The ICES Foundation and its Mission

Dr. Robert Bishop – President
Me Andre Kaplun – Secretary
Mr. Julien Pitton - Treasurer

www.icesfoundation.org

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

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Formed in January 2010, the Geneva-based ICES Foundation aims to:

- Improve our understanding of planet Earth by holistically integrating all sciences, from the natural sciences through to the socioeconomic sciences

- Improve preparation and predictability for climate change, resource depletion & natural disasters - understand precursor signals, and thereby prevent ‘multiple synchronous collapse’ in our societies

- Utilise advanced computing, modelling, simulation and visual-isation to create a ‘near real-time’ high-resolution digital model of Earth, with inputs from collaborating partners, publicly available data and the Internet.

The frequency of recent major disasters indicates that society is ill prepared!

- Japan quake, tsunami, nuclear contamination, supply chain
- Earthquakes in Turkey, New Zealand, China, Chile & Haiti
- Floods in Thailand, Queensland, China, Pakistan, Brazil
- Heat-waves in Russia, Europe & the USA
- Wildfires in Australia, Europe & USA
- Ash clouds in Iceland & Chile
- BP oil spill
- Katrina

Such catastrophes cost $ billions in damage, repair and reconstruction

- With enormous loss of life
- With little predictability as to when they start or finish
- And no understanding as to when a catastrophe in one domain will create a disaster in other areas of society!

The frequency of such events will accelerate as the world's population increases from 7B to 10B

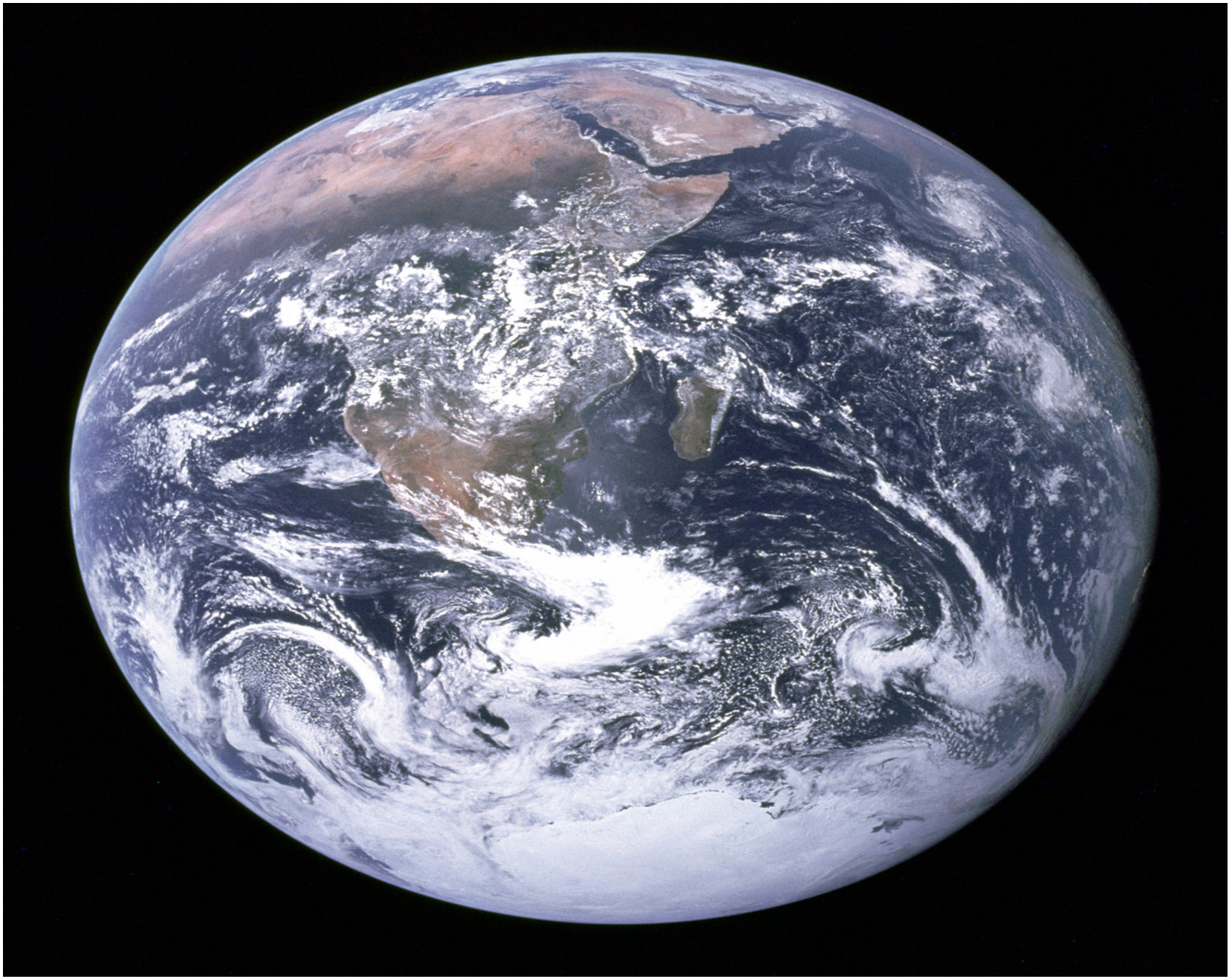
by the end of the 21st Century.

Has science become specialized & reductionist?

- In Research
- In Research Funding
- In Publishing
- In Peer-review
- In Conferences
- In University Faculties
- In Government Departments & Ministries

We have been treating the sciences as silos and stovepipes for more than 200 years!

Whereas Nature is Borderless & Integrated!



From over-specialization, we miss important cues and pre-cursor signals that Nature gives us, and which can help us avert natural & man-made disasters!

Nature is integrated and built from multiple interlocking sub-systems:

- Such sub-systems are mostly non-linear and non-Gaussian
- And because there is a high degree of coupling between them, risk in any one sub-system spills over into risk in the other sub-systems
- This ‘bleed-over’ effect causes reverberation, amplification and saturation in the many feedback loops
- Moreover, certain ‘tipping points’ exist, beyond which there is no recovery, and this allows multiple synchronous collapse to occur across a large subset of the entire system
- Such dangers are exacerbated when we simply treat each sub-system in isolation; that is, when we over-specialize!

A Nuclear Accident is a Borderless Event

- M9.0 quake off-shore Japan on 11/3/2011
- Followed by 10-metre high tsunami one hour later
- Northeast Tohoku coastline totally swamped & devastated
- 500,000 displaced people, 23,000 fatalities, over $300B cost
- Fukushima Daiichi Plant - 4 Nuclear reactors destroyed
  - contaminated air, water, sea, land and food supply
  - electric power shortage, disrupted supply chain worldwide
  - resignation of Japanese PM; future collapse of TEPCO?
  - change in nuclear reactor safety guidelines worldwide
  - change of nuclear policy in Germany, Switzerland & Belgium

Multiple synchronous collapse occurs across several subsystems!

ICES will apply ‘global integrative thinking’ and advanced technology to this complex problem:

- Based on modelling, simulation, visualisation & optimisation
- ‘Near real-time’ high-res digital models of the Whole Earth
- Deploying Cloud, HPC & remote visualization capabilities
- Assimilating data from local & global sensor networks:
  - remote sensing, lidar, satellites
  - in-situ, mobile & fixed platform
  - land based & ocean based
- And communicating globally via the Internet

… all of this using only publicly available data!

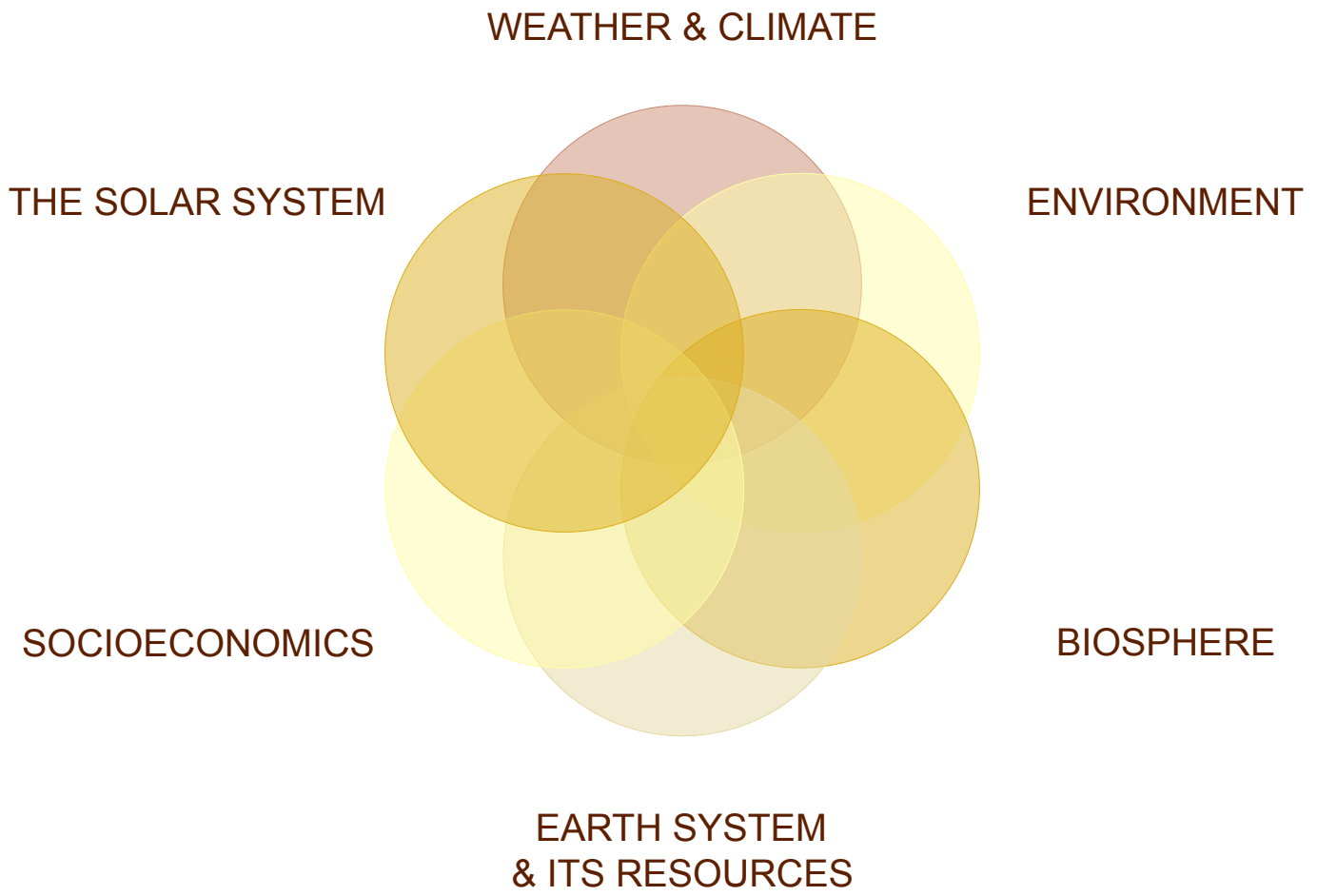
The ICES Challenge …

To model the Earth System as a whole - an Holistic Approach

- Multiscience (physical, chemical, geo, bio, socio-economic)
- Multiscale (spectrally, spatially & temporally)
- Unitary & seamless

… to integrate, connect & couple what we already know!

ICES will focus on the bigger picture



ICES will extend, embrace & integrate …

From Natural Sciences to Socioeconomic Sciences

Weather	Food
Climate	Water
Environment	Health
Solar, Planetary	Education
Cosmology	Energy, Transport

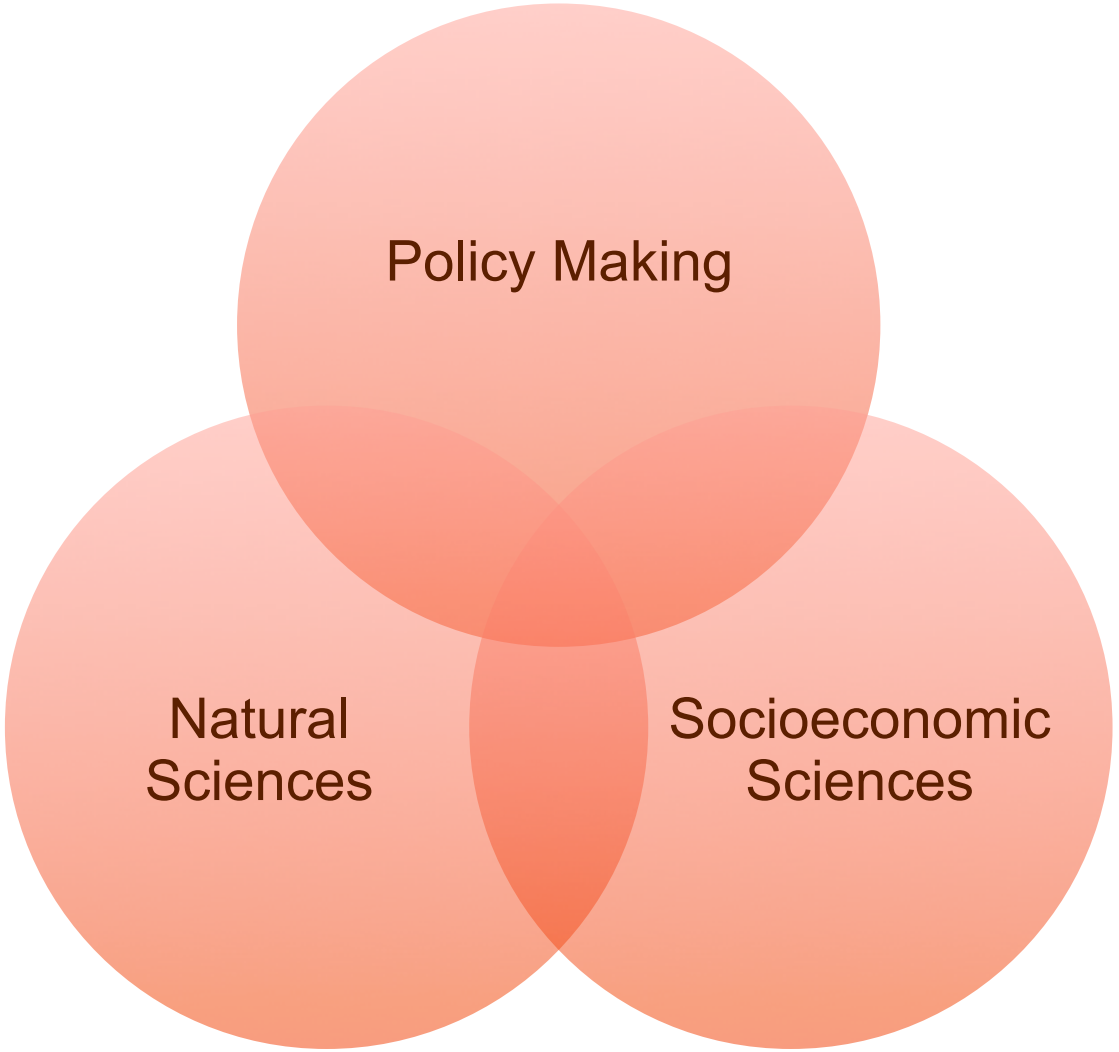
… a 10-year path to understanding the planet Earth while generating a unitary knowledge system that leads to safer policies and better governance – a 'CERN for the Climate'!

Modelling, Simulation, Visualisation, Optimisation are tools which can provide a number of answers

- They can answer difficult ‘what if’ questions
- They can help integrate the multiple technologies
- They can help integrate the multiple scientific bodies
- They can help educate the public & our policy makers
- They can supply visualization of very complex processes

…Assuming we have open access to multiple layers of publicly financed sensor data!

Even so, it is a big challenge to bridge from scientific understanding to policy creation!



ICES Organisation Structure

- Geneva based
- Not-for-profit Foundation
- Public-Private Partnership
- Broad Scientific Participation
- Inter-disciplinary Governance
- Participation by Int'l Organisations
- Experts Committee, Ethics Committee

ICES Experts Committee

- Dr. Ghassem Asrar**:**

  Director, World Climate Research Programme, WMO, Geneva
- Professor Martin Beniston:

  Chair for Climate Research & Director, Institute of Environmental Science, Uni Geneva
- Professor Marc Palange:

  Dean of the School of Architecture, Civil & Environmental Engineering, EPFL
- Dr. Michael Rast:

  Head of the Programme Planning Office, Directorate of Earth Observations, ESA
- Professor Jagadish Shukla:

  President, Institute of Global Environment and Society, USA

Why Public-Private Partnership?

- Fast
- Agile
- Simple
- Flexible
- Responsive
- Non-political
- Independent
- Private sources of funding
- Using publicly available data, ideas, & publications

Why Switzerland?

- History of international humanitarianism
- Multi-lingual, neutral & trusted country
- Science literate, educational infrastructure
- Proximity to global policy bodies:

  WMO (*WCRP, WWRP*), IPCC, GEO
  WHO, UNHCR, ICRC, UNISDR
  UNEP, IUCN, WWF, WBCSD, R20
  WTO, WEF, UNCTAD, ILO, ITU, EBU, ISO

- Partnerships: CERN, ETH, Canton Universities
- Corporates: Reinsurance, pharma, energy, food, etc
- Networked into national and global research centres

ICES Top Priorities

- Drive next generation modelling & simulation by integrating weather, climate, bio, geo, space & social-economic sciences
- Support training of next generation 'holistic thinkers'
- Develop world-class HPC leadership and consultation skills
- Supply HPC cycles, consultation support & thought leadership to national and regional weather/climate/geo centers worldwide (especially in the developing countries)
- Leverage education, media and communications through Swiss-based International Organisations & NGOs

10-Year Goals & Objectives

Develop next-generation Earth System Models including:

- Coupled ecosystems, environment & biodiversity
- Coupled mantle, volcanic & tectonic plate models
- Coupled Earth's magnetosphere & core dynamics
- Coupled solar & planetary sciences; space weather
- The extension of natural sciences to socioeconomics:
  - resource depletion, sustainability
  - transport, emissions, pollution
  - energy, water, food, health

More specifically …

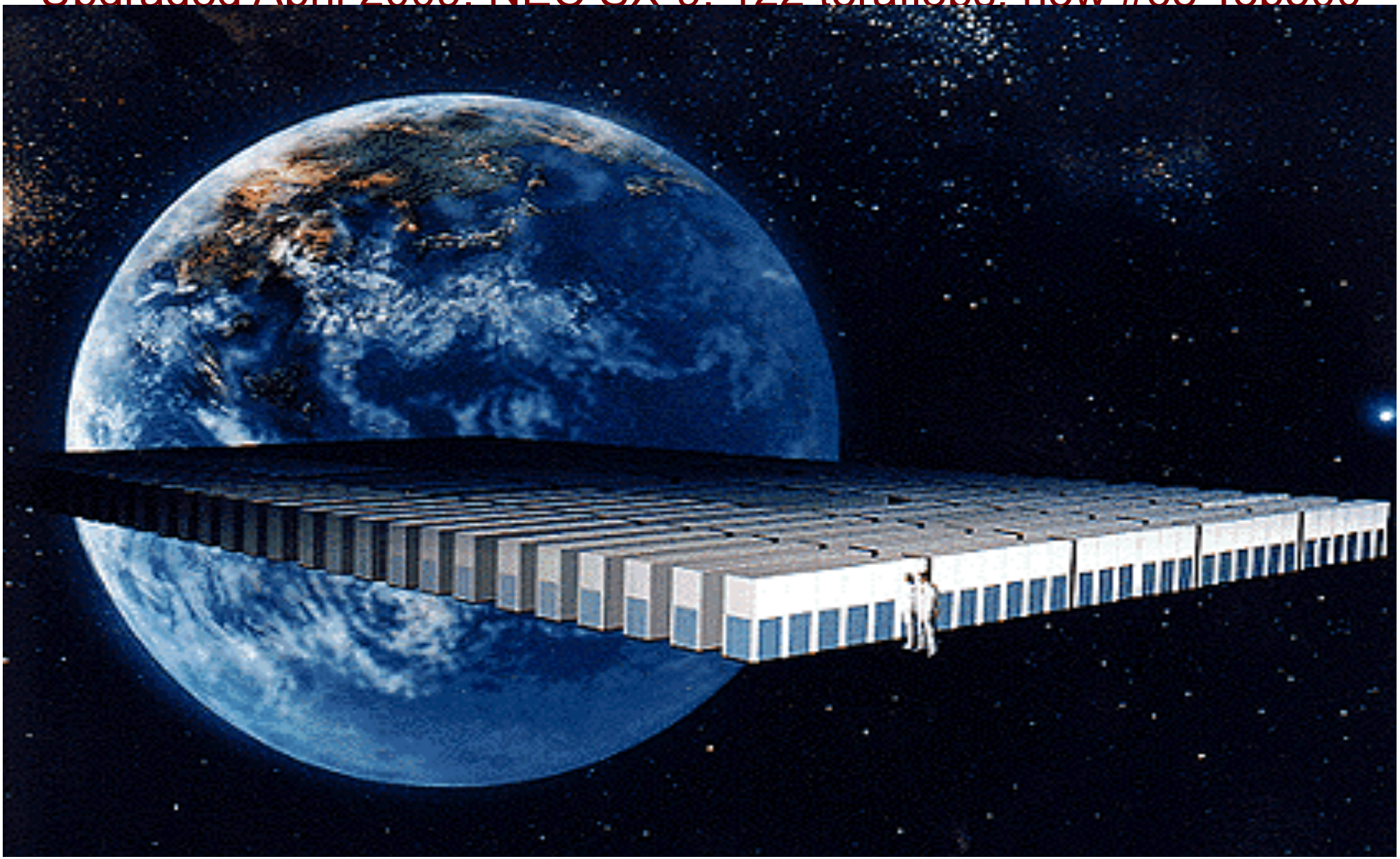
- Extend NWP models to seasonal, annual & interannual (since weather factors into 90% of all natural disasters)
- Improve regional downscaling of climate models
- Incorporate aerosols, cloud physics & convection activity
- Incorporate dynamic land usage and vegetation models
- Incorporate seismology, volcanology & models of the mantle
- Include solar dynamics, space weather & Sun-Earth coupling
- Integrate these factors into a better understanding of Earth's climate, water cycle, energy & resource dynamics

.. *All of which will demand a huge increase in compute resources!*

Yokohama Earth Simulator

Opened March 2002, NEC SX-6, 36 teraflops, #1 in Top500

Upgraded April 2009, NEC SX-9, 122 teraflops, now #68 Top500



Dedicated Weather-Climate-Environment Systems

(TAKEN FROM THE NOVEMBER 2011 LIST OF TOP500 SUPERCOMPUTER SITES)

Worldwide Ranking	Organization	Country	Peak Teraflops	**Sustained Teraflops**	Supplier
# 20	NOAA/ORNL	USA	715.98	**565.70**	CRAY XE6
# 31	KMA	Korea	379.01	**316.40**	CRAY XE6
# 32	KMA	Korea	379.01	**316.40**	CRAY XT6
# 51	NOAA/ORNL	USA	259.66	**194.40**	CRAY XT6
# 55	ECMWF	UK	251.40	**185.10**	IBM Power 775
# 56	Environment Canada	Canada	251.40	**185.10**	IBM Power 775
# 57	Environment Canada	Canada	251.40	**185.10**	IBM Power 775
# 63	UK Met Office	UK	235.68	**174.90**	IBM Power 775
# 71	NOAA/ESCC	USA	382.65	**161.80**	SGI Altix ICE
# 90	NOAA/ESRL	USA	148.12	**126.50**	Aspen Cluster
# 94	JAMSTEC	JAPAN	131.07	**122.40**	NEC SX-9
# 98	DKRZ	Germany	151.60	**115.90**	IBM Power 575
# 99	ECMWF	UK	156.42	**115.90**	IBM Power 575
#100	ECMWF	UK	156.42	**115.90**	IBM Power 575

Dedicated Weather-Climate Systems

(TAKEN FROM THE JUNE 2011 LIST OF TOP500 SUPERCOMPUTER SITES)

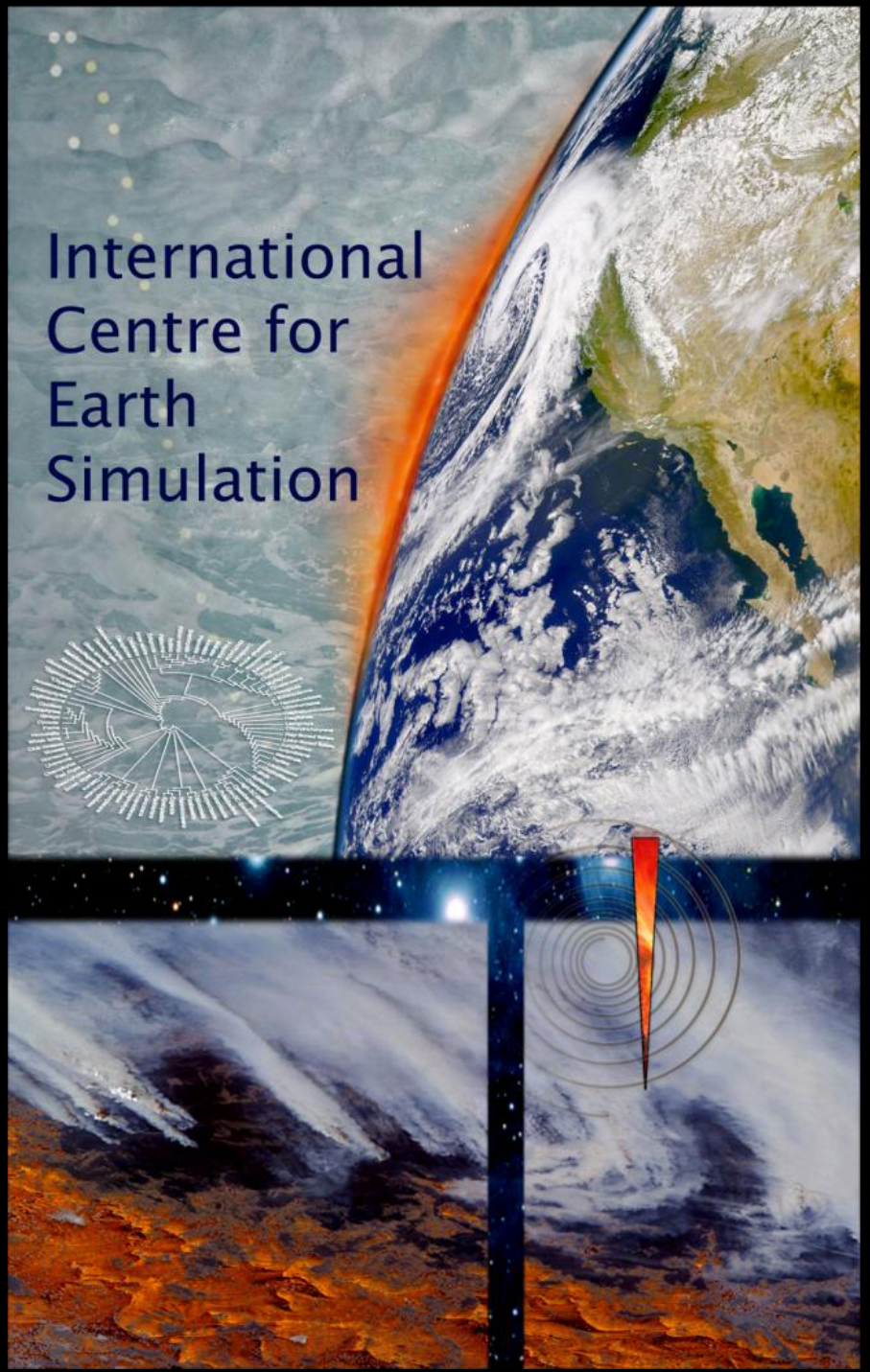
Worldwide Ranking	Organization	Country	Peak Teraflops	**Sustained Teraflops**	Supplier
# 20	KMA	Korea	379.01	**316.40**	CRAY XE6
# 21	KMA	Korea	379.01	**316.40**	CRAY XE6
# 37	NOAA/ORNL	USA	259.66	**194.40**	CRAY XT6
# 62	NOAA/ESRL	USA	148.12	**126.50**	Aspen Cluster
# 68	JAMSTEC	JAPAN	131.07	**122.40**	NEC SX9
# 70	ECMWF	UK	156.42	**115.90**	IBM Power 575
# 71	ECMWF	UK	156.42	**115.90**	IBM Power 575
# 72	DKRZ	GY	151.60	**115.90**	IBM Power 575
# 92	NAVO	USA	122.11	**96.55**	CRAY XT5
# 115	NAVO	USA	102.27	**78.68**	IBM Power 575
#126	NIES	JAPAN	177.12	**74.84**	HP Cluster
#132	NCEP	USA	93.85	**73.06**	IBM Power 575
#133	NCEP	USA	93.85	**73.06**	IBM Power 575
#187	NCAR	USA	76.40	**59.68**	IBM Power 575

Climate Modelling

- 2007 AR4 IPCC ….. CMIP3 …24 Models
- 2013 AR5 IPCC ….. CMIP5 …50 Models
- Sources of error - truncation
  - initialisation
  - parameterisation
  - data assimilation
  - physical processes
- Methodology - ensemble averaging
  - mean & standard deviation
  - equal weighting for all models
  - tested backwards (10 & 30 year hindcast)
  - future projection skill (decadal, centennial)

HPC Architectural Issues

- Processors: stochastic vs bit-reproducible?
- CPU-GPU: ARM-NVidia/AMD-ATI/Intel-MIC?
- IBM: Power 8, Power A2 - Blue Gene/Q, Cell?
- From petascale to exascale
  - photonics
  - the power wall
  - the memory wall
- One rack ~ one petaflop, 1000 racks ~ one exaflop!
- Memory hierarchy: global shared vs distributed?
- Co-design: hardware & software – the complete stack?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