Avoid the Unmanageable, Manage the Unavoidable

What can we expect from the climate in the coming decades, and what can we do?

J. H. Plumb Auditorium, Christ's College, Thursdays, 5:30 to 7 pm

Charles F. Kennel

**Director, Vice-Chancellor, and Distinguished Professor Emeritus,
Scripps Institution of Oceanography,
University of California, San Diego**

**Distinguished Visiting Fellow,
Christ's College, Cambridge**

**Visiting Research Fellow,
Centre for Science and Policy
University of Cambridge**

Feb 27: Adaptive Management of Climate Change

The essential role of assessment in the adaptive management of complex systems; the regional specificity of climate change impacts; the critical role of local communities; the complexity of knowledge assembly for regional and local decision-support; the need to encourage timely decisions; and the capacity problem. "Knowledge Action Networks" comprising international experts and local decision-makers can inform and motivate good decisions

Reprise

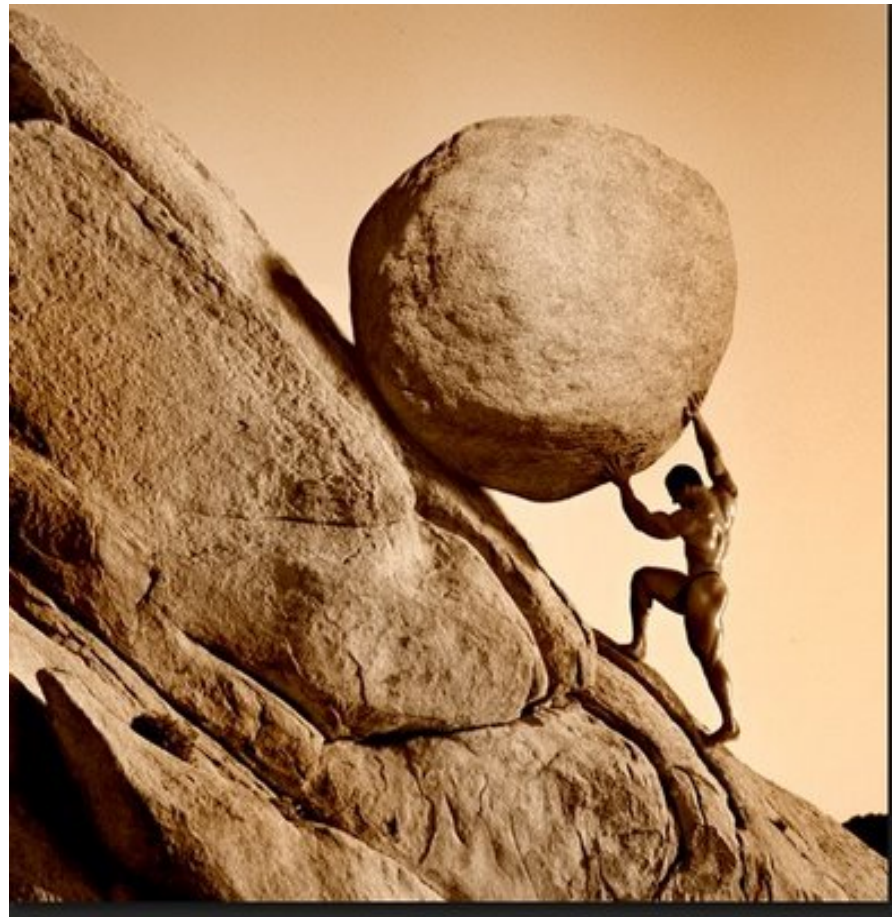**Avoid the Unmanageable, Manage the Unavoidable**
What can we expect from the climate in the coming decades, and what can we do?
J. H. Plumb Auditorium, Christ's College, Cambridge
Thursday, Feb. 27, 5:30 to 7 pm

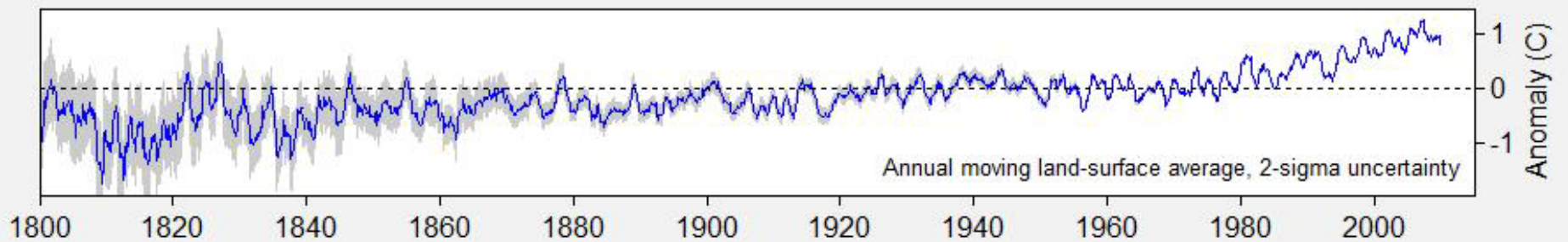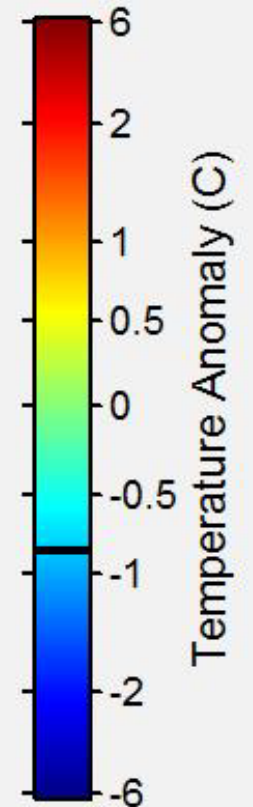# "...the greatest threat facing humanity"
U.N. Secretary General Ban Ki-Moon

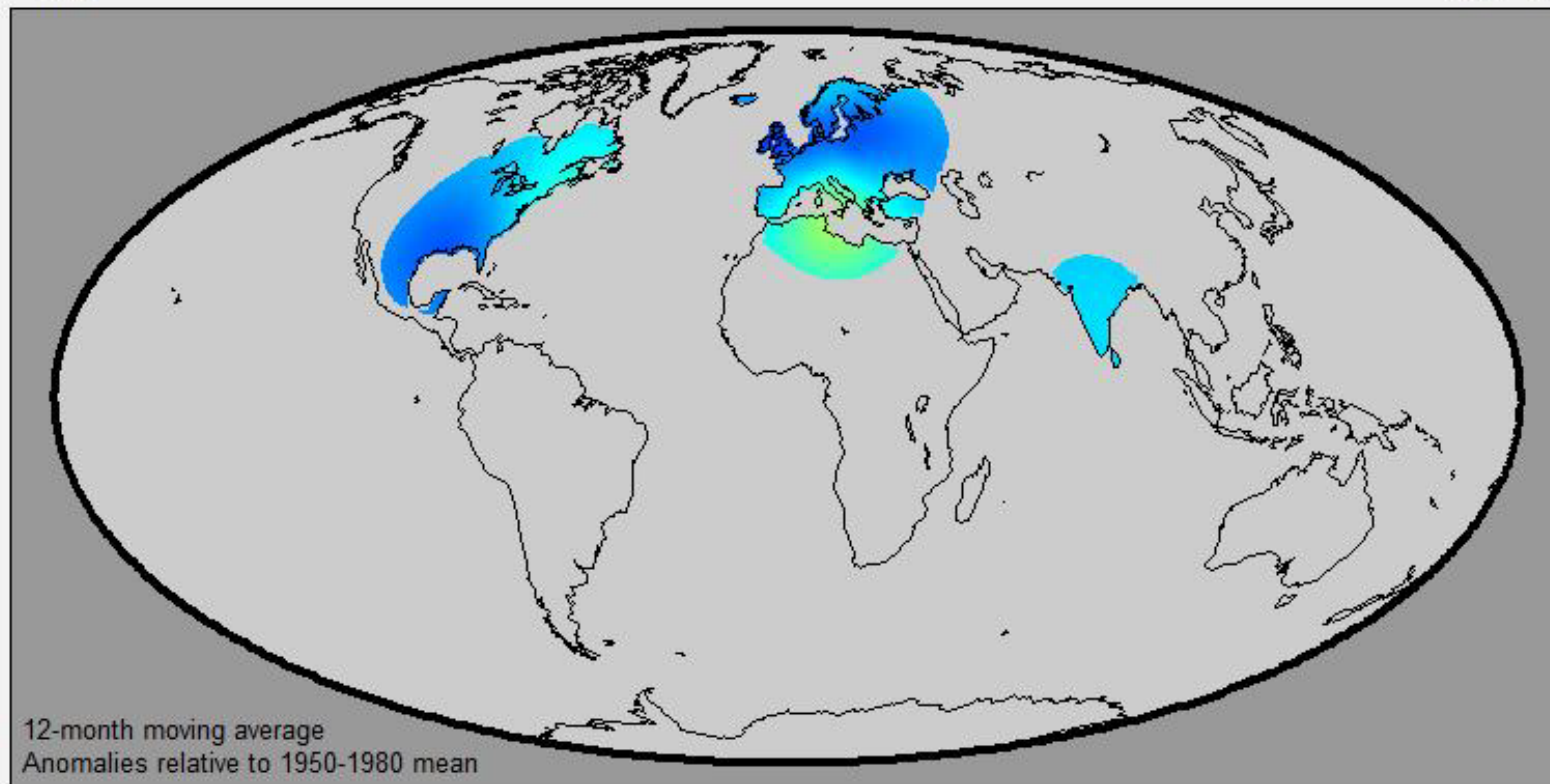# "The journey of a thousand years begins with small steps"
With thanks to Lao Tzu

Stations-Years
41.3

1800.00

Land Coverage
10.7%

Temperature Anomaly (C)

12-month moving average
Anomalies relative to 1950-1980 mean

Annual moving land-surface average, 2-sigma uncertainty

Anomaly (C)
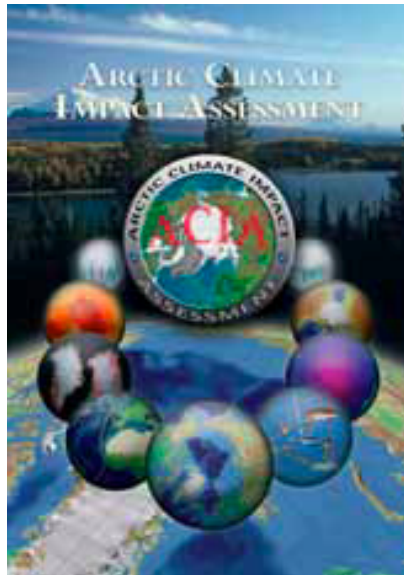
Summer Arctic Sea Ice Area.

The sea ice extent in September 2012 was more than 40% below the median for 1979-2000

Polar Regime Shift In Progress

ACIA, 2005: Polar Amplification a reality
SWIPA, 2011: Warming accelerated and changed character after 2000

SWIPA: 2005-2010 were the warmest years ever recorded.
Warming now fastest in spring and autumn; before 2000, in winter, consistent with GCMs.
**Warming now faster over the oceans than over land.**

Both changes suggest that declines in snow cover (spring) and sea-ice extent (fall)
are accelerating Arctic climate change.

Screen, J.A. and I. Simmonds, The Central Role of Diminishing Sea Ice in Recent Arctic Temperature Amplification,
Nature 464, 1334–1337 (29 April 2010) doi:10.1038/nature09051

Ice Melt Acceleration Confounded AR4

"The average rate of ice loss from the Antarctic ice sheet has likely increased from 30 [–37 to 97] Gt yr–1 over the period 1992–2001 to 147 [72 to 221] Gt yr–1 over the period 2002 to 2011" IPCC AR5, 2013
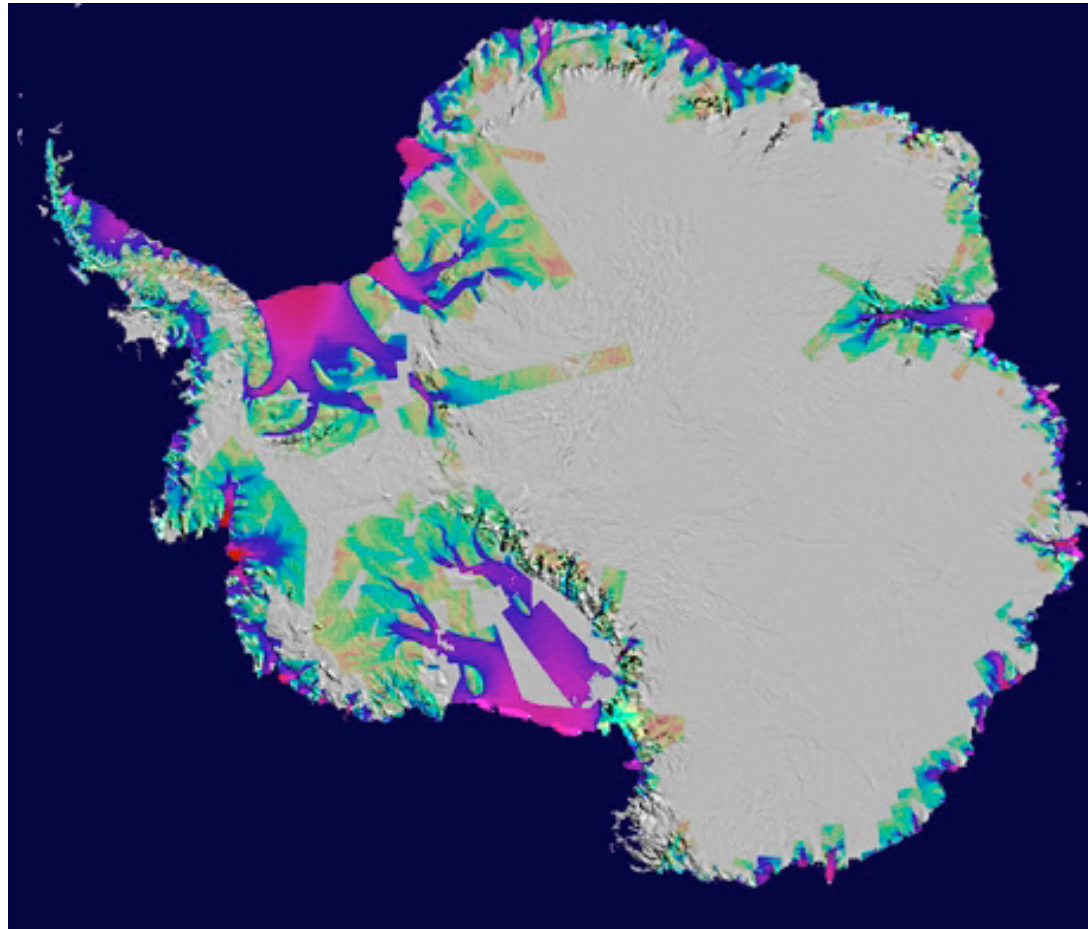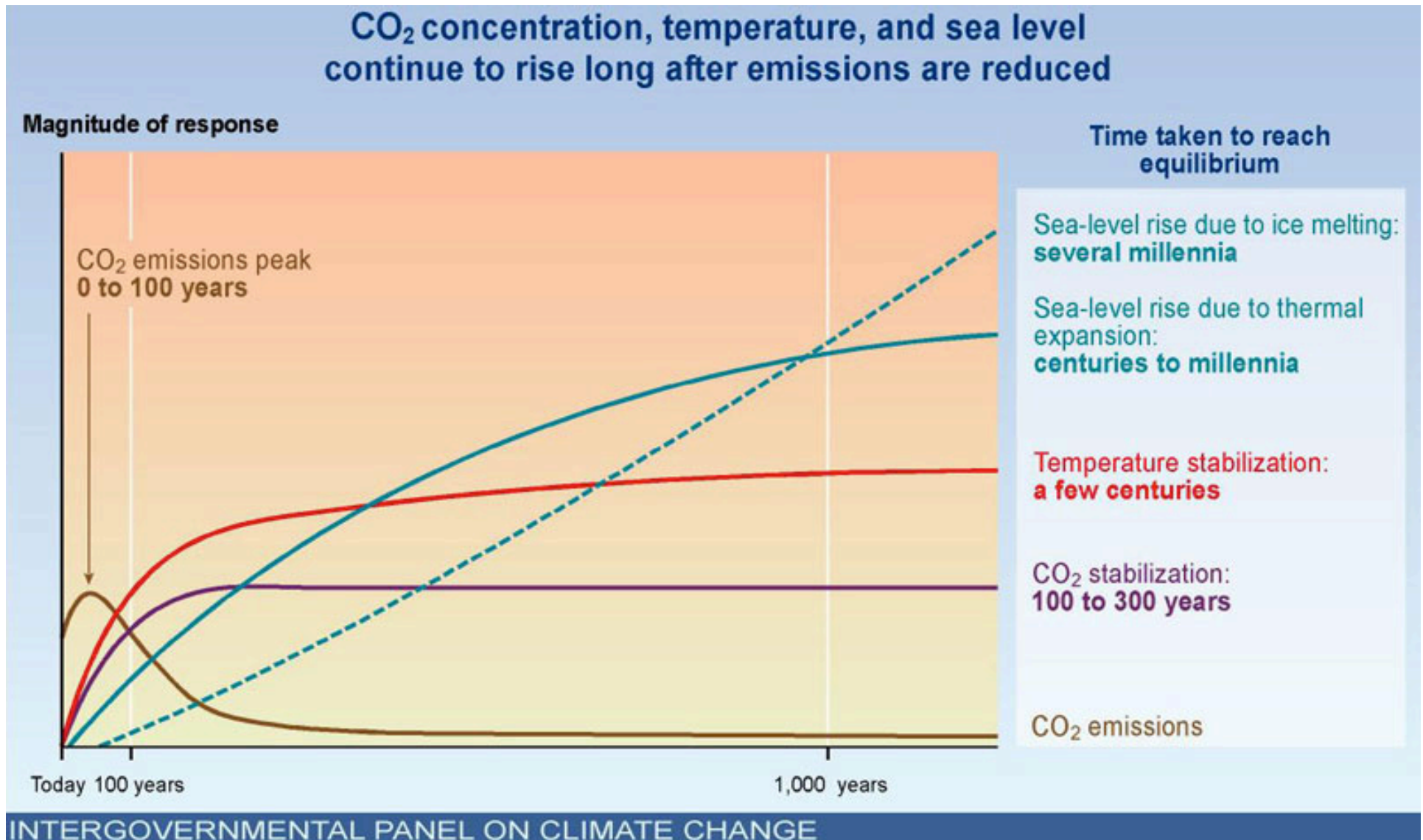

Regions of ice loss between 1996 and 2006 Rignot, *et.al., Nature Geoscience, 1*, 108, 2008

We Cannot Avoid Long-Term Climate Change
Because of what we have already done, much less what we are about to do
The oceans, right now our friend, are storing up problems

CO₂ concentration, temperature, and sea level continue to rise long after emissions are reduced

Magnitude of response

Time taken to reach equilibrium

CO₂ emissions peak 0 to 100 years

Sea-level rise due to ice melting: several millennia

Sea-level rise due to thermal expansion: centuries to millennia

Temperature stabilization: a few centuries

CO₂ stabilization: 100 to 300 years

CO₂ emissions

Today 100 years

1,000 years

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

The Case for Adaptation

What can we expect if we meet CO2 targets for stabilization, act on short-lived climate pollutants, but also reduce cooling air pollution?

To stay below 2C by 2050, we should begin reducing GHG emissions by 2015, but global emissions are accelerating, and show no sign of moderating.
Even if we try everything, we may not keep warming in 2050 below 2C.
We should prepare for at least 1.2C additional warming by 2050.
This would mean the rate of climate change could more than double.

V. Ramanathan and Y. Xu, The Copenhagen Accord For Limiting Global Warming, PNAS, May 4, 2010
C.F. Kennel, V. Ramanathan, and D. Victor, *Proceedings American Philosophical Society*, *156, 4*, 398-415, 2012

Rethinking The Way We Think About Climate

Policy Balance
Adaptive Management
More Forgiving Thinking
Adaptive Management and Governance
Bridging Knowledge and Action
Knowledge Action Architecture
Adaptation's Ethical Dilemma

Policy Balance

Many mitigation advocates disparaged talk of adaptation

- Absolves emitters of their ethical responsibility to mitigate
- Bad for morale; admits we have lost the Carbon battle

Mitigation and Adaptation have different requirements

- CO_2 mitigation policy focuses on measures of global reach: deployment of greener energy technologies, macroeconomic, regulatory, and innovation incentives
- Key adaptation decisions are about local resilience, and focus on specific regional issues of current urgency which are expected to grow in importance

Mitigation and Adaptation Assessments have different audiences

- IPCC assessments were designed to support a small number of large mitigation decisions by a comparative handful of central decision makers
- Adaptation assessments are required for hundreds of regions and thousands of communities and organizations

A World New to Human Experience

Can we get a feel for Earth's future from observing today's climate change?
What can be learned from dissecting projections of future climate change?
How adequate are contemporary assessments for adaptation purposes?

Adaptive Management
Adaptive management is what you do when you know you have a problem but you don't know how it will unfold

Assess, Decide, Act
Think Globally, Assess Regionally, Act Locally

Adaptive Management
Assess, Decide, and Act-For A Thousand Years

Be Practical: Do all you can do at any one time
- Accommodate political and economic realities
- Take progress where you find it, even if it's not everything
- Incremental progress is better than none

Be Reasonable: Allow for mistakes
- Rethink when circumstances warrant
- Relieve anxiety of decision makers

Be Tolerant: No "one size fits all"
- Regions have different economic, political, and technical capacities
- Nations take action in different ways and at different rates

Be Timely: Do not delay decisions
- Motivate decision makers to decide
- Translate new knowledge as it is generated

Be Vigilant: Look out for tipping points
- Task assessments to search for precursors
- Have "insurance policies" and back-up plans

Be Resolute: Build Enduring Institutions
- Global knowledge management and decision support networks
- Hierarchy of coordinated governance structures

Adaptive Management and Governance
Past Experience No Longer A Guide To The Future

Assessment
Prepares knowledge for use
by governance

Governance
Makes Decisions
Guides evolution of outcomes

Like it or not, decision-makers have to rely on assessments to identify and characterize the issues they must decide.

Assessment and governance are inseparable: each needs the other.

By designing an assessment regime, we constrain a governance regime and *vice versa*.

Assessment Bridges Knowledge and Action

Knowledge
Creates Situational Awareness
Articulates options

Action
Implements Decisions
Promotes desired outcomes

Think Globally

Scientific knowledge is managed by a loosely organized club* of advanced nations that makes much of it freely available internationally.

Assess Regionally

Governing bodies form groups of experts to identify adaptation issues, assemble pertinent knowledge, and deliver a synthesis in useful forms

Act Locally

Communities within regions make and interrelate complex, multi-disciplinary, and geographically distributed decisions. Ostrom** proposes the name "polycentric" for this kind of decision-making.

*Keohane, R.O. and D. G. Victor, The Regime Complex for Climate Change, Perspectives on Politics, v.9, no. 1, March 2011

**Ostrom, E., Beyond Markets and States: Polycentric Governance of Complex Economic Systems, *American Economic Review 100 (June 2010):* 1–33http://www.aeaweb.org/articles.php?doi=10.1257/aer.100.3.1

Knowledge Action Architecture

Assessment
**Identifies and articulates Issues**
Frames "Decisions"

Governance
Makes "Decisions"
Guides evolution of outcomes

Adaptation calls for a consortium of international knowledge management services to support, via assessment, polycentric decision making at regional and local levels

Adaptation's Ethical Dilemma

The countries least responsible and least able to adapt will suffer the most

A Climate of Injustice

Global Inequality, North-South Politics, and Climate Policy
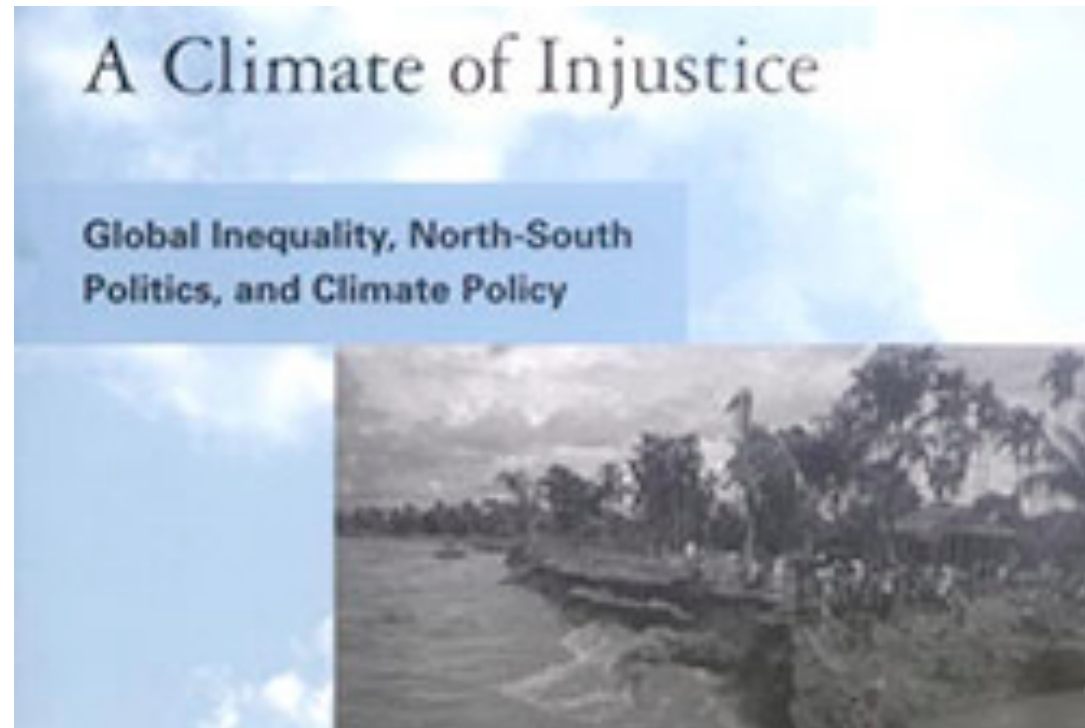
There are assertions of blame and responsibility but few approaches that appeal to the interests of both developed and developing countries. However, there is a potential mutuality of interest in a global knowledge action network for disaster management and adaptation. It will help developing nations make their own assessments. Though there will be an asymmetry in scale and nature of investment, both developed and developing countries can see benefit in investing. It won't solve everything but it could help.

What have we learned about assessments for adaptation?

Experience Base
Components of Assessment
Knowledge Assembly & Synthesis
Knowledge Certification
Knowledge Translation
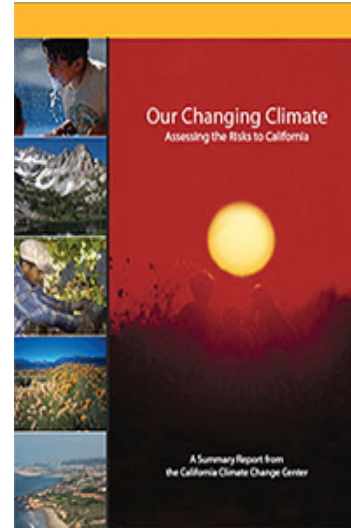**Knowledge Delivery**
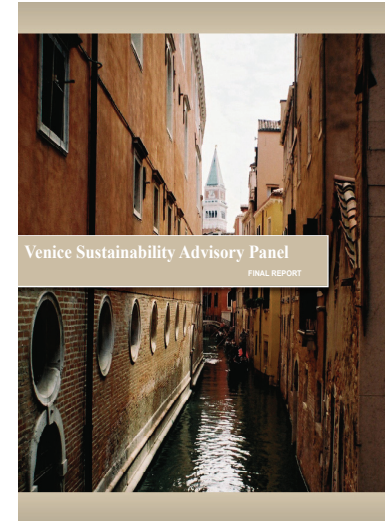
Experience Base

Sub-Global International Governance Regime

National Governance
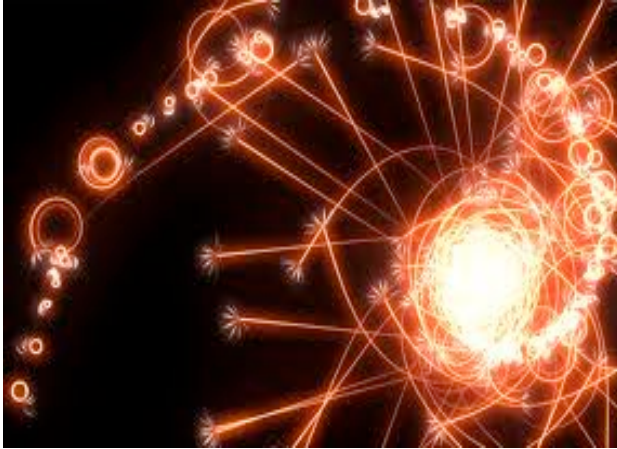
Regional Governance

Local Governance

Assessments conforming to their governance regimes
Frameworks for polycentric decision-making

Components of Assessment
Knowledge Management Processes

Assembly & Synthesis

Certification

Delivery
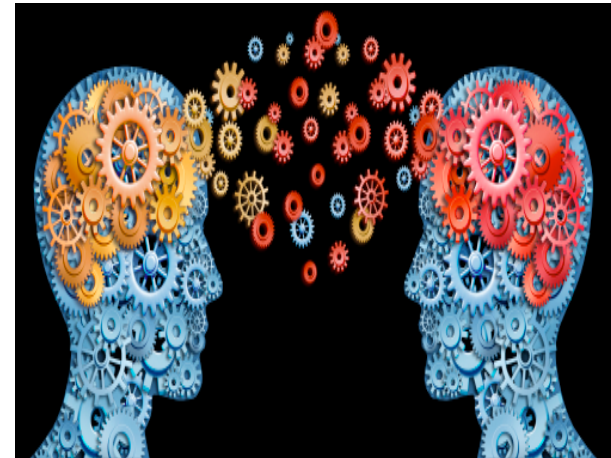
Translation

Knowledge Assembly & Synthesis
Think Globally, Assess Regionally, Act Locally

Knowledge Percolation
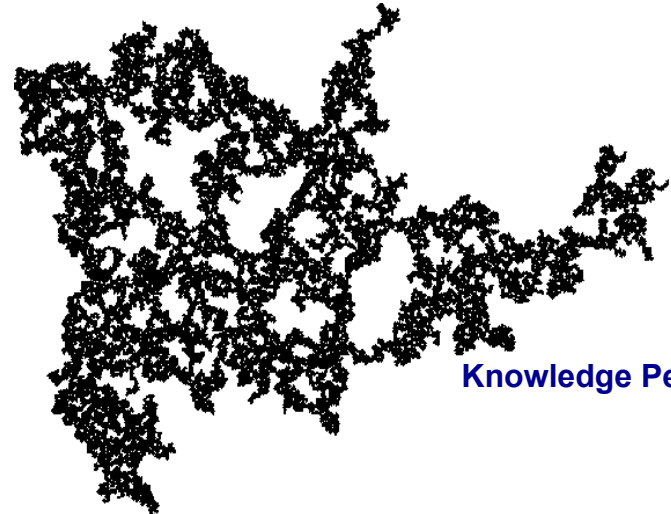
Global Science Sets the Stage
Space observations, global models
Regional Assessments Frame Impacts
Regional natural and human systems
Local Knowledge Shapes Objectives
Locally unique social and technical interactions

Knowledge Certification
IPCC's Most Important Value Added Product
Deploys the Authority of Science

Extensive Literature Review

Informal Ranking of Reviewers

Exhaustive Small Group Discussion

Consensus of Experts Present

Knowledge Translation
Inform *and* Motivate Local Action

Knowledge
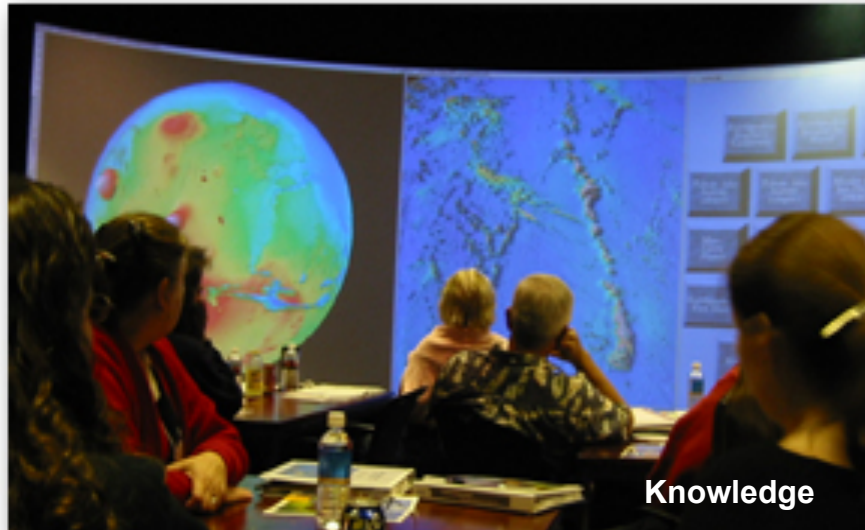
Action

Not Enough to be Correct

If you can't make yourself understood, they won't listen

If you neglect social justice and economic development, they will neglect you

If you are culturally insensitive, they won't respond

Trust Motivates Action

Personal contact is the precursor to trust.

Decision makers should participate in assessments.

Trusted local leaders will carry out adaptation strategies

UNFCCC Conference of Parties

Adaptation Decision-Makers

Knowledge Delivery
Connect Efficiently to Governance

Deliver the right knowledge to the right people at the right time

Deliver it when they need it and where they need it

Deliver it in forms they can use

Keep on delivering it

Looming Problems

Capacity

Complexity

Certification

Delivery

Quality Assurance

Timeliness

Sustainability

The Capacity Problem

Specialized decision support will be needed for dozens of sectors, hundreds of regions, and millions of decision makers.

How can the relatively small science, technology, and policy community meet the coming demands?

The Complexity Problem

Adaptation Knowledge Cascade

Weather and Ocean Patterns

Large atmospheric systems-equator to pole heat transport, polar vortex, atmospheric rivers,…

Ocean circulation-El Nino/La Nina, Pacific Decadal Oscillation, Gulf Stream…

Regional characteristics- temperature, wind, rainfall, relative sea level…

Extreme events-heat waves, cold snaps, storms, droughts, floods,...

Regional Geophysical Systems

Cryosphere-Sea ice, Greenland, Antarctic, mountain glaciers and snows, permafrost…

Mountains and Watersheds-river networks, aquifers, deltas, sediment transport…

Deserts-dust transport,…

Regional Ecosystems

Biodiversity: species distributions and abundances…

Biomes- chaparral, grassland, savannah, forest, tundra, marshlands, coastal zones…

Habitats-invasive species, fragmentation,..

Regional Technical Systems

Managed Ecosystems-Agriculture, forestry, fisheries…

Managed Water and Air Supplies-Irrigation, pollution,..

Managed Extreme Events-Disaster response and civil infrastructure…

Managed Human Services-Electricity production and transmission,…

Humans

Health-Malaria, cholera, respiratory diseases, …

Security-Food, water, and energy, environmental conflict, migration

Economics-Industries, trade, investment

Welfare-Socio-Economic Development

The Complexity Problem
Regional and Sectoral Polycentric Governance
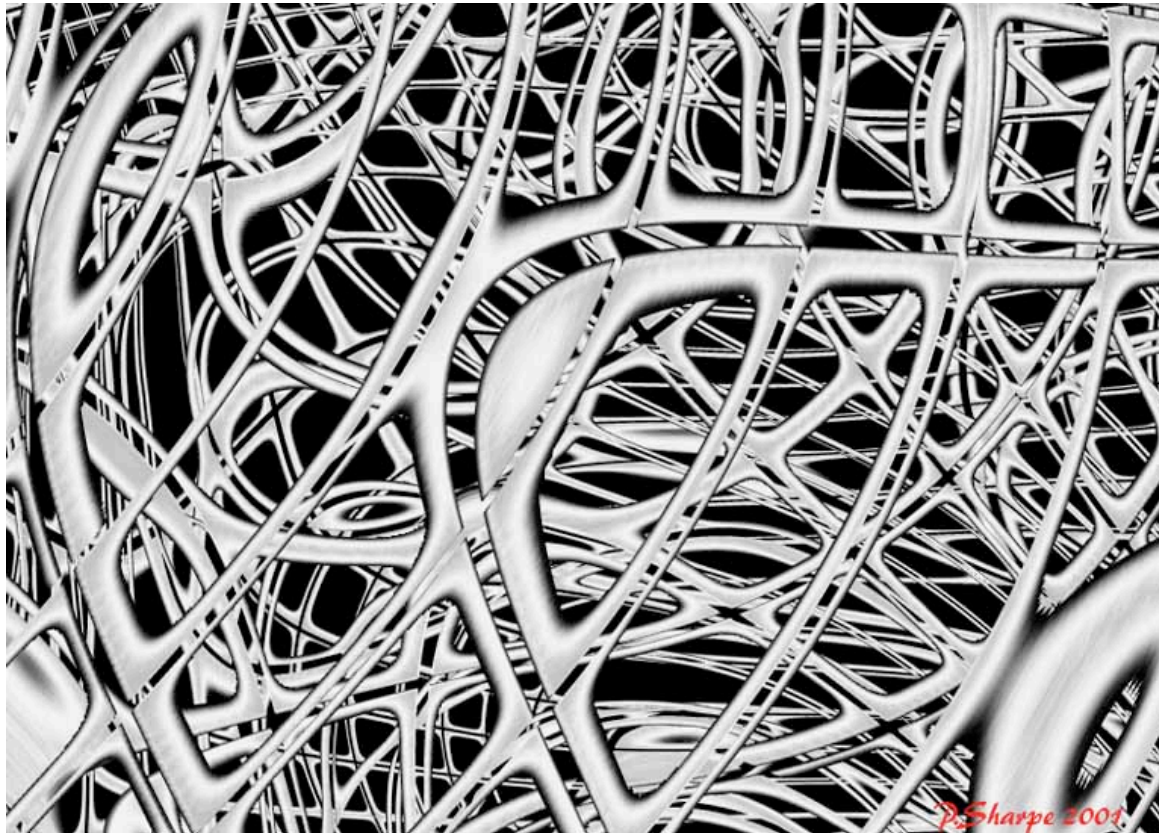
Adaptation is not suited to a centralized, top down, command-and-control management style. No central actor-leader, committee, government agency- can conceive of all the tasks ahead and how they interrelate.

The Delivery Problem
Meet Assessment Needs of Communities
Centers of innovation for resilience

UN Development Programme

Communities, one by one, will have to comprehend the economic, social, and cultural implications of climate change. Only they will be able to estimate socially realistic costs of adaptation, and only then will the world know the true magnitude of the challenge.

Quality Assurance
The key enabler

**Local leaders find themselves faced with decisions they cannot delay.
They will not wait for knowledge to trickle down to them.
Can they find knowledge they can trust on their own?**

The Timeliness Problem

- **Climate, as measured by global temperature, likely to change twice as fast in the next twenty years as it did in the last forty**
- **Significant change increasingly likely to occur between IPCC reports**
- **Research will have to keep up**-Arctic 2004 Assessment out of date after 7 years
- **Communities at risk cannot wait for knowledge to cascade from global to regional to local**

Assessment should become an "always on" knowledge management service

The Sustainability Problem
Plan to keep knowledge in active use for 1000 years
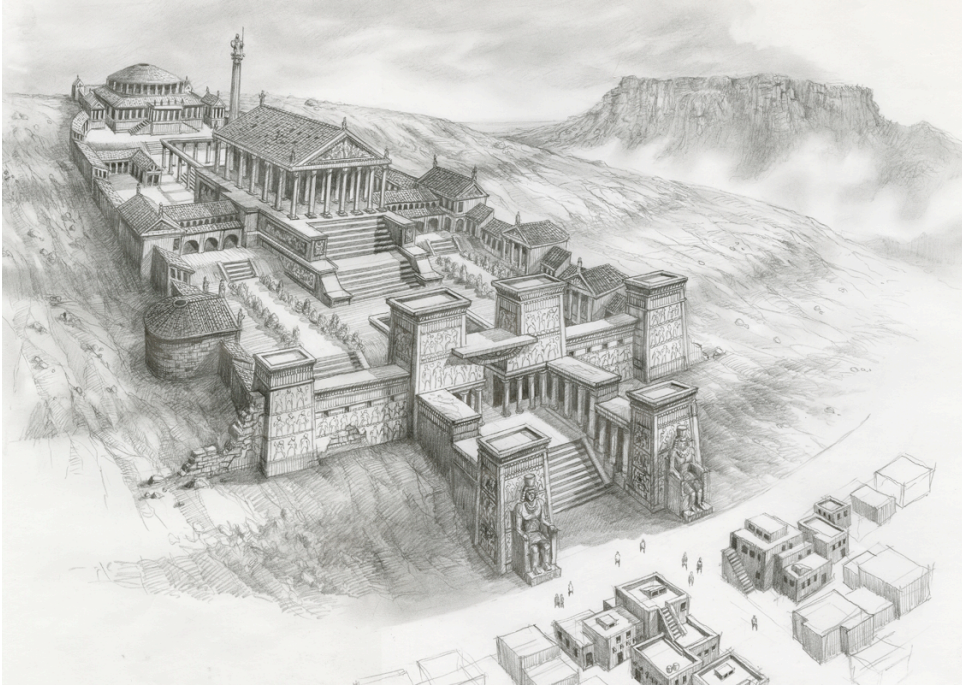
Ancient Library of Alexandria, 300 BCE-400CE

Modern Library of Alexandria, 2002 CE-

Enduring Meta-Institutional Framework
Resilience to Disasters, Disruptions, and Political Change
Obsolescence Strategy

What can we do with what we've got?

Adaptive research management

Embed assessment services in internet

Work towards federation

What have we got?

Communications Architecture

Cyber-Infrastructure

Data Repositories

Federated Research Networks

Global Earth System of Systems

Adaptive Research Management

Research management needs to anticipate that the pace of climate change may accelerate

No bright line separating research and monitoring
New observational results *de facto* policy relevant

Flexible Research Grants
More autonomy, core funding for research institutions and networks

Synthetic Research Projects
Reward integration as well as originality

Timely Knowledge Synthesis

Should authoritative global* and regional organizations post reviews of research as soon as a synthesis seems mature?**

***IPCC, ICSU…**UNEP, Academies…**

Earth System Science Partnership (ICSU)
World Climate Research Programme (1980)
International Geosphere-Biosphere Programme (1987)
DIVERSITAS (1991)
International Human Dimensions Programme (1996)

Who reviews the reviews?

Embed Assessment Services in Internet
Ameliorate Capacity, Complexity, and Timeliness Problems

Assemble, catalog, disseminate, and preserve knowledge from a vast range of sources
Provide tools for knowledge synthesis, certification, and search
Encourage bottom-up initiatives via Open Access

Work Towards Closer Federation

Collection, Connection, Comprehension, Conservation, Communication

Some technical and management tools needed to integrate global, regional, and local knowledge services are in place.

Articulating agreements, standards, communications

World-Wide Communications Architecture
High capacity networking among archives and research centres
Access by polycentric users enabled by the World-Wide Web

Global Lambda Information Facility

Global Mutual Learning
Integration of distributed local actions

Cyber-Infrastructure
Knowledge Management Tools

High-performance computing
for modeling, simulation, data
processing/mining

Humans

Individual &
Group Interfaces
& Visualization

Collaboration
Services

Global
Connectivity

Instruments for
observation and
characterization.

Physical World

Facilities for activation,
manipulation and
construction

NSF Report on Revolutionizing Science
and Engineering through Cyber-
Infrastructure
(Atkins Report)
www.communitytechnology.org/
nsf_ci_report/

Knowledge Management
institutions for collection building
and curation of data, information,
literature, digital objects

Data Repositories

**International Coordination
National Management
Global Access**

World Conservation Monitoring Center

Essential Climate Variable (ECV's) ...

U.S. Department of Commerce/NOAA/NESDIS
National Oceanographic Data Center

NODC

NOAA's National Climatic Data Center

USGS EROS DATA CENTER
LANDSAT 7 DATA CAPTURE & PROCESSING SYSTEM

WDC
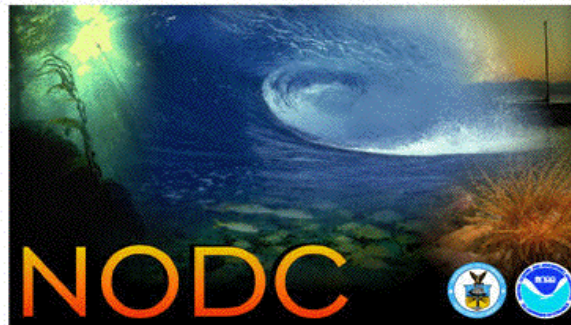
**World Data Centers (1957)
52 centers, 12 countries
Solar, Geophysical,
Environmental, Human
Dimensions**

Federated Research Knowledge Network
NASA Distributed Active Archives (DAACs)
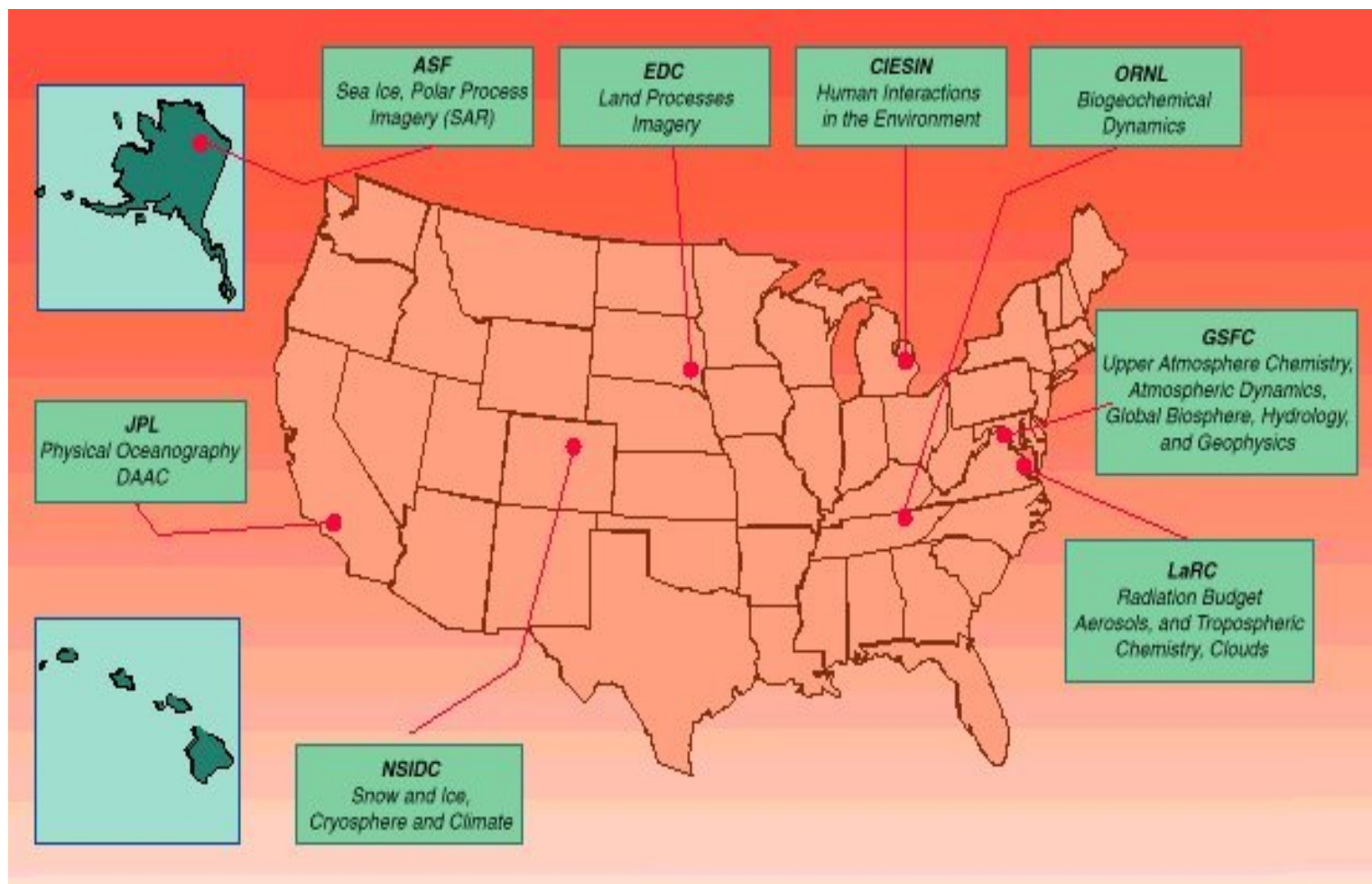
Global Earth Observation System of Systems
Integrating Data in Nine Societal Benefit Areas
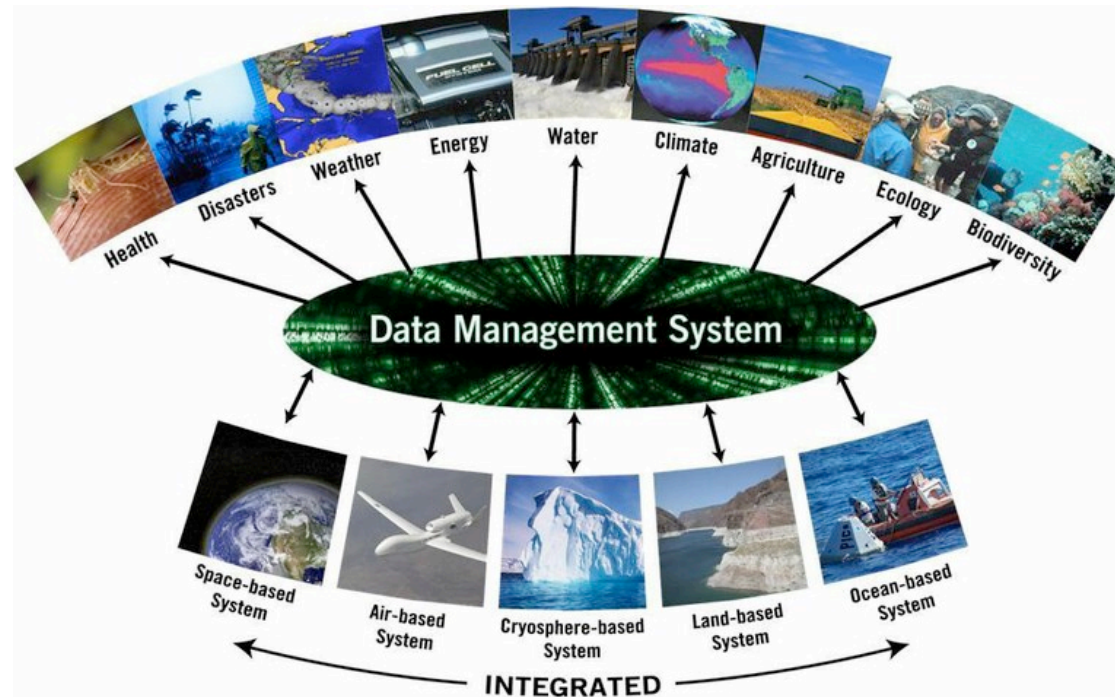
2002 WSSD and 2003 G-8 Summit
2003 Ministerial Meeting, Washington, DC
2005 Intergovernmental Agreement
  88 governments, EC, and 64 affiliates as of 2012
Synthesis of a common pool of data
  Space and *In Situ;* global and regional
  Physical, chemical, biological,
  Atmosphere, land, oceans
Common infrastructure for interoperability

What's missing?

Streamlined Certification

Decision readiness-A NASA example

Knowledge readiness levels?

Bibliometric indicators

Annotated search engines

Hunting for Decision-Ready Knowledge in the Information Jungle
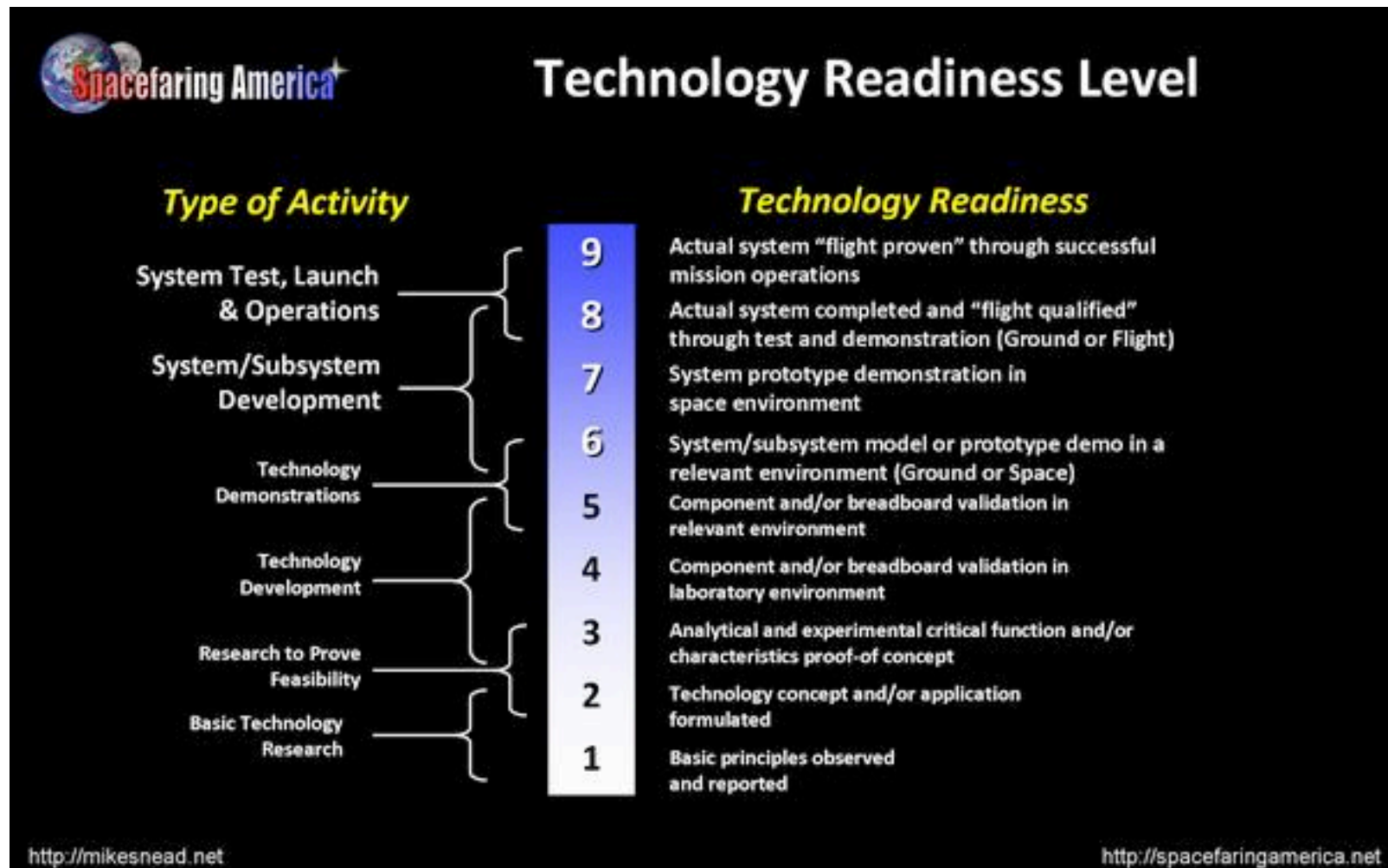
Streamlined Certification
Put Knowledge To Work Soon After It Appears

There is an urgent need to invent social and internet-based processes to characterize how ready new research is for practical use by non-experts.

Decision Readiness
A NASA Example

Technology Readiness Level

Type of Activity

System Test, Launch & Operations

System/Subsystem Development

Technology Demonstrations

Technology Development

Research to Prove Feasibility

Basic Technology Research

Technology Readiness

9 — Actual system "flight proven" through successful mission operations

8 — Actual system completed and "flight qualified" through test and demonstration (Ground or Flight)

7 — System prototype demonstration in space environment

6 — System/subsystem model or prototype demo in a relevant environment (Ground or Space)

5 — Component and/or breadboard validation in relevant environment

4 — Component and/or breadboard validation in laboratory environment

3 — Analytical and experimental critical function and/or characteristics proof-of concept

2 — Technology concept and/or application formulated

1 — Basic principles observed and reported

http://mikesnead.net   http://spacefaringamerica.net

Knowledge Readiness Levels?

Level 1: **Presented at conference**
Level 2: **Published in gray literature**
Level 3: **Peer-reviewed publication**
Level 4: **Multi-disciplinary citations**
Level 5: **Expert Synthesis**
Level 6: **Decision-Readiness**
Level 7: **Use***
Level 8: **Best Practice**

*For a discussion of the complex factors affecting science use, see Dilling, L., & M.C. Lemos, Creating Usable Science: Opportunities and constraints for climate knowledge use and their implications for science policy, *Global Environmental Change, 21,* 680-689, 2011

Bibliometric Indicators
Inform But Not Replace Human Judgment

Social Maps
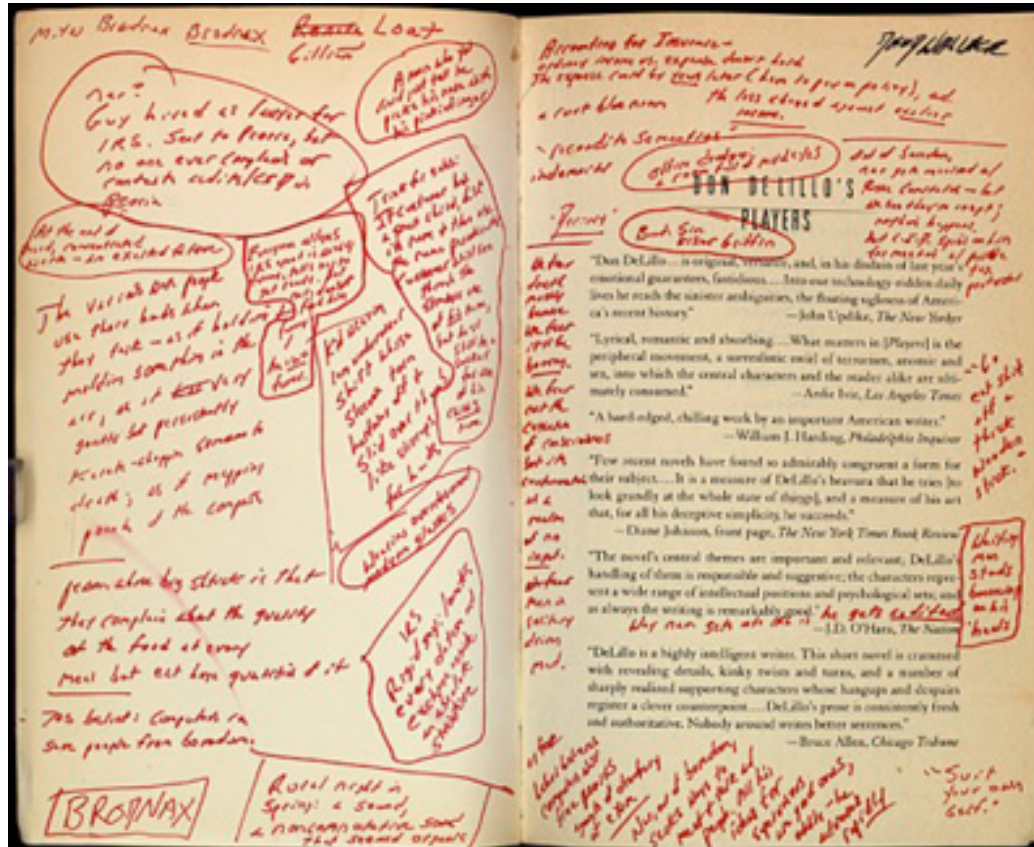Citations
Adoption
Media Coverage

Ranking
Reviewers, Citations,
Journals, Wikis

Oreskes, N., Beyond the Ivory Tower, The scientific consensus on climate change, Science, 306, 1686, 2004

Annotated Search Engines

Locate and characterize synthesised "decision-ready" knowledge

Annotation enables a knowledge system to support a knowledge action system and encourages bottom up adaptation initiatives

Social Networking

Fundamental Premise

It requires courage for non-experts to risk reputation and resources to act on expert knowledge

"TRUST DIES BUT MISTRUST BLOSSOMS."

SOPHOCLES

© Lifehack Quotes

Social networking conveys knowledge and motivation in equal measure

Stakeholder Consultation
A Precursor to Knowledge Action Networks

The BaltCICA project (Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region) ran from 2009 to 2012 and included 24 academic partners. Each partner prepared a local case study. Each developed scenarios that illustrated possible impacts of climate change and the kinds of adaptation strategies that were open to the community. Each worked with stakeholders-local politicians, experts, and citizens in workshops and interviews.

Knowledge Sharing Consortia

The Asia Pacific Adaptation Network (APAN), established in October 2009 as part of the Global Climate Adaptation Network (GAN), aims at building the resilience of vulnerable human systems, ecosystems, and economies by mobilizing knowledge and technologies to support adaptation capacity building, policy-setting, planning and practices.

http://apan-gan.net

Best Practice Consortia

Action leaders from around the world consult with one other
Compare strategies, reinforce the confidence of superiors

Global Forest Coalition (NGOs)

Mitigation

Climate and Clear Air Coalition

Mountain Ice, Snow, and Water TPE

Adaptation

C-40

Knowledge Action Networks

Explicitly Connect Assessment and Governance
Forums on Science and Technology in Society
Kyoto, 2009-2013

The first special session on regional climate change, "Creating an international framework for regional climate change impact assessments and local action" was convened on October 3, 2009. A sequel was convened on October 2, 2010, "Adaptation to the natural and social impacts of regional climate change". The Knowledge Action Network concept was first presented at these Forums. Subsequent special sessions were devoted to examining examples of knowledge-action networks.

Knowledge Action Networks

Face to face interactions among leaders of knowledge and action
Forum on Science and Technology in Society, Kyoto, 2009, Special Session on Regional Climate Change

Incubated internationally, empowered regionally, initiated locally

Global, regional, and local participants-a "vertical" structure

Science, technology and policy experts, regional leaders, local decision makers

Secretariats comprising professional knowledge translators-boundary organizations

Knowledge uptake improved by frequent interpersonal interaction

May be useful in developing world

Promote capacity-building and intercultural understanding

A peer group for those who do not participate in international peer circles

Kennel, C. F., and S.Daultrey, Knowledge Action Networks, Connecting regional climate change assessments to local action, University of California, e-scholarship, 2010, http://escholarship.org/uc/item/8gd6j0k5

What Knowledge Action Networks Do

STS, Special Session on Regional Climate Change, Kyoto, 2010

Global Science, Technology, and Policy Communities

Regional Knowledge leaders

Local Decision Makers

Understand local impacts of regional climate change

Characterize risks to the things local communities care about

Leverage existing resources and programs

Interrelate decisions at the global, regional, and local levels

Build capacity

Translate scientific knowledge into locally usable forms

Communicate the need for adaptation action in culturally appropriate terms

Develop technical systems for local use

Relay local knowledge to the regional, national, and international levels

Support local leaders as they implement adaptation actions

Challenge to the International Community

The world cannot wait for a perfect top-down framework.
Take the first steps now.

Incubate knowledge action networks
- Seed funding and core secretariat support
- Communications and common tools

Federate knowledge management services
- International diplomatic, technical initiatives
- Strengthen GEO

Connect knowledge management and decision support infrastructures
- Annotated search engines
- Boundary organization services

Promulgate standards for decision readiness and federation
- Convene conferences, workshops
- Propose certification processes

Internet Protocols enabled the spread of the internet around the world by enabling millions of small initiatives.

Could knowledge management protocols transform how the world adapts to climate change?

Knowledge Management Protocols

A High Leverage Investment

Taxonomy Standards

Labelling of subjects

Data formats and data quality characterization

Meta-languages

Repository Standards

What should be preserved, and for how long

Redundancy and security

Technological evolution strategy

Incentives to contribute

Accessibility Standards

Intellectual property and security

Price and public release

Configuration management and traceability

Annotation Standards

Characterization of decision readiness

Descriptors, labels, notation

Global Adaptation
An Emergent Property of Distributed Local Actions
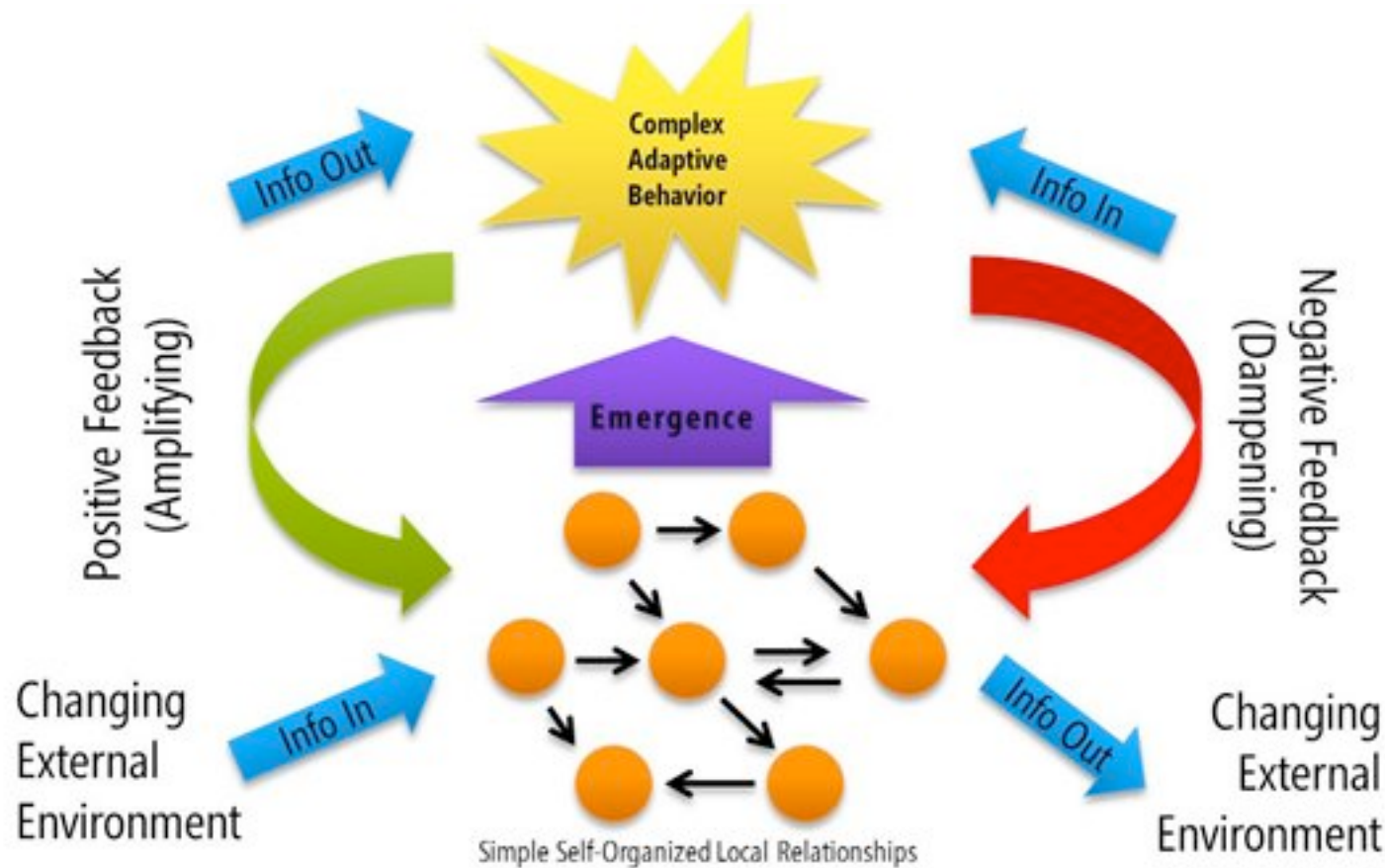### *Made possible by interconnectivity*

Figure adapted from Wikipedia; Complex Adaptive System by Alan Hakimi, The New World of Emergent Architecture and Complex Adaptive Systems, MSDN Blogs, Zen and the Art of Enterprise Architecture