

2009. 03. 18@OakRidge

Sustainability and High-end Super-Computing

AkimasaSumi

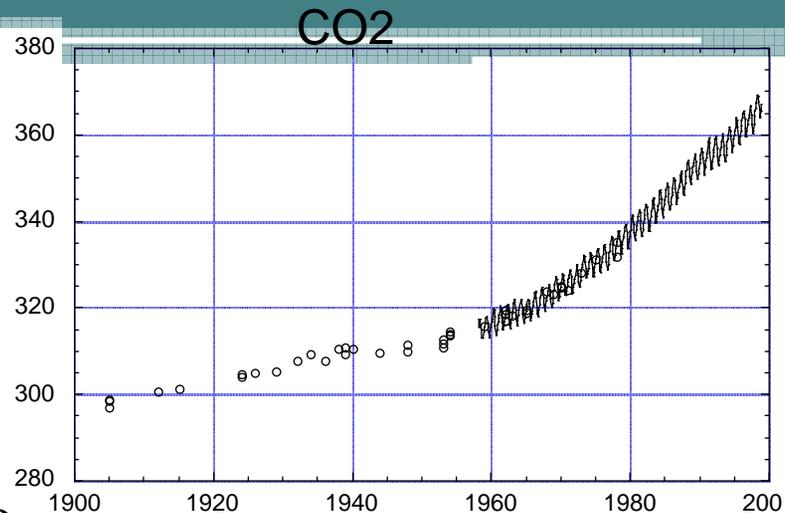
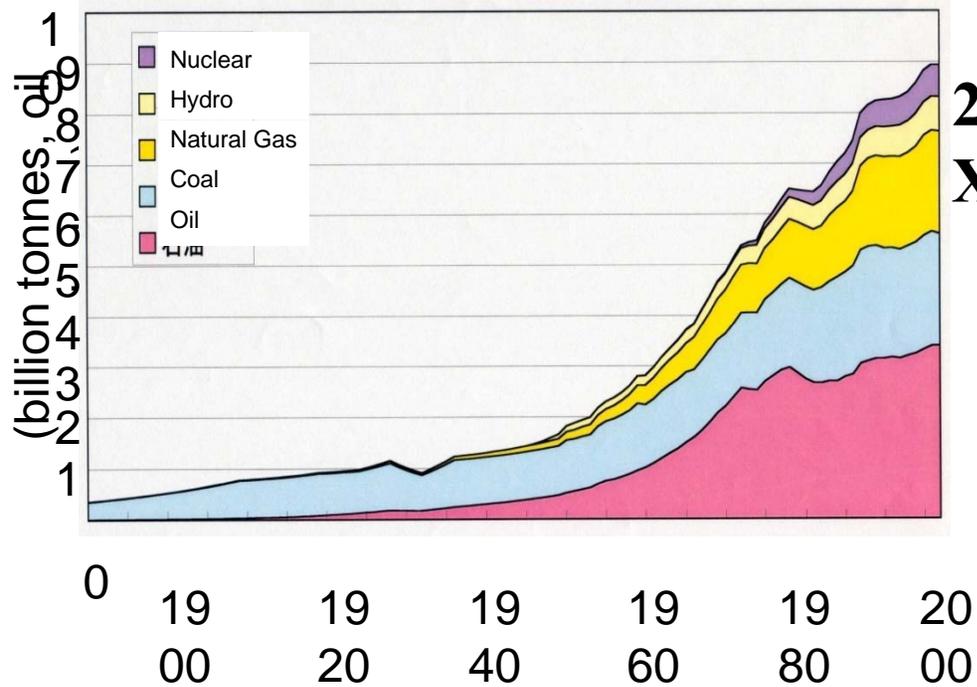
Integrated System for
Sustainability Science(IR3S)
Transdisciplinary Initiative for
Global Sustainability(TIGS)
The University of Tokyo

Sustainability

- 20th Century was an age of wars and explosion of everything!
 - For example, energy supply, food, steel production, garbage and knowledge
- 21st Century should be an age of peace and sustainability !

爆発の時代

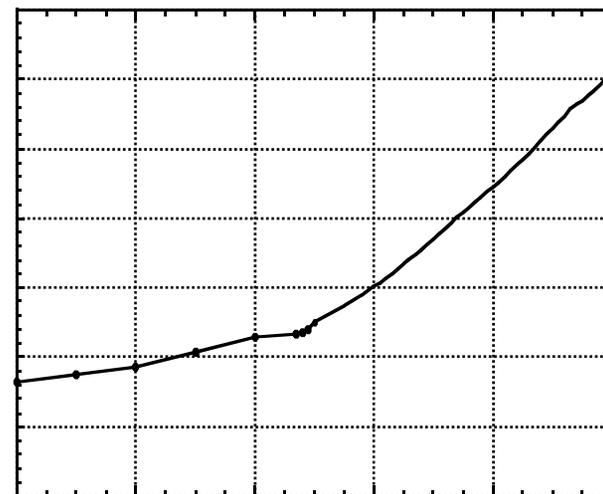
Age of Explosion



20
X

人口

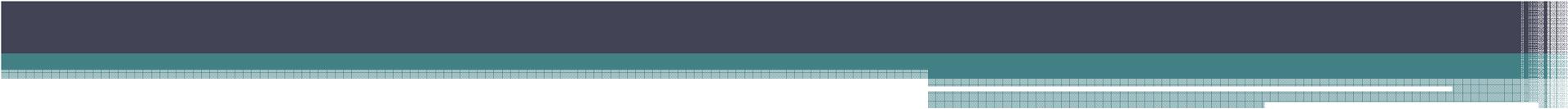
70億



1900

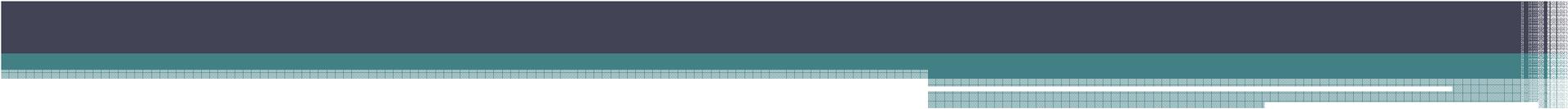
2000

Sources: UN Statistical Yearbook, BP Statistical Review of the World Energy



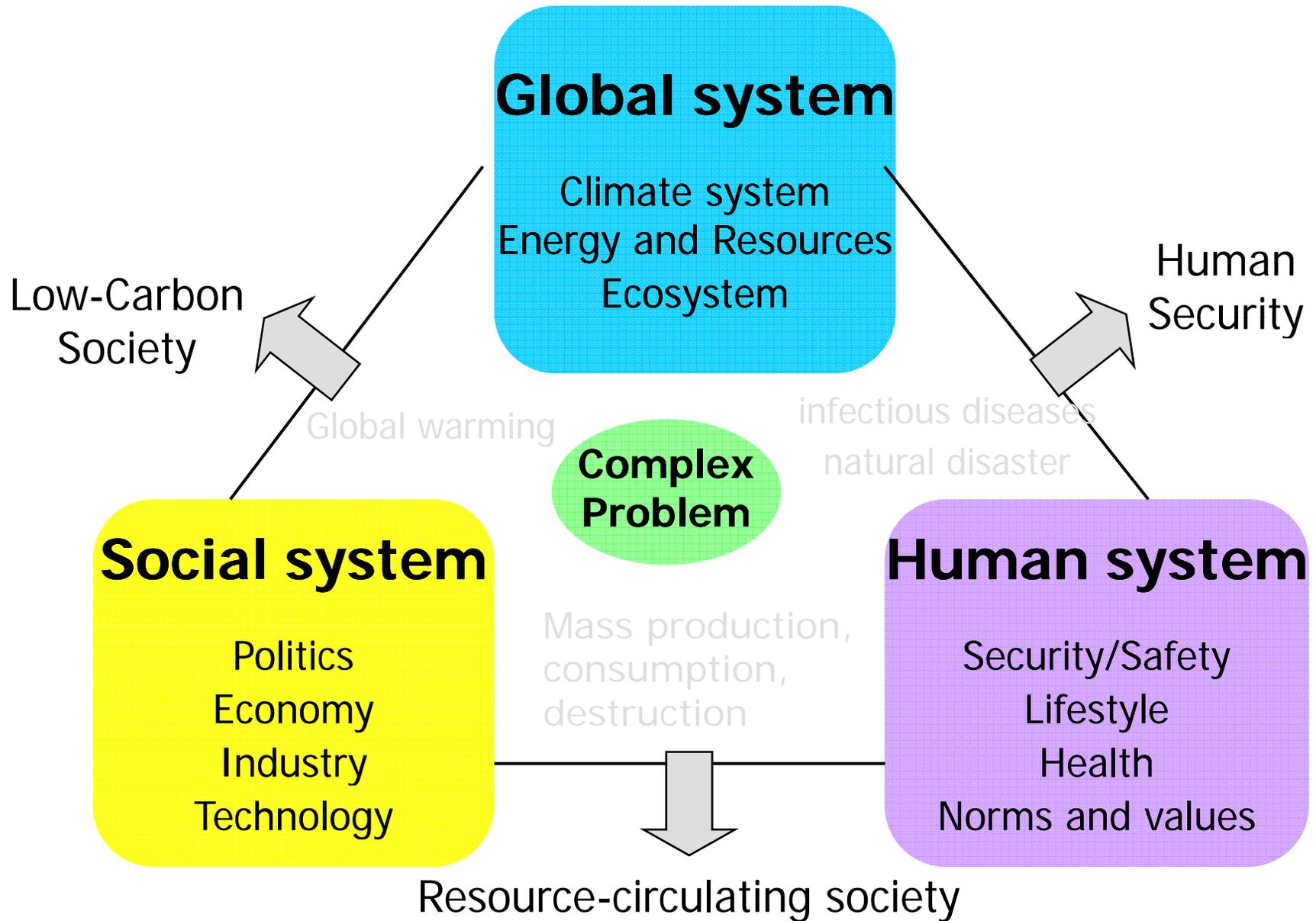
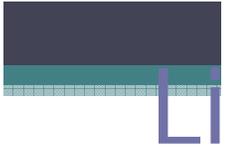
Our knowledge was accumulated through battle to evils

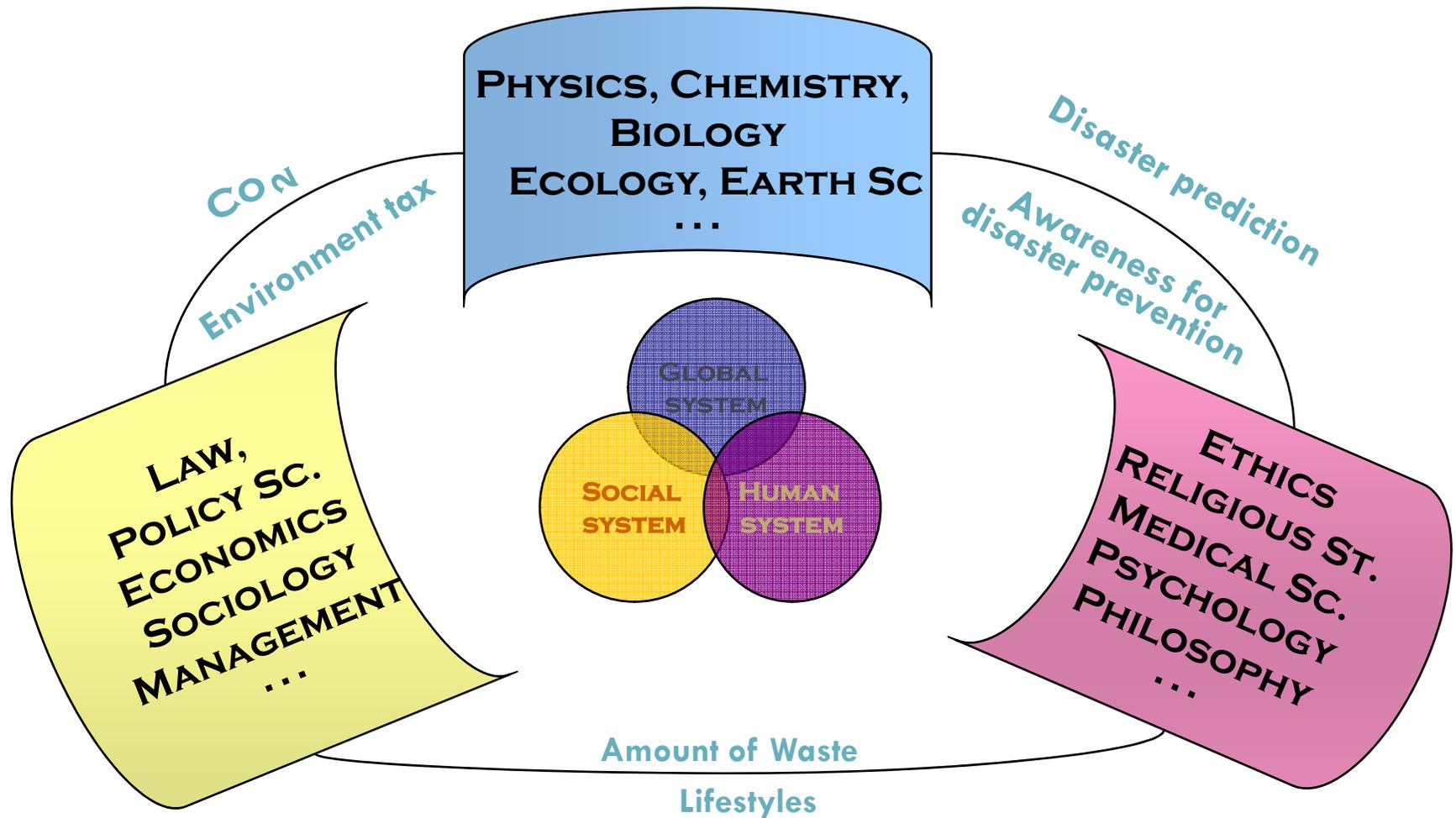
- Meteorology Storm
- Medicine Diseases
- Law Conflict between people



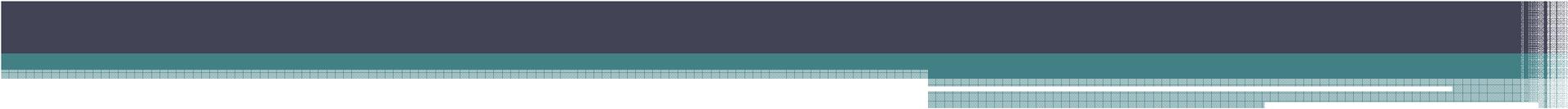
Modern evil is

- Global Warming
- Poverty
- Loss of meaning of life
- Terrorism
- Complex and multi-discipline!



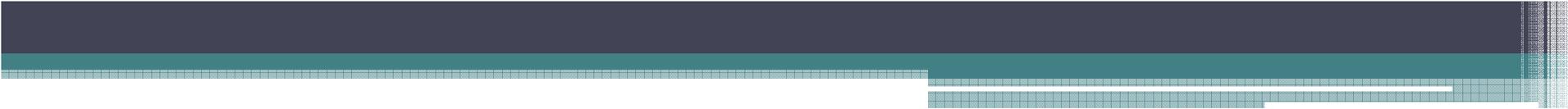


**Sustainability Science fuses
Natural and Social Sciences with indicators**



In the 19th and the 20th century, our knowledge was accumulated by

- Science is toward horizontal structure.
- Microscope and Telescope are contributed to expansion of our knowledge.



Tools

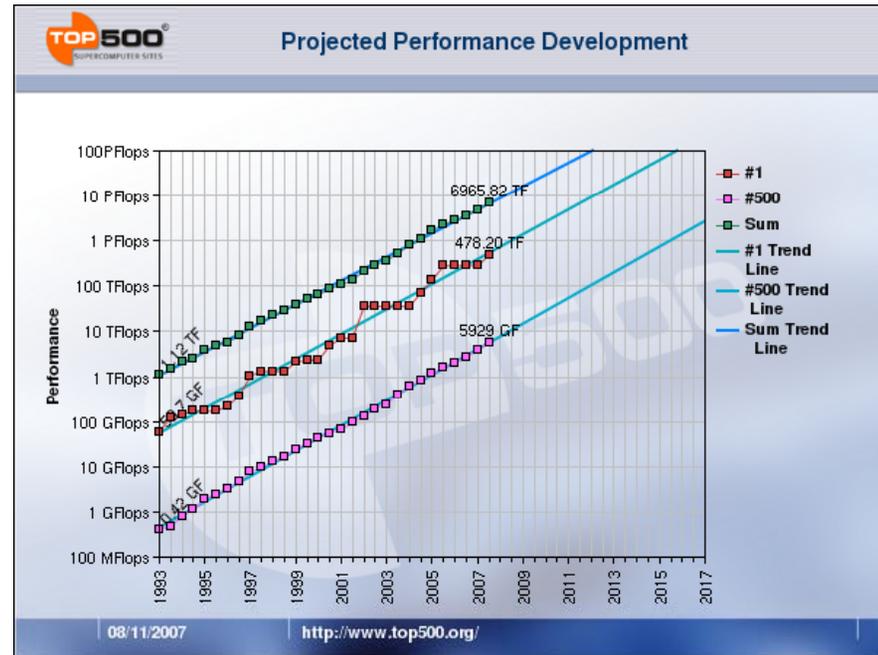
- Expansion of our view in space-time domain
- Space-domain
- Microscop
- Telescope
- Expansion of our view in space-time domain
- Simulation by models

In the 21st century,

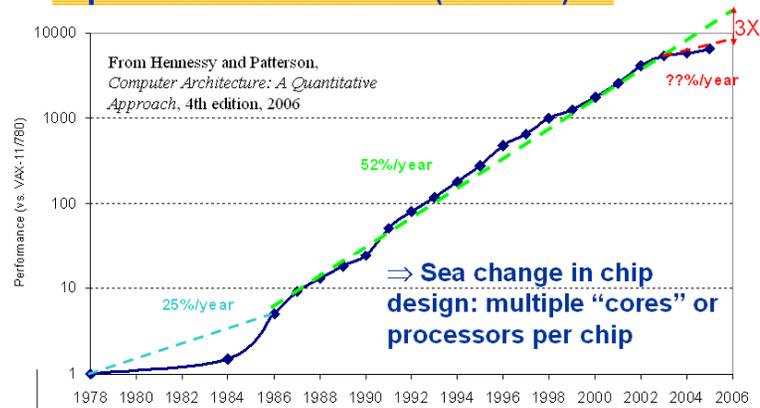
- Issues are in the spacial and temporal domain.
- We need a tool to survey this 4-dimensional space.
- Relation between space and time is a law.
- Numerical models are another new tools to survey issues in the 4-dimensional space.

Recent Trend of HPC

- **From Tera to peta: approx.10 years**
- **the 10 peta (Japan) : 10 years**
- **One order rise up 3 years**
- **Exa scale computing 2018 around**
- Peta scale computing
 - . . . the real thing
- **With rapid innovation,**
Exa-scale computing
 - . . . expected to be real in near future . . . by 2015?

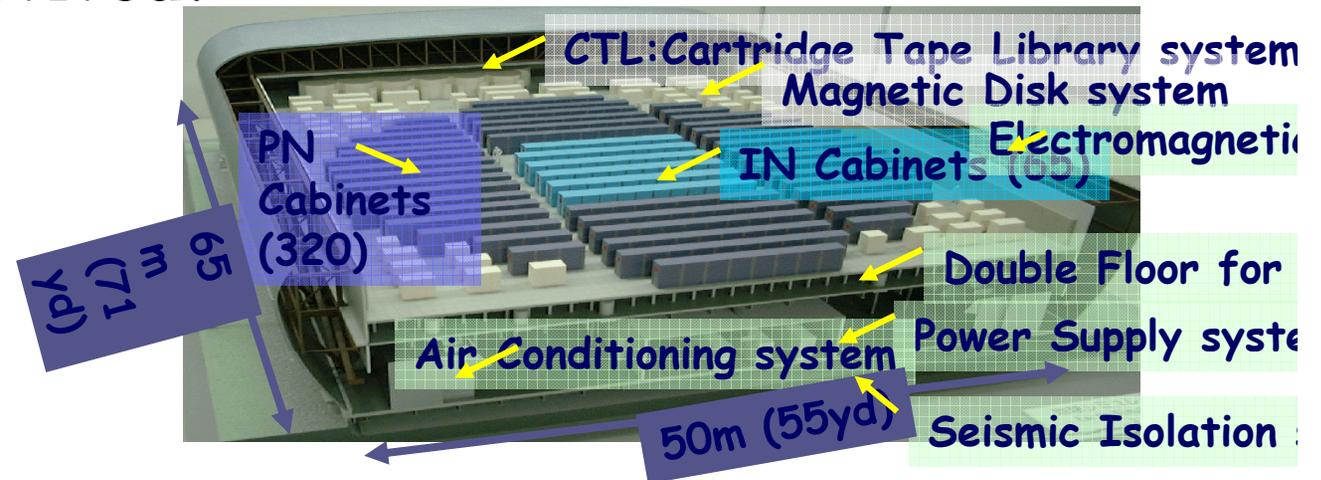


Uniprocessor Performance (SPECint)



The Earth Simulator Project

- 1998-2002
- Remarkable impacts to super-computer world!
- CRAY revived!



The CCSR/NIES/FRCGC Coupled Ocean-Atmosphere GCM for the Earth Simulator: *MIROC 3.2*

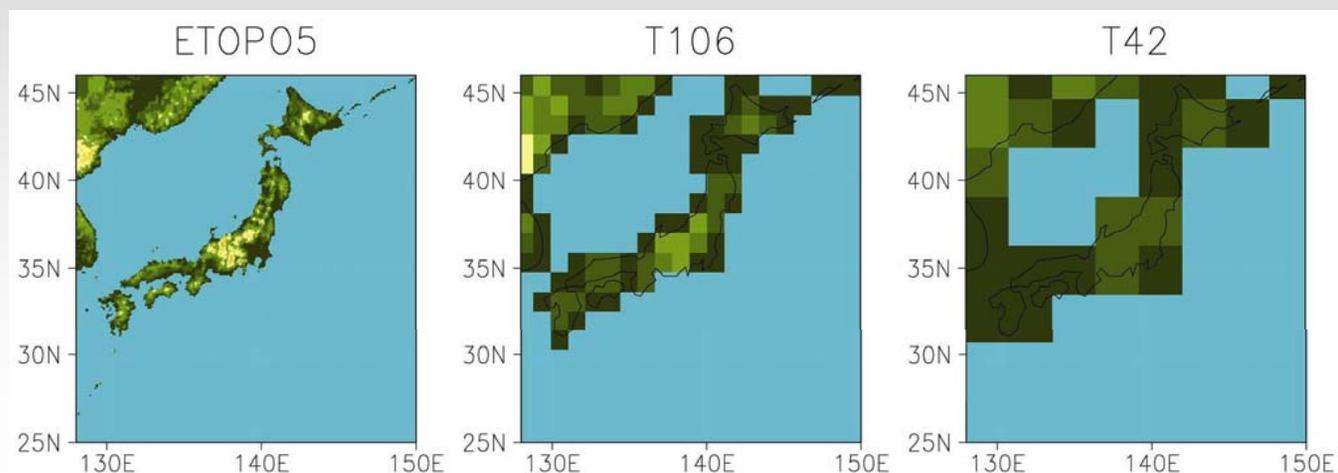


High-resolution version

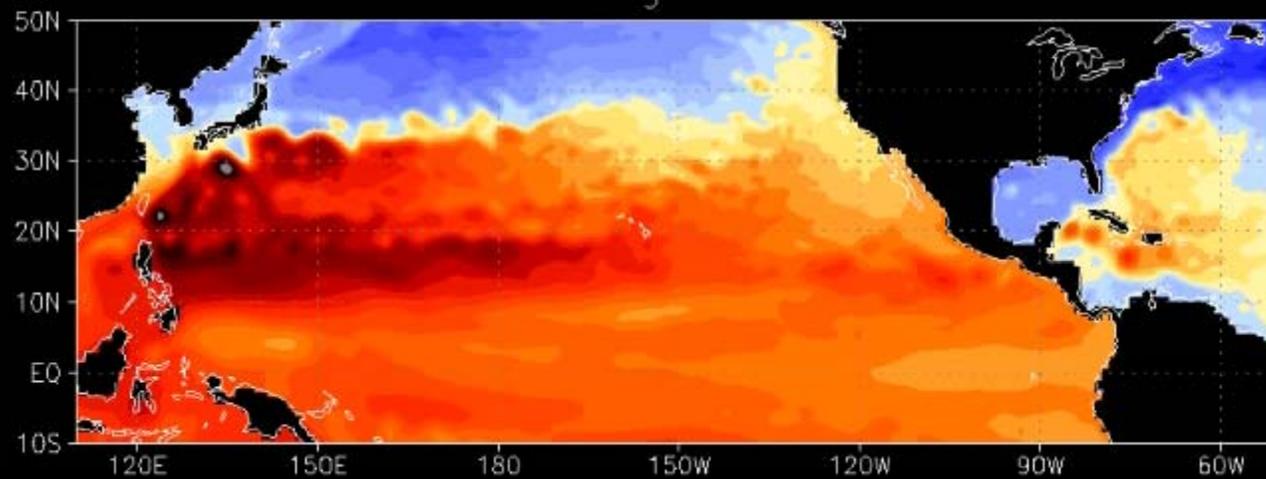
Atmos: T106 ($\sim 1.1^\circ$) L56 Ocean: $1/4^\circ \times 1/6^\circ$ L48
for regional as well as global climate change and extreme events

Medium-resolution version

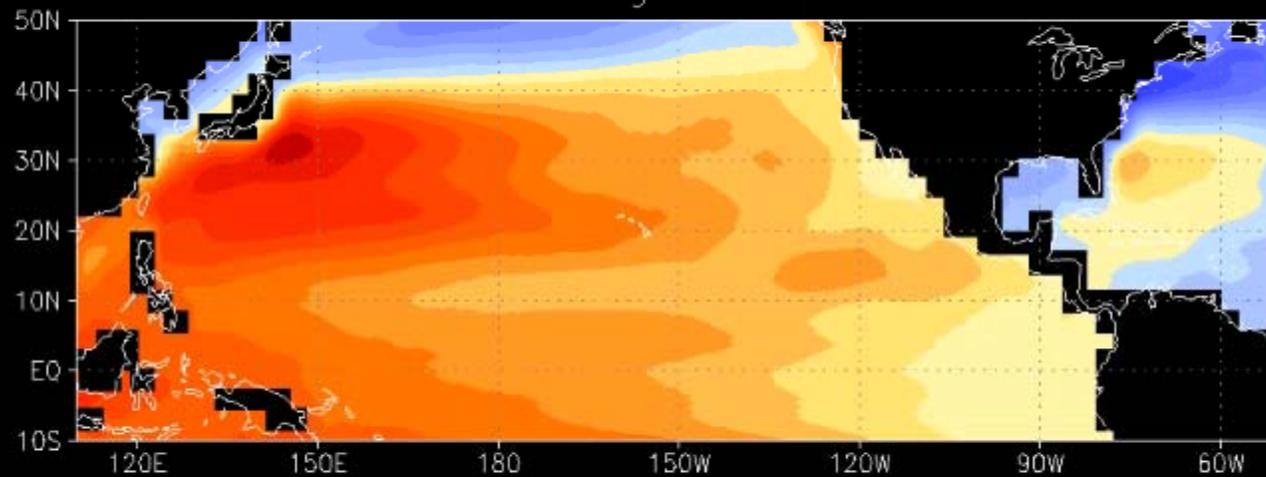
Atmos: T42 ($\sim 2.8^\circ$) L20 Ocean: $1.4^\circ \times (0.5^\circ - 1.4^\circ)$ L44
for many scenarios, ensembles and climate sensitivity issues ...



Sea Surface Height Hi-CGCM JAN21



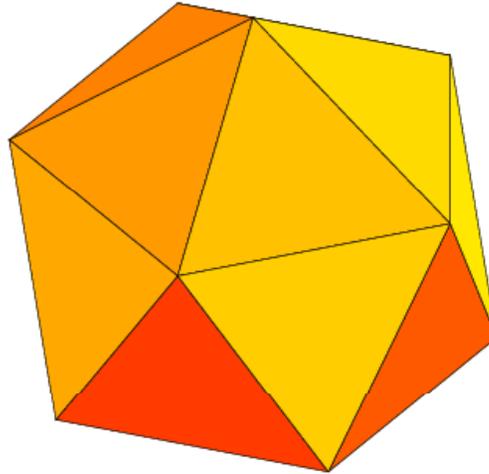
Sea Surface Height Mid-CGCM JAN21



Icosahe

Original Icosahedron

Glevel-0

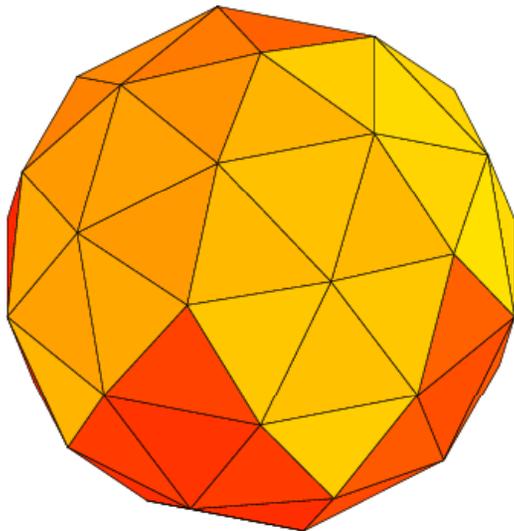


Glevel-9: $\Delta x=14\text{km}$

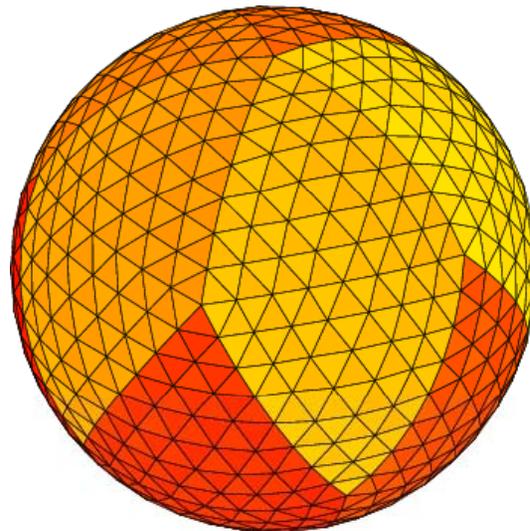
Glevel-10: $\Delta x=7\text{km}$

Glevel-11: $\Delta x=3.5\text{km}$

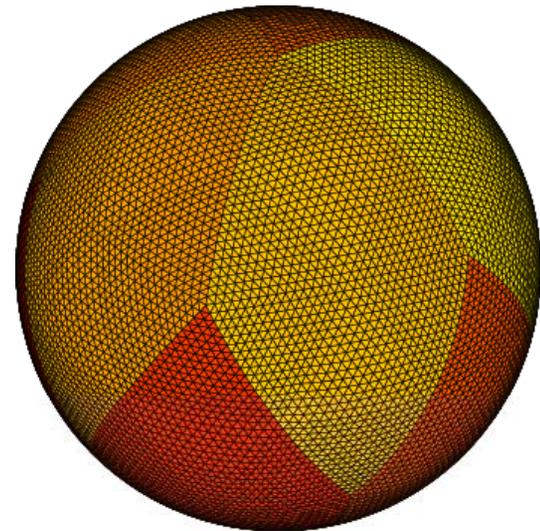
Glevel-1

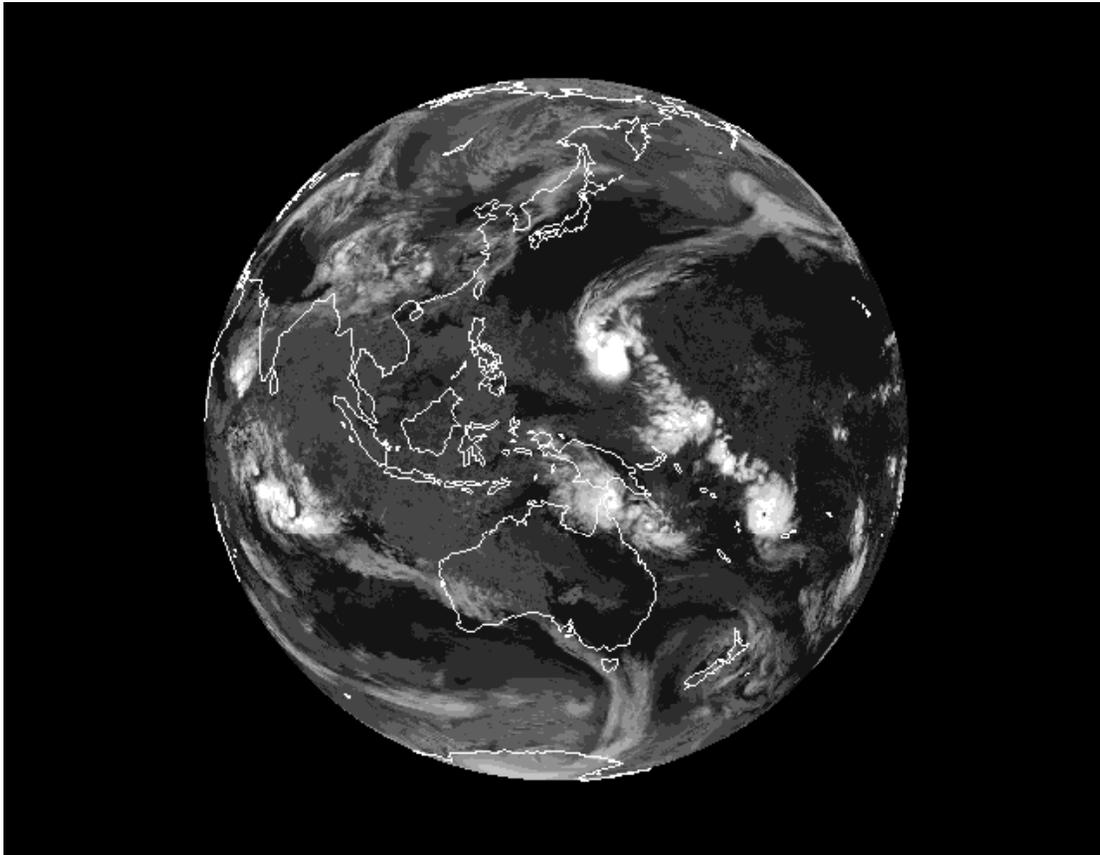


Glevel-3



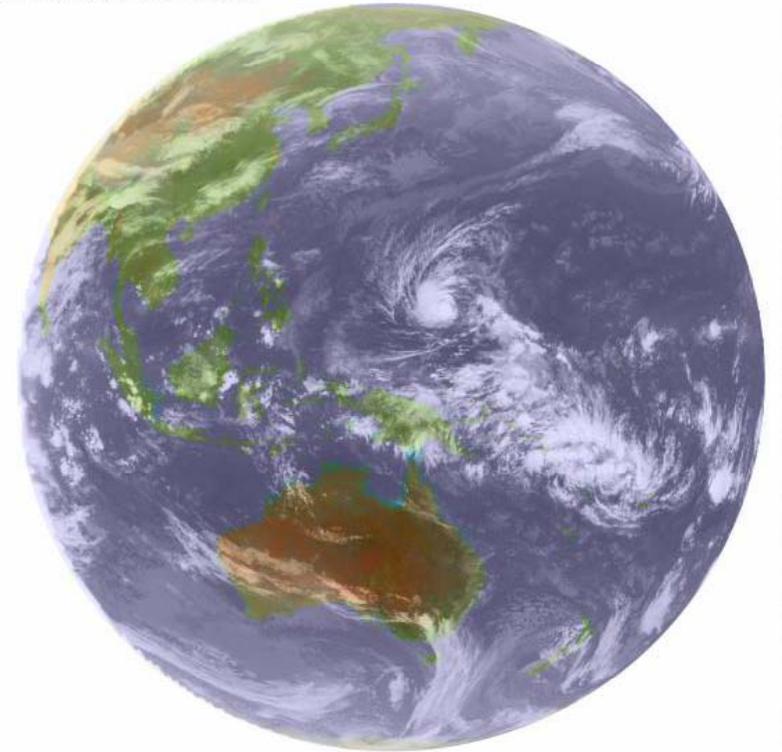
Glevel-5



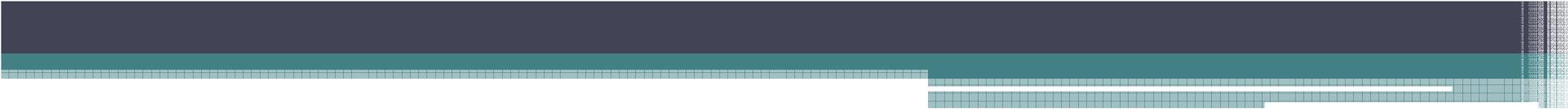


NICAM 3.5km

GOES9 IR1 04040609JST Kochi Univ.



GMS/GOES



Summary

- Strong demand about the future climate and environment!
- Only simulation can do this job.
- Huge demand for computation and high-end computer!
- “Easy to maintain” Code
- Efficient Code
- Dialogue between climate scientists and computer scientists is critical.