GEVOLGEN VAN KLIMAATVERANDERING WERELDWIJD

Prof. Nicole van Lipzig

Department Earth and Environmental Sciences

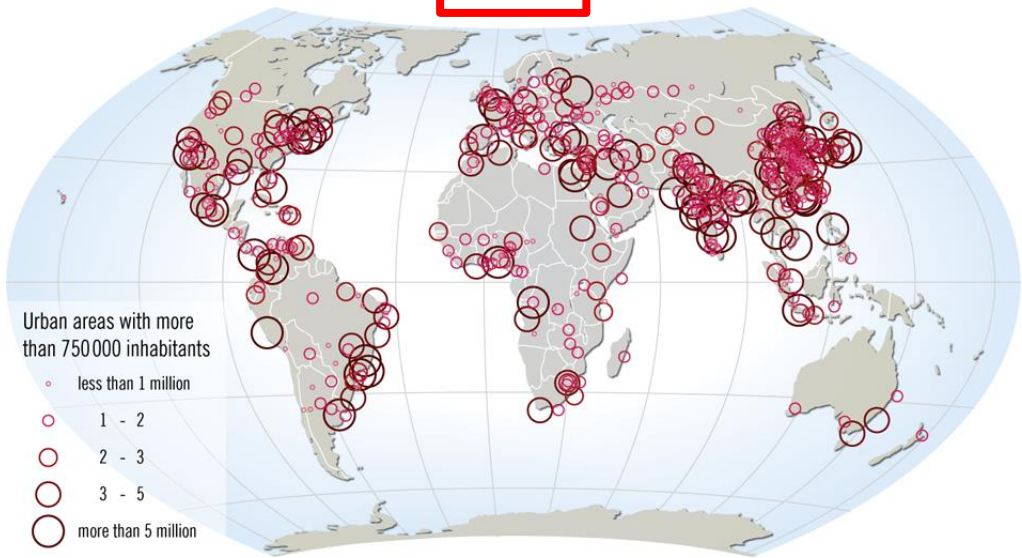
KU Leuven

Ik neem jullie mee op reis…

East Africa

Antarctica

Cities

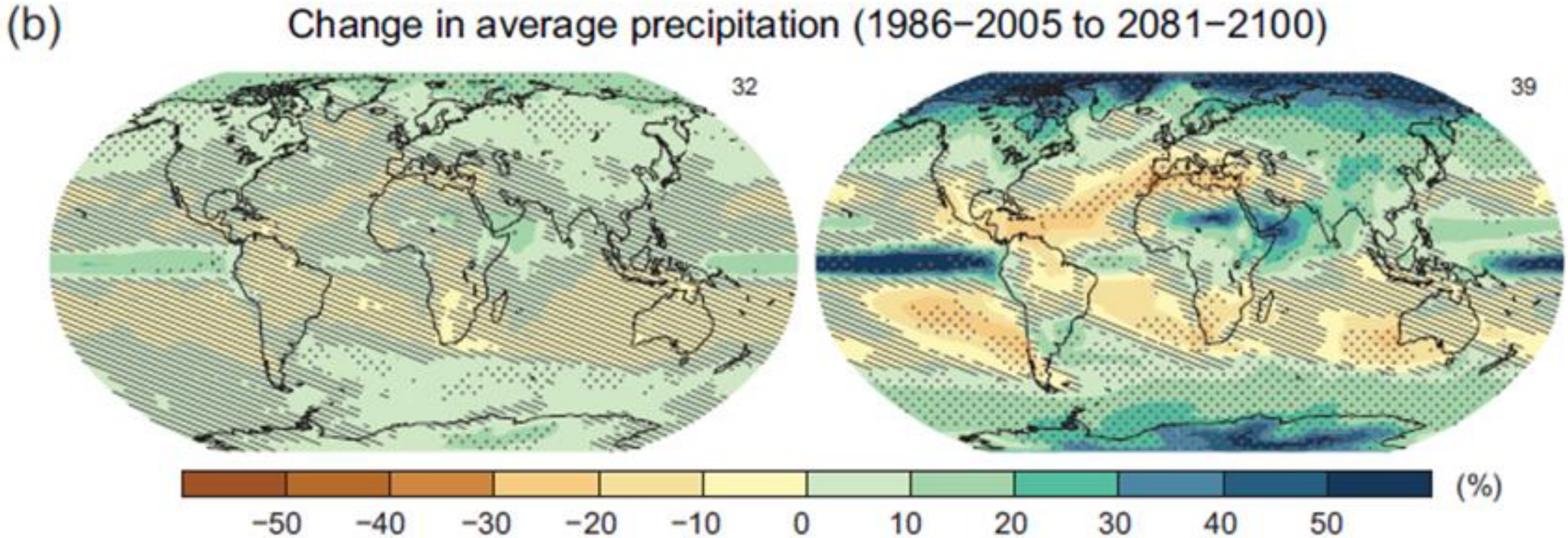


… maar eerst iets meer over regionale impacts

Verschillende impacts

- Hevige neerslag, droogte, hittestress…
- Sommige gebieden worden meer getroffen dan andere gebieden
- Recent zagen we bijvoorbeeld extreme droogte in Zuid-Afrika
- Hoe zit dat nu eigenlijk?

Theewaterskloof Dam

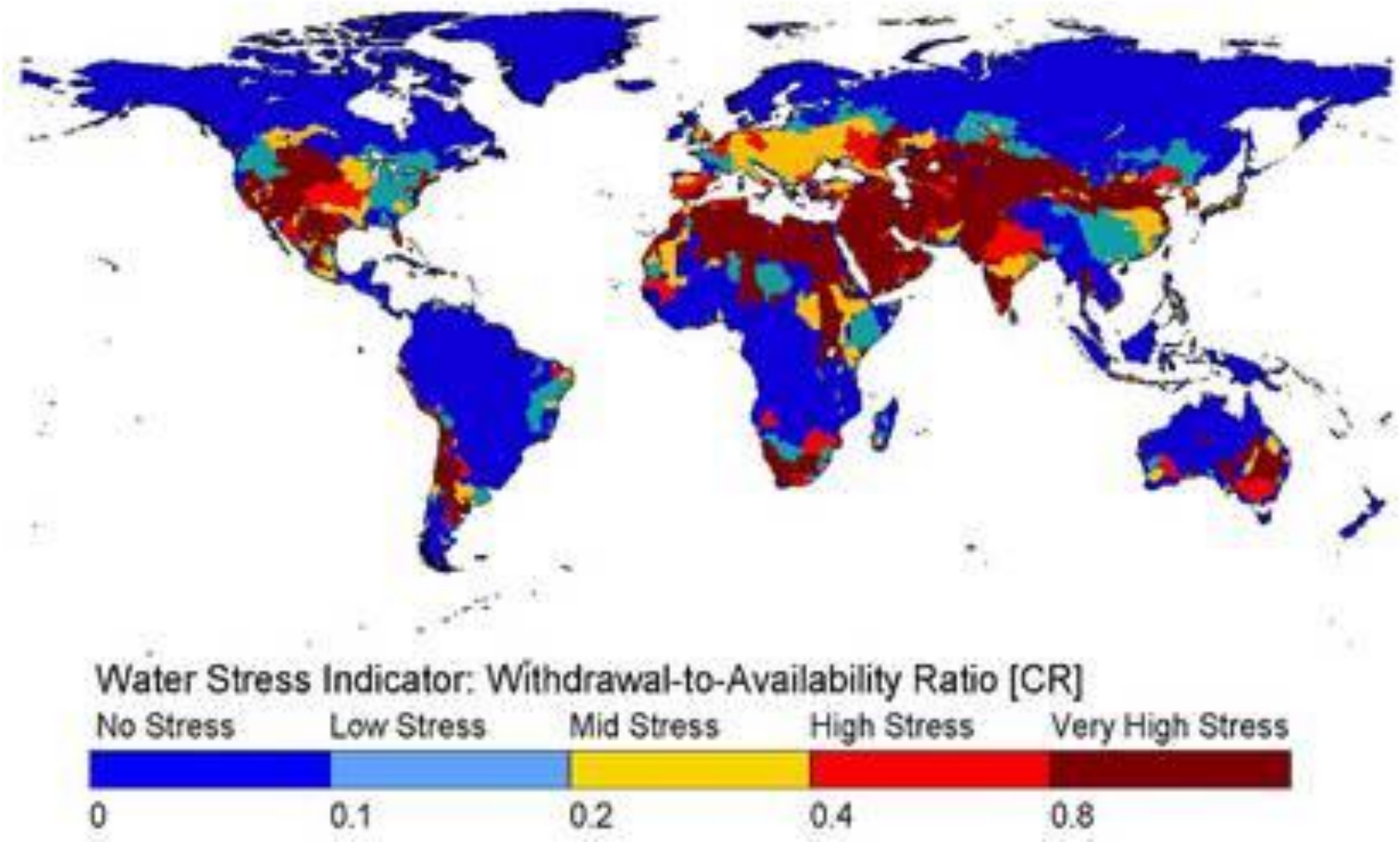


Paris-agreed world versus business as usual CO_2 emissions

Grootste verdroging in gebieden met waterstress

Waterstress: ratio tussen afname van water en beschikbaarheid

- 20e eeuw: bevolking verdriedubbeld; watergebruik verzesdubbeld
- één op de zes mensen geen veilig drinkwater
- zoetwater is gelimiteerd
- Afname in neerslag in gebieden met waterstress
- Zuid-Afrika

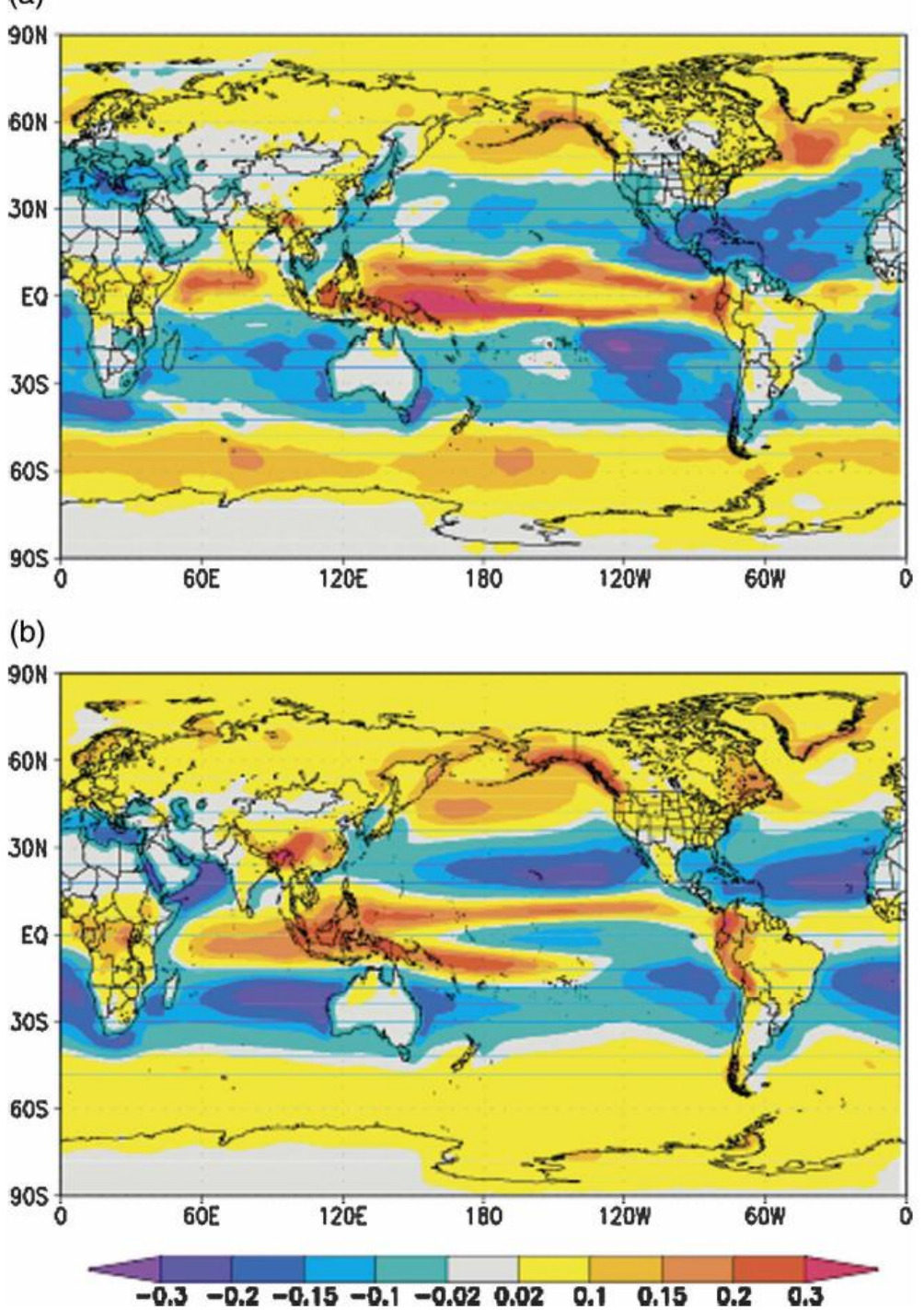


http://www.worldwatercouncil.org

Mechanisme:

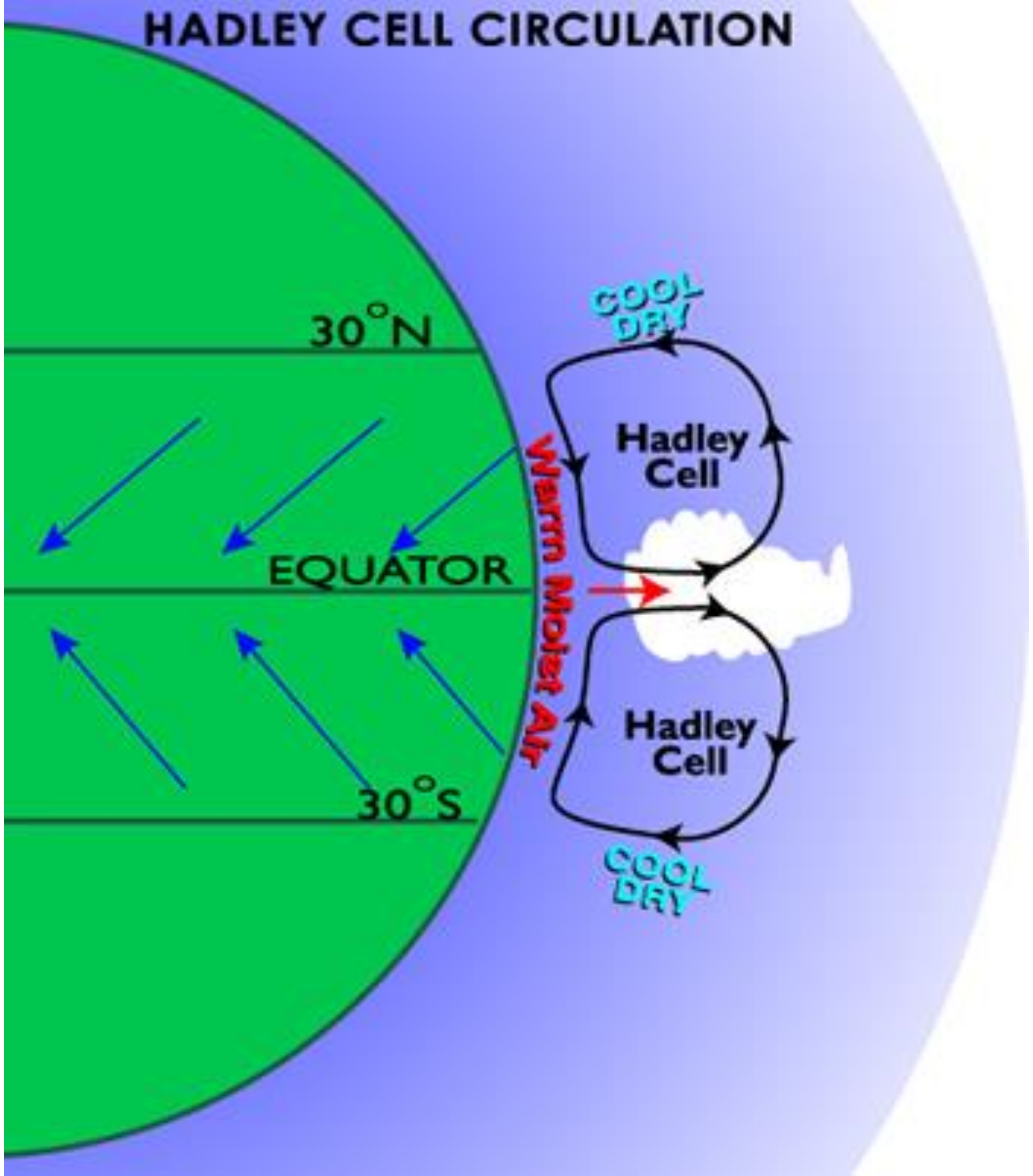
- Warme lucht kan meer vocht bevatten
- We kunnen dit kwantificeren met de Clausius-Clapeyron relatie
- Voor temperaturen op aarde neemt het vocht in de atmosfeer toe met 7% per °C
- Vochttransport is gelijk aan neerslag minus verdamping
- Nulde orde benadering van probleem:

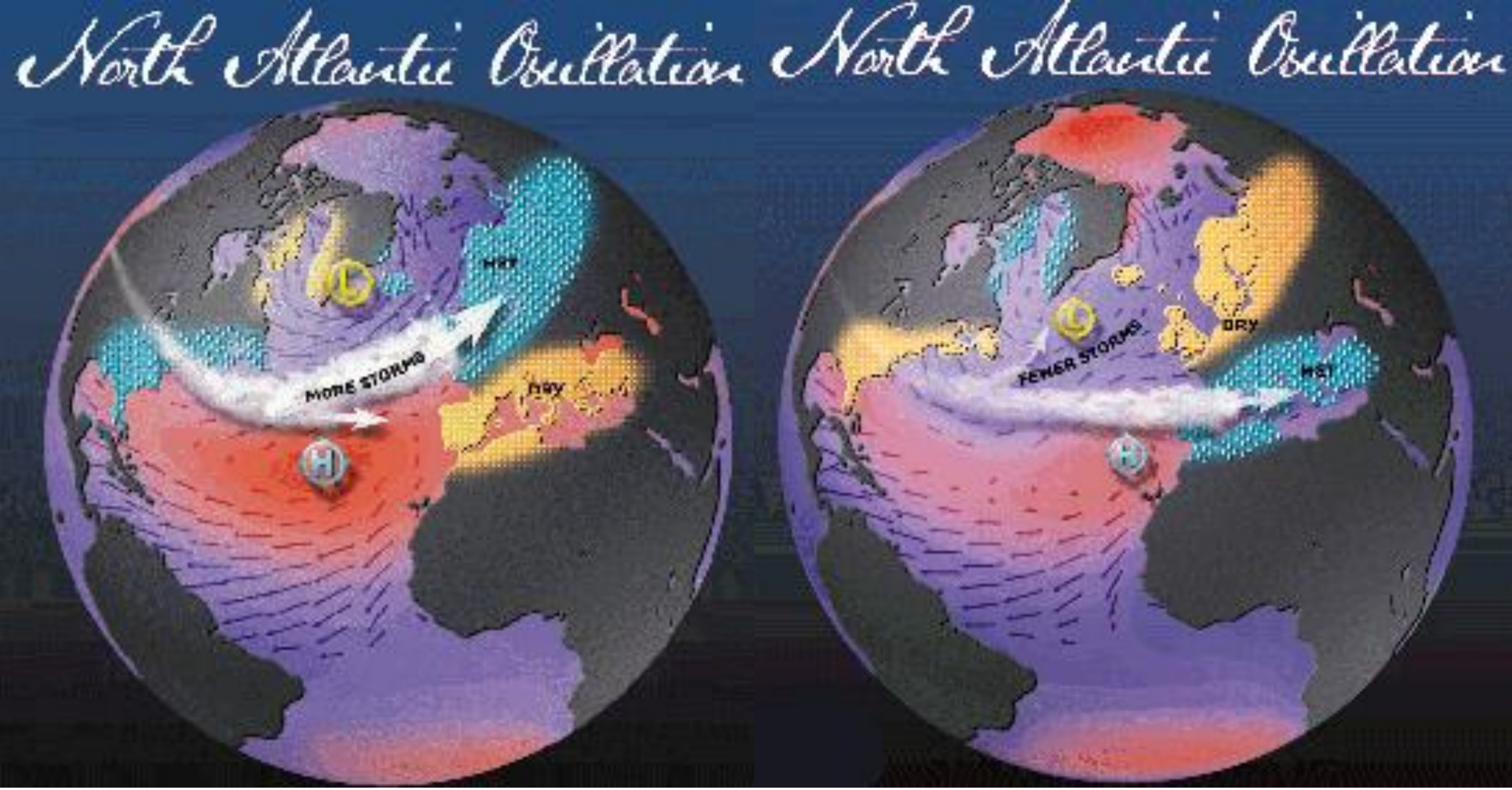
$$\Delta P = 0.07 \cdot \Delta T \cdot (P - E)$$



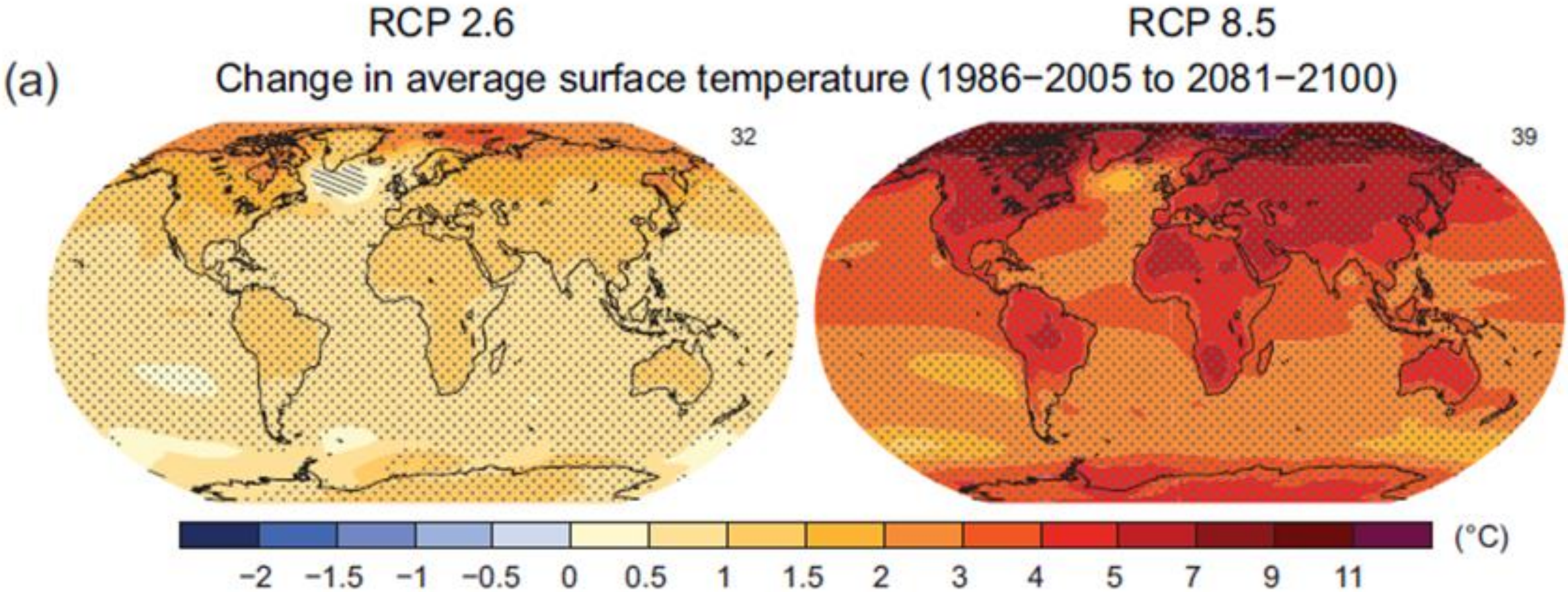
Held en Soden, J. Clim., 2006

- Poolwaartse expansie van:
- Hadley cel
- Subtropische hoge drukgebieden
- Stormbanen




North Atlantic Oscillation
L
H
MORE STORMS
DRY
H
North Atlantic Oscillation
L
H
FEWER STORMS
DRY
H

Ook in temperatuur zijn er grote regionale verschillen



Paris-agreed world versus business as usual CO_2 emissions

Fysische processen verklaren weer het signaal

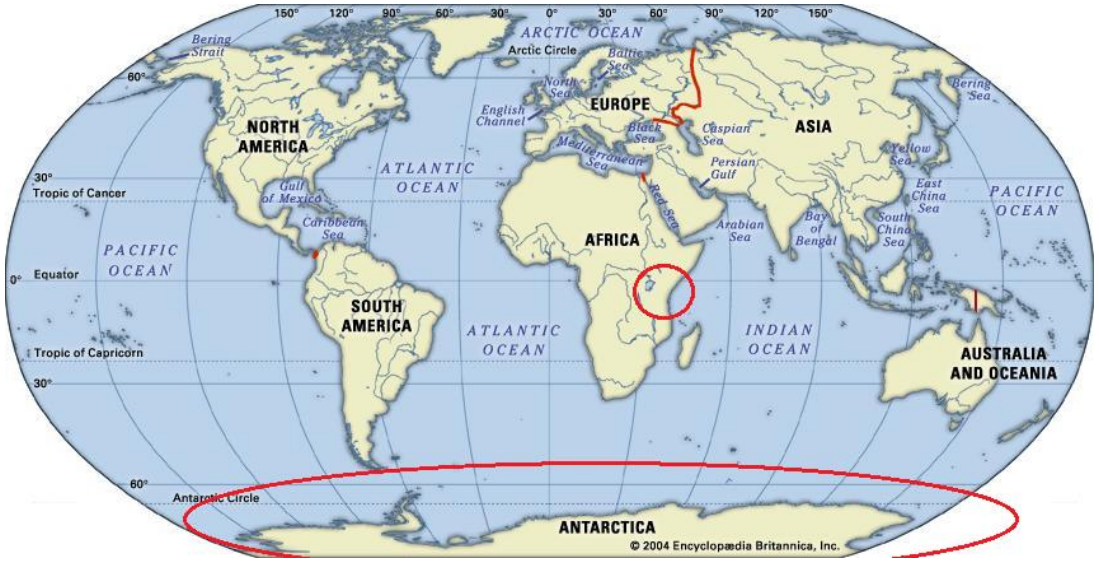
Mondiaal versus lokaal

- Wereldwijde CO_2 uitstoot → Lokaal verschillende impact
- Lokale impact → Wereldwijde gevolgen: Voedselzekerheid, Migratie, Zeeniveau

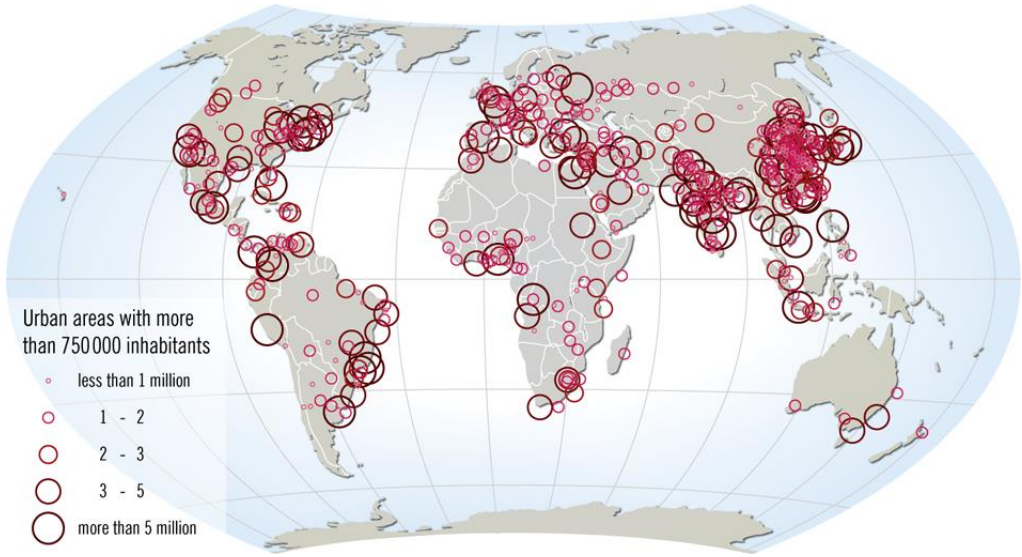
.. Dit brengt ons naar onze eerste bestemming - Antarctica

The Antarctic continent

With N. Souverijns, A. Gossart, M. Demuzere, J.T.M. Lenaerts, B. Medley, I.V. Gorodetskaya, S. Vanden Broucke

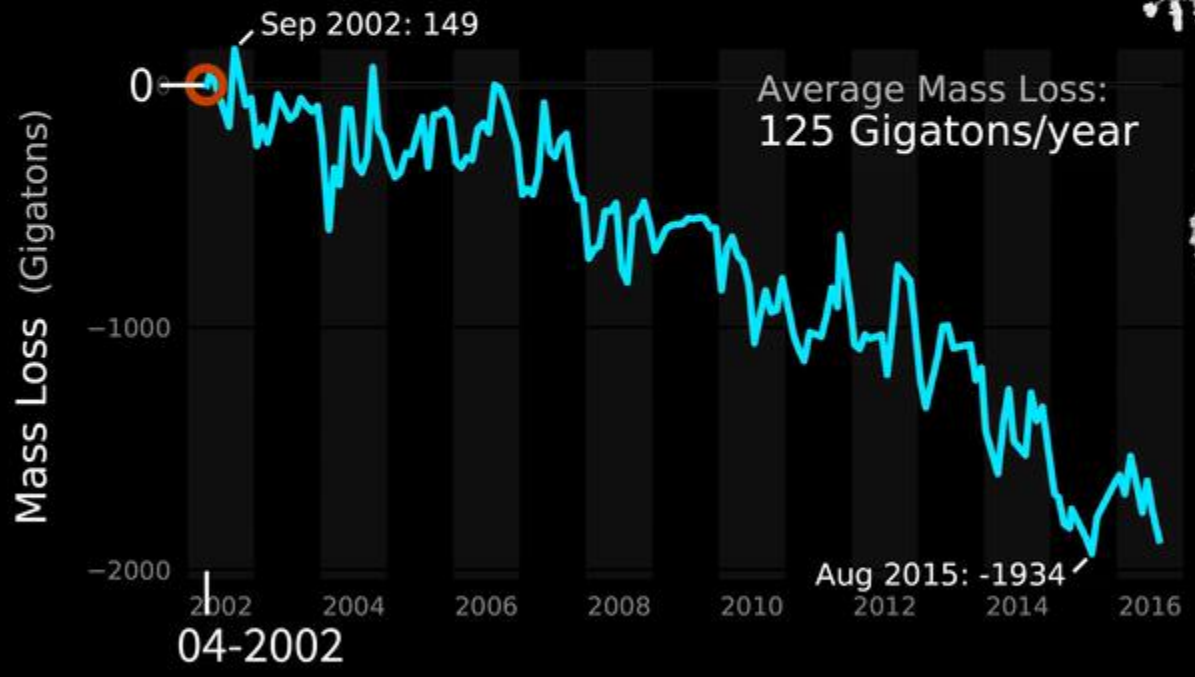


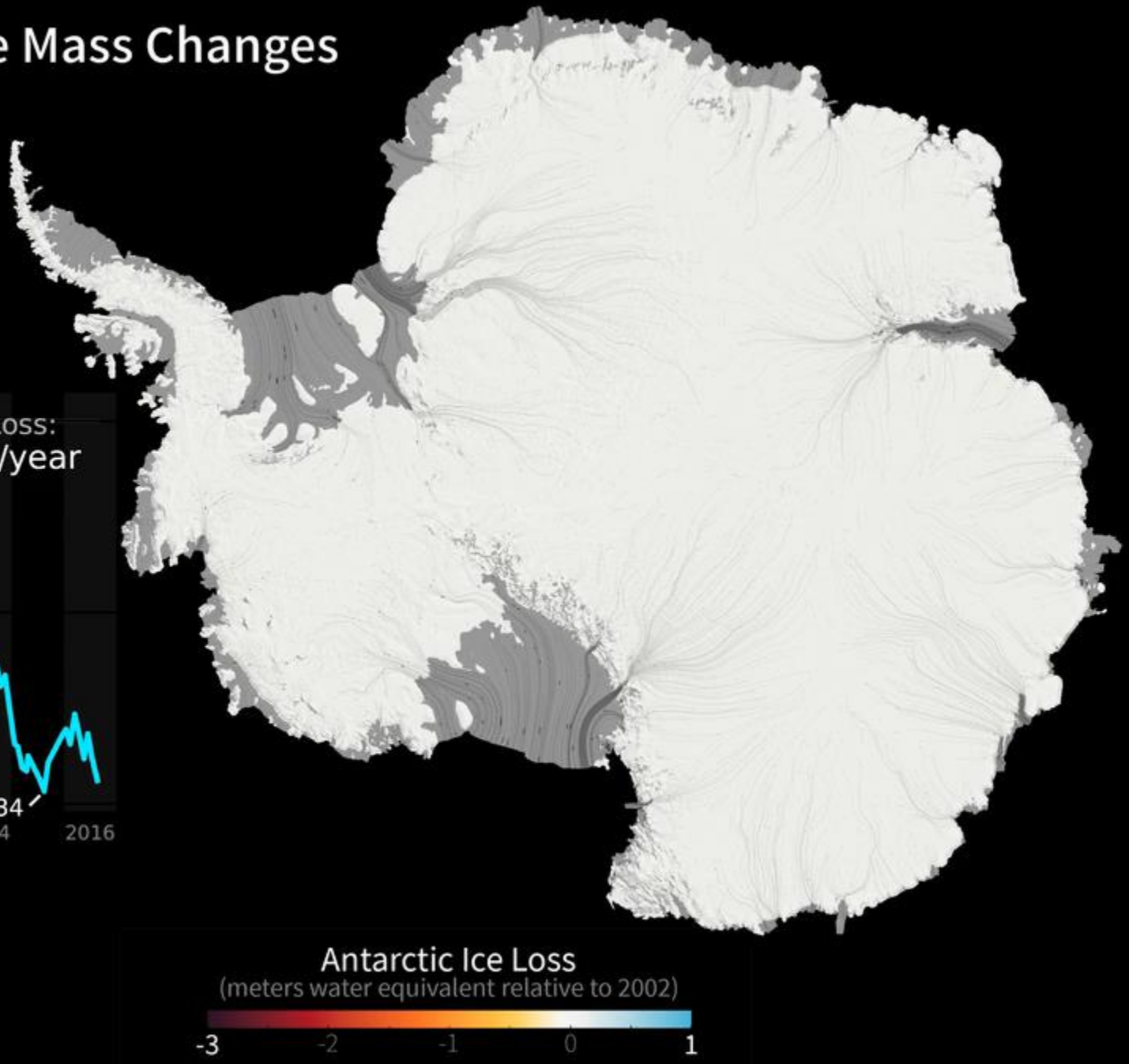
cities



GRACE Observations of Antarctic Ice Mass Changes

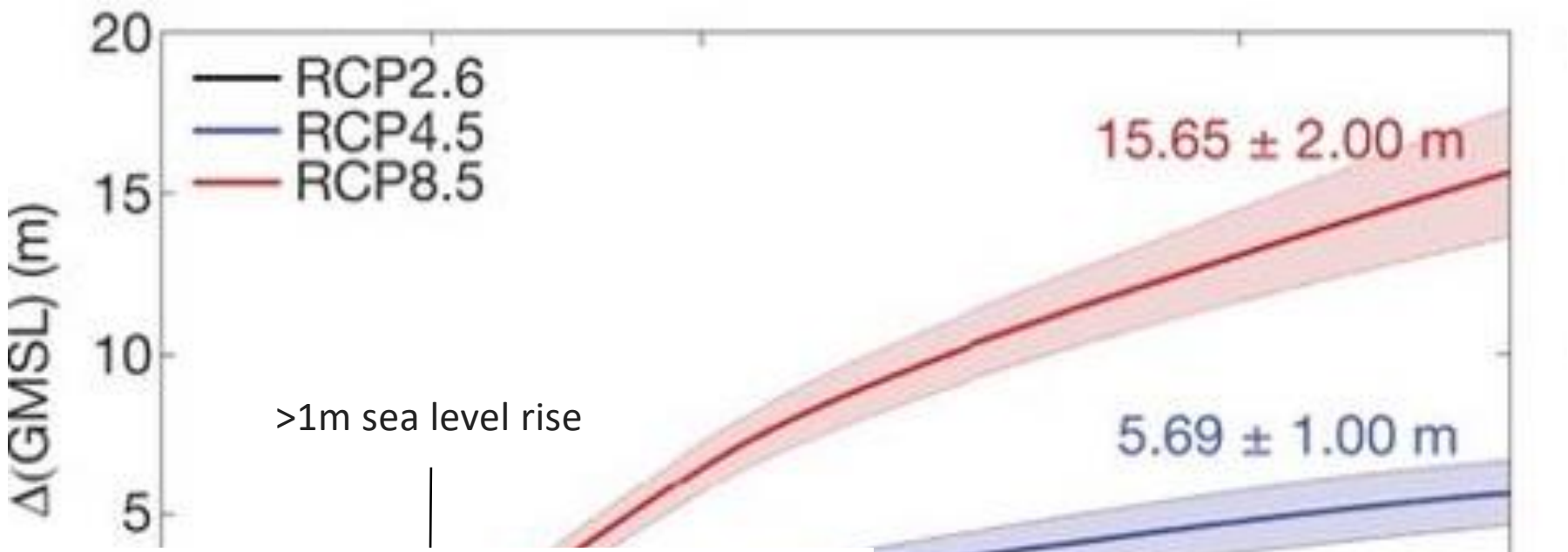
1.5 times area of Europe
61% percent of all fresh water
equivalent to about 58 m of sea-level rise
Question: why increasing mass in some parts?



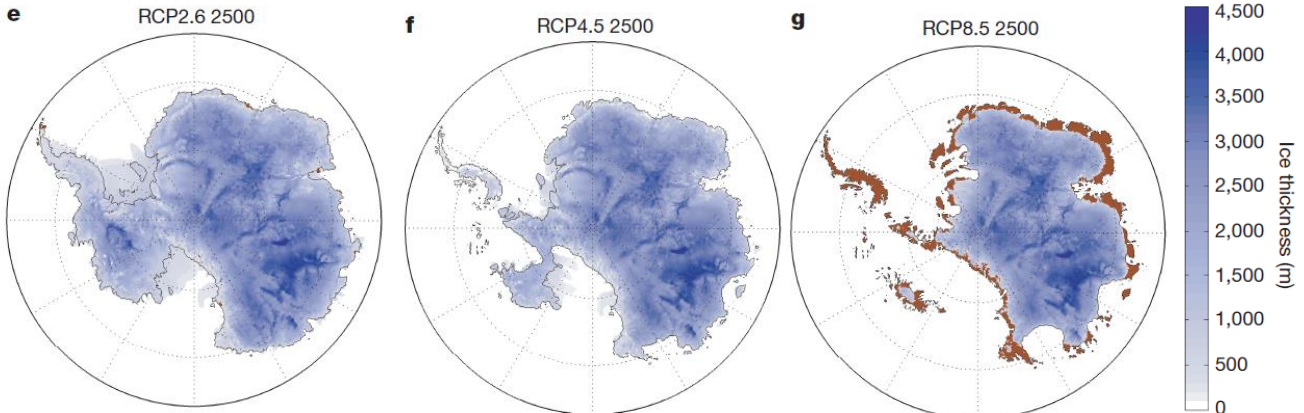


De ijskap heeft potentieel een zeer grote invloed op ons zeeniveau…

Antarctic contribution to sea-level rise



>1m sea level rise

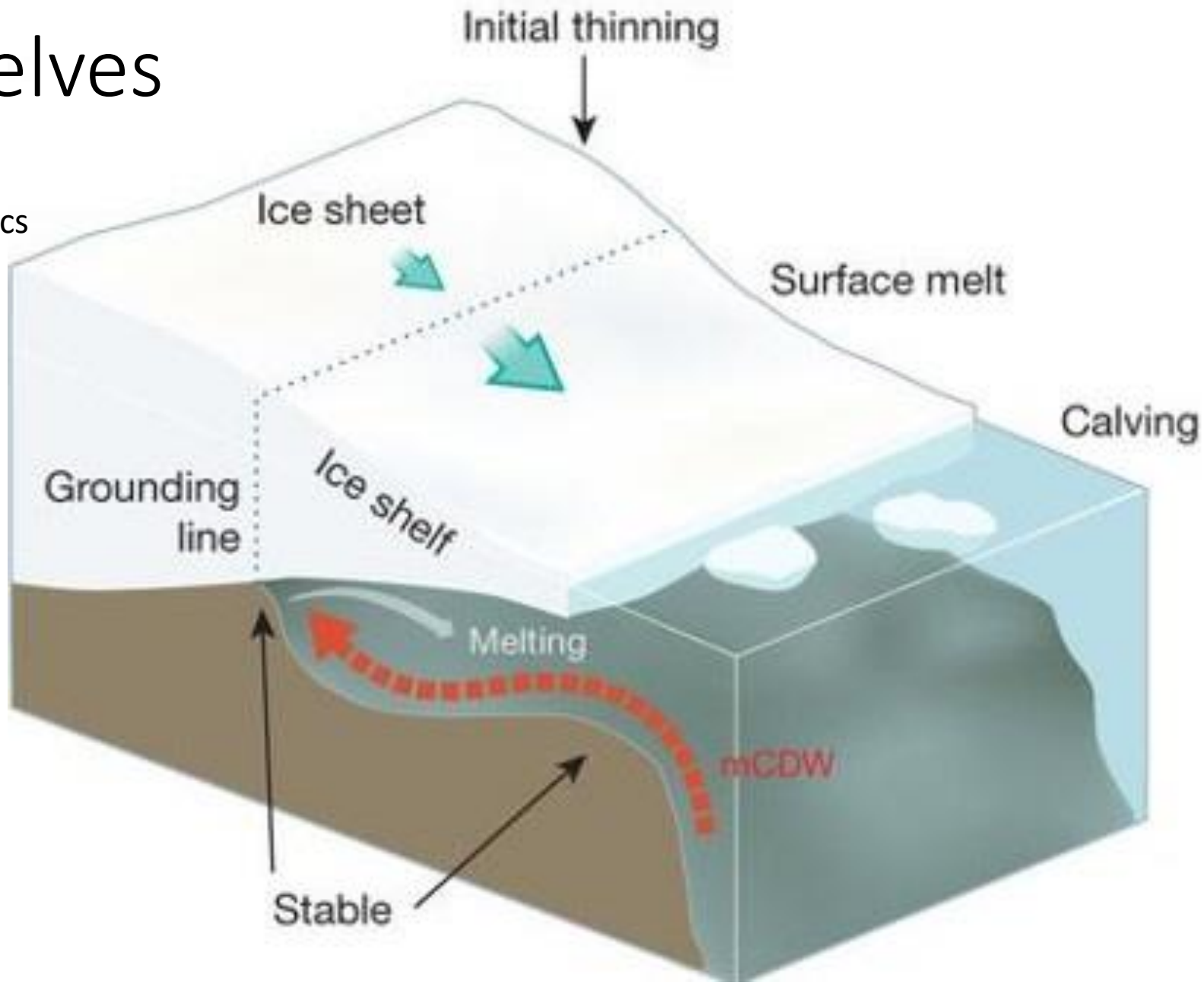


DeConto and Pollard Nature 2016

Ijsplaten spelen een cruciale rol…

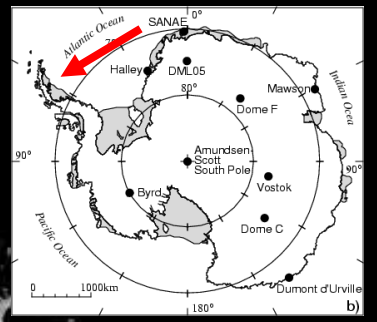
Role of ice shelves

Melt from below and above
Buttressing effect on ice dynamics



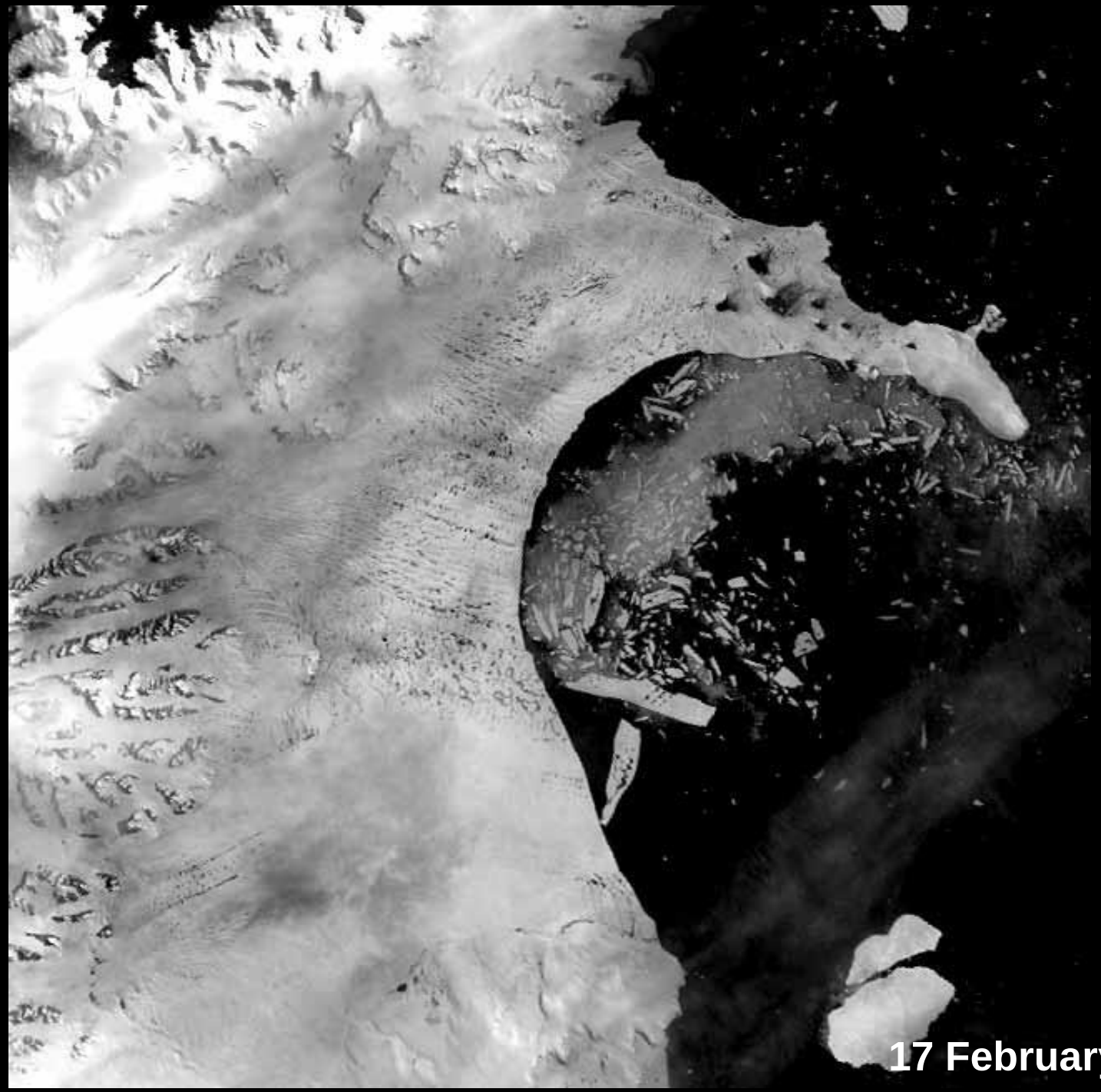
Ijsplaten smelten van beneden
en van boven
Twaits glacier eerder van onder
Lasten eerder van boven

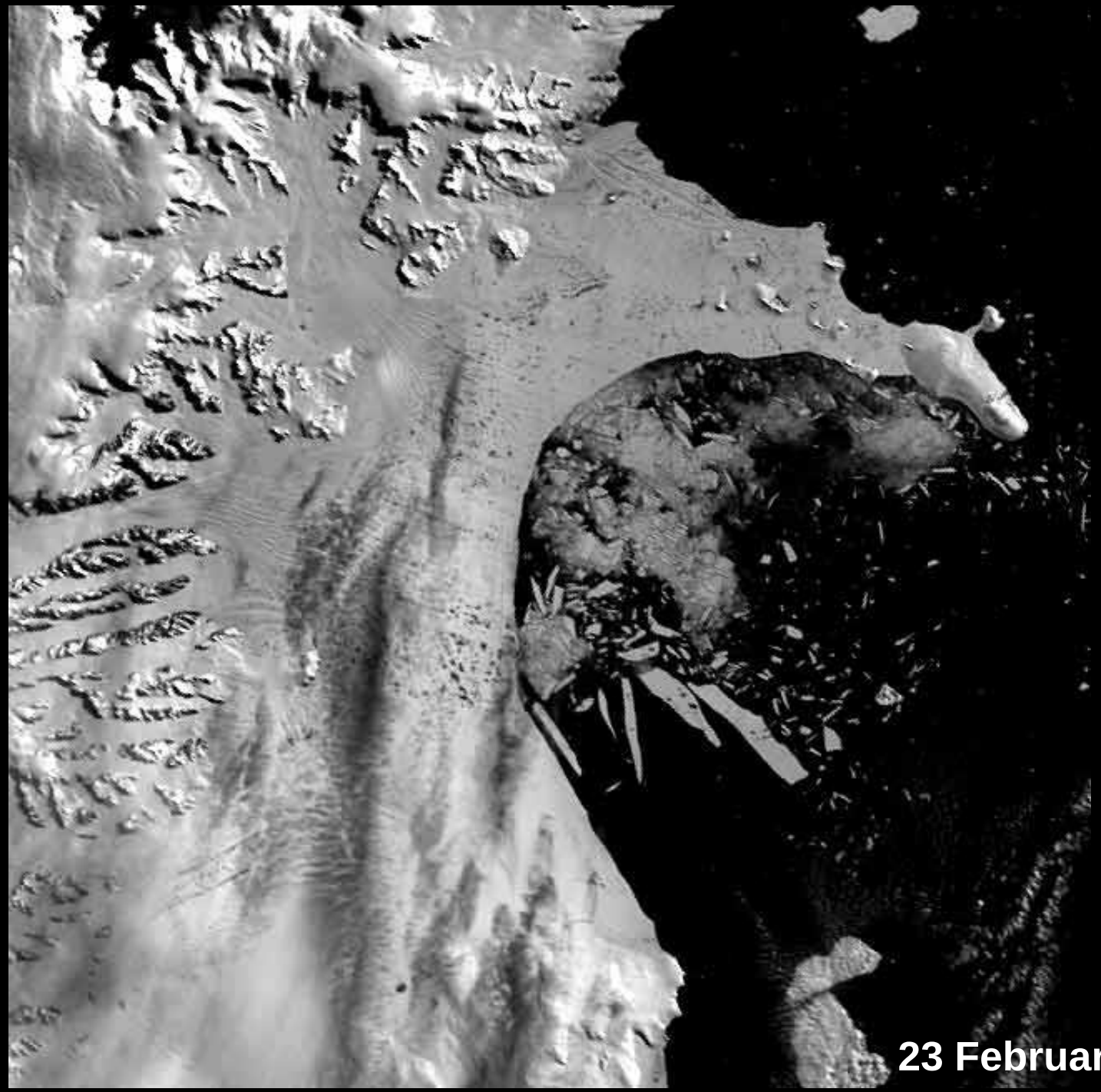
Larsen Ice Shelf 2002

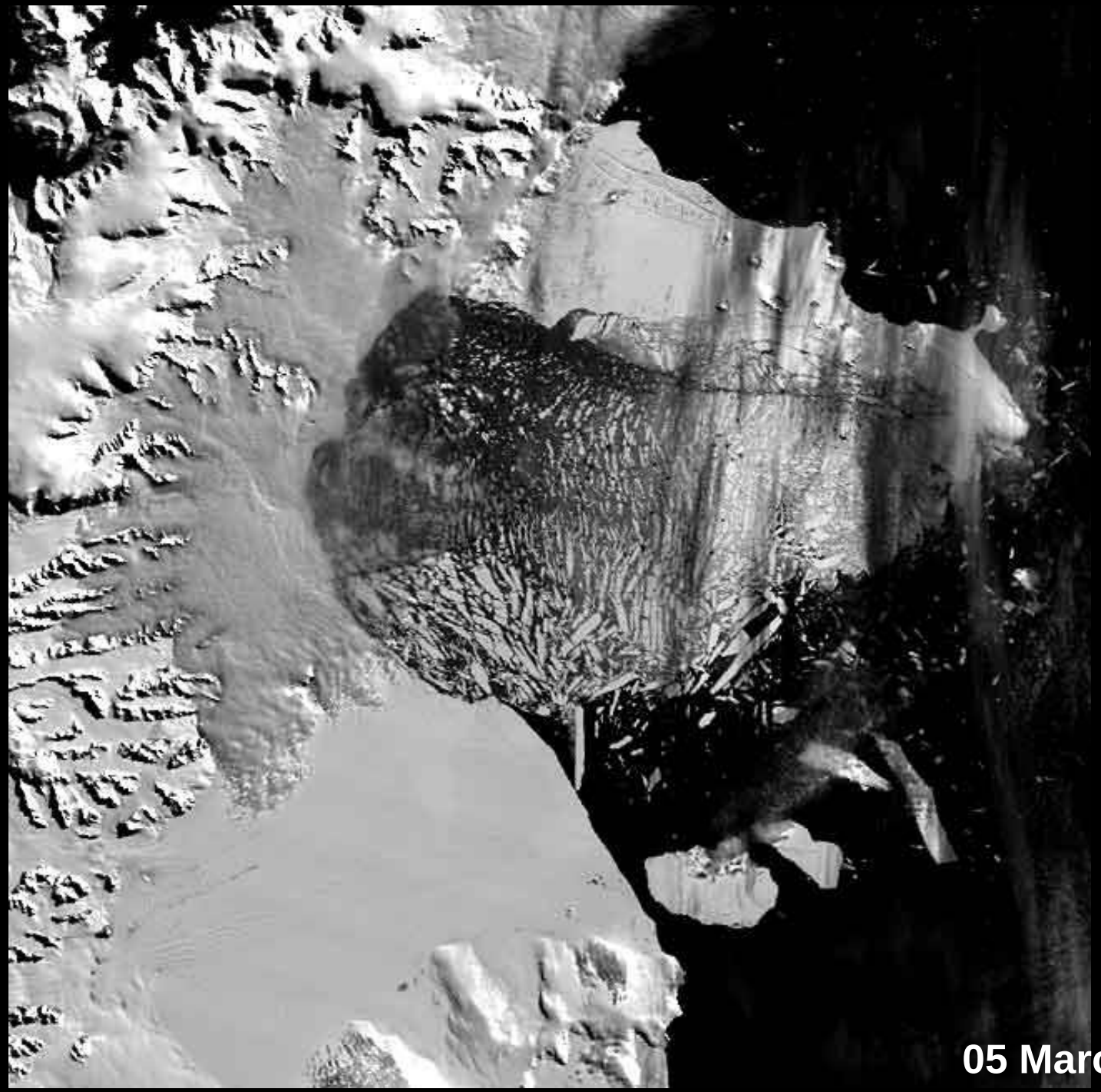


31 January 2002

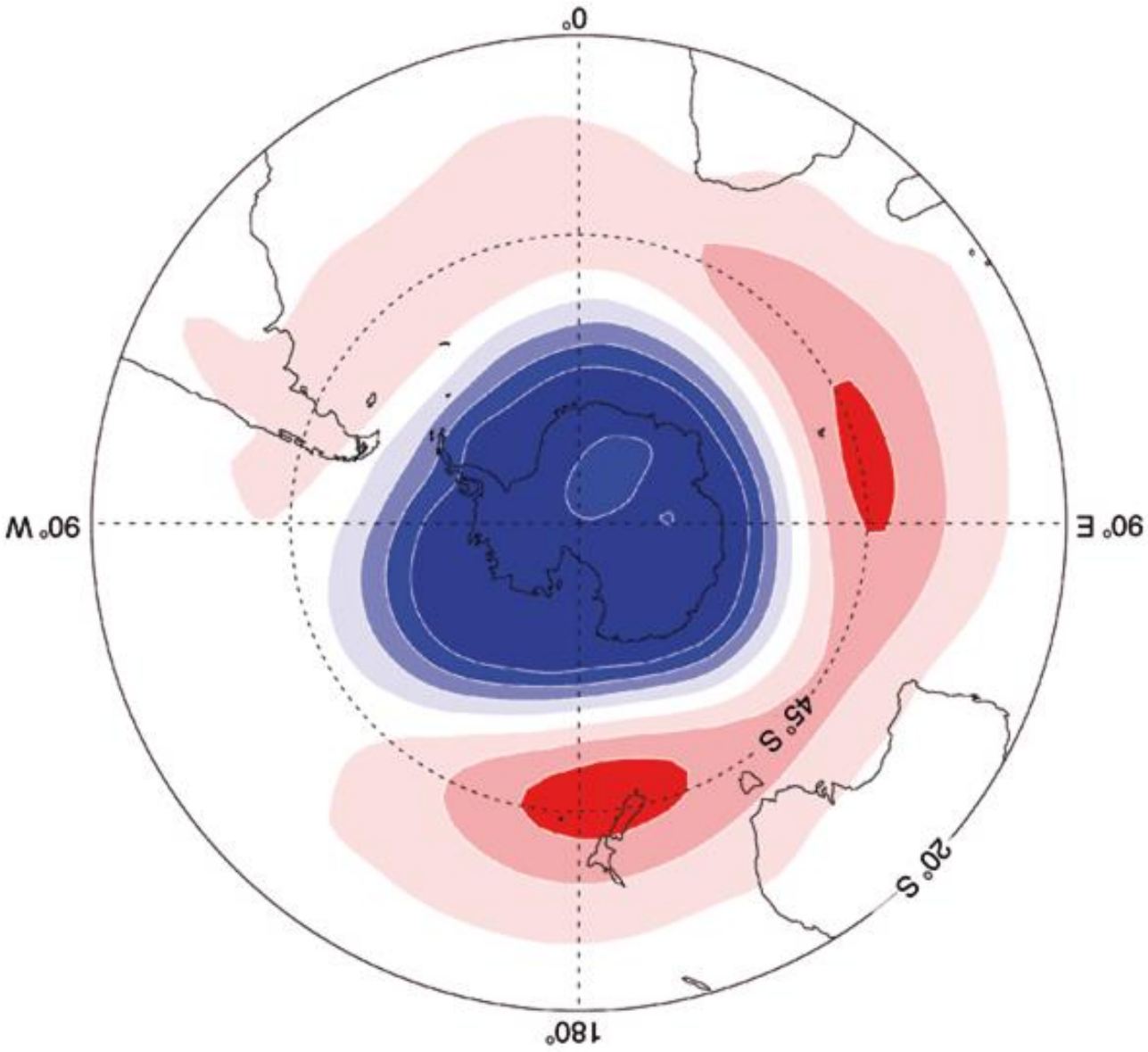
MODIS beelden van NASA's Terra satellite, National Snow and Ice Data Center, University of Colorado, Boulder


17 February 2002

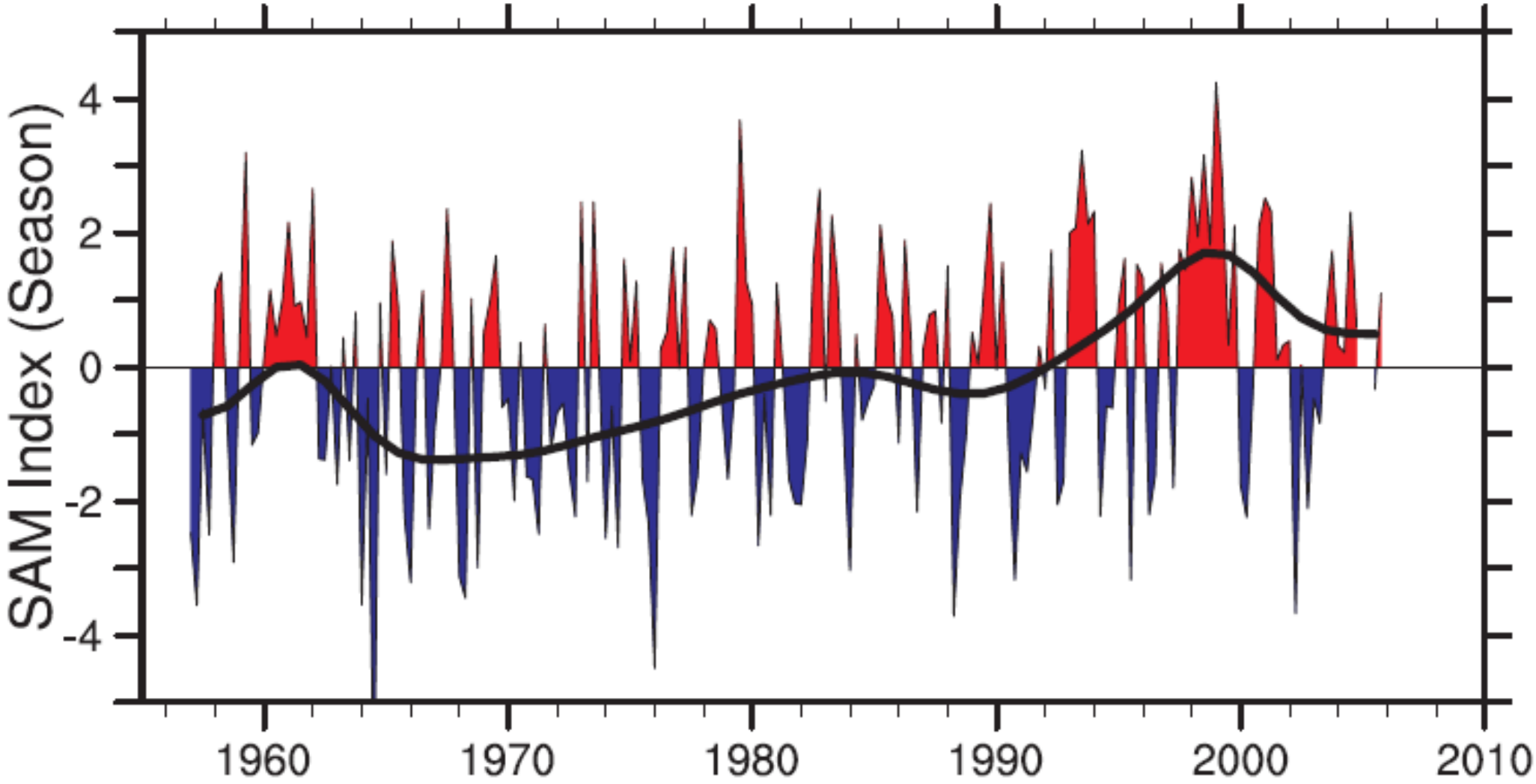

23 February 2002


05 March 2002

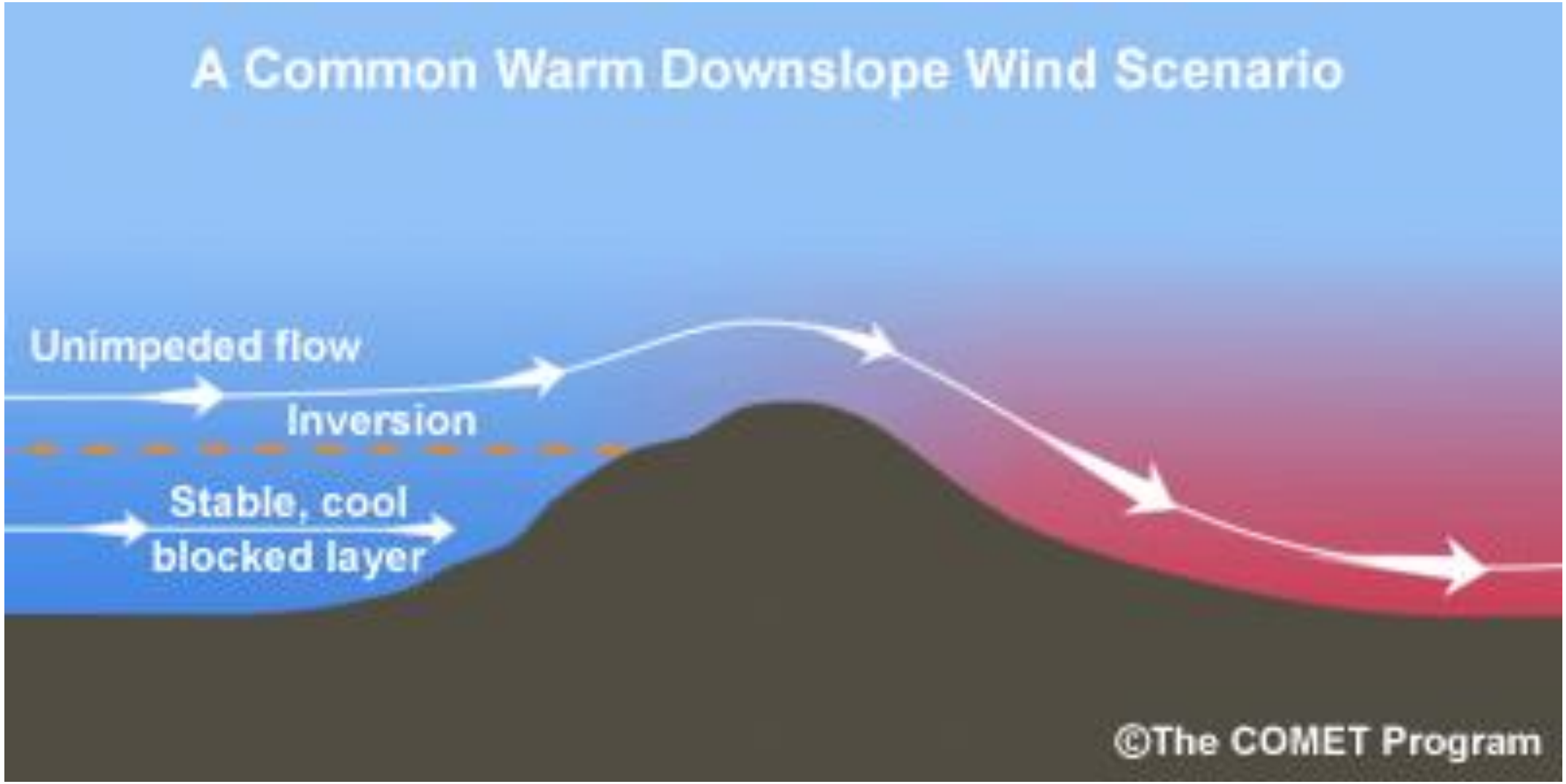
Belangrijkste circulatiepatroon is de southern hemisphere annular mode



Sam index is toegenomen (drukverschil tussen polaire gebieden en gematigde breedtes): sterkere westenwinden



Toename in westenwinden leidt tot een toename in temperatuur aan de lijzijde van de berg (Föhn-effect) (van Lipzig et al., J. Clim, 2008)

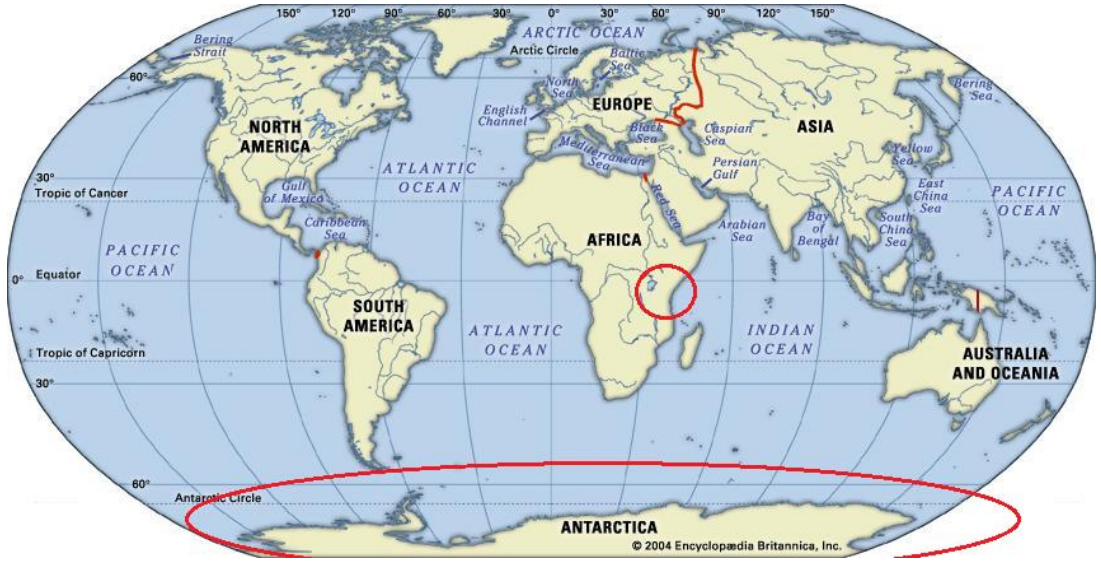


Lokale impacts vaak gerelateerd aan veranderende atmosfeerstromingen

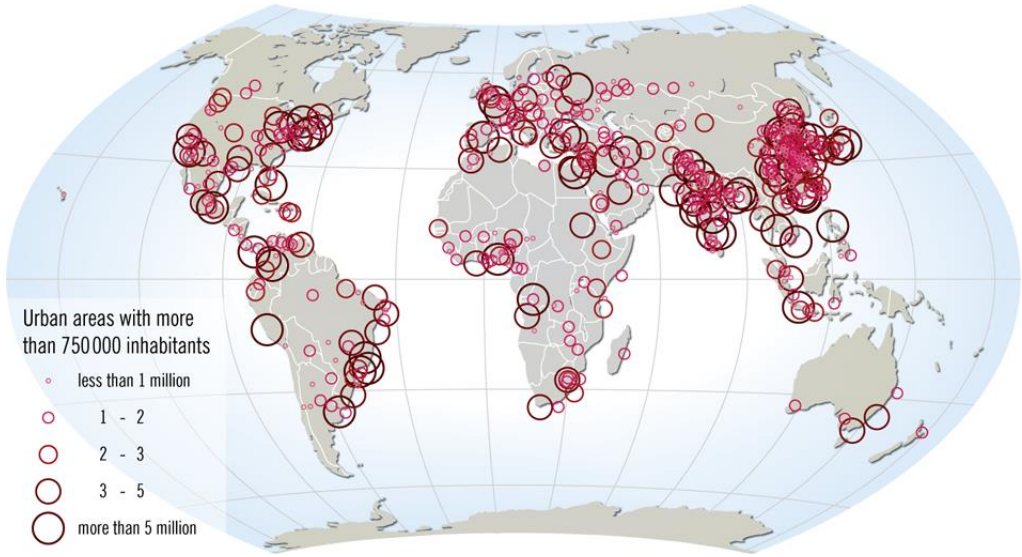
Veranderingen in Antarctica hebben gevolgen in wereldsteden

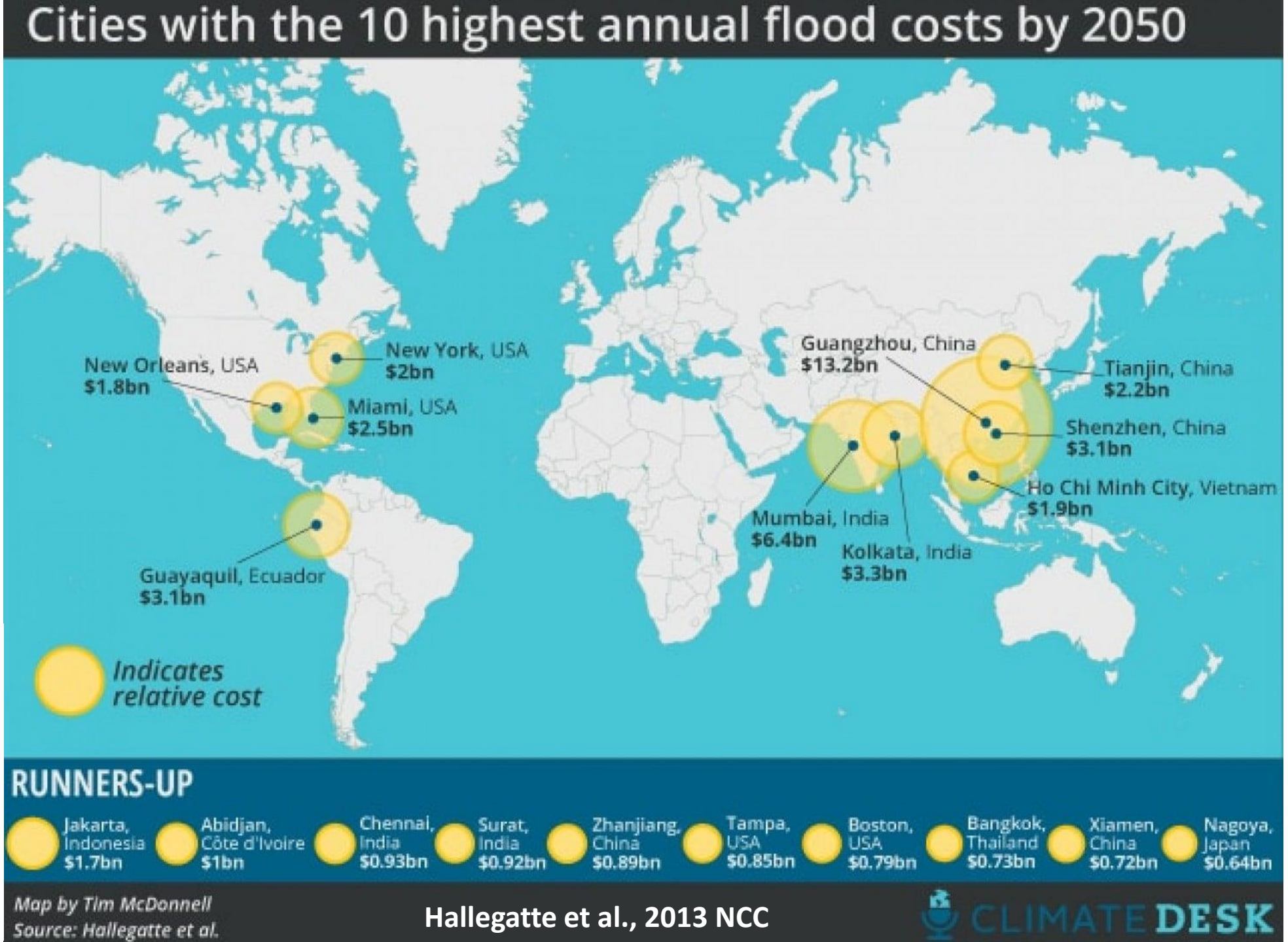
Veel steden liggen aan de kust

With Wouters, H. and M. Demuzere



cities





- Of all people living in cities threatened by sea level rise, an estimated 25% lives in China.
- Risks increase due to: extreme precipitation, storm surges and sea level rise

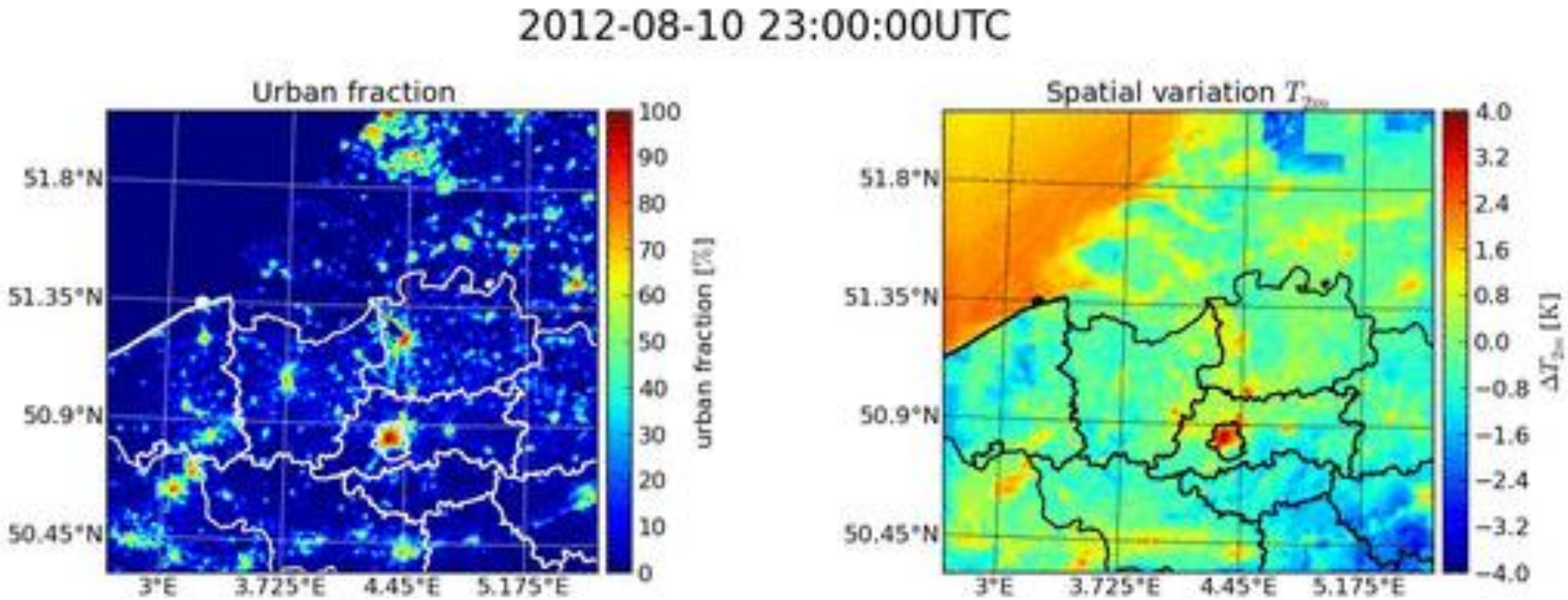
Hallegatte et al., 2013 NCC

Benelux: 9 – 88 cm stijging zeeniveau tegen 2100, maar nog grote onzekerheid

Département de Géographie, UCL

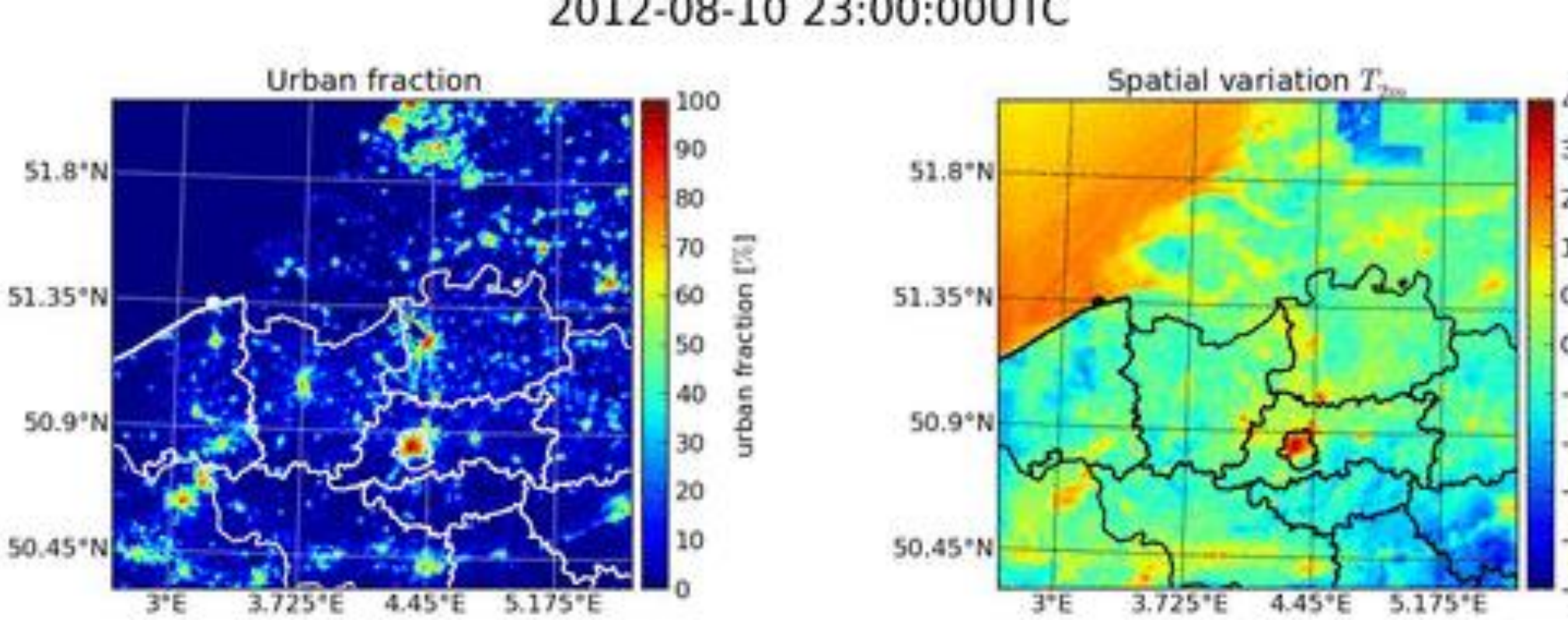
Illustratie voor 1 m stijging in zeeniveau

… cities are hot!



Anomaly in T2m compared to domain average

… cities are hot!

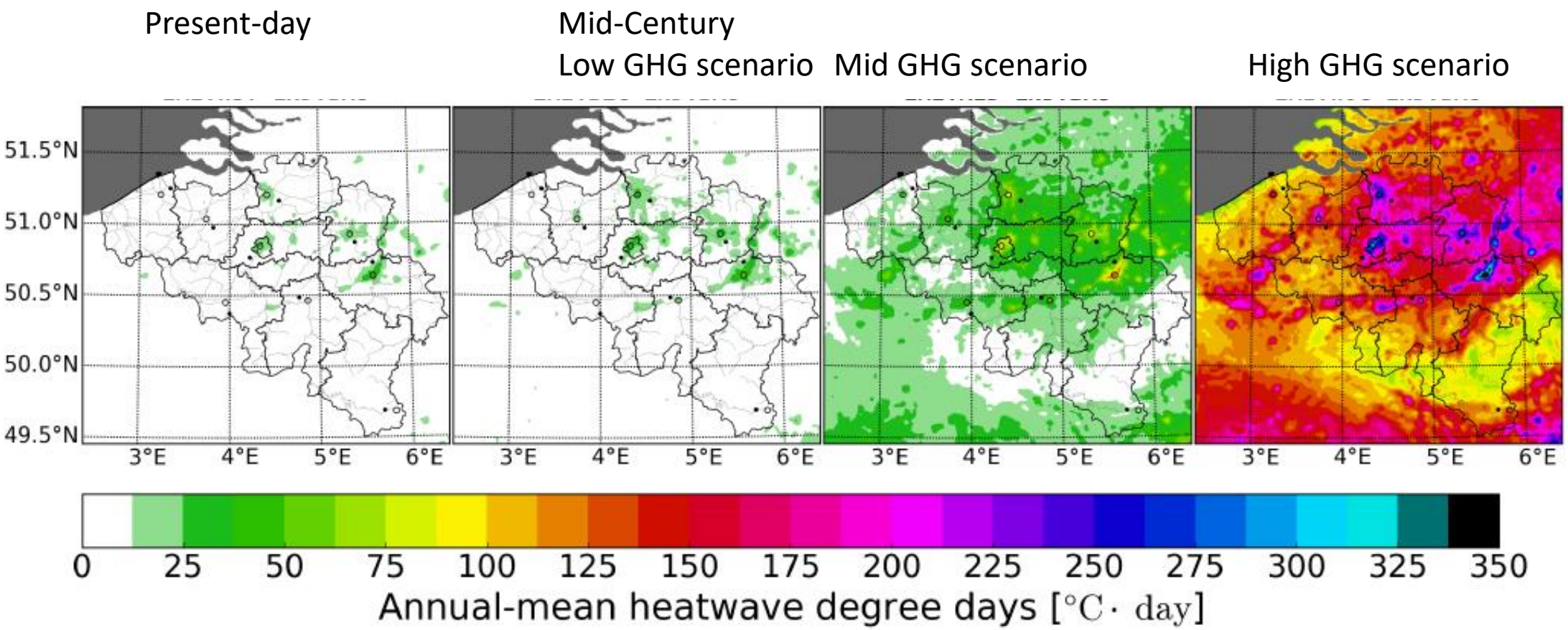


Heat stress indicator:

$$\sum_i \left[(T_{\min,i} - 18.2\,^\circ\mathrm{C})^+ + (T_{\max,i} - 29.6\,^\circ\mathrm{C})^+ \right] h_i$$

We wanted a metric closely related to stress and this is used by the health authorities in Belgium

Mid-century heat stress



- Mid GHG scenario: increase in heatwave days from 7 to 16
- Heat stress in the urban centers is multiplied by a factor up to 15 depending on the emission scenario
- The heat-stress increase is about twice as large for the city centers as for the natural surroundings.

Should we then move out of the city?
No – cities hold the key to solutions

Team Vlaams Bouwmeester
Meerjarenprogramma 2017-2020

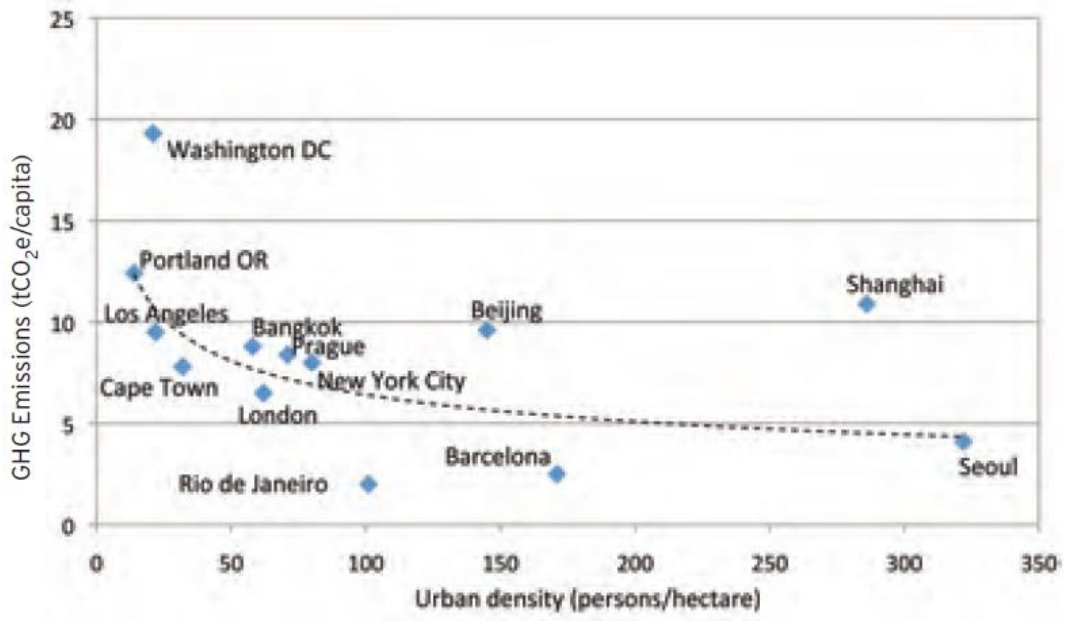
Vlaamse overheid

BWMSTR 2017–2020
Ruimte maken voor mens en natuur

"Cities are where change is happening the fastest and we must seize the opportunities we have been presented with to make that change significant and permanent."

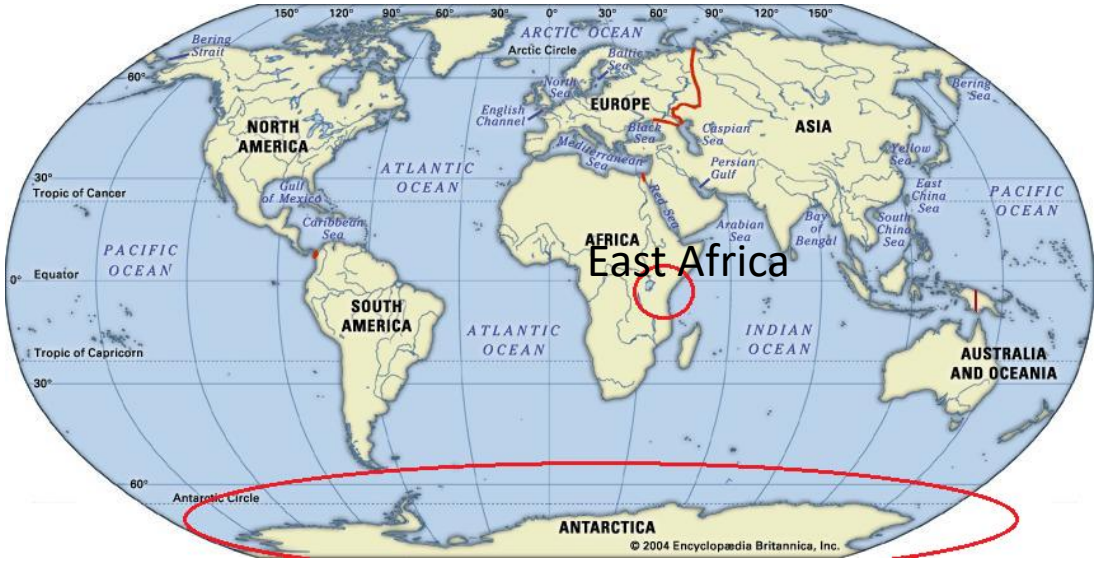
DAVID MILLER
Mayor of Toronto (2007)

City Densities and their Greenhouse Gas Emissions per Capita



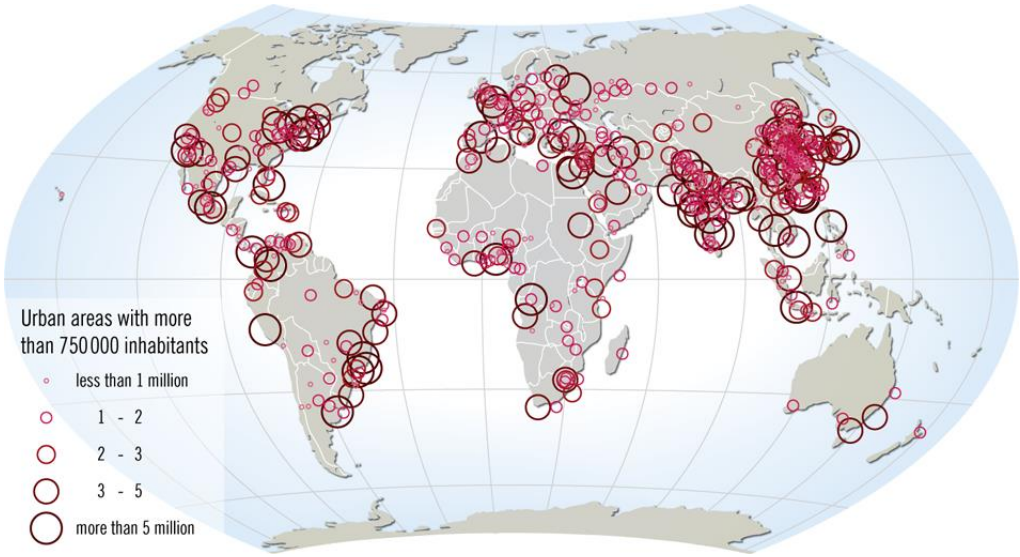
What about tropical cities?

With Jonas Vande Walle, Oscar Brousse, Hendrik Wouters, Matthias Demuzere and Wim Thiery

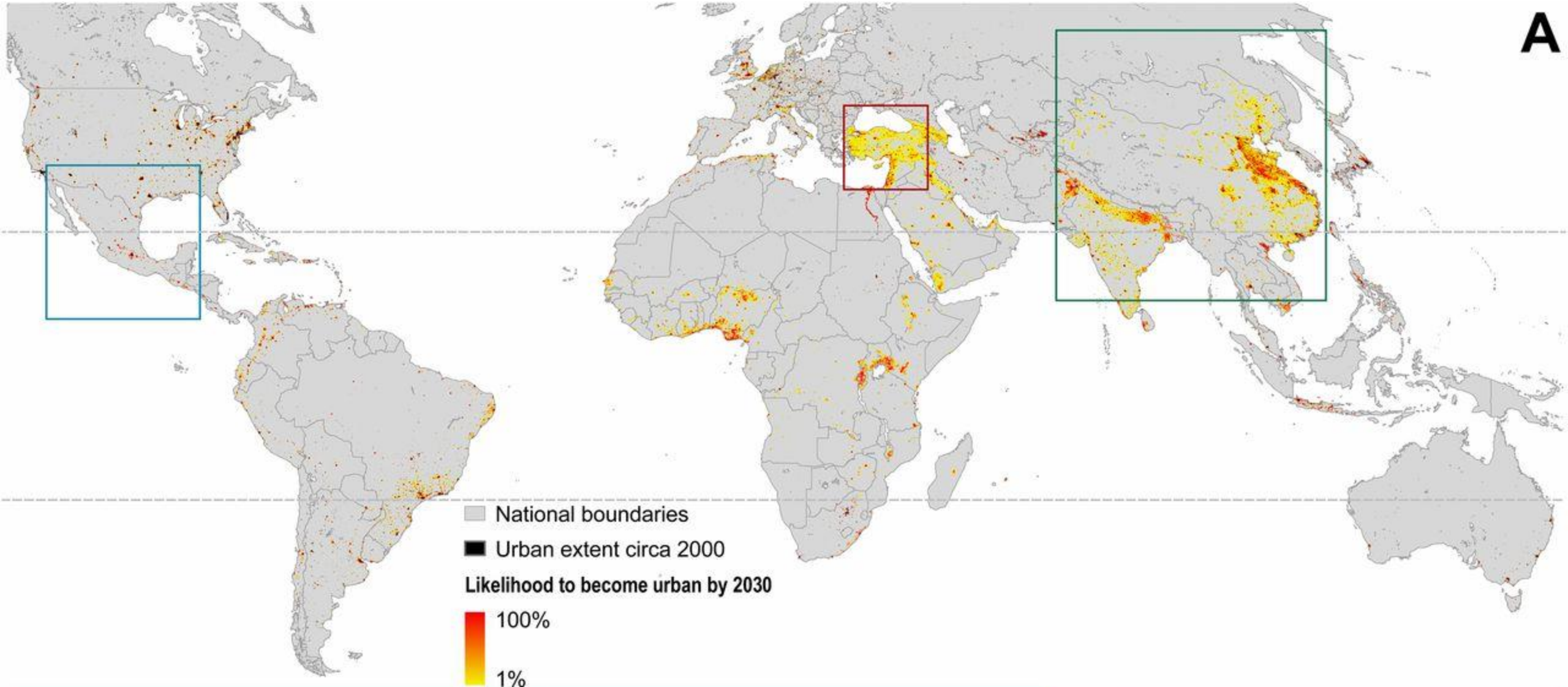


Àntarctica

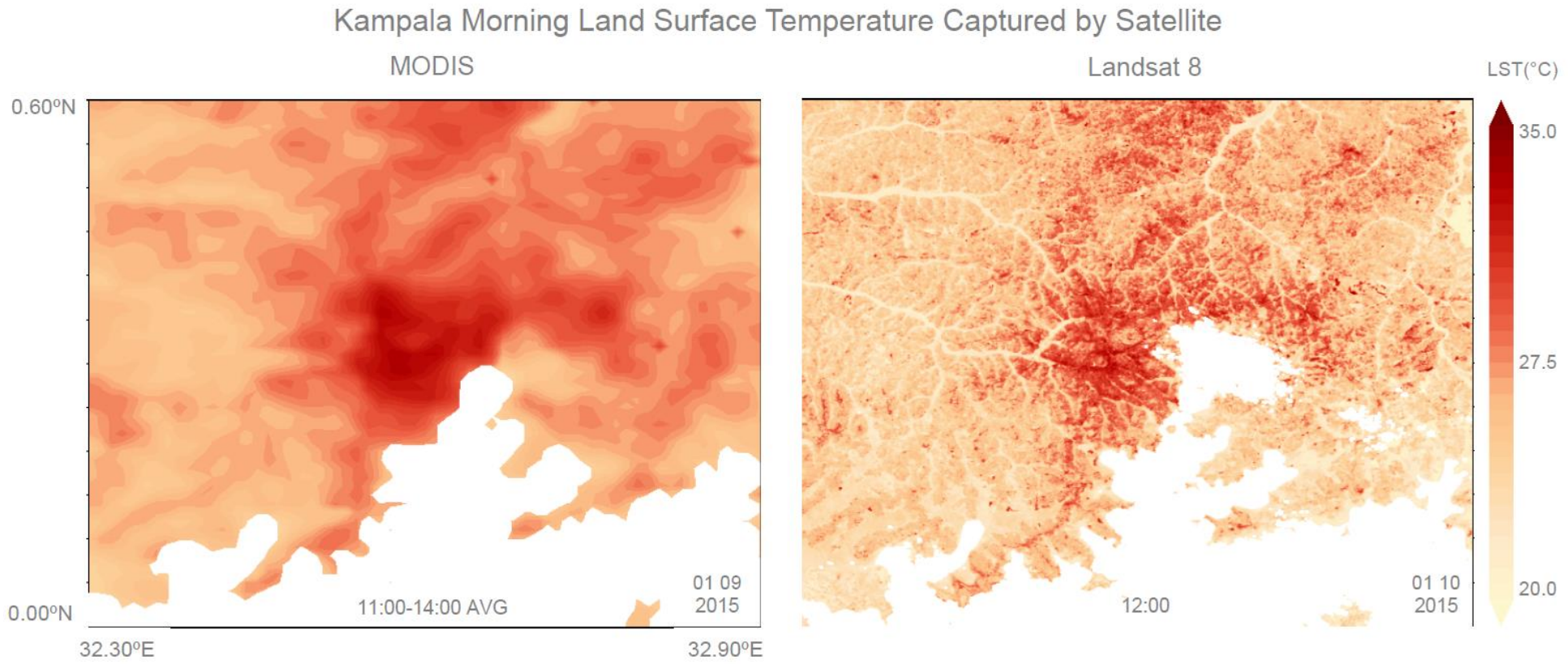
cities



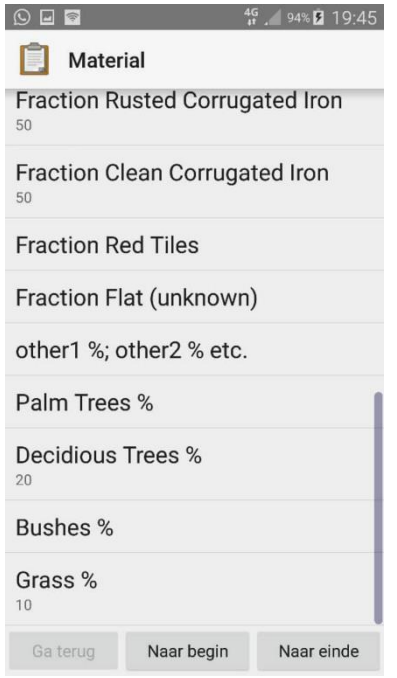
Large urbanization trend ongoing and expected in the Lake Victoria region
Informal estimates for Kampala are around 3 million inhabitants
annual growth rates of 5.6%; (a city like Leuven each year is added)



Urban heat island over Kampala



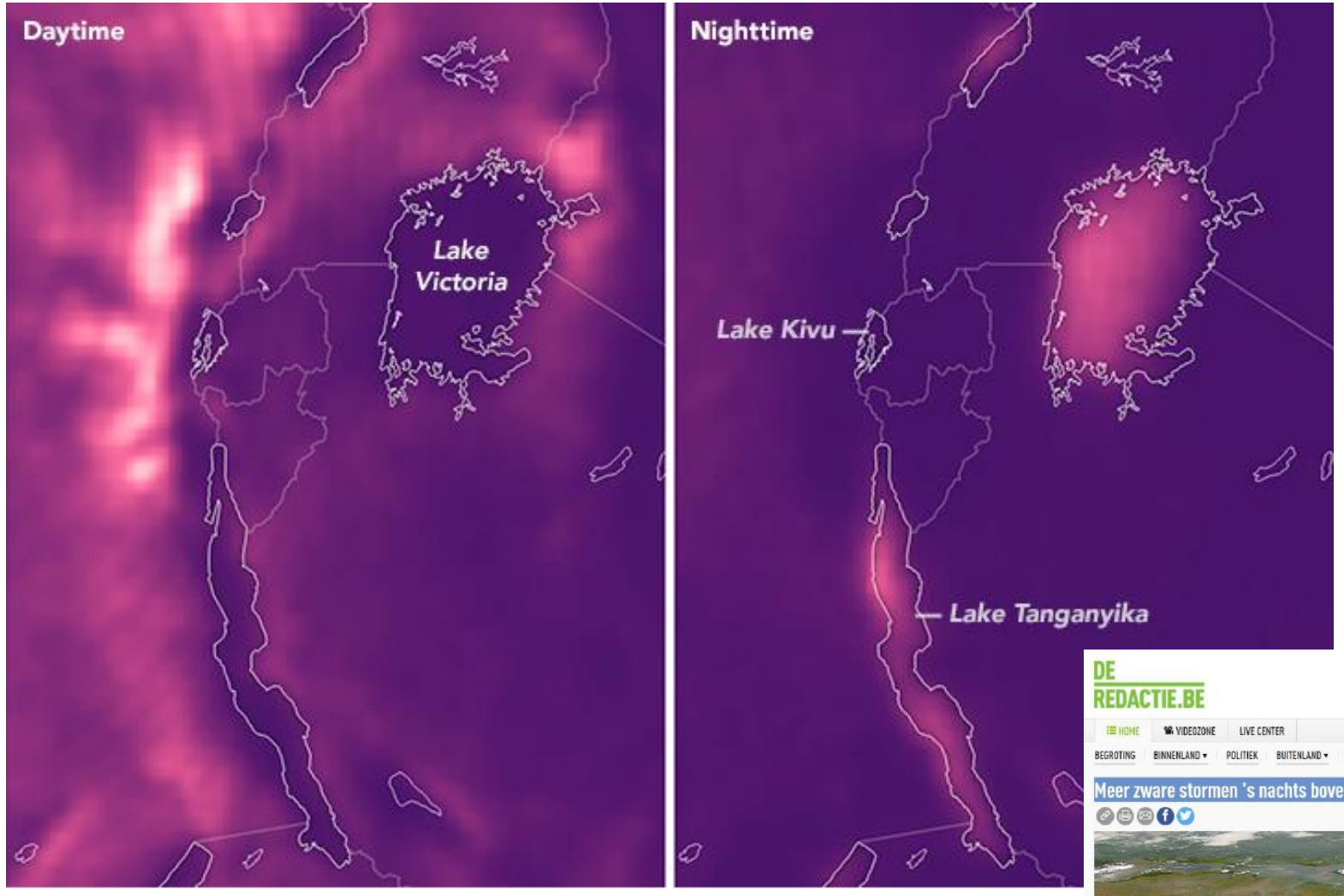
Canyon and Material



…. Implement this in the climate model

Thiery, Lhermitte, van Lipzig and three others, 2016, Nature Communications.

… region has also other challenges



Earth Observatory

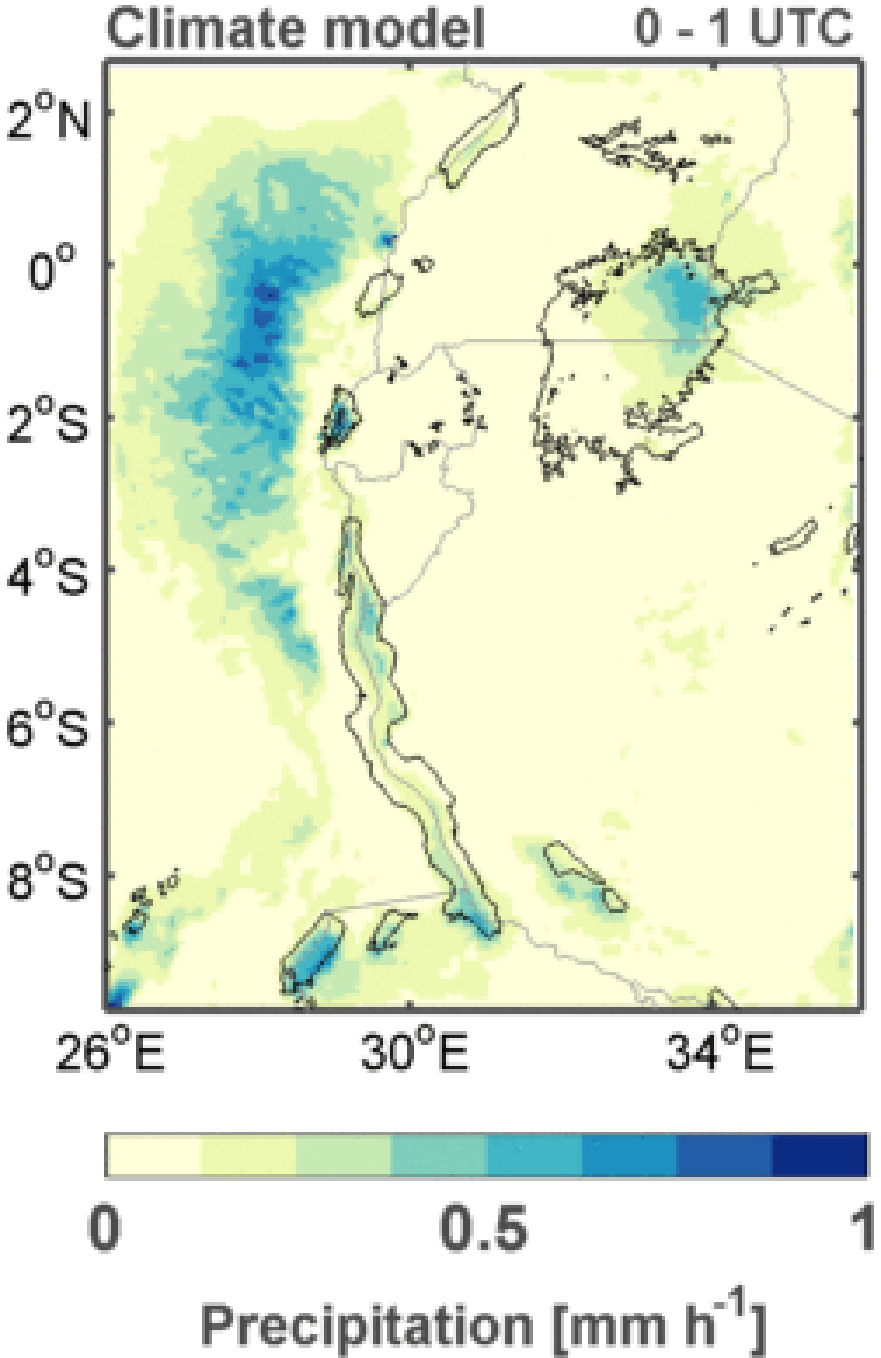
NASA ‘Earth Observatory image of the day’ 13 October 2016


OVERSHOOTING TOP
2007-06-22 © MARTIN SETVÁK
EUMETSAT / M.Setvak

Thiery, Lhermitte, van Lipzig and three others, 2016, Nature Communications.

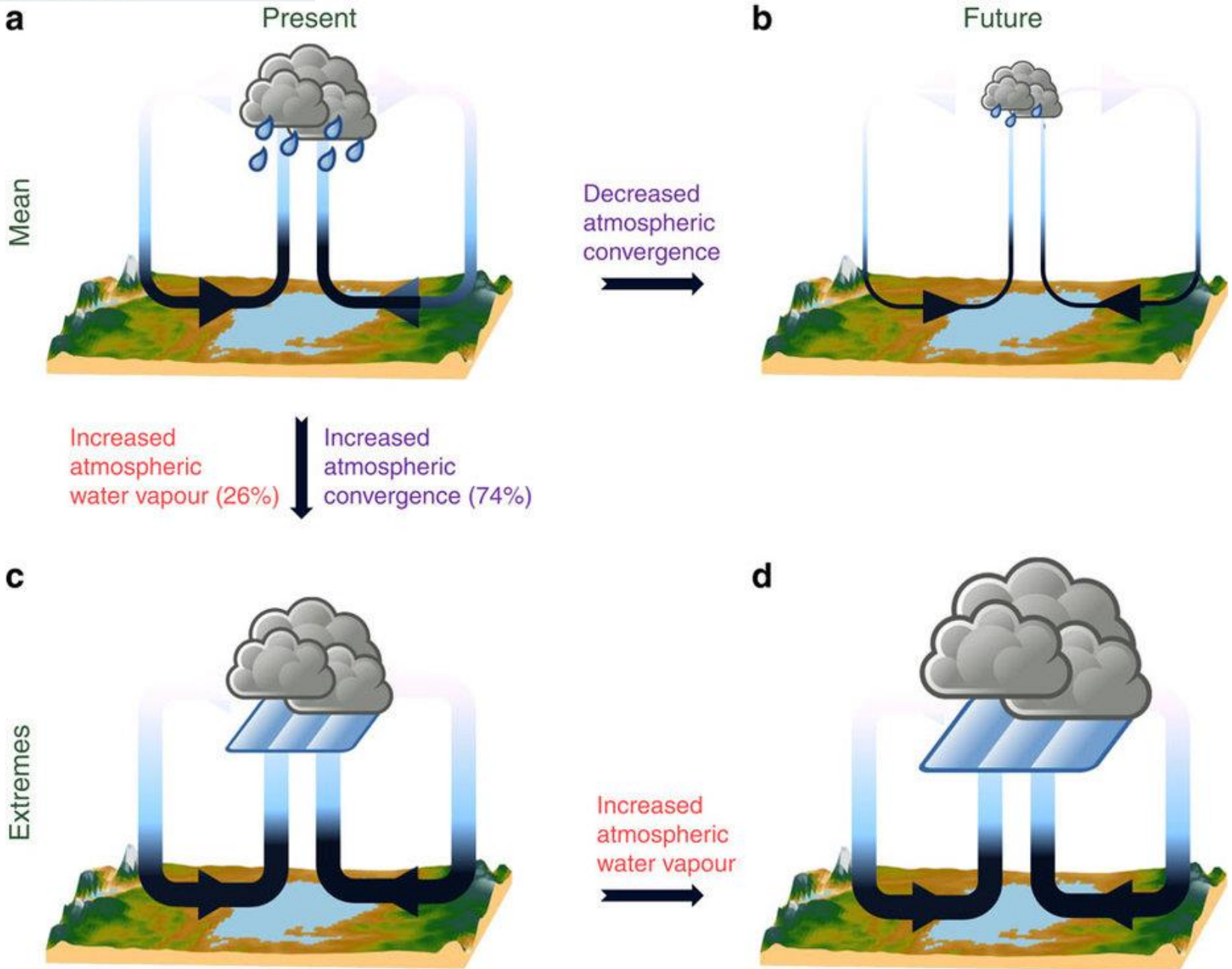
Climate model simulations on VIC3 at unprecedented resolution of 7 km

16 000 CPU days on VIC3



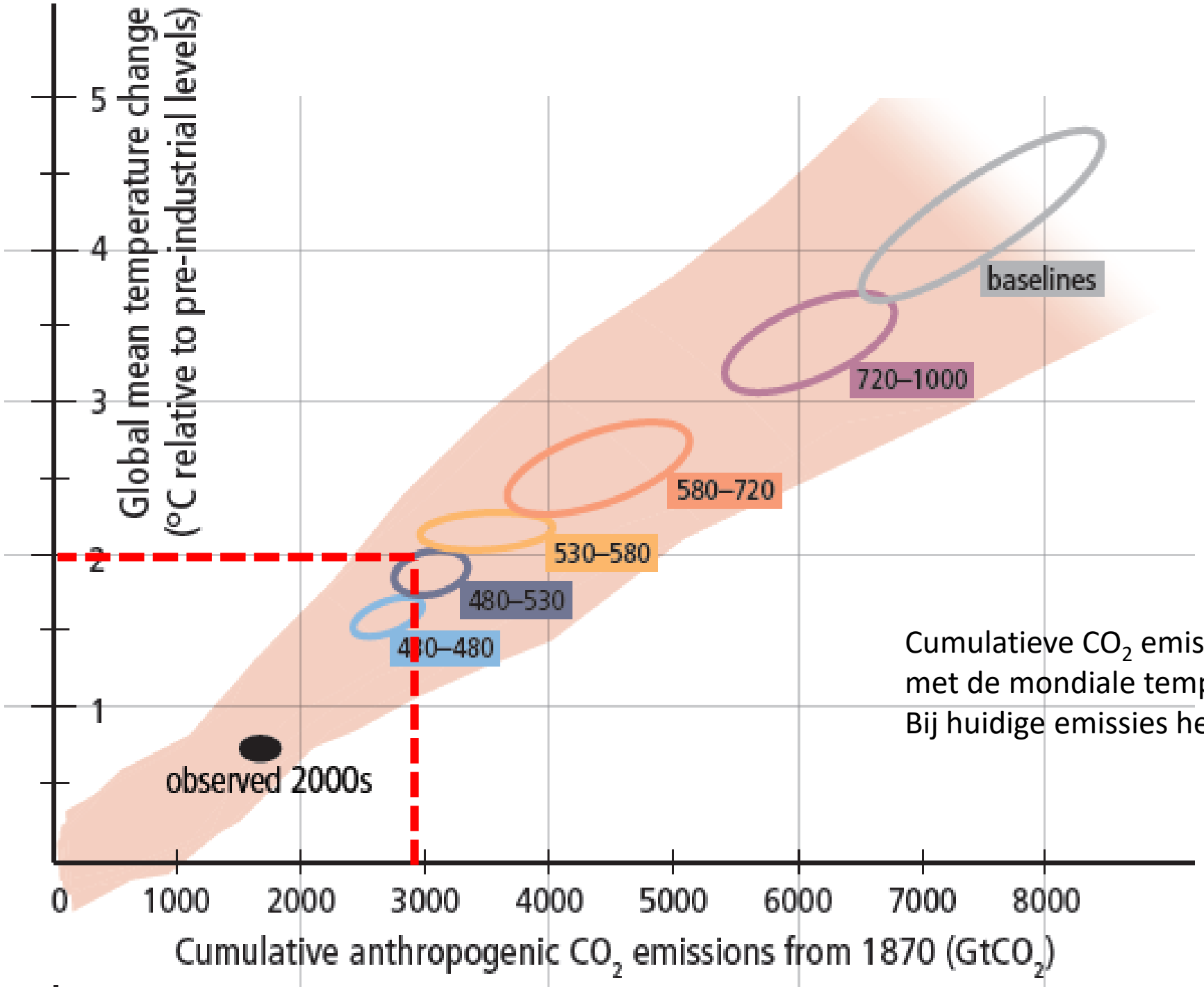
nature COMMUNICATIONS

Thiery, Lhermitte, van Lipzig and three others, 2016, Nature Communications.





- We hebben een reis gemaakt over onze prachtige aarde.
  De fysica (o.a.) heeft ons geleerd wat voor impact uitstoot van broeikasgassen heeft.
  Wat moet er nu gebeuren?

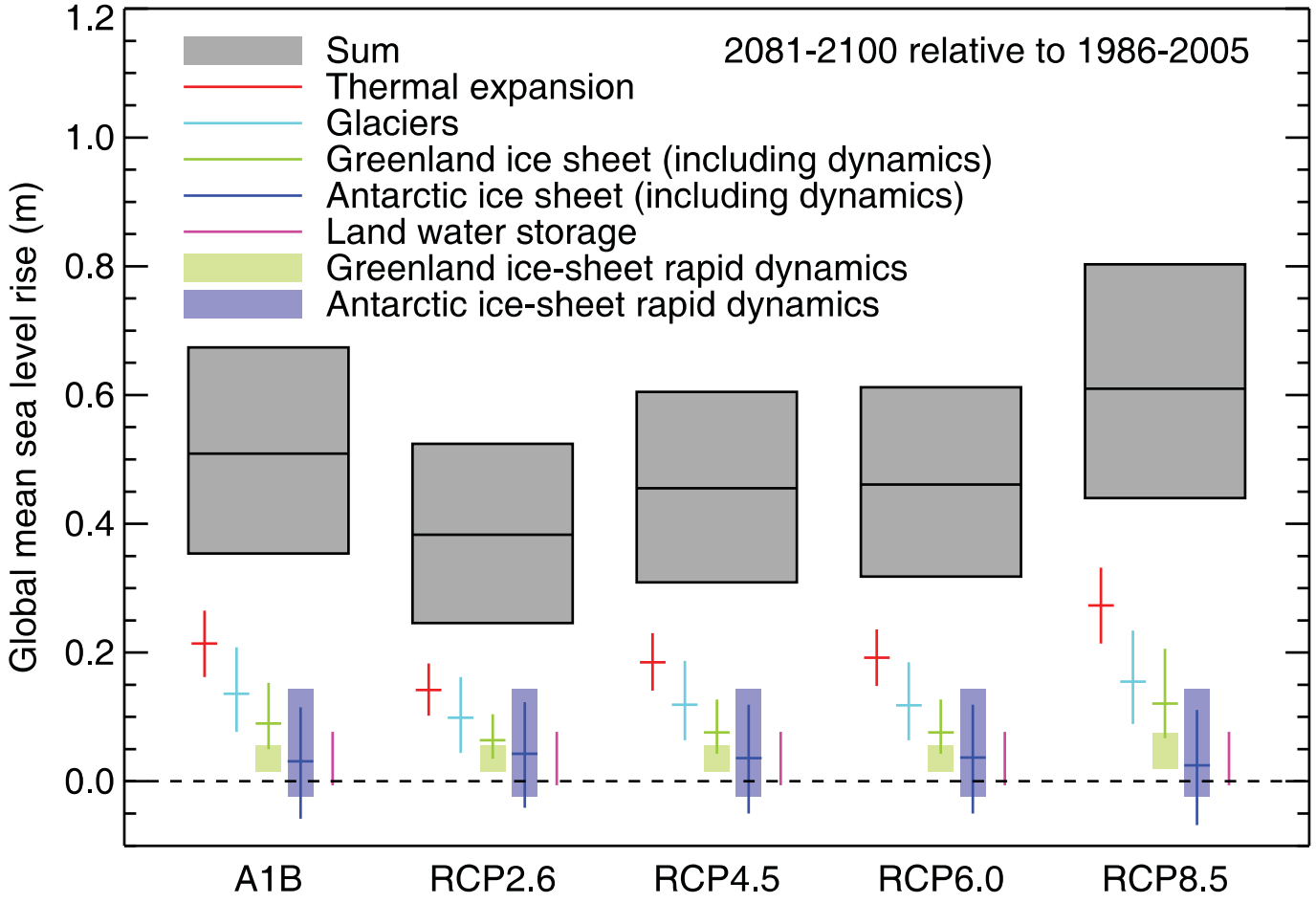


Cumulatieve CO_2 emissies schalen lineair met de mondiale temperatuurstoename
Bij huidige emissies hebben we nog 35 jaar

From AR5

Projecties voor de toekomst

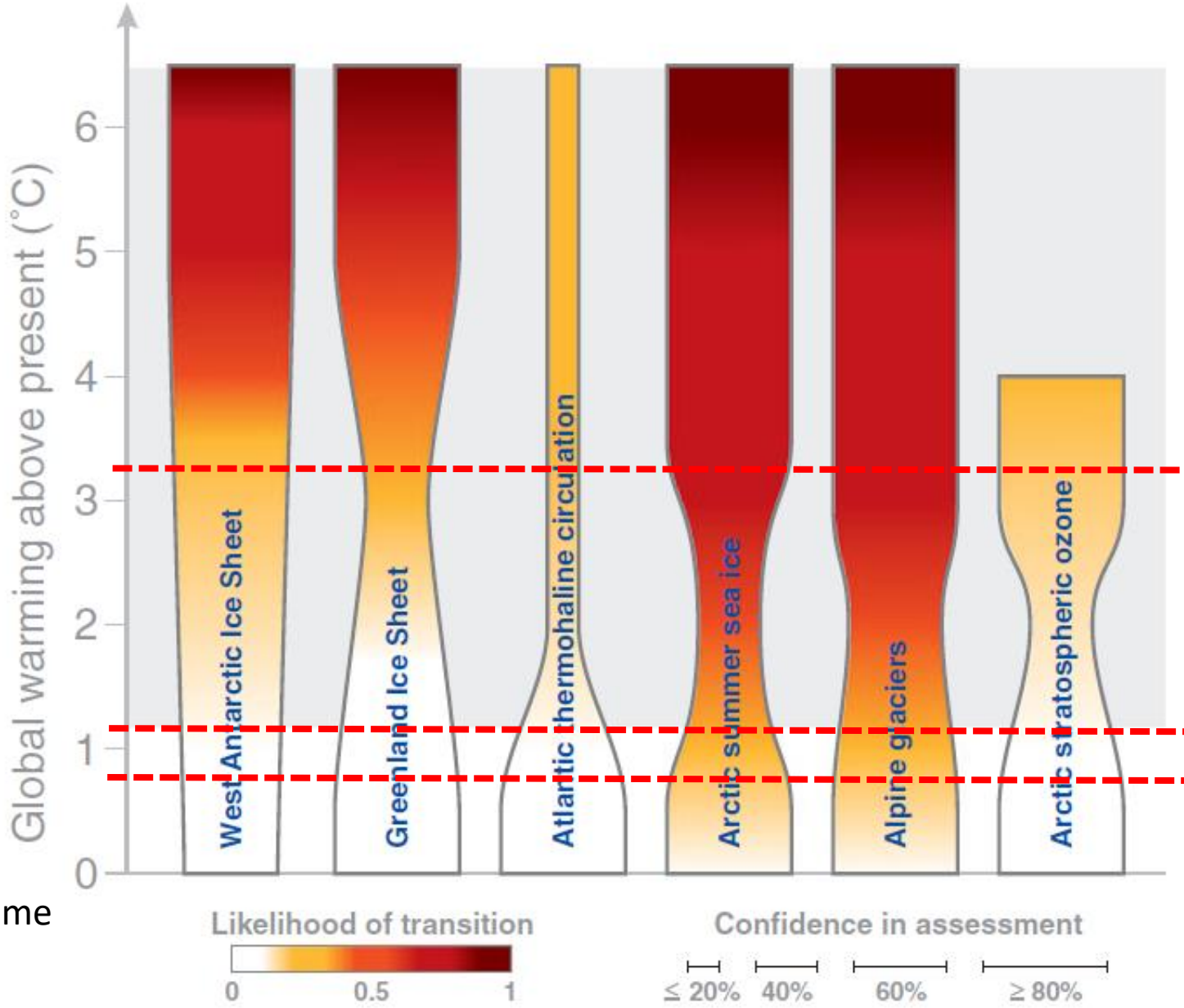
Gemiddelde zeeniveau stijging 25-80 cm tegen 2100



AR5, IPCC 2013

Emissies bepalen de grootte van de impacts

Opwarming is al 0,8°C



Business-as-Usual world

Paris agreed world

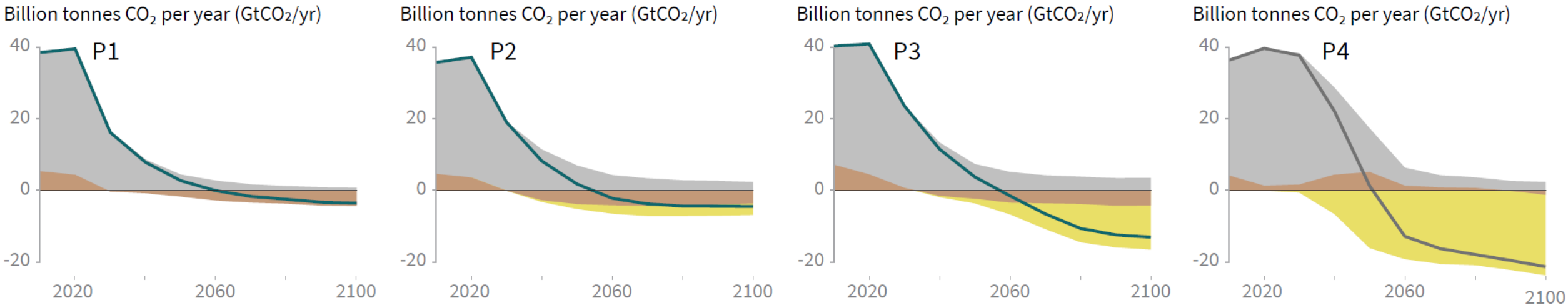
1.5 degrees

mondiale temperatuurstoename bepaalt het risico

Levermann et al., 2012

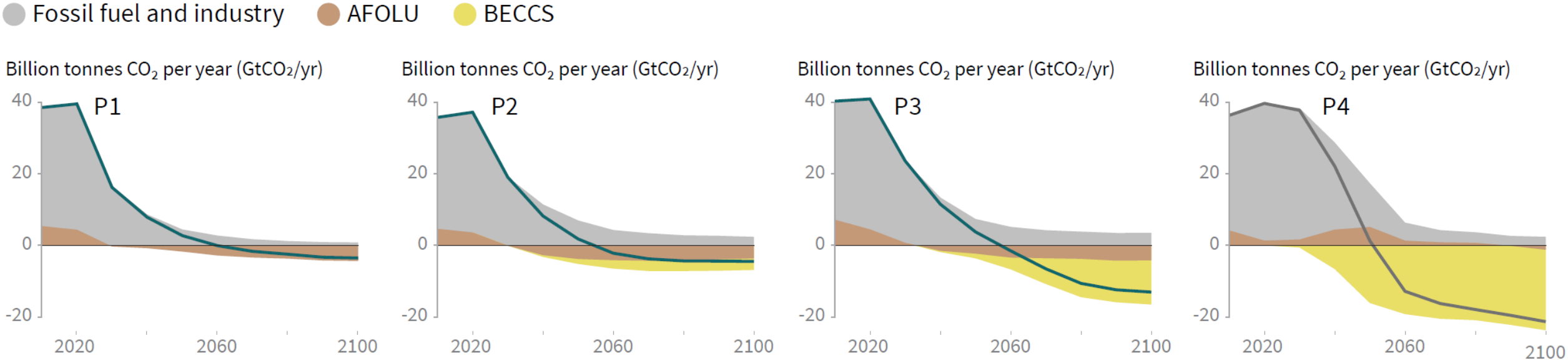
Er zijn verschillende paden

Fossil fuel and industry AFOLU BECCS



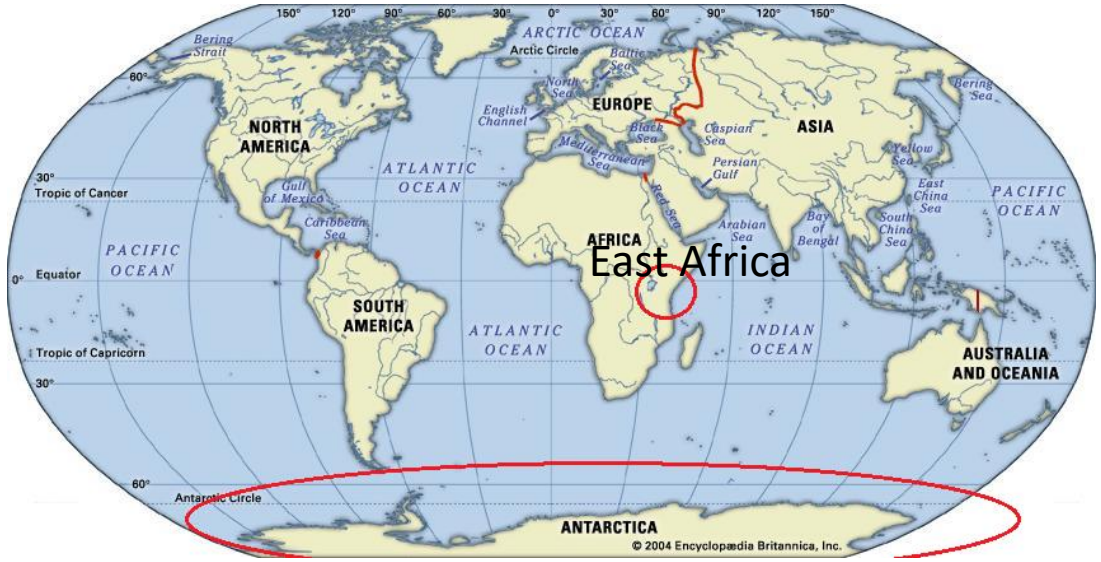
Primary energy from coal in 2030 (% rel to 2010)	-78	-61	-75	-59	(-78, -59)
↳ *in 2050 (% rel to 2010)*	-97	-77	-73	-97	(-95, -74)
from oil in 2030 (% rel to 2010)	-37	-13	-3	86	(-34,3)
↳ *in 2050 (% rel to 2010)*	-87	-50	-81	-32	(-78,-31)
from gas in 2030 (% rel to 2010)	-25	-20	33	37	(-26,21)
↳ *in 2050 (% rel to 2010)*	-74	-53	21	-48	(-56,6)
from nuclear in 2030 (% rel to 2010)	59	83	98	106	(44,102)
↳ *in 2050 (% rel to 2010)*	150	98	501	468	(91,190)
from biomass in 2030 (% rel to 2010)	-11	0	36	-1	(29,80)
↳ *in 2050 (% rel to 2010)*	-16	49	121	418	(123,261)
from non-biomass renewables in 2030 (% rel to 2010)	430	470	315	110	(243,438)
↳ *in 2050 (% rel to 2010)*	832	1327	878	1137	(575,1300)

Er zijn verschillende paden



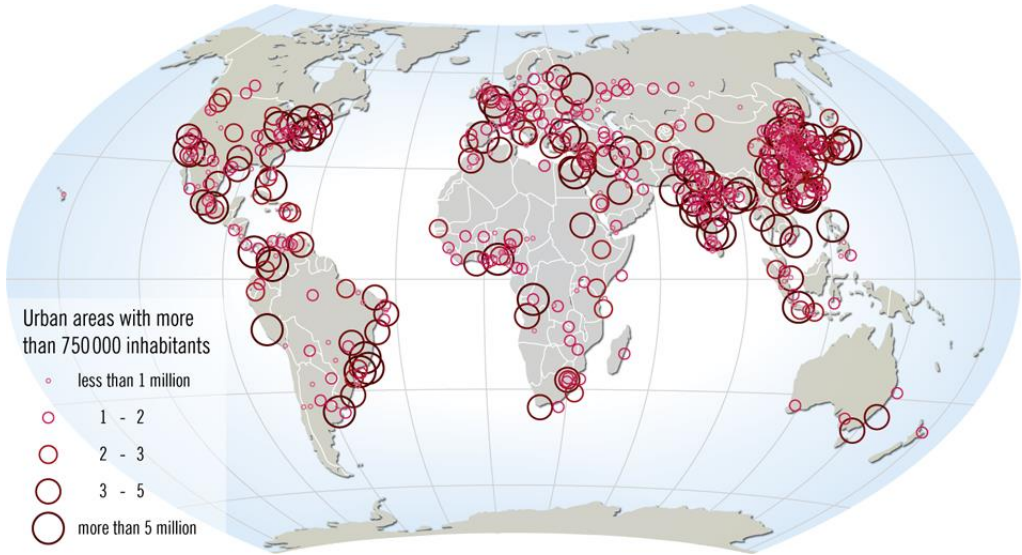
Alle paden gaan naar nul-emissie tegen midden van deze eeuw
Het is nu ‘all-hands-on-deck’ om deze transitie nu te maken:

- technologie-transitie
- gedrags-transitie: wonen, mobiliteit, consumptie



Antarctica

cities



… I hope you enjoyed the journey!