

# Mega-crises demand Mega-solutions

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Predicting future conditions on Earth

involves understanding many

**complex non-linear interlocking systems**

# When complex systems fail we get multiple synchronous collapse

- Japan – subduction, megathrust, tsunami, nuclear plant failure, evacuation, weather, power, logistics, economy, food, travel, shelter, contamination, global supply chain
- 12,500 fatalities; 15,000 missing

# Similar complex failures over the last few years:

- Haiti, Chile, Christchurch, Sichuan earthquakes
- Queensland, Pakistan, Brazilian floods
- Australian bushfires
- Russian heat-wave
- Icelandic ash cloud
- Katrina, Xynthia
- BP oil spill

# Many disciplines are involved: natural sciences through socioeconomic sciences

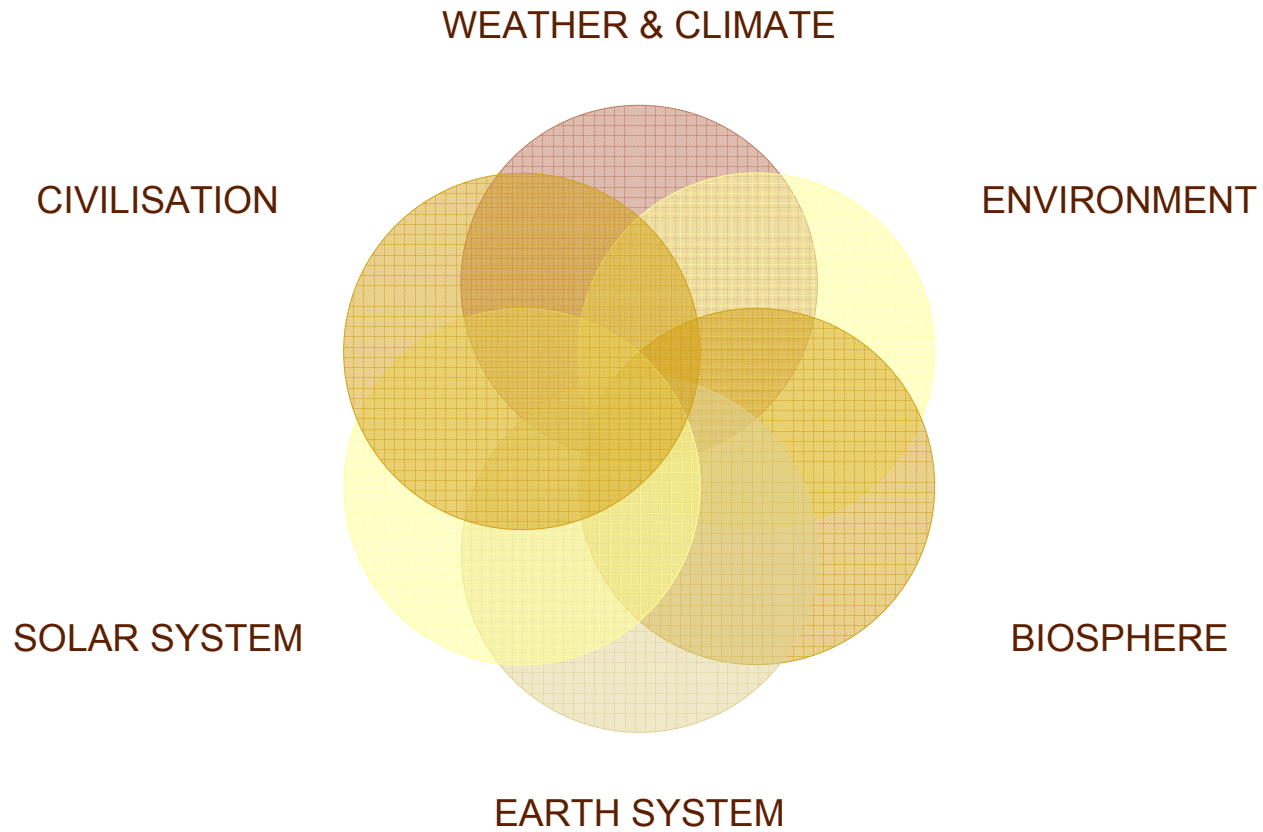
- Interactive nature of risk
- Bleed-over: one risk driving another
- System reverberation, feedback loops
- Risk is time integrated, catastrophe is time discrete!

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

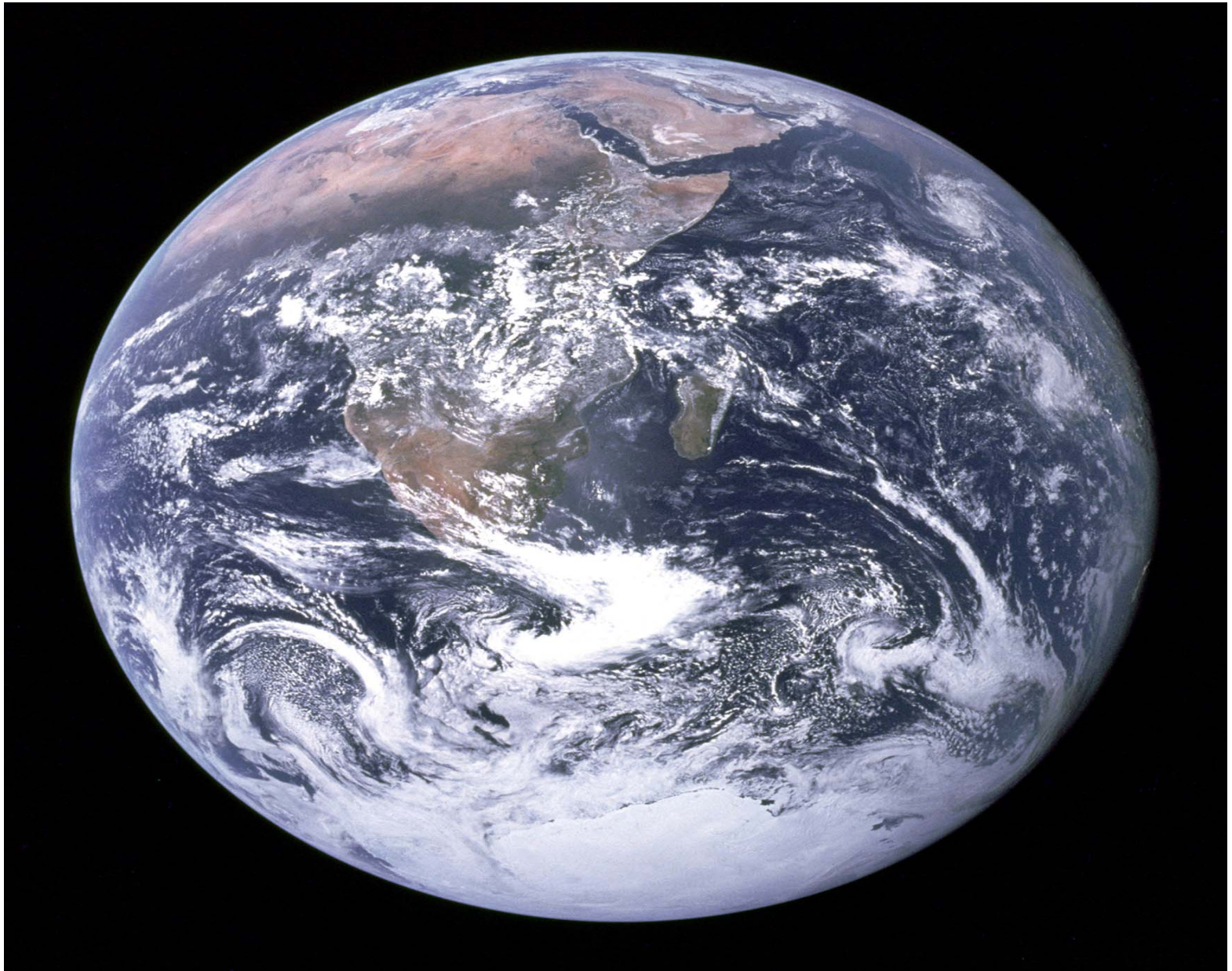
- In Research
- In Research Funding
- In Publishing
- In Peer-review
- In Conferences
- In University Faculties
- In Government Departments & Ministries

Specialization has its strengths & weaknesses!

# There is a Bigger Picture



**Nature is Seamless, Borderless & Integrated!**





# Our New Grand Challenge

To view the Earth as a whole and take an **Holistic Approach**

- Multi-science (physical, chem, bio, socio-economic)
- Multi-scale (spectral, spatial & temporal)
- Seamless

**The 21C is an era of Integration vs. Dis-Integration!**

**But how?**

Weather and Climate are only  
the thin edge of the wedge!

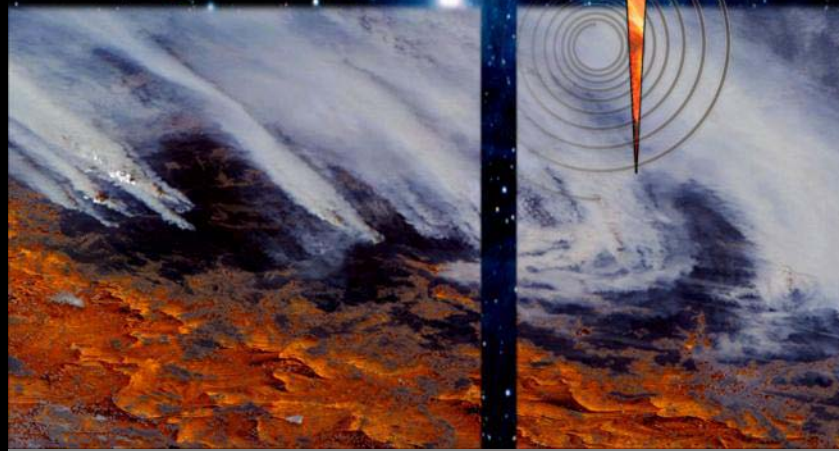
# Best idea is to extend, embrace & integrate!

- Weather – Climate
- Weather – Climate – Geophysical
- Weather – Climate – Geophysical – Biophysical
- Natural Sciences – Socioeconomic Sciences

A 10-year path to an 'holistic' world model !

**This is the genesis of the ICES FOUNDATION**

# International Centre for Earth Simulation



# ICES Organisation Structure

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



# Why Public-Private Partnership?

- Fast
- Agile
- Simple
- Flexible
- Responsive
- Non-political
- Independent
- New sources of funding



# Why Switzerland?

- History of international humanitarianism
- Global thinking, neutral, trusted country
- Science literate, educational infrastructure
- Proximity to global policy bodies:

WMO (*WCRP*, *WWRP*), GEO

WHO, UNHCR, ICRC, UNISDR

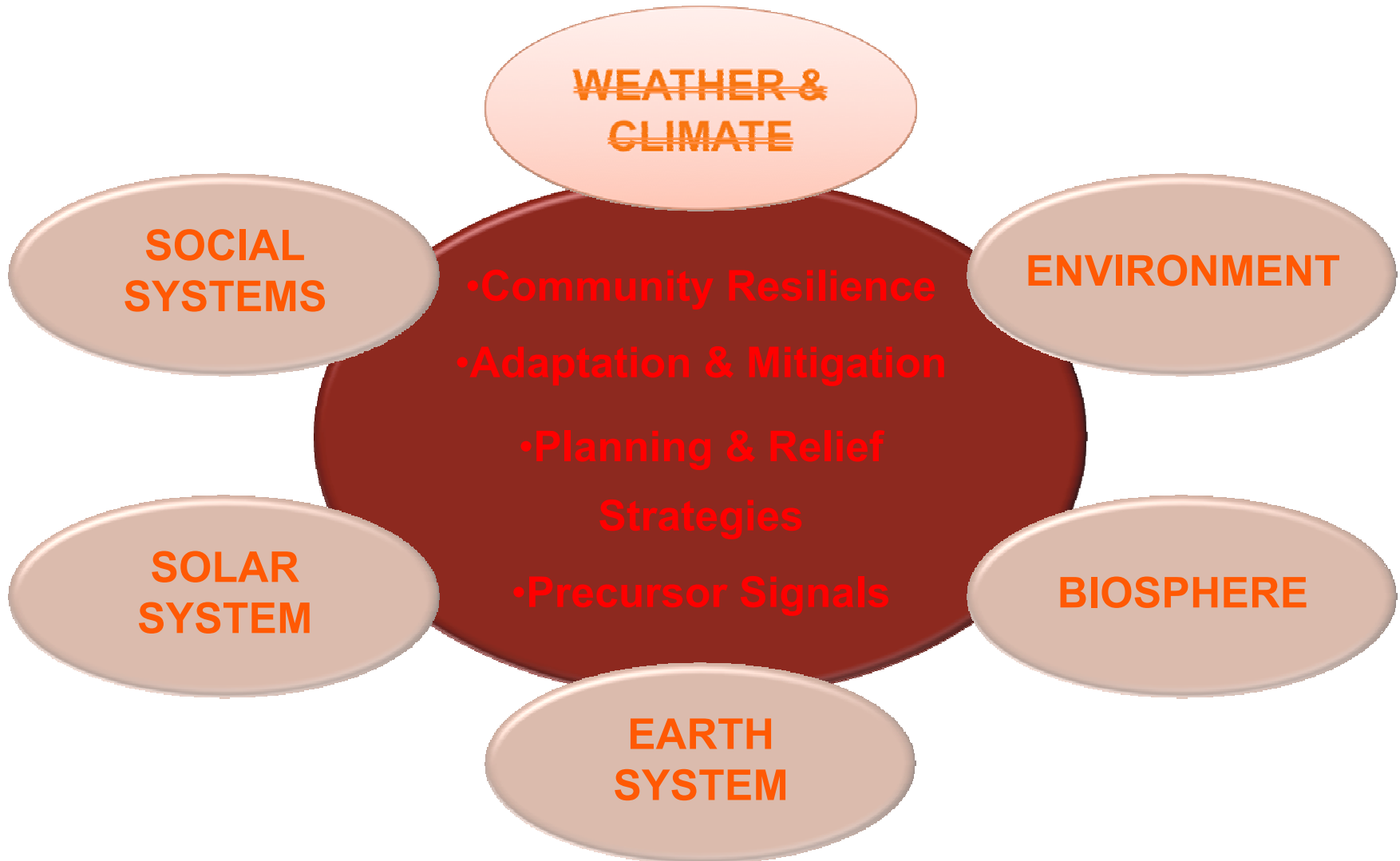
UNEP, IUCN, WWF, WBCSD

WTO, WEF, UNCTAD, ILO, ITU, EBU, ISO

- **Partnerships:** CERN, ETH, Canton Universities

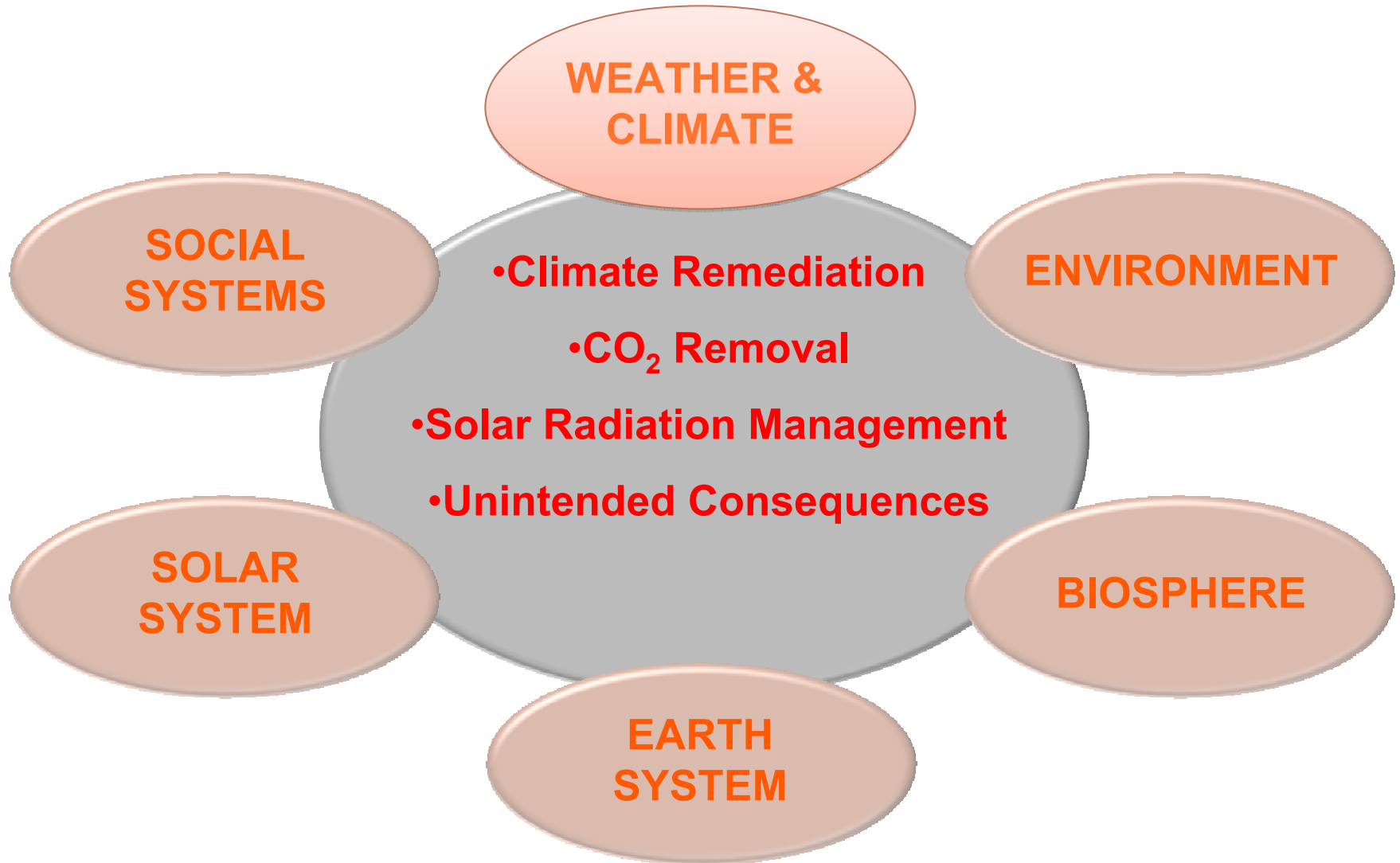


# ICES and Disaster Reduction

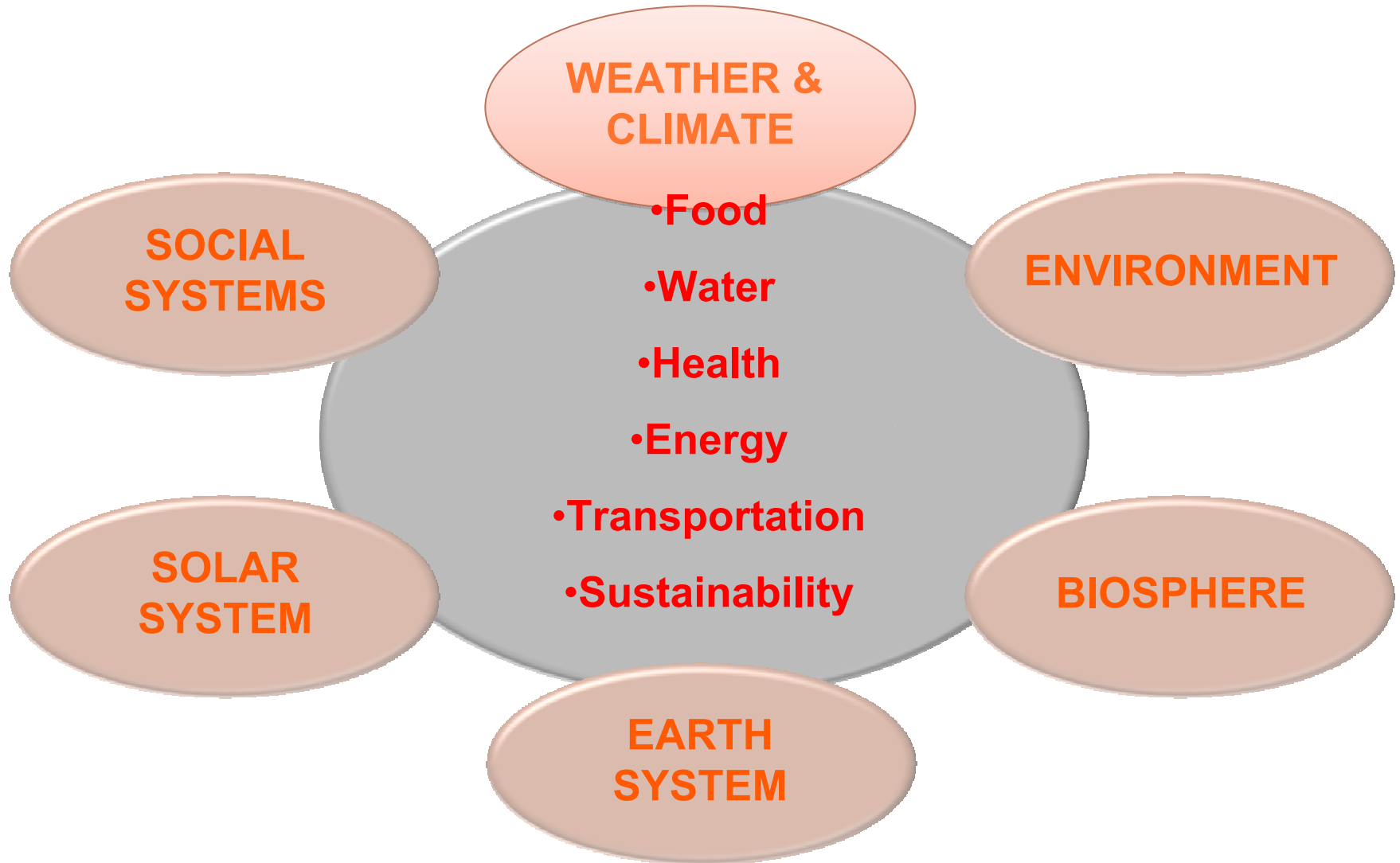




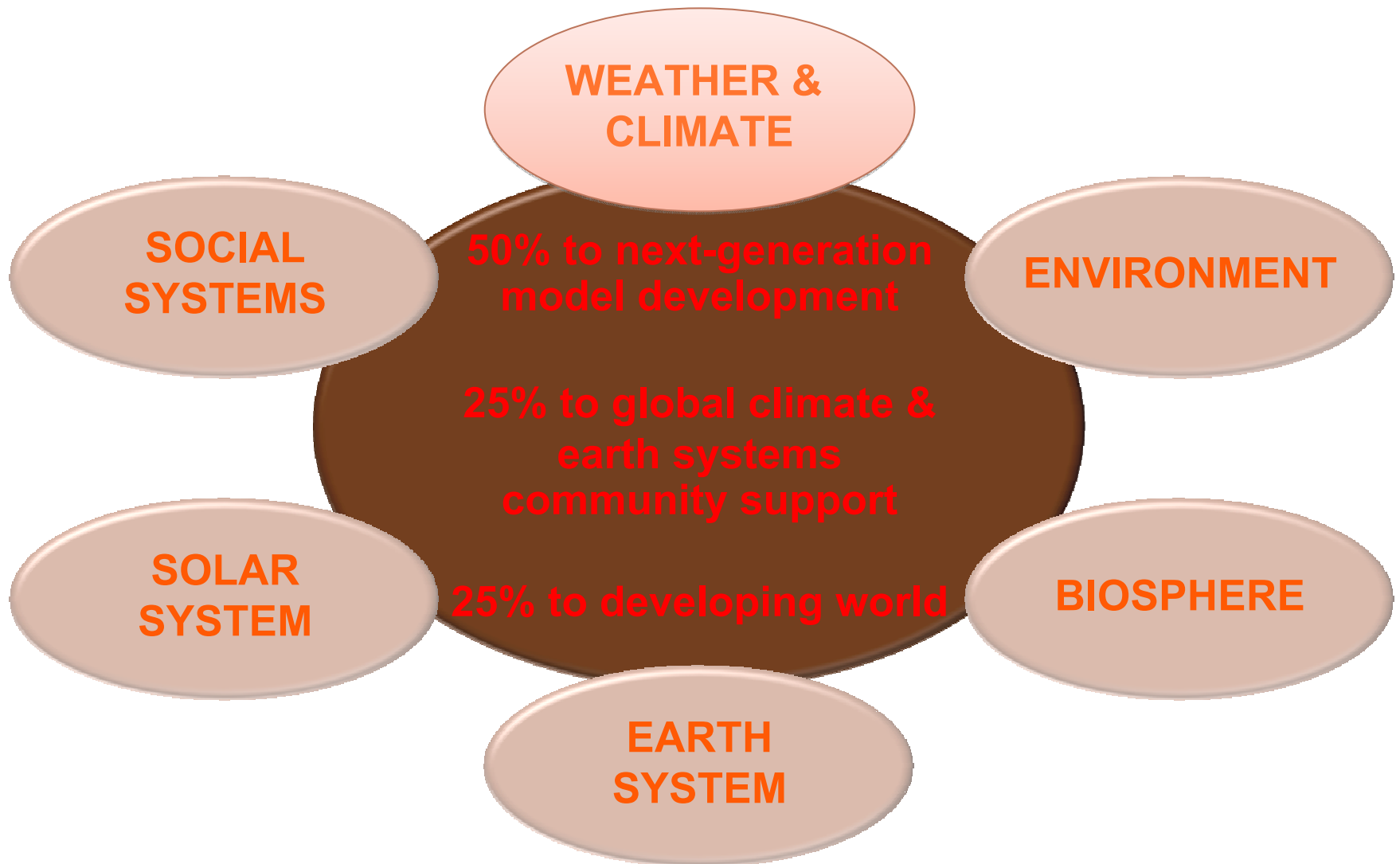
# ICES and Geoengineering



# ICES and Society



# ICES Resource Allocation



# ICES Core Actor's Network

- World Meteorological Organisation (WMO)
  - World Climate Research Programme (WCRP)
  - World Weather Research Programme (WWRP)
- European Centre Medium-Range Weather Forecasts (ECMWF)
- European Network for Earth System Modelling (ENES)
- Group on Earth Observations (GEO Portal, GEO Grid)
- Center for Ocean-Land-Atmosphere (COLA), IGES
- International Council of Scientific Unions (ICSU)
- UN International Strategy for Disaster Reduction
- National Disaster Management Agencies
- National Meteorology Bureaus
- National Geological Surveys
- Global Earthquake Model
- National Climate Centres
- National Ocean Centres
- National Space Centres
- Research Universities



# ICES Top Priorities

- Drive **new generation** simulation modeling by integrating weather, climate, bio, geo, space & social sciences
- Support training of next generation **'holistic thinkers'**
- Maintain **dedicated** HPC in the **top 10** of machines worldwide
- Supply backup **HPC cycles and software engineering support** to national and regional centers worldwide
- Education, media and communications **via Int'l Orgs & NGOs**





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

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Many recent events were not predicted nor well understood!

# Volcanic ash cloud disrupts European economy

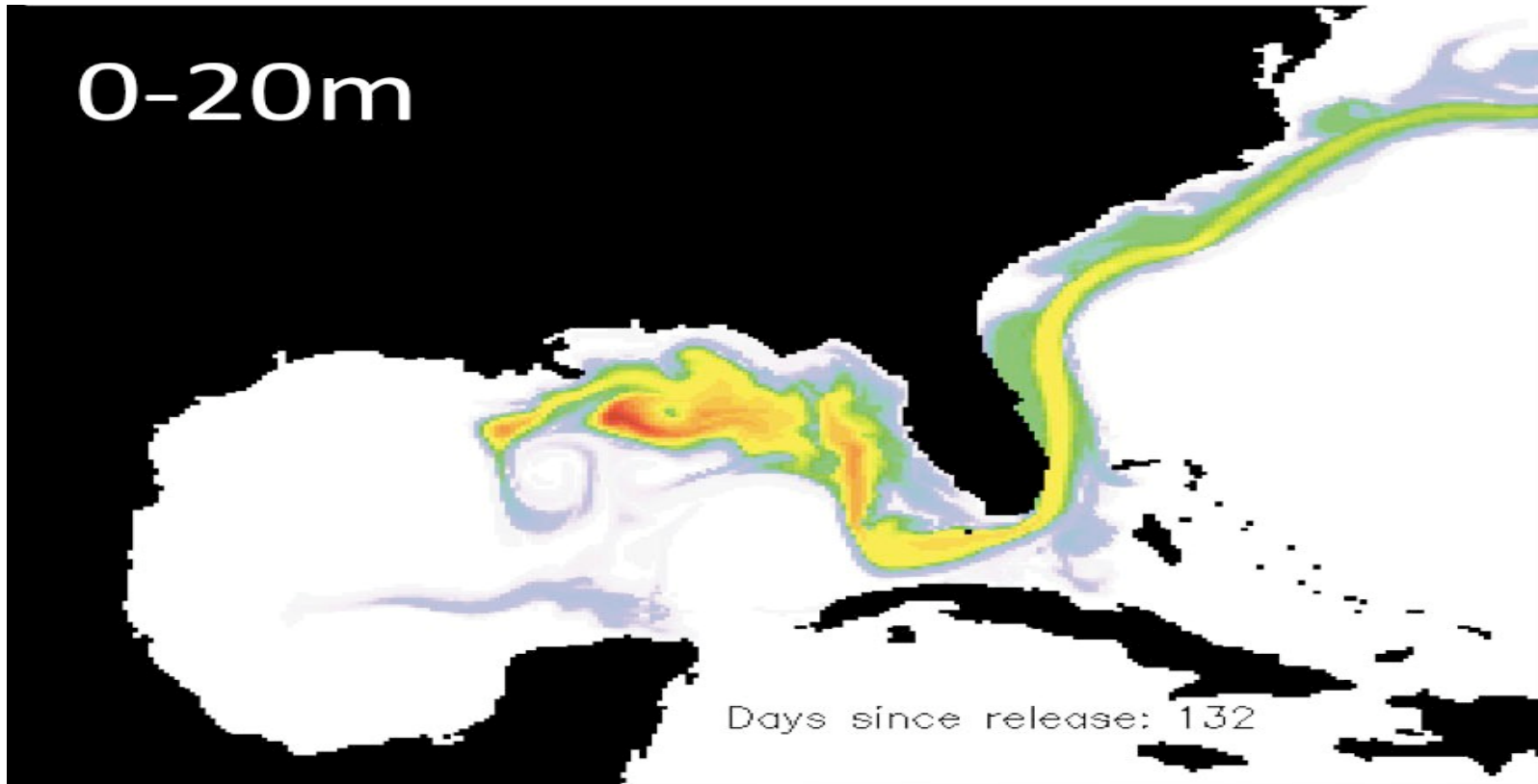
- Mantle-Crust-Glacier-Rivers-Oceans
- Weather-Agriculture-Economy-Society
- 150,000 flights cancelled, 15 million re-bookings





# BP Oil Slick disrupts Gulf States economy

- 87 days of continuous flow
- 50km oil slick below the surface
- 5 million barrels of oil spilled - largest spill in history



# Extreme Rainfall – Northwest Pakistan

- Heaviest monsoon in 80 years
- 20 million people displaced
- 1700+ deaths



# Record Heat Wave – Western Russia

- Highest temperatures in 130 years
- Spontaneous fires – peat bogs, crops, forests
- 70+ deaths from fire, 2000+ deaths from drowning



# China - Gansu Landslide

- Disruption from 47 hydro-electric projects
- Massive deforestation - landslides
- 1500+ deaths



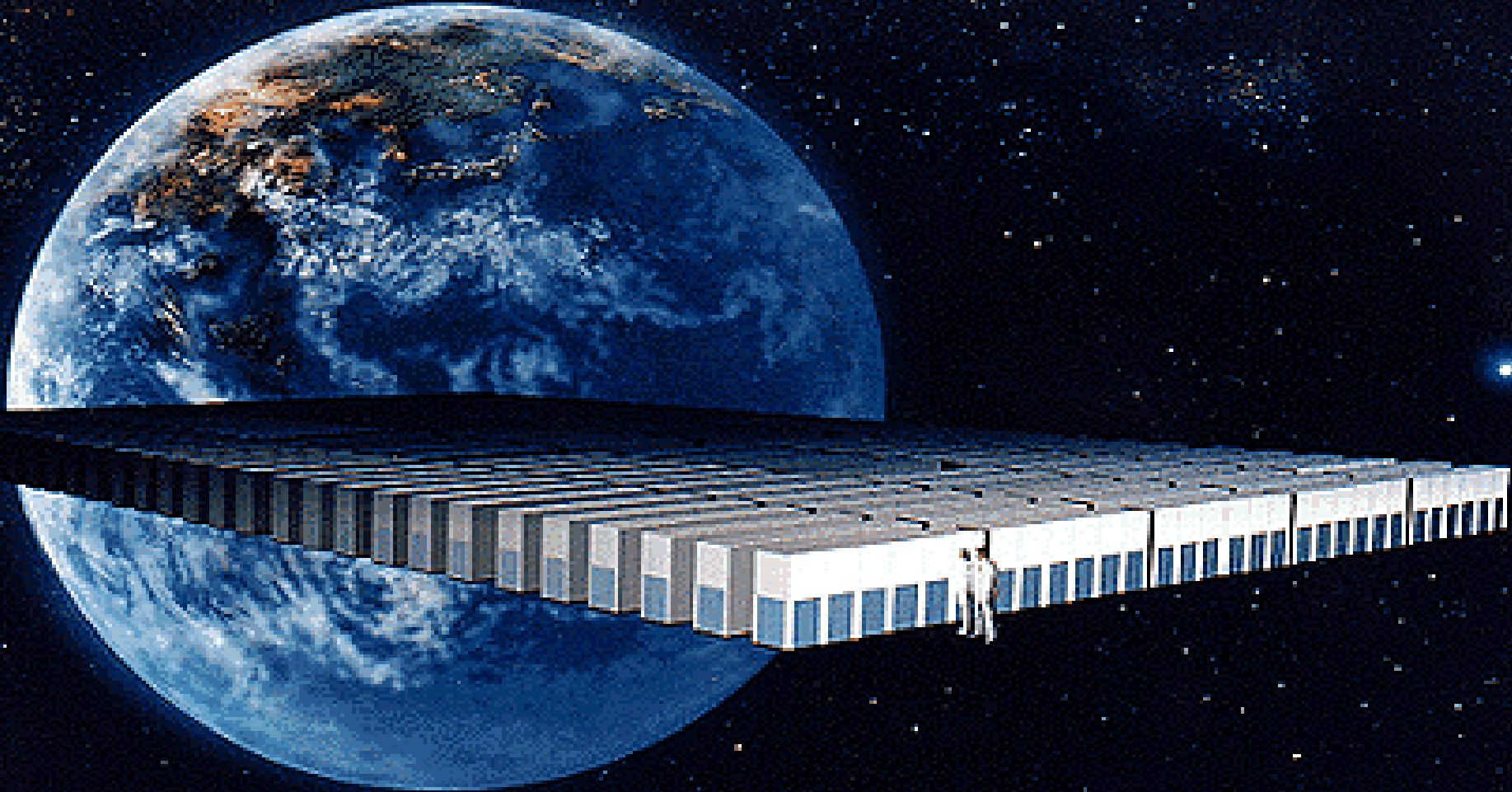
# Recent Flooding Disasters

December 2010	Colombia	200+	floods, landslides
November 2010	Belgium	3	flash floods
October 2010	Vietnam	48+	flash floods
October 2010	Wasior Indonesia	91+	flash floods
September 2010	Jamaica	5+	floods, landslides
September 2010	Southeast Mexico	7+	floods, landslides
August 2010	Gansu China	1500+	floods, landslides
August 2010	Kashmir	170+	flash floods
August 2010	Central Europe	15+	flash floods
July-Aug 2010	West Pakistan	1700+	heavy monsoons
June 2010	Southern France	25	flash floods
June 2010	Southern China	200+	floods, landslides
June 2010	Northern Brazil	100+	floods, landslides
June 2010	Poland	15	river flooding
April 2010	Brazil	200+	rain, mudslides
March 2010	Uganda	350+	rain, mudslides
Feb 2010	Xanthia, France	50+	tempest, sea walls



# Yokohama Earth Simulator

Opened March 2002, NEC SX-6



# Dedicated Weather-Climate Systems

(TAKEN FROM THE NOVEMBER 2010 LIST OF TOP500 SUPERCOMPUTER SITES)

Worldwide Ranking	Organization	Country	Peak Teraflops	<b>Sustained Teraflops</b>	Supplier
# 19	KMA	Korea	379.01	<b>316.40</b>	CRAY XE6
# 20	KMA	Korea	379.01	<b>316.40</b>	CRAY XE6
# 32	NOAA/ORNL	USA	259.66	<b>194.40</b>	CRAY XT6
# 50	NOAA/ESRL	USA	148.12	<b>126.50</b>	Aspen Cluster
# 56	JAMSTEC	JAPAN	131.07	<b>122.40</b>	NEC SX9
# 57	ECMWF	UK	156.42	<b>115.90</b>	IBM Power 575
# 40	ECMWF	UK	156.42	<b>115.90</b>	IBM Power 575
# 58	DKRZ	GY	151.60	<b>115.90</b>	IBM Power 575
# 81	NAVO	USA	117.14	<b>90.84</b>	CRAY XT5
# 93	NAVO	USA	102.27	<b>78.68</b>	IBM Power 575
#101	NIES	JAPAN	177.12	<b>74.84</b>	HP Cluster
#103	NCEP	USA	93.85	<b>73.06</b>	IBM Power 575
#104	NCEP	USA	93.85	<b>73.06</b>	IBM Power 575
#127	NCAR	USA	76.40	<b>59.68</b>	IBM Power 575

# Multiple non-linear interlocking systems imply:

- Increasingly complex system dynamics
- Interactive nature of risk – one risk drives another
- Mega-crises can create multiple synchronous failures
- Japan: subduction, earthquake, tsunami, nuclear plants, internal displacement, burial, shelter, water, food, financial, logistics, power, supply-chain, exports, travel, global circulation, contamination air/sea
- **There has been multi-dimensional collapses likewise in:**  
Haiti, Chile, Iceland ash cloud, BP oil spill, Russia, Pakistan, Queensland, Brazil, China, Christchurch



# In the next 10 years ...

- Earth System models will learn to integrate all natural sciences
  - weather, climate, earth, enviro, helio & planetary sciences
- Such models will assimilate vast amounts of observational data
  - in situ, ocean, airborne, space based, (*cell phone, automobiles*)
- These new models will resolve fine-detailed relevant phenomenon
  - cloud microphysics, convection, vorticity, aerosols, etc
- Supercomputing, cloud computing, grids will all play their part, as will Google Earth, Wolfram Alpha, Facebook, Twitter & Citizen Science
- Natural Science & Socio-economic models will integrate, p
- Public-Private Partnerships will emerge as new key players

