Perspectives of Flood Management and Mitigation

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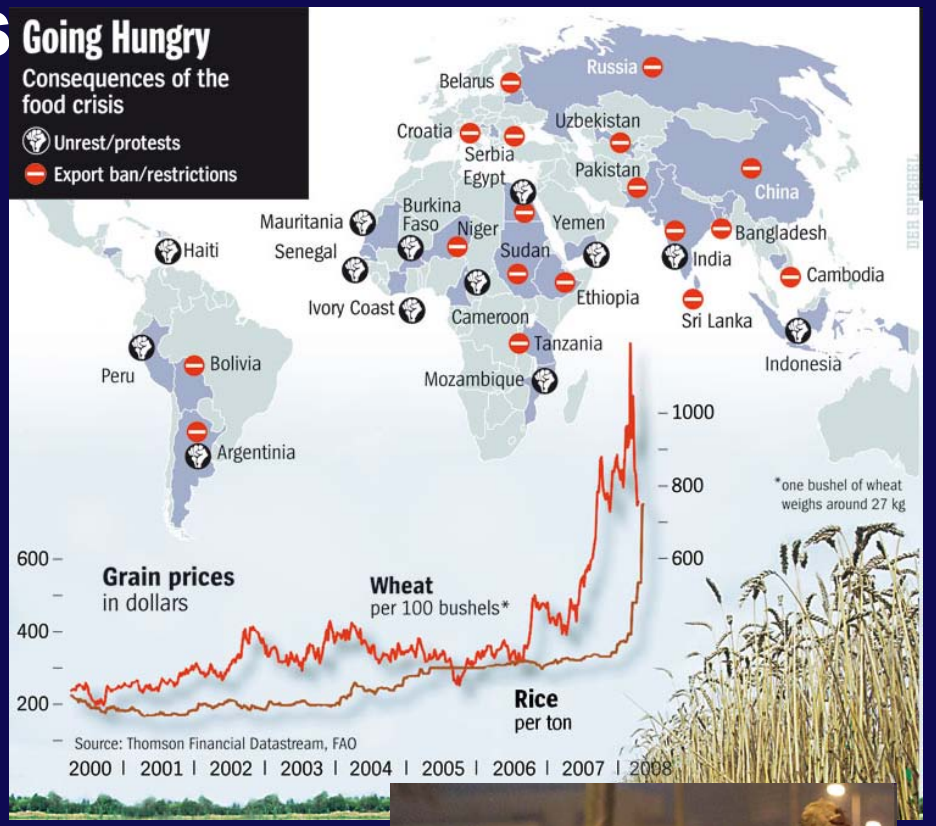
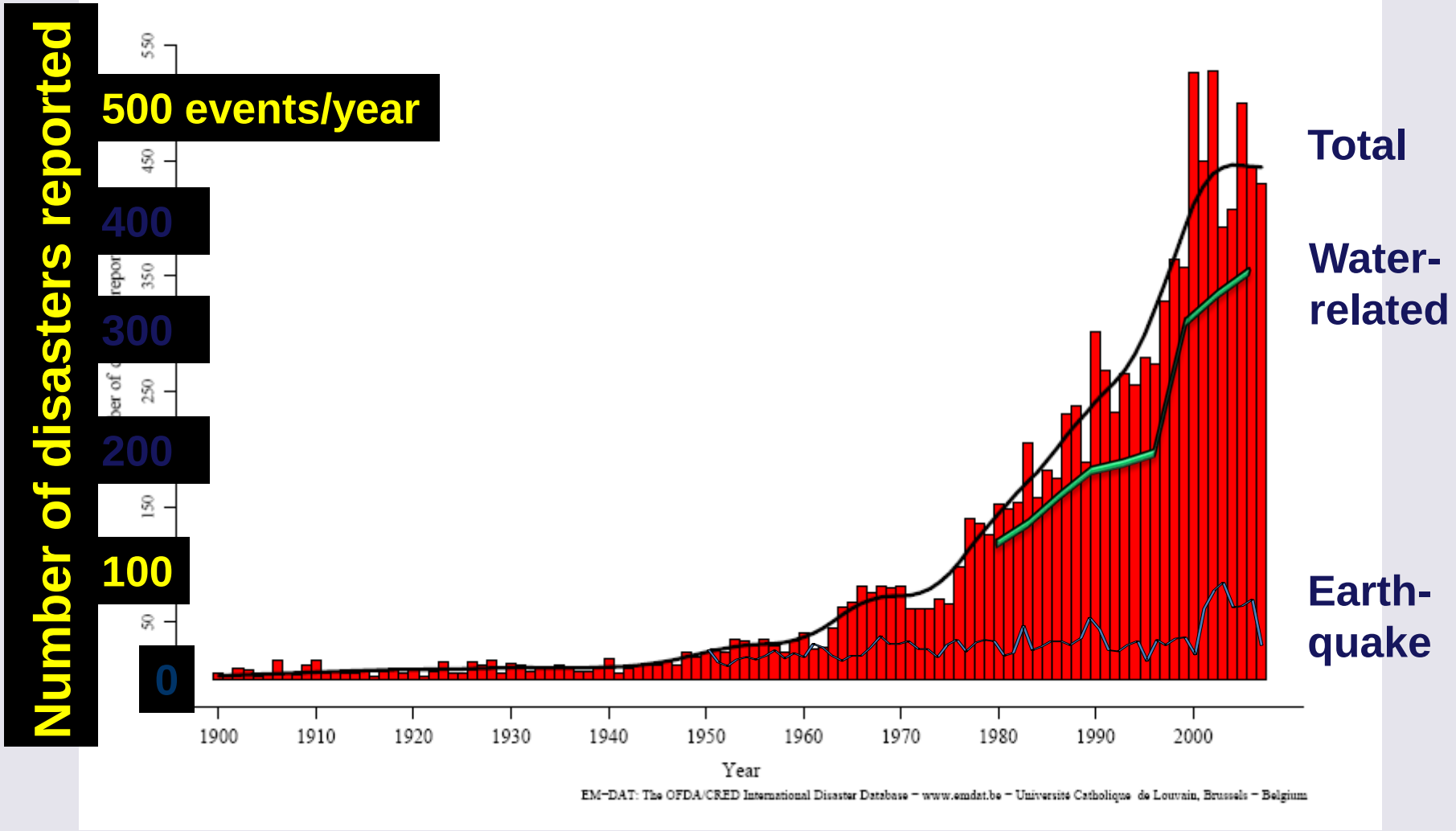
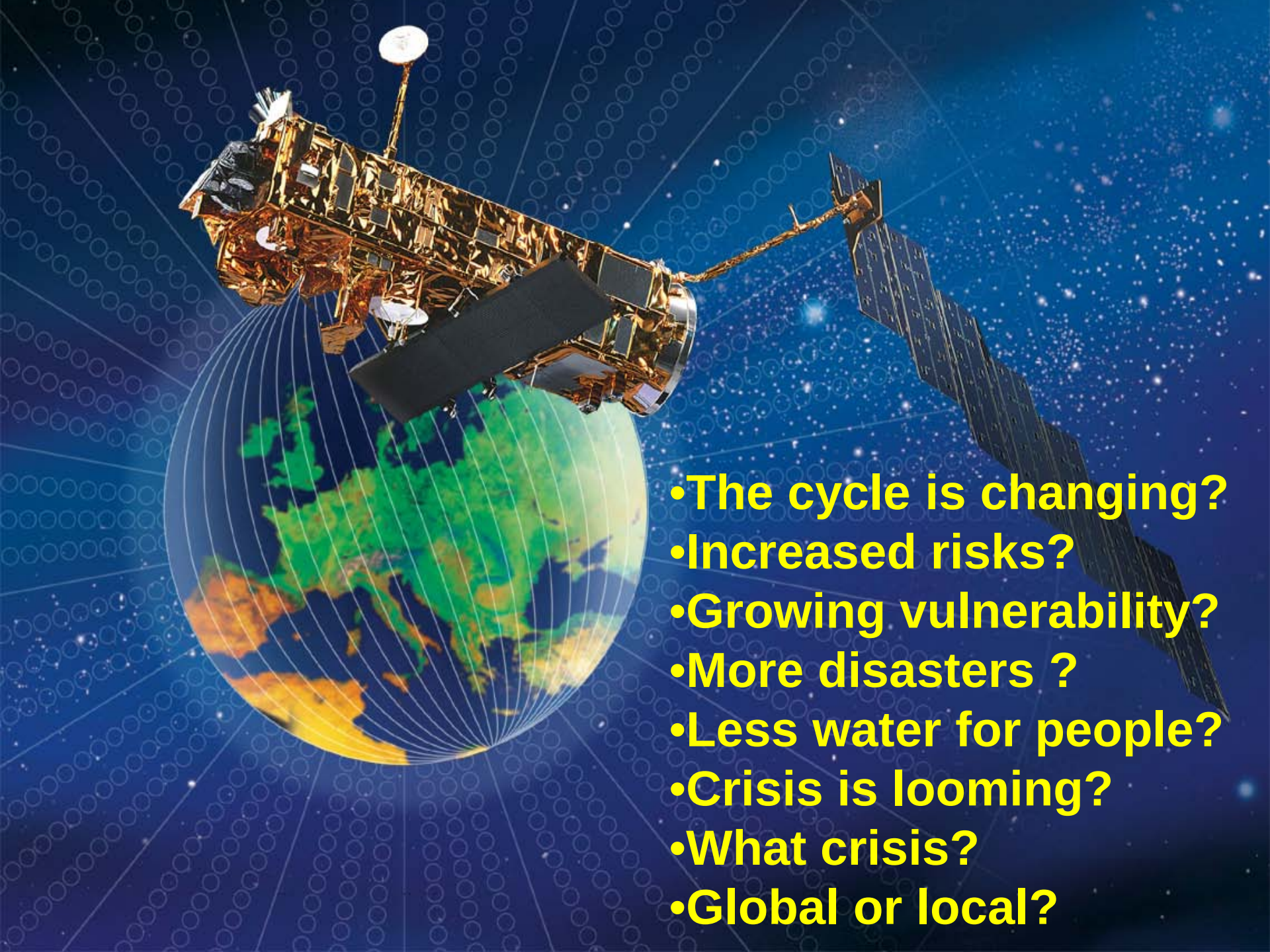
Flood and droughts: food, human lives, political crises

- Food prices up. Reasons:
  - floods: Australia
  - drought: Russia
  - bad weather: South America
  - biofuel policies
- → better forecasting models,
  optimal management of water resources



Number of natural disaster events since 1900 to 2007




•The cycle is changing?
•Increased risks?
•Growing vulnerability?
•More disasters ?
•Less water for people?
•Crisis is looming?
•What crisis?
•Global or local?

First message:

Humans are changing the global water system in a globally-significant way

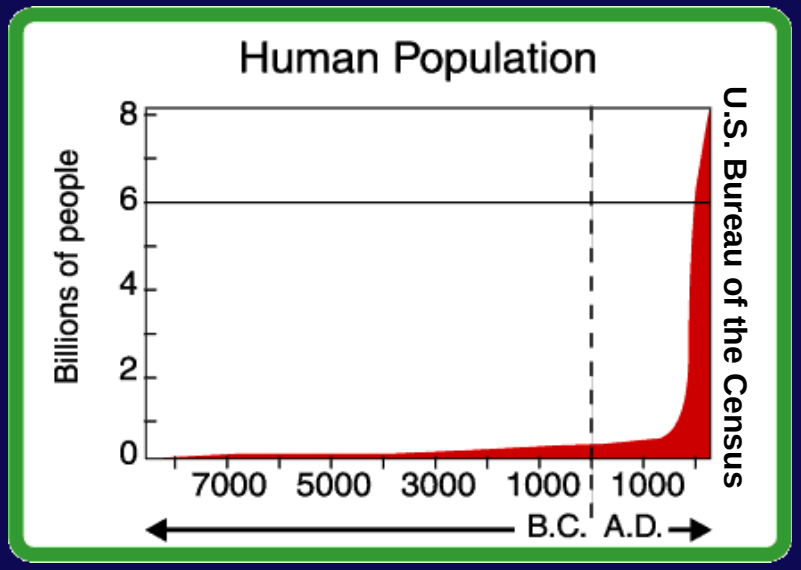
without…..

adequate knowledge of the system and thus its response to change

(GWSP)

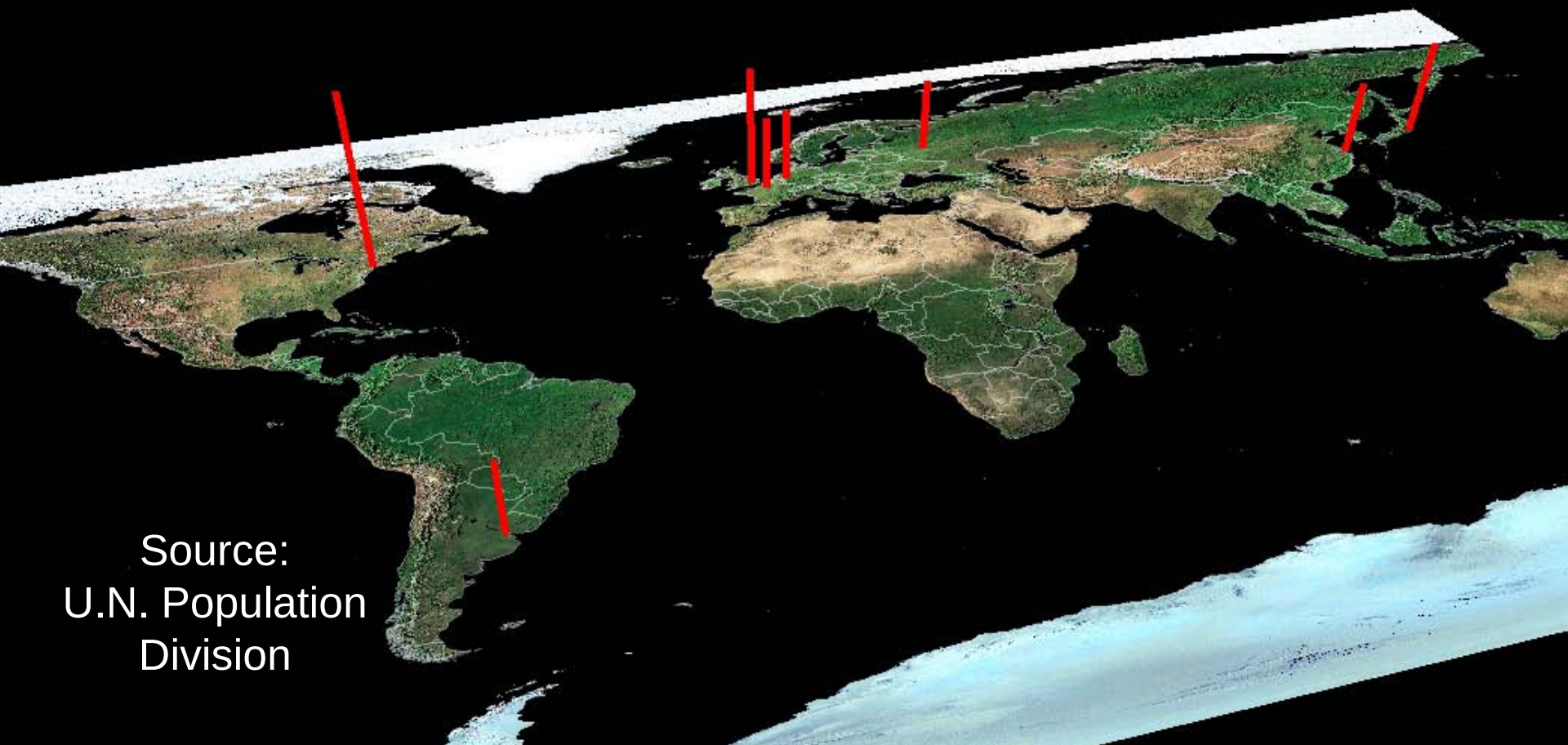
Global change drivers:

- Population growth, movement and age structures
- Geo-political changes and realignments
- Trade and subsidies
- Technological changes
- Climate change



World Cities exceeding 5 million residents

1950



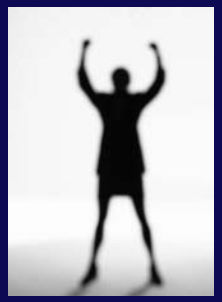
Source:
U.N. Population
Division

World Cities exceeding 5 million residents

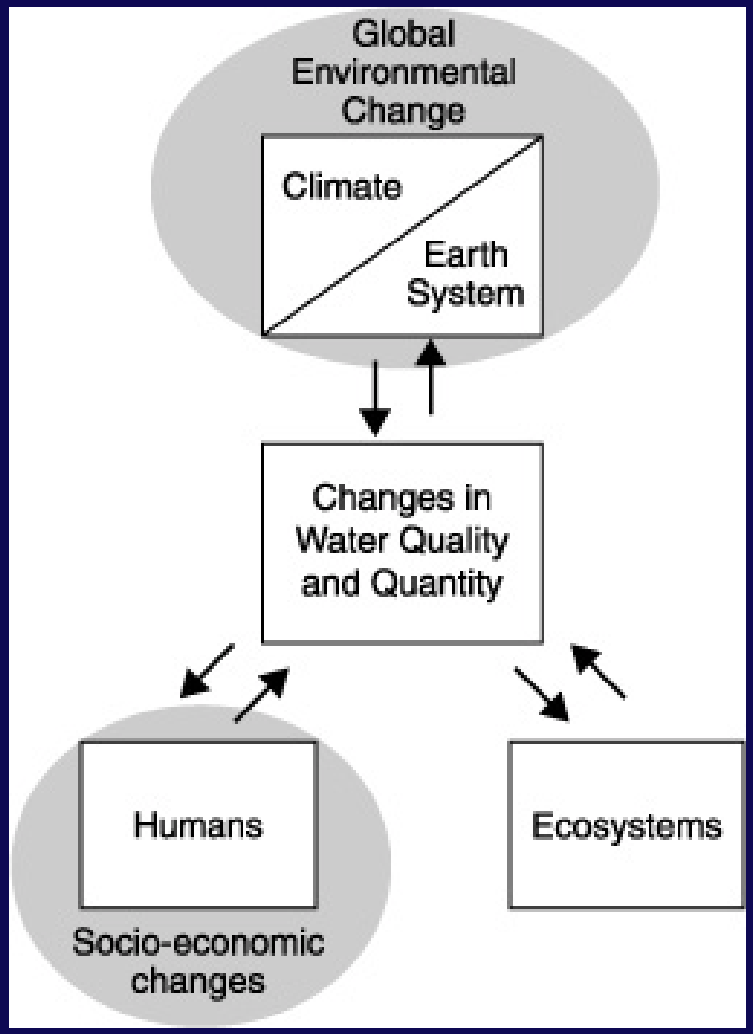
2015

Source:
U.N. Population
Division

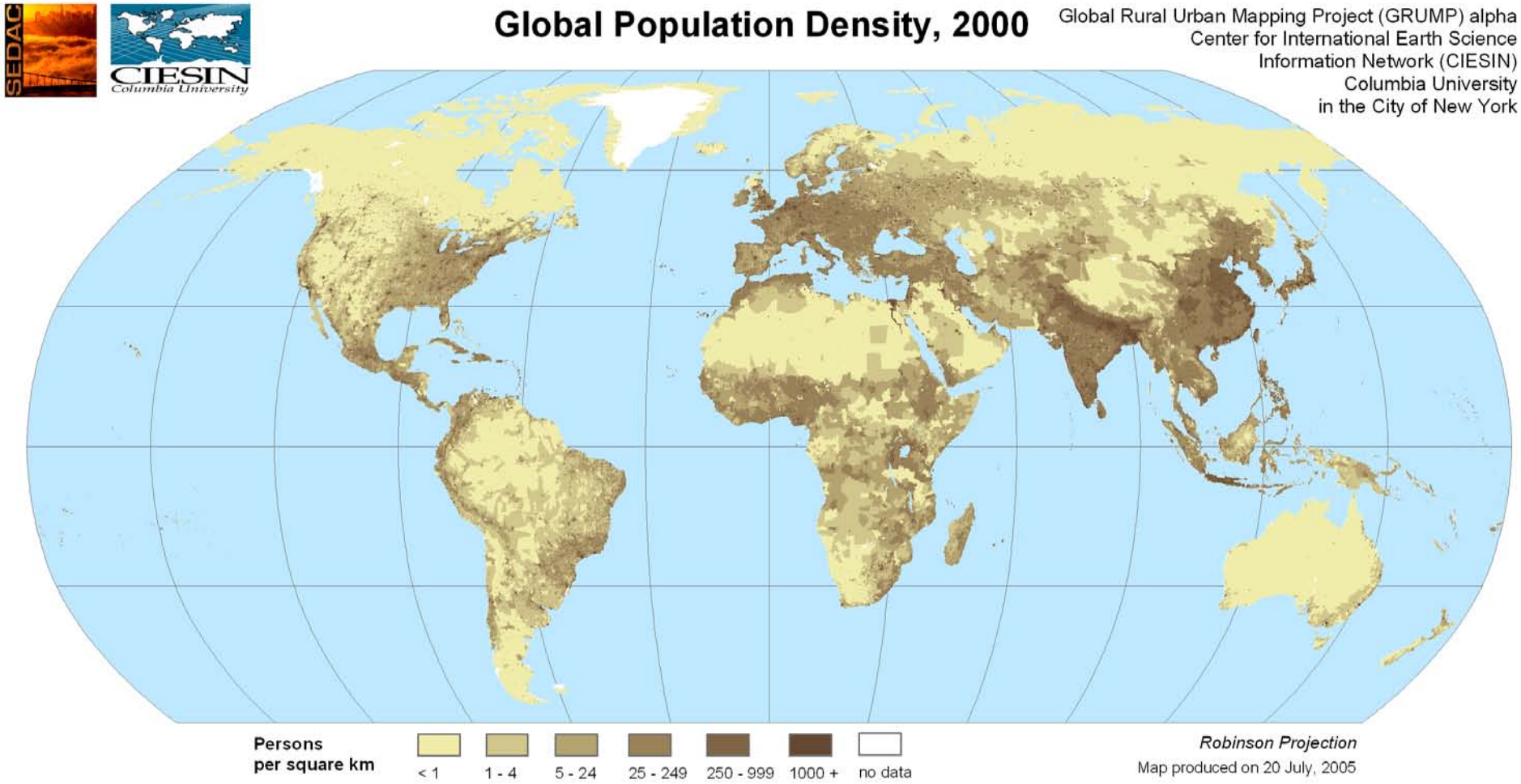
The Global Water System



- Water ***Cycling*** Deeply Embedded in Earth System
- Interconnections are Strong
- Change to One Part Reverberates Throughout



Rural and Urban Population Density

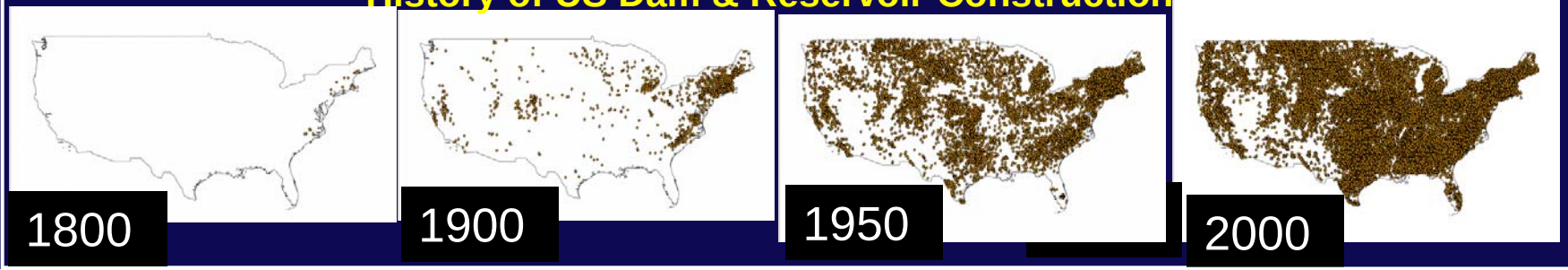


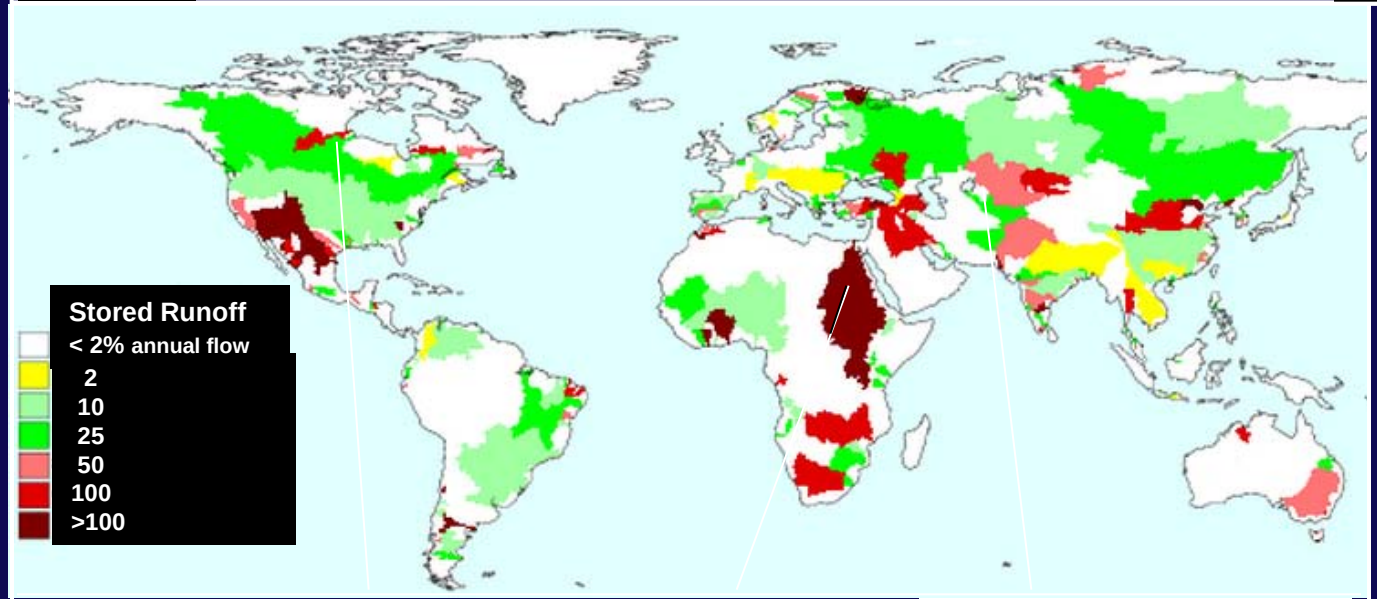
IMPACTS OF FOREST CLEARINGS:

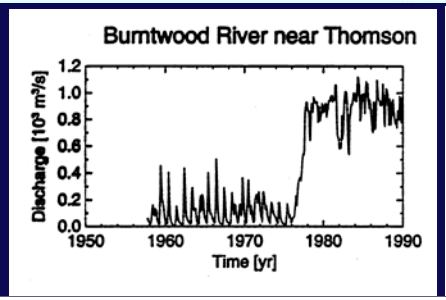
- Concentration time is changing

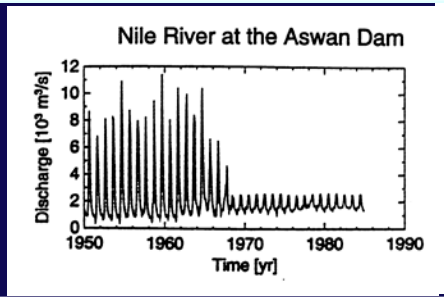
- INCREASED RUNOFF
- INCREASED FLOODING
  - Increased volume
  - Shortened time-base
  - Increased frequency

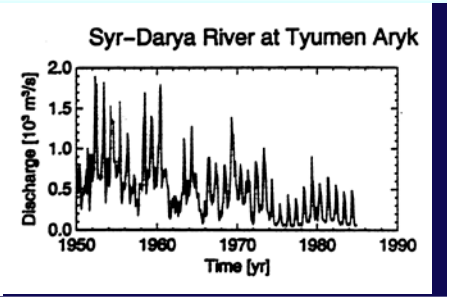
History of US Dam & Reservoir Construction







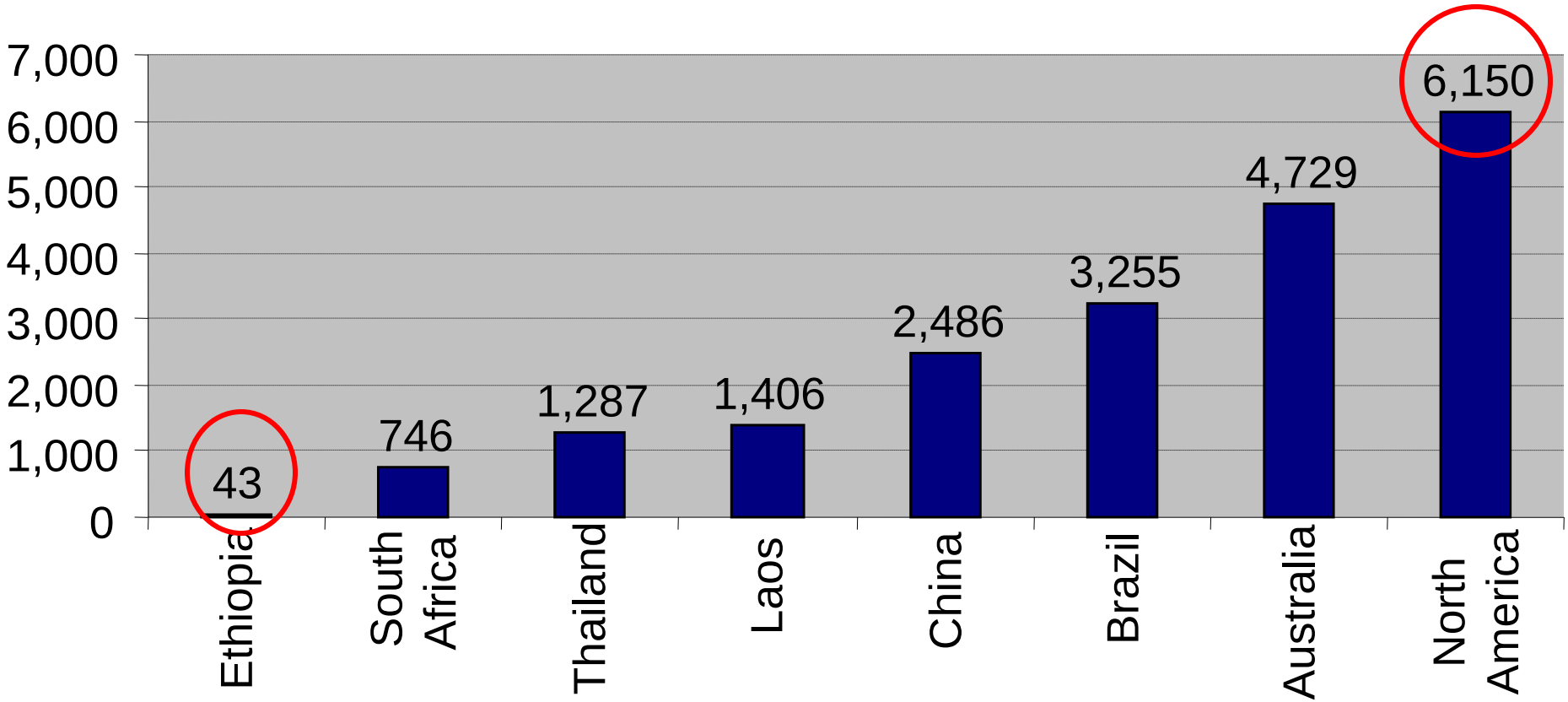


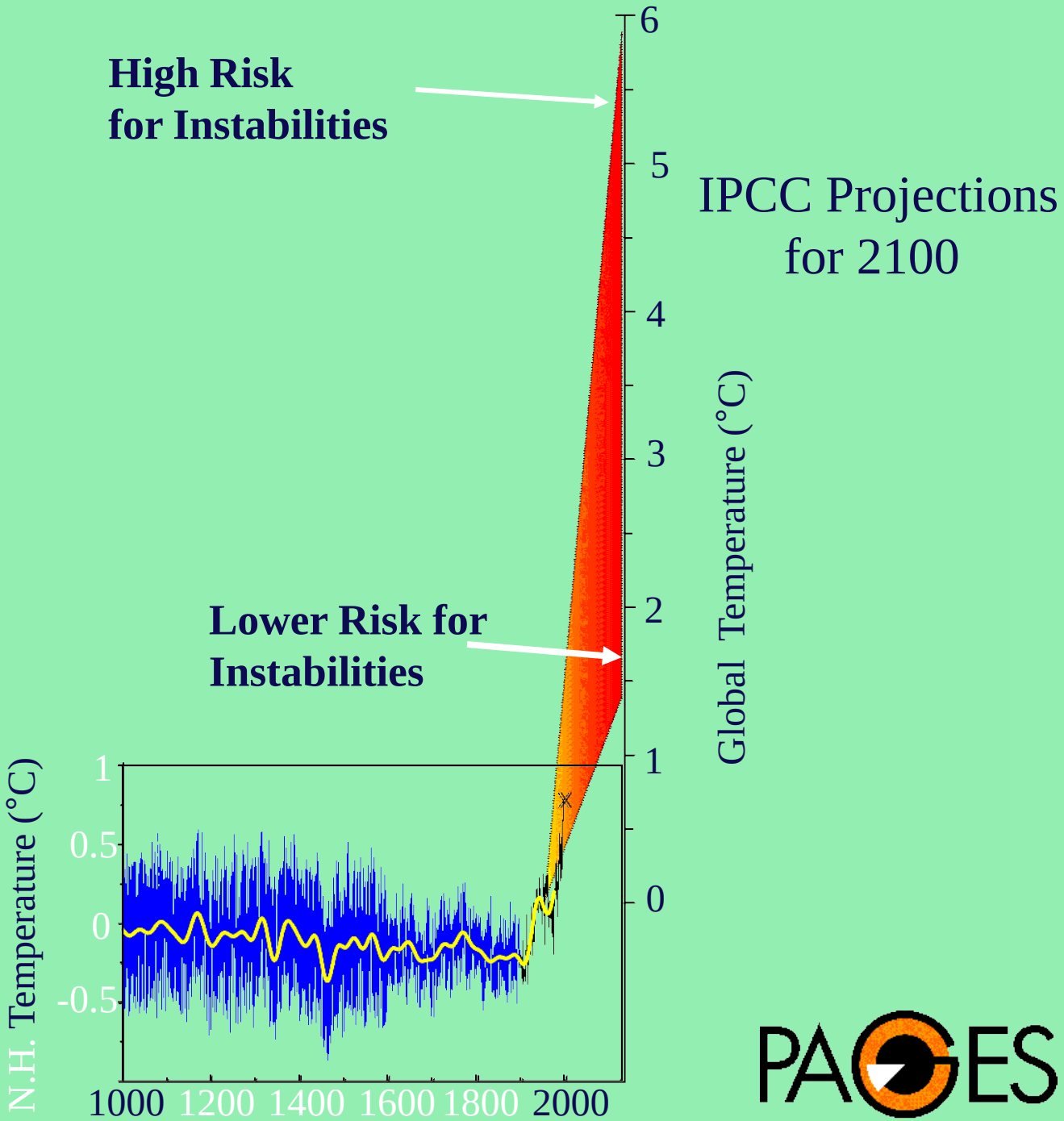


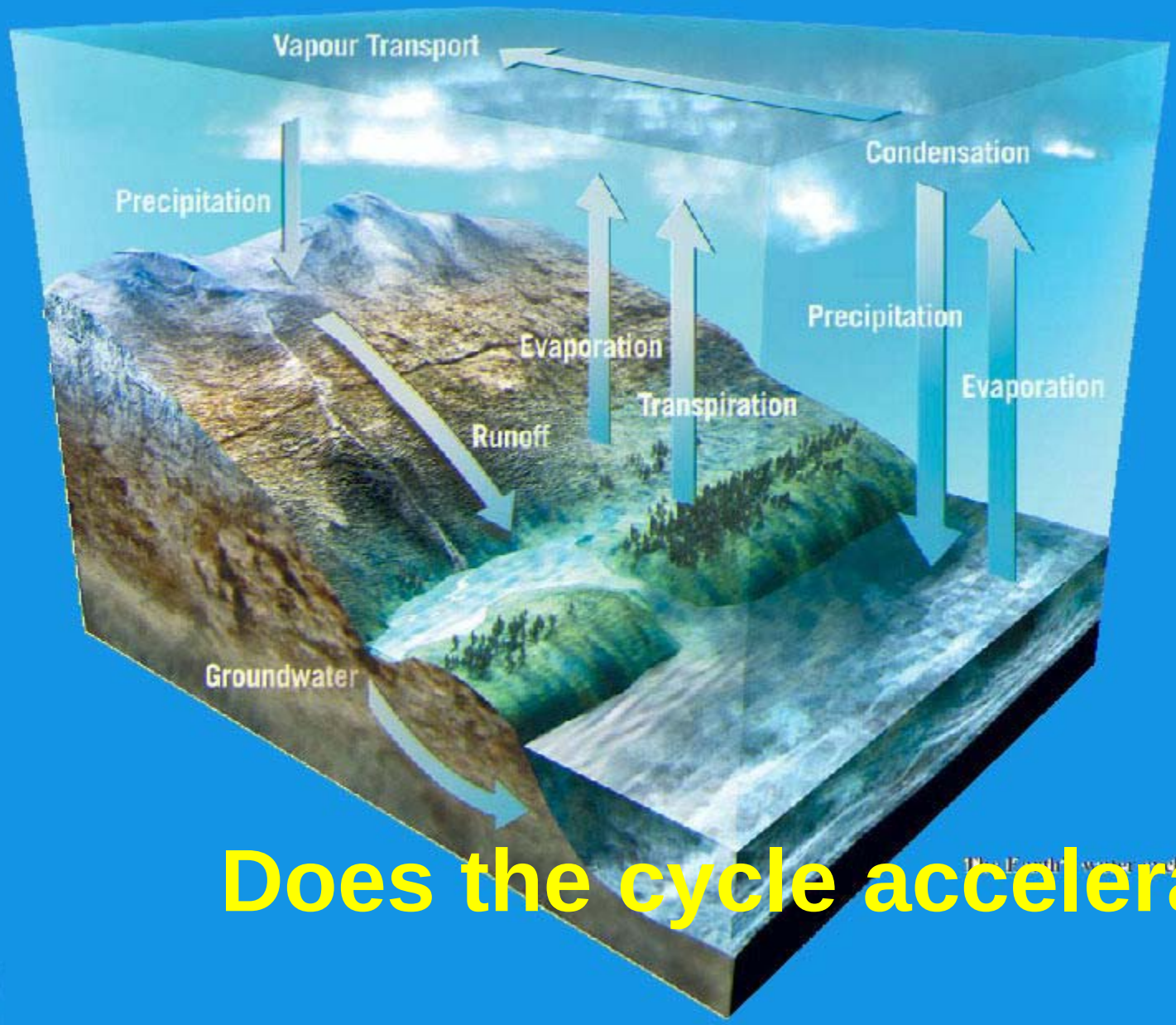
- 700% increase in water held by river systems
- Several years of residence time change in many basins
- Tripling of river runoff travel times globally (from 20 up to 60 days)
- Substantial impact on aquatic biodiversity
- Interception of 30% of continental TSS flux

From: Vörösmarty et al. 2004, *Eos-AGU Trans.*

Infrastructure gap: Water storage [m3/person]




High Risk
for Instabilities
Lower Risk for
Instabilities
IPCC Projections
for 2100
Global Temperature (°C)
6
5
4
3
2
1
0
N.H. Temperature (°C)
1
0.5
0
-0.5
1000
1200
1400
1600
1800
2000



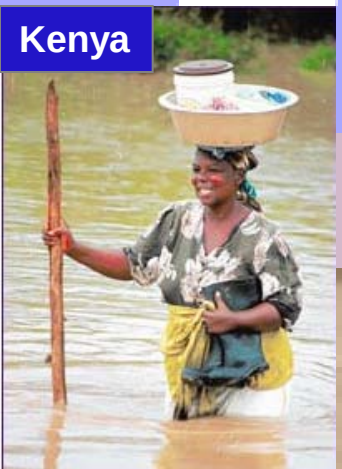
Does the cycle accelerate?

Budapest - Parliament

Major floods and droughts worldwide in 2002

Flood Drought

Austria
Czech
Russia
France
Turkey
Afghanistan
China
Korea
Senegal
Nepal
Bangladesh
India
Philippines
Ethiopia
Vietnam
Sri Lanka
Indonesia
Kenya
Micronesia
USA
Mexico
Haiti/ Jamaica
Ecuador
Peru
Bolivia
Uruguay



There is pressing need to develop advanced risk management on water hazard in order to secure human life and ensure sustainable socio-economic development and poverty alleviation.

ADAPTATION OPTIONS:

- MORE STORAGE
- MORE HYDROPOWER
- MORE GROUNDWATER USE
- MORE INLAND NAVIGATION
-
-
-

Climate is changing…

- There are many factors leading to
  changes in the rate of climate change
- Whatever the main reason is, the climate variations prompt for
  developing the water management strategies that take climate uncertainties into account

- → the need for
  - More observation systems
  - Better predictive modelling tools
  - Methods to handle uncertainty
  - Changes in design and adaptive management practices
  - Changes in educational programmes at all levels

Water hazard as a major challenge

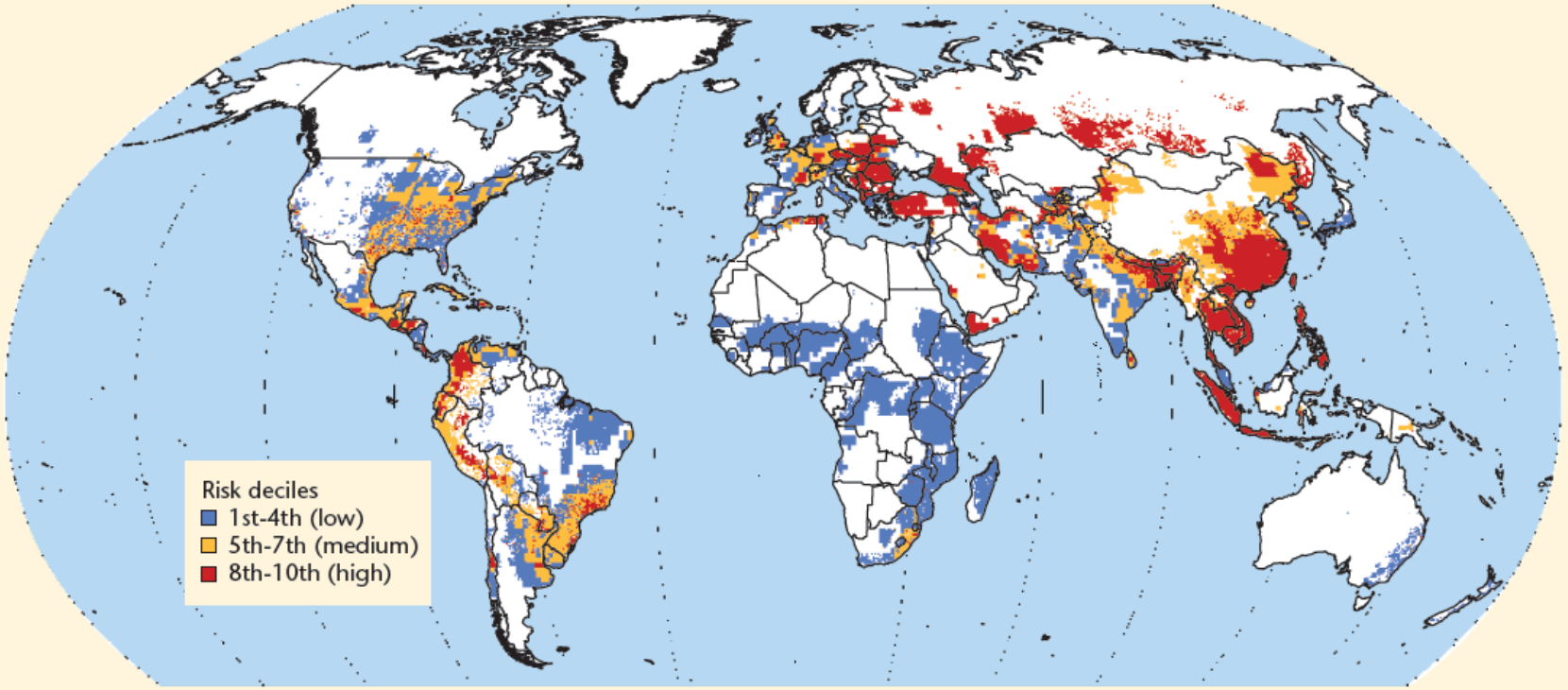
- Intensifying and increasing occurrence of water related hazard in many part of the world
- Serious concern on climate change such as extreme hydrologic events and sea level rising



(1 Aug 2007 Sirajgong District, Bangladesh)

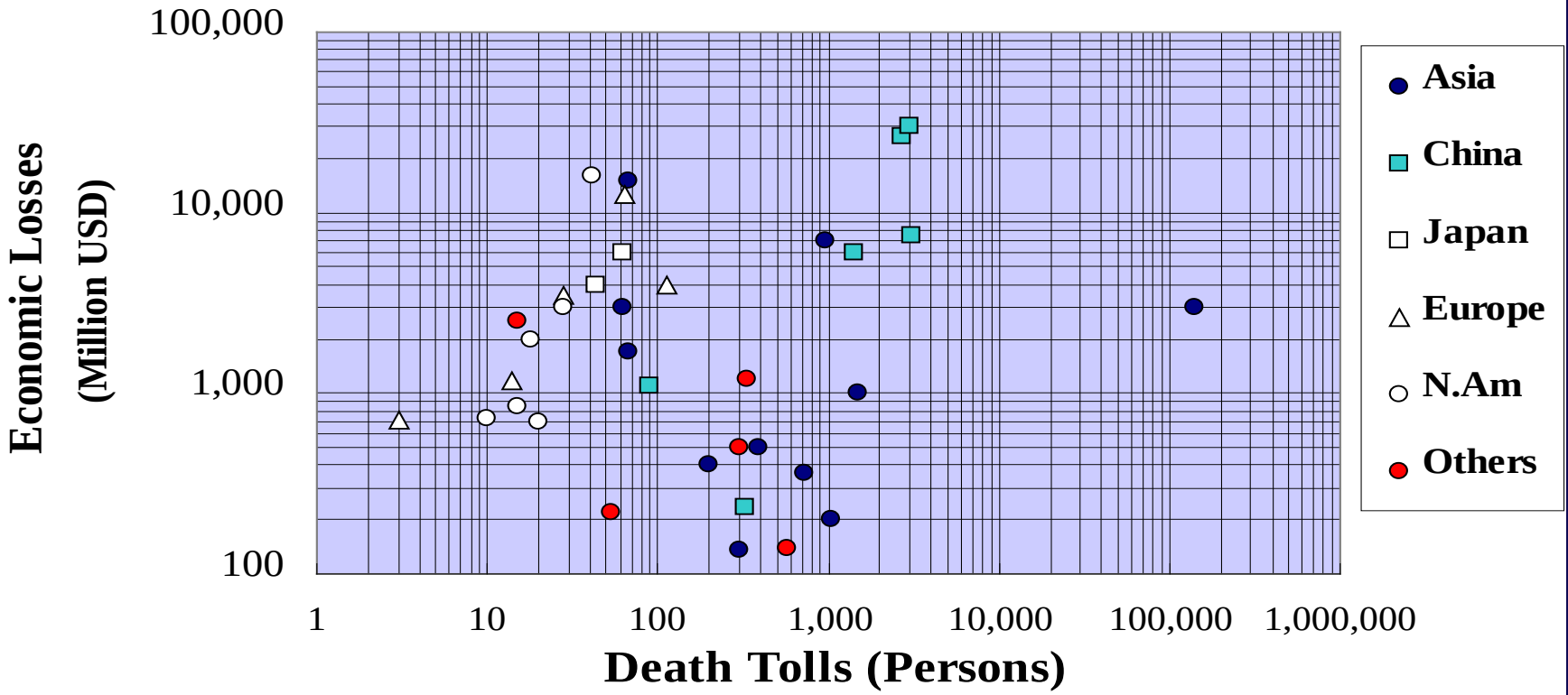
FLOOD LOSSES IN FUNCTION OF GDP

Map 10.3 **Impact of flood losses (comparative losses based on national GDP)**



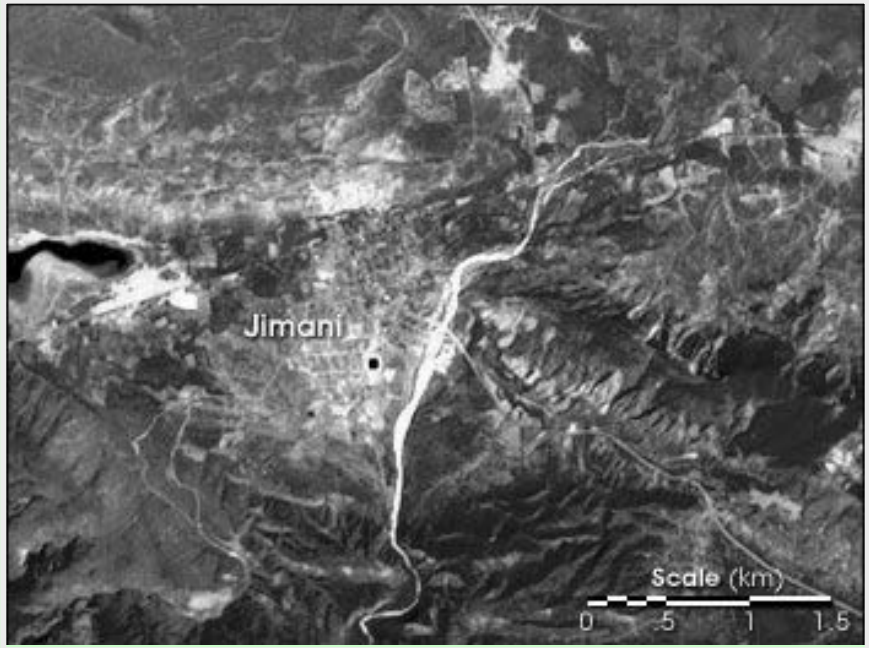
Note: Deciles refer to the level of risk, normalized for comparing 10 categories.
Source: Based on Dilley et al. 2005.

Damages of Floods in 1990's



Urban expansion in flood prone areas

May 24th, 2004: flooding of the trans-boundary River Soliette killed >1,000 Haitian and Dominican people



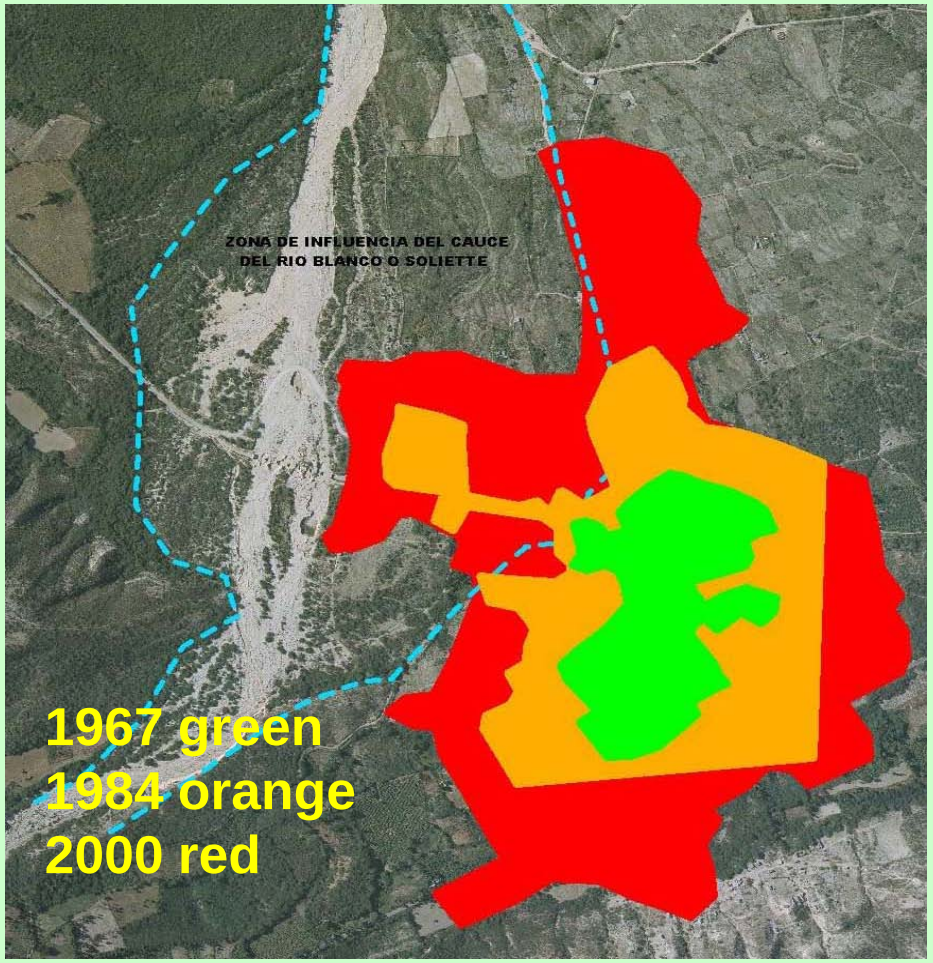
Before

After

(Brandimarte et al., 2009)

Urban expansion in flood prone areas

May 24th, 2004: flooding of the trans-boundary River Soliette killed >1,000 Haitian and Dominican people



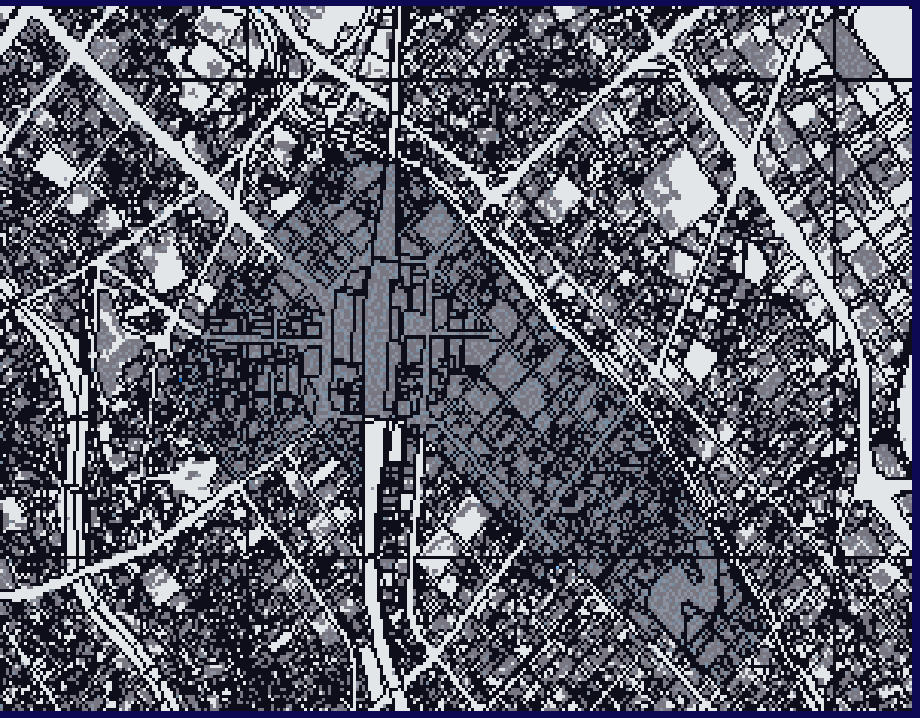
(Brandimarte et al., 2009)

Fukuoka Flood in 1999

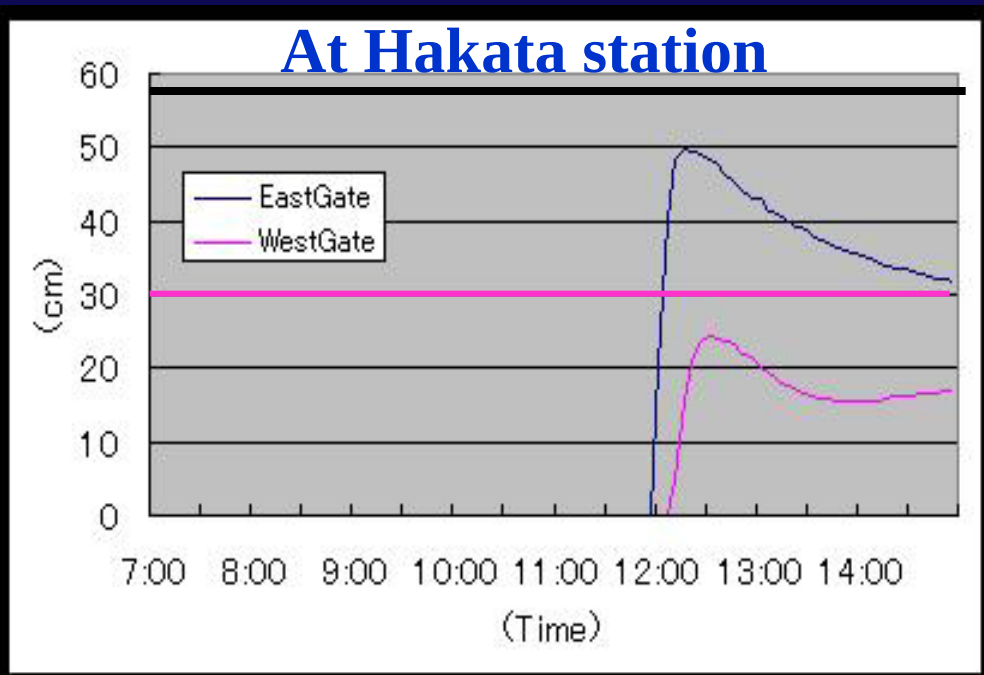
(Source : MLIT)

- Urban expansion taking place downward → Underground flood risk
- Recent developments → Long term risks are not experienced

(Source: Herat, UNU)



Fukuoka simulation



Volume of water entered into underground space:

- 2,017 m3 (simulated volume)
- 1,320 m3 (total pumped water station)

International Hydrological Programme

Fourth message:

“There is no sustainable development without adequate information about the state of the Earth and its environment”

Statement at WSSD

Flow of information in a Hydroinformatics system

Data → Models → Knowledge → Decisions

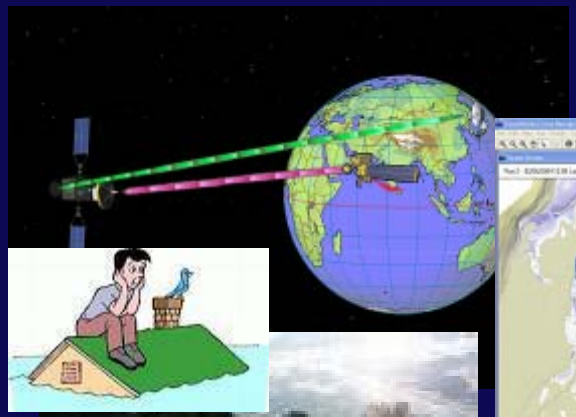
Earth observation, monitoring

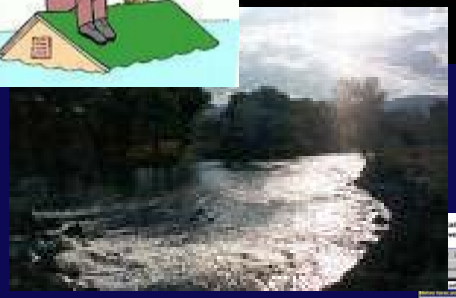
Numerical Weather Prediction Models

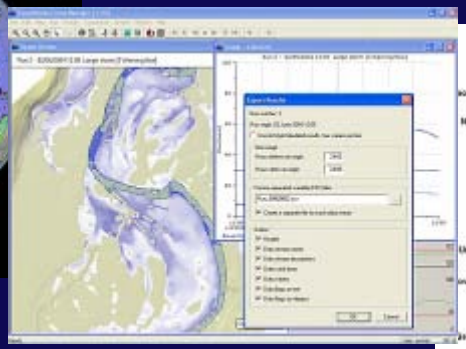
Data modelling, integration with hydrologic and hydraulic models

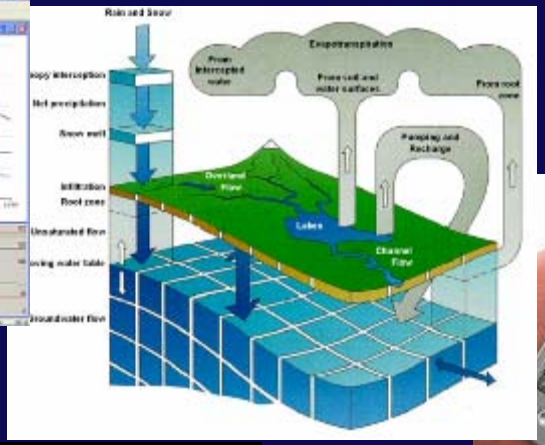
Access to modelling results

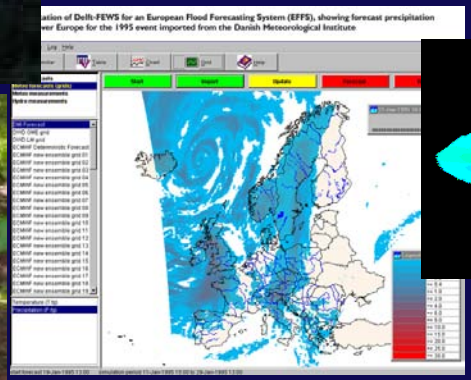
Decision support

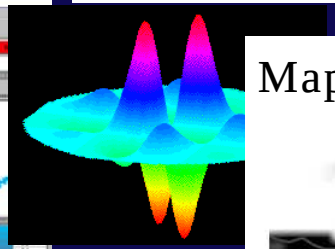


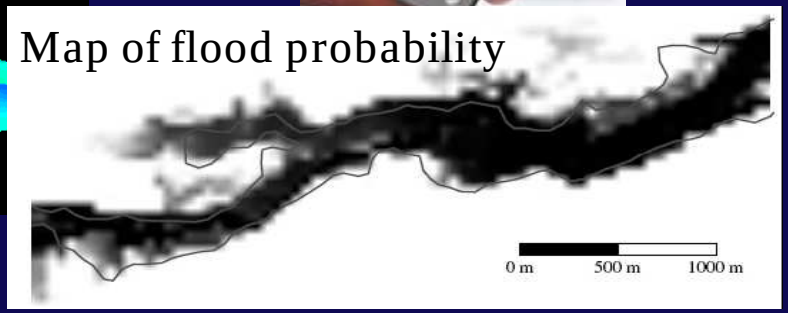








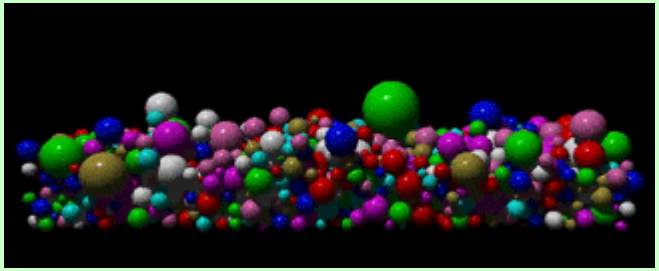




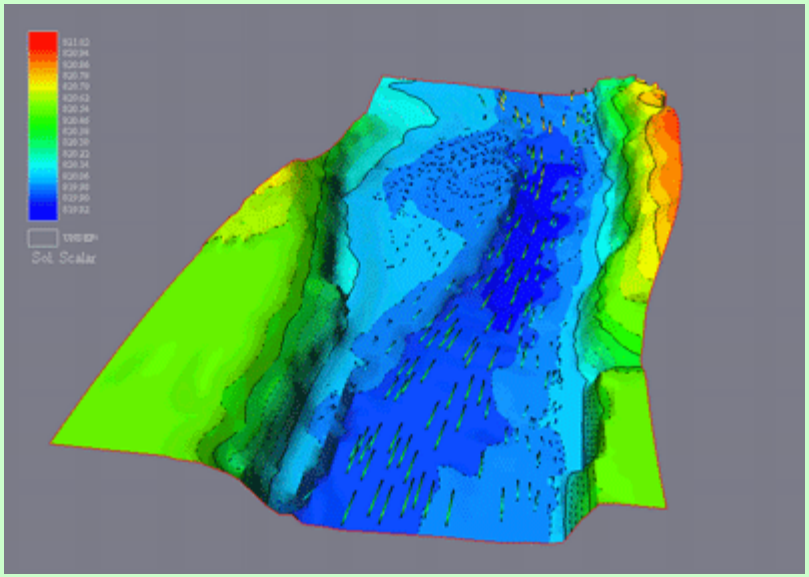
urce: D. Solomatine

Modelling is the heart of Hydroinformatics

- Technologies ensuring the whole information cycle, and *integrates data, models, and humans*



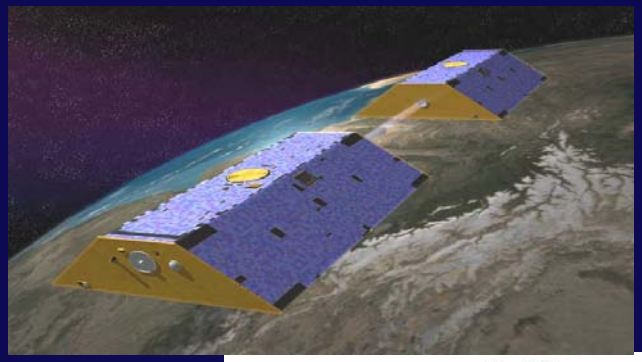
$$\frac{\partial Q}{\partial t}+\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right)+gA\frac{\partial h}{\partial x}-gAS_o+gAS_f=0$$

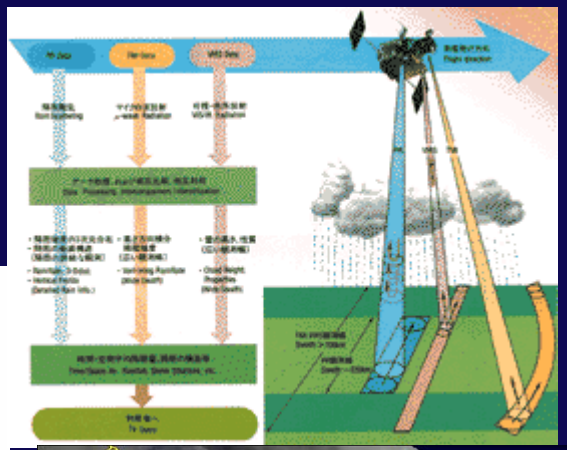


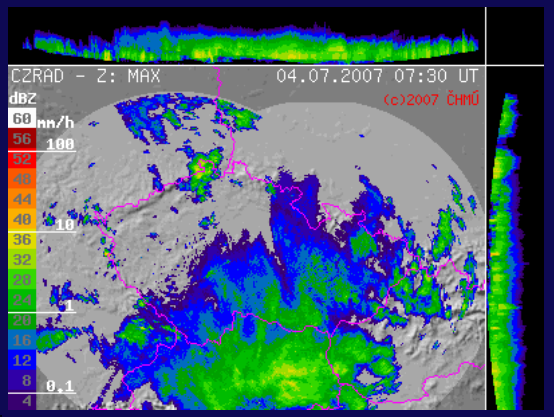
Applications of models for RT situations:

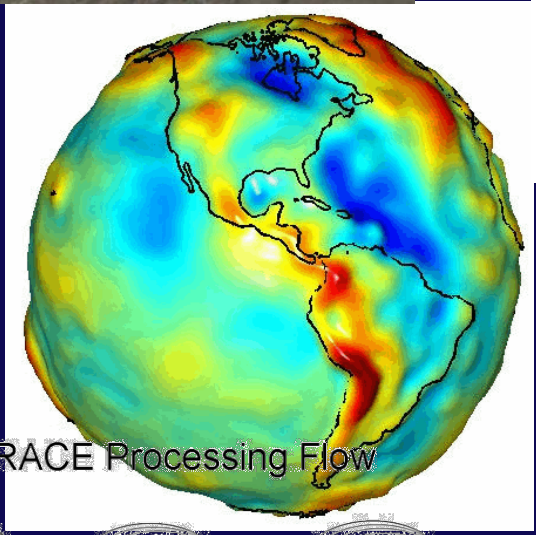
- River / urban flood forecasting and management
- Reservoir operations
- 2D inundation forecasting
- Forecasting storm surges and coastal flooding
- Warning and evacuation alerts through ITCs

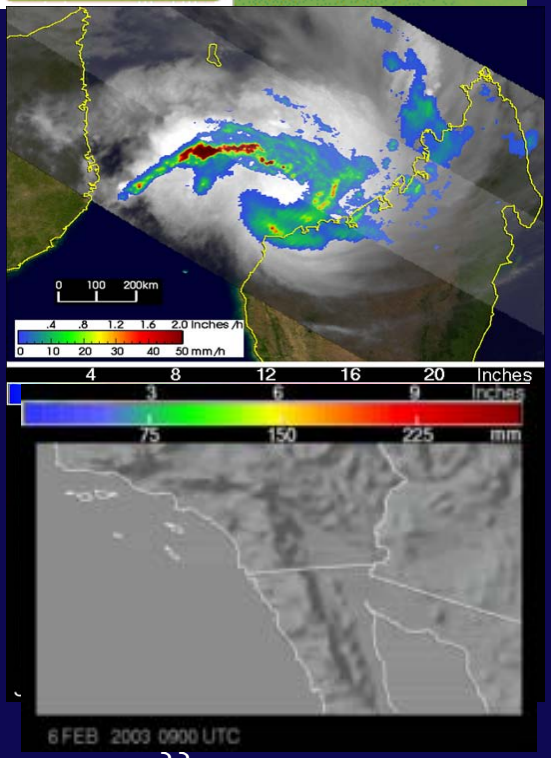
Remotely sensed data

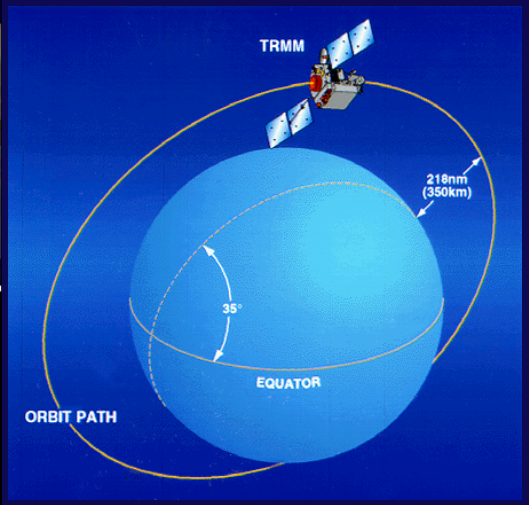


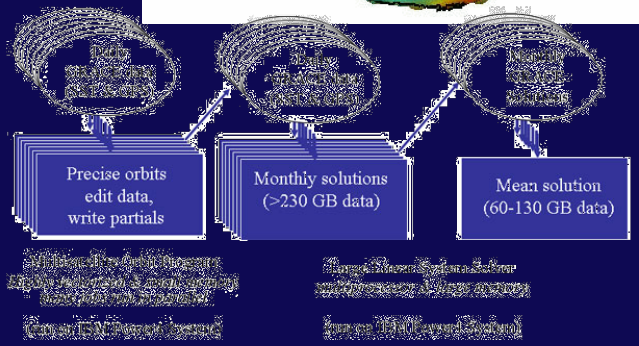






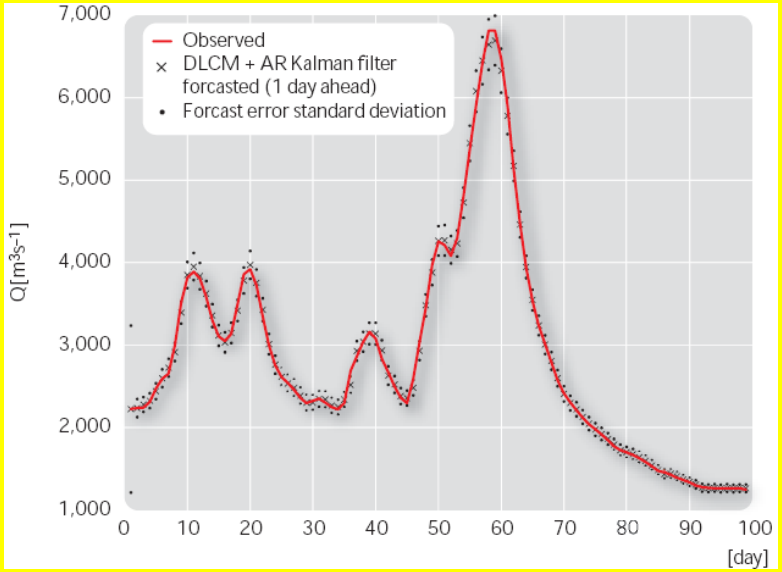




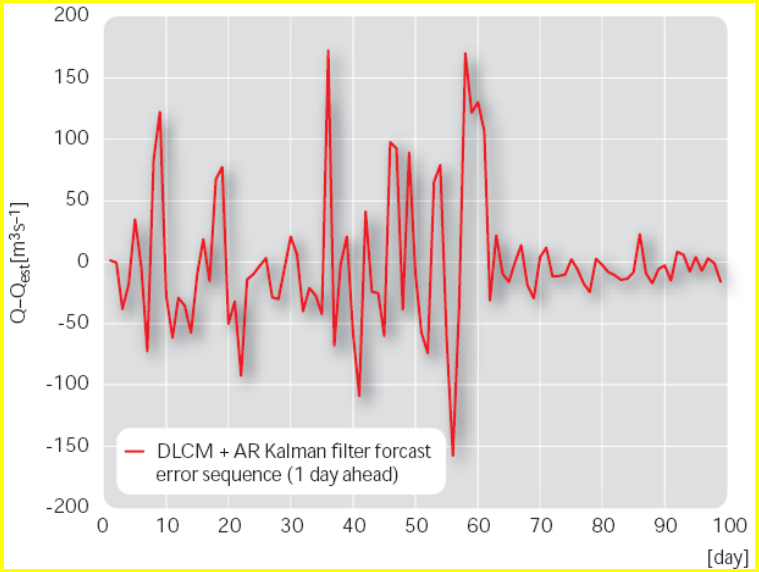


(Source: D. Solomatine)

One-day-ahead forecasts of the KALMAN-filtered DLCM structural and AR(1) autoregressive (stochastic) combined model with the forecast error standard deviation (+/- σ)



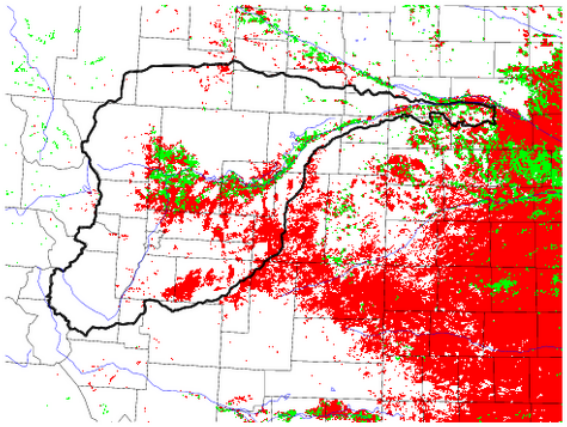
One-day-ahead forecast error sequence.

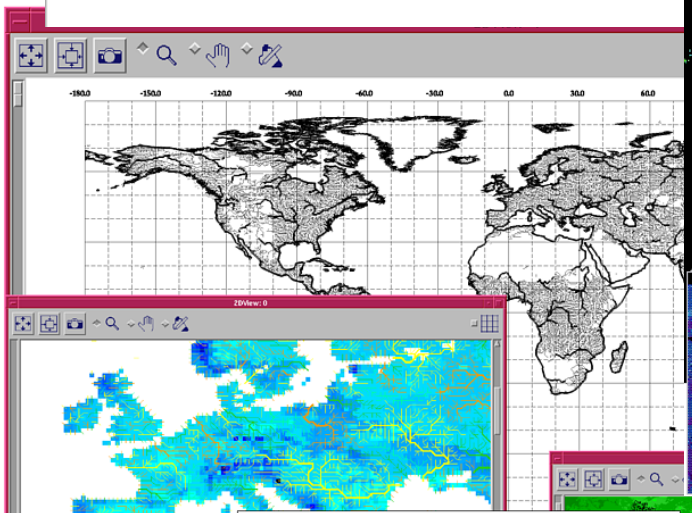


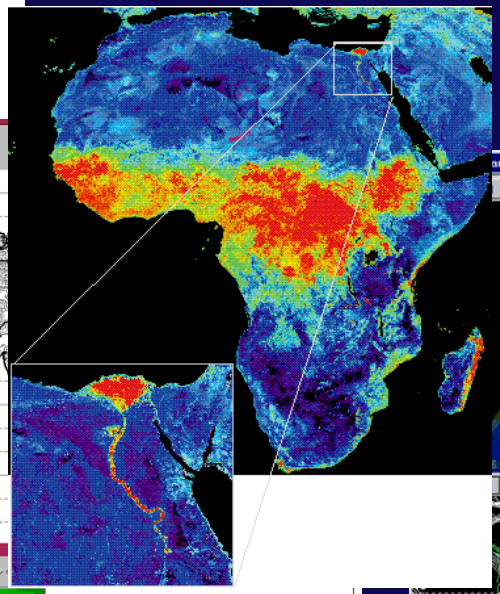
High Technology Earth Systems Tools

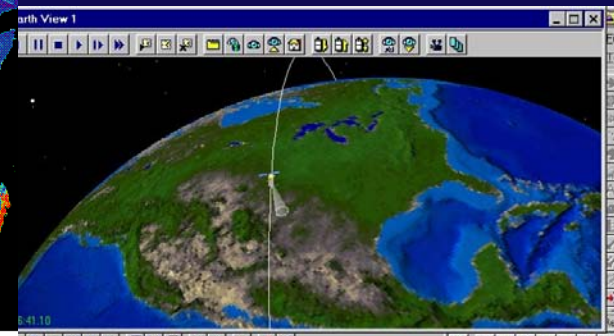
- Satellite data
- Simulation models
- Geospatial analysis tools

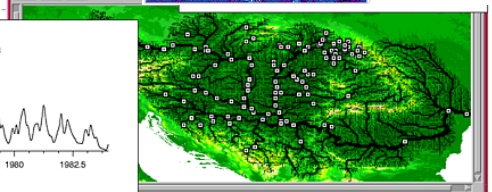
Huge progress but…

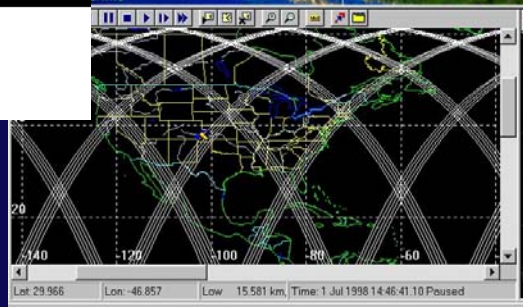








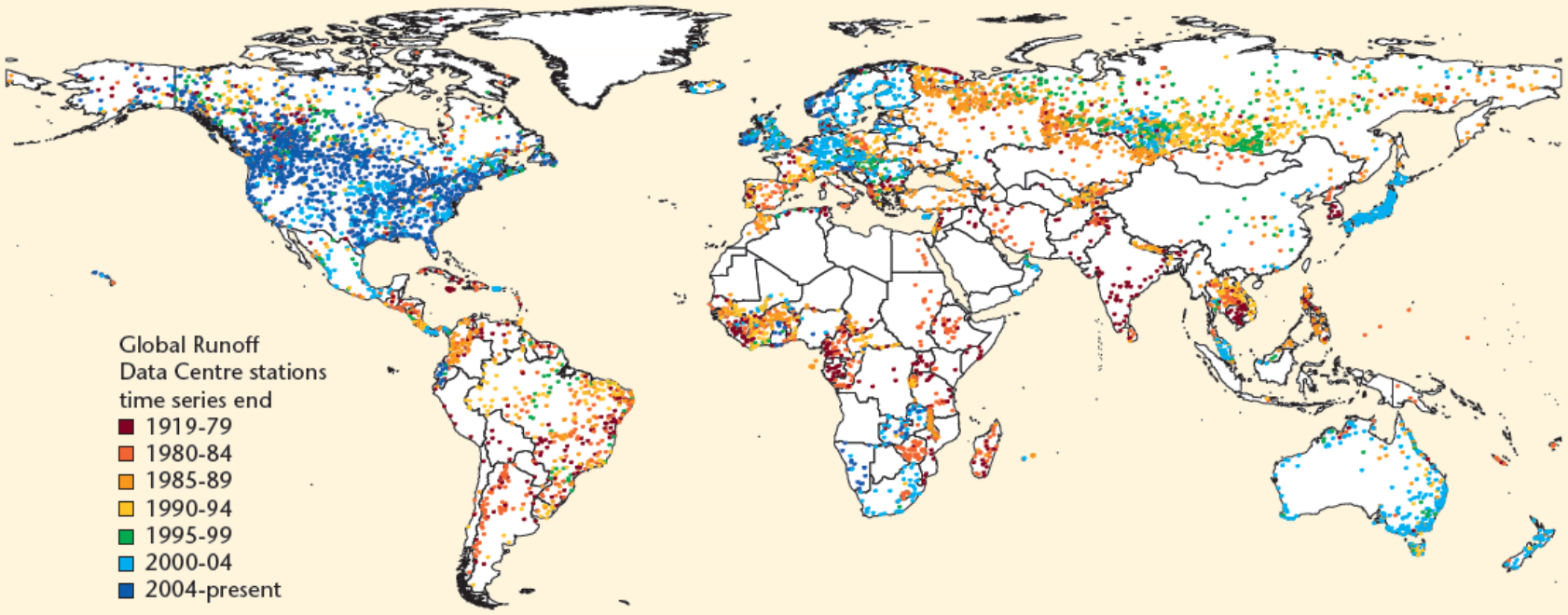




Fifth message:

Our capacity to monitor remains limited

Map 13.1 **Distribution of Global Runoff Data Centre streamflow gauges**



Source: Global Runoff Data Centre (http://grdc.bafg.de/).

The data issue: a major source of risk and vulnerability

- The case of **Africa**
- Interconnectedness through data
- Local data networks:

  The ethical choice vs.

  The global needs to mimimize bias
- GEOSS: space and in situ observations
- Will data secrecy be gone?
- Will it be replaced by sharing?
- What is the way out of trouble?

The challenge we all have

How to put water in the minds of people?

International Hydrological Programme

SIXTH MESSAGE:

WATER EDUCATION AND CAPACITY BUILDING

- IS THE HYDROLOGICAL CYCLE ACCELERATING?
- IS THE WORLD STATIONARY?
- ARE OUR AGE OLD HYDROLOGICAL CONCEPTS STILL VALID?
- WHAT WILL BE THE BIGGEST DRIVER 40 YEARS FROM NOW?
- ISN'T URBANIZATION TOTALLY CHANGING THE SHOW?
- SHOULDN'T WE DO MORE IN WATER GOVERNANCE?

Where do we go from here?

Eight lessons learned:

- **Firstly, a flood forecasting model should always encapsulate, even if in a strongly simplified manner, the physics of the processes involved.**
- **Secondly, a forecasting model should always encapsulate the treatment of the unavoidable uncertainties as well.**
- **Thirdly, the deterministic – structural part and the stochastic part, which describes the dynamics of the errors of the previous part, need to be coupled in combined forecasting models.**

Eight lessons learned:

- **Fourthly, forecasts are to be updated through error feedback whenever a new piece of relevant information becomes available.**
- **Fifthly, there is no unique forecasting model.**
- **Sixthly, there is no best forecasting model.**
- **Seventhly, in operational hydrological forecasting backup systems are always needed (see Murphy's extended relevant Laws).**

Eight lessons learned:

- **Eighthly, never fully trust your model but trust your oldest technician in the Forecasting Center. Models are excellent decision support tools, yet the human operator should never be excluded from the process of issuing forecast.**

The Eight Laws of Flood Studies

(Modified after Mr. Murphy):

§1 The flood always hits at Sunday 02:00 AM when there is nobody in the forecasting center.

§2 If § 1 does not apply than the flood comes when the staff is windsurfing on the nearby lake.

§3 If one is lucky one meets only once in a life time the flood that is greater than the design flood.

The Eight Laws of Hydrological Forecasting

§4 If one is unlucky this happens regularly.

§5 The 100-year return period flood returns every ten years minimum twice.

§6 When the Big Flood comes the on-line data collection system fails within minutes.

§7 When the Big Flood comes all our precious hardware breaks down in maximum *K* hours, where *K* is one fifth of the concentration time of the catchment.

The Eight Laws of Hydrological Forecasting

§8 The probability of the joint occurrence of unfixable computer bugs in the code of our forecasting model and the Big Flood is one.

Final lessons:

- **Model development and usage is only a small fraction of the costs of establishing and running an operational hydrological forecasting system.**
- **Models play the same role as the heart does in the human body. Small but one just cannot live without them.**