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# "Transboundary Environmental Problems: Facts and Management – a European perspective"

*Part II: management, practice and policies*

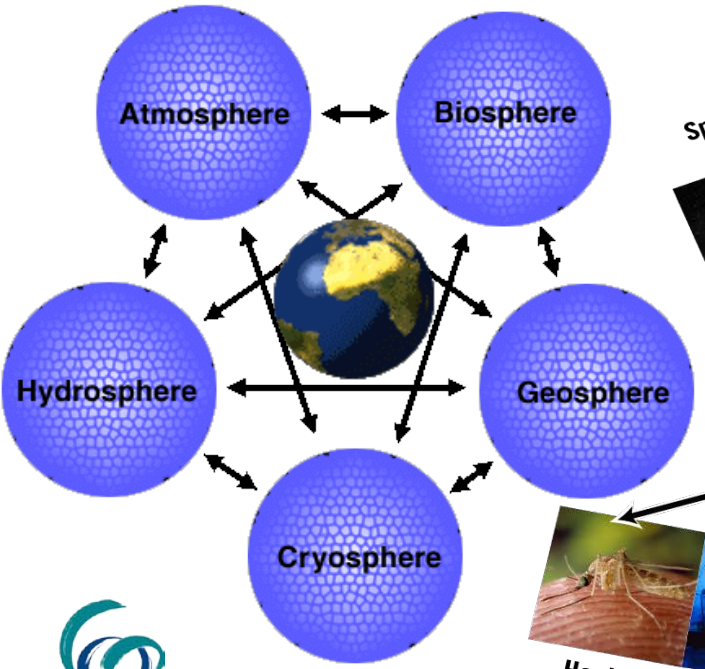
Freek van der Meer
Faculty ITC, University of Twente

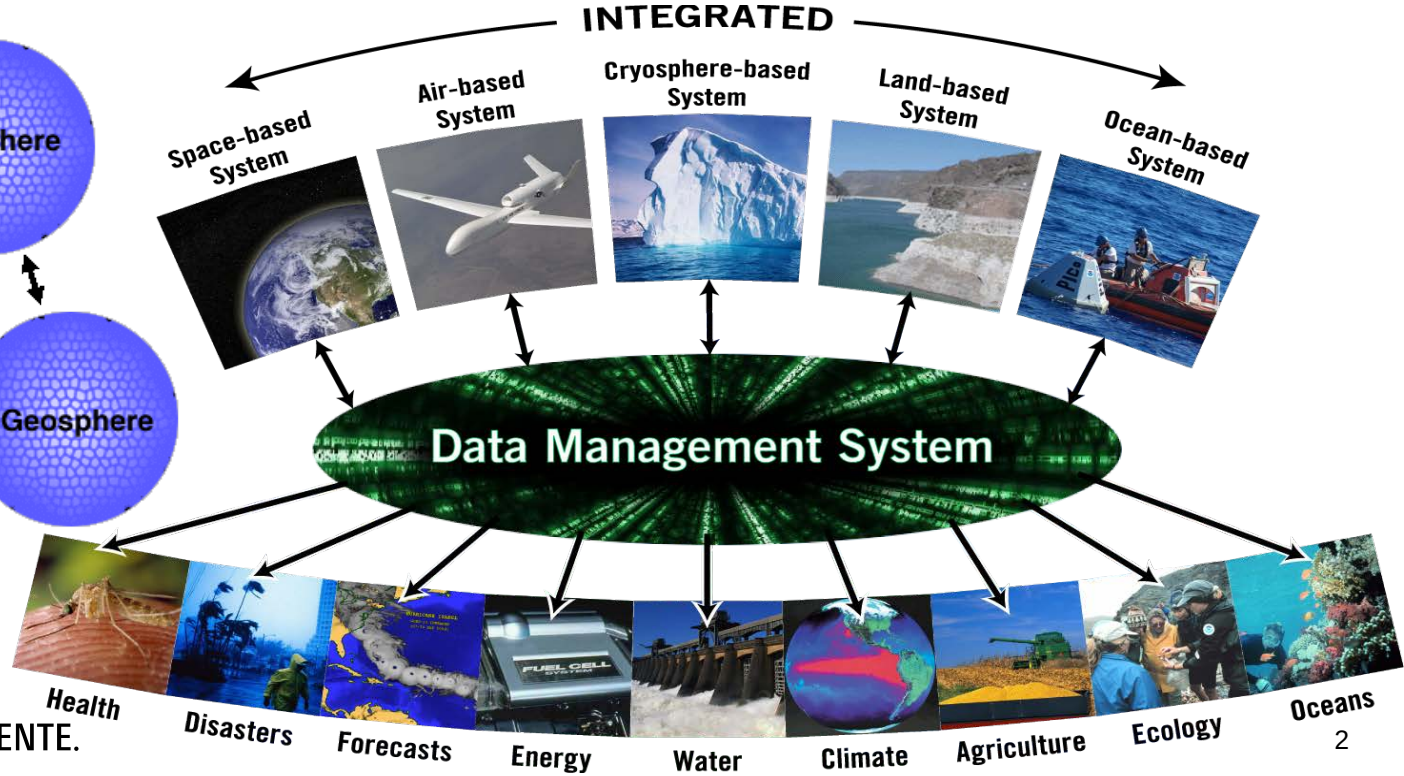
*Panel discussion of the 3rd EnvironmentAsia International Conference June 17th, 2015 during 10.05-12.00 am*

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

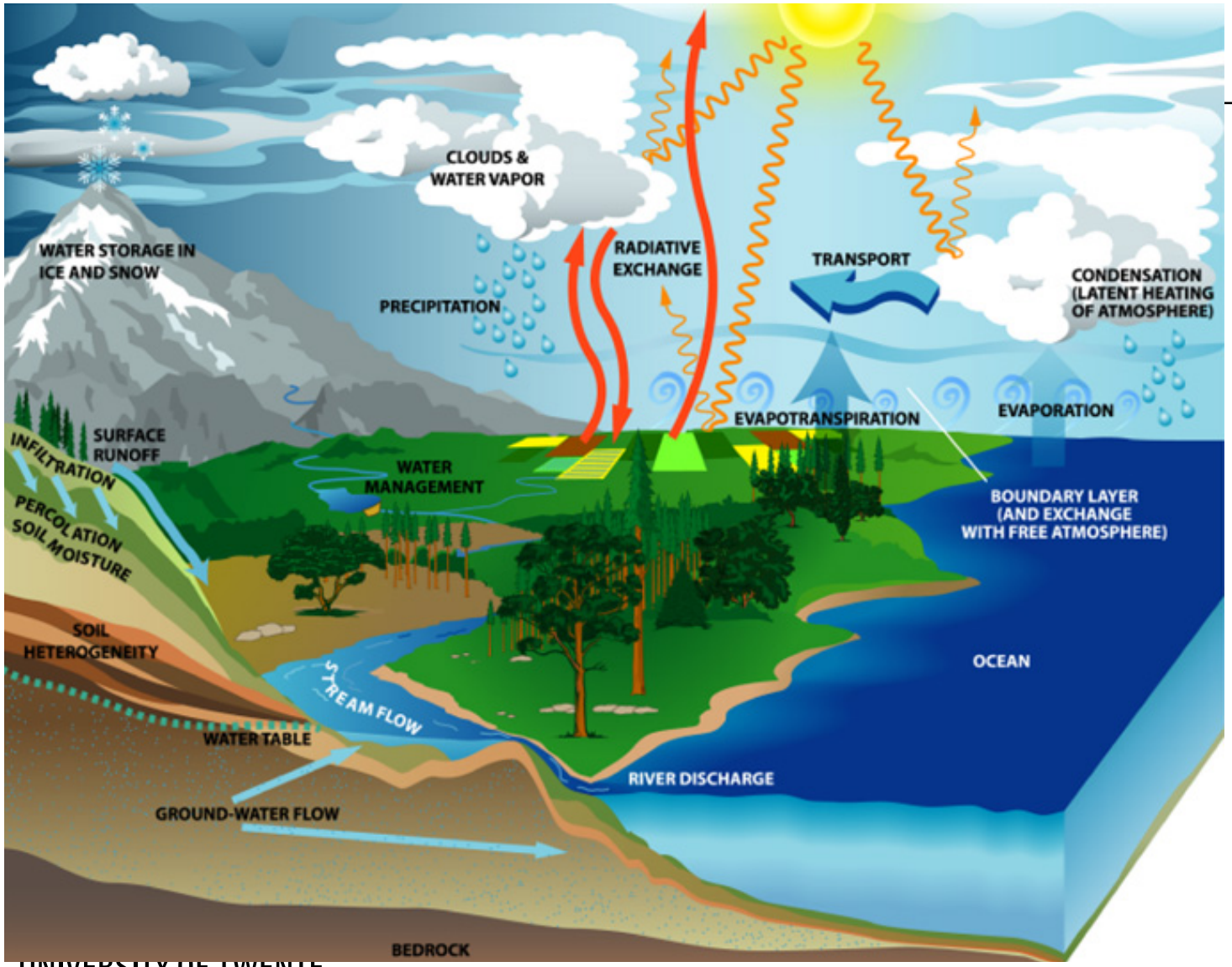
# We need New thinking: Earth as a system

"Earth **System** Science“ acknowledges that changes in the solid earth (land - lithosphere or geosphere) result from interactions among the **atmosphere (air), hydrosphere (water, including oceans, rivers, ice), biosphere (life)** and the **lithosphere**.



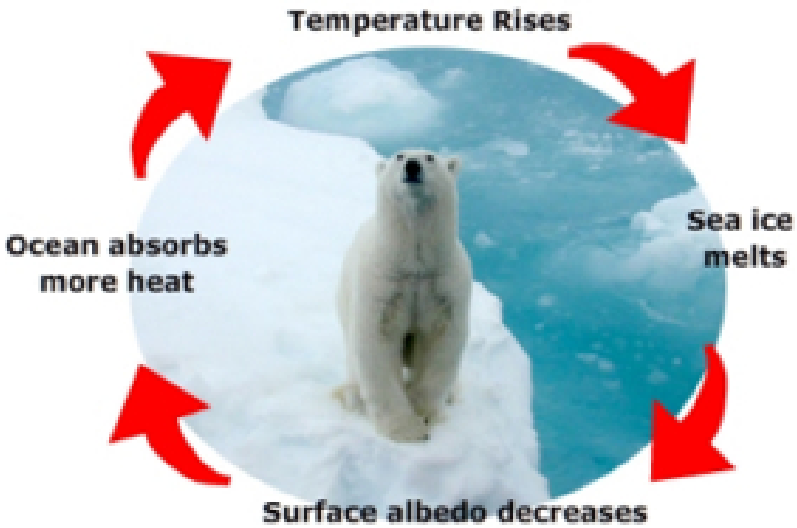
# The water cycle: a complex system with unexpected feedbacks

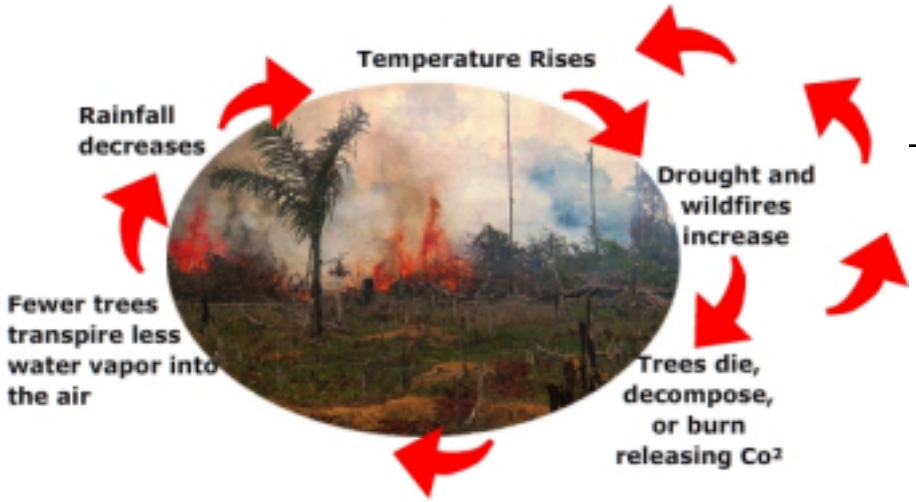




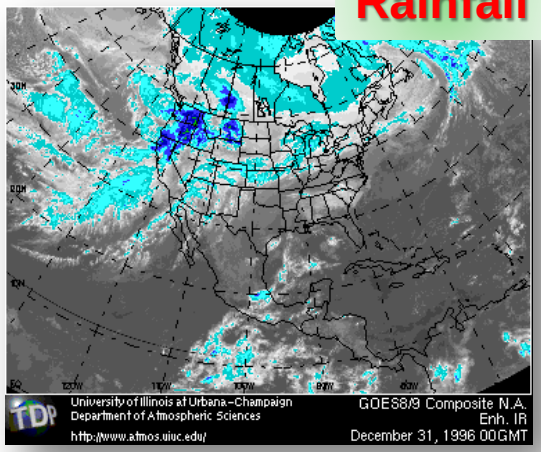

Source: http://cd7.e2bn.net/

# Better understanding of feedbacks is needed…

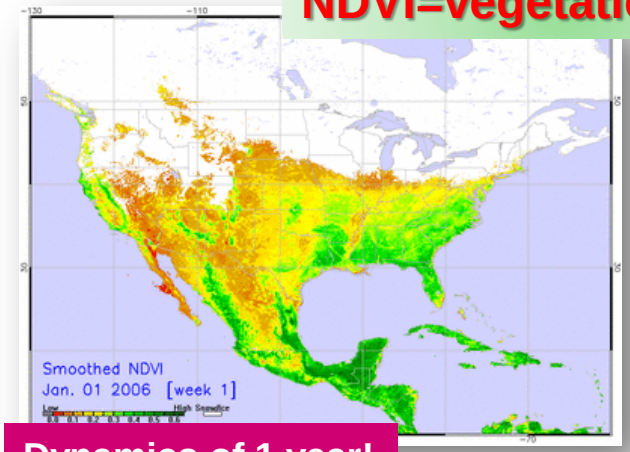



**Rainfall**



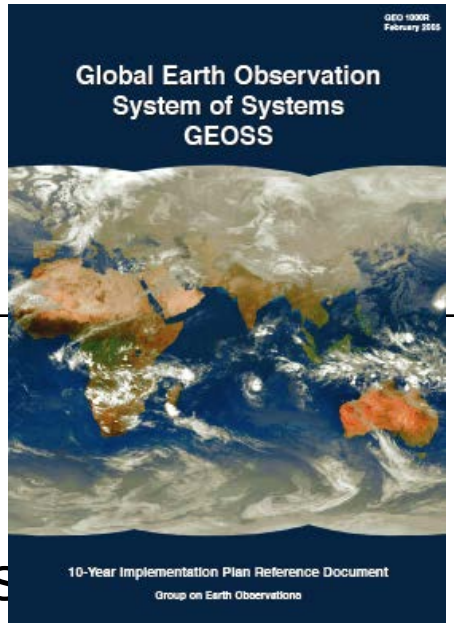

**NDVI=vegetation cover**




**Dynamics of 1 year!**

…and better observations.

# GEO and GEOSS; transnational earth observation




- **GEO** = Group on Earth Observation
  - 96 Nations, 87 Participating Organizations
- **GEOSS** = One Vision
  - The global earth observation system of systems
  - A globally coordinated, comprehensive and sustained system of Earth observing systems
- **Societal Benefit Areas**: Reduction and Prevention of Disasters, Human Health,Energy Management, Climate Change, Water Management, Weather forecasting, Ecosystem, Agriculture, Biodiversity.

First Earth Observation Ministerial Summit
July 31, 2003, Washington DC

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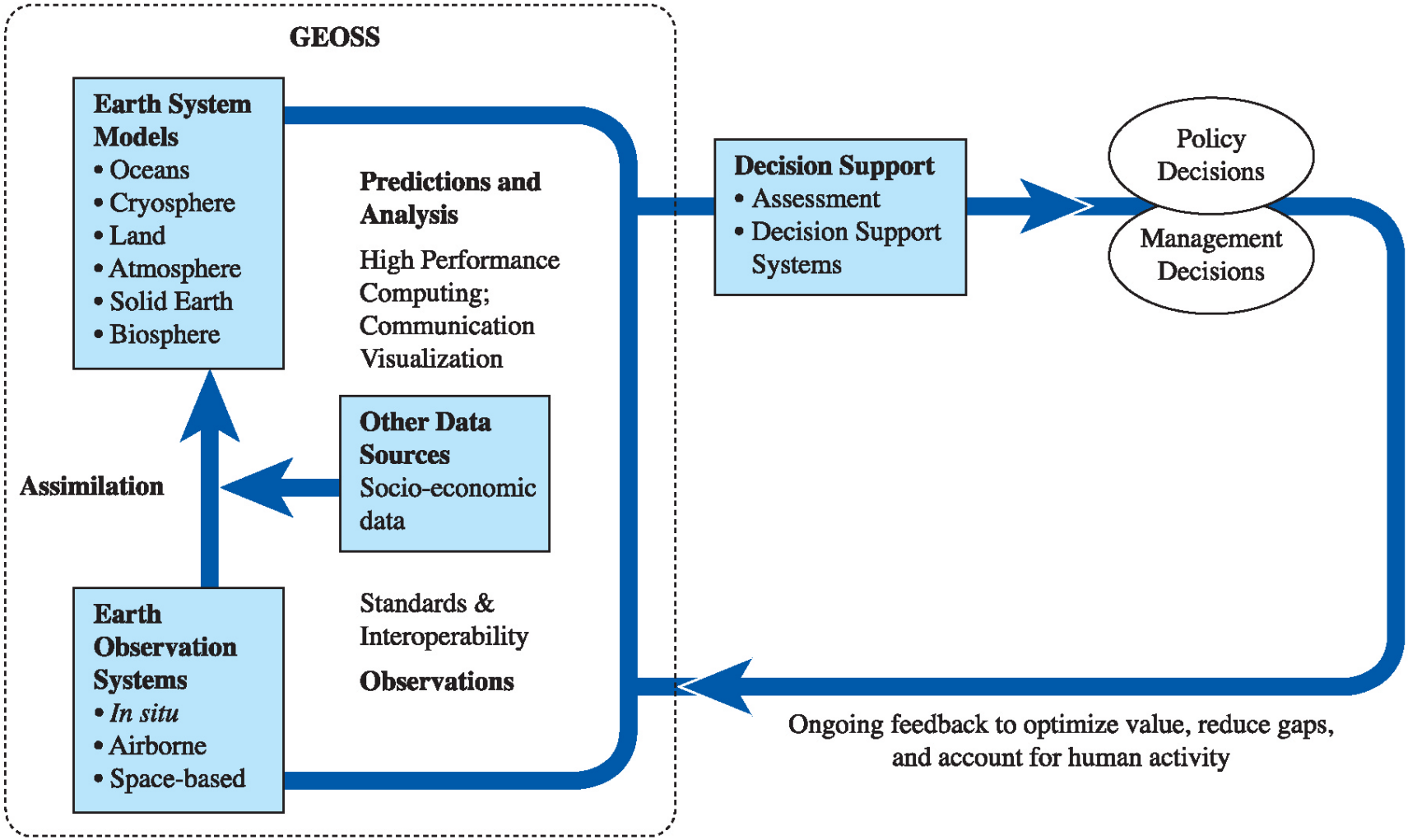
# GEOSS

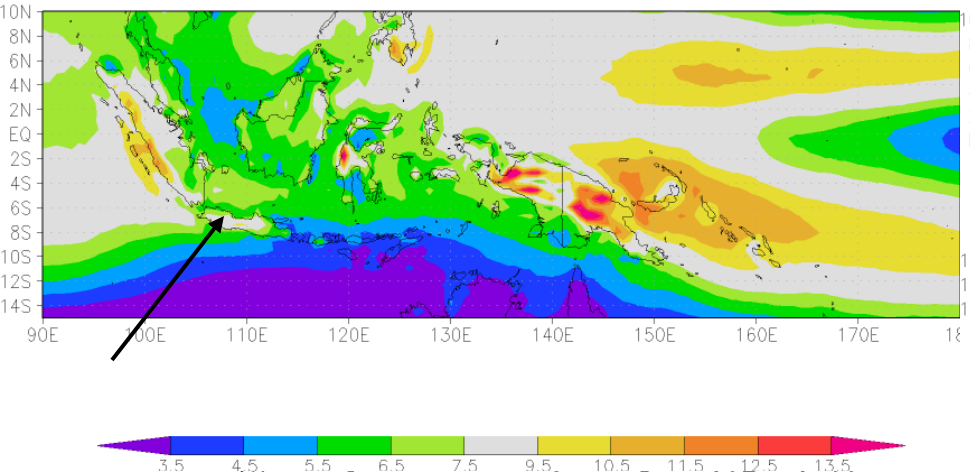



Source: J. Achache

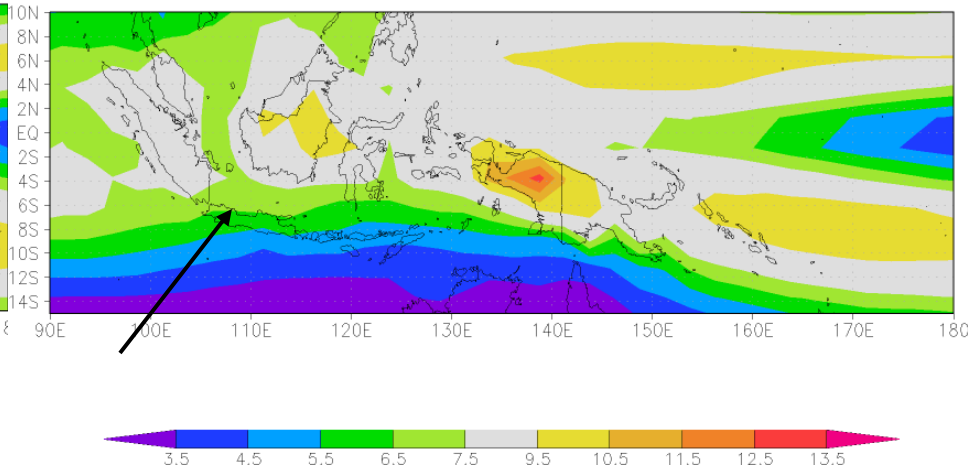
# ..AND BETTER (GLOBAL) CLIMATE MODELS

## MEAN PRECIPITATION PRESENT-DAY (1981-2012) VERSUS FUTURE (2071-2100)

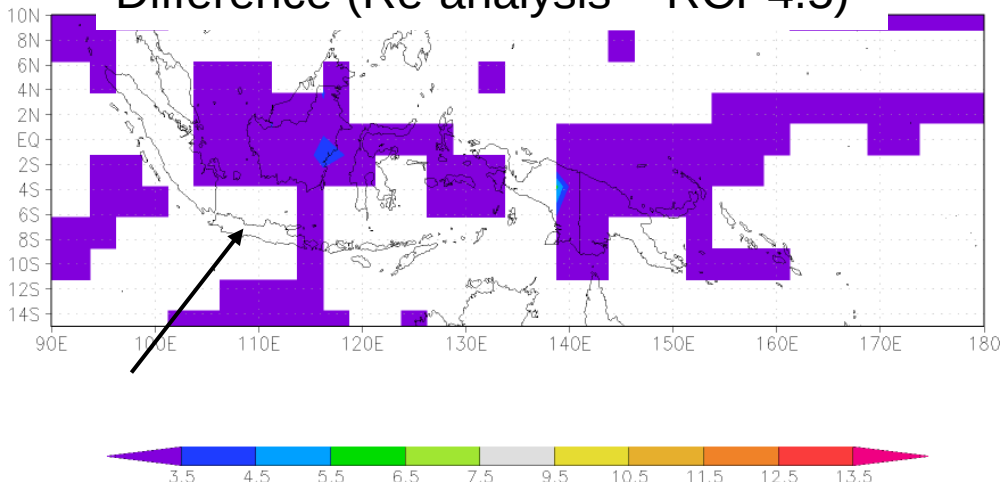
Re-analysis 1981-2012




RCP4.5 ensemble mean 2071-2100




Difference (Re-analysis – RCP4.5)




Global climate models do not solve small-scale features, such as orographic uplift >> Need for downscaling to include local effects

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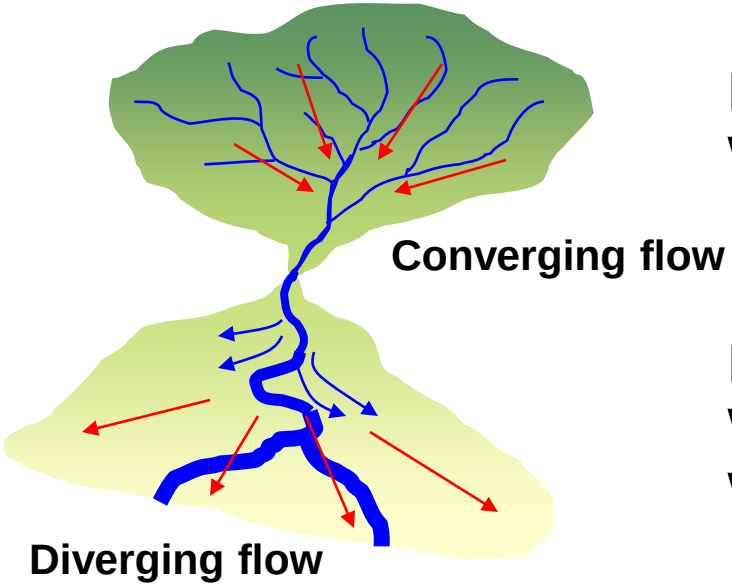
# River basin management

**System 1: Precipitation**

How much ?

**System 2: Upstream**




How much ?
When ?

How much ?
When ?
Where ?

**System 3: Downstream**

# Downstream problems: flooding

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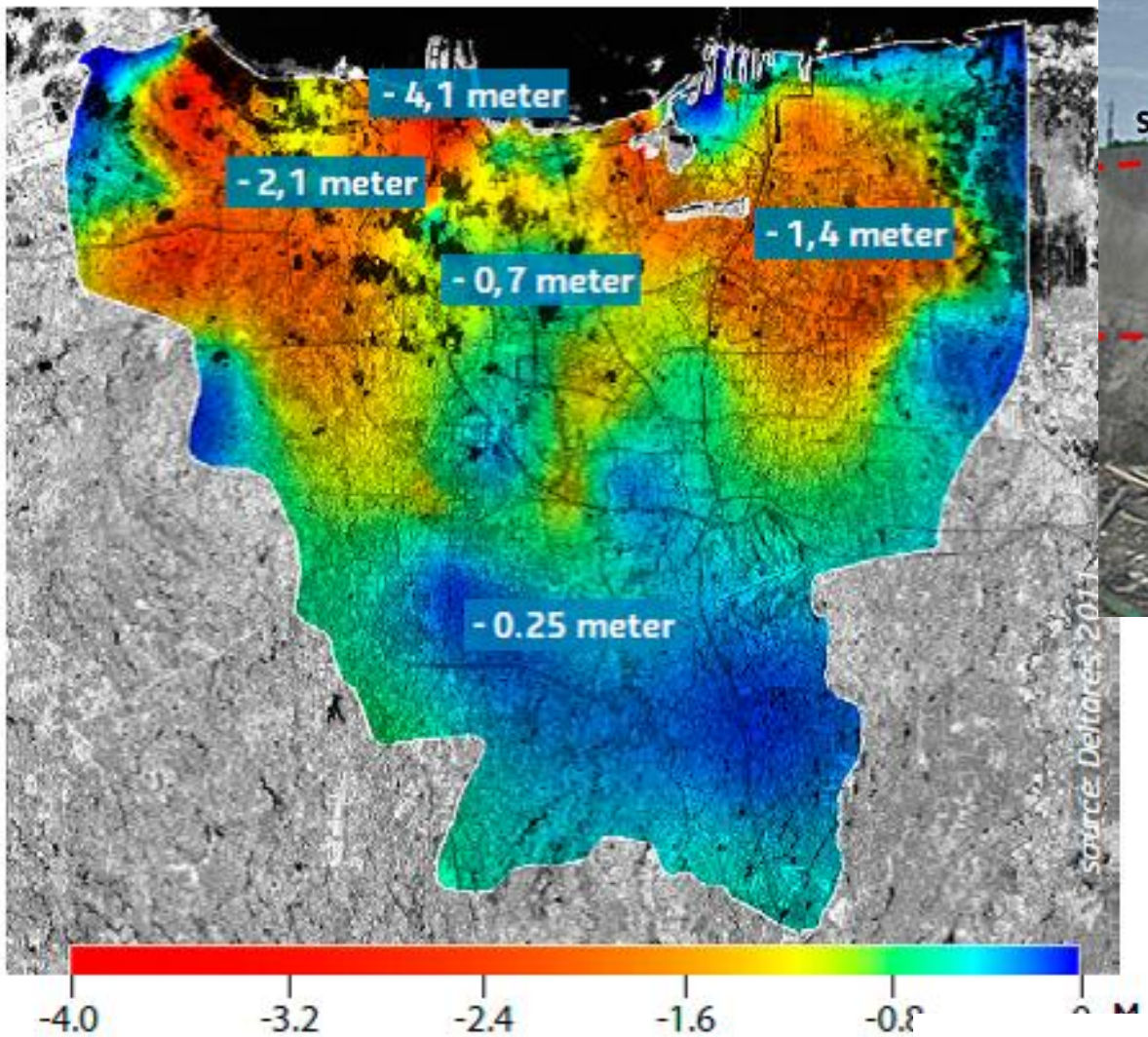
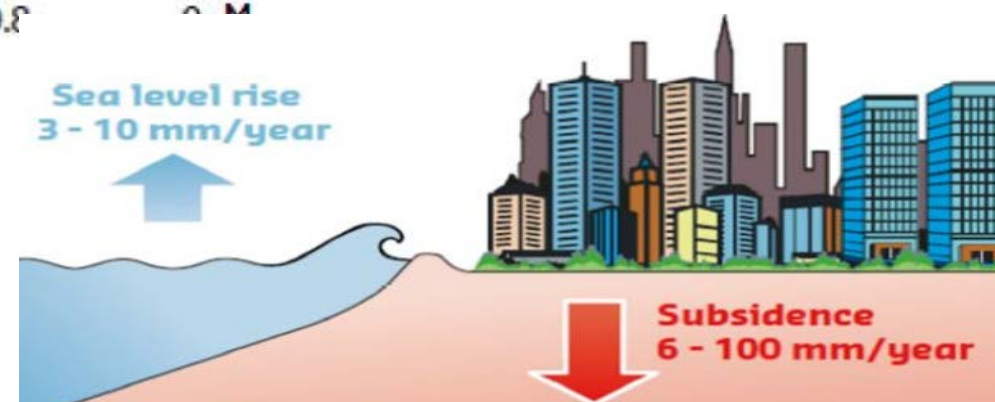
A grand challenge: Flooding of Jakarta


Joint Cooperation Program (JCP) objective is to carry out joint research and to develop systems in the field of water management. KNMI, Deltares, Alterra (Wageningen UR) and UT- ITC and Indonesian partners will be working together





*Land subsidence in Jakarta in period 1974-2010*

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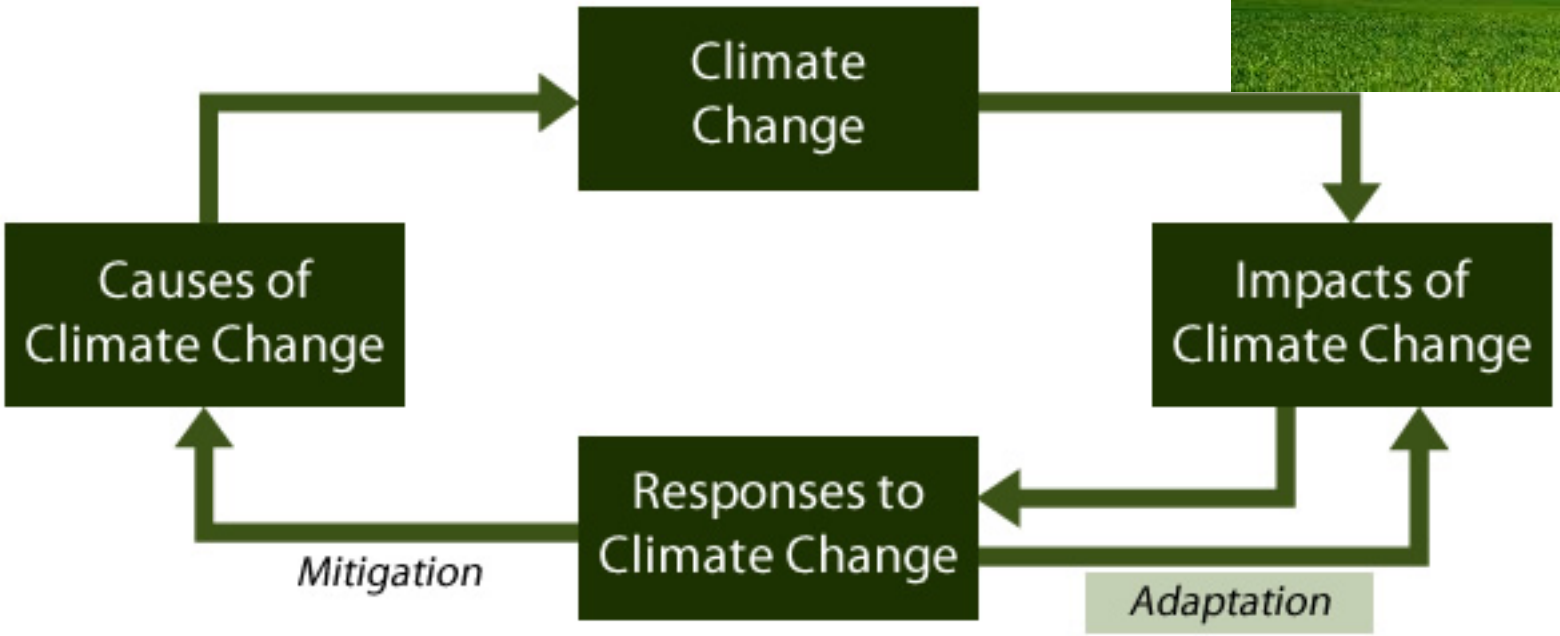
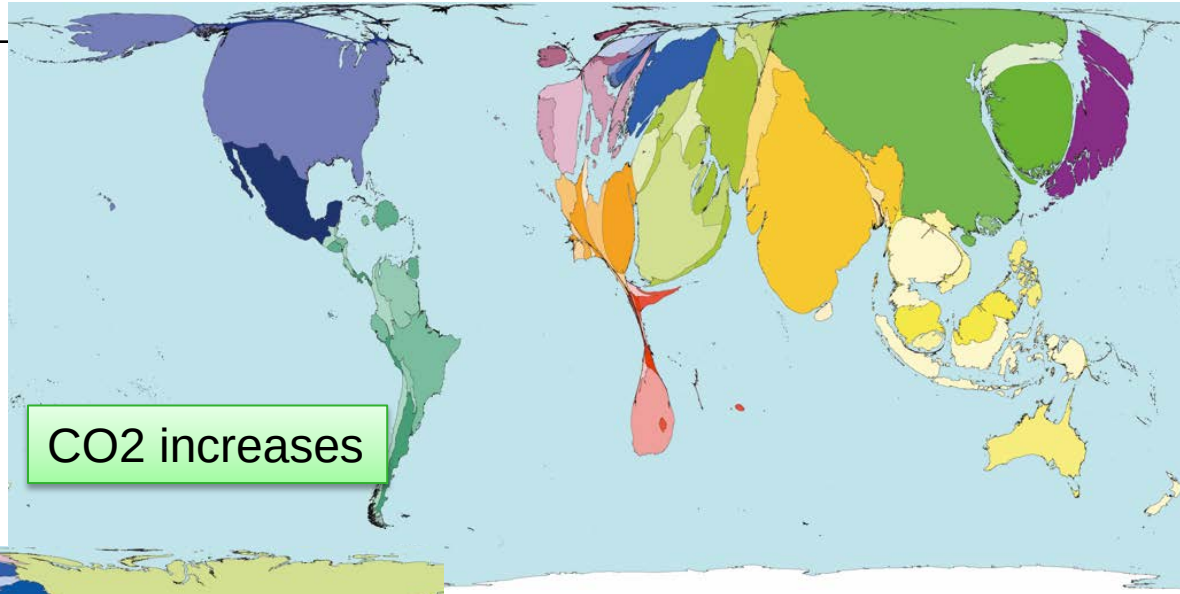
# ADAPTATION

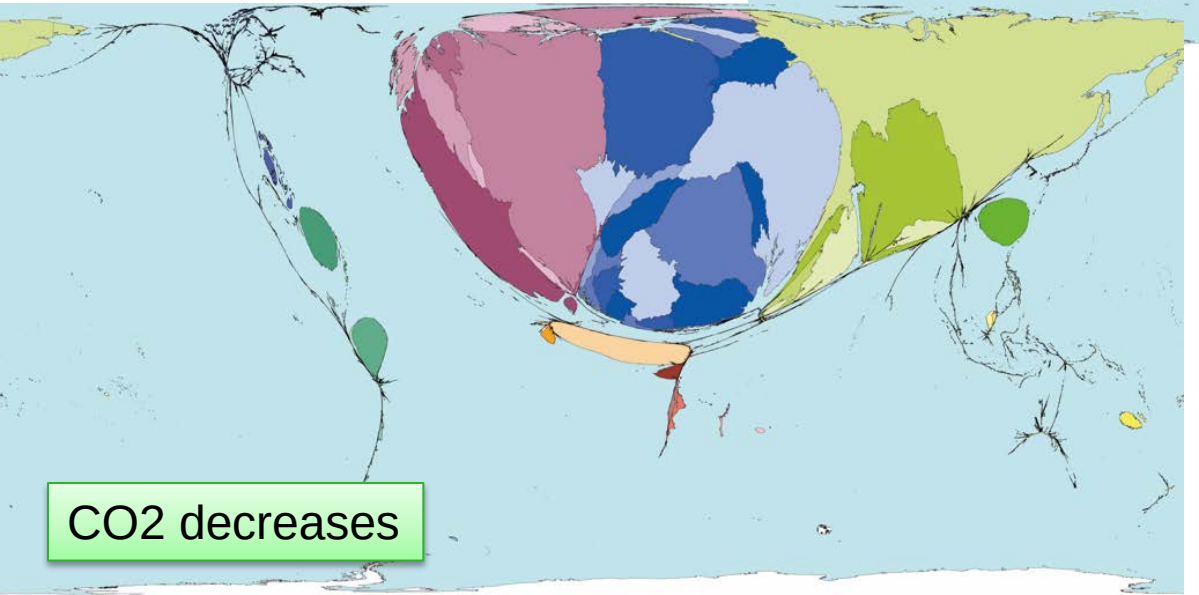




Carbon dioxide causes roughly 60% of the 'enhanced greenhouse effect' or global warming resulting from certain gases emitted by human activities. In 2000 there were almost 23 billion tonnes of carbon dioxide emitted worldwide.

# CO2 TARGETS ACHIEVED? 1980-2000 STATS

Increases in carbon dioxide emissions are in China, the United States and India. 42% of the world population live in these 3 territories, they caused 45% of the world increases.



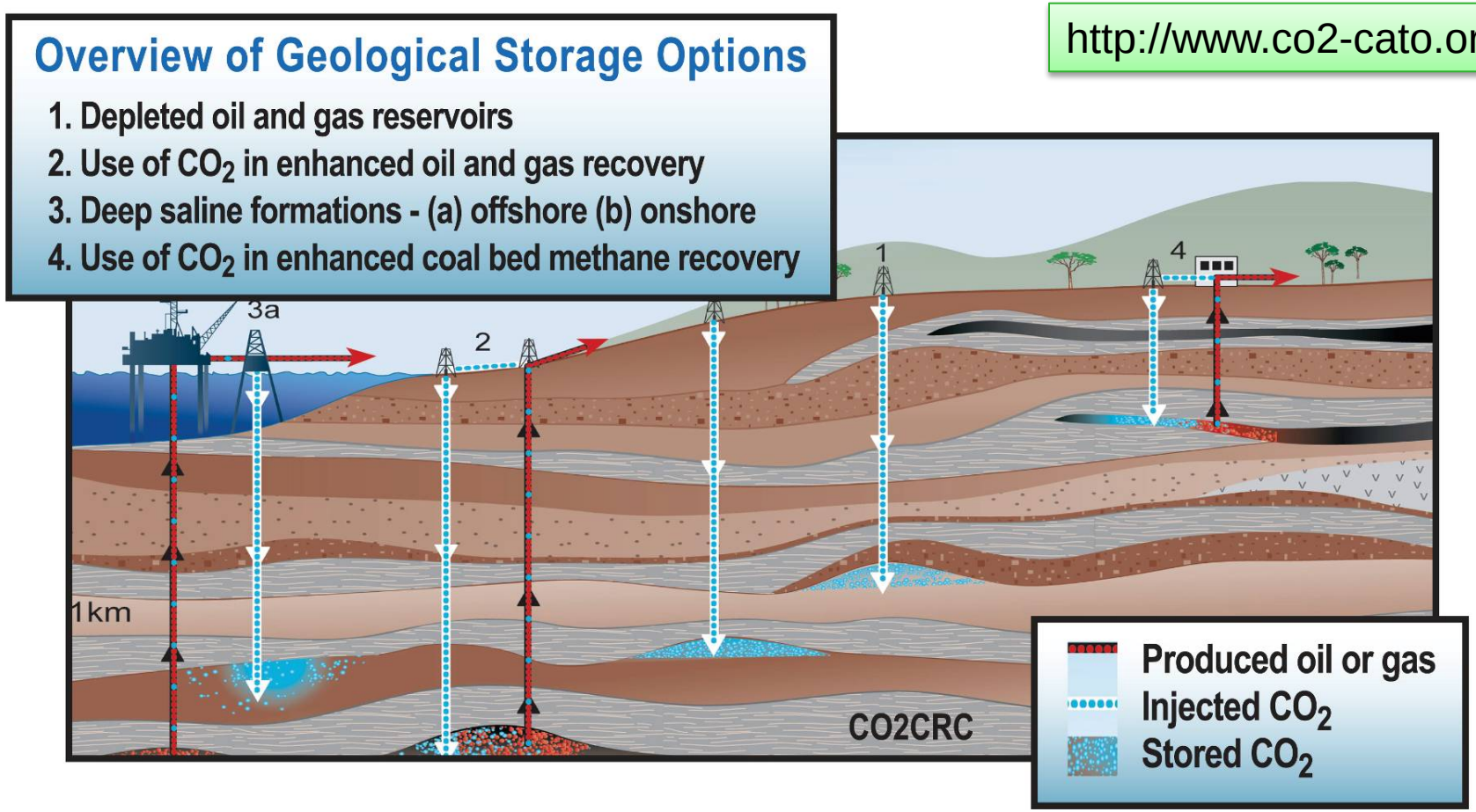




Almost half of the decrease was in territories formerly in the Union of Soviet Socialist Republics, followed by Germany at 15%, Poland at 8%, and France at 6%.

Source: worldmapper.org

# Options for Geological Storage of CO2

http://www.co2-cato.org/




**Capture** → **Compression** → **Pipeline Transport** → **Geological Storage**

Benson 2015, Gordon Research Conference on CCUS

# The Future Coal or Natural Gas Power Plant

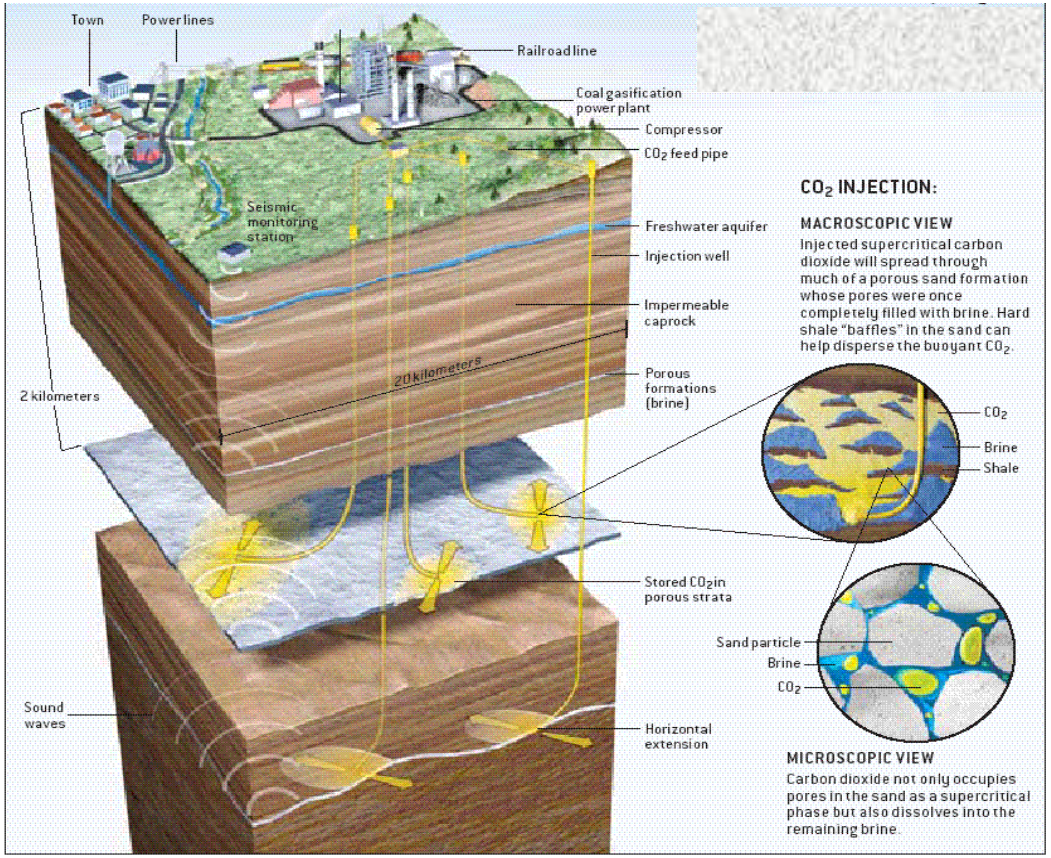



ILLUSTRATION BY DAVID FIERSTEIN, CONCEPT BY JULIO FRIEDMANN Lawrence Livermore National Laboratories

www.sciam.com



SCIENTIFIC AMERICAN 51

~~*Shown here*: After 10 years~~ of operation of a 1000 MW coal plant, 60 Mt (90 $Mm^3$) of $CO_2$ have been injected, filling a horizontal area of 40 $km^2$ in each of two formations.

*Assumptions:*

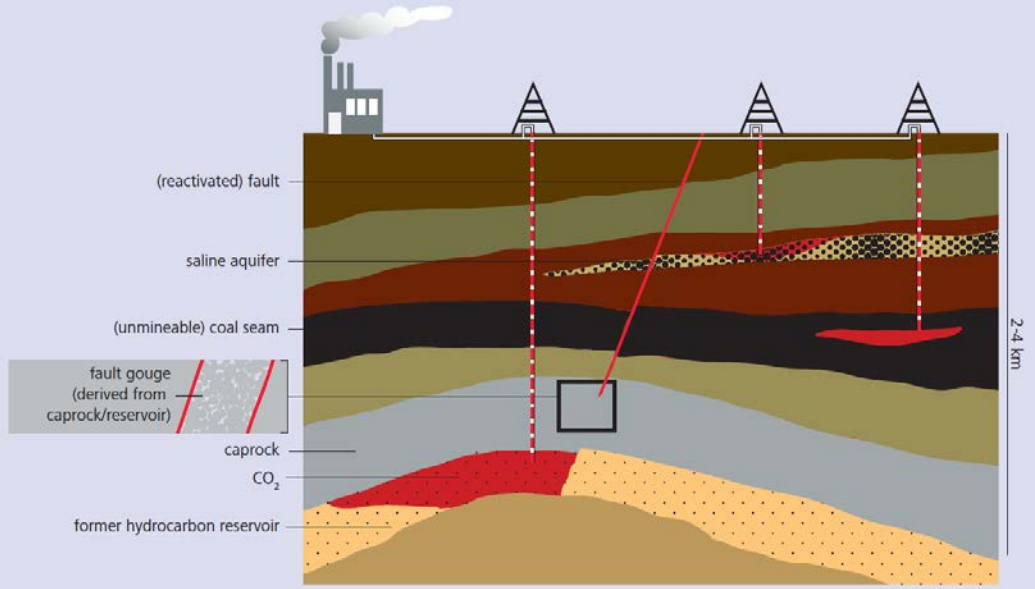
- 10% porosity
- **1/3 of pore space accessed**
- 60 m total vertical height for the two formations.

Socolow 2015, Gordon Research Conference on CCUS

Injection rate is 150,000 bbl($CO_2$)/day, or 300 million standard cubic feet/day. That's 3 billion barrels, or 6 trillion standard cubic feet, over 60 years.

# ASSESSING RISKS POSED BY FAULTS

- Geologically stored CO2 will mainly reside in the pores of the reservoir rock as a highly compressed or ‘supercritical’ phase, with some dissolving in the pore water.
- The natural sealing capacity of overlying ‘cap rocks’ and cross-cutting faults must be maintained.
  - A key risk here is that of fault (re-)activation and its potential for causing both leakage and induced seismicity.

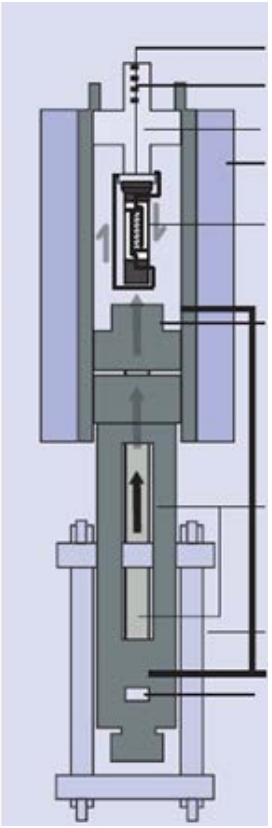



A schematic impression of a storage site.

(Utrecht University)

# ASSESSING RISKS POSED BY FAULTS

- Research has shown that risk of fault activation and its potential for causing both leakage and induced seismicity is hardly affected by CO2 storage on the timescale of 10 to 100 years.
- Reassuringly, in the long-term, carbonate precipitation within faults will tend to increase fault strength and inhibit reactivation.



(Utrecht University)

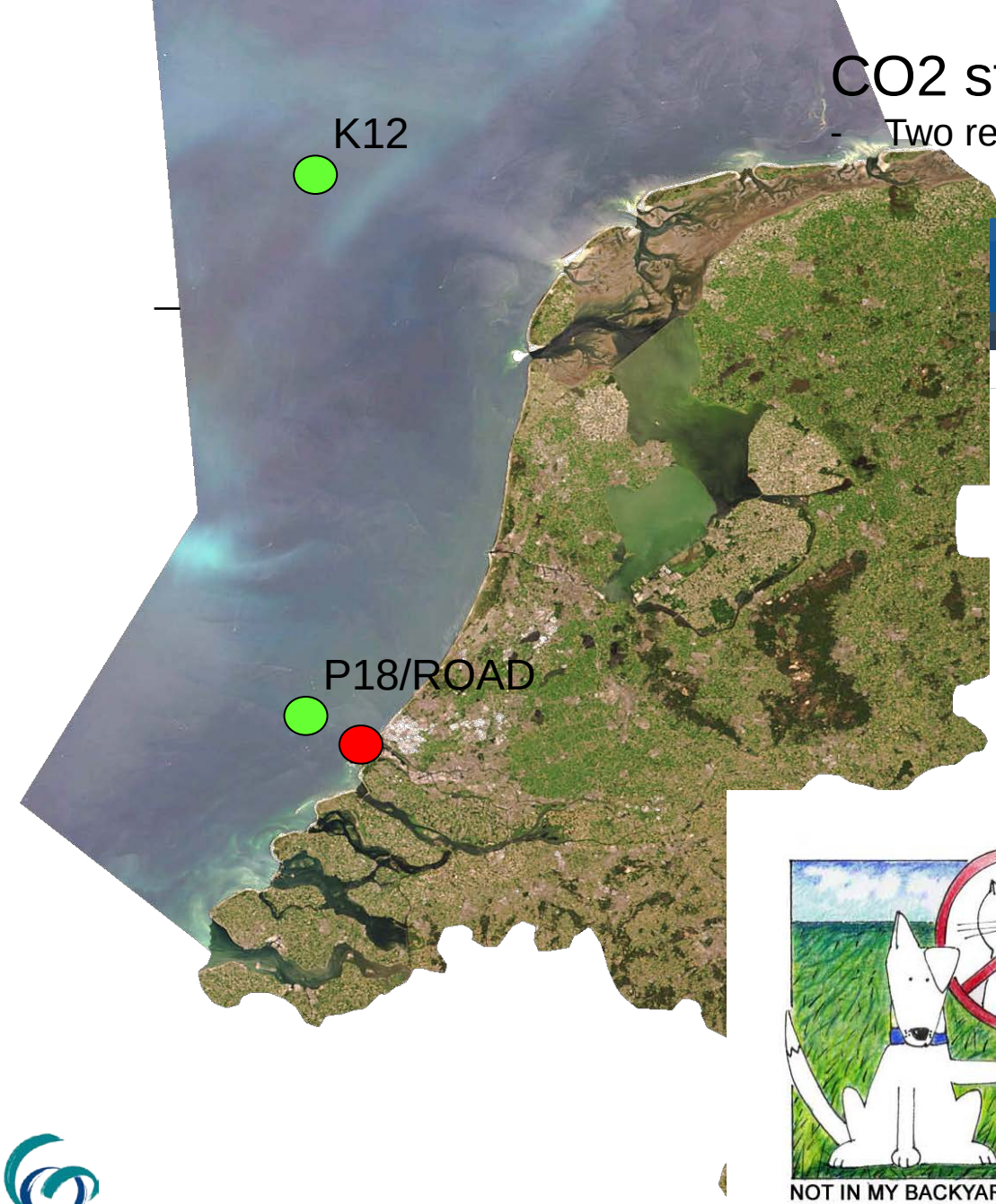
# CO2-WATER-ROCK REACTIONS

- Over time CO2 partially dissolves in the formation water, thereby increasing the acidity of the water.
- Consequently some minerals in the rocks will partially dissolve, while in return part of the dissolved CO2 reacts and becomes mineralized in carbonates.
- Mineralized CO2 is immobile and highly beneficial in terms of efficient storage. Yet the dissolution of minerals may have negative side effects.
- The geochemical reactions involved prove to be highly case-specific and the full assessment of the gas-water-rock interactions over the long-term is of great importance.

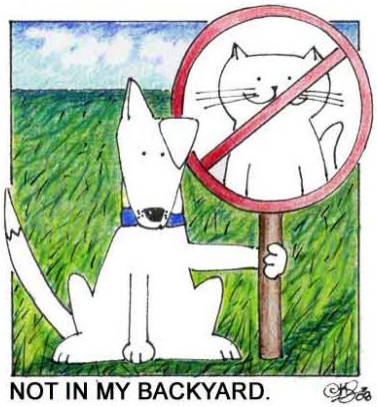
Only an estimated 1 % of global population is estimated to be a global citizen. They all have to operate in a local context

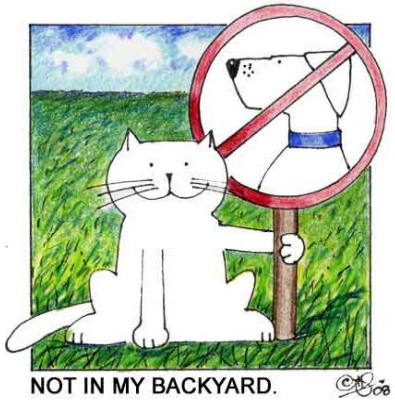
# CO2 storage in the Netherlands

- Two remaining storage locations



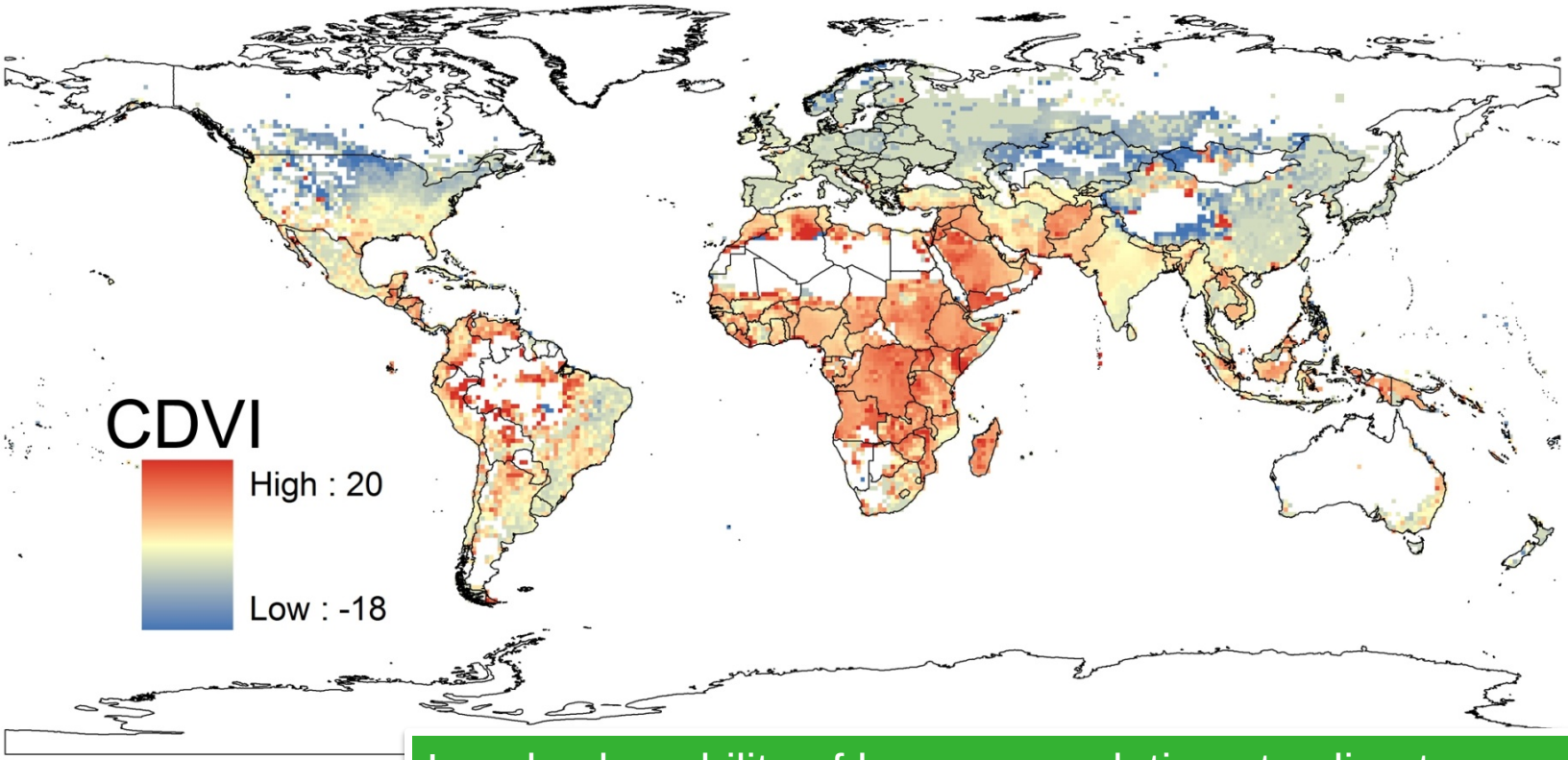




# GLOBAL CLIMATE-DEMOGRAPHY VULNERABILITY INDEX (CDVI) – HOW TO TELL THE STORY TO POLICY MAKERS

SAMSON ET AL.




Local vulnerability of human populations to climate change based on ecological and demographic models. The regions in red are expected to be most negatively impacted by climate change.

# WATER FOOTPRINT

## HOW TO INFORM POLICY MAKERS

water footprint is the amount of water that is consumed and polluted in all processing stages of production. It tells us how much pressure that product has put on freshwater resources.

### Tracking Water Use

Faced with the growing threat of shortages of fresh water, a handful of companies have started tracking their "water footprints," tallying the amount of water that goes into manufacturing their products. But the measure can be tenuous, since there are no clear standards for what a water footprint should count. **See examples below.**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Facing shortage of fresh water we ask the question “how much water is needed to produce a certain product?”

# Conclusions ?...

- Models are a simplification of reality, models have uncertainties, earth is a complex system with many unknown feedbacks.
- Tools are based on “regular” functioning of the landscape, does this system description apply to extreme events?
- The Dutch approach of ‘engineering the future’ should be based on more sound geologic understanding

# ACKNOWLEGDEMENT OF MATERIALS USED

Climate models: Janneke Ettema (and various internet sources)

GEO/GEOSS:  Jose Achache (former Director GEO)

Flooding: Janneke Ettema, Dinand Alkema, Tom Veldkamp (UT-ITC)

CryoSAT: Michael Berger (ESA)

Rhine: Michael Wiering

Disaster management: Victor Jetten (UT-ITC)

Water footprint: Arjen Hoekstra (UT)

CO2 storage: Jan Hopman (TNO)

And various online sources of information

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