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The New Variables

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The New Variables

The importance, and challenges, of predictive analysis for environmental change and the resiliency of human systems to extreme events

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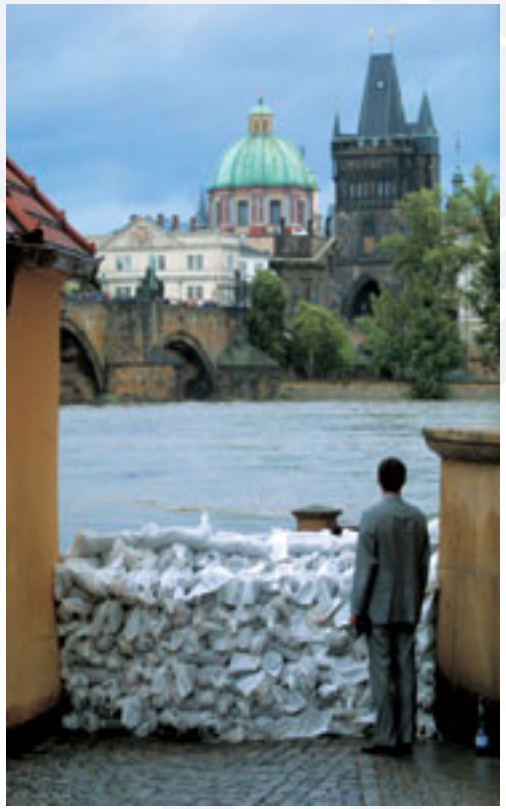
2 October 2009



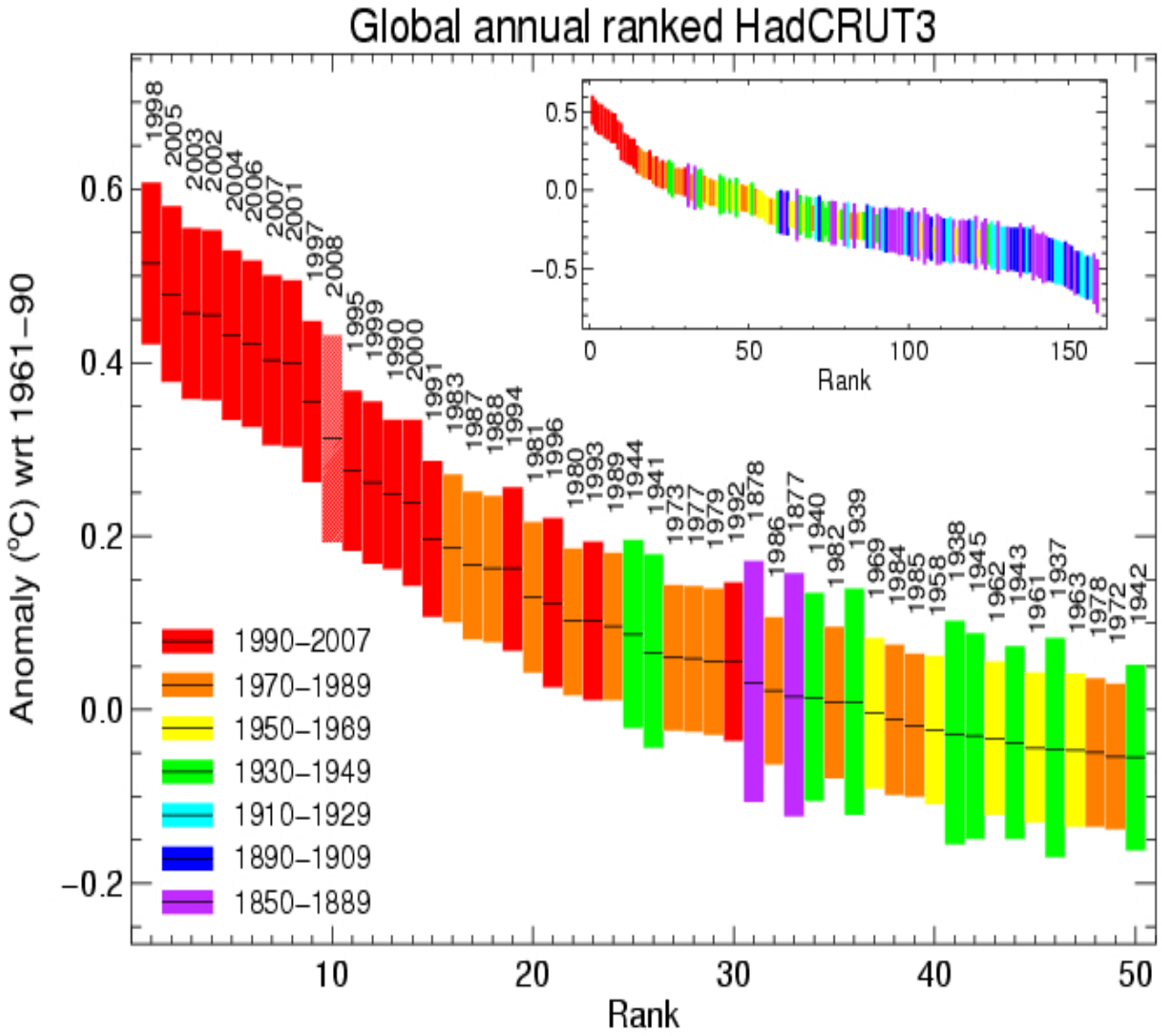
Outline

- When the environment becomes a variable
  - Beyond earthquakes
- Challenges for physical infrastructure
  - Case study: Energy infrastructure
- Challenges for legal infrastructure
  - Case Study: Gaps in the UN Convention on the Law of the Sea
- Variability of social response
  - Vulnerability methodologies (3Rs)

Some extreme environmental events in 2008

(data from WMO)

- 2008 was one of the ten warmest years since modern records began in the 1850s;
- In the region's worst weather disaster in modern history, flooding affected 1.5 million people in Brazil;
- Tropical Storm Fay was the first storm to hit the same US state four times;
- Portugal, Chile, Argentina, Paraguay and Uruguay all experienced their worst droughts in decades. Some places in Australia have now had drought conditions for over a decade;
- Hurricane Ike was the third most destructive hurricane to hit the US after Katrina (2005) and Andrew (1992);
- Arctic sea ice reached its second lowest extent on record. The lowest was in 2007;
- Tropical Cyclones Nargis was the worst cycle to hit Asia since 1991 and caused widespread devastation in Myanmar;
- Unusually heavy rains displaced approximately 10 million people in India;
- In China over 78 million people were affected by the most severe winter weather in half-a-century.


Global annual ranked HadCRUT3
Anomaly (°C) wrt 1961–90
Rank
1990–2007
1970–1989
1950–1969
1930–1949
1910–1929
1890–1909
1850–1889
1998 2005 2003 2002 2004 2006 2007 2001 1997 2008 1995 1999 1990 2000 1991 1983 1987 1988 1994 1981 1996 1980 1993 1989 1944 1941 1973 1977 1979 1992 1878 1986 1877 1940 1982 1939 1969 1984 1985 1958 1938 1945 1962 1943 1961 1937 1963 1978 1972 1942

Complicating complex systems

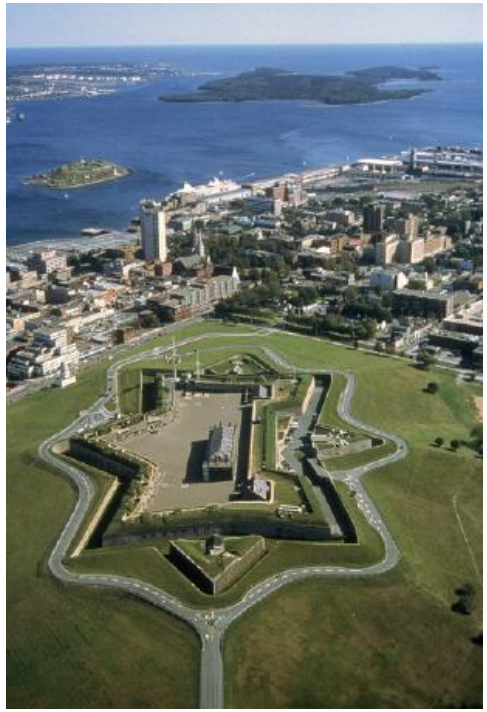
Triggers (i.e. earthquakes)

- Unusually large summer glacial melt may affect load and contribute to seismic activity (seen in Greenland).
- Under certain conditions, extreme precipitation events may contribute to increase in seismic activity.
- “Clean Development Mechanisms” (funding for low-carbon emitting energy generation) contributing to more dam building which can contribute to increased seismic activity.

Impacts

- Vulnerabilities are growing; with population/consumption increases, the carrying capacity and environmental resilience of the planet is stretched, so smaller triggers can have greater impacts.

Our transportation systems, cities, defensive capabilities, agriculture, power generation, water supplies and more are all designed for the specific parameters of our physical environment



Citadel, Halifax

Edinburgh Castle, Scotland

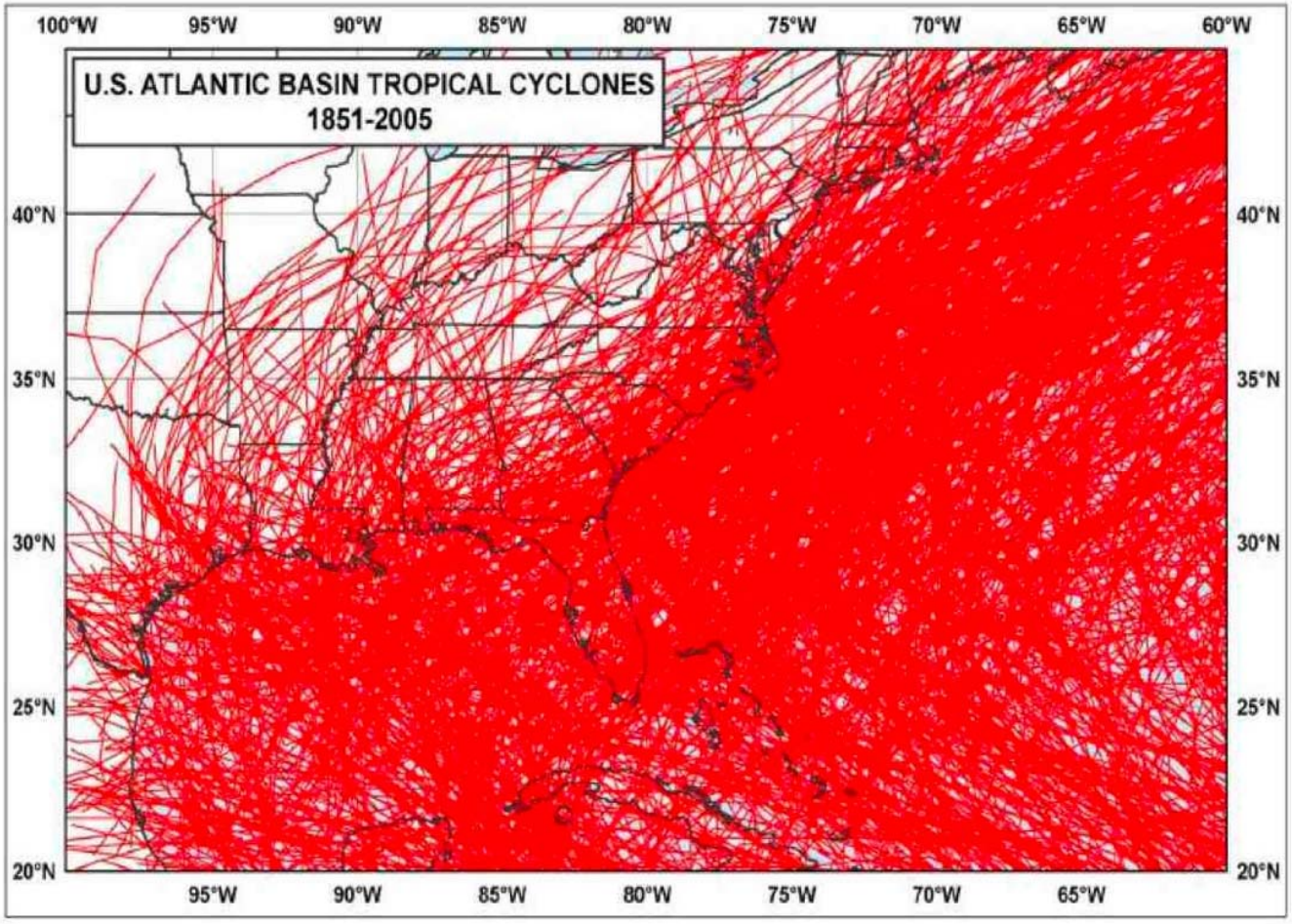
Masada, Israel

That is why unplanned environmental change almost always has a negative effect -- we literally aren't designed for it.

And why predictive methodologies can be so important.

New Orleans, 2005

In some cases, complex methodologies are not needed. When Katrina hit the U.S. Gulf Coast in 2005 it was, at most, a Category 3 in a known hurricane zone



Each red line is a the track of a hurricane that hit between 1851 and 2005

Physical factors that contributed to the disaster in New Orleans in 2005

- Faulty levee design and implementation
- A lack of town planning
- Large scale subsidence
  - → Draining of wetlands
  - → Extraction of groundwater
  - → Inappropriately designed waterways

Economic impacts

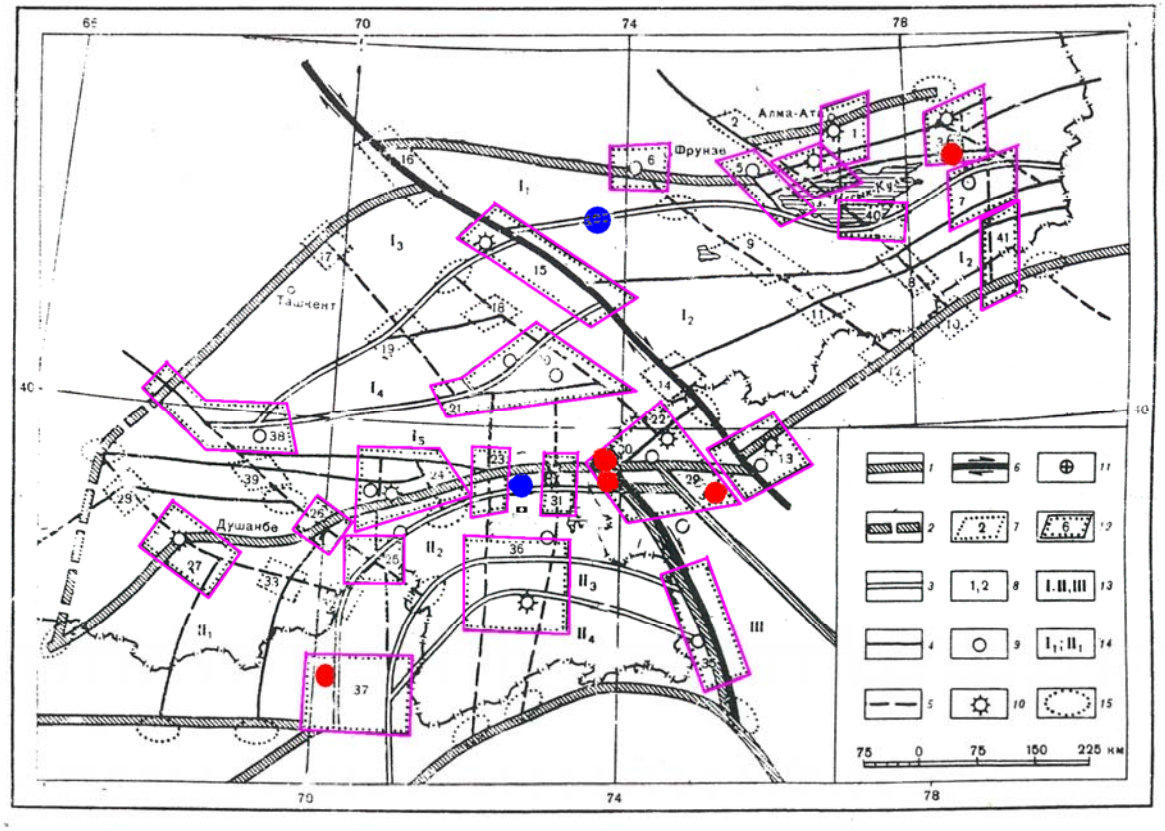
- Katrina damages estimated at over $100 billion. By comparison, that same year the official U.S. military and diplomatic spending in Iraq was $87.3 billion. Northridge quake (1994) cost an estimated $25-40 billion.

- Critical infrastructure, including ports, rail lines, airports and runways knocked out. Much being rebuilt in more or less same places, leaving them vulnerable again.

The environment as a variable

- Due to the fact that our infrastructure is designed for a given set of environmental parameters, and that in many areas the environment is changing, we may well see an increase in crises.
- It is currently uncertain if climate change will be predominantly linear, or will undergo ‘critical transition’.
- Regardless, given the complexity of the dynamics, predictive methodologies of the sort pioneered by MITPAN may prove invaluable for planning – assuming policy makers listen.

Earthquake-prone (M>=6.5) nodes in Central Asia



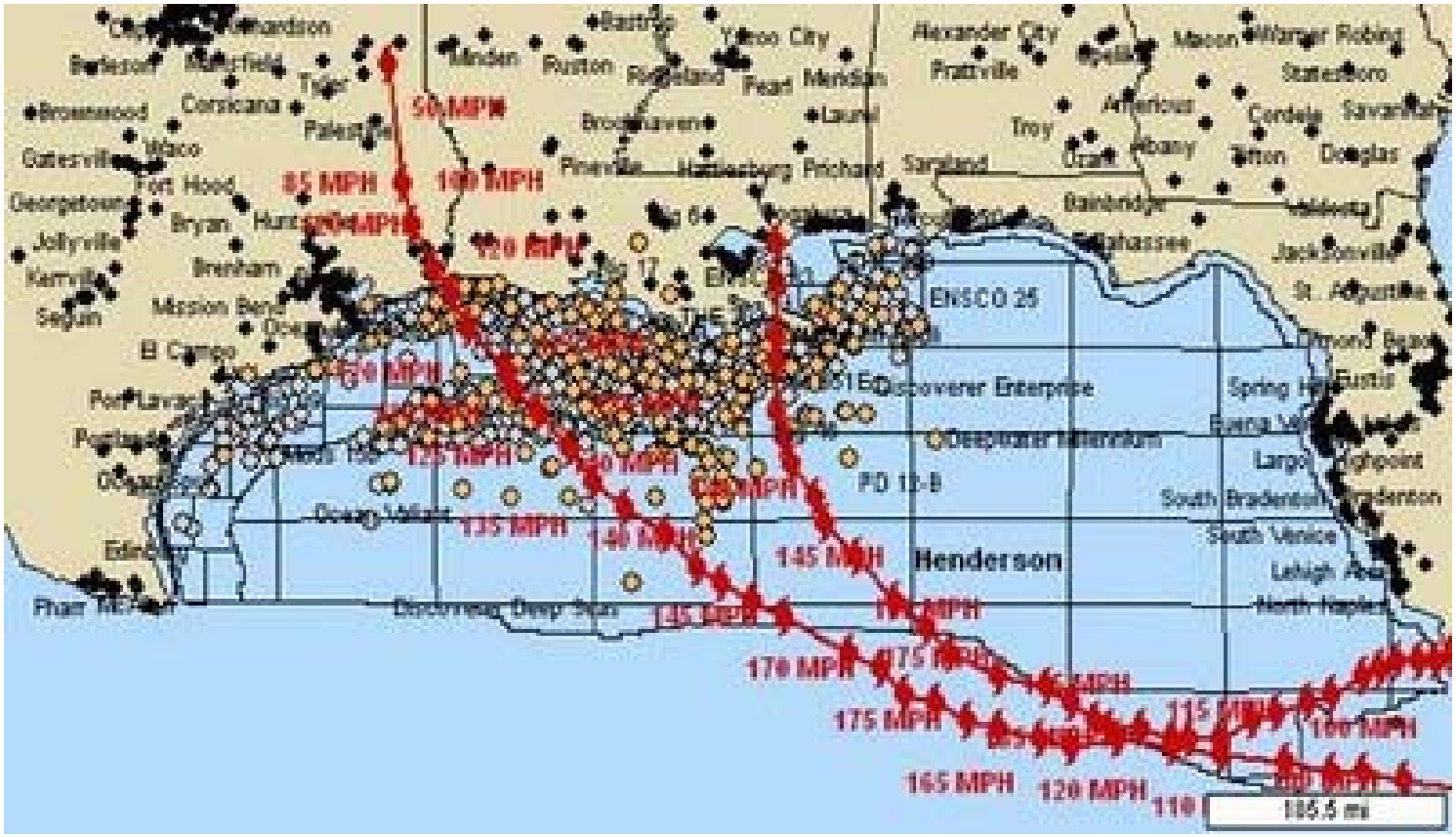
Pink: Earthquake prone nodes determined in 1972
Red: Epicenters of earthquakes M>= 6.5 post-1972 (within nodes)
Blue: Epicenters of earthquakes M>= 6.5 post-1972 (outside nodes)

(A. Soloviev, et al)

Challenges for physical infrastructure

Case study: Energy infrastructure

Off-shore oil and gas



Hurricane Rita and Katrina's tracks through the US Gulf Coast, 2005

Damage caused by Katrina and Rita, 2005

- 457 damaged pipelines
- 113 Platforms destroyed
- Gulf Coast oil production dropped 57.37%, natural gas dropped to 40.35%
- Spike in global oil prices

- Summer of 2008, Hurricanes Gustav and Ike shut down much Gulf offshore production.

Low-lying installations

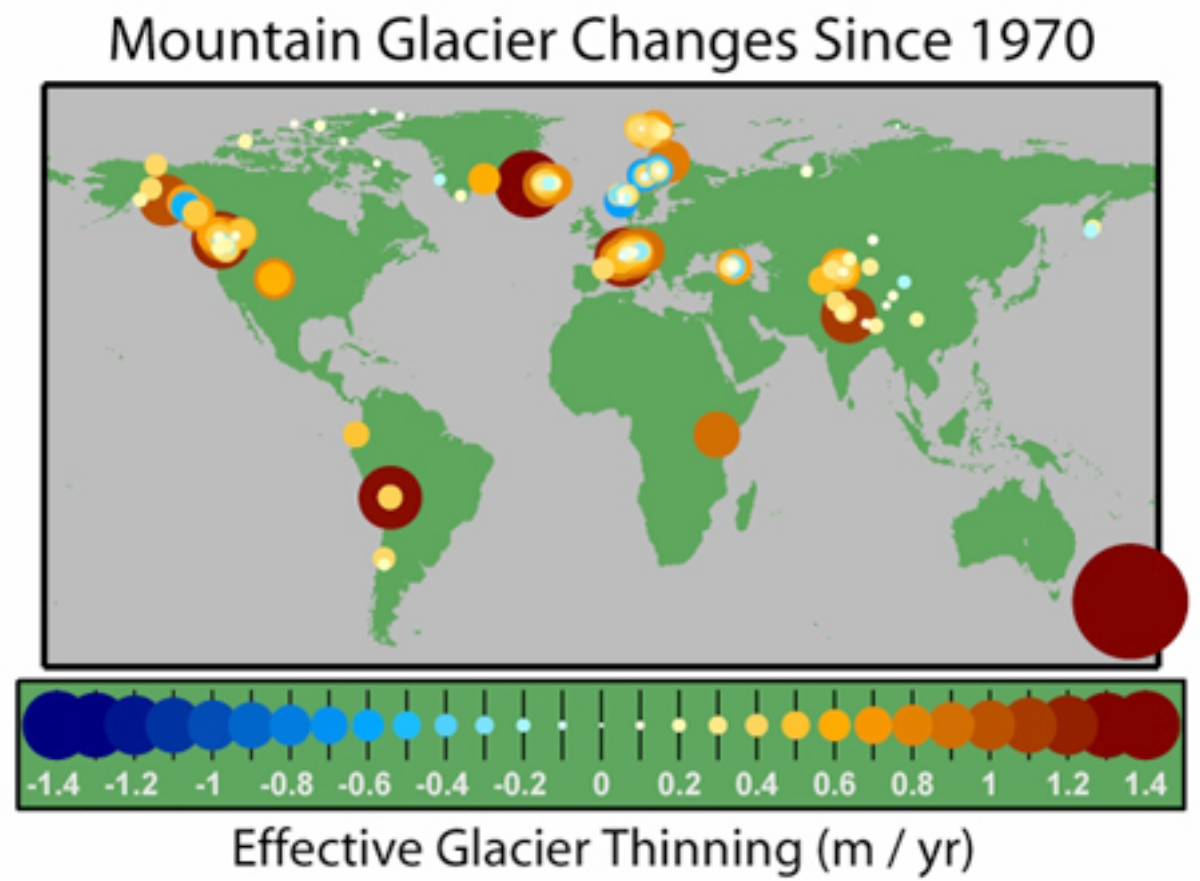
(Ras Tanura, Saudi Arabia; Jurong Island Refinery, Singapore; Rotterdam Refinery; and major installations in the Niger Delta)

Jamnagar Refinery, India, 2007

Hydro dams designed for given precipitation patterns, rate of glacier melt, etc.

India 2008 hydro generation down 8.42%
India 2009 hydro generation down 12% (so far)

Glaciers: Going, going, gone?



Nuclear and coal need water for cooling

• Summer 2003, France, 17 reactors powered down or shut off. Cost to Électricité de France: Euros 300 million.

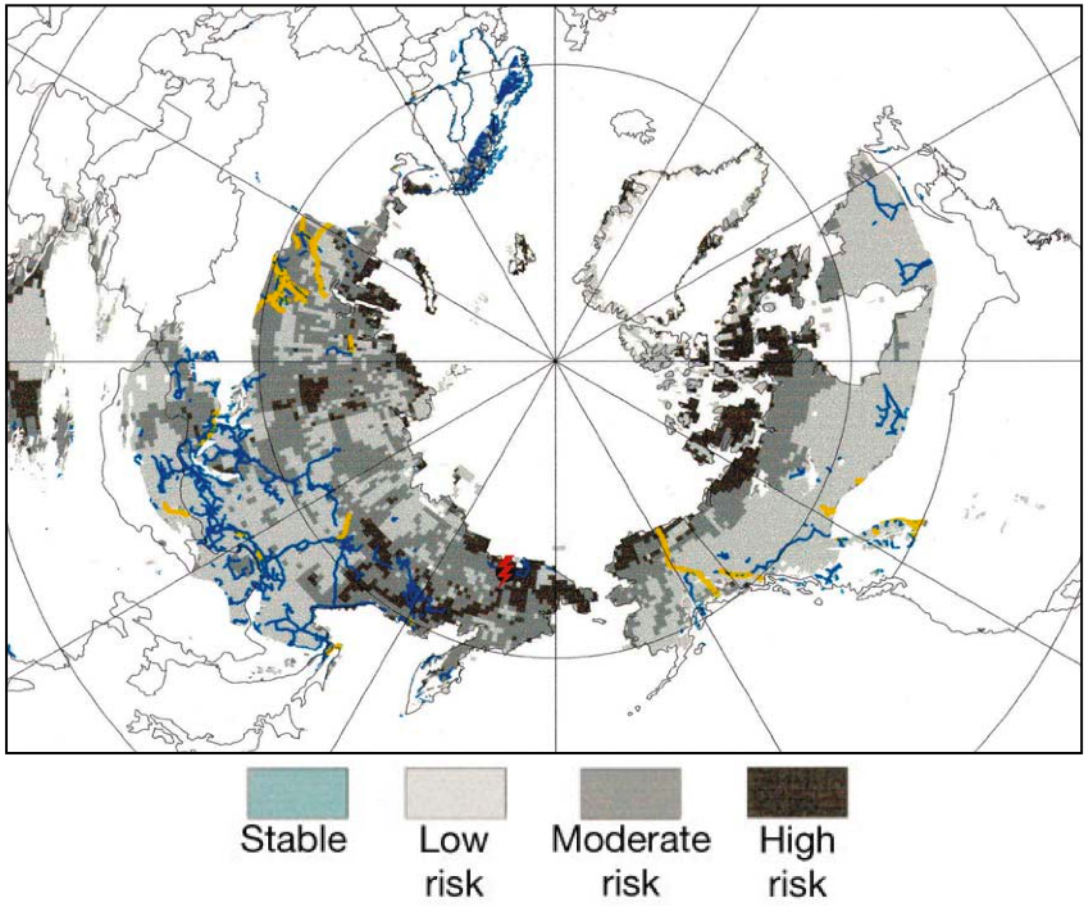
• Summer 2006 France, Spain and Germany had to power down.

• Summer 2009, 1/3 of France's nuclear power stations powered down, had to buy power from UK.

Sample of effect of thawing permafrost

- Number of days when it is possible to drive on permafrost/ice roads dramatically decreasing.
- Severe coastal erosion in many areas.
- Port/airport/storage installations compromised.
- Key supply routes unstable.

Energy infrastructure on permafrost



Blue: Electrical transmission lines
Yellow: Pipelines
Red: Bilibino nuclear power station

Source: *Nature*

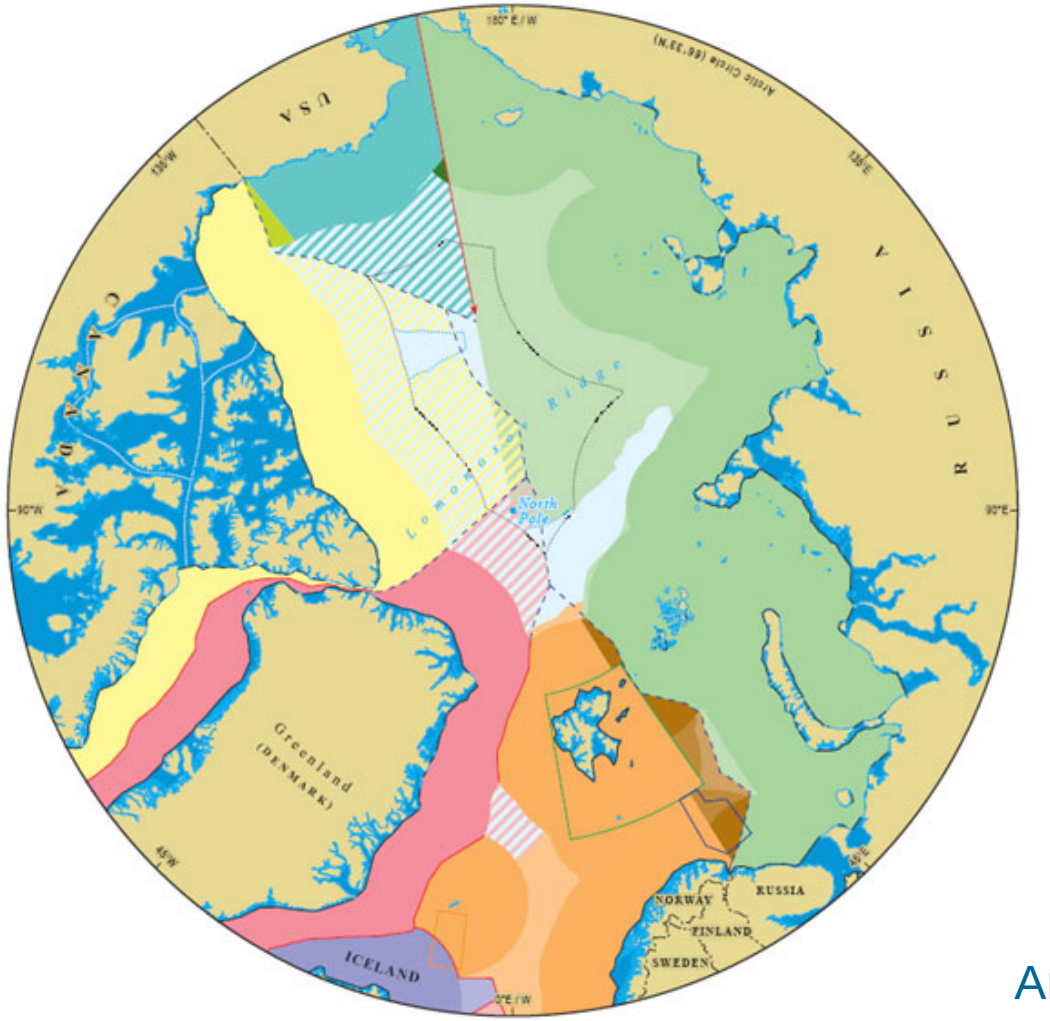
It is no longer enough to look only at our impact on a changing environment; we must also look at a changing environment's impact on us

Cedar Rapids solar plant, 2008

There is no point building a solar power plant if you erect it in a flood zone.

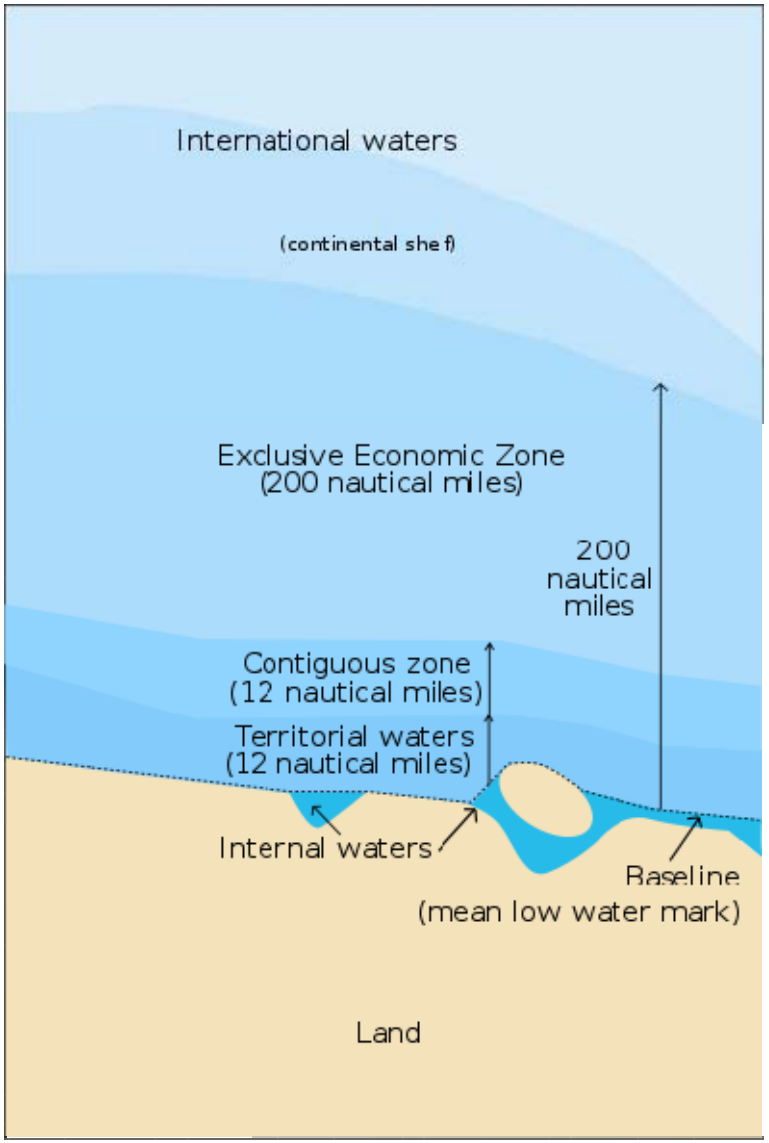
When physical and legal infrastructure fall out of sync

Case study: UN Convention on the Law of the Sea

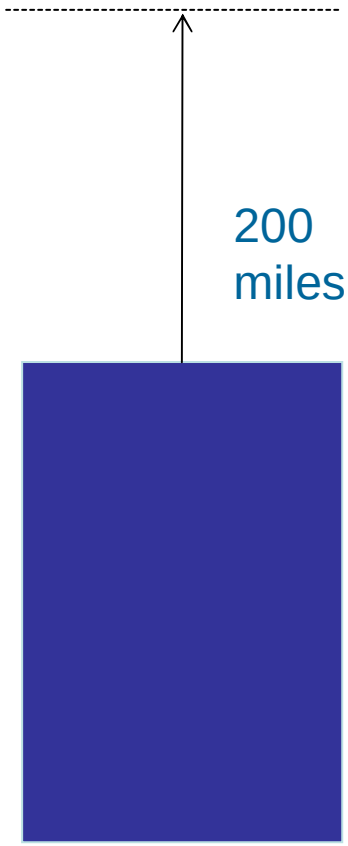


Arctic

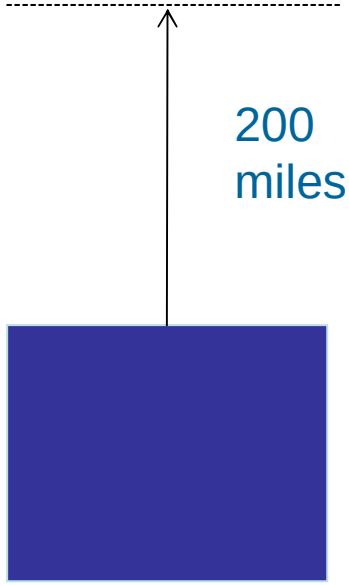
UN Convention on the Law of the Sea



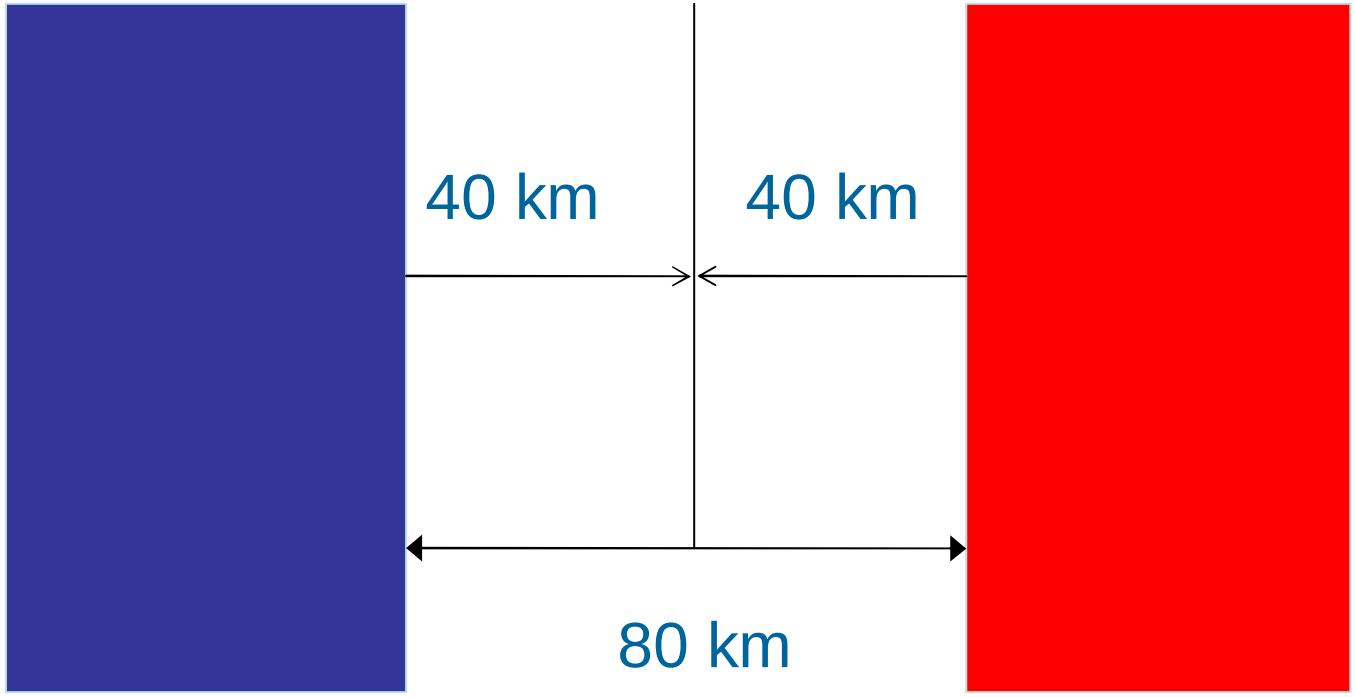
Changes to coastlines



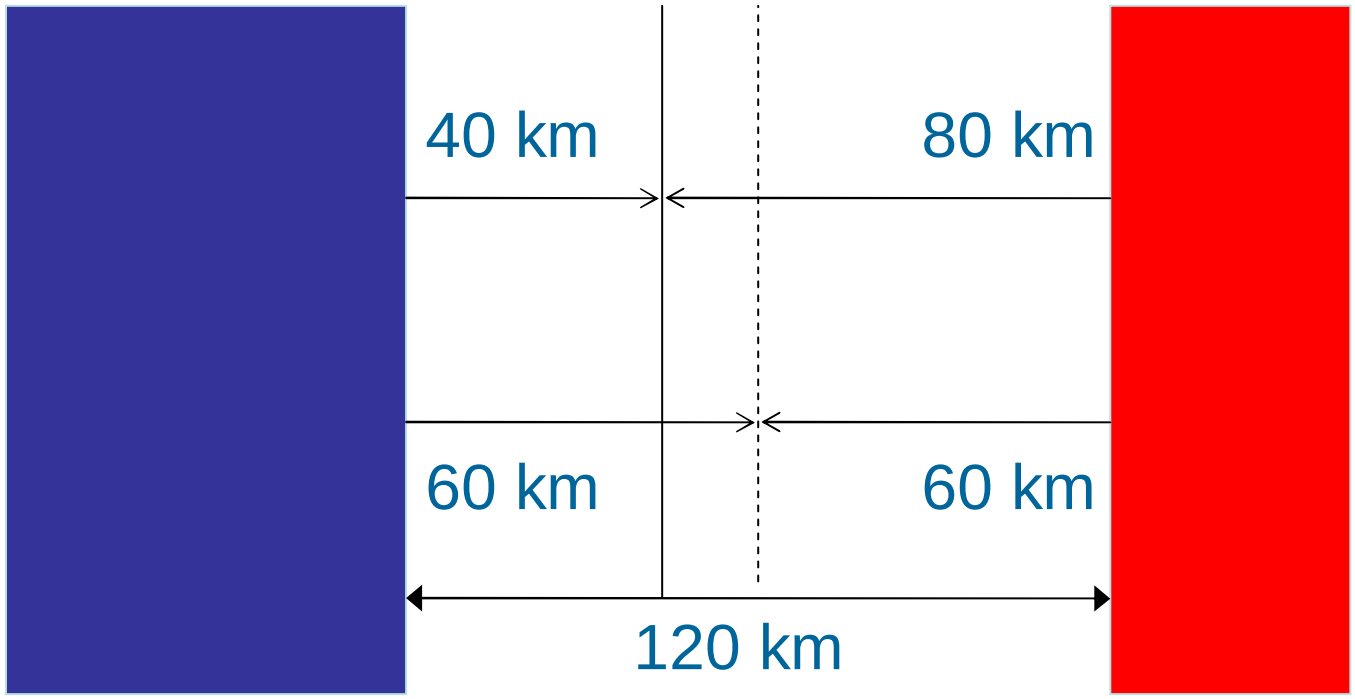
Changes to coastlines



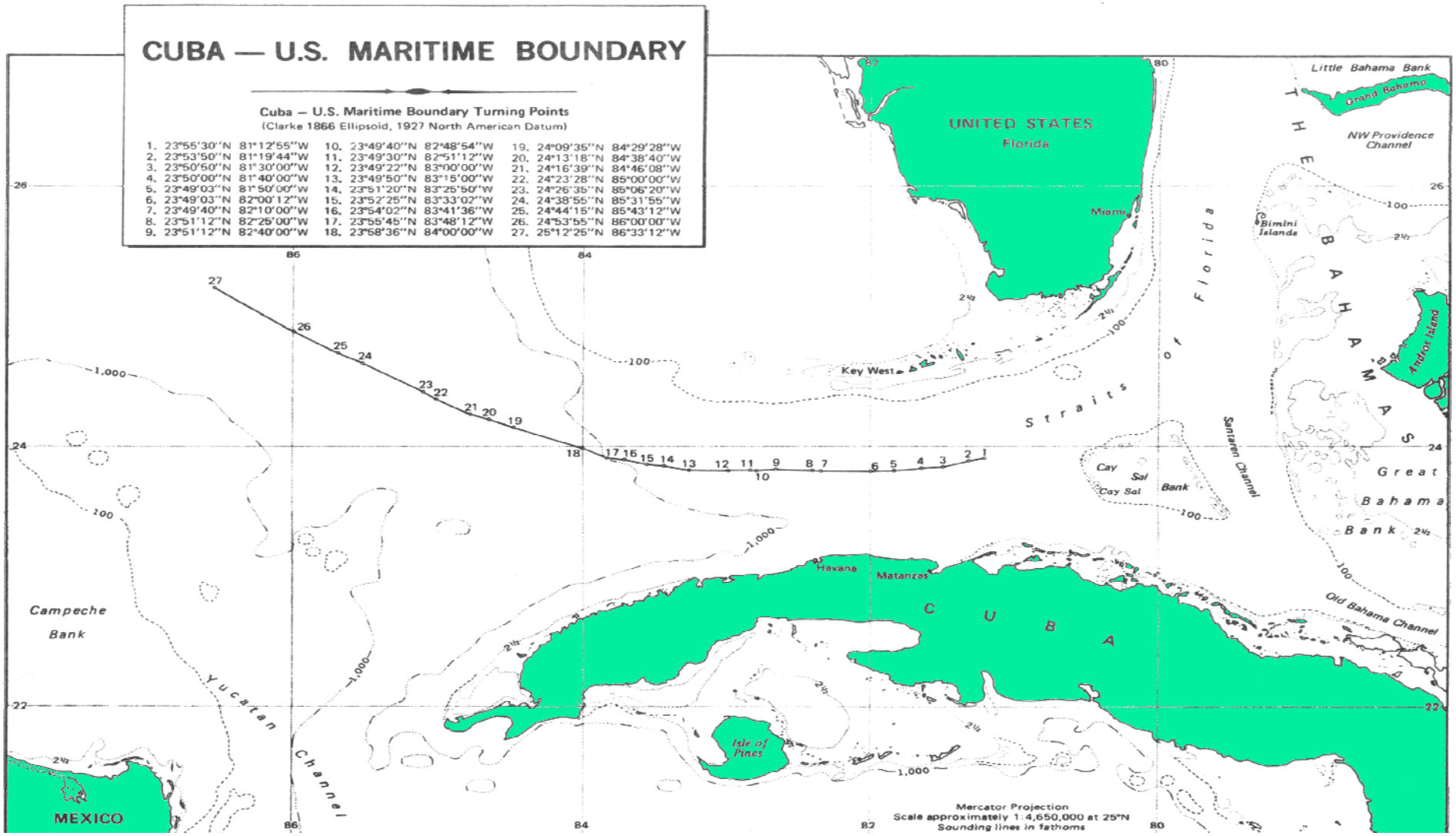
Equidistant Borders



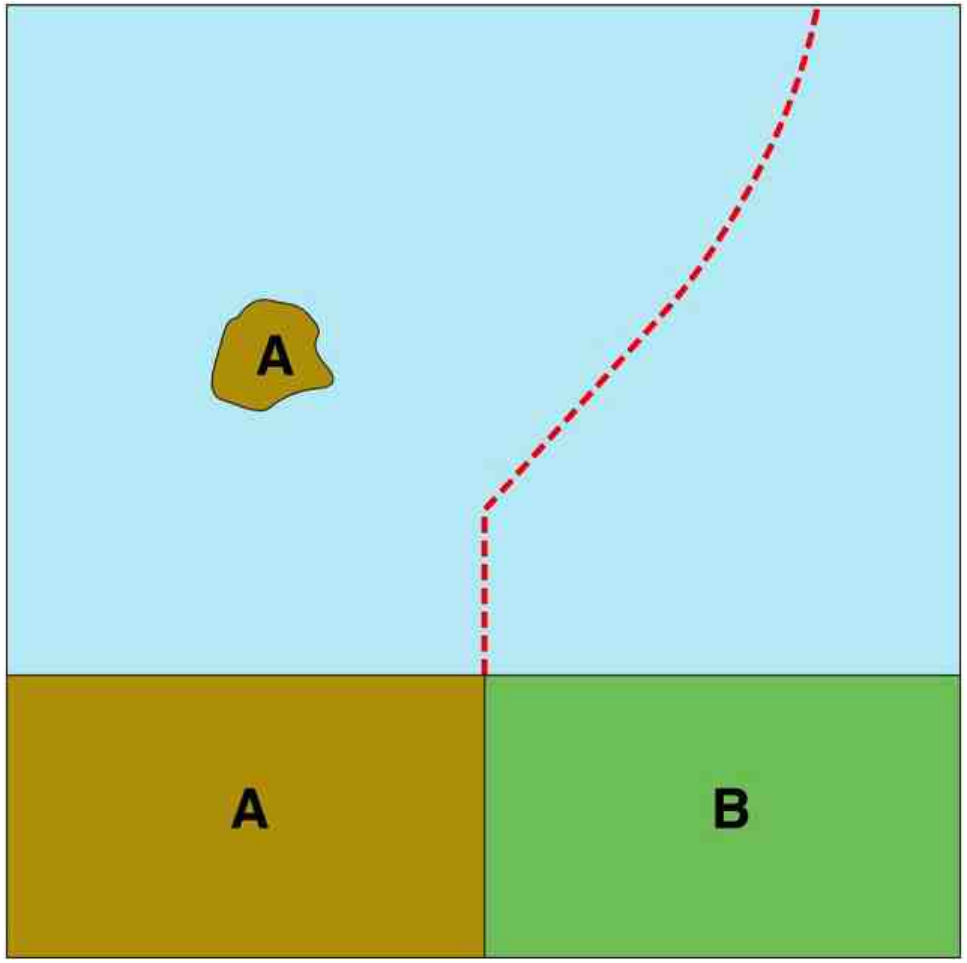
Equidistant Borders



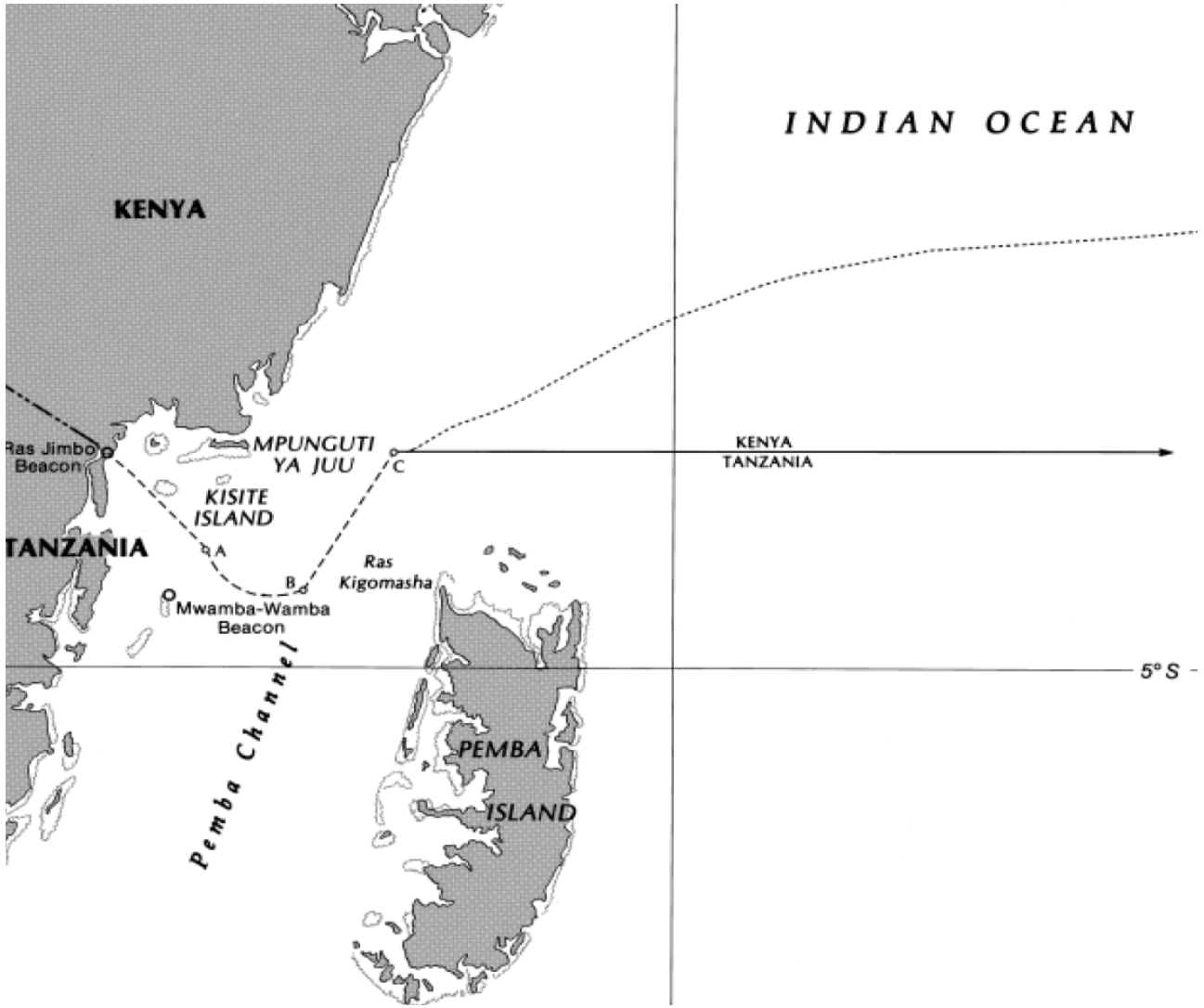
US/Cuba maritime border



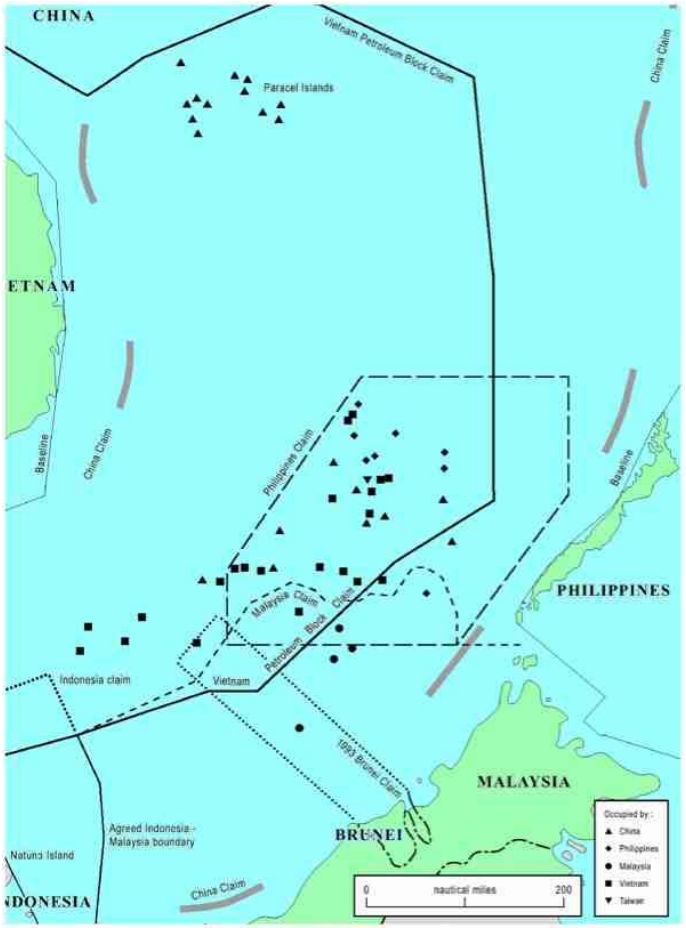
Role of off-shore islands



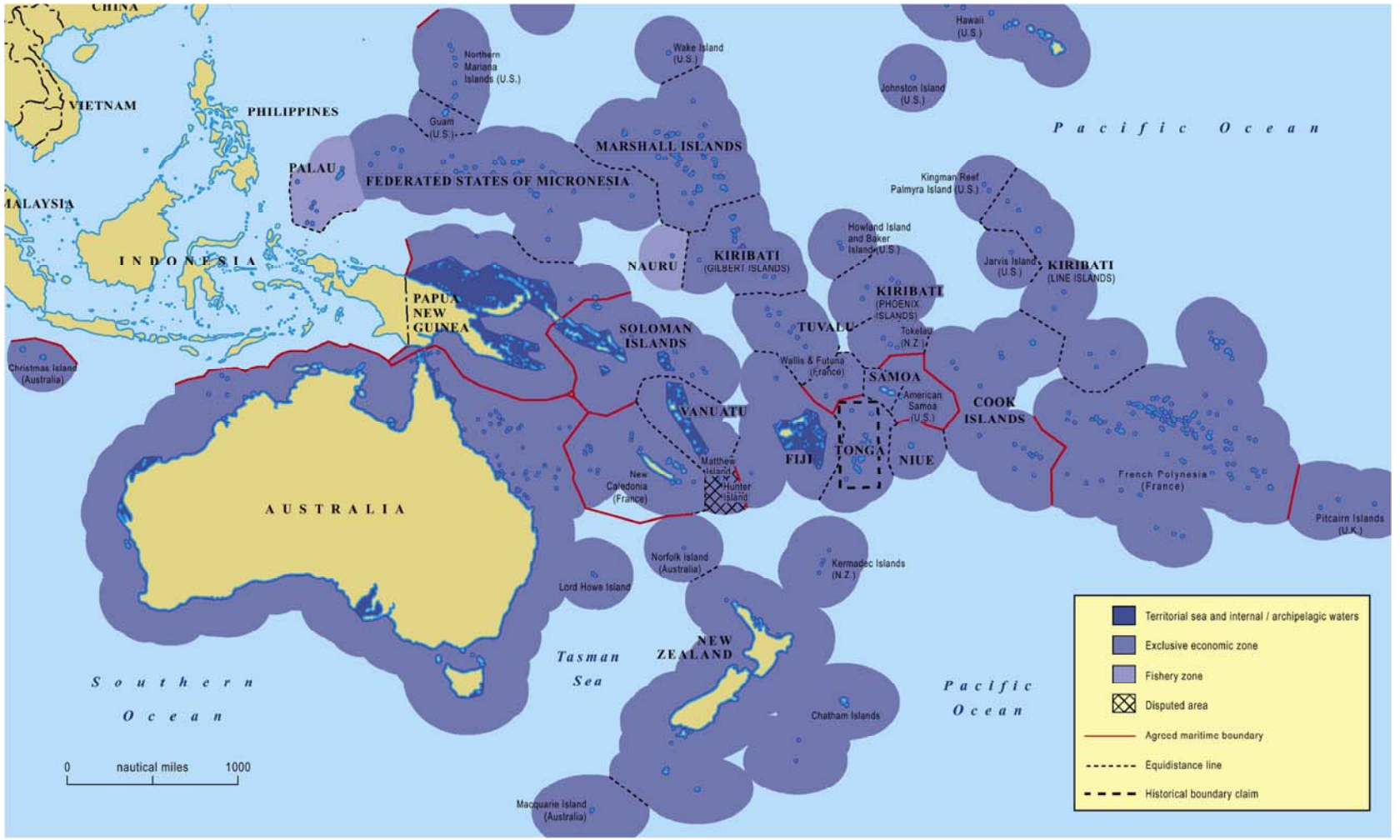
Kenya-Tanzania Maritime Border



South China Sea



Pacific


VIETNAM
PHILIPPINES
Northern Mariana Islands (U.S.)
Guam (U.S.)
Wake Island (U.S.)
Hawaii (U.S.)
Johnston Island (U.S.)
Pacific Ocean
MARSHALL ISLANDS
PALAU
FEDERATED STATES OF MICRONESIA
Kingman Reef
Palmyra Island (U.S.)
MALAYSIA
INDONESIA
NAURU
KIRIBATI (GILBERT ISLANDS)
Howland Island and Baker Island (U.S.)
Jarvis Island (U.S.)
KIRIBATI (LINE ISLANDS)
KIRIBATI (PHOENIX ISLANDS)
PAPUA NEW GUINEA
SOLOMON ISLANDS
TUVALU
Tokelau (N.Z.)
Wallis & Futuna (France)
SAMOA
American Samoa (U.S.)
COOK ISLANDS
Christmas Island (Australia)
VANUATU
TONGA
NIUE
FIJI
Matthew Island
Hunter Island
New Caledonia (France)
French Polynesia (France)
Pitcairn Islands (U.K.)
AUSTRALIA
Norfolk Island (Australia)
Kermadec Islands (N.Z.)
Lord Howe Island
NEW ZEALAND
Tasman Sea
Southern Ocean
Pacific Ocean
Chatham Islands
Macquarie Island (Australia)
0 nautical miles 1000
Territorial sea and internal / archipelagic waters
Exclusive economic zone
Fishery zone
Disputed area
Agreed maritime boundary
Equidistance line
Historical boundary claim

More examples of agreements that may cause more damage than they prevent

- Water-sharing agreements based on a litre amount (rather than percentage of flow). This will become problematic as water levels alter dramatically.
- Fisheries-sharing agreements. Many will be thrown into chaos as fish shift to other regions due to climate change and as overfishing takes it toll (a current problem in the European Union).
- Hydropower-sharing agreements. This will be a major problem, especially in glacier regions such as the Alps, where there will be above-average flows as the glaciers melt, followed by droughts, resulting in wildly fluctuating production.

A failure of legal infrastructure can be as disastrous as a failure of physical infrastructure – and all the more tragic because it is unnecessary.

In both cases, threats can be eased by understanding that, with environmental change, constants have become variables.

Vulnerabilities of human systems: another variable

New Orleans vs Mumbai

- July 26 2005. Mumbai received almost 1m rainfall in a single day and flooded. Approx. 1100 dead, $100 million in damage
- August 29 2005. Katrina hits US Gulf Coast. Approx. 1800 dead, $100 billion in damage.

- In Mumbai drop in crime rate, relatively quick economic recovery.
- In New Orleans, Governor issues shoot-to-kill orders on Day 4, after city descends into chaos. Still not economically recovered.

Socio-political factors that contributed to the disaster in New Orleans in 2005 (and continue to create vulnerabilities)

- Political use of U.S. Army Corps of Engineers sometimes resulting in undermining of physical infrastructure.

- National Flood Insurance Program.

- Under-trained, ill-equipped, over-stretched military/National Guard ill-prepared for ‘environment wars’.

- Lack of political will for difficult, expensive decisions, such as ‘urban triage’, coastal defences, etc.

- Many areas at risk of flooding (i.e. coastal southern states) are also among the poorest leaving residents fewer options for relocation, etc.

- Chronic problems with prison system. Extreme events/heat can increase crime, putting more into system.

	Reinforce	Rescue	Recovery
Government	- Climate proofing infrastructure (including decentralizing power grid) - Adequate training and equipping of emergency services - Disasters plans in place and regularly updated - Strong alliances with other nations - Assessment of laws, regulations, subsidies, etc., to ensure they are making things better, not worse	- Clear, viable command and control structure - Good communications between rescuers and those affected - Operationally flexible and easily implementable plans and measures	- Economic incentives to help rebuild economies in environmentally stable areas - Clear communication about progress of recovery - Honest lessons learned assessment of future vulnerabilities
Society (NGOs, faith-based groups, etc.)	- Public awareness of disaster plan and citizen participation - Large, aware social networks - Adequate inter-citizen communications	- Strong social cohesion in crises situations - Adaptability to swift changes in conditions and needs - Ability to not rely exclusively on government or other external assistance	- Extensive non-governmental support networks to help rebuild socially and economically - (In partnership with government) effect a social services/NGO call-up to mitigate trauma of recovery and, if needed, resettlement
Private Sector	- Disaster plans in place that cover corporate as well as employee interests - Ensure investments are environmental/climate change-proofed, and generally plan for long-term - Lobby for regulations/policies that promote stability and sustainability in the market	- Work with government and society to mitigate disruptions - Resist crisis profiteering that will hamper rescue effort and create lingering resentment	- During rebuilding phase, focus on long-term stable growth rather than short-term gain that can contribute to future instability
Media	- Cover regional vulnerabilities and question plans that exacerbate them - Maintain up-to-date information on emergency procedures and contacts	- Ensure dissemination of accurate information - Calm panic	- Participate in lessons learned phase with a focus on how to move forward

Summary

- One must consider not just our impact of the environment, but the environment's impact on us.
- As our infrastructure and our environment fall out of sync, there is an increased likelihood of disasters.
- This is compounded if our legal infrastructure is also out of sync.
- Resilience of human systems is a key component to mitigating disaster – and is sometimes misunderstood.
- Predictive methodologies have the potential to play a crucial role in understanding the new variables.
- Working with various sectors in order to understand their potential is key to implementation.

Thank you.

Спасибо.