NEC APPROACH FROM HPC APPLICATION PERSPECTIVES

Hiroshi Takahara[1]

[1] HPC Division
NEC Corporation
1-10 Nisshin-cho, Fuchu, Tokyo 183-8501, JAPAN
h-takahara@bc.jp.nec.com

Scientific computing is spearheading the evolution of high performance computing technologies due to the demanding number crunching and intensive data handling with the increased model resolution and the growing sophistication of simulation models themselves. There are emerging requirements for the hardware and software infrastructures toward peta-scale simulations.

This presentation addresses some of the key technological elements to realize such a system from the application point of views. NEC recognizes that the SIMD-based approach is getting pervasive as a core processor technology capable of providing viable solutions to the requirements for higher sustained performance of applications and reduced performance-usability gap.

The latest vector supercomputer SX-9 boasts the world fastest single-core performance exceeding 100GFlops. Up to 16 of such cores can be built into a single node with a 1.6 TFlops peak, which is further configurable up to 512 nodes to create one of the world most powerful computers having a theoretical peak vector processing speed of close to 1 PFlops.

Not only performance but also usability is an integral part of the system; NEC has been putting an emphasis on reduced power consumption and floor space by pursuing energy-efficient and environment-friendly Green computing.

Meantime, NEC has also attempted to come up with solutions to cope with increasingly diversified requirements for number crunching with the emerging scalar and accelerator-type technologies considering the nature of applications.

In the presentation, the outline of the approach in high performance computing will be given. Also, some examples of major applications on the NEC systems will be described, such as those on the Earth Simulator (and its recently upgraded ES2), as well as the approach to emerging technologies.

NEC is committed to advancing HPC solutions through its continuous technological evolution and breadth of experience in customer support.

20th CCSE Workshop

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NEC Approach from HPC Application Perspectives

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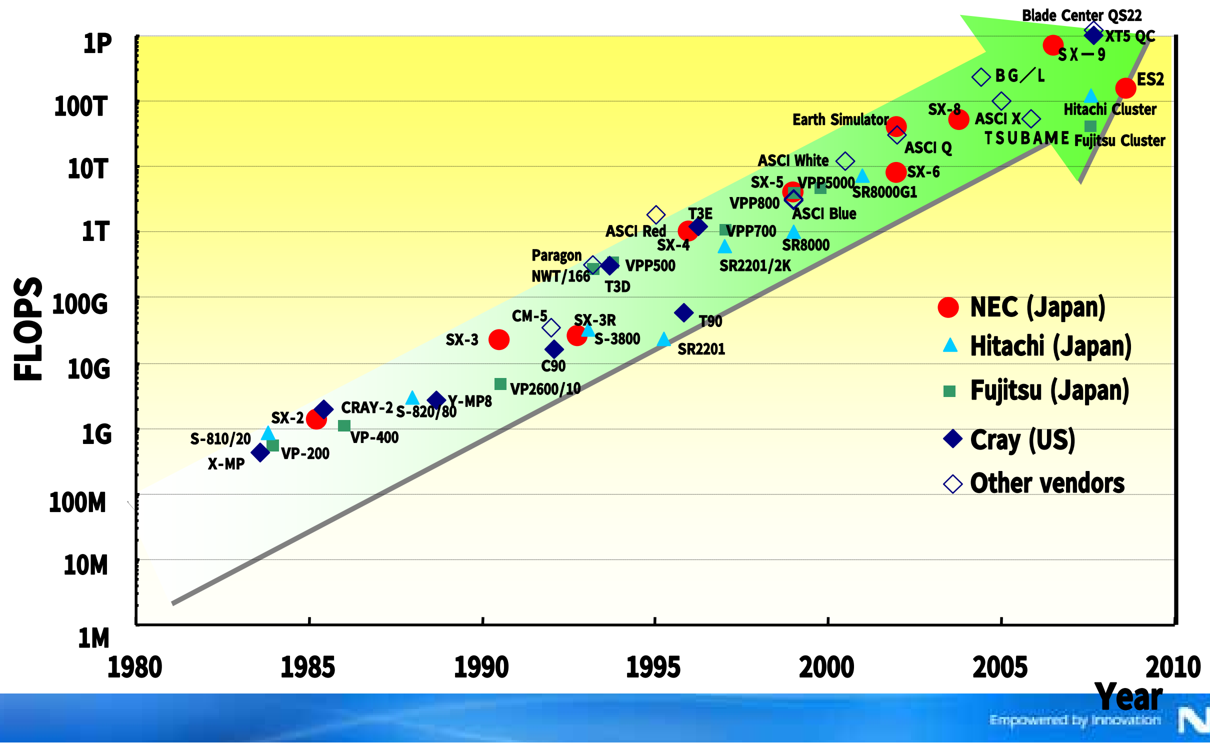
Hiroshi Takahara

HPC Division
NEC Corporation

Evolution of High Performance Computing

FLOPS: Number of calculations per second



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HPC Trend at a Glance …

Market requirement

- ✓ Eroding system price
- ✓ Commoditized large-scale HPC
- ✓ Performance/energy consumption → Tradeoff
- ✓ Limited floor space
- ✓ Emerging hybrid application

Diversification

Technical barrier

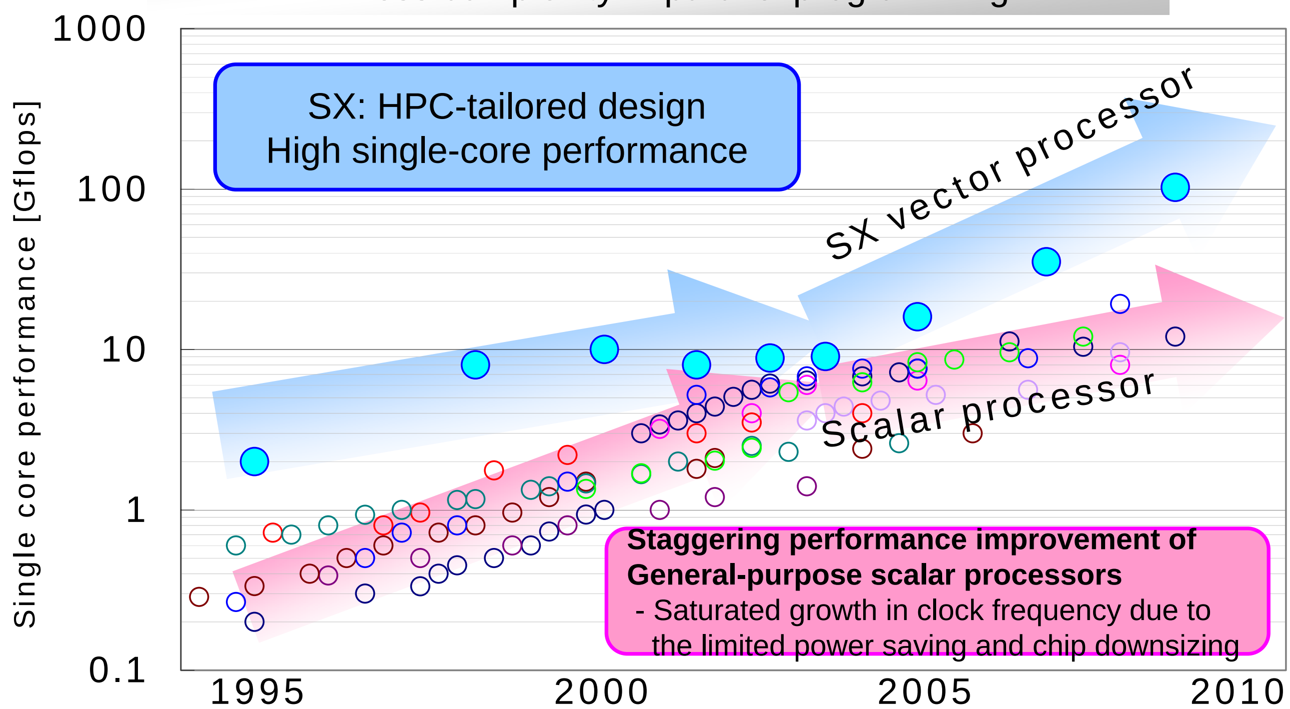
- ✓ Slow down in performance growth of single core
- ✓ Relying on multi-cored CPU
- ✓ Declining bandwidth --- NOT commensurate with processor performance

Stagnating evolution

No Single Architectures Fit All Applications.
→ Needs Right Architectures (SIMD, hybrid, accelerator…)

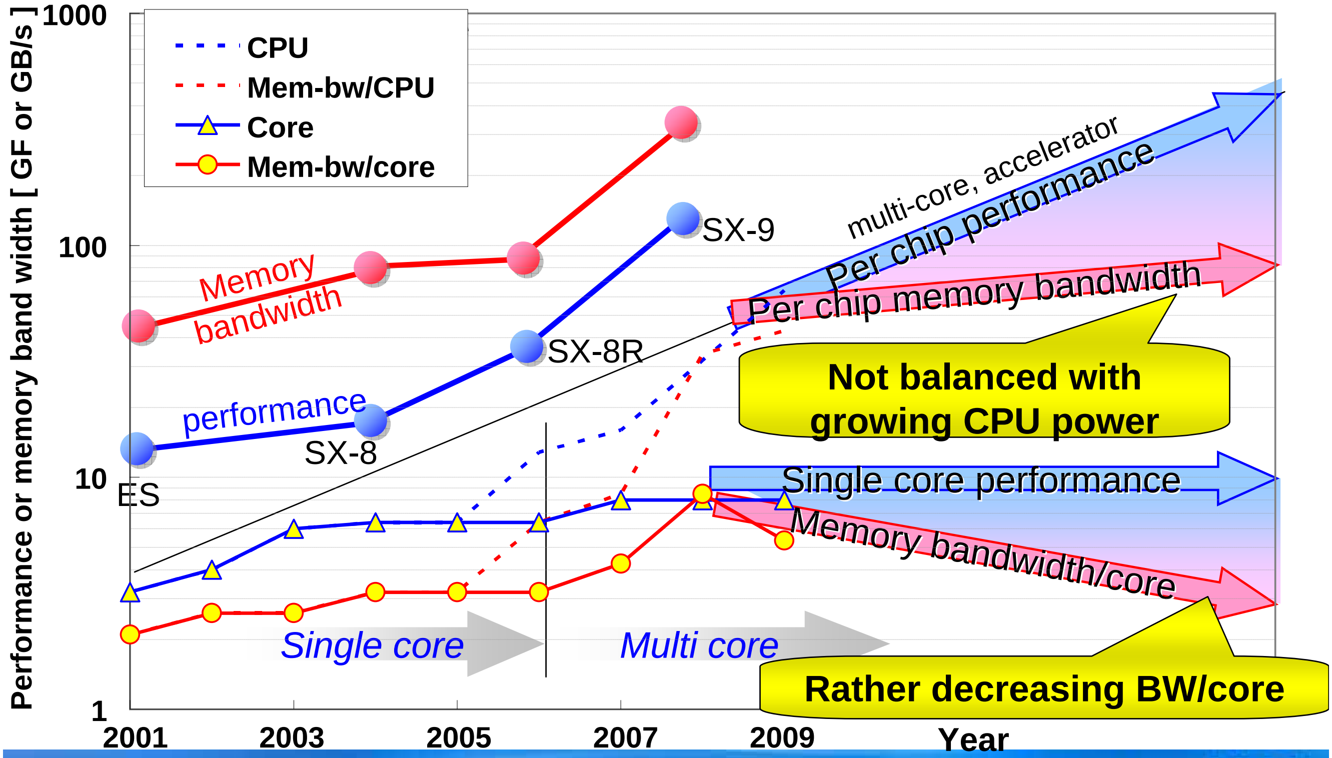
Trend of Single-core Performance

Advantages of high-performance single core
→ Less complexity in parallel programming



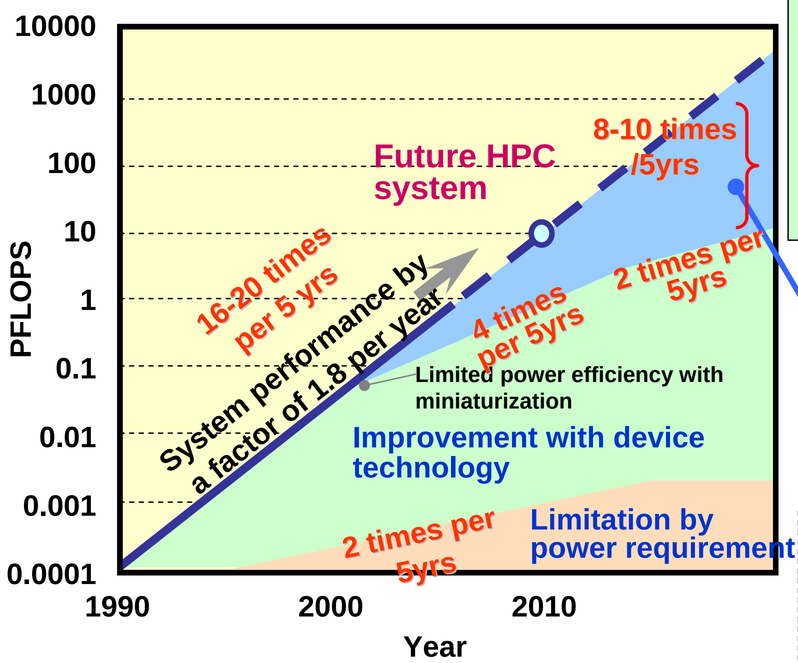
Widening Gap : per-Core Performance & Band Width

Serious issue with multi-cored scalar processors



Saturated Growth of System Performance

Getting out of CPU-performance plateau needs a novel approach…



Deceleration of improvement in power consumption

- Performance growth per power consumption limited to a factor of 2 for 5 years

Limited power equipment /facility for HPC system

Limit to performance improvement

Technical challenges

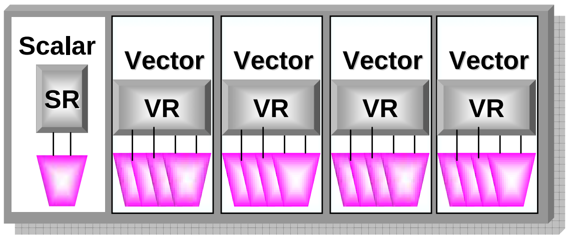
- **Simplification of core**
- **Multi-core technology**

Adoption of accelerator mechanism

Prevailing SIMD

--- Spearheading HPC technology ---

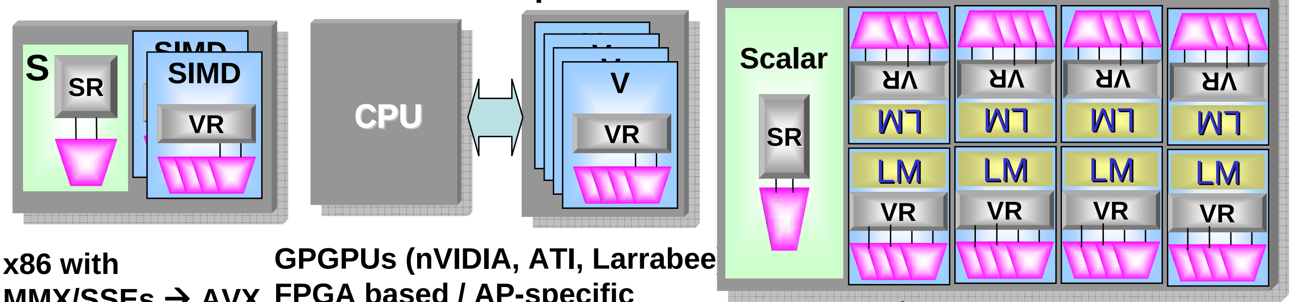
Conventional Vectors



Vector – conventional SIMD
- **High computing capability**
- **Large bandwidth**

Advent of various SIMD processors

①SIMD extension ②Add-on co-processor ③Heterogeneous multi-core



x86 with MMX/SSEs → AVX

GPGPUs (nVIDIA, ATI, Larrabee)
FPGA based / AP-specific

Cell (SCE/Toshiba/IBM)

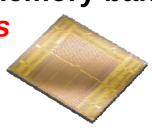
As a tool for advanced research, SX-9 offers ease of use and high performance.

CPU

Powerful core

High performance single core
>100GFLOPS per CPU

World No1. single core performance ：*102.4GF*
Large memory bandwidth：*256GB/s*



NODE

Powerful node

High efficiency without parallelization
>1TFLOPS per node

Large SMP：*1.6TF*
Large memory：*1TB*

MULTI NODE

Scalable system

Large system applicable to ultra-large problems
Toward PFLOPS

High speed interconnect：*128GB/s/node*
System scalability：*512nodes*

Technological Breakthroughs for SX-9

LSI technology

CMOS LSI with the cutting-edge 65nm design rule

High performance technology

- Parallel processing technology
- Cluster control technology

High-speed interface technology

- High-speed interface for high performance
- Optical interconnection spearheading the next-generation HPC

Cooling technology

Pursuing breakthroughs in cooling for the heat generation of 200W+

Supercomputer *SX-9*

High-density packaging technology

World most advanced packaging with high-speed data transfer

Components of HPC System

Applications

Application tuning/expertise

SW Layers

Libraries

Compiler SDK | Scheduler Mng.sw | MPI Coupler

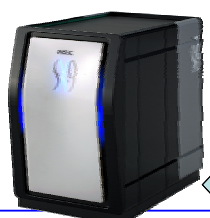
OS / File System

Vector | Scalar | Co-Proc.

Interconnect / Network

Storage

HW Platforms



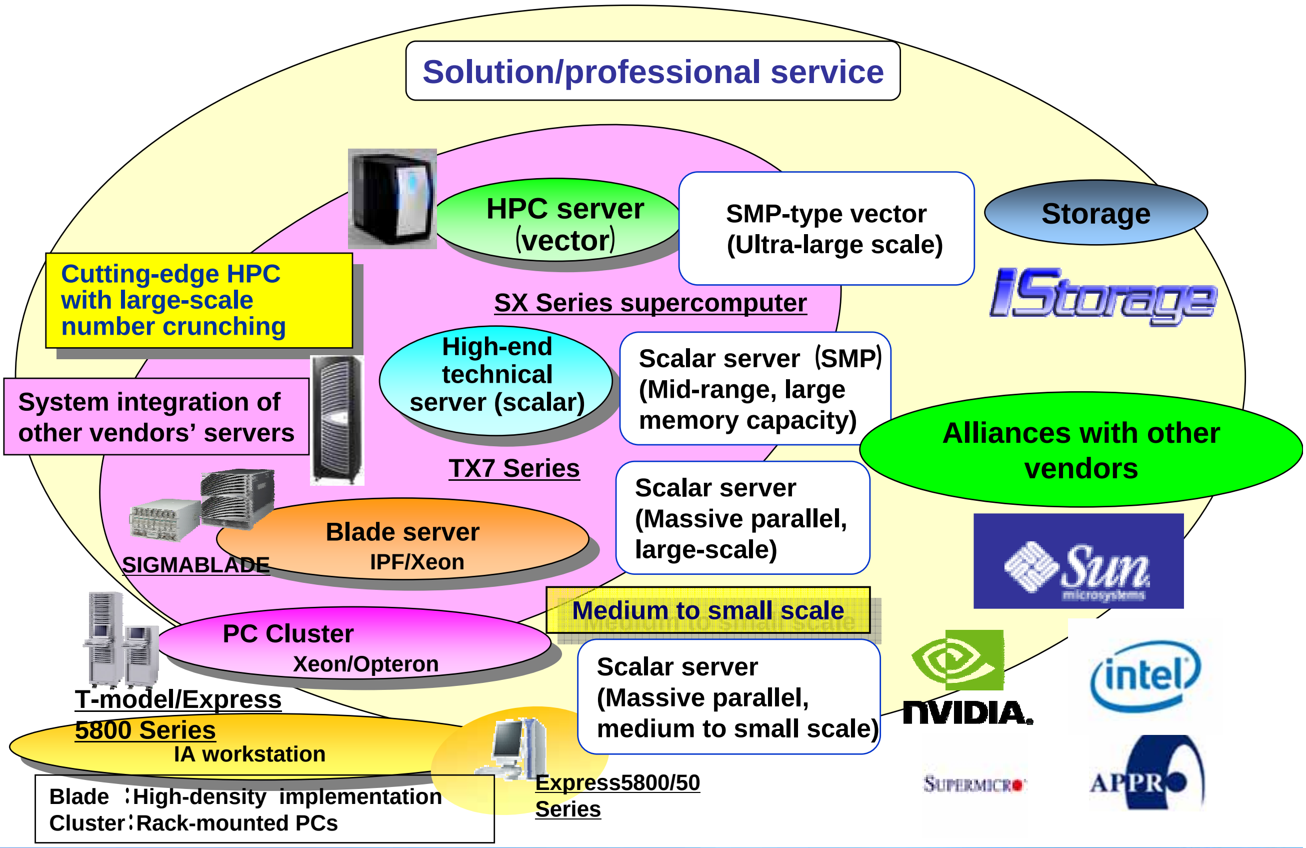
Massive data/large-scale computation /large-capacity memory/bandwidth

Distributed memory /small bandwidth

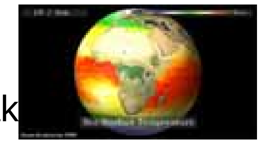
Local intensive computation

System integration technology

NEC HPC Product Lineups



Upgraded Earth Simulator (ES2)



- Japanese national project to create a “Virtual Earth”
- Original ES launched in March 2002 with 40TFLOPS peak (5,120 CPUs) --- **Manufactured by NEC**
- Number 1 on the TOP500 (Linpack) List for 2.5 years creating media hype with a new jargon “ Computenik ”

Original ES

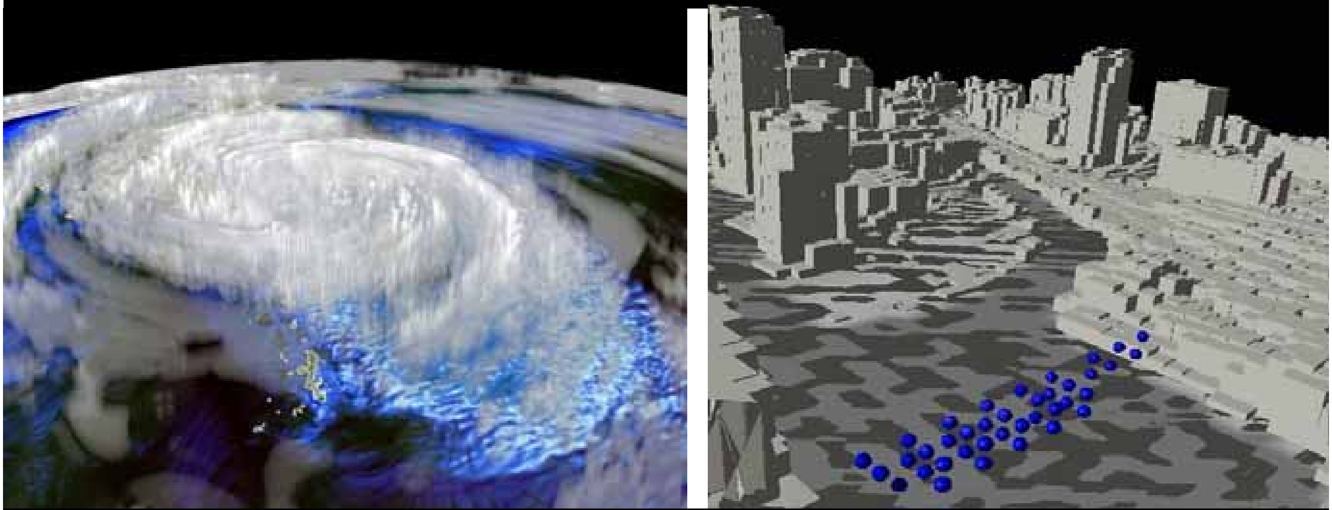
✓Vector-type
✓640 nodes (5120 CPUs)
✓Peak speed = 40TFlops
✓Main Memory=10TBytes

Upgraded ES (ES2)

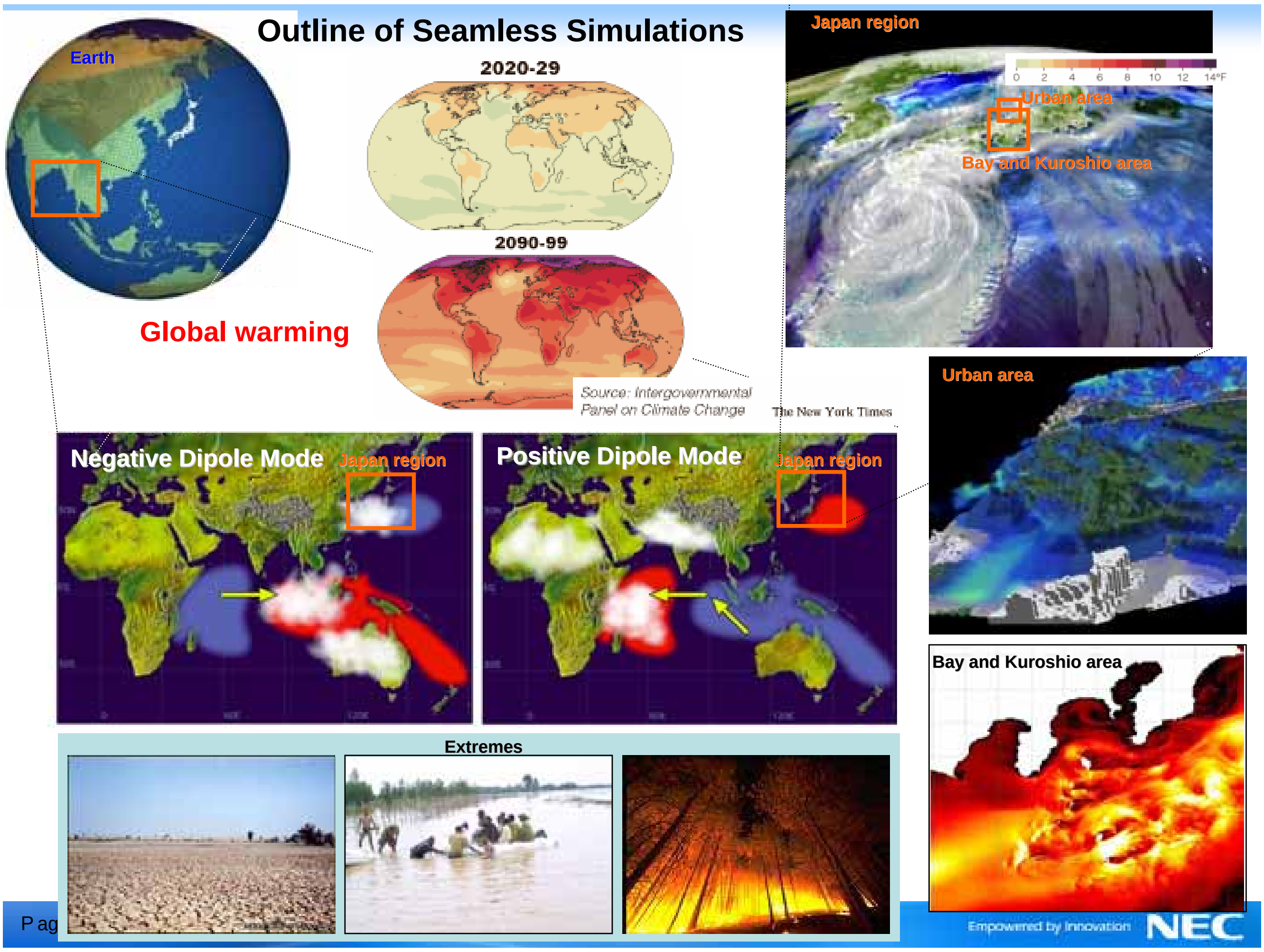
✓Vector-type
✓160 nodes (1280 CPUs)
✓Peak speed = 131TFlops
✓Main Memory=20TBytes

EARTH SIMULATOR

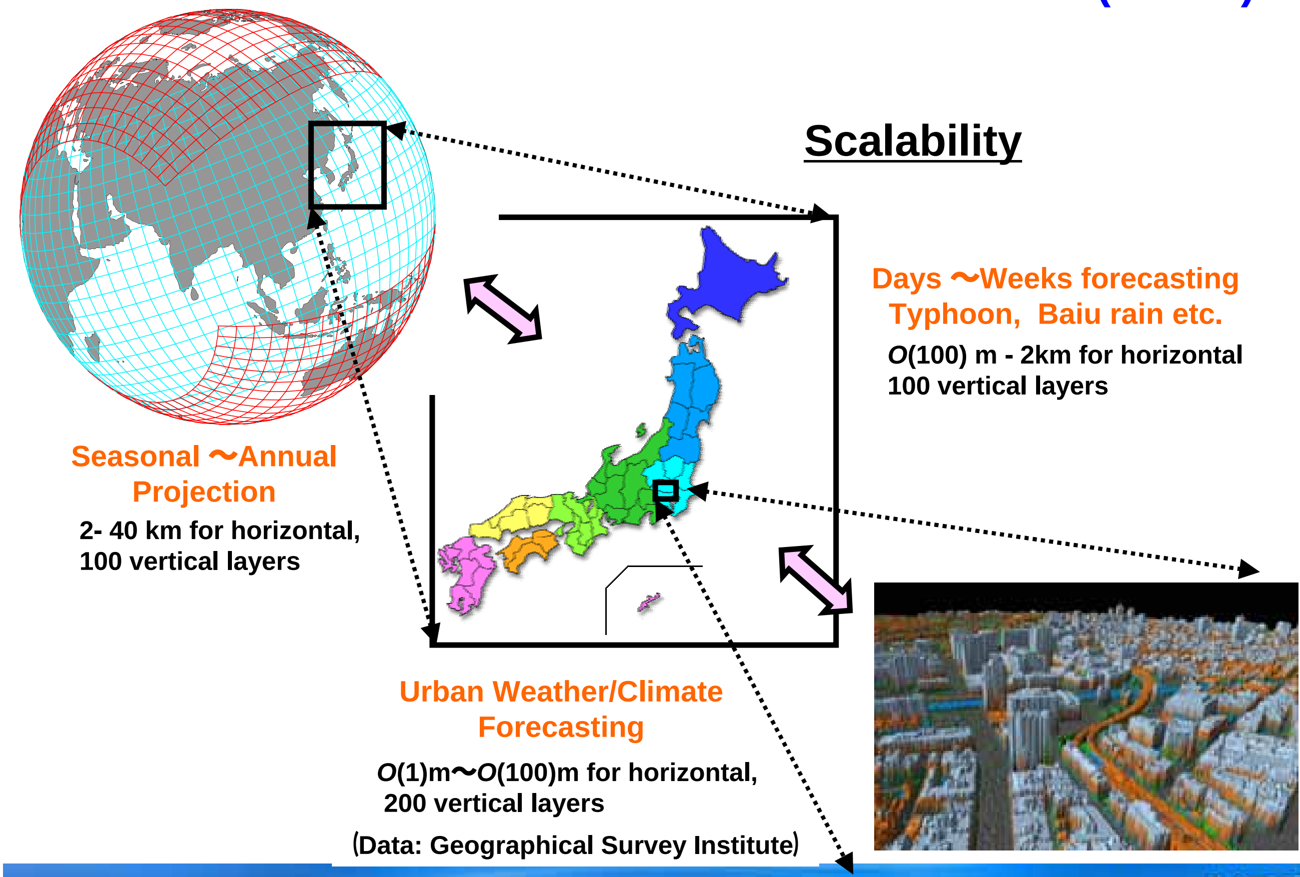
Multi-Scale Simulation on the Earth Simulator



Contents courtesy of Earth Simulator Center,
Japan Agency of Marine-Earth Science and Technology (JAMSTEC)



Multi-Scale Simulator for the Geoenvironment (MSSG)

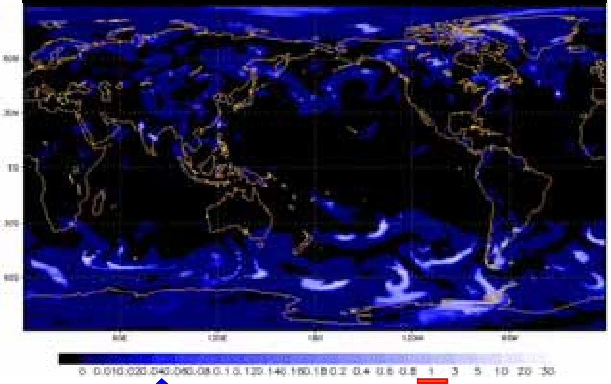


Outline of MSSG

		MSSG-A	MSSG-O
		Non-hydrostatic AGCM	Non-hydrostatic /hydrostatic OGCM
governing eqs.		Fully compressive N-S eqs.	incompressive N-S eqs.
grid system		Yin-Yang grid (overlapped 2 lat-lon)	Yin-Yang grid (overlapped 2 lat-lon)
discritization	space	Arakawa-C grid (horizontal), Z* (vertical)	Arakawa-C grid (horizontal), Z* (vertical)
	time	3rd/4th Runge-Kutta	3rd/4th Runge-Kutta
adv. schemes		5th flux form, WAF, CIP-CSLR	5th flux form
non-adv. schemes		4th flux form	4th flux form
sound wave		HEVI, HIVI	Implicit methods (2D, 3D)
microphysics		Bulk method (Qc,Qr,Qi,Qs,Qg)/ hybrid-Bin method	-
turbulence model		static Smagorinsky scheme	static Smagorinsky model
other models		cloud radiation model, backet land model, UCSS urban canopy model	sea-ice model
parallelization		horizontal 2D decomposition by MPI/ vertical decomposition by micro-task	horizontal 2D decomposition by MPI/ vertical decomposition by micro-task

MSSG-A

Horizontal:1.9km, Vertical:32layers, 14 days integration

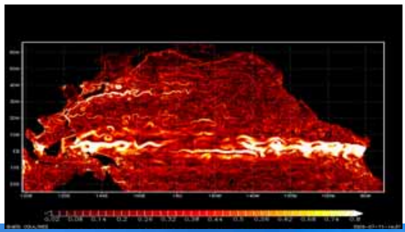


SST

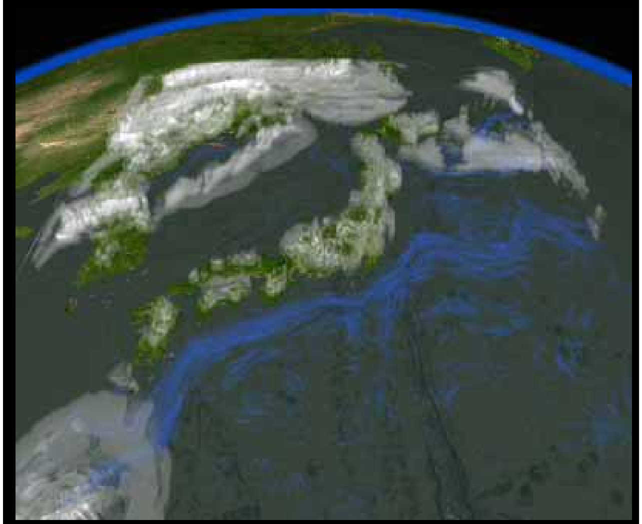
Heat, Fresh water, Momentum fluxes

MSSG-O

Horizontal: 2.78 km, vertical: 40 layer, 15 years integration



MSSG



Typhoon ETAU in 2003

Sea Ice

Okhotsk-sea (1/12deg.)

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