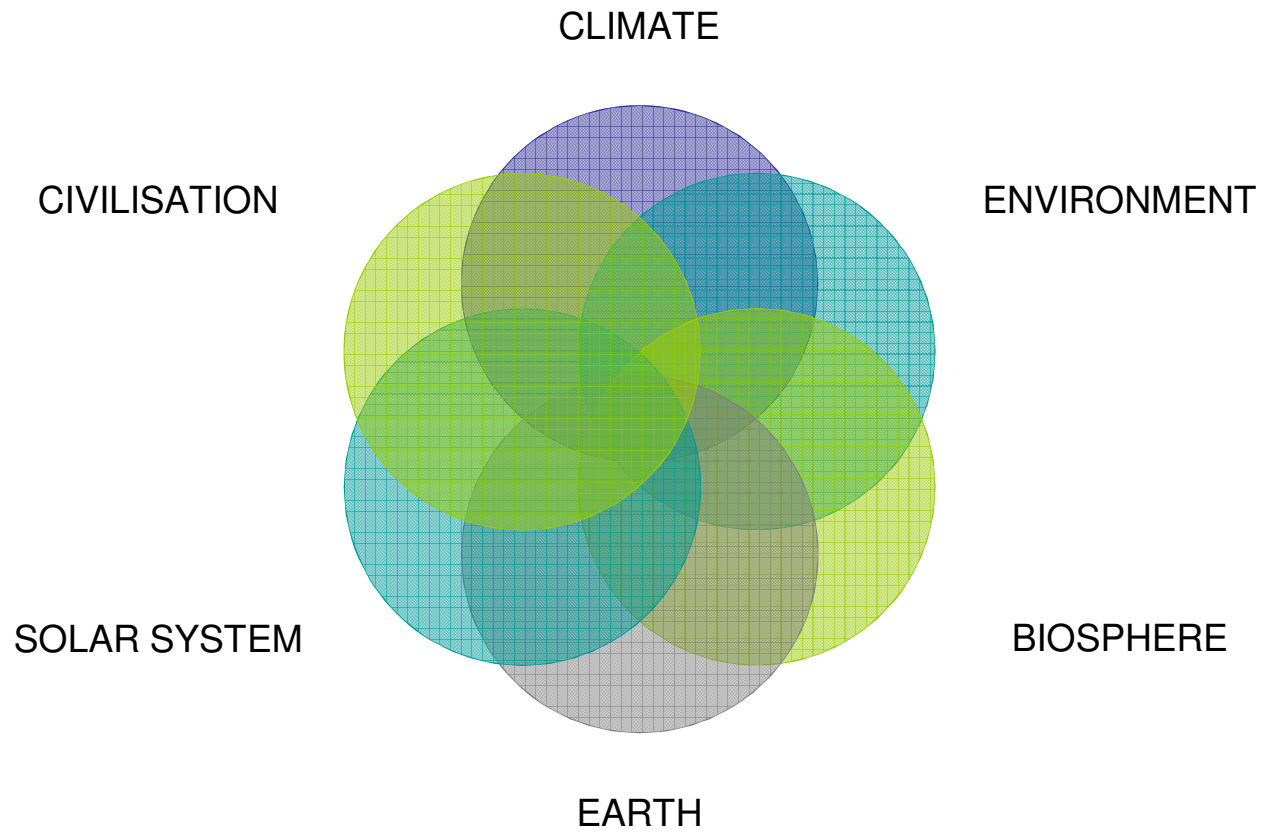


# The Role of Computing in Climate Science

Dr. Robert Bishop  
CERN 29 January 2010

Climate is the thin edge of the wedge!

# The Bigger Picture



We have been treating the sciences as  
separate stovepipes and silos  
for over 200 years!

- In Research
- In Publishing
- In University Faculties
- In Government Departments

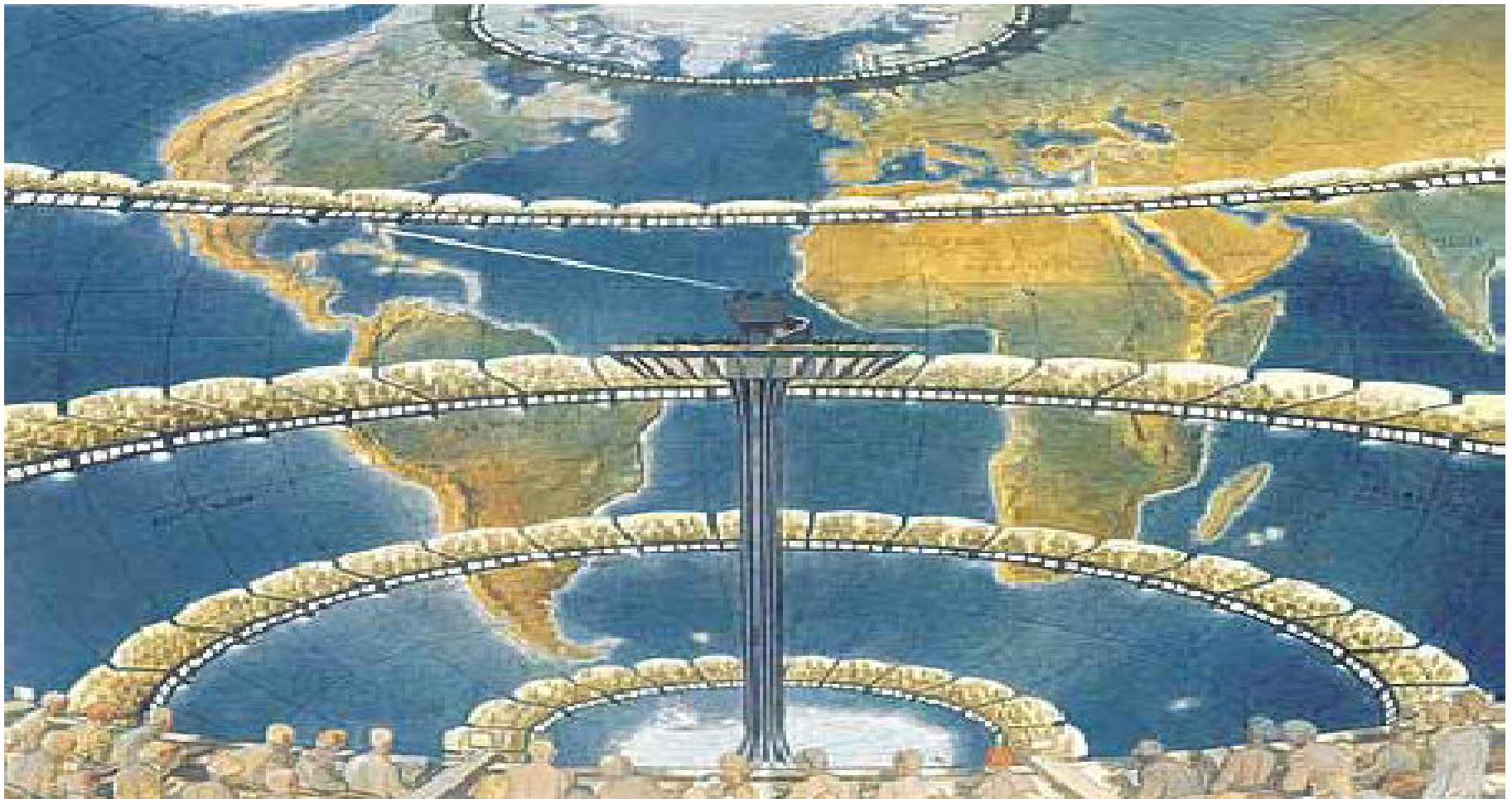
# 21C: Integration vs Dis-Integration

## The Whole Earth

- Seamless
- Multi-science
- Multi-scale (spatial & temporal)

## The New Grand Challenge



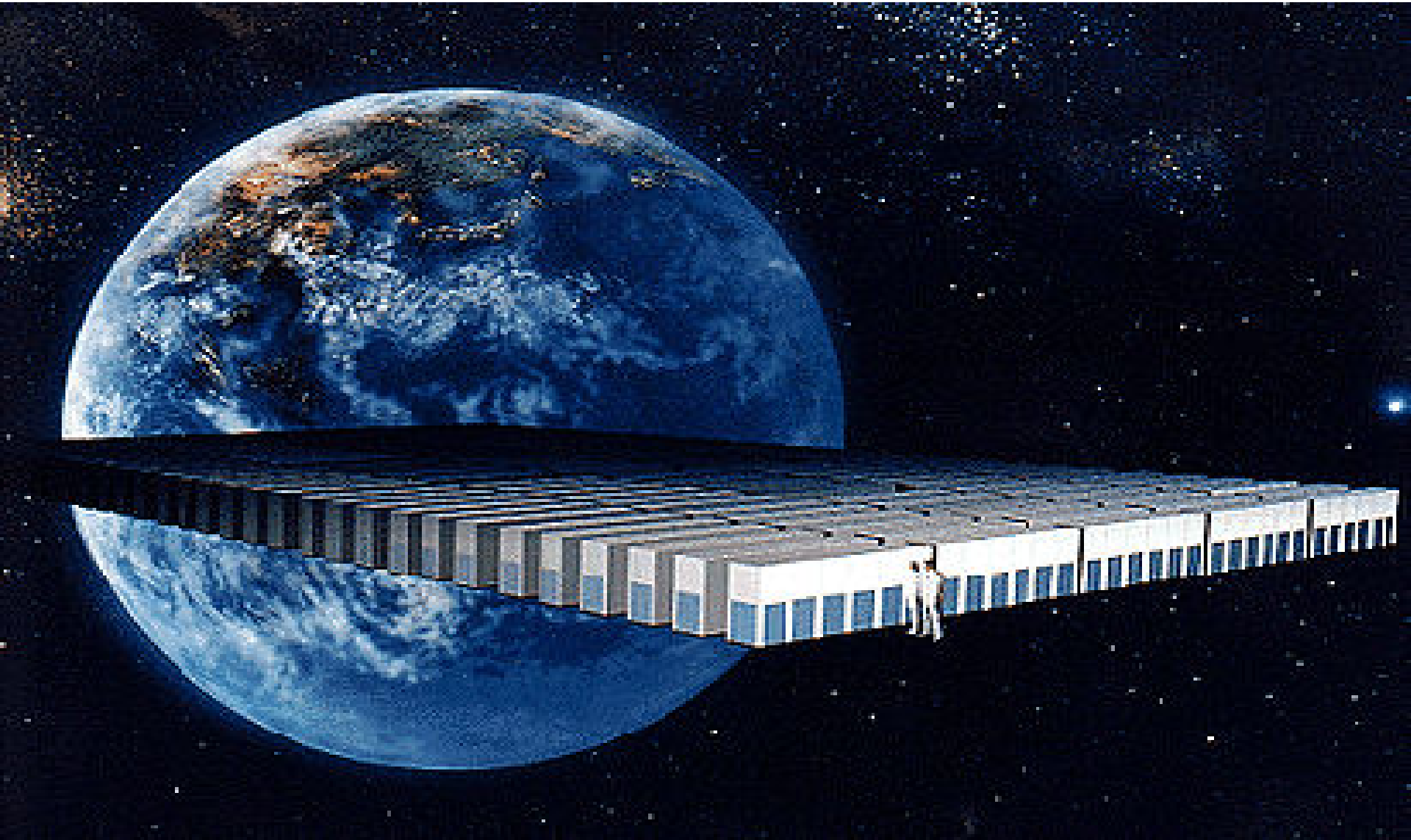


## **Before the Age of Computing**

In 1922, Lewis Fry Richardson, a mathematician and meteorologist, proposed an immersive giant globe to numerically forecast weather. This “factory” would employ 64,000 human computers to sit in tiers around the interior circumference of a giant globe.

# Yokohama Earth Simulator

Opened March 2002, NEC SX-6



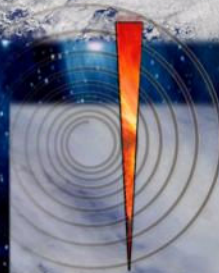
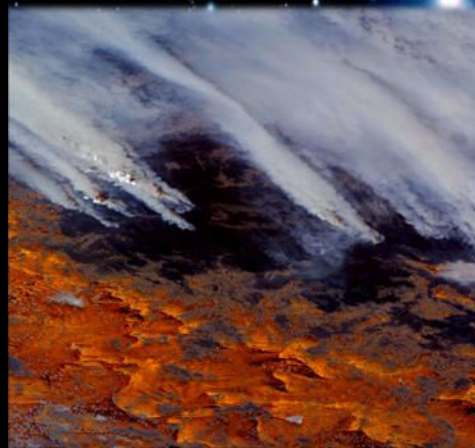


# WW Dedicated Climate Machines

(TAKEN FROM THE NOVEMBER 2009 TOP500 SUPERCOMPUTER SITES)

Worldwide Ranking	Organisation	Country	Peak Teraflops	<b>Sustained Teraflops</b>	Supplier
# 31	JAMSTEC	JAPAN	131.07	<b>122.40</b>	NEC SX-9
# 33	ECMWF	UK	156.42	<b>115.90</b>	IBM Power 575
# 34	ECMWF	UK	156.42	<b>115.90</b>	IBM Power 575
# 35	DKRZ	GY	151.60	<b>115.90</b>	IBM Power 575
# 54	NAVO	USA	117.13	<b>90.84</b>	CRAY XT5

# International Centre for Earth Simulation



# Proposed ICES Computing Resources

- Dedicated High Performance Computing
  - 20 year transition: petaflop( $10^{15}$ )-exaflop( $10^{18}$ )-zettaflop( $10^{21}$ flops)
- High-resolution 3D interactive immersion
  - auditorium level viewing with remote viewing & remote steering
- Low cost (nuclear) power from France
- Ultra-high-speed networking from ITU
- Green Computing, Cloud Computing



# HPC Computing Choices

- Homogeneous vs heterogeneous architectures
- Multi-core, CPU-GPU, FPGA, ASICs or full custom
- Cluster vs SMP, distributed vs shared memory
- Power management, flops/megawatt
- Software tools, compilers and middleware
- ICES Speed-up requirement  $\sim 1000$  x real-time



# ICES Modeling Challenges

- Algorithm development
- Coupling, feedbacks and linkages
- Representation of physical processes
- Uncertainty estimates & management
- Massive data ingest, management & re-analysis
- Data availability, quality control & harmonization
- Ensembles, statistical & stochastic methods
- Initial & boundary condition determination
- Output validation & verification
- Multi-Decadal focus

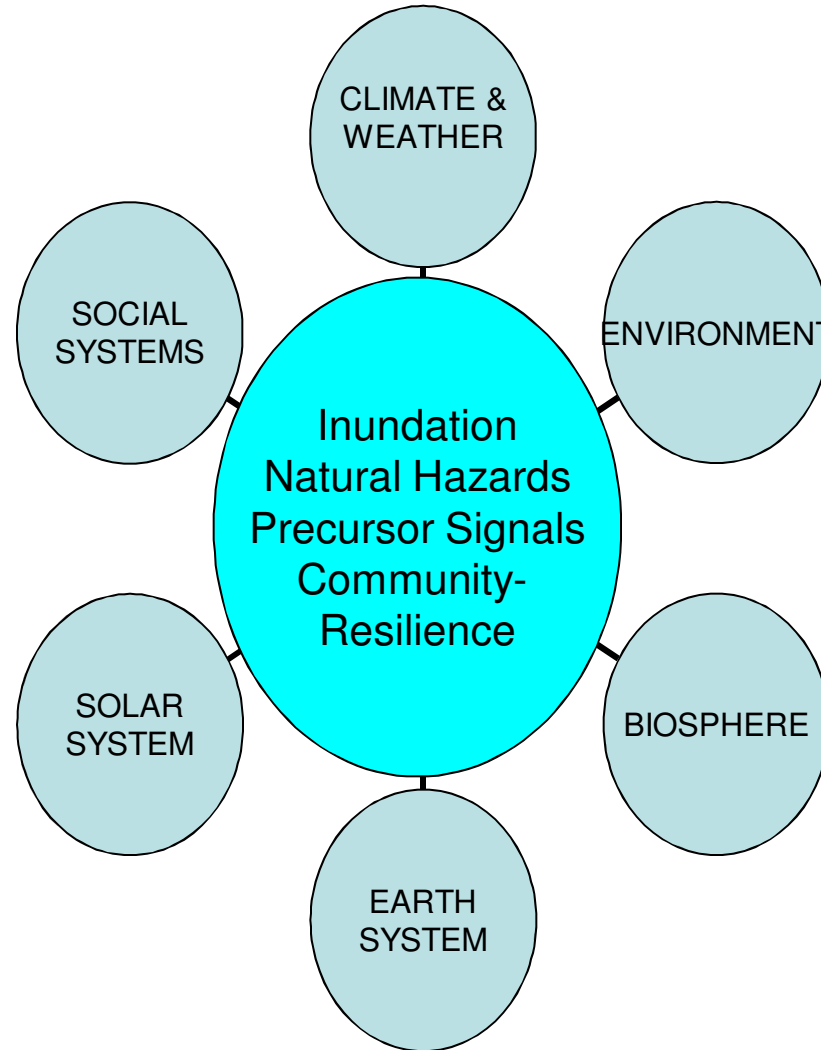


# ICES Fundamentals

- 200 professionals including many seconded experts
- Climate/Weather/Environ/Geo/Bio/Social Sciences
- Analytics, decision making, discovery, innovation
- Research, teaching, training, capacity building
- Advanced modeling and simulation
- Dedicated Supercomputing
- Visually Intensive



# ICES and Disaster Risk Reduction



# ICES Organisation Structure

- Geneva-based
- Not-for-profit Foundation
- Public-Private Partnership
- Multi-institute actor's network
  - WMO/WCRP/GEO, National Climate Services, Research Centers
- Governance from scientists & Int'l Orgs.





# Why Geneva?

- Science literate, educational infrastructure
- International city, neutral country, trusted
- Proximity to policy bodies:  
WMO, UNEP, WHO, WTO, WEF, UNCTAD,  
WBCSD, ITU, ICRC, UNHCR, IUCN, WWF

Partnerships with EPFL, Uni GE, CERN



# Learn from CERN

- New tools
- New platforms
- New knowledge
- New organization
- Global networking
- 'CLOUD' experiment



# ICES Funding

- PHASE 1 (2010~2015) \$350M  
from sources: 1/2 public, 1/2 private
- PHASE 2 (2016~2020) \$450M  
from sources: 1/3 public, 1/3 private, 1/3 products and services, such as:
  - test bed for large scale construction projects
  - industry specific services
  - disaster risk reduction
  - 'what if' scenarios



# ICES Foundation Members

BOARD MEMBERS:	Bob Bishop	President
	André Kaplun	Secretary
	Julien Pitton	Treasurer

BANKERS: UBS

AUDITORS: PricewaterhouseCoopers

EXPERT COMMITTEE: in formation





**Helping guide the successful transformation of human society  
in an era of rapid climate change and frequent natural disasters.**