

# Climate Change -science and policies, prospects for “Paris”-

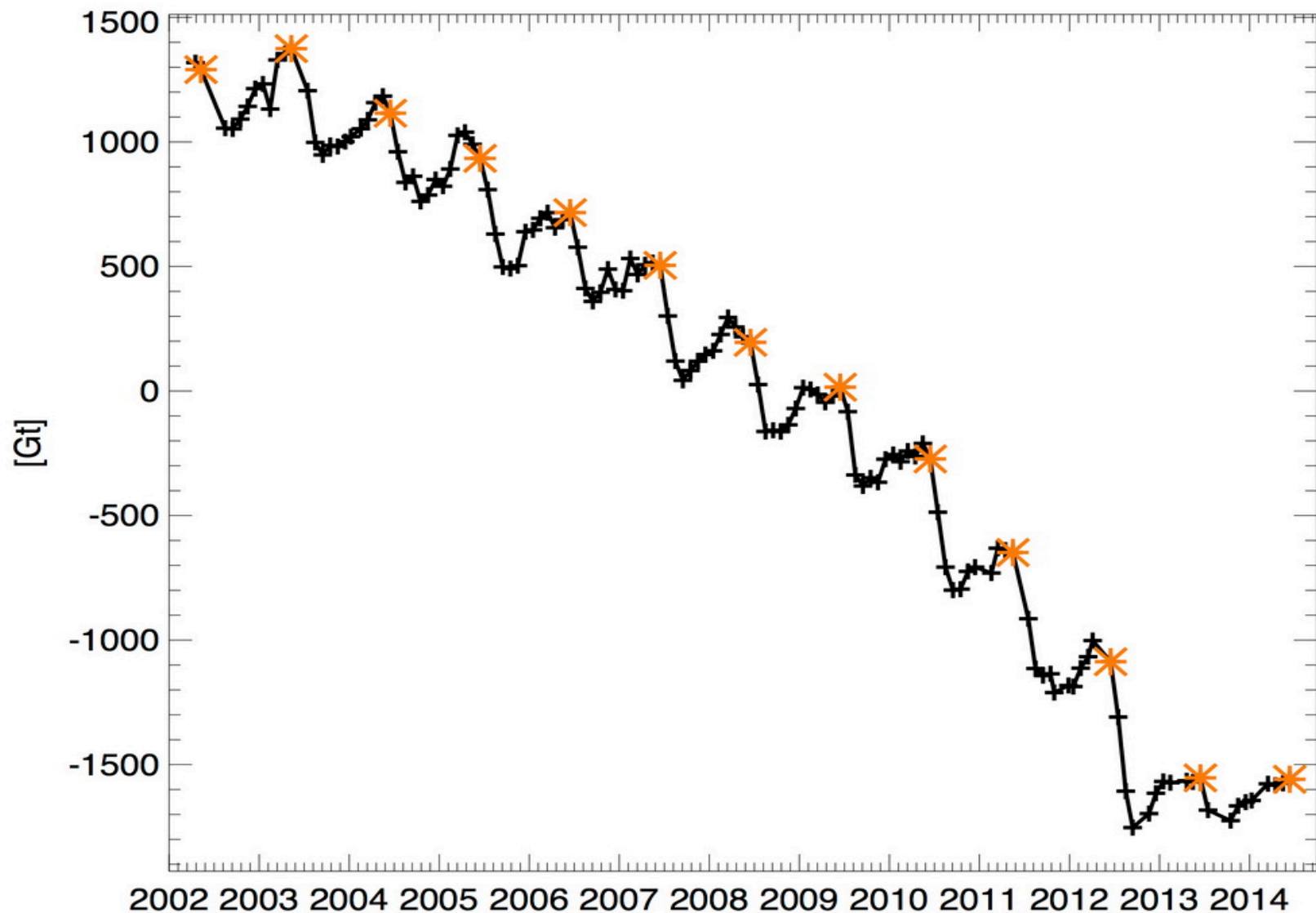
Presentation for the Dutch Association for CSP  
The Hague, November 13 2015.

by  
Pier Vellinga  
Chairman of the National Research Program  
'Knowledge for Climate'





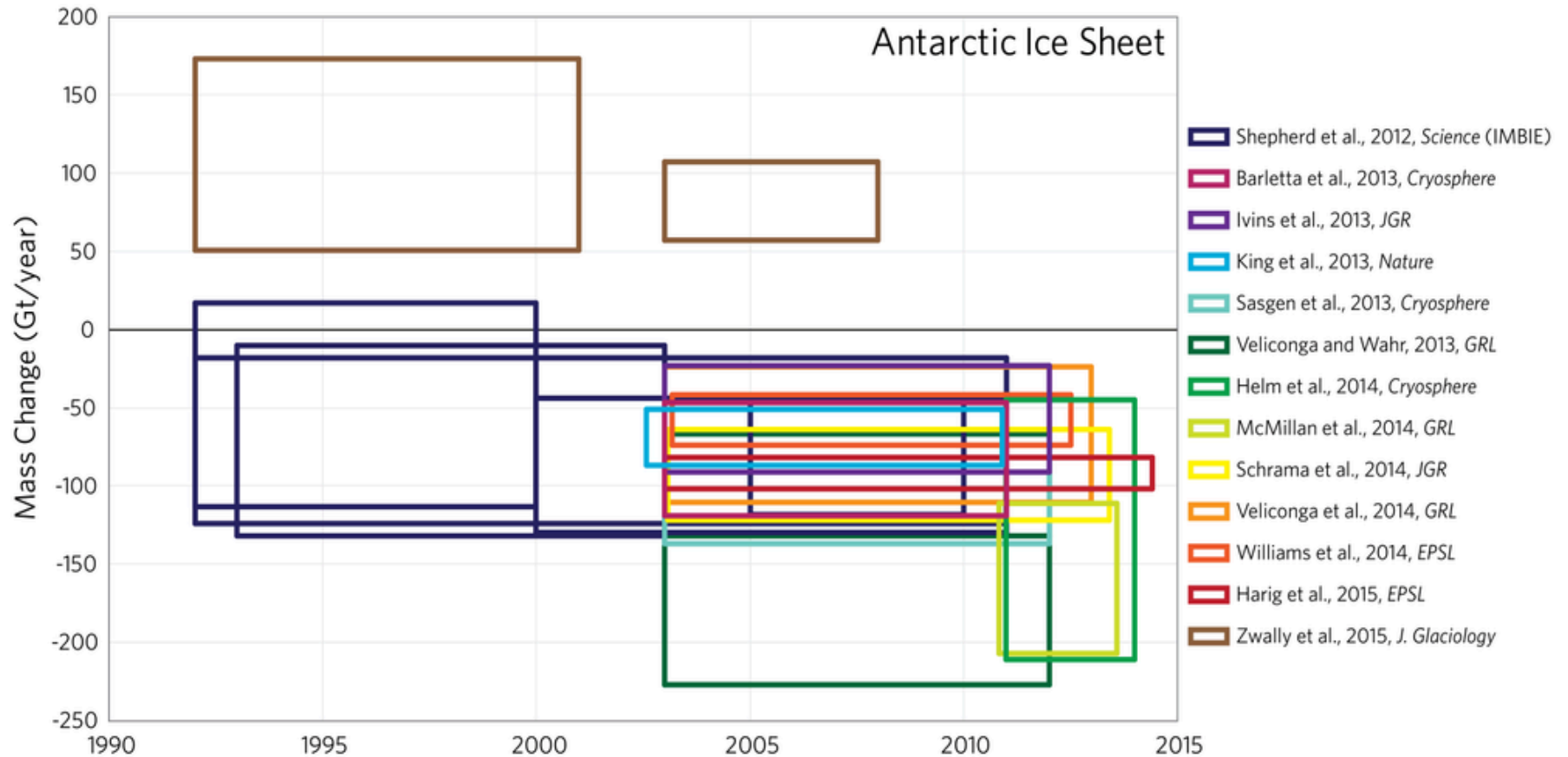


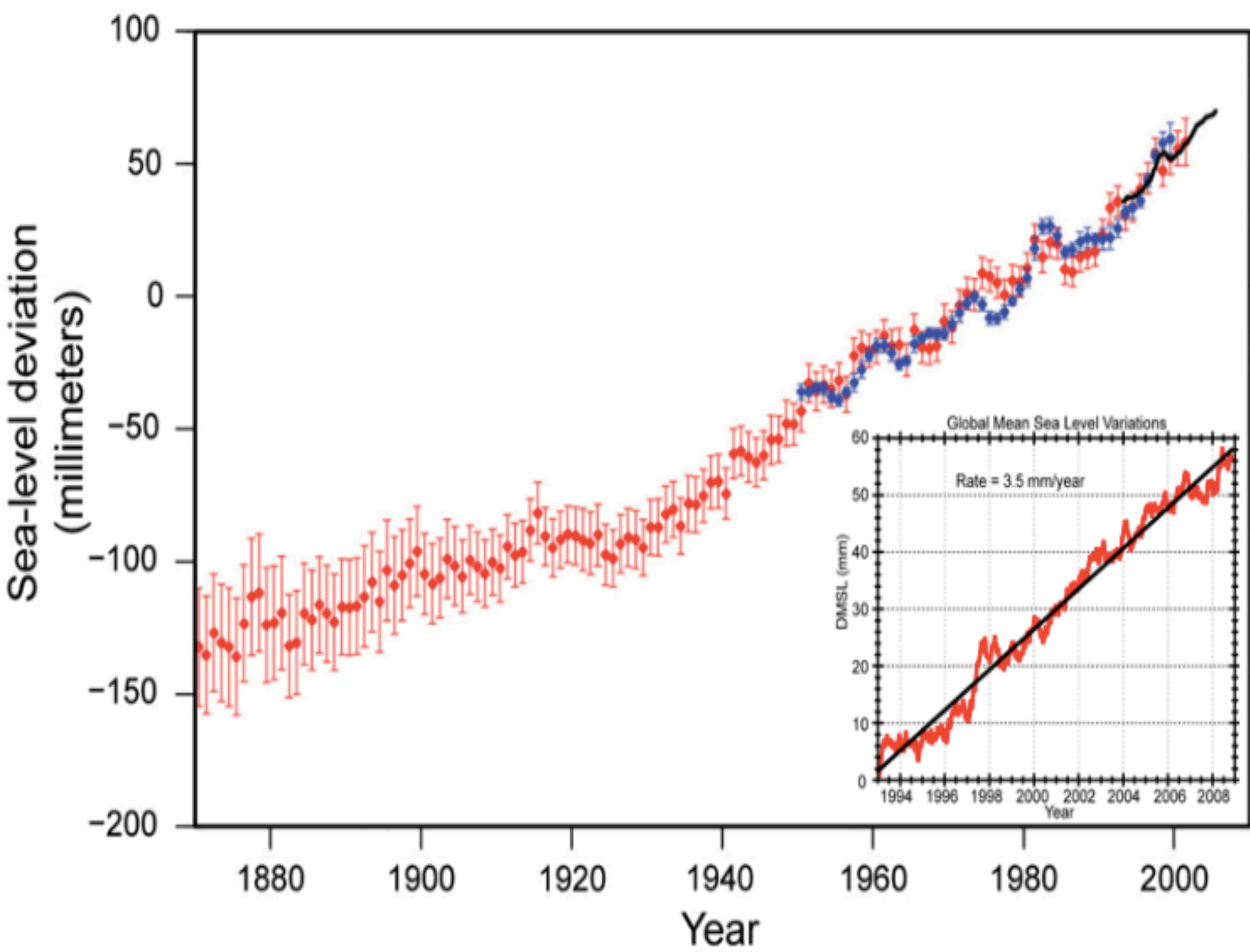


Loss of Greenland ice cap in giga tons of ice, with refence to the average situation over 2002-2014.  
“Grace measurements” published by M. Tedesco, J. E. Box, J. Cappelen, X. Fettweis, T. Mote,  
R. S. W. van de Wal, C. J. P. P. Smeet, sJ. Wahr; January 2015.



# Antarctic ice sheet measurements







# 30 years dealing with Climate Change

1. Looking back over the last 30 years.
2. The 2013/2014 IPCC report; how can we be so sure;
3. Why international climate negotiations make such little progress so far;
4. The renewable energy revolution will be leading;
5. Adaptation to climate change increasingly relevant, but how to adapt?
6. Considerations about the future: climate change and climate policy.

# The history of science regarding properties and effects of increasing concentrations of greenhouse gasses

- John Tyndall in 1850; Svante Arrhenius in 1896;
- Start measurements of CO<sub>2</sub> concentrations on Hawaii by Richard Keeling in 1958;
- First discussions in US politics in the 1960's;
- Club of Rome 1972;



# The 1980 's

- First World Climate Conference, organized by the WMO in 1979; possibility of 5 meters rise in sea level by 2100, circulating in 1983;
- Villach en Bellagio meetings in 1985/1987 about "winners and losers", "climate change" or "global warming" and about putting the issue on the international agenda.
- Report : Our Common Future in 1987, introducing the concept of sustainable development; Toronto conference in 1987; Noordwijk: the first international ministerial conference held in 1989. Establishment of IPCC in 1989/1990
- UN Framework Convention on Climate Change (UNFCCC) agreed in 1992 in Rio de Janeiro, cap and trade versus pledge and review as guiding principle for the sharing of efforts to reduce emissions

# The 1990 's

- From UN Framework Convention (Rio 1992) to Kyoto Protocol, agreed in 1997, including a reduction of industrialized country emissions by 5 % in 2010/2012 as compared to 1990; ratified in 2005.
- USA not prepared to ratify Kyoto Protocol;
- Development of EU emission trading scheme;
- International implementation of Montreal protocol on the reduction of CFC 's affecting the ozone layer.
-



# The years 2000 - 2010

- EU efforts to bring the USA , India and China into the game of international agreements on greenhouse gas emission control; and broadening the agenda including international financing mechanisms for mitigation and adaptation measures and agreements on international cooperation on forest management and adaptation;
- Fourth IPCC assessment report published in 2007 with far reaching conclusions: greenhouse gas emissions with high probability responsible for at least part of global warming measured since 1970.
- Agreement about “unilateral” emission control measures by the EU countries: the so called 20/20/20 goals for 2020 regarding energy efficiency gains, renewable energy and greenhouse gas emission reduction;
- Copenhagen Accord: political agreement to keep global temp. rise below two degrees; no commitments for implementation of reduction targets; Especially USA, and in its wake China and India were not prepared to agree on internationally binding targets for emission control/reductions.

# The years 2010-2011

- Enormous backlash after failure of Copenhagen and the apparent lack of political will to agree on an international regime for greenhouse emissions control/reductions.
- Aggressive attack on the IPCC, on individual climate scientists and on climate policy in general,
- Formally established national and international review committees conclude in their reports that the virulent attacks on the scientific quality of the IPCC findings are not justified. The main findings of IPCC remain valid.



# 5 th IPCC report, 2013

- The rise of temperature of the last 50 years is for at least the major part, and possibly in total due to the increased concentrations of greenhouse gases in the atmosphere ( 95 percent certain);
- The rise in ghg concentrations is a result of human activities mainly fossil fuel use and to some extent landuse changes;
- With “business as usual” rising concentrations average temperatures will continue to rise up 3 to 5 degrees Celsius by the end of this century,
- 
- If global average temperature rise is to be kept below two degrees major reductions in ghg emission will be required up to 80 percent by 2050;

# How can we be so sure?

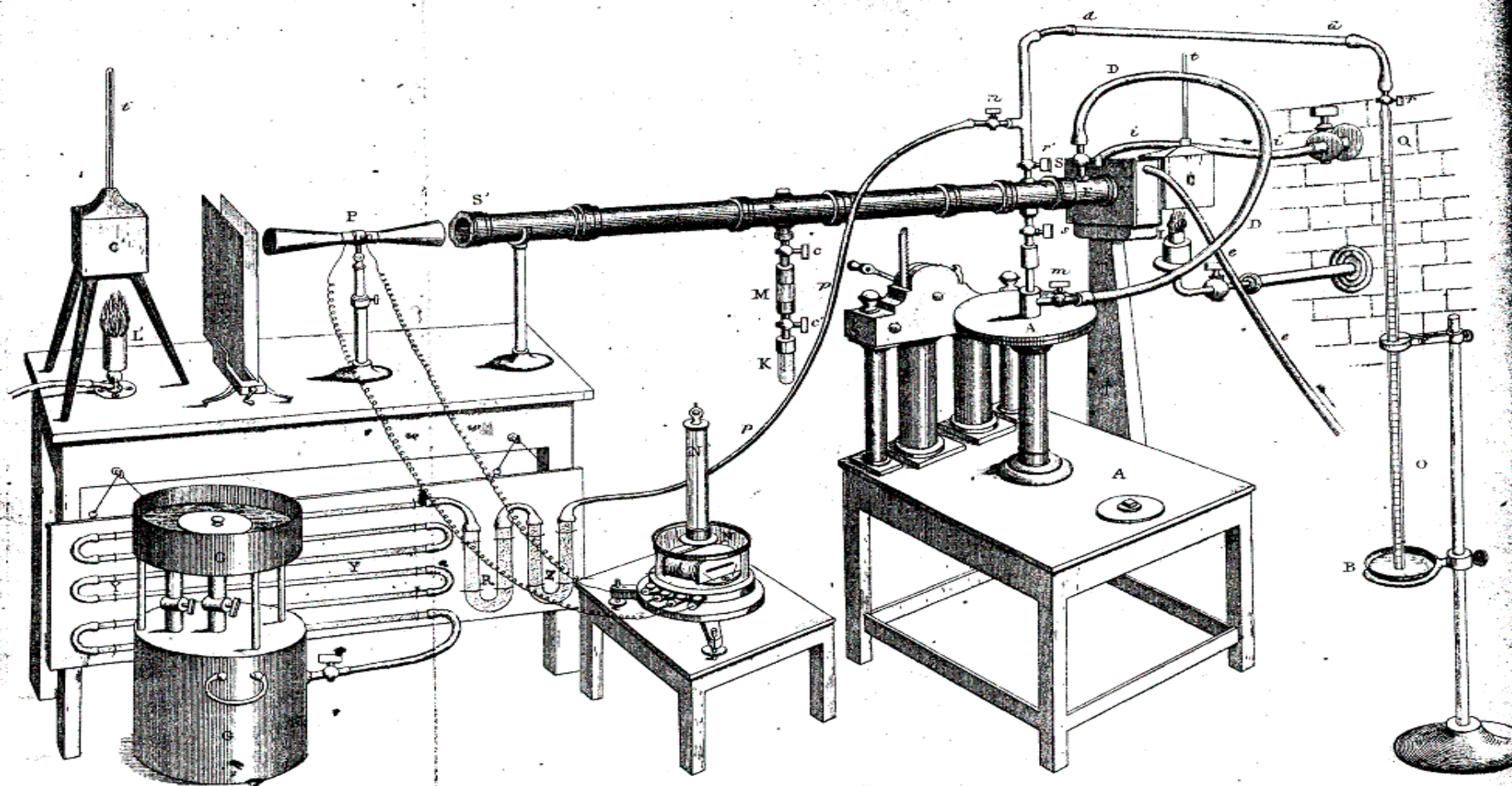
- Radiation physics (experimental verification and theoretical basis);
- Growing concentrations (measurements since 1958);
- As a result of human activities (measurement, isotopes);
- Other planets (measurements);
- Geological history of planet earth (measurements);
- Record of global average temperatures of the last 50 years (measurements);
- Pattern of warming around the globe and vertically in the atmosphere (measurements);
- Solar variation, volcanos or inherent earth dynamics can not explain recent warming of 0.6 degrees in 50 years;
- There is no plausible scientific argument why growing concentrations of ghg would not lead to higher temperatures on the surface of the earth.

# Why does society make so little progress in reducing emissions of green house gasses?

- Lack of political will, especially in the USA protecting the vested interests in coal and oil; and an active climate policy will cause major shifts in power, between countries and between companies;
- Not enough sense of urgency as the direct economic effects of climate change on the rich northern countries (middle and north EU, Russia, Canada and USA) will initially (until 2030/2050) be relatively small, maybe even positive. Net negative effects likely to become apparent at later stage...beyond 50 to 100 years.
- The denial global climate change has become an ideological issue, promoted originally by industrial groups but later on supported by politically right wing groups, groups that are a priori against government interference in existing markets and resource use (Oreskes and Conway; de Twijfelbrigade).

# The years 2012-2015

- A number of major international companies take initiatives to reduce CO<sub>2</sub> and other greenhouse gas emissions...in the Netherlands: Unilever, AKZO, DSM, in the USA: Apple, Google, Ikea,.....
- Investments in renewable electricity generation plants increase rapidly; these are in 2012, 2013 and 2014 increasingly larger than investments in fossil fuel electricity generation.
- International studies carried out by major European energy companies illustrate that 80 % of ghg emission reduction can be achieved by 2050 without economic losses (European Climate foundation, Citi report);





verbranding  
fossiele  
brandstoffen

7,2

uitwisseling bodem  
en vegetatie

120

fotosynthese

120

Bodems en  
vegetatie

2261

1,6

ontbossing+  
verandering landgebruik

2,6

uitwisseling  
ocean - atmosfeer

90

92

Oceanen **38150**

Niet opgeboorde  
fossiele brandstoffen

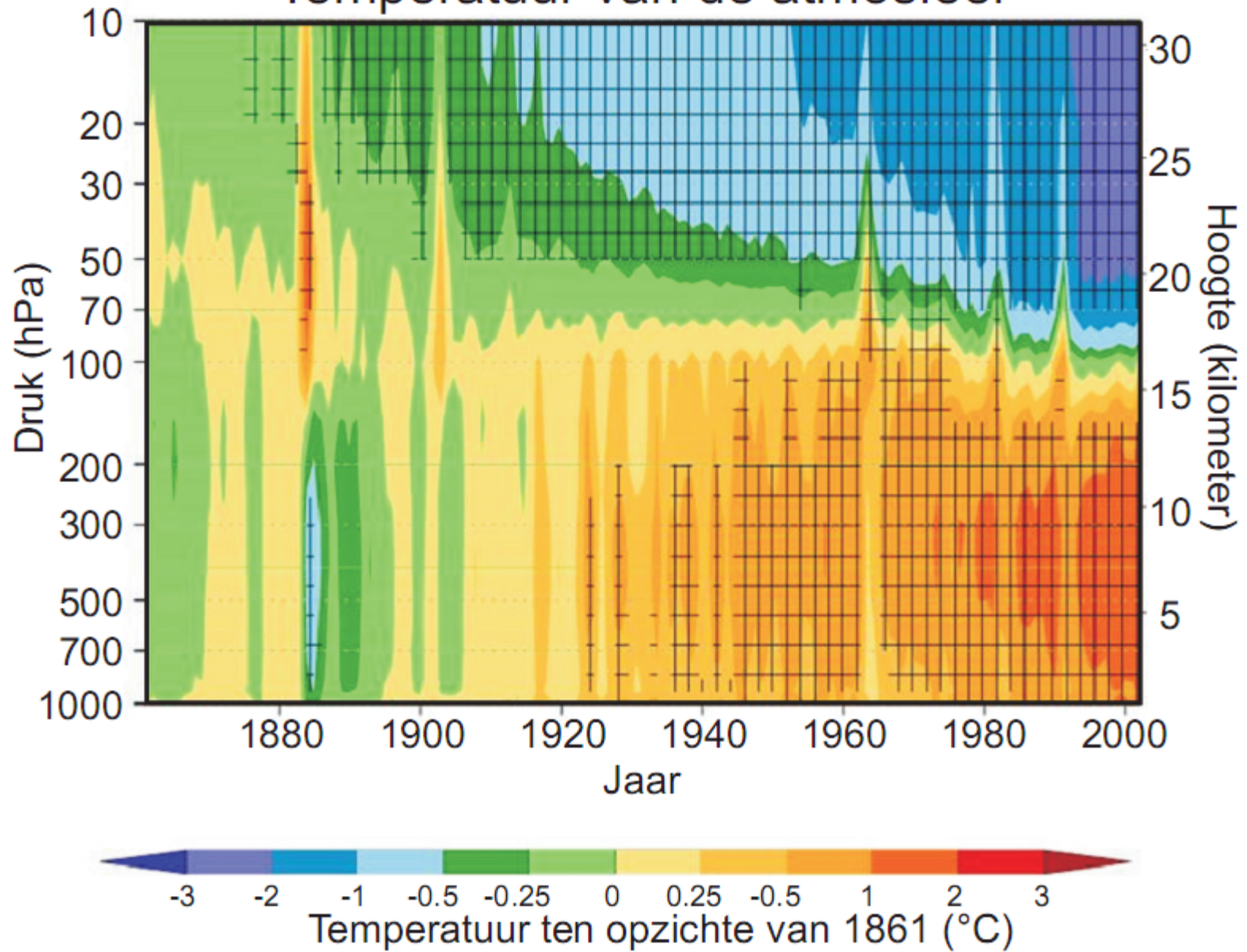
**3700**

Atmosfeer **825**

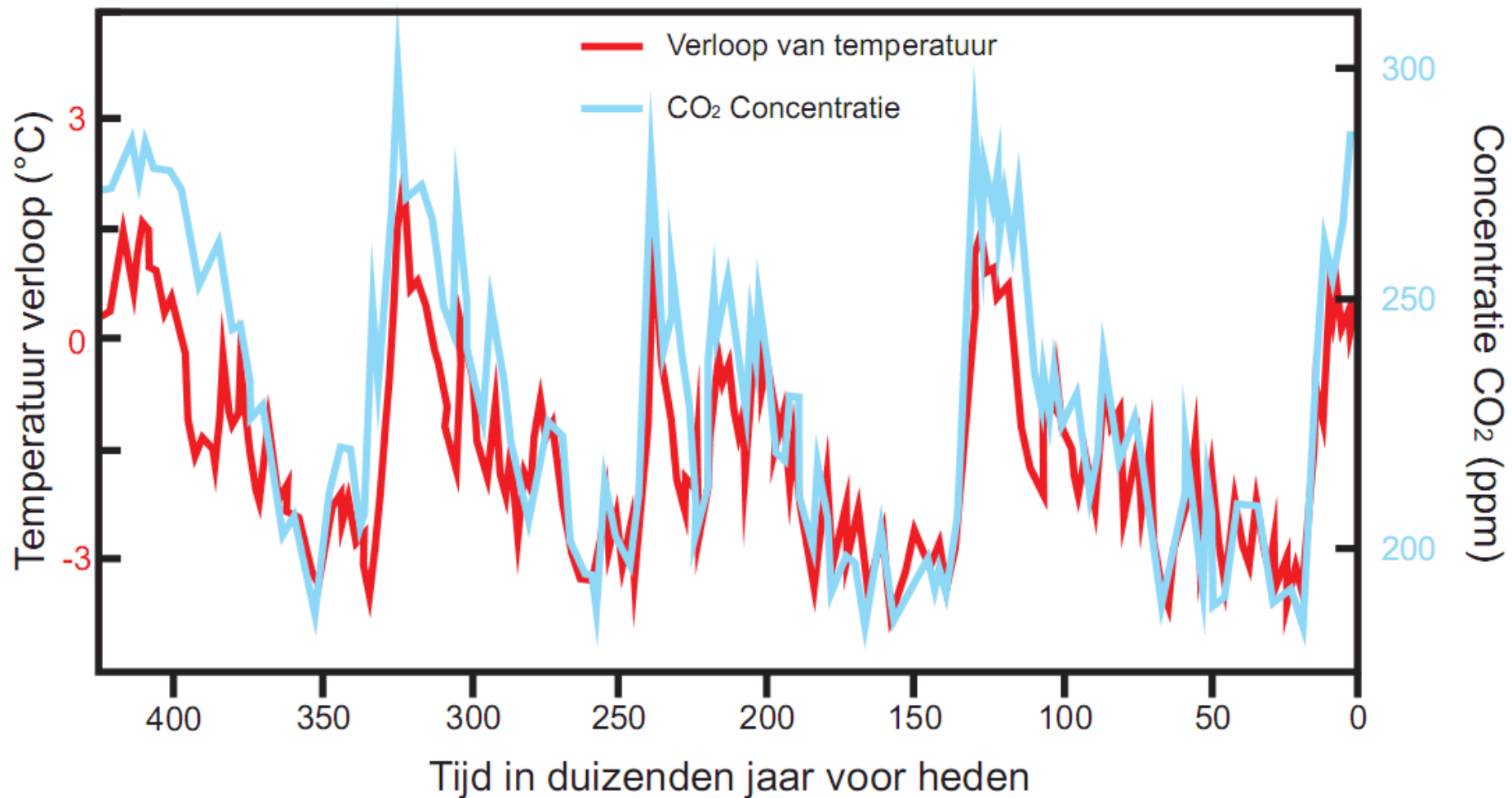
**3700** (vetgedrukt) = Reservoirs (Gigaton C)

90 (cursief) = Stromingen (Gigaton C/jaar)

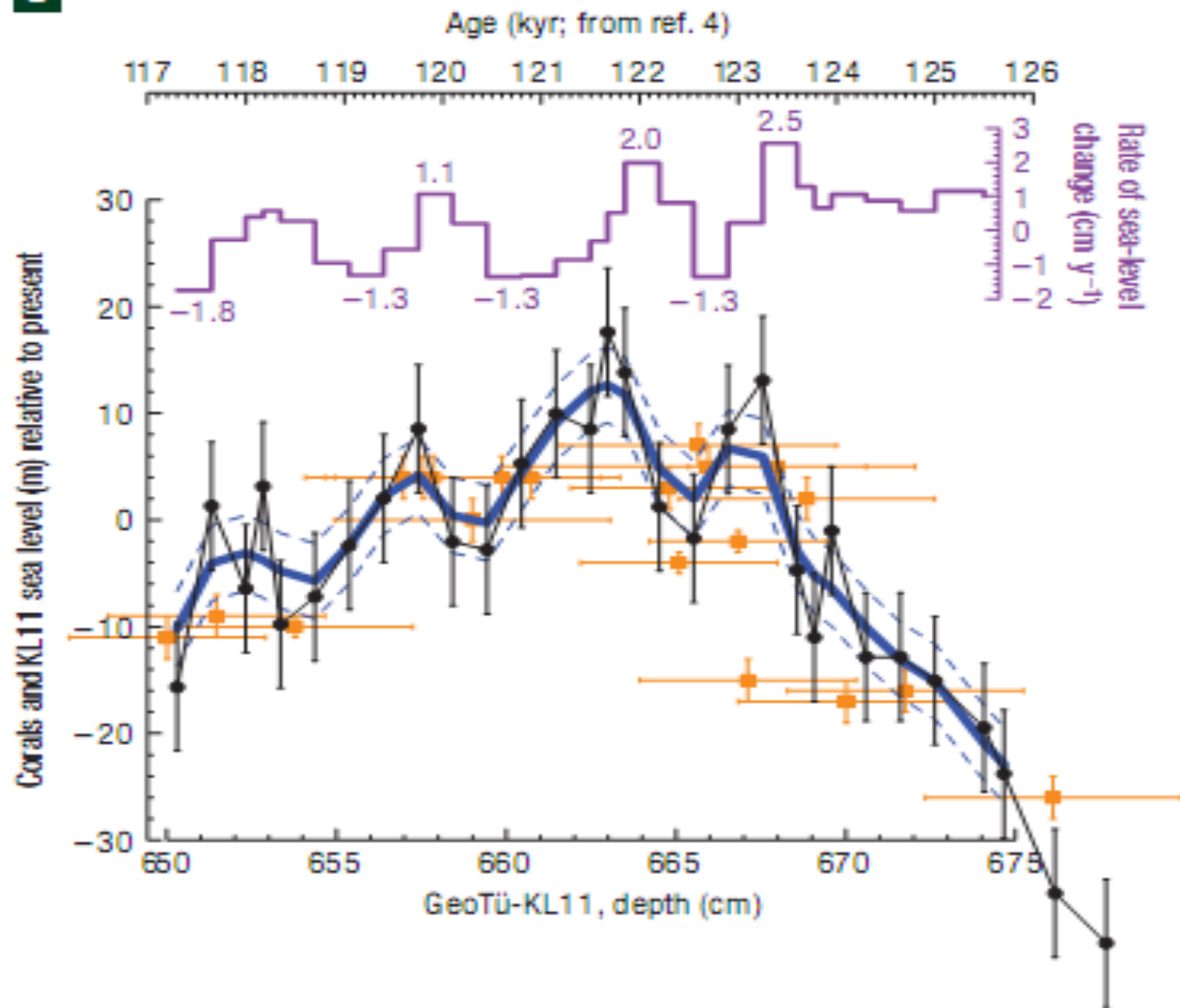
# Temperatuur van de atmosfeer



## Temperatuur en CO<sub>2</sub>-concentratie op geologische tijdschaal



e



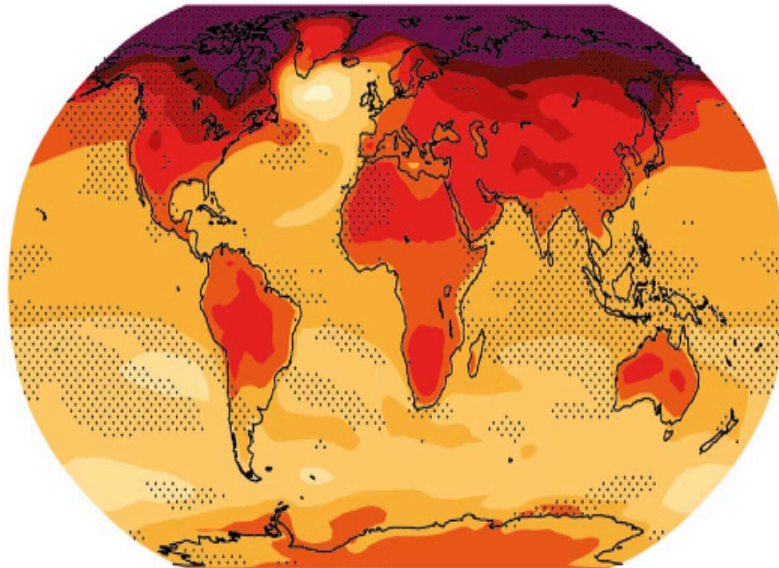
Bron: Rohling et al (2007)



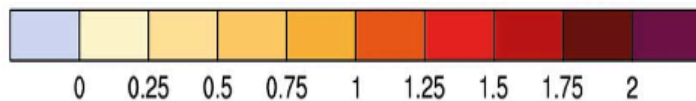
# Stable Patterns of Change with Warming

temperature scaled by global T ( $^{\circ}\text{C}$  per  $^{\circ}\text{C}$ )

CMIP5 : 2081-2100

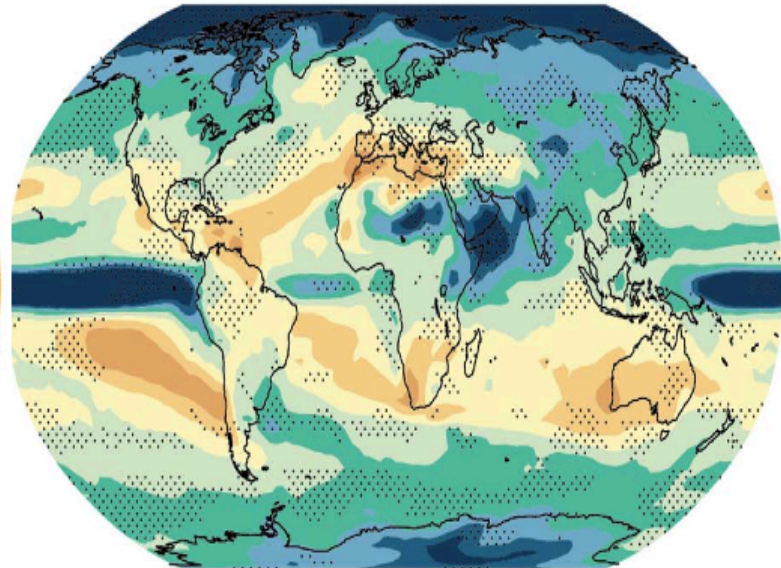


( $^{\circ}\text{C}$  per  $^{\circ}\text{C}$  global mean change)

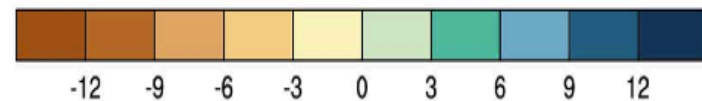


precipitation scaled by global T (% per  $^{\circ}\text{C}$ )

CMIP5 : 2081-2100



(% per  $^{\circ}\text{C}$  global mean change)



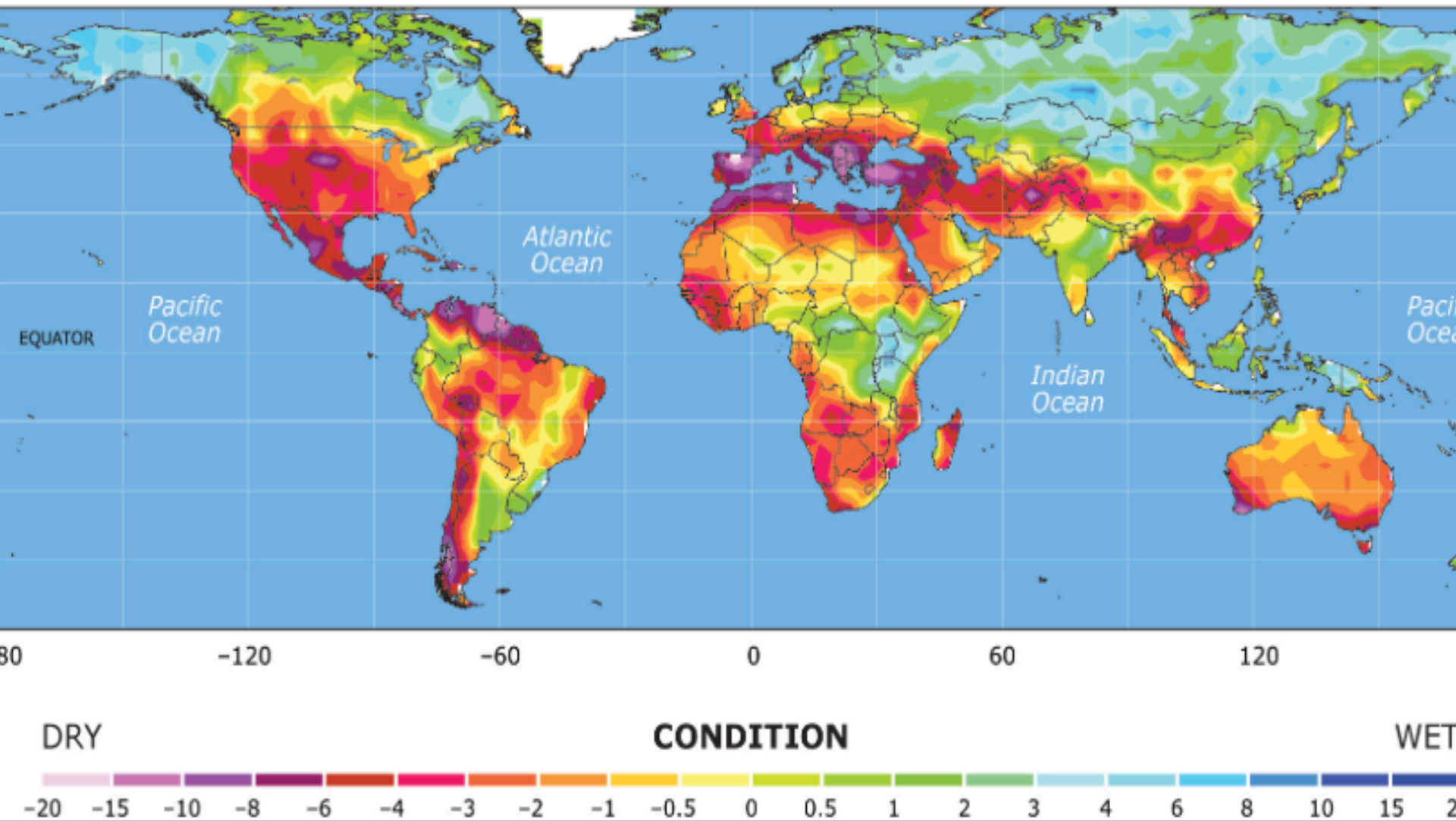
Change at each grid point for a  $1^{\circ}\text{C}$  change in Global Mean Temperature



# Dryer and wetter areas as projected for the period 2030-2039

National Centre for Atmospheric Research

**2030-2039**



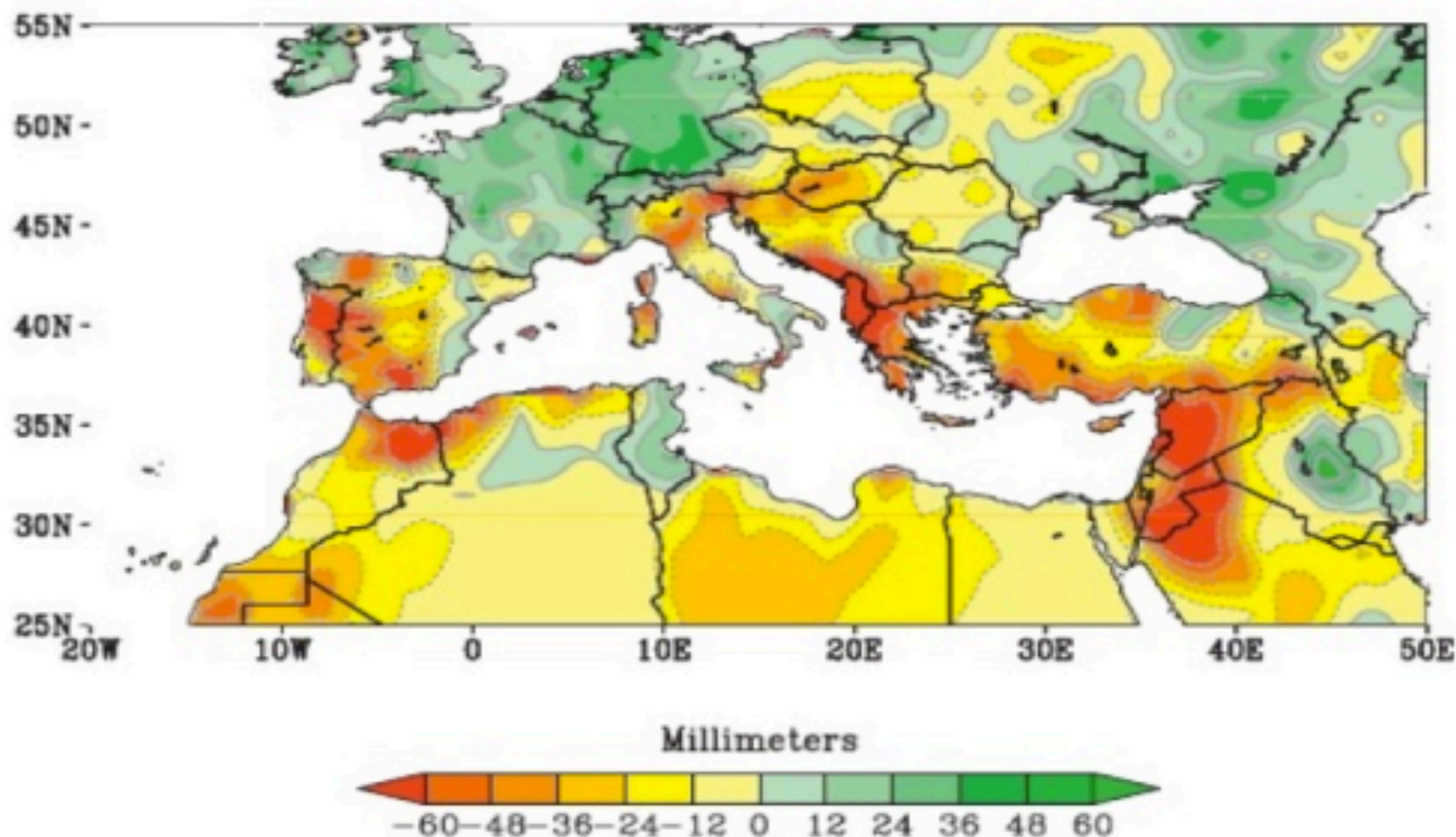
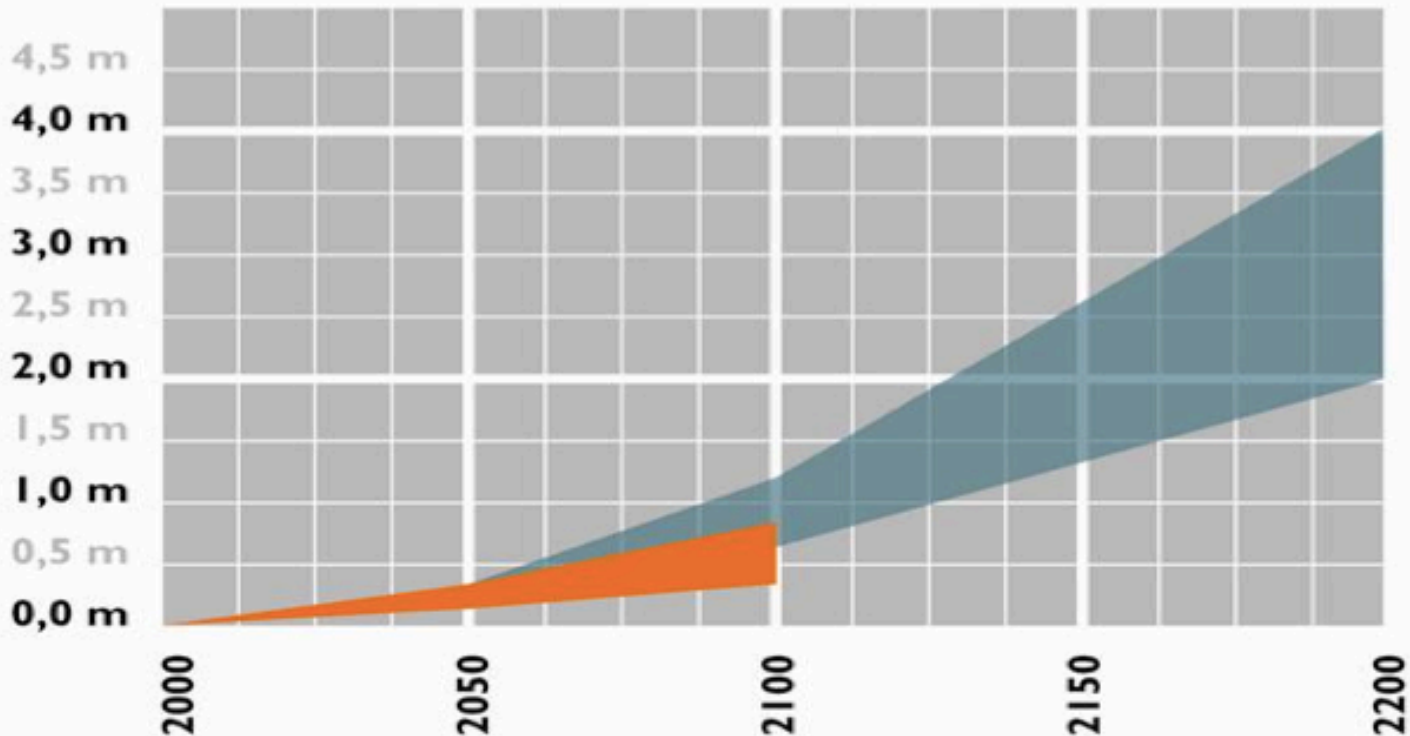


Figure 4. Observed change in cold season precipitation for the period 1971–2010 minus 1902–70. Anomalies (mm) are relative to the 1902–2010 (source: Hoerling et al., 2012).

# Sea-level rise projection (m)



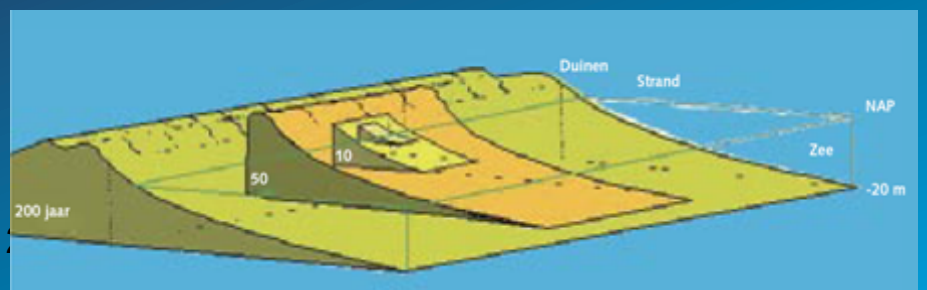
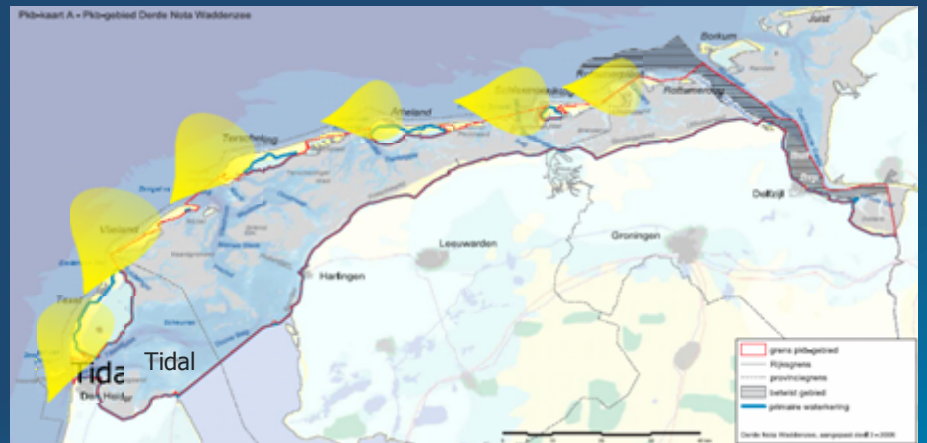
-  = KNMI 2006 scenario's
-  = Delta Commissie 2008



# Nourishment of the coastal sand-river



Images Courtesy RIKZ





# PORT FLOOD PROTECTION





# De Hondsbossche zeewering van hard naar zacht



# Examples of existing broad (super) dikes, “unbreakable dikes”



Overstroombare superbrede dijk in Japan



Brede dijk langs Wantij in Dordrecht met ook functie voor recreatie en natuur

# Multifunctional flood defence in Hamburg, Germany



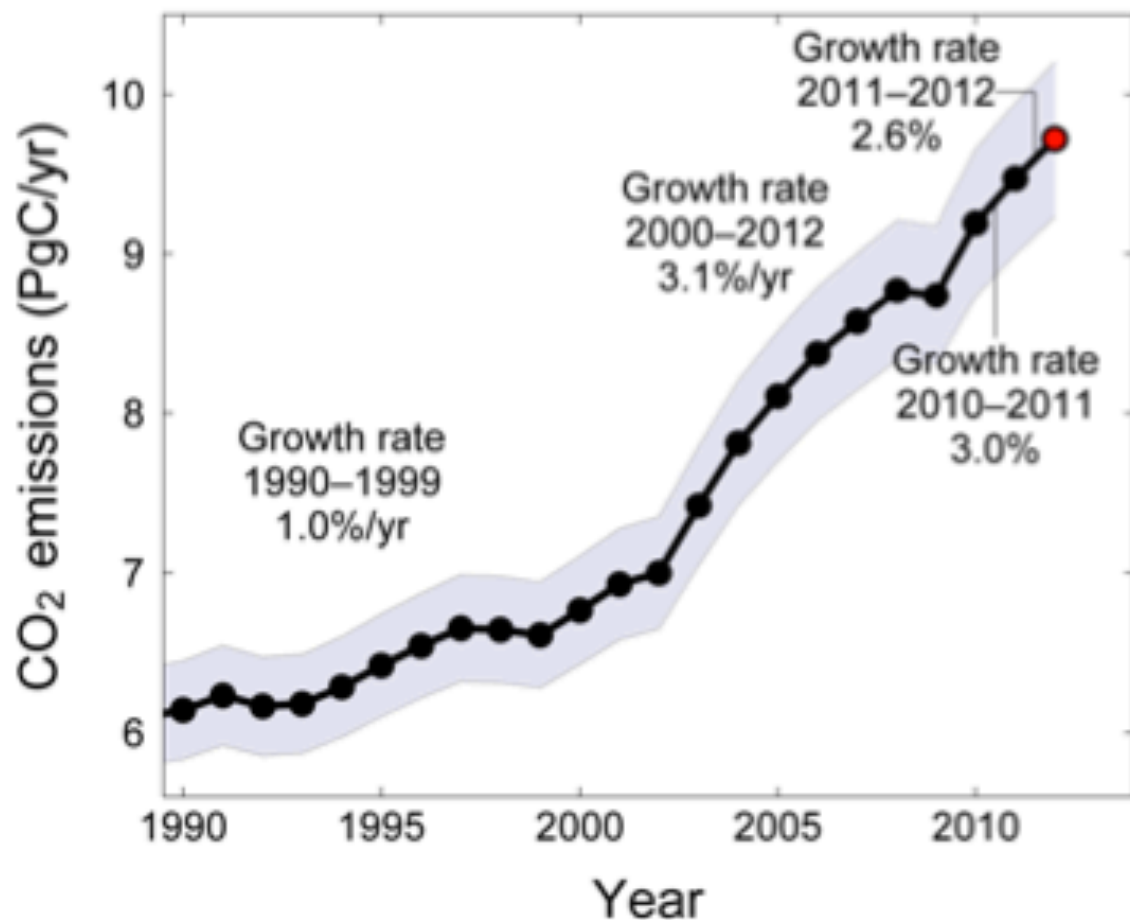




# Fossil and Cement Emissions

Global fossil and cement emissions:  $9.5 \pm 0.5 \text{PgC}$  in 2011, 54% over 1990

Projection for 2012:  $9.7 \pm 0.5 \text{PgC}$ , 58% over 1990



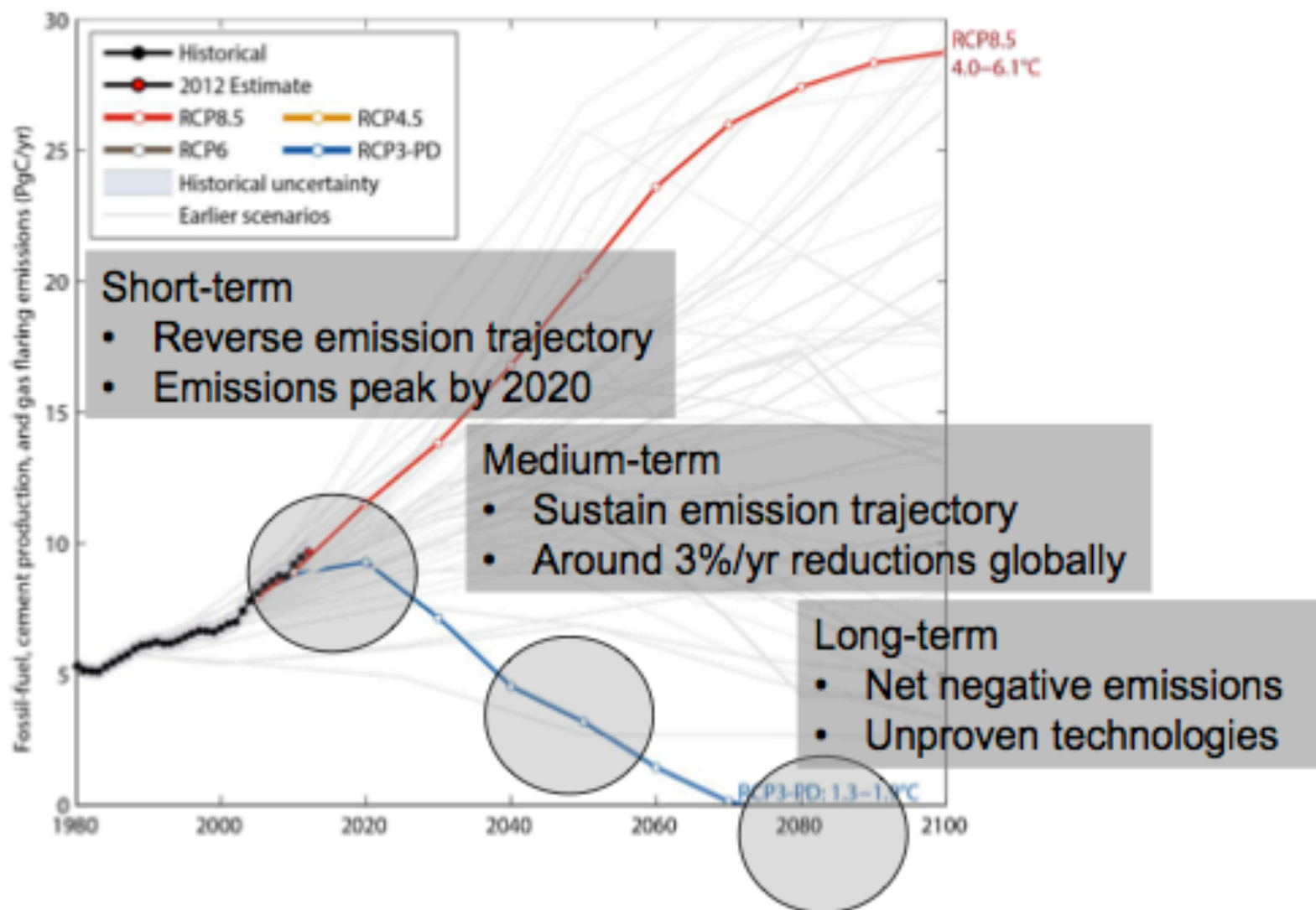
Uncertainty is  $\pm 5\%$  for one standard deviation (IPCC "likely" range)

Source: [Peters et al. 2012a](#); [Le Quéré et al. 2012](#); [CDIAC Data](#); [Global Carbon Project 2012](#)

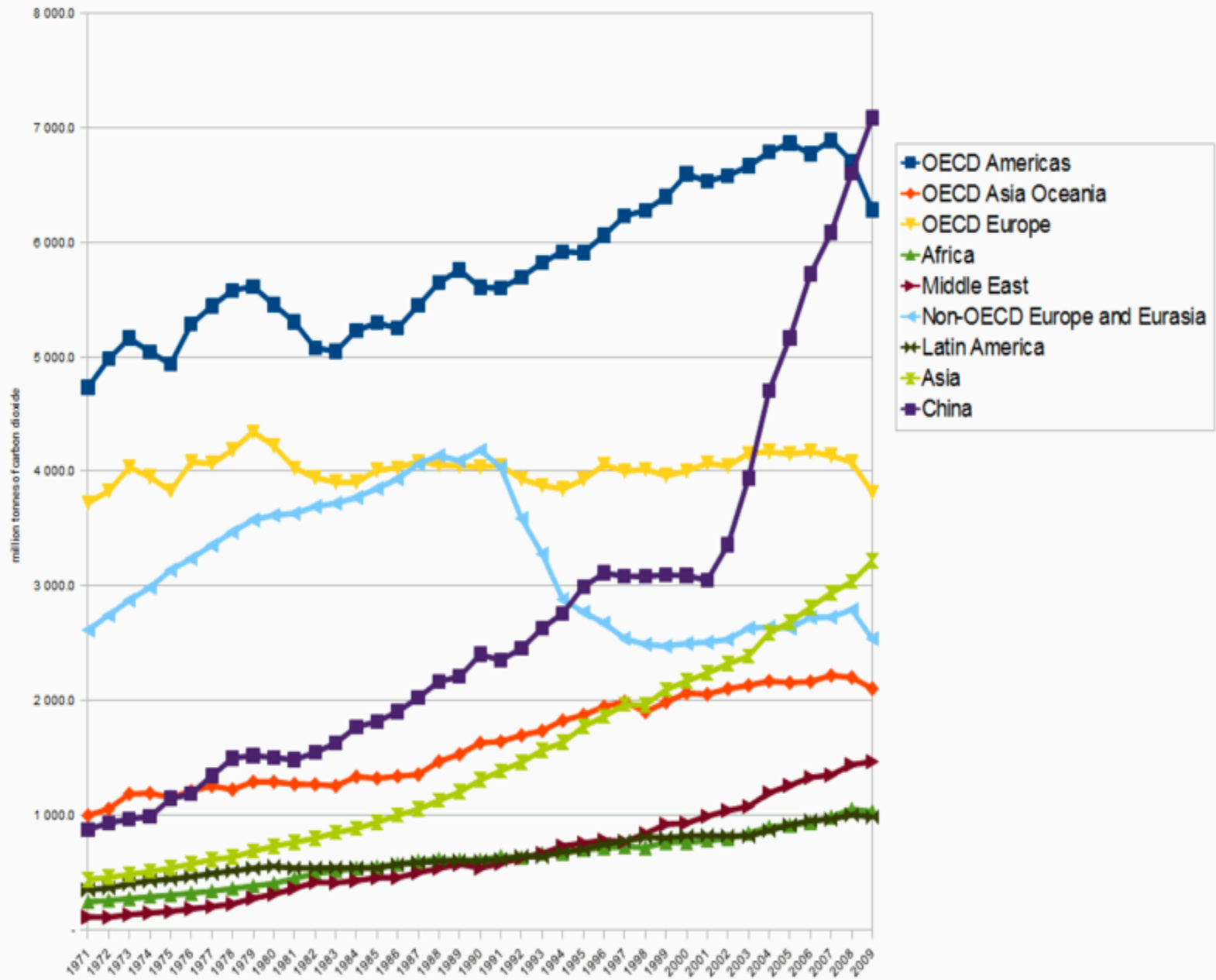


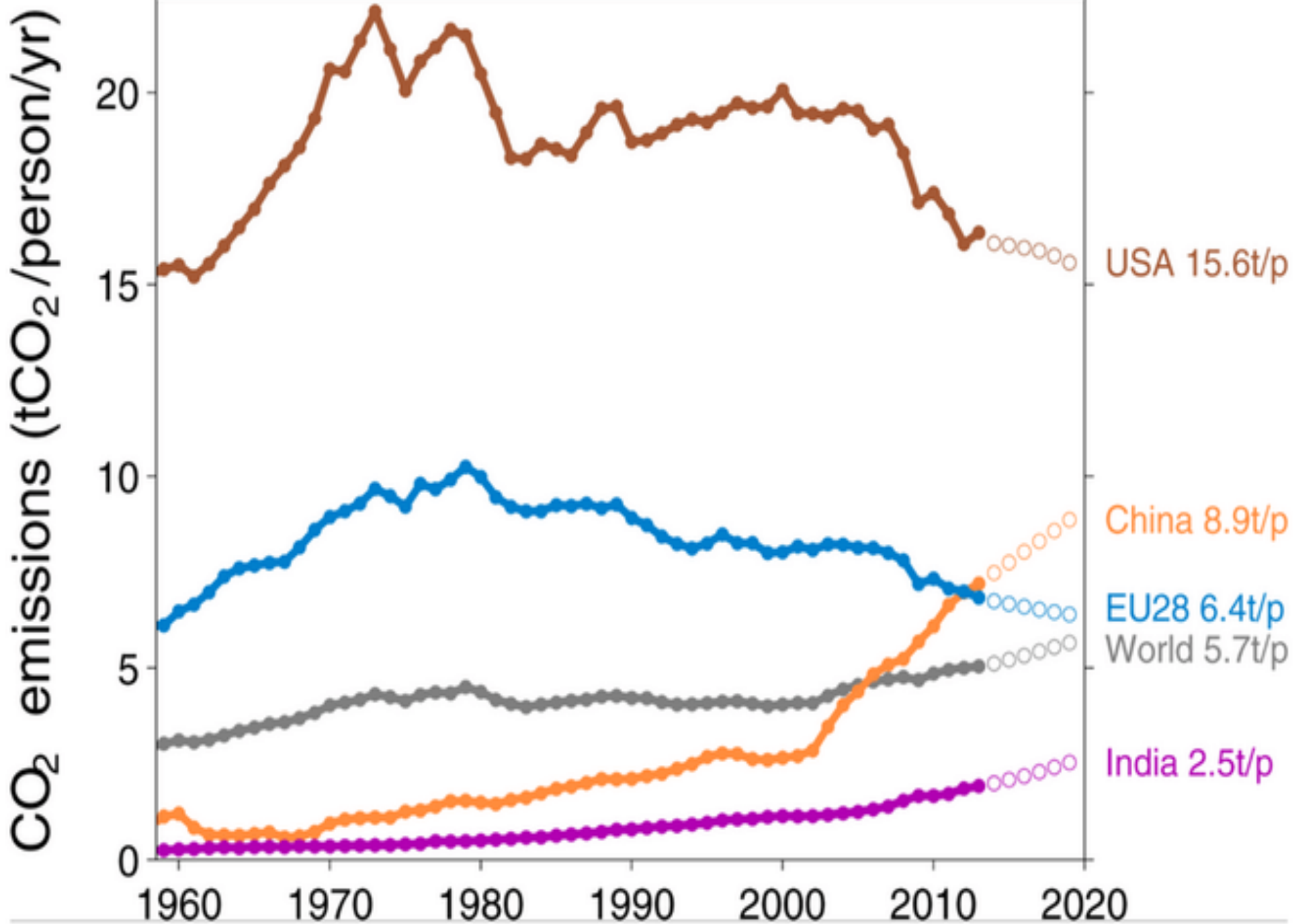
# Challenges to keep below 2°C

An emission pathway with a "likely chance" to keep the temperature increase below 2°C has significant challenges

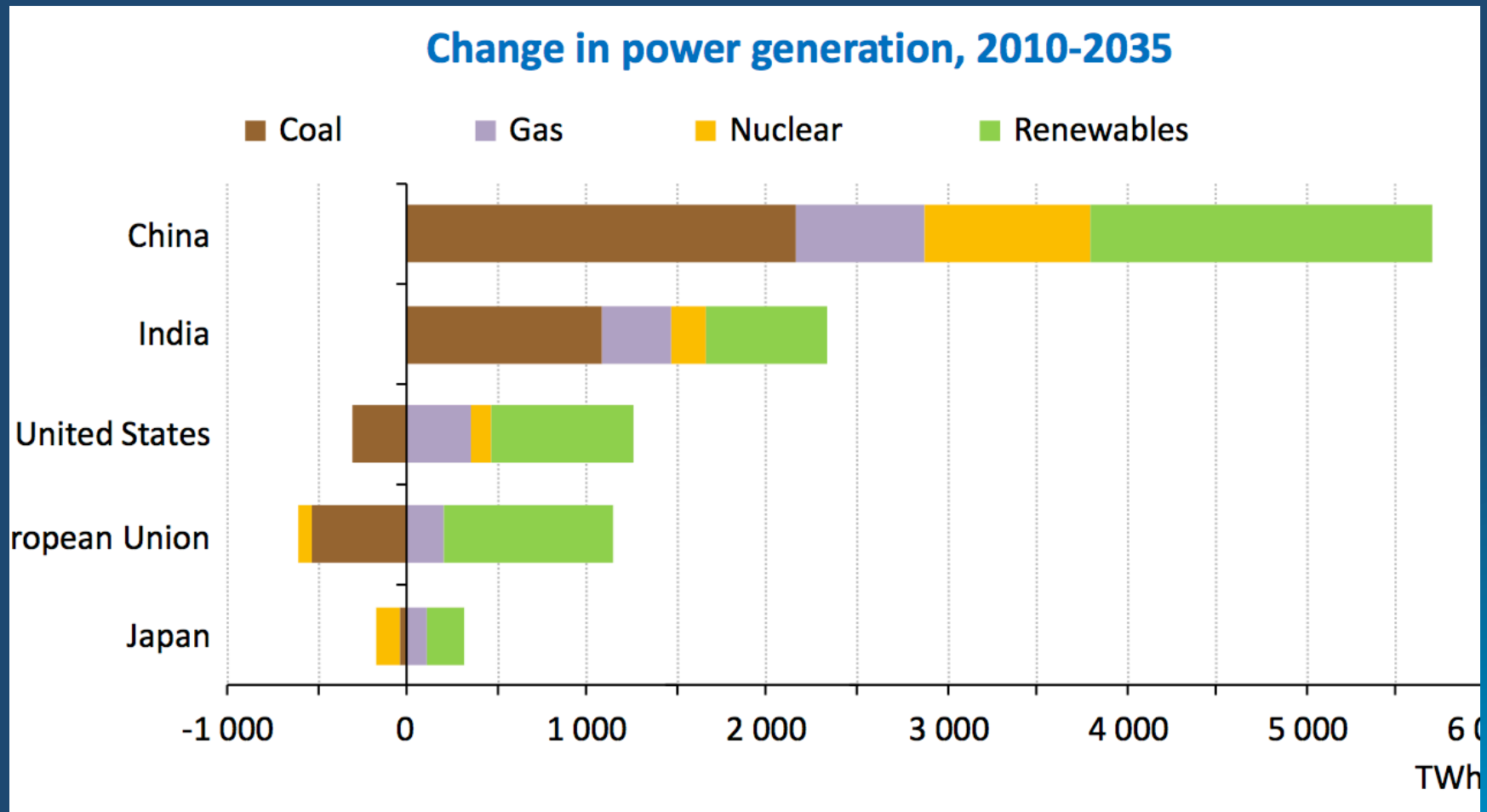


Annual regional carbon dioxide emissions from fuel combustion between 1971-2009





# China investing in renewable energy

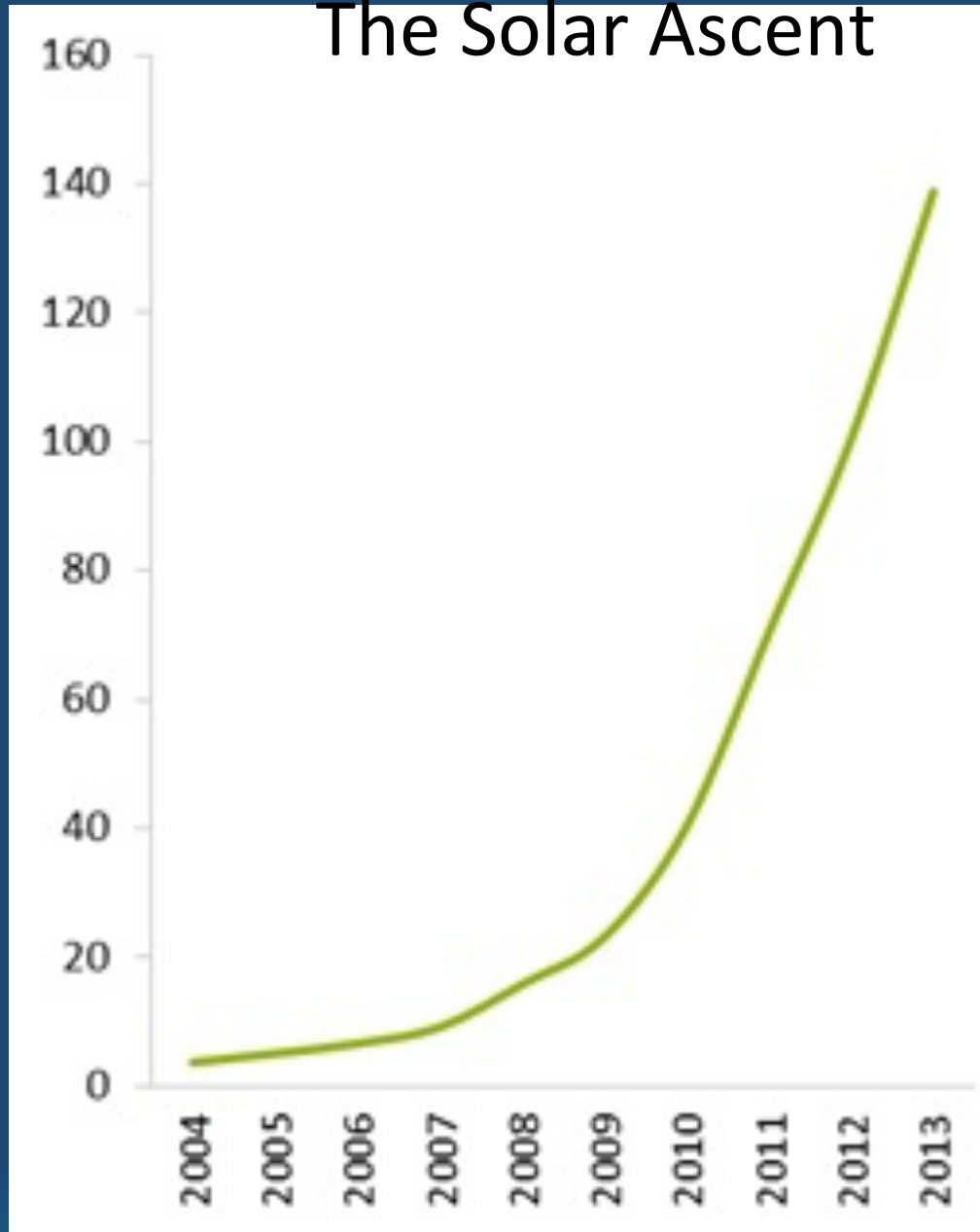


## Market Capitalization of American Coal Companies (billions)

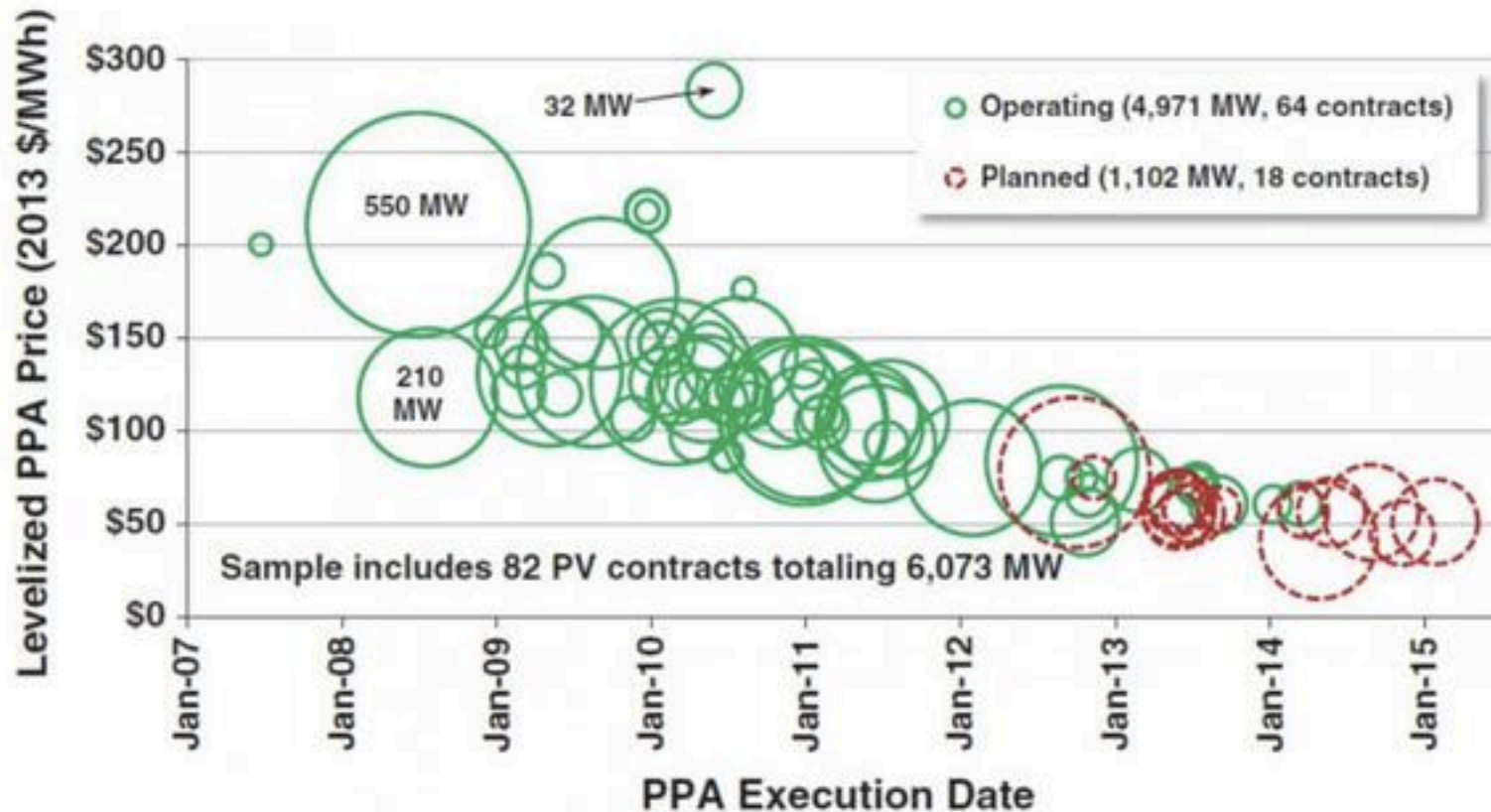




# The Solar Ascent



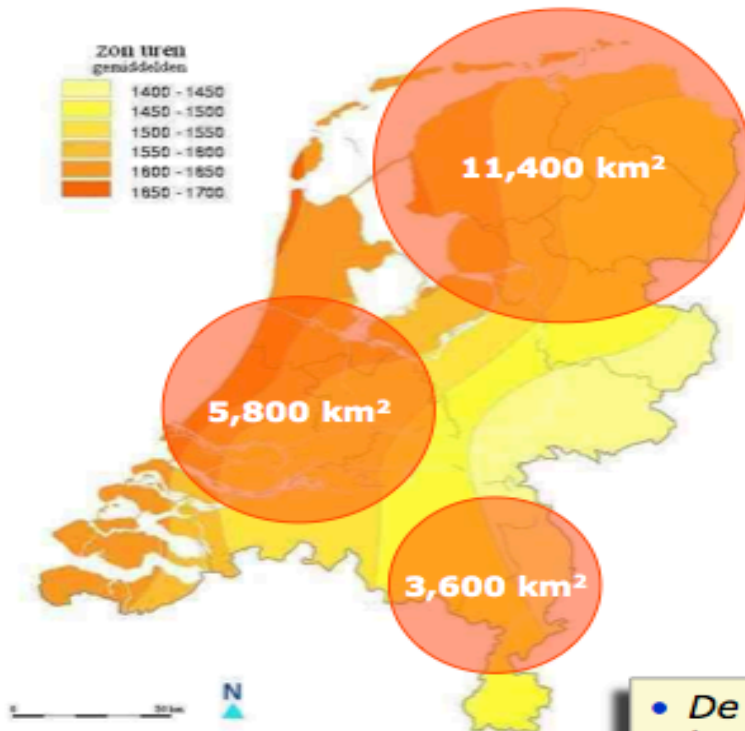
Cumulative Global Installations in Gigawatts



**Figure 1.** Levelized US utility-scale photovoltaic power purchase agreement (PPA) prices by operational status and PPA execution date.

# Ruimte beslag zonnepanelen als we voor heel nederland met zon pv in onze energie willen voorzien, nog zonder opslag capaciteit

## Het ruimtebeslag van zonne-energie



### Hoe groot is het ruimtebeslag van 100 GW gemiddeld opwekvermogen met vaste panelen?\*

	2010	2050?	2050?
Lichtinval per m <sup>2</sup>	110 W	110 W	110 W
PV-dichtheid	40%	45%	50%
PV-efficiency	20%	35%	50%
Ruimtebeslag	11,400	5,800	3,600

\* Op basis van een capaciteitsfactor van 11% en een invallend piekvermogen van 1,000 W

- De huidige leveringszekere energiebehoefte in Nederland is circa 150 GW
- De conclusie is dat Nederland bij een zelfvoorziening van 67% circa 3,600 km<sup>2</sup> aan zonneakkers nodig heeft.

# Toenemende hoogte en vermogen van windturbines

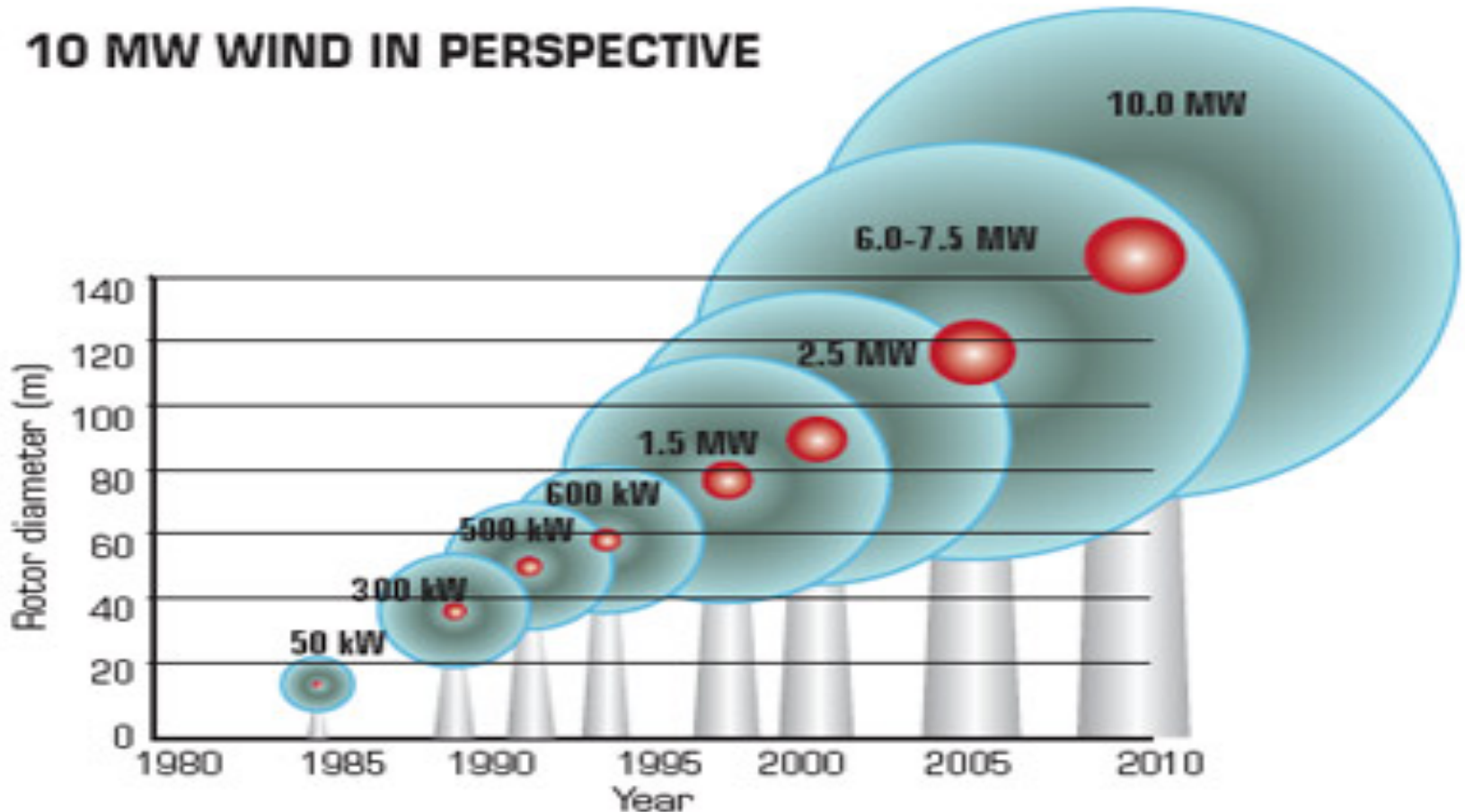
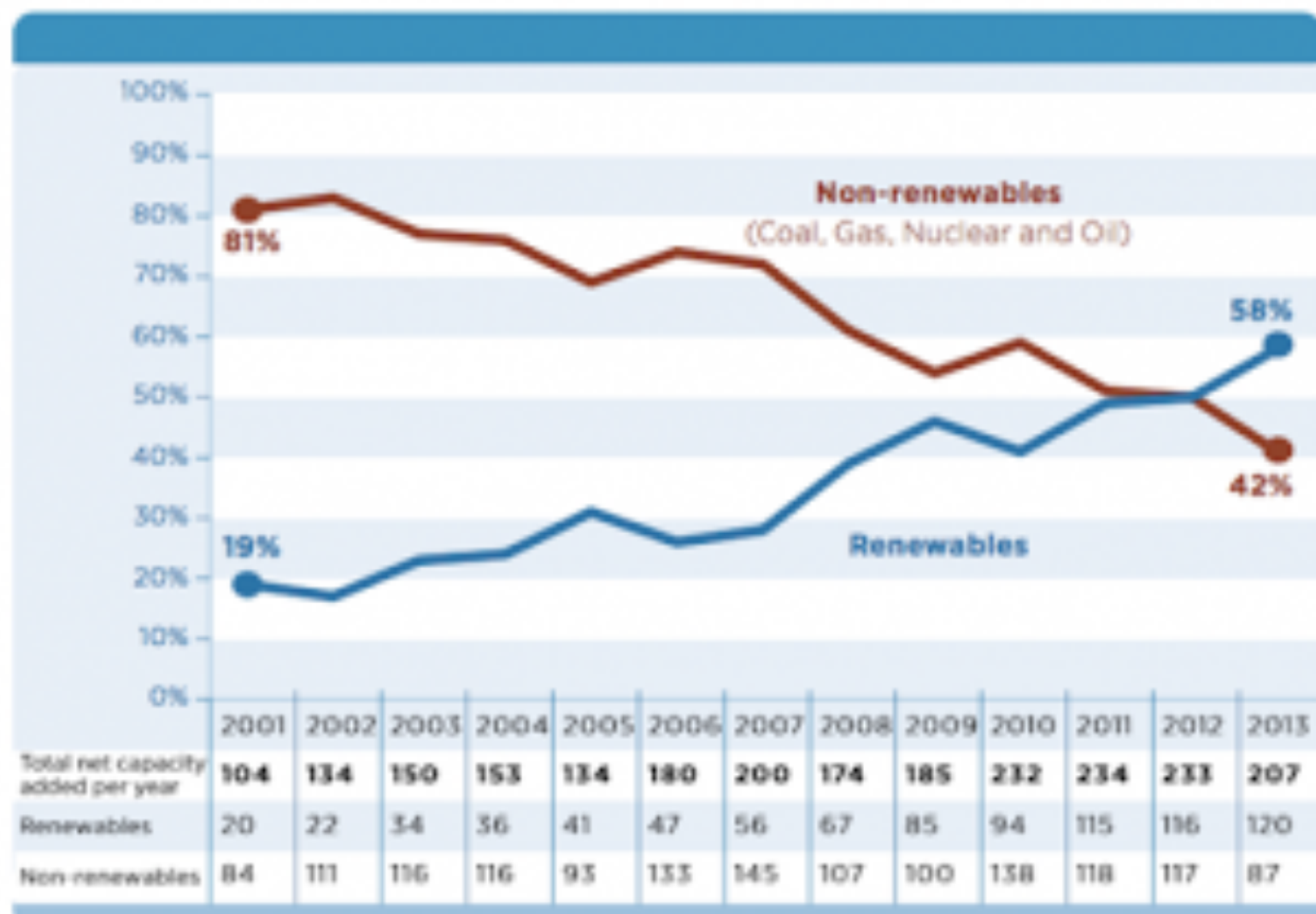


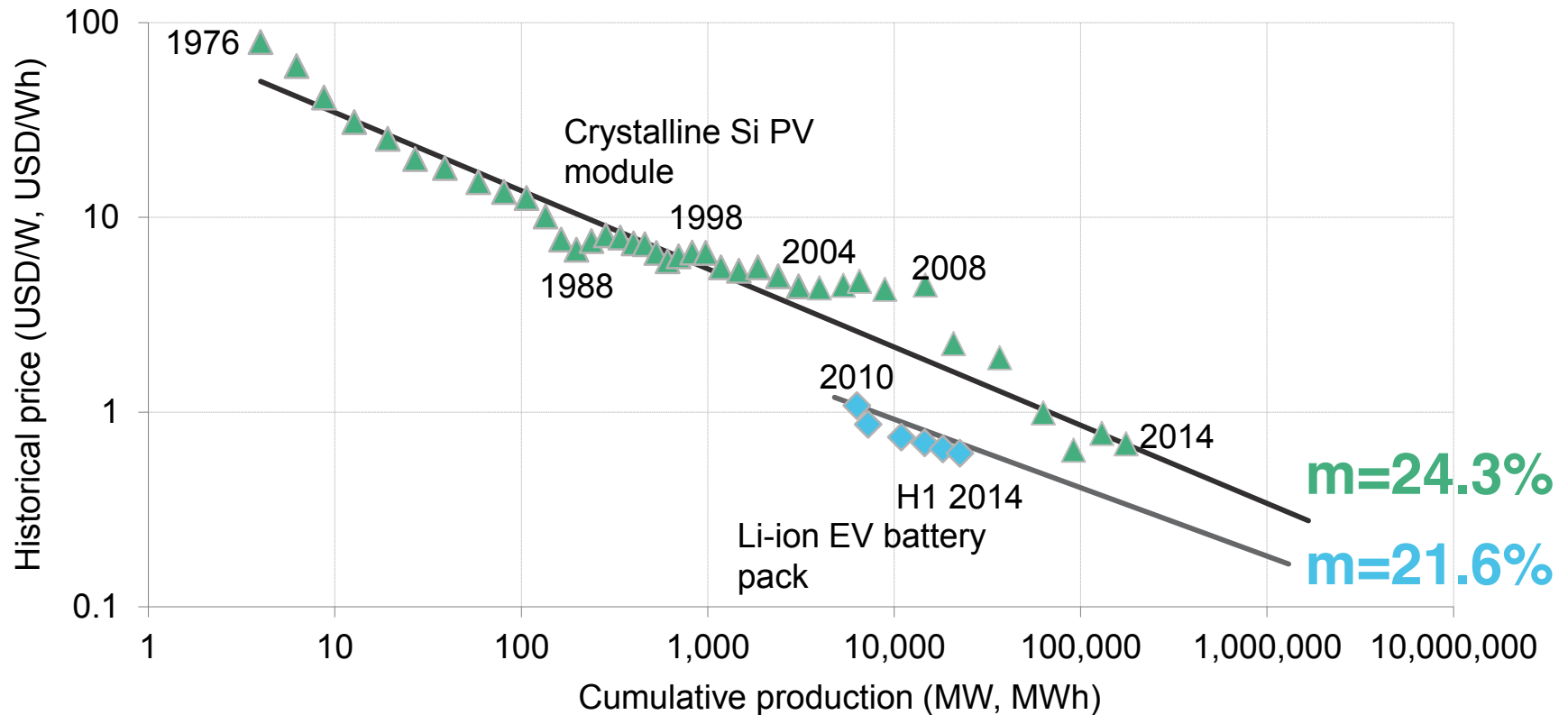
Figure 4: Renewables as a share of global capacity additions (2001-2013)



Source: IRENA database



# Li Ion Battery Experience Curve Compared with PV Experience Curve



Note: Prices are in real (2014) USD.

Source: Bloomberg New Energy Finance, Maycock, Battery University, MIT

## Fossil fuel divestment

Keep it in the ground

# Institutions worth \$2.6 trillion have now pulled investments out of fossil fuels

Coalition of 2,000 individuals and 400 institutions are shifting assets from coal, oil and gas companies to tackle climate change

Damian Carrington and  
Emma Howard

Tuesday 22 September 2015 16.26 BST



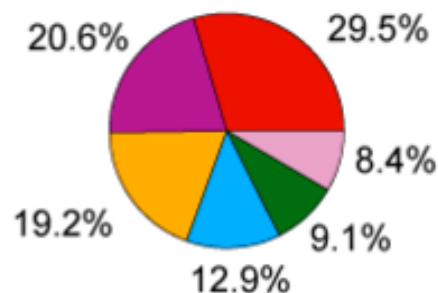
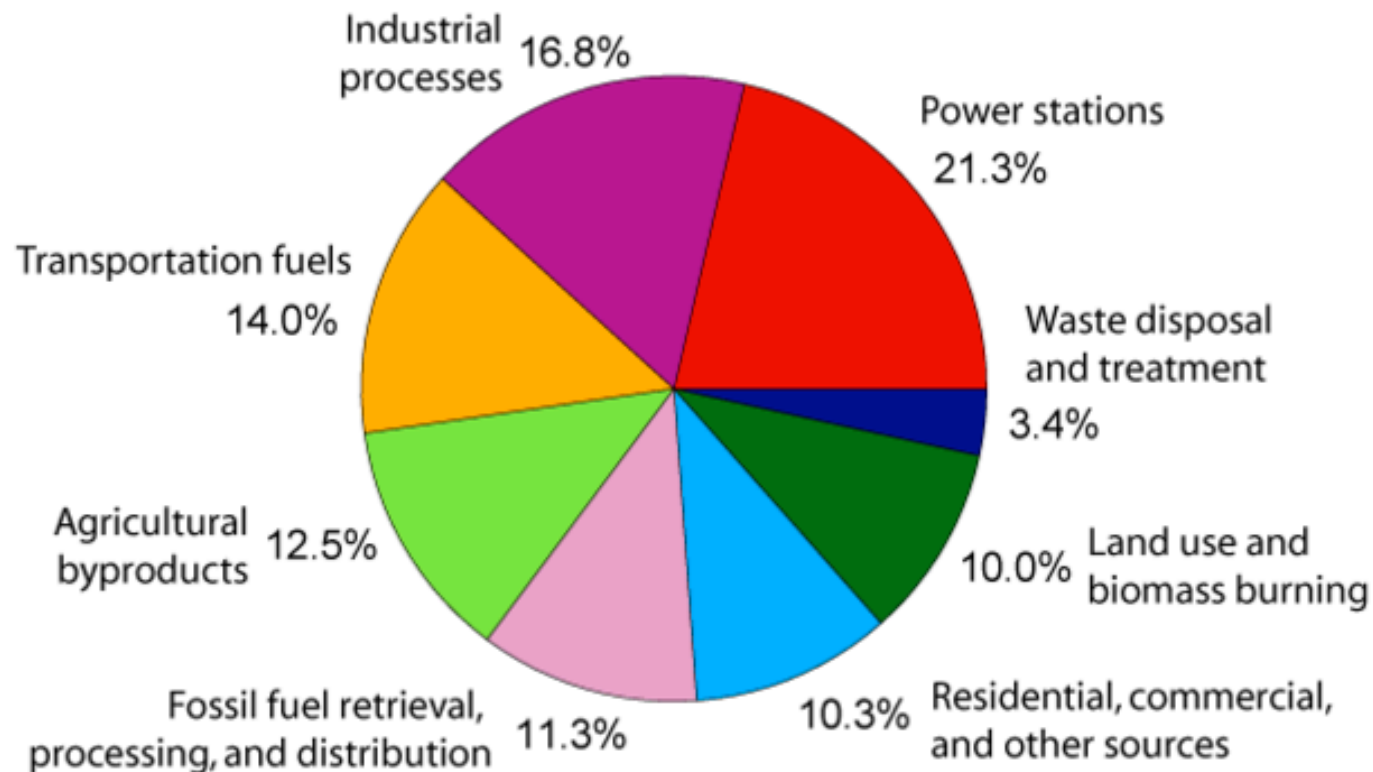
Shares  
16,882

Comments  
94

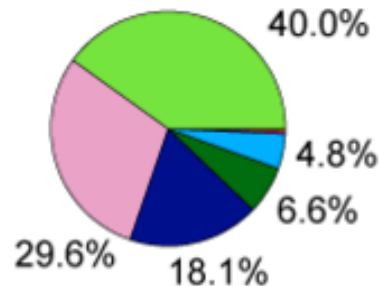


📷 Leonardo DiCaprio on a climate change march in New York in 2014. The actor has committed to divesting his money from fossil fuels. Photograph: Eduardo Munoz/Reuters

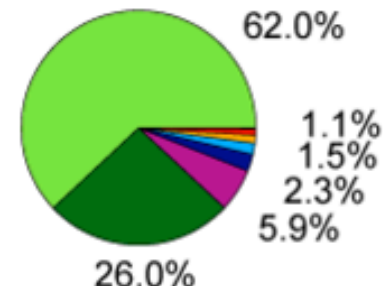
# Annual Greenhouse Gas Emissions by Sector



**Carbon Dioxide**  
(72% of total)



**Methane**  
(18% of total)



**Nitrous Oxide**  
(9% of total)

# 2015 towards Paris Climate Summit

- New renewable energy power plants produce electricity at lower cost per kwh than new fossil fuel power plants;
- Major losses of total stock market value of major USA and EU coal power companies: 50 up to 90 percent in the last four years;
- Stock market value of major international oil companies is falling as OPEC kartel is not effective;
- Call for divestment in fossil fuels takes effect;
- Electric cars are introduced by major international ict companies, ict companies that have surpassed the oil companies in total stock market value.



# Additional benefits of transition towards renewable energies are increasingly recognized

1. Air pollution and health;
2. Geo political aspects of energy security and financial flows;
3. Jobs and international economic competition;
4. Regional and local cohesion through decentral renewable energy systems;

# Paris 2015

- From top down national targets and time tables such as Kyoto Protocol towards bottom-up national, regional, public and private voluntary contributions, without sanctions;
- From a binding agreement on emissions with sanctions towards a voluntary “pledge” mechanism with monitoring and periodic review;
- From cooperation based on responsibilities towards cooperation based on national opportunity's and international competition;
- Paris: too little too late to keep global average temperature rise below two degrees; still the Paris summit will act as an accelerator of the introduction of renewable energy world wide; A review of INDC (intended nationally determined contributions) to occur within 5 years.
- After Paris scientific and political attention will increasingly go beyond fossil fuel emissions, toward emissions from agriculture and food.