

CT3011: Inleiding watermanagement

1: Water in de wereld

College 1: Waterbeheer
1 september 2008

Nick van de Giesen

**Maurits Ertsen, Frans vd Ven,
Ronald v Nooyen, Eric Mostert
Peter-Jules v Overloop**



CT3011: Inleiding watermanagement

CT3011 Twee delen:

I: Waterbeheer

**II: Gezondheidstechniek
(Prof. Hans van Dijk)**



CT3011: Inleiding watermanagement

College	Onderwerp	Docent
Ma 1 sept	Water in de wereld	vd Giesen
Do 4 sept	Water in de bodem	vd Giesen
Ma 8 sept	Polders	vd Giesen
Do 11 sept	Irrigatie	vd Giesen
Ma 15 sept	Hydrologie	Savenije
Do 18 sept	Kunstwerken en Operationeel	vd Giesen
Ma 22 sept	Reservoirs (& review)	vd Giesen
Do 27 sept	Inleiding gezondheidstechniek	van Dijk
Ma 1 okt	Waterkwaliteit I	van Dijk
Do 4 okt	Waterkwaliteit I	van Dijk
Ma 8 okt	Grondwater	van Dijk
Do 11 okt	Oppervlakte water	van Dijk
Ma 15 okt	Transport en distributie I	van Dijk
Do 18 okt	Transport en distributie II	van Dijk

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CT3011: Inleiding watermanagement

Water in de wereld

- 1. Aarde als water planeet**
- 2. Belangrijkste wateropgaves**
- 3. Water systemen**
- 4. Vak overzicht**

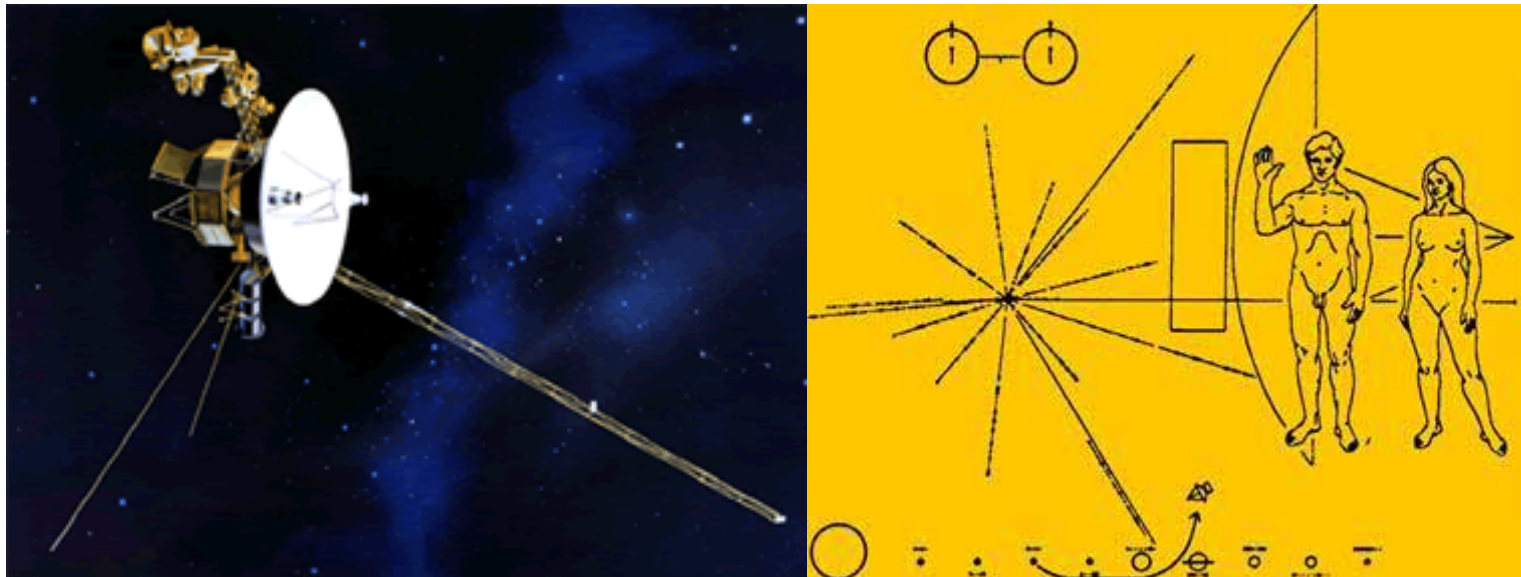


1: Aarde als water planeet



"Pale blue dot"

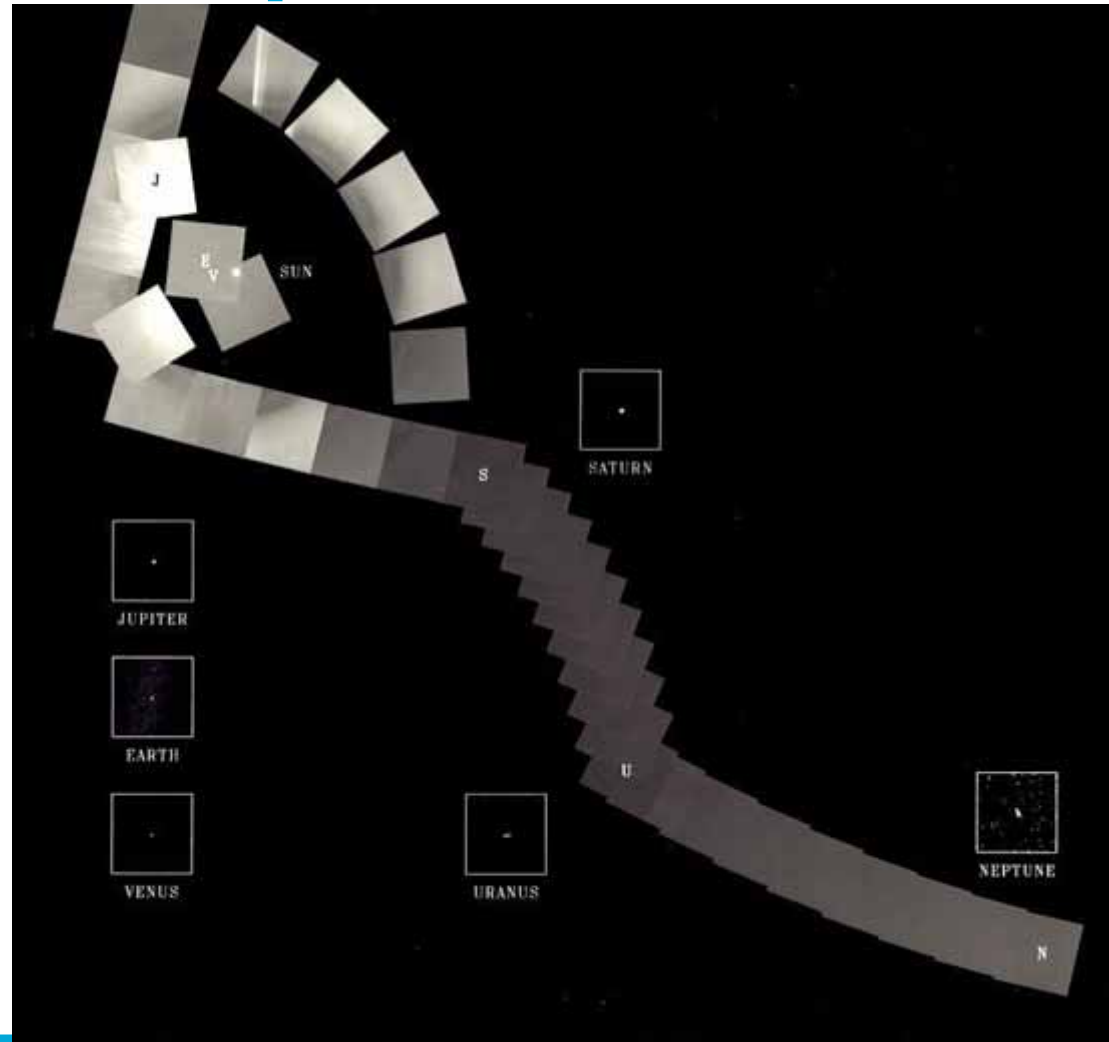
1: Aarde als water planeet



1977: Voyager 1&2

1: Aarde als water planeet

Look back.
One more time.



1: Aarde als water planeet



"Pale blue dot"

10

1: Aarde als water planeet



“Pale blue dot”

1: Aarde als water planeet



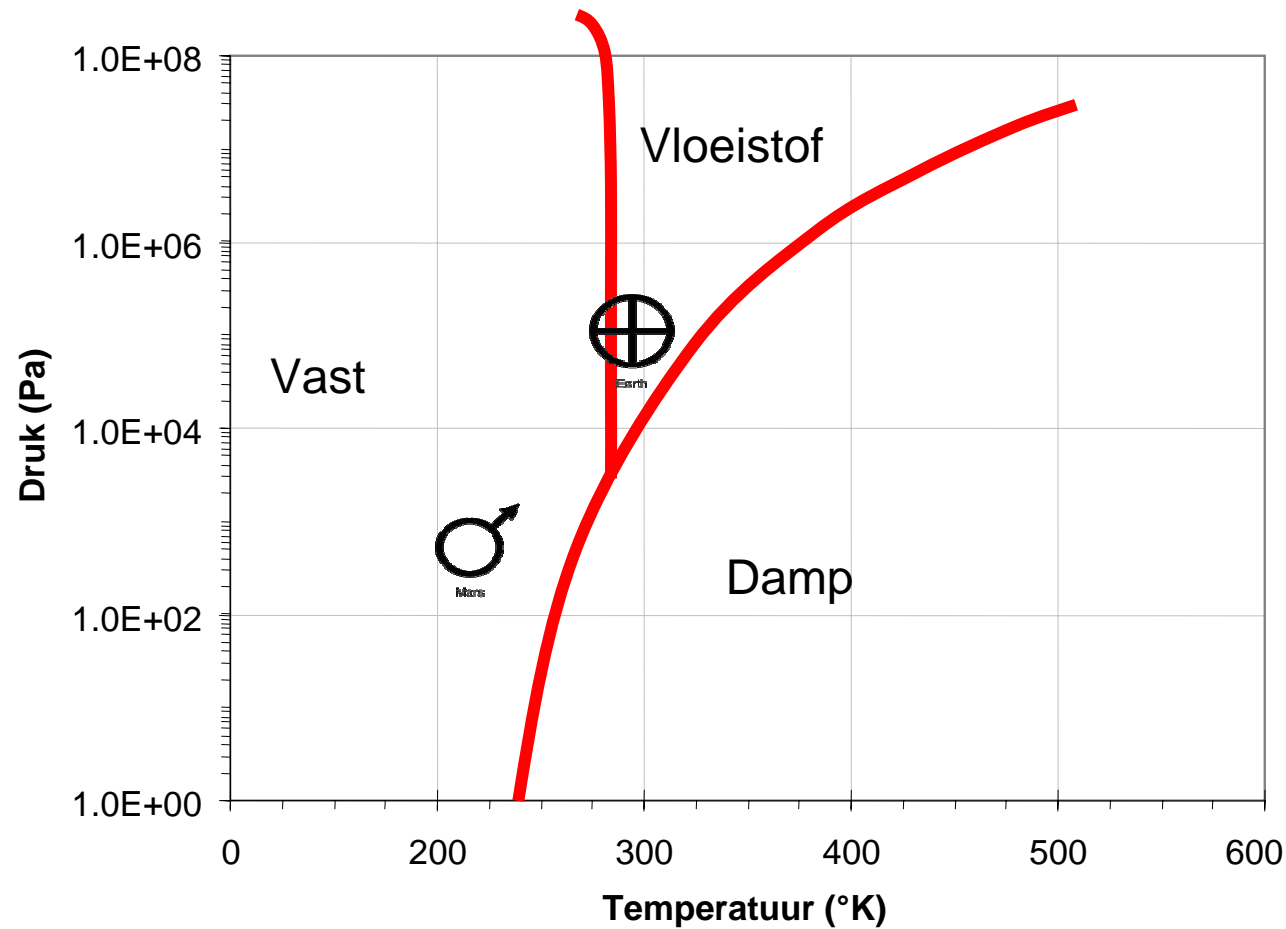
wolken / oceanen / ijs

1: Aarde als water planeet



Waarom?

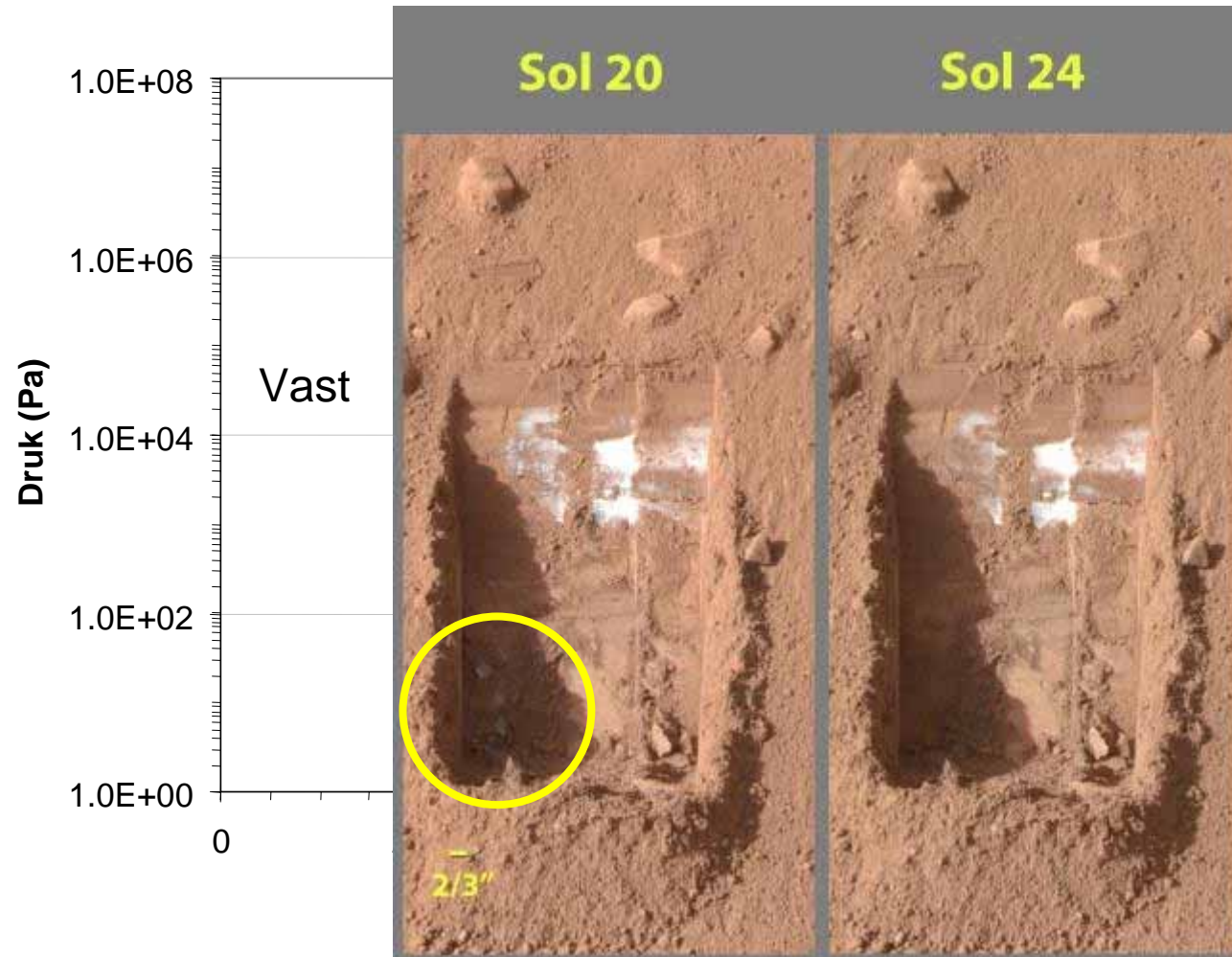
1: Aarde als water planeet



Venus

Daarom!
(Dooge)

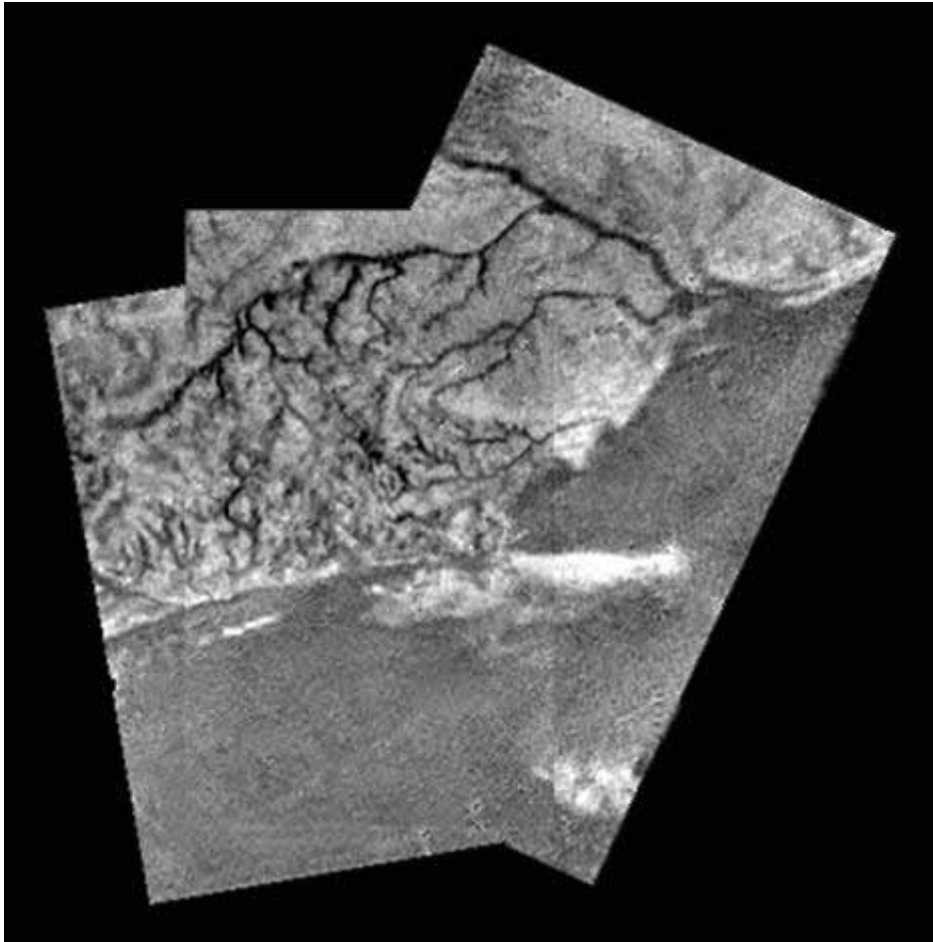
1: Aarde als water planeet



IJs op Mars

NASA 6/08

1: Aarde als water planeet



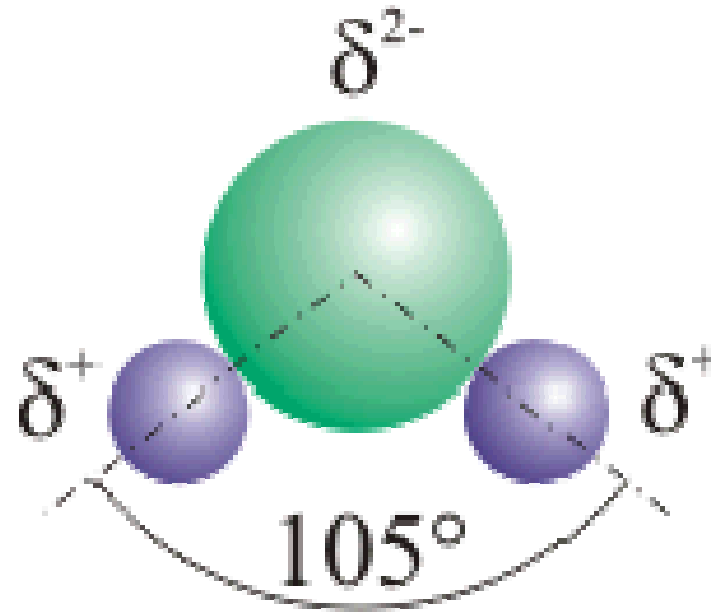
**Titan als metaan
planeet**

**(Saturnus)
(Cassini-Huygens)**

1: Aarde als water planeet

Water is beter:

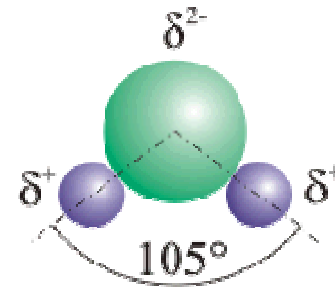
- **Zwaarst bij °4 C**
- **Dipool moment**



1: Aarde als water planeet

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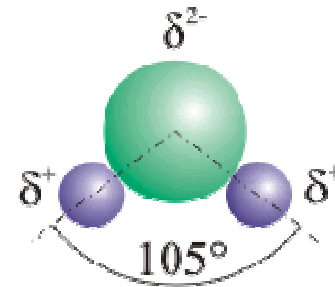
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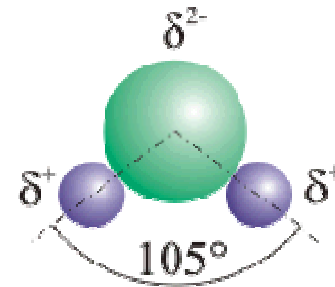
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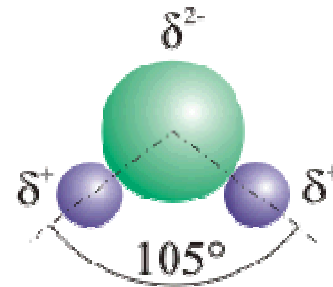
- **Zwaarst bij °4 C**
- **Dipool moment:**
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 - **Hoge oppervlakte spanning**
 - **Hoge soortelijke warmte**



1: Aarde als water planeet

Water is beter:

- **Zwaarst bij °4 C**
- **Dipool moment:**
 - **Oplosmiddel zouten**
 - **Hoge oppervlakte spanning**
 - **Hoge soortelijke warmte**
 - **Hoge latente warmte verdamping**



1: Aarde als water planeet

Hoeveel water waar:

	Waterlaag (m)	Percentage
Oceanen	2643	97%
IJs, gletschers	55	2.0%
Grondwater	16	0.59%
Grondwater-Antarctica	7	0.25%
Bodemvocht	0.12	0.0044%
Meren	0.25	0.0092%
Rivieren	0.0021	0.000077%
Atmosfeer	0.0255	0.00094%

Baumgartner&Reichel (in Brutsaert, 2005)

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1: Aarde als water planeet

Waterbeheer

- Oceanen ?
 - Ontzouten heel duur
 - 20 km³/j wereldwijd
 - Alleen in speciale gevallen



1: Aarde als water planeet

Waterbeheer

- Atmosfeer?
 - Cloud seeding



1: Aarde als water planeet

Waterbeheer

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Wat Gandhara Budha



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1: Aarde als water planeet

Waterbeheer

- Atmosfeer?
 - Cloud seeding

Wat Gandhara Budha



1: Aarde als water planeet

Waterbeheer

- IJs?
- IJsbergen



1: Aarde als water planeet

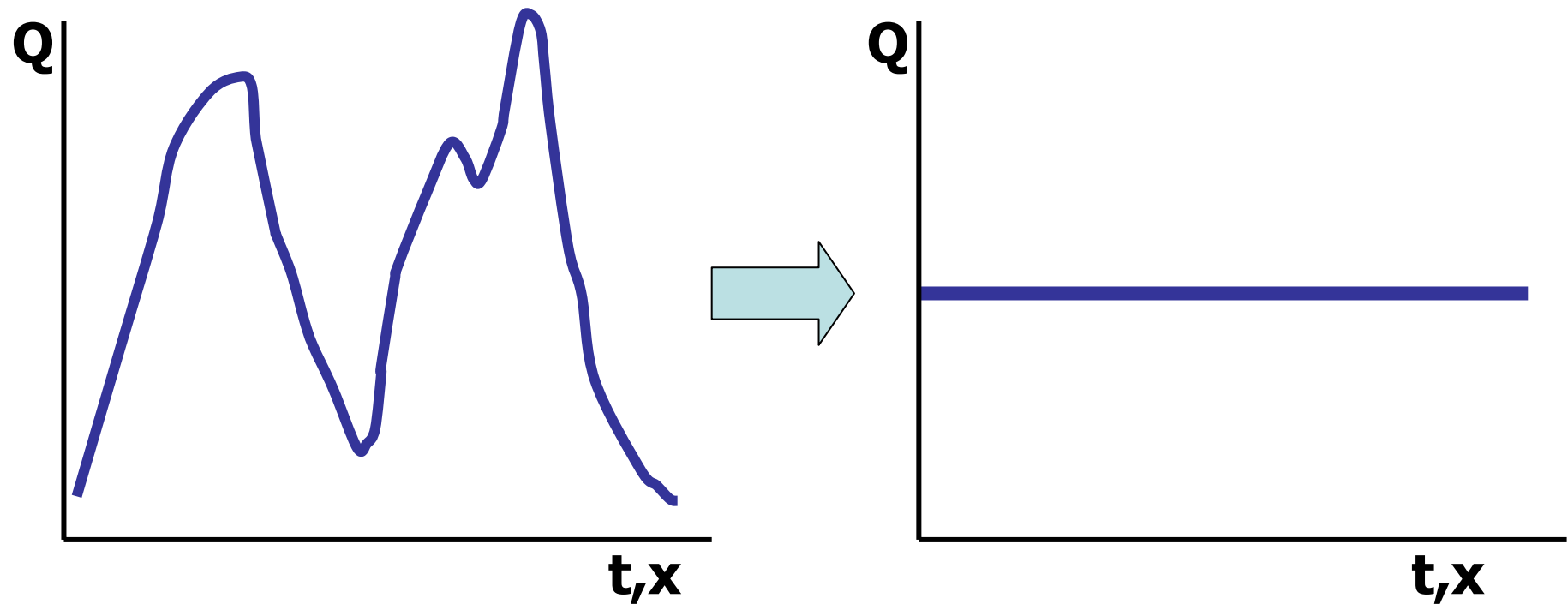
Waterbeheer >99%

- **Rivieren (& meren)**
- **Grondwater**
- **Bodemvocht**



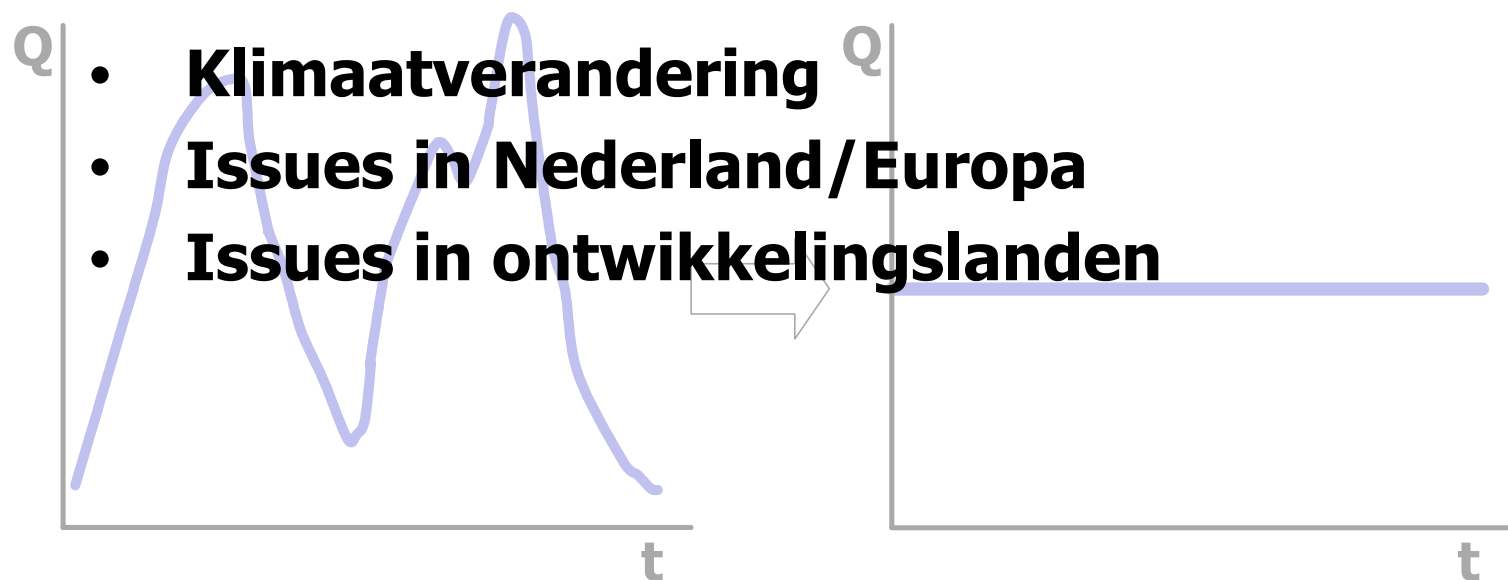
1: Aarde als water planeet

Waterbeheer: Beterre verdeling ruimte & tijd

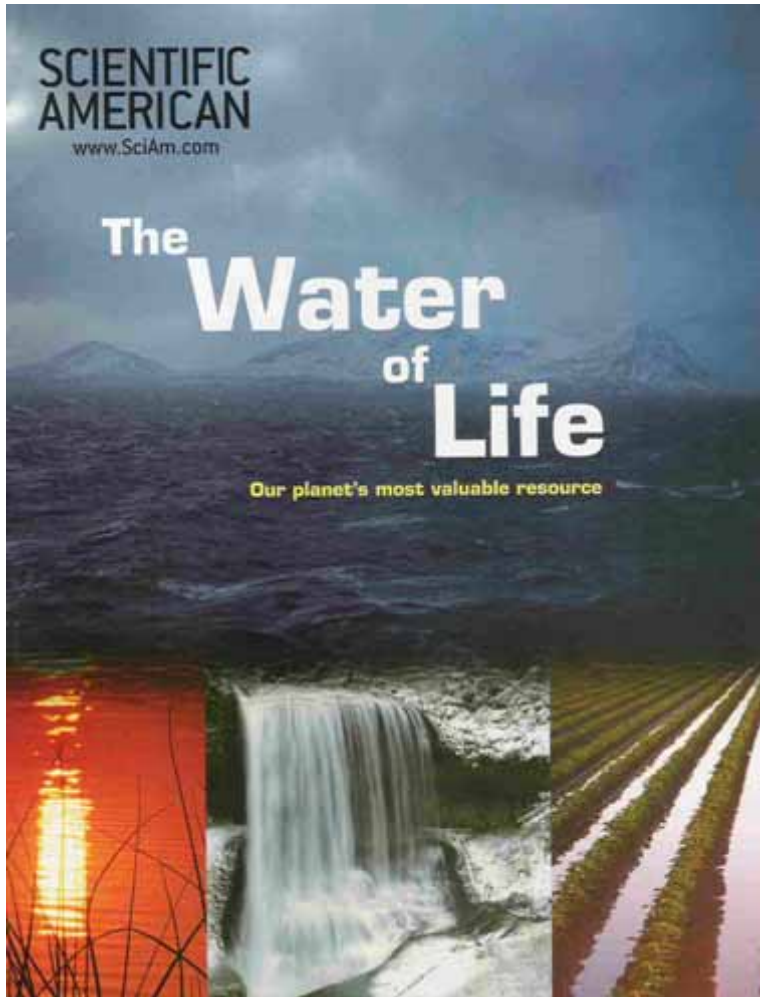


2: Grote water opgaves

Drie thema's:



2: Grote water opgaves



- Er is veel te doen
- Het is serieus
- Gezond verstand

2: Grote water opgaves

Tribune **MARKETPLACE** *International Herald Tribune* | 15
Monday, June 26, 2006
by Bloomberg

As need grows, value of water flows uphill

By Sajjel Kishan and Madelene Pearson

LONDON: Jean-Marie Messier lost billions of euros turning the world's biggest water company into Vivendi Universal, an entertainment conglomerate. He should have stuck with water.

The United Nations estimates that by 2050 more than two billion people in 48 countries will be short of water. The shortage has made the resource potentially more valuable than oil.

The Bloomberg World Water index of 10 utilities has returned 35 percent annually since 2003, compared with 29 percent for oil and gas stocks and 10 percent for the Standard & Poor's 500 index.

From Boone Pickens, the hedge fund manager, to Guy Hands, a buyout specialist, many investors view water as the commodity that will appreciate the most in the next decades.

"There is only one direction for water prices at the moment, and that's up," said Hans Peter Portner, who manages \$2.9 billion in the Water Fund at Pictet Asset Management in Geneva. The fund jumped 26 percent last year, and Portner forecasts annual returns from water of 8 percent through 2020.

The cost of water, which does not trade on commodity exchanges, is usually set by government agencies and local regulators.

Short supply is not the only problem: The world also lacks the means to deliver resources. About \$180 billion

needs to be invested annually in water infrastructure in developing countries like China and India, double the amount being spent today, according to the World Water Council in Marseille.

"It's incomprehensible to ignore the importance of water as an asset class when deciding where to put capital," said Neil Berlant, managing director of the water division at Seidler, an investment banking company in Los Angeles. Berlant, who has been following the water industry for 20 years, expects annual returns as high as 10 percent in the next three years.

Water is a finite resource that will only become more expensive, Pickens, the fund manager, said in a recent interview in New York. He compared the demand for water to China's purchases of oil fields in places ranging from Canada to Kazakhstan. "I'd be the same way about water," he said.

Water is rising in value faster than many other commodities. The 35 percent annual return over three years for the Bloomberg Water index beat the 27 percent return for the Bloomberg World Basic Materials index, which includes 239 companies that produce commodities including copper, aluminum, paper and steel. Both indexes reached peaks in May, but the water index has fallen 12 percent since then, while the basic materials stocks is down 17 percent.

The water industry generates as much as \$450 billion in revenue each year, trailing only electricity and oil,



Jack Atley/Bloomberg News

Mud cracks at the bottom of a dry dam in Australia. With two billion people expected to be short of water by 2050, the resource could become more valuable than oil.

according to Rod Parsley at Terrapin Asset Management in New York, whose \$50 million hedge fund invests only in water-related companies and in water rights. Terrapin's Water Fund has returned 22 percent since it was introduced in April 2005. However, most water supplies are owned by governments, reducing the chances for investments.

"It sounds like an exciting opportunity, but you have to have viable vehicles with which people can buy into the asset," said Stewart Aldcroft, a regional director with Noble Investments Hong Kong.

Technology Partners, a venture capital firm in Palo Alto, California, invests in small private companies like Sensicore, a maker of equipment for testing water supplies based in Ann Arbor, Michigan.

But the two biggest water companies are Veolia and Suez, both based in Paris. Veolia owns utilities that provide water and sewer services to 110 million people. The company, whose shares are up 26 percent in the past year, owns the transport and energy services businesses spun off by Vivendi in 2000.

At that time, Messier reduced Vivendi's stake in the 152-year-old water company to raise cash for his entertainment empire. In the five years ended May 31, the average annual return for Veolia was little changed. Meanwhile, Vivendi shares lost 16 percent.

Bloomberg News

Madelene Pearson reported from Hong Kong.

- Er is veel te doen
- Het is serieus
- Gezond verstand

2: Grote water opgaves

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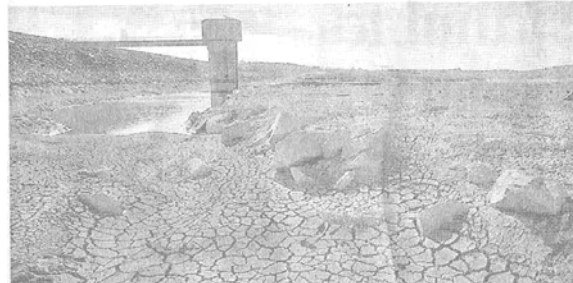
"It's incomprehensible to ignore the importance of water as an asset class when deciding where to put capital,"

said Neil Berl, the water division manager at banking firm BNP Paribas, who says water industry annual returns are expected to rise in the next three years.

Water is only becoming a commodity, the fund manager said in an interview in New York. Demand for water is rising in oil fields in Canada to Kazakhstan and elsewhere.

Water is rising in price, but it is not becoming a commodity, the fund manager said in an interview in New York. Demand for water is rising in oil fields in Canada to Kazakhstan and elsewhere.

The water industry generates as much as \$450 billion in revenue each year, trailing only electricity and oil,



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2: Grote water opgaves

1 liter olie => $38.5 \cdot 10^6$ J

1 liter water => $2.25 \cdot 10^6$ J

- Er is veel te doen
- Het is serieus
- Gezond verstand

1 liter olie => 17 liter water

2: Grote water opgaves

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1 liter olie => 17 liter water

(membraan: 100x efficiënter)

2: Grote water opgaves

Klimaat

Start september nog niet eerder zo warm

DE BILT — Het is in honderd jaar niet eerder zo warm geweest in de eerste tien dagen van september als nu. Het etmaalgemiddelde kwam in De Bilt uit op 19,6 graden en daarmee zijn de eerste tien dagen van september 1949 - gemiddeld 19,1 graden - van de troon gestoten, zo liet het KNMI gisteren weten. (ANP)

Spits, 12/9/05

Is er iets aan de hand...?

2: Grote water opgaves

Klimaat



Vakantie 2008
Wisconsin

Is er iets aan de hand...?

43

2: Grote water opgaves

Klimaat



Vakantie 2008
Wisconsin

Is er iets aan de hand...?

44

2: Grote water opgaves

Klimaat

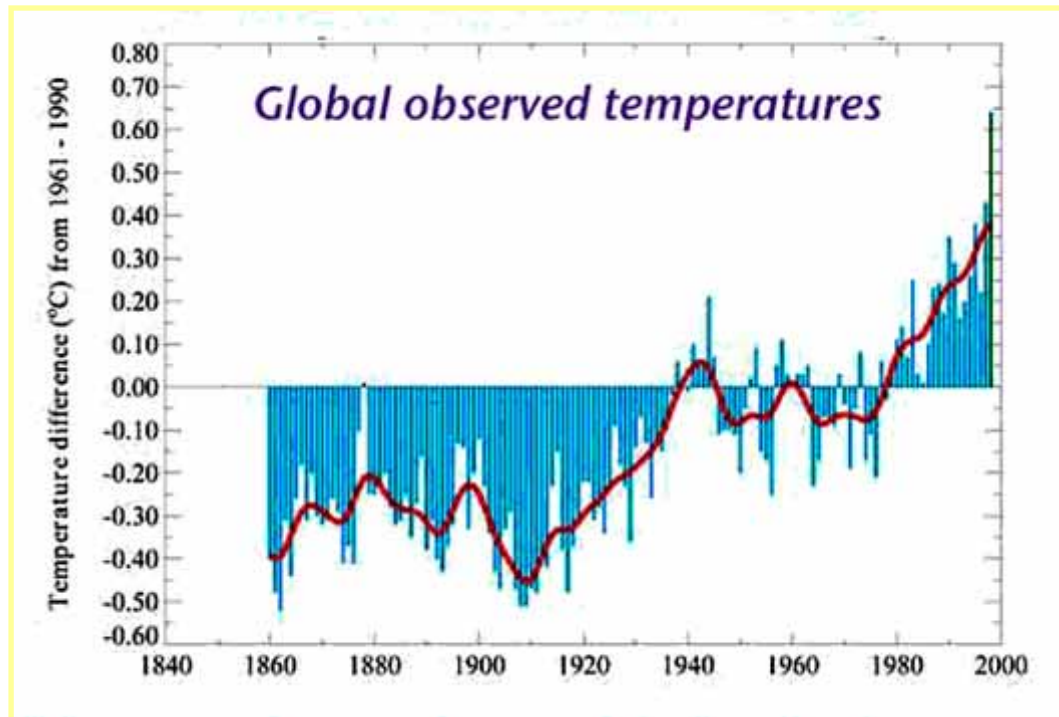
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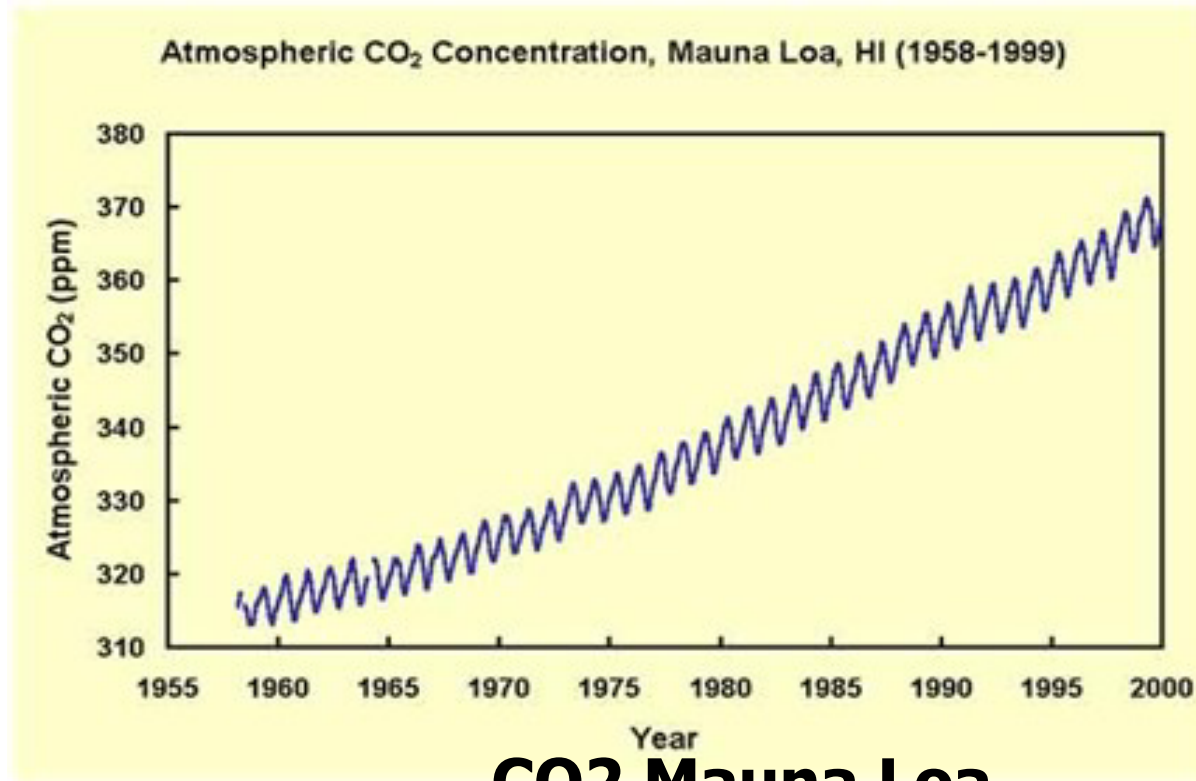
Klimaat



Er is iets aan de hand...!

2: Grote water opgaves

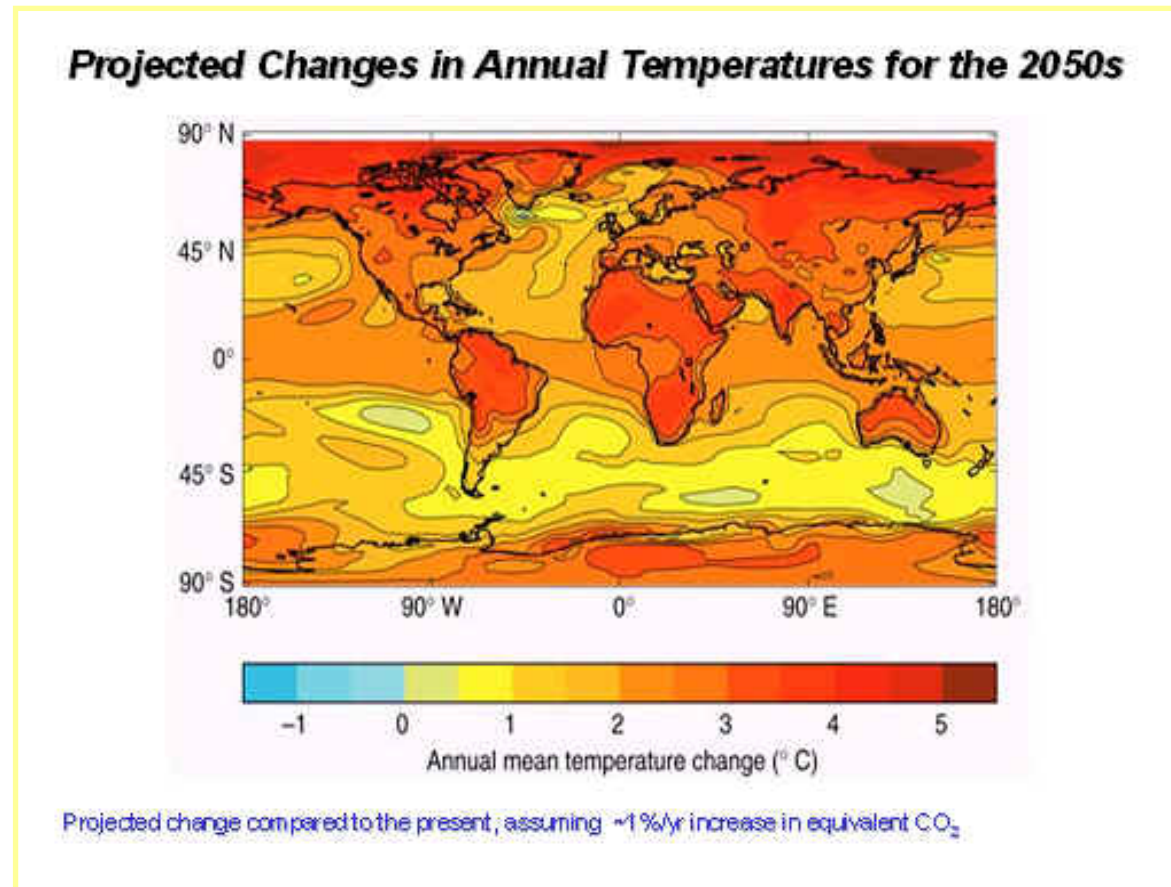
Klimaat



2: Grote water opgaves

Klimaat

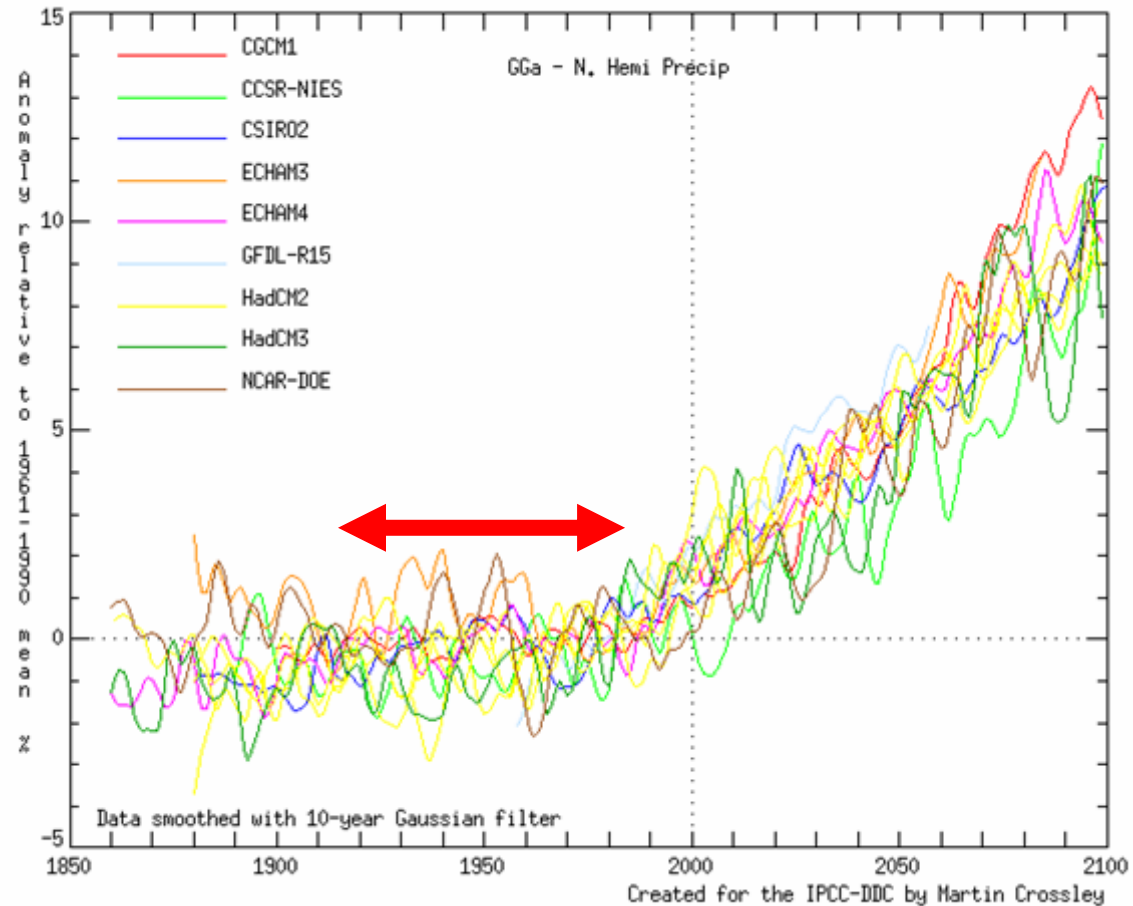
T vrij duidelijk



2: Grote water opgaves

Klimaat

H₂O niet zo duidelijk...

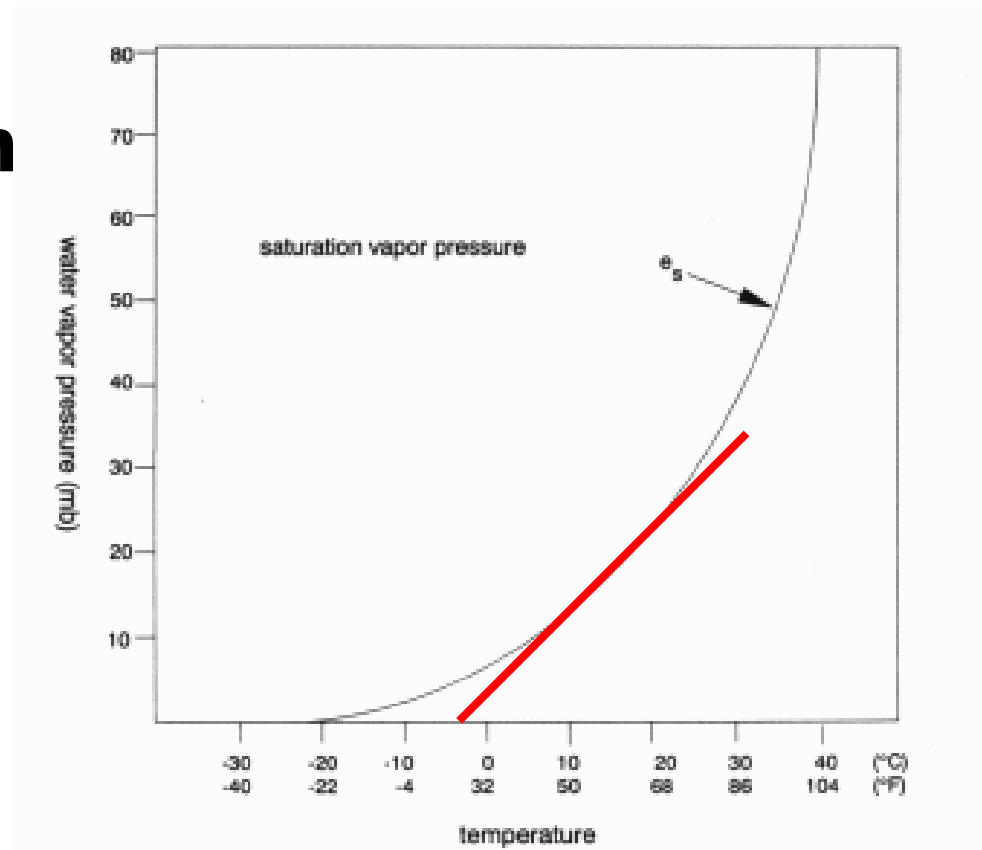


2: Grote water opgaves

Klimaat

Clausius-Clapeyron

$$\frac{d \ln p}{dT} = \frac{\Delta H_{vap}}{RT^2}$$



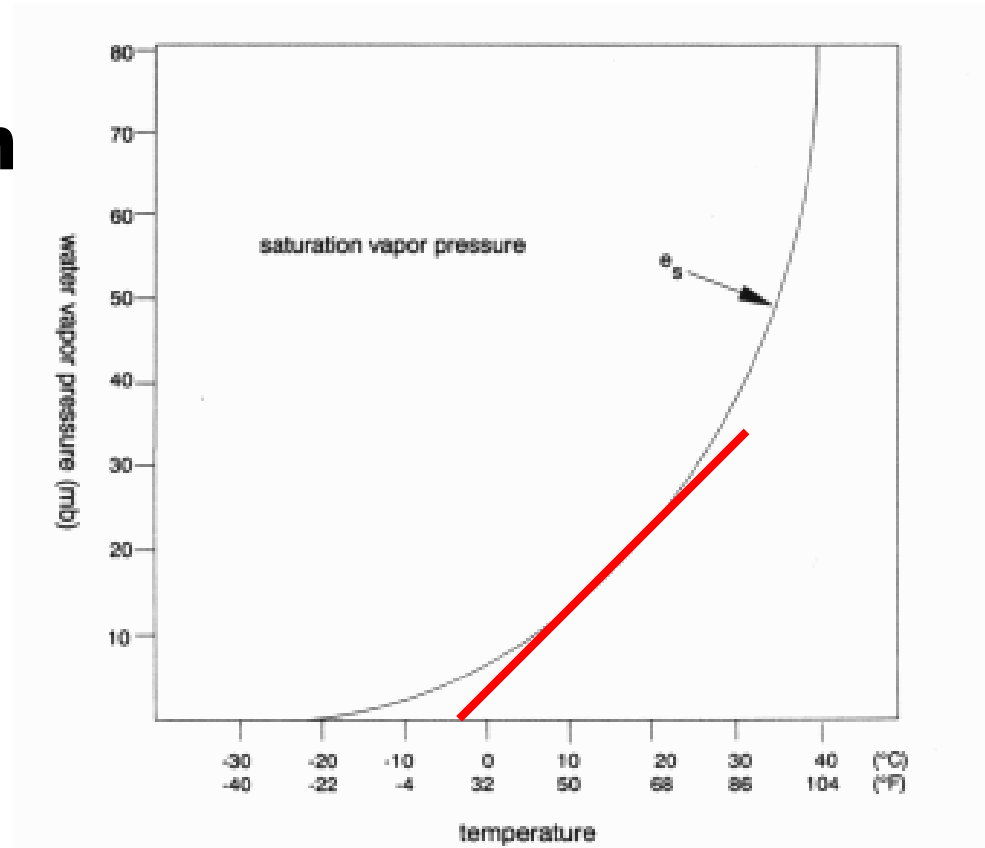
2: Grote water opgaves

Klimaat

Clausius-Clapeyron

$$\frac{d \ln p}{dT} = \frac{\Delta H_{vap}}{RT^2}$$

+1°C ⇒ +7% H₂O



2: Grote water opgaves

Klimaat

Clausius-Clapeyron

+1°C ⇒ +7% H₂O

Tot voor kort:

Waarschijnlijk

+1°C ⇒ +2-4% H₂O

2: Grote water opgaves

Klimaat

Waarschijnlijk

+1°C ⇒ +2-4% H₂O

Hydrologic cycle explains the evaporation paradox

The evaporation of water, measured using evaporation pans, has been decreasing in the past few decades over large areas with different climates. The common interpretation is that the trend is related to increasing cloudiness, and that it provides an indication of decreasing potential evaporation and a decreasing terrestrial evaporation component in the hydrologic cycle. Here we show that, although these studies are valuable, pan evaporation has not been used correctly as an indicator of climate change.

At first glance, reports of decreasing pan evaporation in European Russia, Siberia and the western and eastern United States¹, India² and Venezuela³ are paradoxical. They are hard to reconcile with well-substantiated increases in global precipitation and cloudiness⁴, which would normally require more surface evaporation as the only source of atmospheric water vapour, rather than less. They also run counter to predictions of increasing evaporation⁵, as one of the more

behaviour; indeed, for instance in the extreme case of a desert environment, E is zero, whereas E_{pa} is at its maximum. The idea of a complementary relationship between actual evaporation and apparent potential evaporation is not new⁷, and it has stimulated advances in the estimation of terrestrial evaporation⁸⁻¹⁰. In the case of a pan filled with water and placed in a region with less than adequate ground wetness to sustain E_0 , elimination of ΔH in the above yields $E = [(1 + b)E_0 - aE_{pa}]/b$.

Because a and b are of order one, this equation indicates how the observed¹⁻³ decreases in pan evaporation, E_{pa} , can be interpreted as evidence for increasing terrestrial evaporation, E , in those regions. This is consistent with data^{4,11} indicating an intensifying hydrologic cycle in large regions: increasing precipitation leads to increasing surface run-off and soil wetness, which in turn generates more evaporation, and so on.

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Ithaca, New York 14853, USA

†Department of Geography and Environmental Engineering, Johns Hopkins University, Baltimore, Maryland 21218, USA

Nature, 396, p30

2: Grote water opgaves

Klimaat

Waarschijnlijk

+1°C ⇒ +2-4% H₂O

+7% !?



Science, 13 July 2007

2: Grote water opgaves

Klimaat

Praktische problemen:

- Lokale impact
- Extremen?

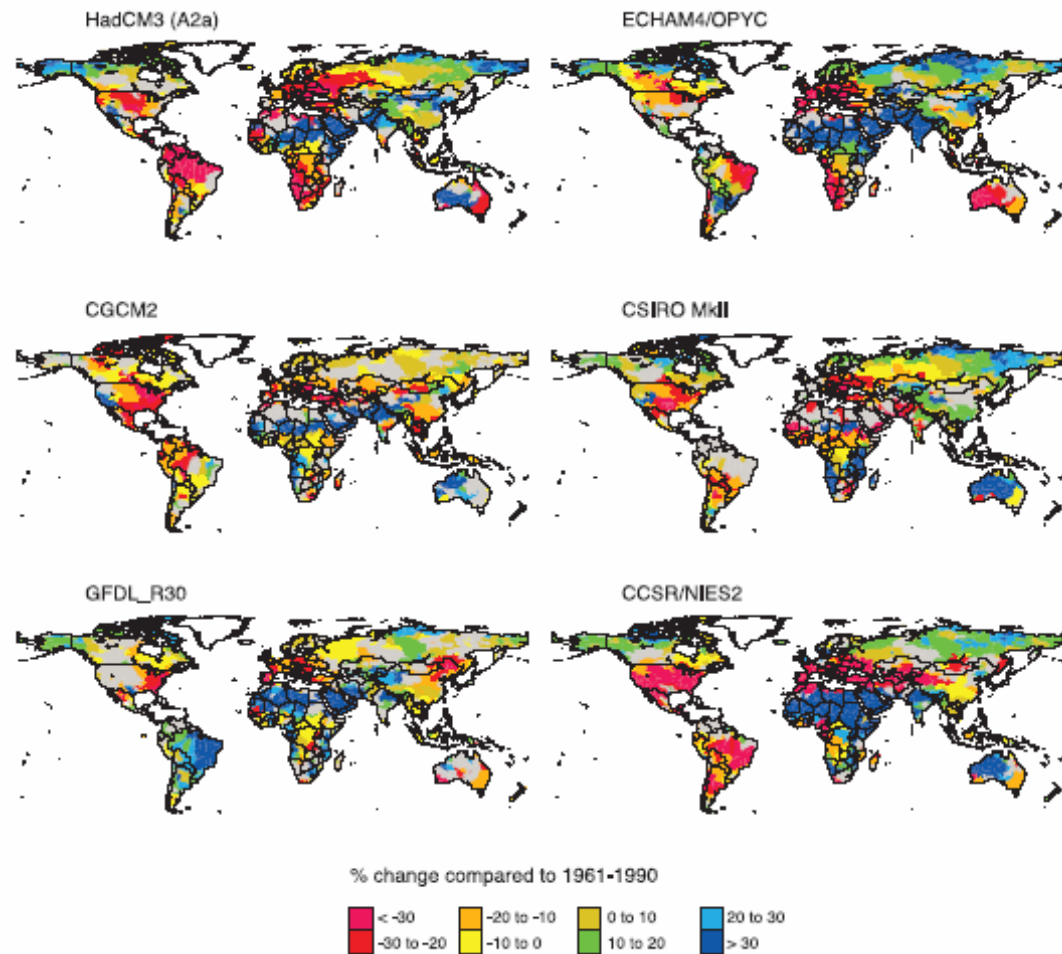
2: Grote water opgaves

Klimaat

Lokale impact

**IPCC Report
AR4, WGII, CH3**

ΔQ 2050



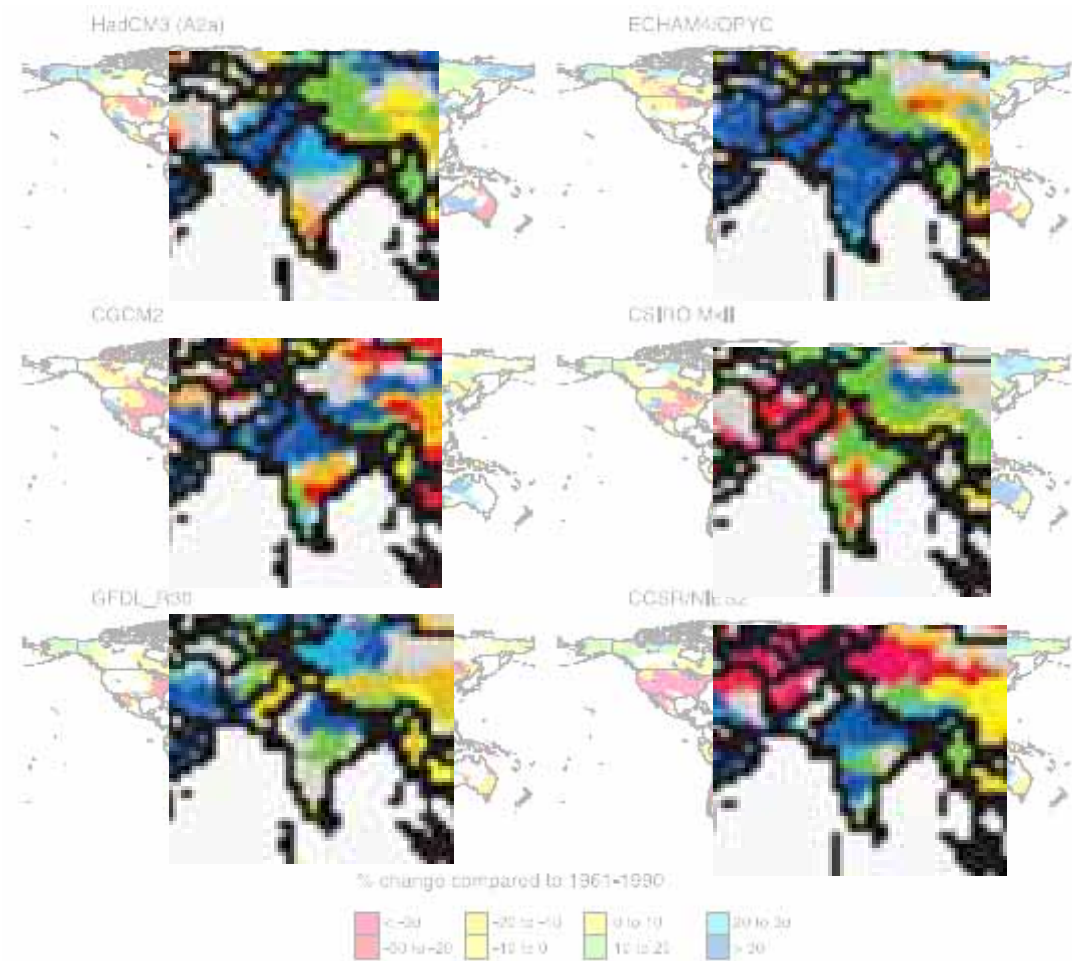
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Klimaat

Lokale impact

**IPCC Report
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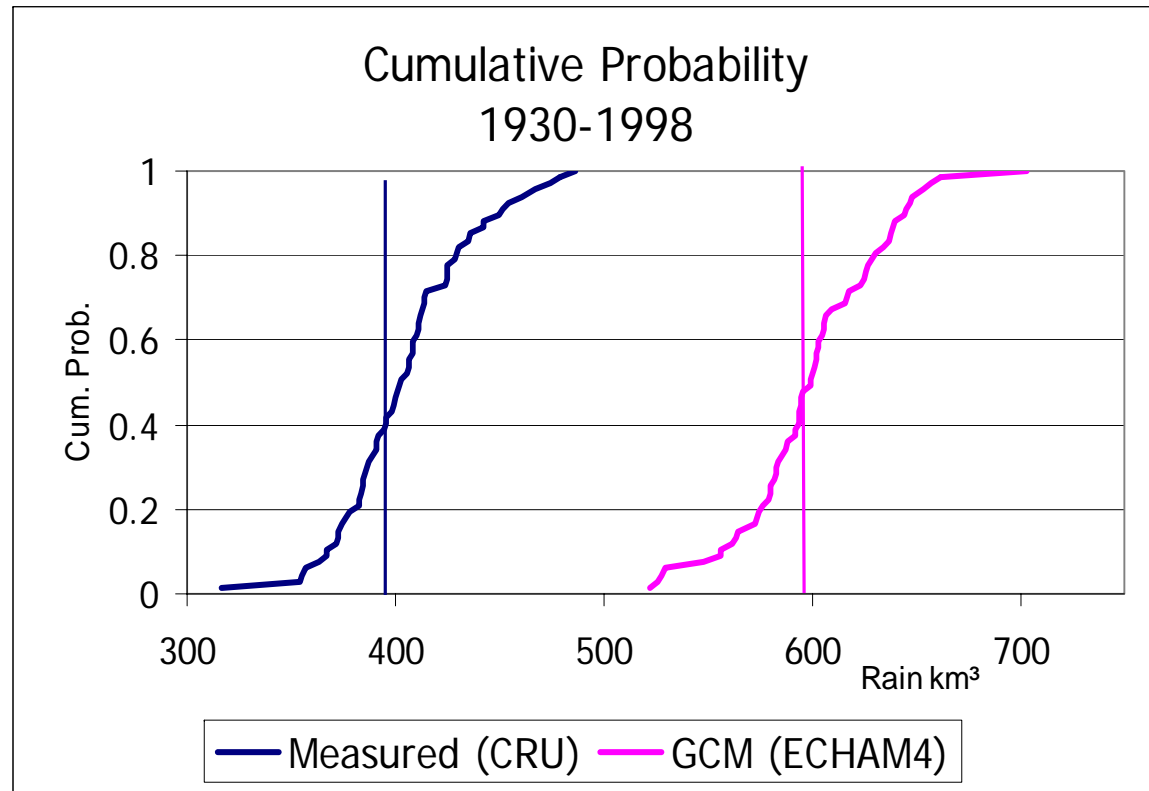


2: Grote water opgaves

Klimaat

Lokale impact

Volta Basin

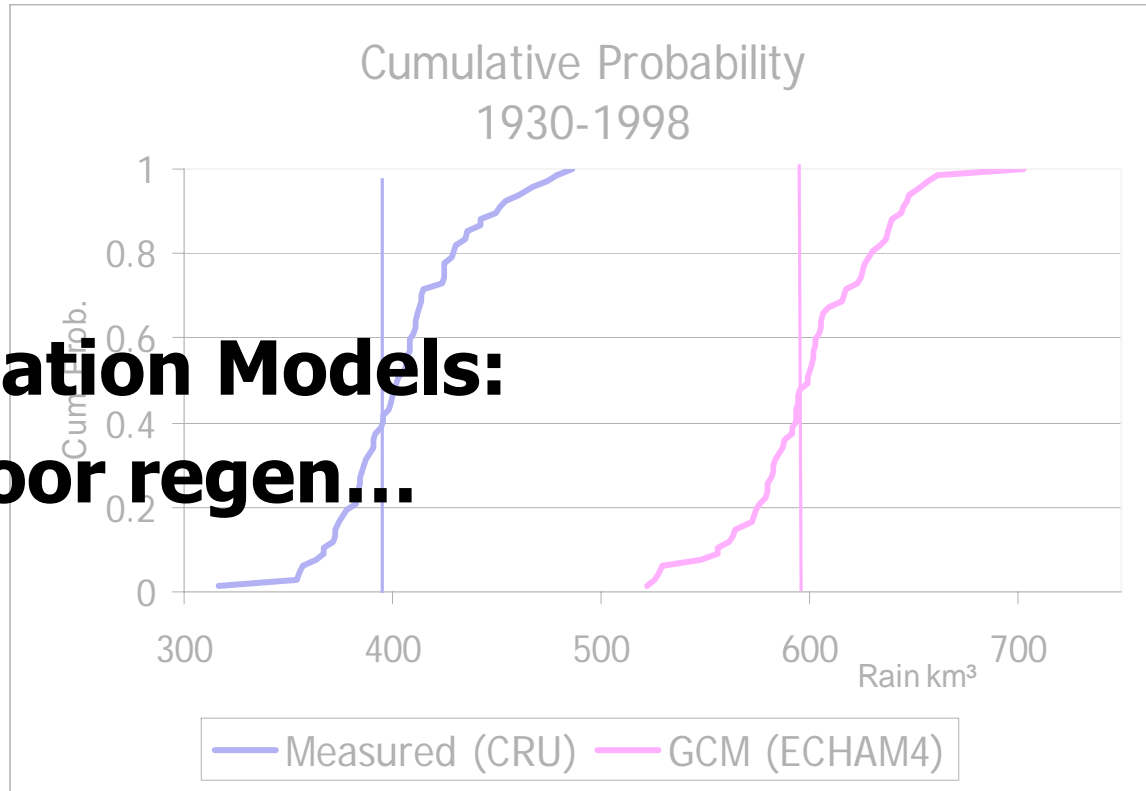


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Klimaat

Lokale impact

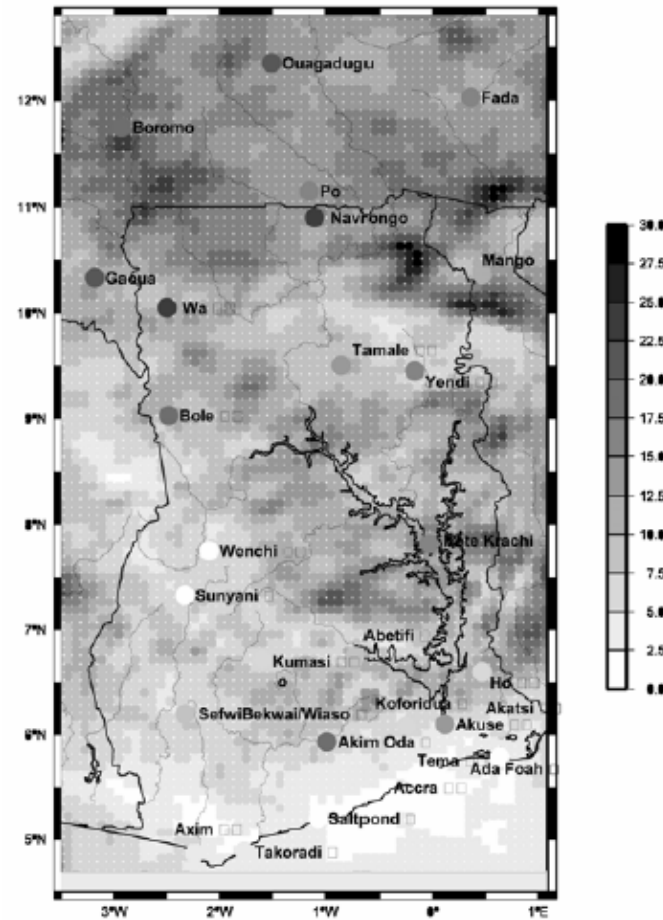
**General Circulation Models:
Waardeloos voor regen...**



2: Grote water opgaves

Klimaat

Lokale impact, Volta Basin (IFU)

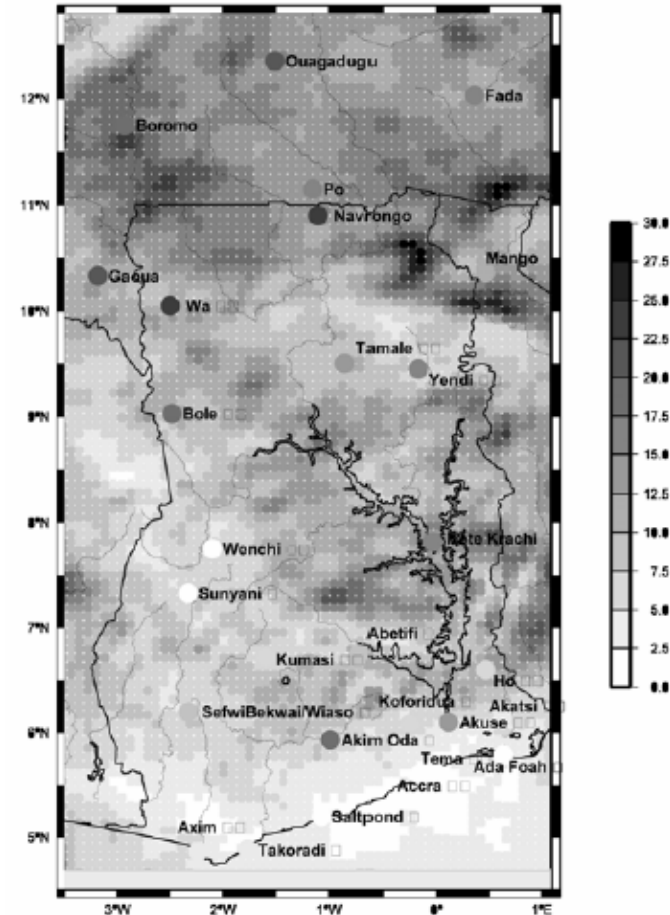


2: Grote water opgaves

Klimaat

Lokale impact, Volta Basin (IFU)

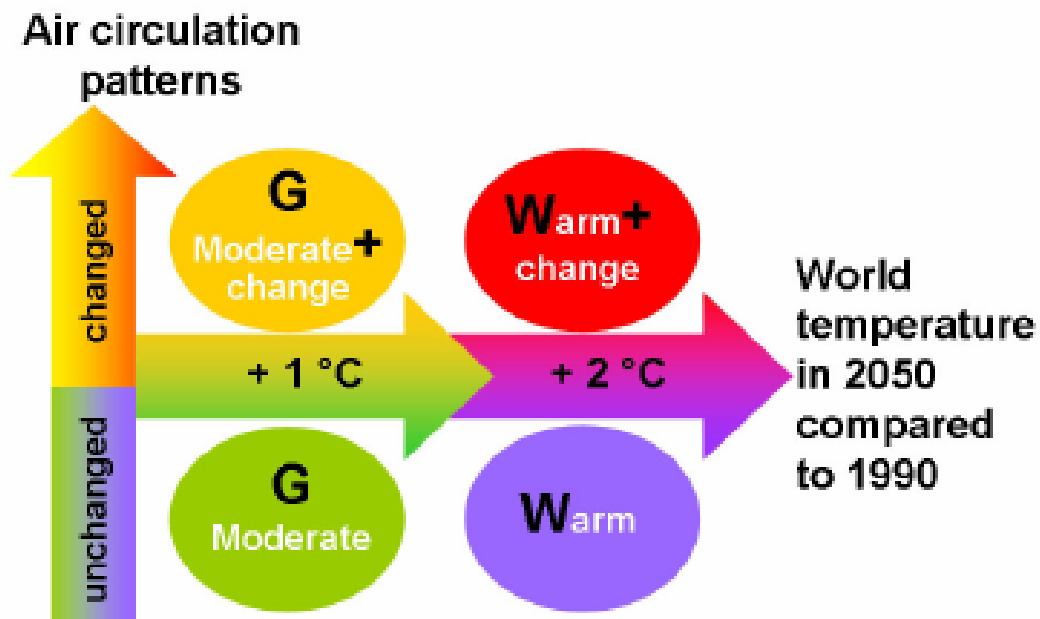
- Zelfde regen
- Korter seizoen
- Latere start



2: Grote water opgaves

Klimaat

Lokale impact, Nederland (KNMI 2006)



2: Grote water opgaves

Klimaat (KNMI 2006)

2050		G	G+	W	W+
Wereldwijde temperatuurstijging		+1°C	+1°C	+2°C	+2°C
Winter	temperatuur	+0,9°C	+1,1°C	+1,8°C	+2,3°C
	neerslag	+4%	+7%	+7%	+14%
	natte dagen	0%	+1%	0%	+2%
	10-daagse P	+4%	+6%	+8%	+12%
Zomer	temperatuur	+0,9°C	+1,4°C	+1,7°C	+2,8°C
	neerslag	+3%	-10%	+6%	-19%
	natte dagen	-2%	-10%	-3%	-19%
	10-daagse P	+13%	+5%	+27%	+10%

2: Grote water opgaves

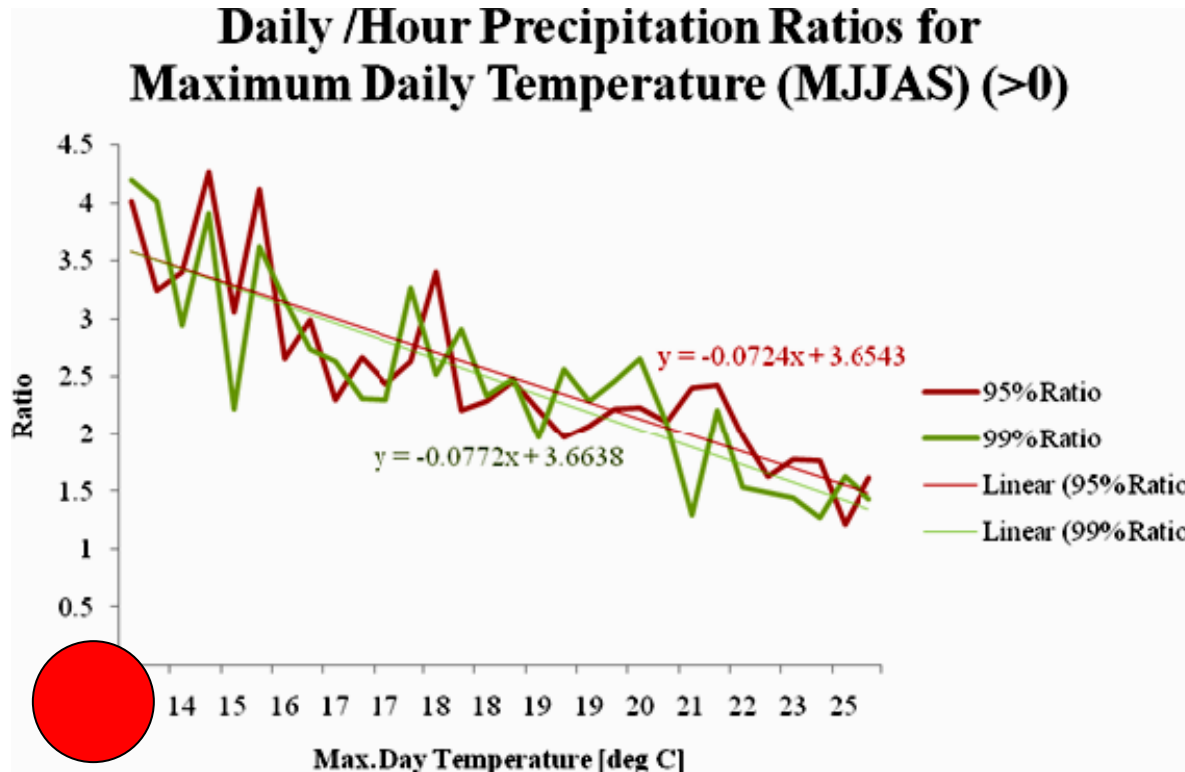
Klimaat (KNMI 2006)

2050		G	G+	W	W+
Wereldwijde temperatuurstijging		+1°C	+1°C	+2°C	+2°C
Winter	temperatuur	+0,9°C	+1,1°C	+1,8°C	+2,3°C
	neerslag	+4%	+7%	+7%	+14%
	natte dagen	0%	+1%	0%	+2%
	10-daagse P	+13%	+5%	+27%	+12%
Zomer	temperatuur	+0,9°C	+1,4°C	+1,7°C	+2,8°C
	neerslag	+3%	-10%	+6%	-19%
	natte dagen	-2%	-10%	-3%	-19%
	10-daagse P	+13%	+5%	+27%	+10%

Wat betekent dit echt voor het Nederlandse water systeem....?!

2: Grote water opgaves

Klimaat (KNMI 2006)



Nina Romero

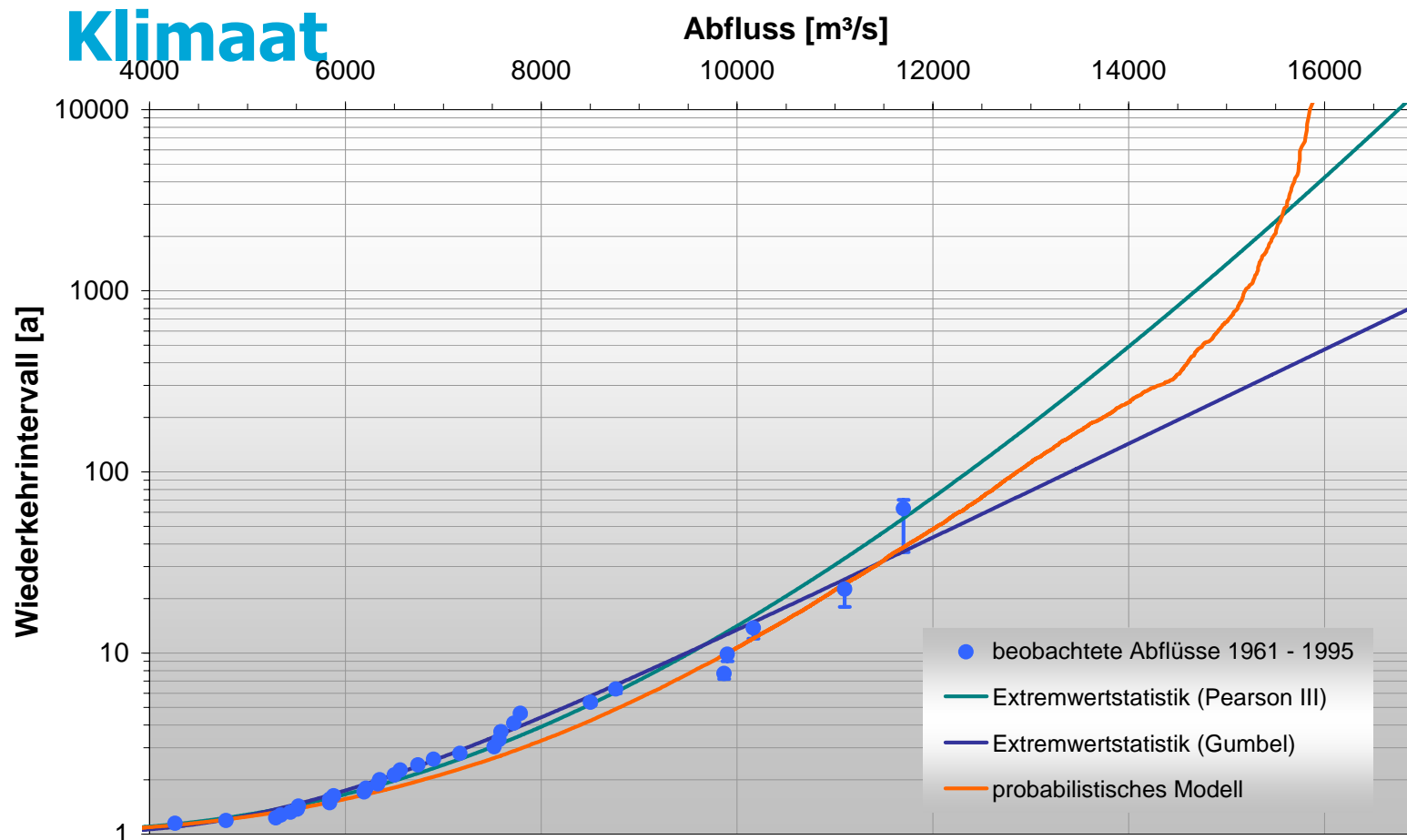
2: Grote water opgaves

Klimaat

Lokale impact, Nederland

- $>T \Rightarrow$ Rijn regen rivier
- Meer afvoer winter
- Minder afvoer zomer
- $16,000 \text{ m}^3/\text{s} \Rightarrow 18,000 \text{ m}^3/\text{s} ???$

2: Grote water opgaves

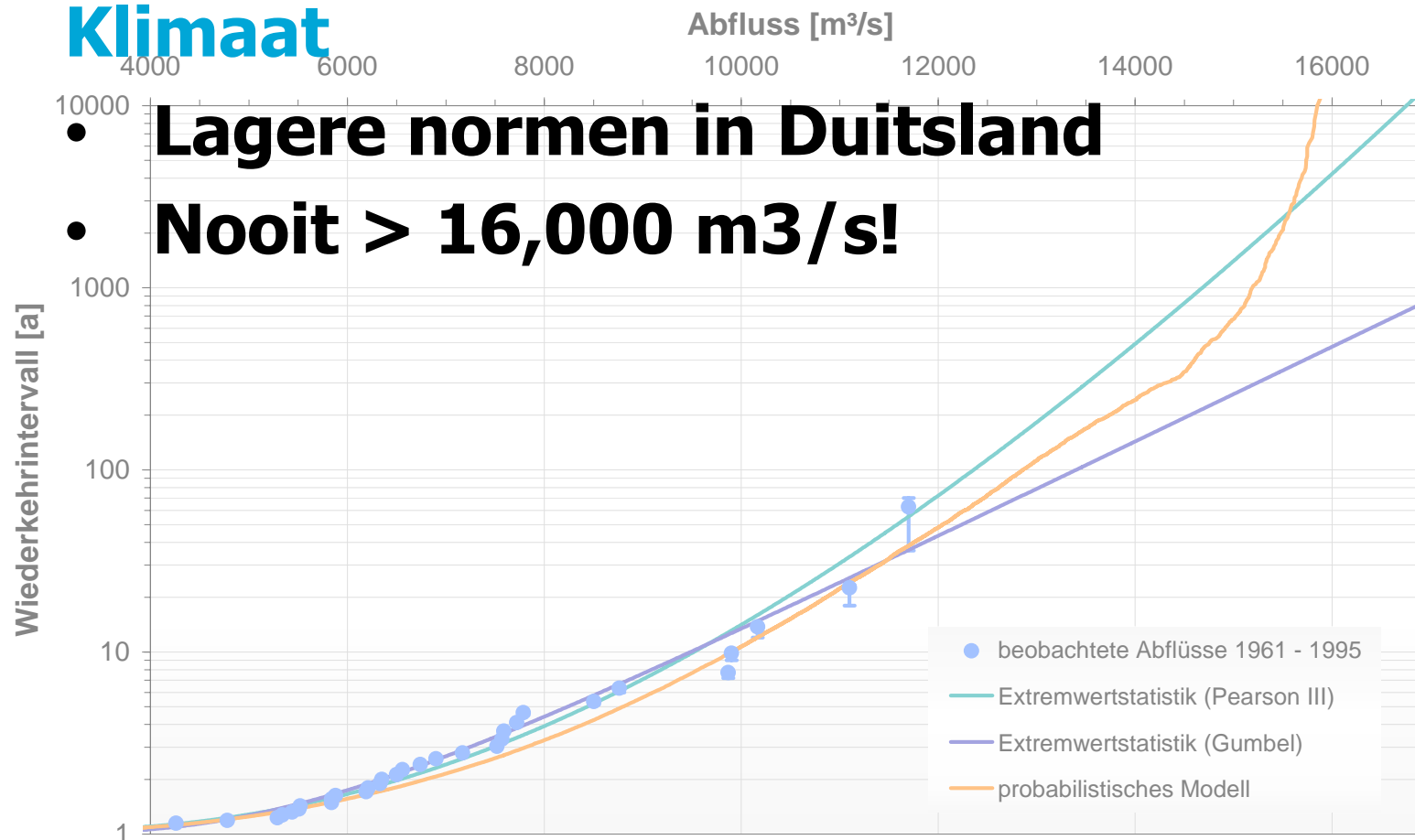


Source: Apel, H.; Merz, B.; Thielen, A.H. (2005) Medium-scale flood risk assessment – a probabilistic-hydrological approach. European Geosciences union - General Assembly, Vienna, Austria, April 24-29, 2005

67

2: Grote water opgaves

Klimaat



Source: Apel, H.; Merz, B.; Thielen, A.H. (2005) Medium-scale flood risk assessment – a probabilistic-hydrological approach. European Geosciences union - General Assembly, Vienna, Austria, April 24-29, 2005

68

2: Grote water opgaves

Klimaat

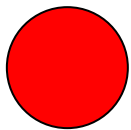
Wat kunnen we zeggen:

- **Er is iets aan de hand...**
- **Lokale impact**
- **Gezond verstand is nooit weg**
- **Robuust ontwerpen**

2: Grote water opgaves

Issues in Nederland

- **Klimaat (miljarden!)**
- **Veiligheid, normen, burgers - overheid**
- **Stedelijk waterbeheer**

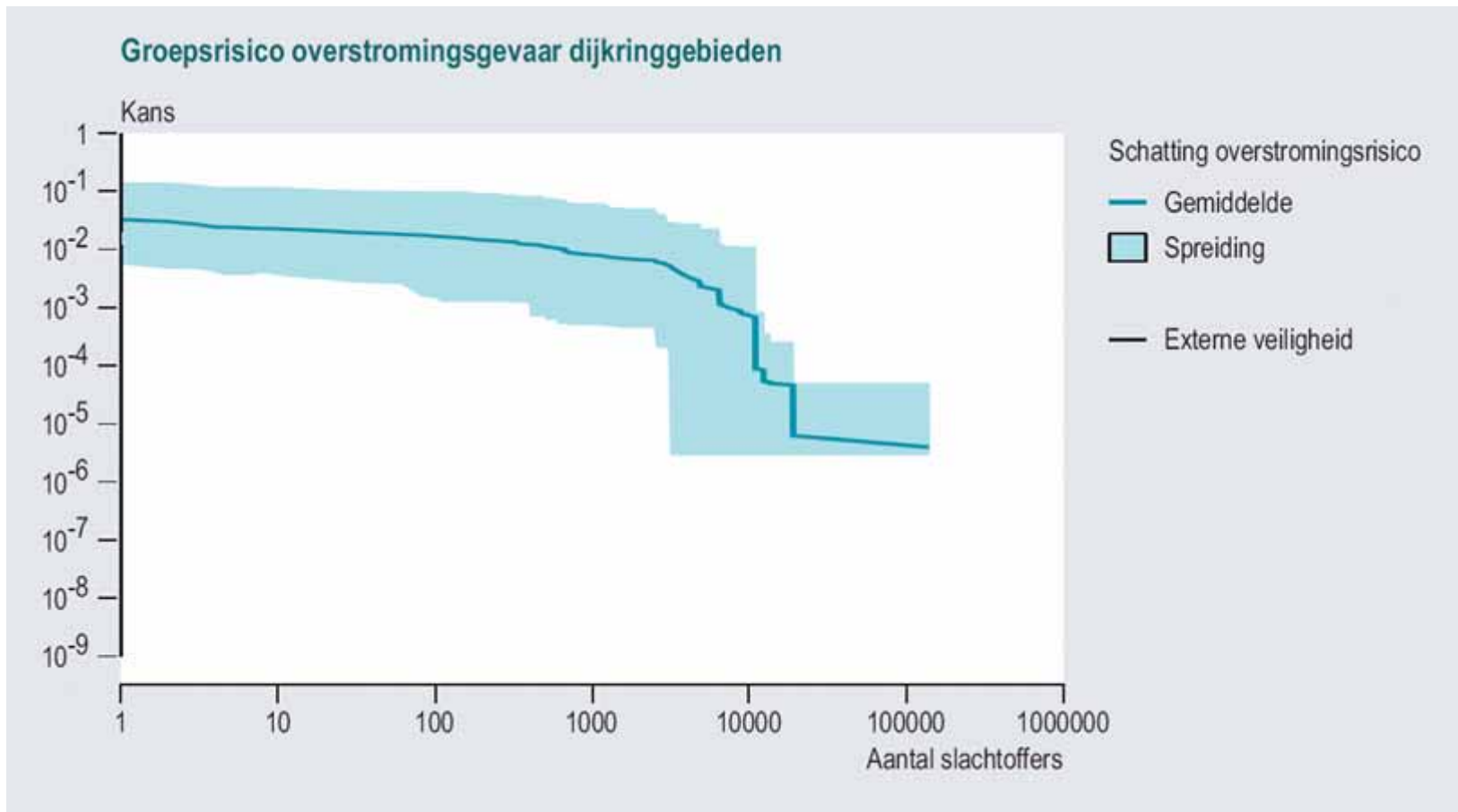


2: Grote water opgaves

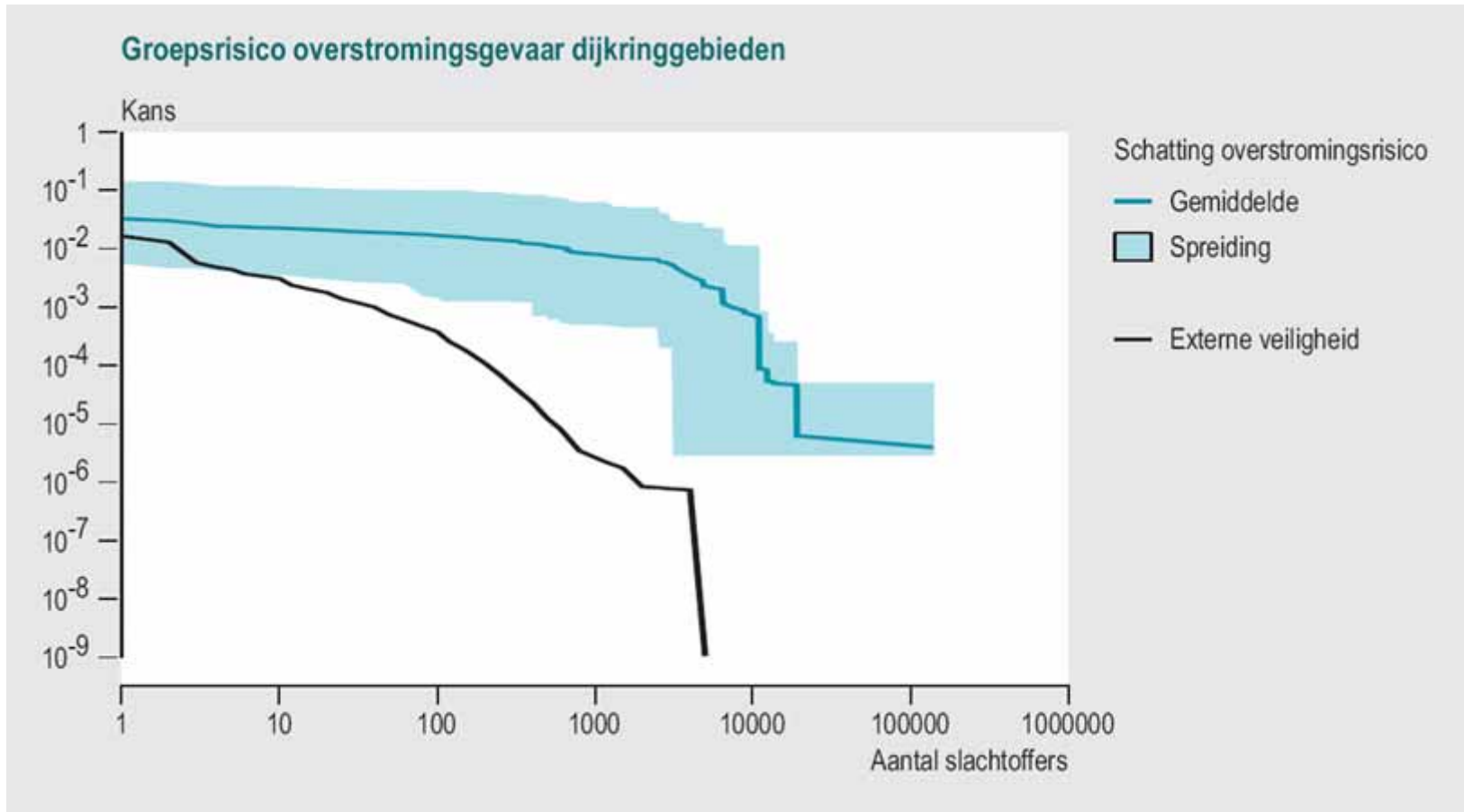
Issues in Nederland

- **Veiligheid, normen, burgers – overheid**
 - **Nationaal Bestuursakkoord Water**
 - **Kaderrichtlijn Water (EU)**
 - **Ruimte voor de rivier**
 - **Nederland leeft met water**
 - **Waterveiligheid 21^e eeuw**

2: Grote water opgaves Issues in Nederland



2: Grote water opgaves Issues in Nederland



2: Grote water opgaves

Issues in Nederland

- **Huidig risico overstroming**
- **Eu 0,70 pp pj**

Arjen Hoekstra, TU Twente, Dijkkring 14 (hier...)

2: Grote water opgaves

Issues in Nederland

- **Huidig risico overstroming**
- **Eu 0,70 pp pj**
- **0,3 personen per jaar**

Arjen Hoekstra, TU Twente, Dijkkring 14 (hier...)

2: Grote water opgaves

Issues in Nederland

- **Huidig risico overstroming**
- **Eu 0,70 pp pj**
- **0,3 personen per jaar**

- **Hogere dijken?**
- **Klimaat significant?**

Arjen Hoekstra, TU Twente, Dijkkring 14 (hier...)

2: Grote water opgaves

Issues in Nederland

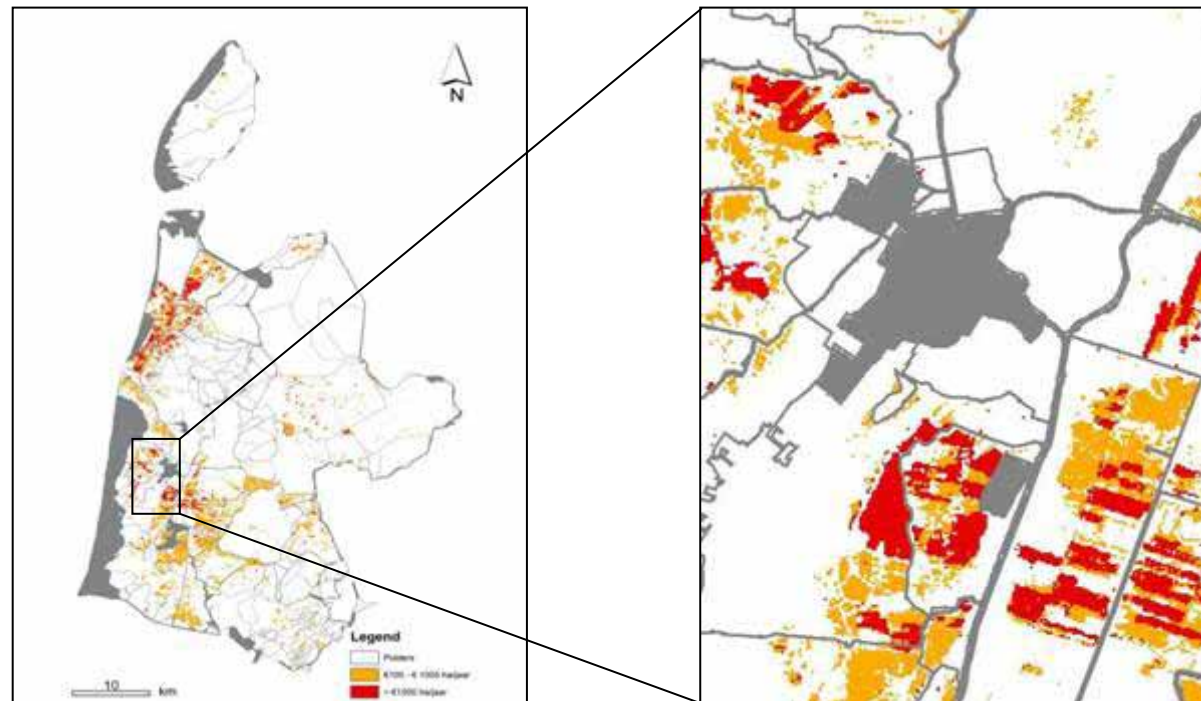
- **Veiligheid, normen, burgers – overheid**

Landgebruik	% Overstroomd	Herhalingstijd
Grasland	5%	1:10 jaar
Akkerbouw	1%	1:25 jaar
Hoogwaardige land- en tuinbouw	1%	1:50 jaar
Glastuinbouw	1%	1:50 jaar
Bebouwd gebied	0%	1:100 jaar

2: Grote water opgaves

Issues in Nederland

- **Veiligheid, normen, burgers – overheid**



Olivier Hoes
Govert Verhoeven

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**



1900



1970



2005

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Betere nieuwbouw**
 - **Sanering grote steden**
 - **Grondwater beheer**
 - **Buitendijks bouwen**

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Betere nieuwbouw**



Rutger de Graaf

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Sanering grote steden**



2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Grondwater beheer**



Lucas vd Winkel

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Buitendijks bouwen**



Bart v Genugten

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Energie opslag & winning**



Evelyn Apericio

85

Urban Surface water as energy source & collector

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Buitendijks bouwen**



Bart v Genugten

Terpen?
Palen?

2: Grote water opgaves

Issues in Nederland

- **Stedelijk waterbeheer**
 - **Drijvend bouwen**



Deltasync

Rutger de Graaf

87

2: Grote water opgaves

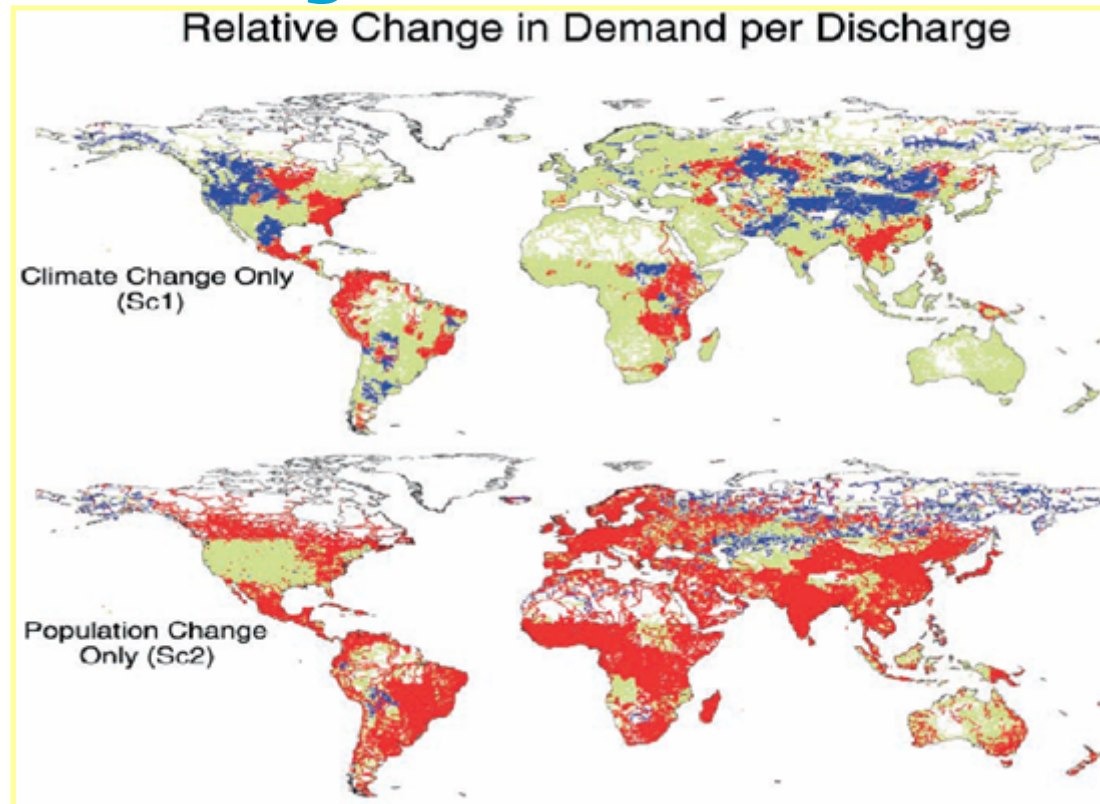
Issues in ontwikkelingslanden

- **Klimaat (?)**
- **Millennium goals**
- **Kleinschalige investeringen**

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Klimaat (?)**



Vorosmarty et al,
Science 289, July 2000

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Millennium goals 2015:**
 - Goal 1 Eradicate extreme poverty and hunger
 - Goal 2 Achieve universal primary education
 - Goal 3 Promote gender equality and empower women
 - Goal 4 Reduce child mortality
 - Goal 5 Improve maternal health
 - Goal 6 Combat HIV/AIDS, malaria, and other diseases
 - Goal 7 Ensure environmental sustainability
 - Goal 8 Develop a global partnership for development

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Millennium goals, World Bank:**

<i>The World Commission on Water has estimated that investments in water infrastructure in</i>	<i>developing countries need to increase from about \$75 billion to \$180 billion a year over the next 25 years</i>
--	---

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Millennium goals, voedsel:**
- 1700 m³ pp / jaar (geen tekort)
 - drinkwater
 - koken etc.
 - wassen etc.
 - toilet
 - industrie
 - vegetarisch dieet
 - vlees (extra)

2: Grote water opgaves

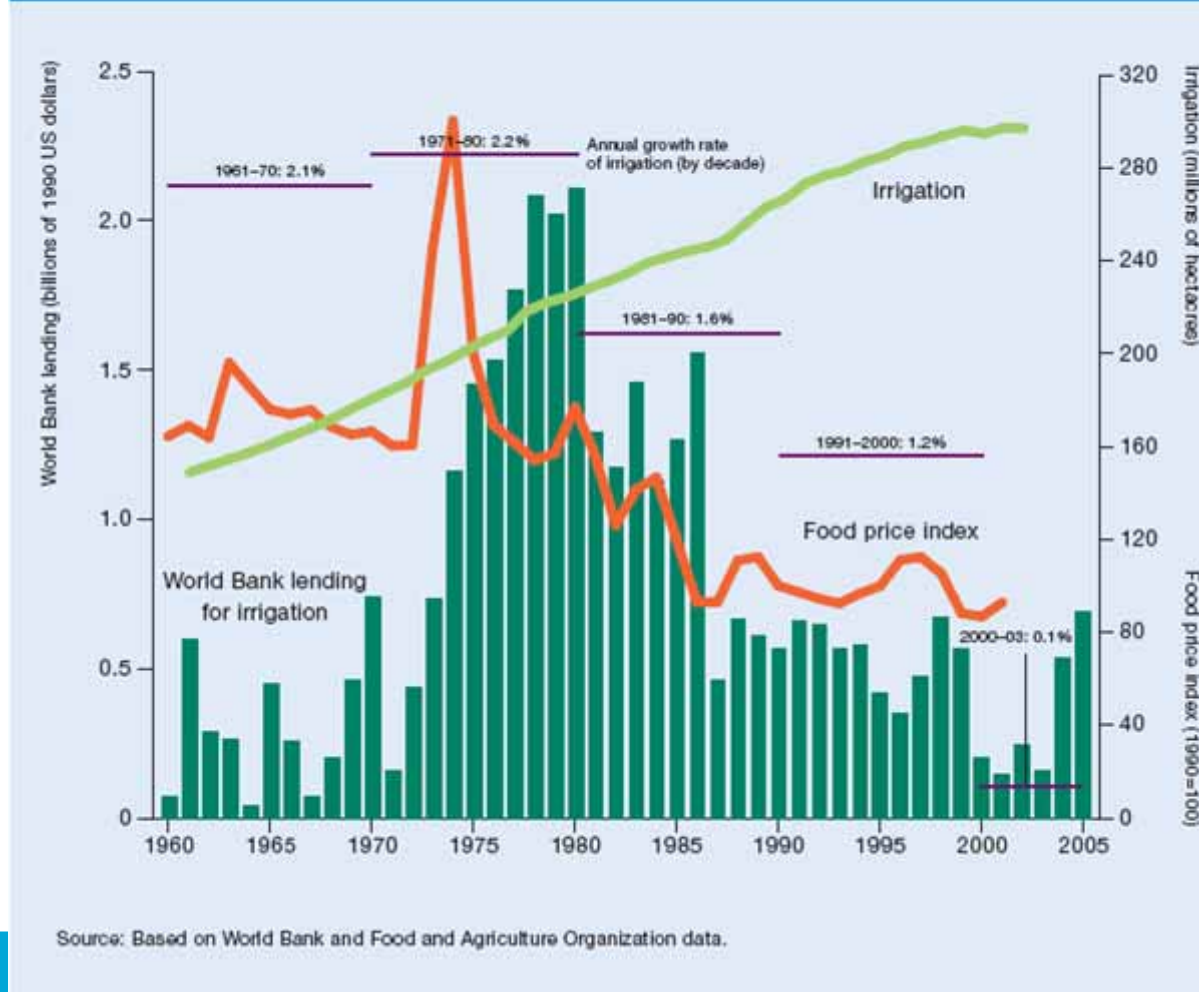
Issues in ontwikkelingslanden

- **Millennium goals, voedsel:**

- 1700 m³ pp / jaar (geen tekort)
 - drinkwater 1
 - koken etc. 5
 - wassen etc. 10
 - toilet 20
 - industrie 200
 - vegetarisch dieet 500
 - vlees (extra) 500-1000

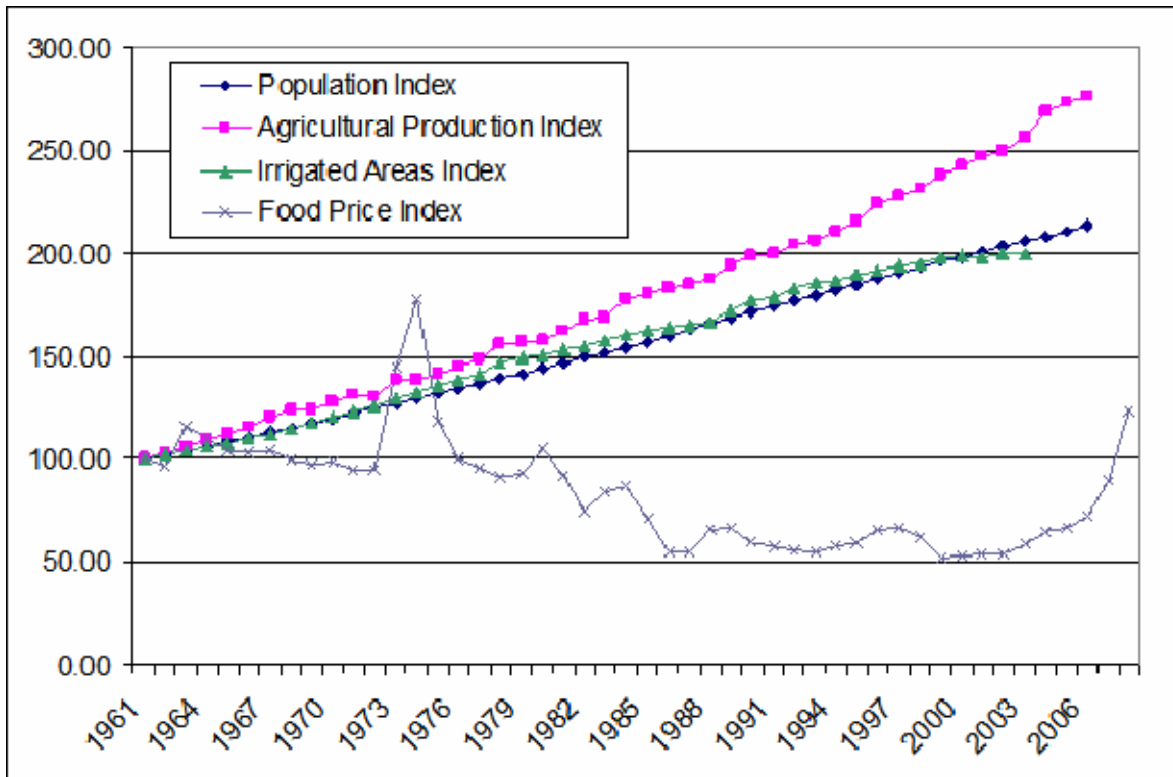
2: Grote water opgaves

figure 9.1 | Irrigation expanding, food prices falling



2: Grote water opgaves

Issues in ontwikkelingslanden

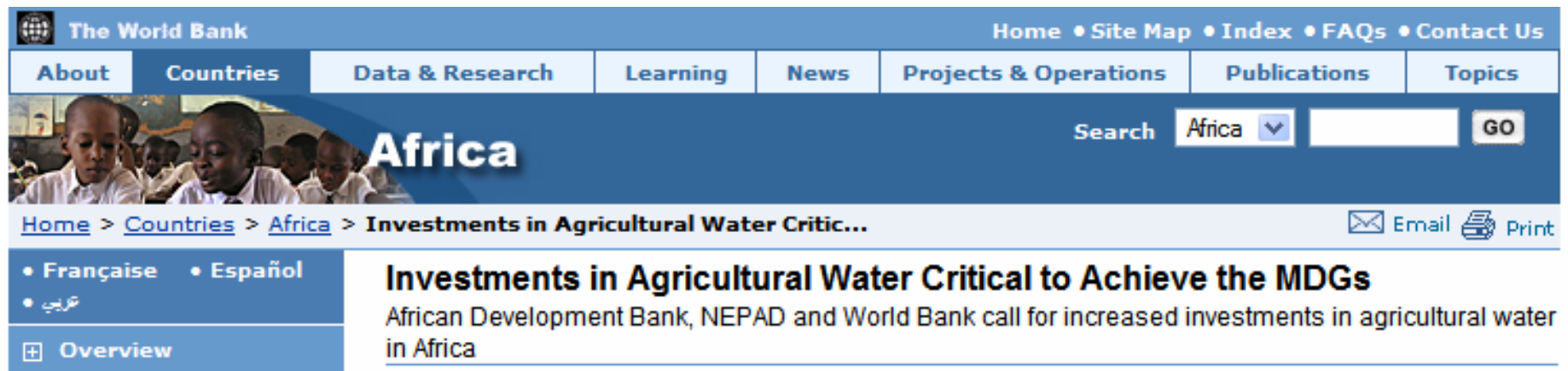


Jippe Hoogeveen

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Voedsel: Maart 2008**



The screenshot shows the top navigation bar of The World Bank website with links for Home, Site Map, Index, FAQs, and Contact Us. Below this is a secondary menu with categories like About, Countries, Data & Research, Learning, News, Projects & Operations, Publications, and Topics. A search bar is visible with 'Africa' selected in the dropdown and a 'GO' button. The main content area features a large image of African children and the word 'Africa' in a large font. Below the image is a breadcrumb trail: Home > Countries > Africa > Investments in Agricultural Water Critic... To the right of the breadcrumb are 'Email' and 'Print' icons. On the left side, there are language options: Française, Español, and العربية. Below these is an 'Overview' link with a plus icon. The main article title is 'Investments in Agricultural Water Critical to Achieve the MDGs', followed by a sub-headline: 'African Development Bank, NEPAD and World Bank call for increased investments in agricultural water in Africa'.

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Kleinschalige investeringen**



Tono, Ghana
70-er jaren
\$45,000 / ha

2: Grote water opgaves

Issues in ontwikkelingslanden

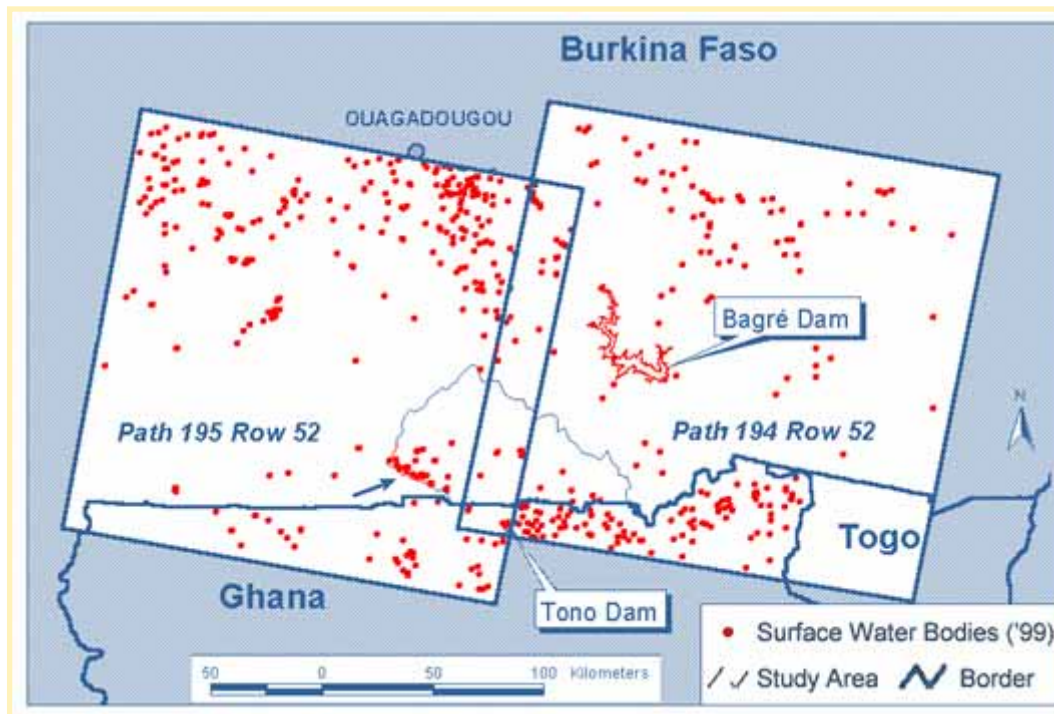
- **Kleinschalige investeringen**



2: Grote water opgaves

Issues in ontwikkelingslanden

- Kleinschalige investeringen



	1984	1999
#	302	710
ha	4134	31200

2: Grote water opgaves

Issues in ontwikkelingslanden

- **Kleinschalige investeringen, hoe:**
 - **Institutioneel?**
 - **Financiering?**
 - **Technisch?**
 - **Opschalen impact?**

2: Grote water opgaves

Issues in ontwikkelingslanden

- Kleinschalige investeringen

<http://ghana2005.oli.tudelft.nl/>

www.smallreservoirs.org

Tijs Dekker

Geertjo van Dijk

Anneke van der Kraan

Martine Poolman



3: Systemen

Colleges: Algemene logika

Eisen \Rightarrow Systeem \Rightarrow Elementen \Rightarrow Technieken



3: Systemen

Systemen

- **Stedelijk gebied**
- **Polders**
- **Irrigatie**
- **Riviergebieden**



3: Systemen

Stedelijk gebied, eisen

- **Geen wateroverlast**
 - **Grondwater**
 - **Oppervlakte water**
- **Water kwaliteit**



3: Systemen

Stedelijk gebied, elementen

- **Regen - afvoer**
- **Ontwatering**
 - **Drain afstand**
 - **Drain diepte**
- **Grachten, kanalen**
- **Riolering**



3: Systemen

Stedelijk gebied, techniek

- Regen afvoer
- **Ontwatering – College 2**
 - **Drain afstand**
 - **Drain diepte**



3: Systemen

Polders, eisen

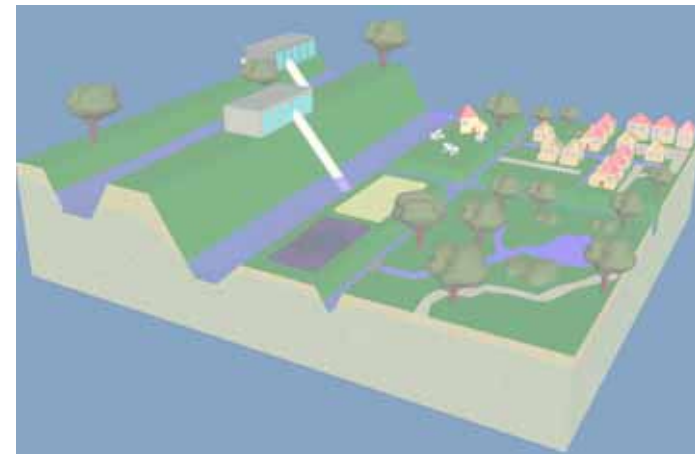
- **Geen wateroverlast (veiligheid)**
- **Geen droogte**
- **Water kwaliteit**



3: Systemen

Polders, elementen

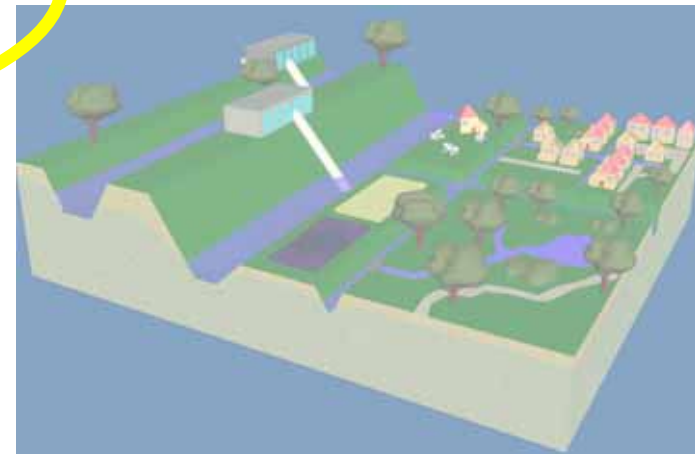
- **Opslag**
- **Ontwatering (drainage)**
- **Afwatering**
 - **Afvoer / ha**
 - **Open kanalen**
- **Kunstwerken (gemalen)**
- **Operationeel**



3: Systemen

Polders, techniek

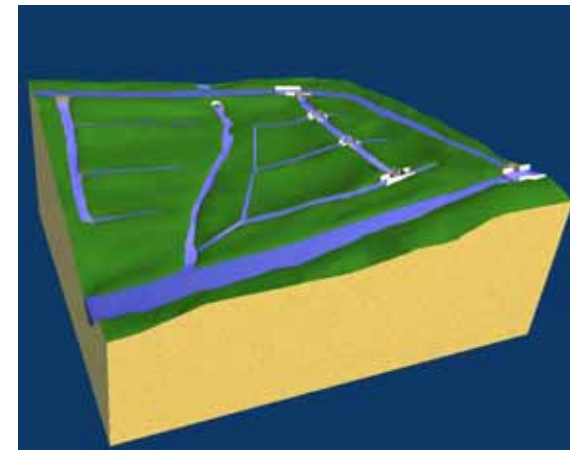
- Opslag
- Ontwatering
- **Afwatering – College 3**
 - Afvoer / ha
 - Open kanalen
- Kunstwerken
- Operationeel



3: Systemen

Irrigatie, eisen

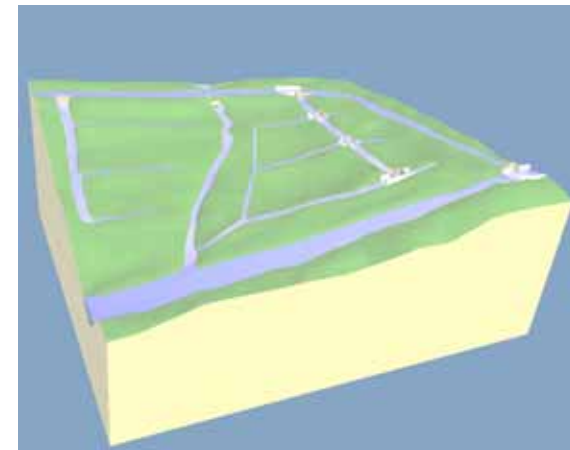
- **Genoeg water gewas**
- **Ontwatering (verzouting)**
- **Doenbaar management**



3: Systemen

Irrigatie, elementen

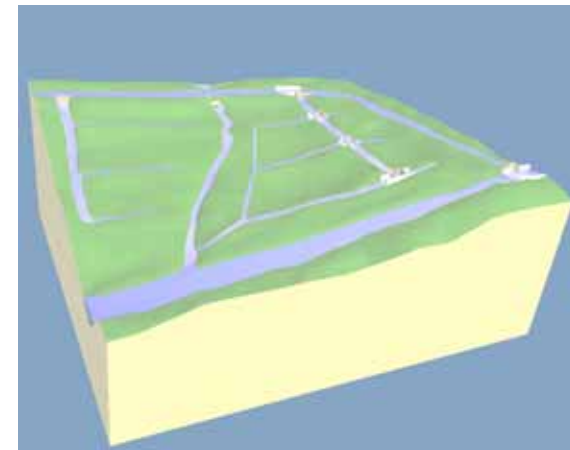
- **Gewas**
- **Kanalen**
- **Kunstwerken**
- **Operationeel beheer**



3: Systemen

Irrigatie, techniek

- **Gewasbehoefte – College 4**
- Kanalen
- Kunstwerken
- Operationeel beheer



3: Systemen

Riviergebieden, eisen

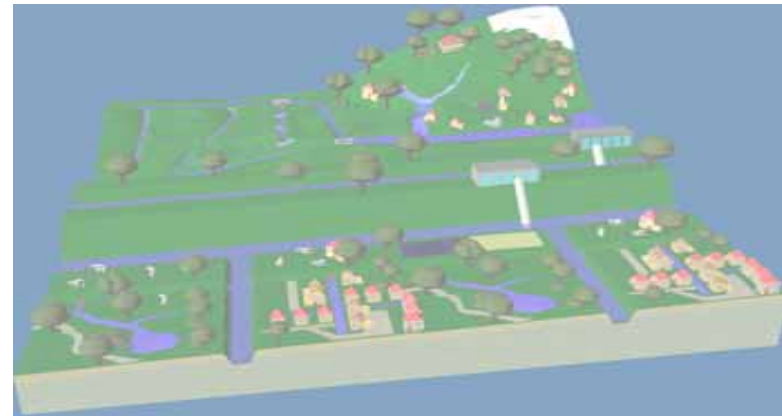
- **Water kwaliteit**
- **Navigatie**
- **Geen droogtes (hydro-energie)**
- **Geen overstromingen**
- **Integratie**



3: Systemen

Riviergebieden, elementen

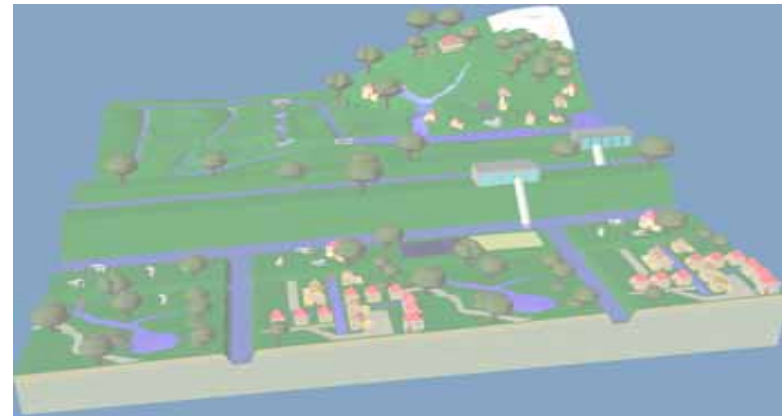
- **Regen – afvoer processen**
- **Rivieren & uiterwaarden**
- **Reservoirs**
- **Anti-erosie werken**



3: Systemen

Riviergebieden, techniek

- Regen – afvoer processen
- Rivieren & uiterwaarden
- **Reservoirs – College 6**
- Anti-erosie werken



4: Waterbeheer CT3011

Onderdelen

- **Colleges**
- **Diktaat**
- **Buiten opgave**
- **Tentamen**

4: Waterbeheer CT3011

Onderdelen

- **Colleges: Algemene logika**

Eisen \Rightarrow Systeem \Rightarrow Elementen \Rightarrow Technieken

4: Waterbeheer CT3011

Onderdelen

- **Colleges: Algemene logika**

Eisen \Rightarrow Systeem \Rightarrow Elementen \Rightarrow Technieken

- **Samenhang begrijpen**
- **Rekenen met technieken**
- **Afleidingen**

4: Waterbeheer CT3011

Onderdelen

Colleges:

1. Water in de wereld
2. Water in de bodem
3. Polders
4. Irrigatie
5. Kunstwerken & operationeel
6. Reservoirs (+review)

4: Waterbeheer CT3011

Onderdelen

- **Colleges: Afleidingen “5 Classics”**
 - **Darcy \Rightarrow Laplace \Rightarrow Boussinesq**
 - **St.Venant \Rightarrow Manning (Strickler)**
 - **Penman**
 - **Lange overlaat**
 - **Hurst**
 - **(Richards)**

4: Waterbeheer CT3011

Onderdelen

- **Diktaat**

Systeem ⇒ Elementen ⇒ Technieken

- **Begrippen & definities**
- **Formules**
- **Details rekenmethodes**

4: Waterbeheer CT3011

Onderdelen

- **Diktaat**

Systeem ⇒ Elementen ⇒ Technieken

- Berekening water behoeftes gewas
- Bergingscapaciteit oppervlakte water
- Afvoercapaciteit
- Ontwerp open kanaal
- Keuze en ontwerp kunstwerken
- Reservoir ontwerp & management
- Ontwatering (drain diepte en afstand)
- Grondwater onttrekking
- Pompen & gemalen

4: Waterbeheer CT3011

Onderdelen

- **Buitenopgave**
 - **Route in buurt van Delft**
 - **Vragen over:**
 - **Stedelijk**
 - **Polders**
 - **Landbouw / natuur**
 - **Kunstwerken**
- **Blackboard onder Activities**



4: Waterbeheer CT3011

Onderdelen

Tentamen opgaves:

1. Weetvraagjes (binnenkomertje)
2. Buitenopgave (vragen/overslaan)
3. Afleiding
4. Rekenen met formules



Buiten opgave

- **Maurits Ertsen (m.w.ertsen@tudelft.nl)**
- **Blackboard**
- **E-mail antwoorden**
- **Dag voor tentamen**
- **Week voor tentamen**



Buiten opgave

- **Maurits Ertsen (m.w.ertsen@tudelft.nl)**
- Blackboard
- E-mail antwoorden
- Dag voor tentamen
- Week voor tentamen

MINOR WATERBEHEER

