of 3D MHD Code by Using MPI



Efficiency of Parallel Computation by Domain Decomposition



To realize high performance computation by scalar-parallel supercomputer

- Longer inner do loop in vector-parallel machine,

This brings to decrease of the hit rate of cache in scalar-parallel machine

- Decrease of amount of communication

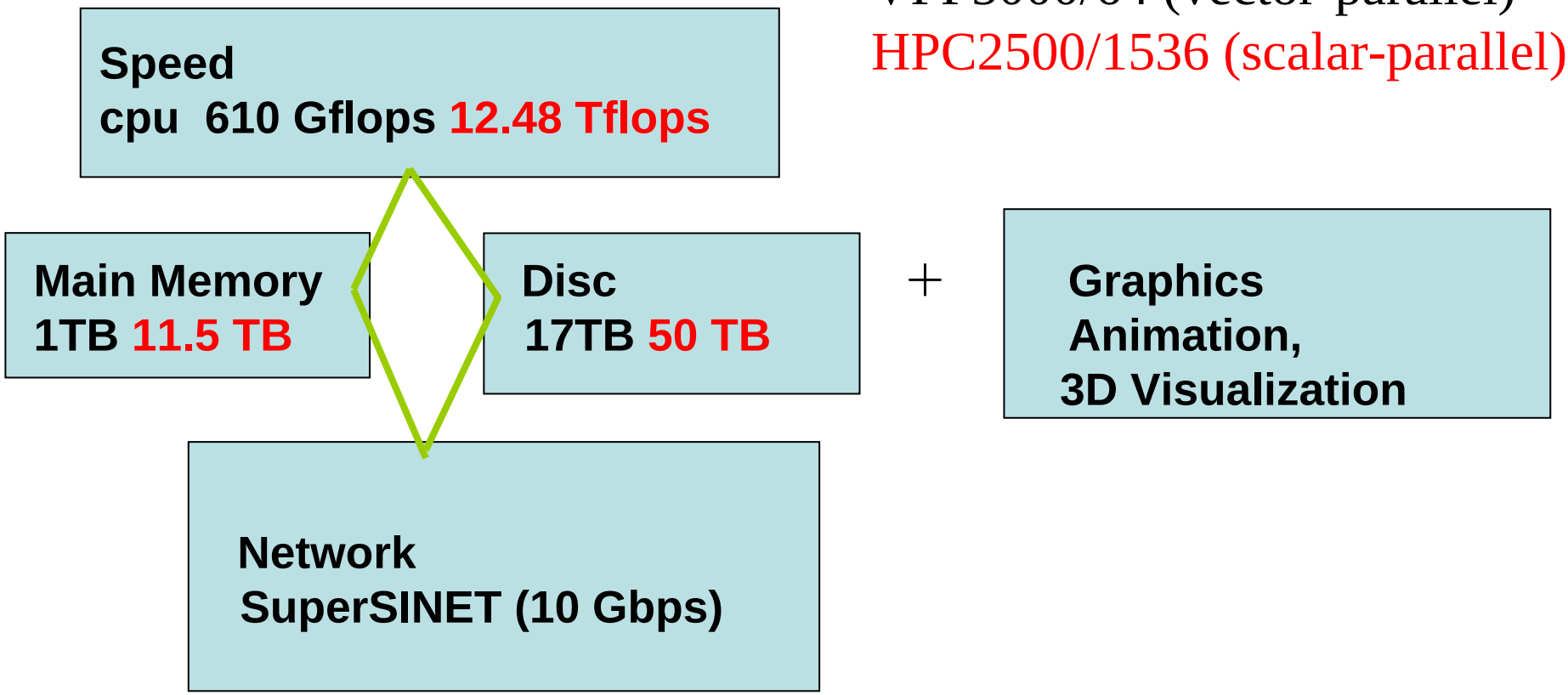
  Adoption of 2D and 3D domain decompositions

- Increase of the hit rate of cache

Put related variables in nearer addresses

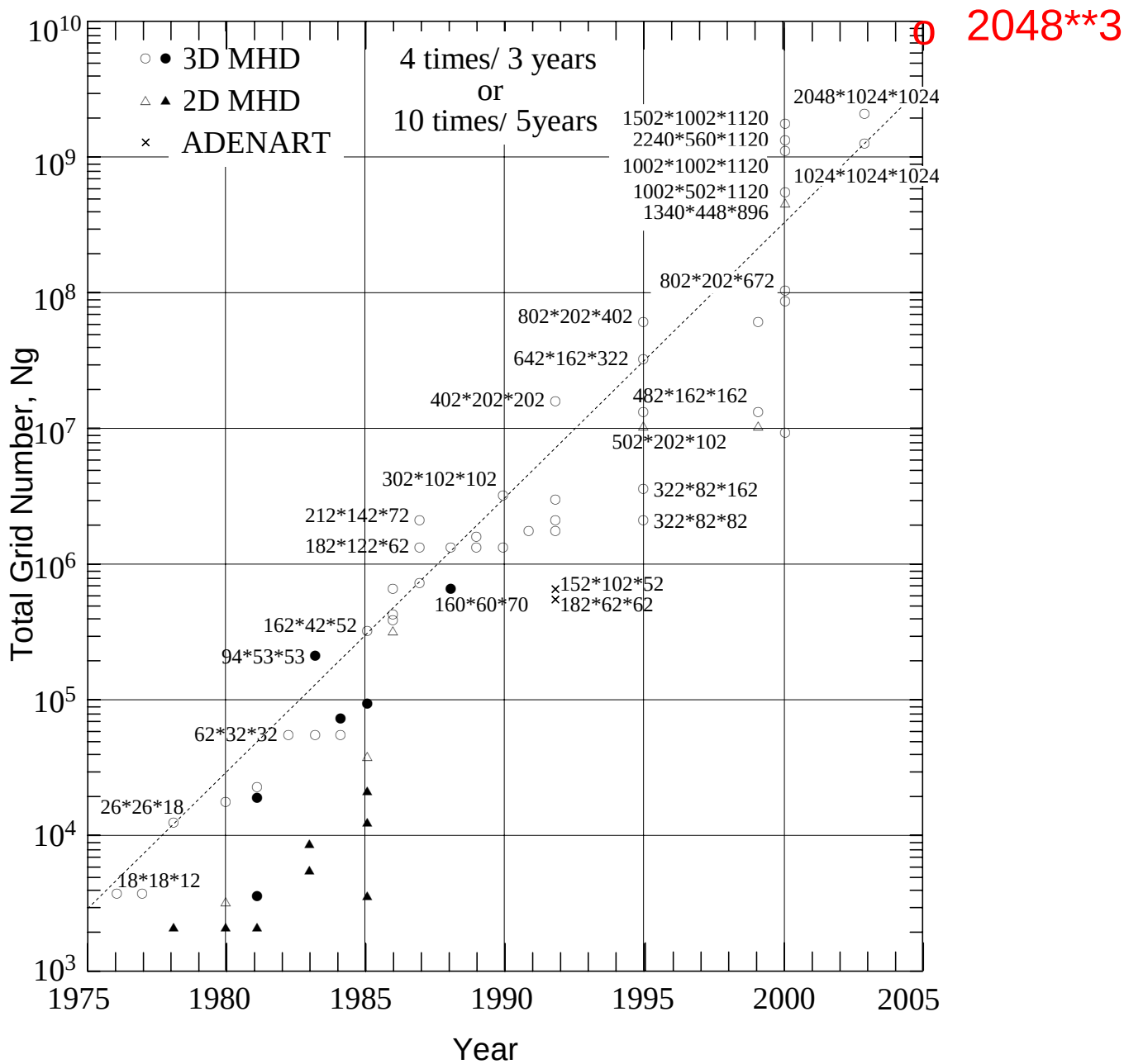
Four Key Functions of Supercomputer

VPP5000/64 (vector-parallel)
HPC2500/1536 (scalar-parallel)




Supercomputer system of the Information Technology Center, Nagoya University
Fujitsu PRIMEPOWER HPC2500/1536
21 Tflops
11.5 TB

Expansion of 2D and 3D MHD Simulations



To carry out Geospace Simulation

Use one of the largest supercomputers in the world

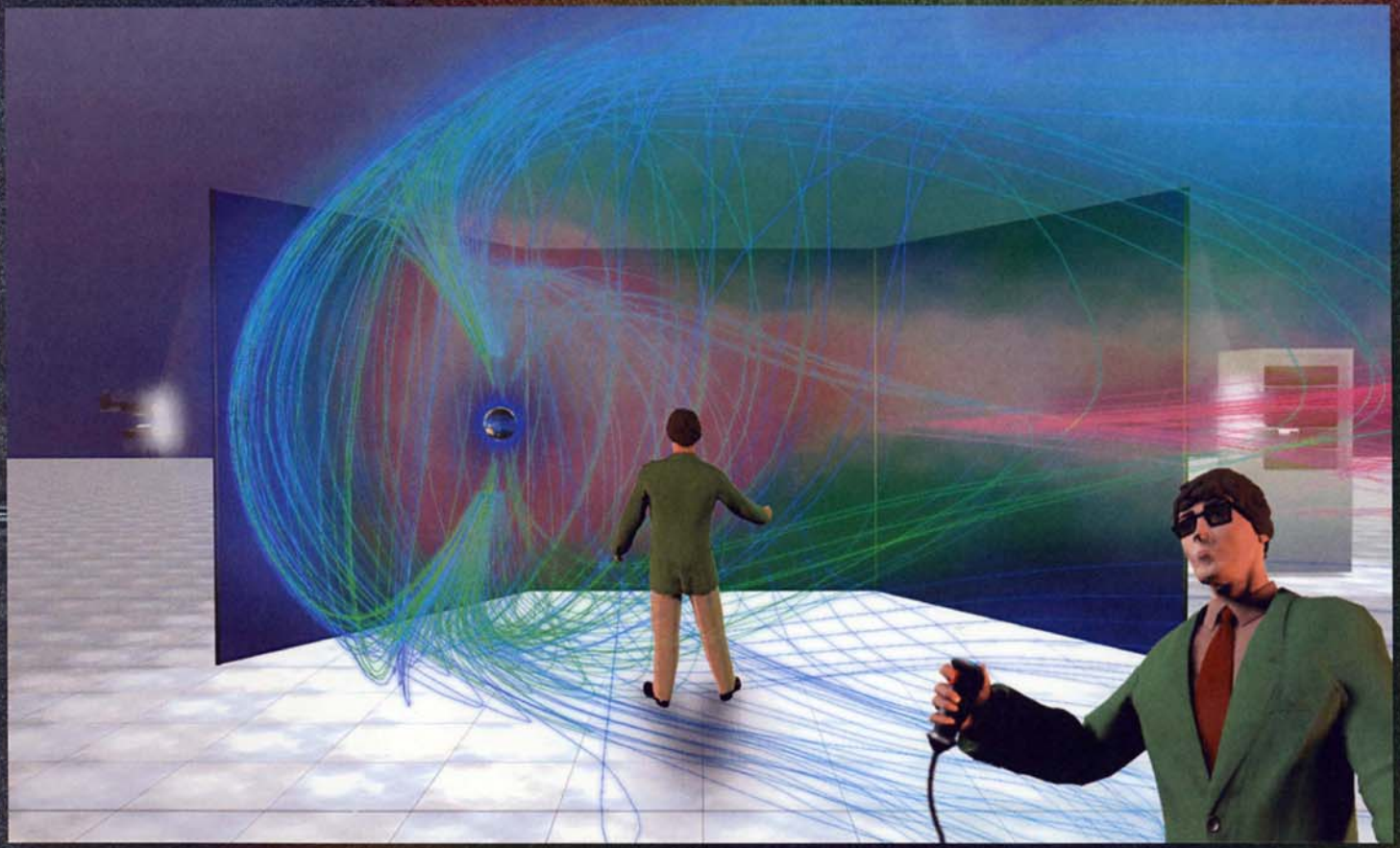
Improve numerical methods

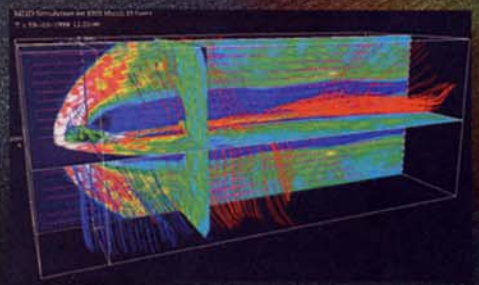
Use efficient parallel computation methods

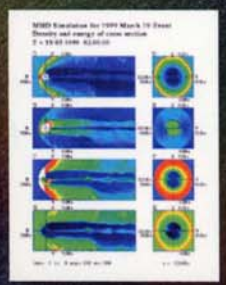
Understand well the simulation results by graphics

Virtual Reality (VR) System Using 3 Screens

SOLIDRAY







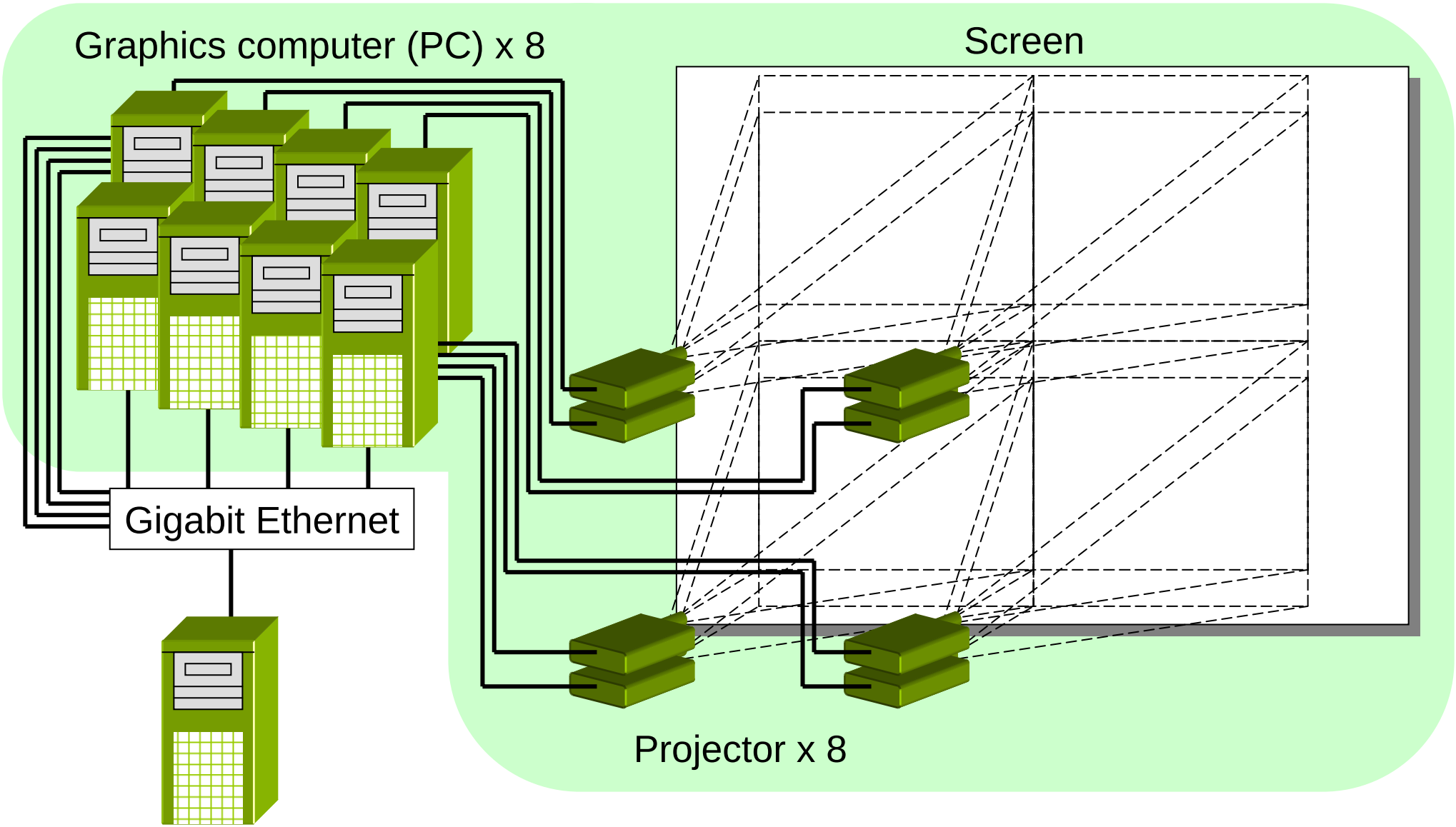
3面スクリーンシステムの特長

1. 並列PCによる高速レンダリング
2. 高性能DLPプロジェクタによる高精彩画面
3. 表示モデルを自由に操作できるWizRod
4. パーツ交換による安価なPCアップグレード
5. 低価格な保守料金

3面スクリーンシステムの主な仕様

1. 3面スクリーン(リア投影)
2. プロジェクタ:DLPプロジェクタ6台
3. PC:高速グラフィックボード　6台
4. 立体方式:円偏光
5. MMI:WizRod
6. ソフトウエア:オメガスペース

Conceptual Diagram of PLAGS VR System



Virtual Reality (VR) System

1. Use VRML, AVS, OpenGL and other softwares

   VRML: Everyone can use freely and everywhere

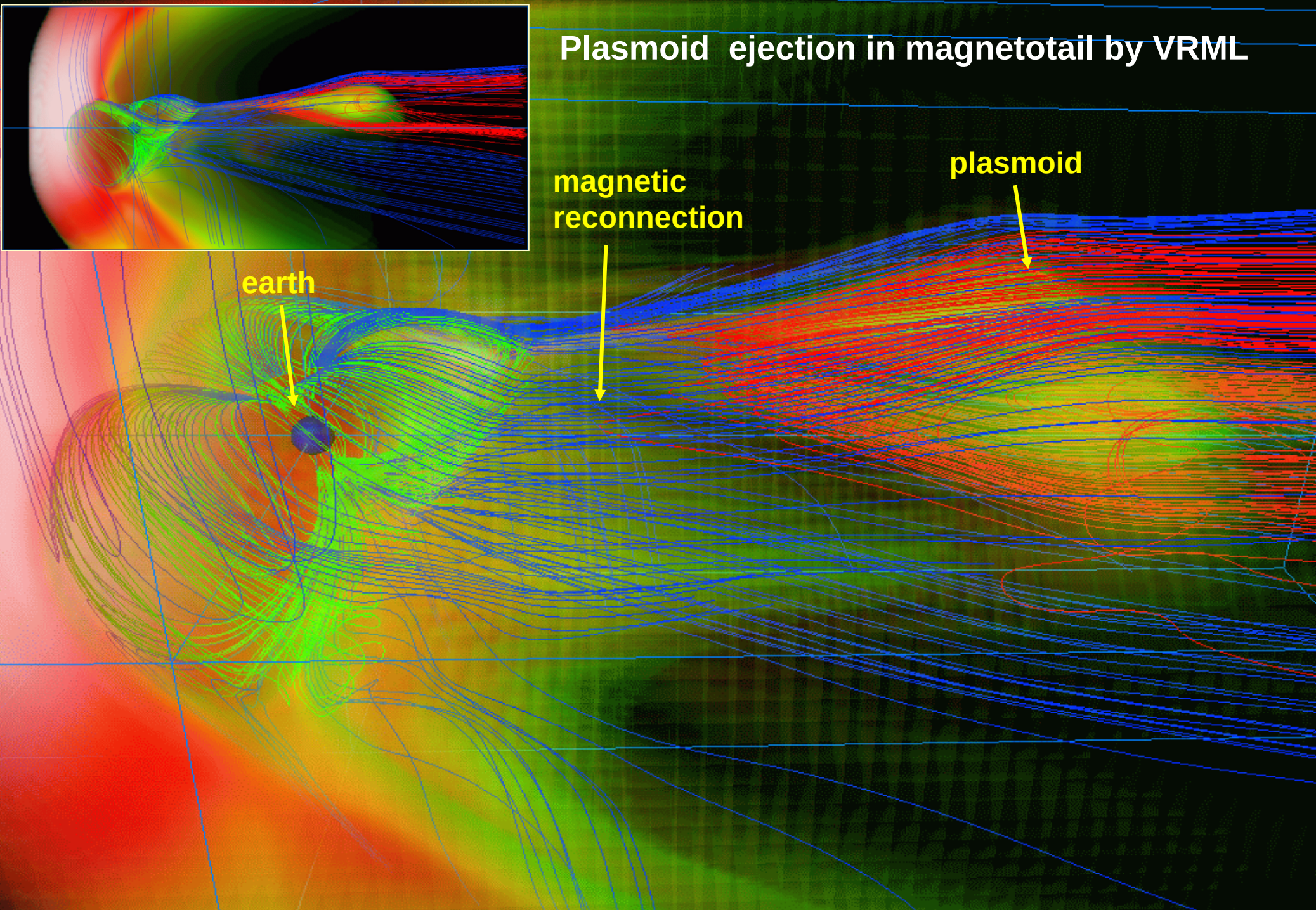
   International Standard

2. CAVE System ~2 M$

3. PC VR System (with large screen) ~20 K$

4. PC VR System (with usual screen) 2~6 K$

polarizing grasses, unaided VR, high speed Internet


Plasmoid ejection in magnetotail by VRML
magnetic
reconnection
plasmoid
earth

CAWSES Space Weather Database in Japan

Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

STEP program (1990－1997)
S-RAMP program (1998－2002)

CAWSES program (2004－2008)
The Climate And Weather of the Sun-Earth System Program

The CAWSES Space Weather Database in Japan has been begun in order to promote the international collaborative CAWSES research program.

Computer / Network

Collaborative Research Program by Using Supercomputer of the Information Technology Center, Nagoya University

From vector-parallel machine, Fujistu VPP5000/64 to scalar-parallel machine, Fujitsu PRIMEPOWER HPC2500/1536

We have developed new programs which efficiently work in the scalar-parallel machine.

GIGAbit Network and TV Conference System

On-line lecture program using a video teleconferencing system
New TV conference system using TCP/IP of Internet

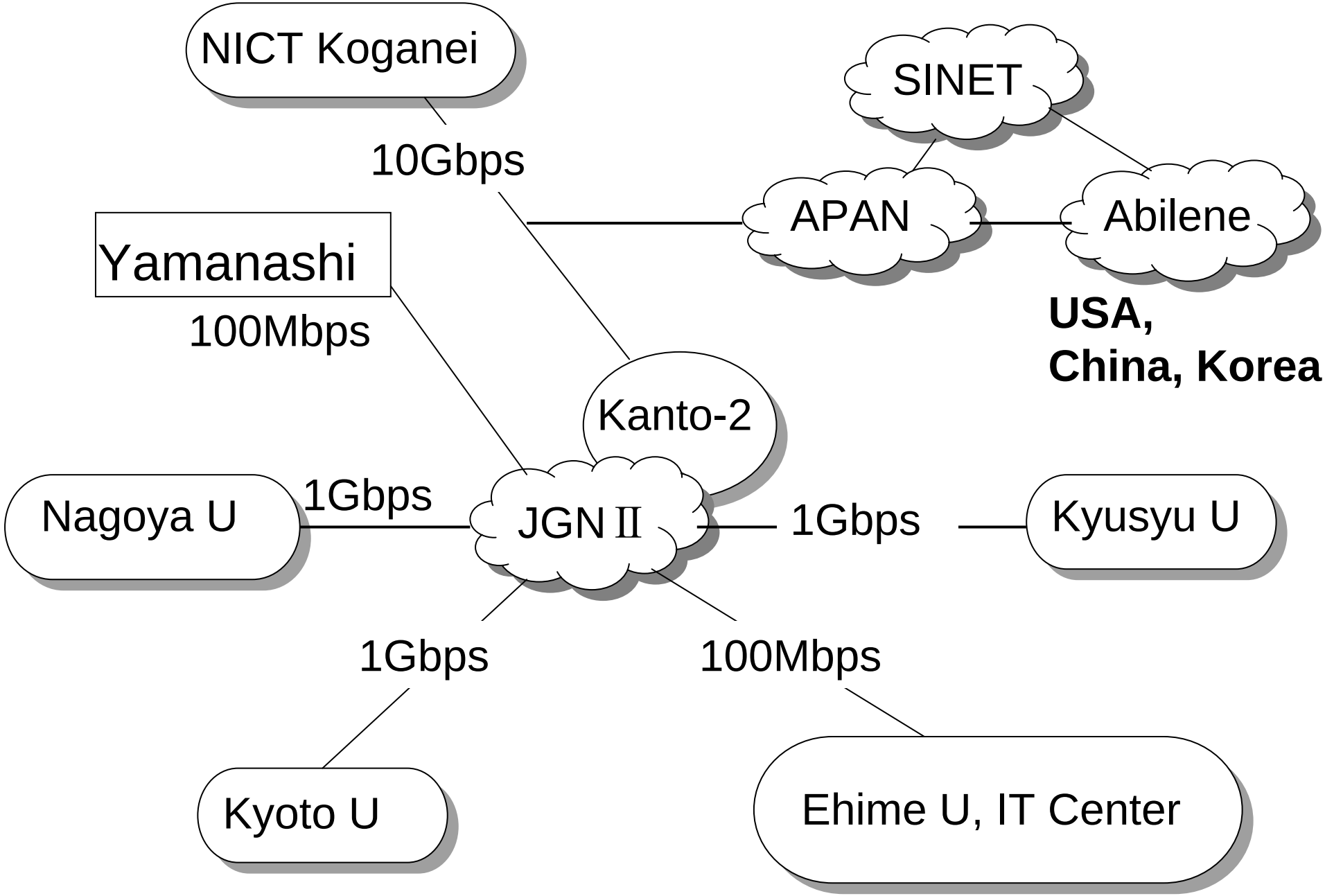
From Gigabit Network (2000-2003) to JGN2 of NICT (2004-2008)

"Common Usage of the Information of Geospace Environment Using High Speed Network" for 2004-2008

Near real-time exchange and common usage of information and data on the Geospace (Solar-Terrestrial) Environment

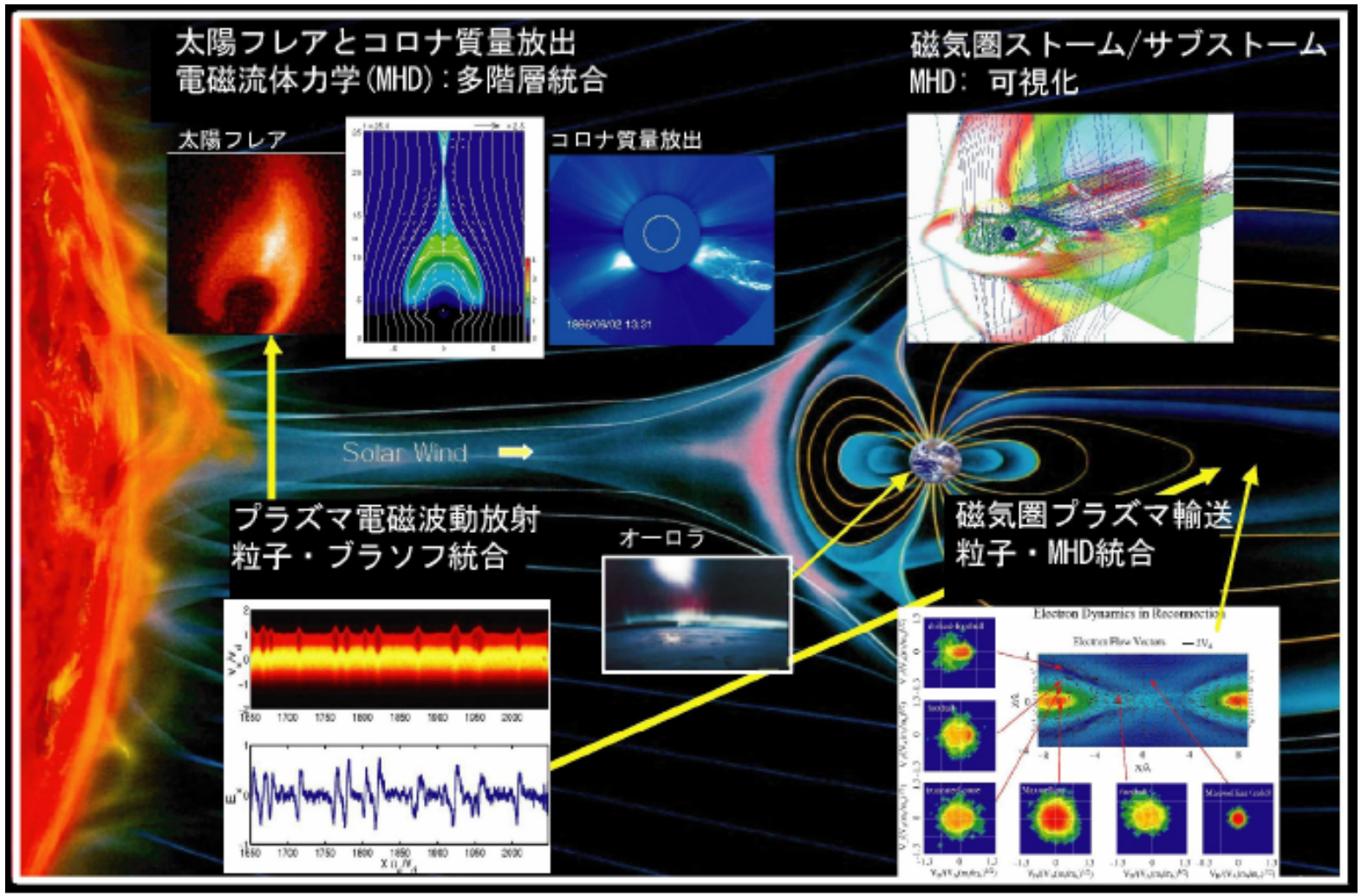
Simulation, animation movie, 3-dimensional visualization, virtual reality (VR), 4-dimensional movie

SuperSINET and JGN-2 (1-10 Gbps)



Virtual Observatory

To estimate physical quantities in the huge space by using cross scale coupling model and exchange the information via high speed network



A synthetic and integrated research project on “Space Weather Forecast”

One of the e-Science Projects (2006~)
“Geospace Virtual Laboratory/Virtual Organization”

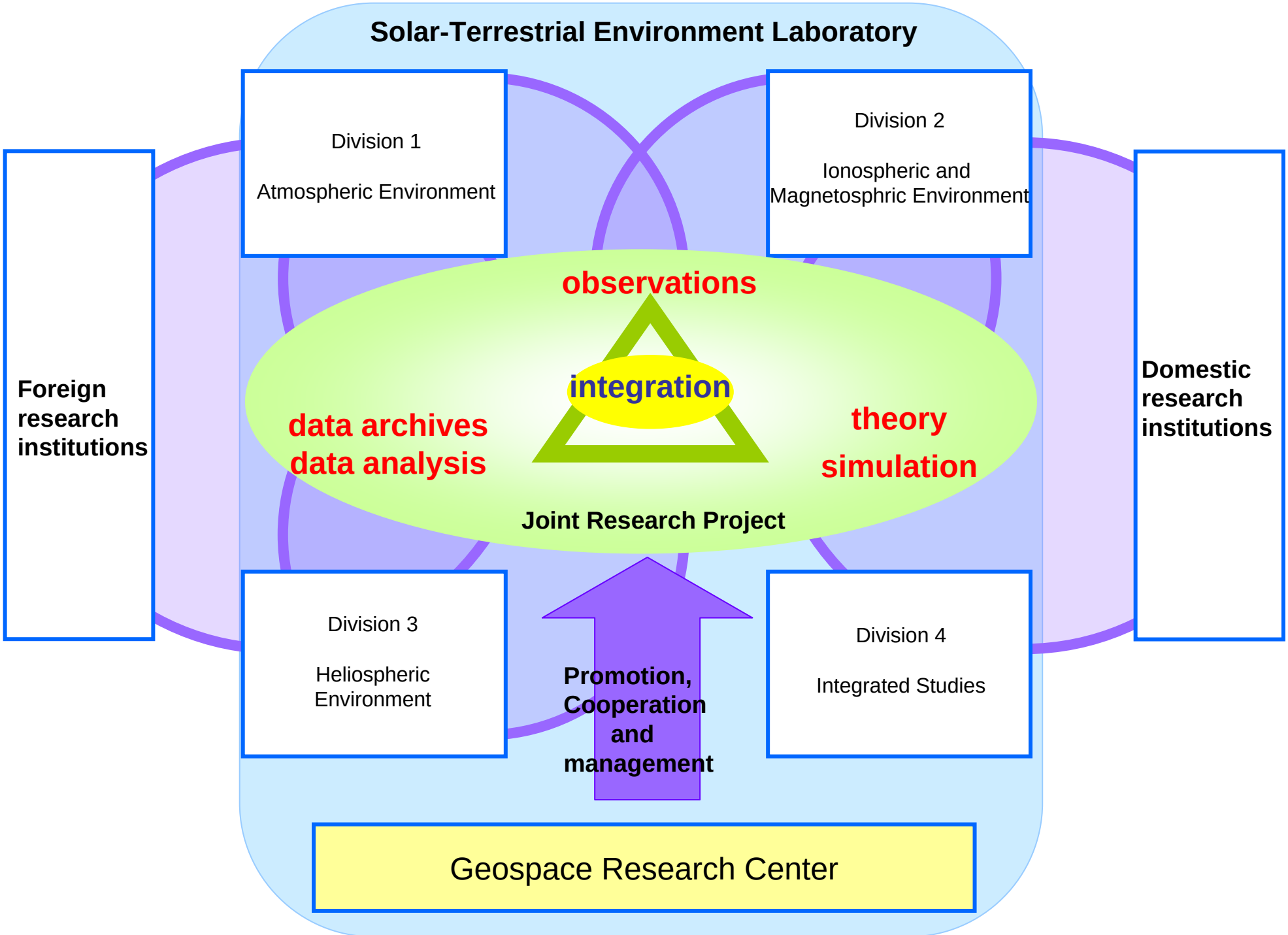
Solar-Terrestrial Environment Laboratory and
Information Technology Center of Nagoya University
(+ JAXA/ISAS, Ehime U and NICT)

Use NAREGI-Beta version grid middleware

(1) Data grid
Laboratory data, S-RAMP data, CAWSES data

(2) Graphics grid and virtual reality grid

(3) Computing grid
scheduler for supercomputers
heterogeneous computer link
programs minimizing communication amount


Solar-Terrestrial Environment Laboratory
Division 1
Atmospheric Environment
Division 2
Ionospheric and
Magnetosphric Environment
Foreign
research
institutions
observations
integration
data archives
data analysis
theory
simulation
Joint Research Project
Domestic
research
institutions
Division 3
Heliospheric
Environment
Promotion,
Cooperation
and
management
Division 4
Integrated Studies
Geospace Research Center

Virtual Laboratory

(1) Provide and share the data of observations and modeling/simulations

(2) Use mutually huge data of graphics, animation and 3-dimensional visualization through high speed network (Super-SINET, JGN-2: 10Gbps to 40Gbps? in 2008)

(3) Share the 3D visualization data (VRML, VR) Establish a system by which people can watch 3D figures of geospace under their own remote control

Real Time, Animation, Virtual Reality (VR), Advanced IT