PROCAM Aula Inaugural
9 Março 2020

Emergência climática em vez de reduções de emissões
E agora?

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Olhando para o futuro

As seis grandes transformações necessárias para o mundo em 2050

Energia

Decarbonização, eficiência, acesso à energia

Consumo e Produção Sustentáveis

Uso de recursos, economia circular, suficiência, poluição

Alimentos, Usos da Terra & Biosfera

Intensificação sustentável, oceanos, biodiversidade, florestas, água, dietas saudáveis, nutrientes

Objetivos de Desenvolvimento Sustentável:

- Prosperidade
- Inclusão social
- Sustentabilidade
- Paz social

Revolução Digital

Inteligência artificial, big data, biotecnologia, nanotecnologia, sistemas autonômos

Cidades

Moradia, mobilidade, Infraestrutura sustentável, água, poluição

Capacitação Humana & Demografia

Educação, saúde, envelhecimento, mercado de trabalho, gênero, desigualdade

Adaptado de The World in 2050

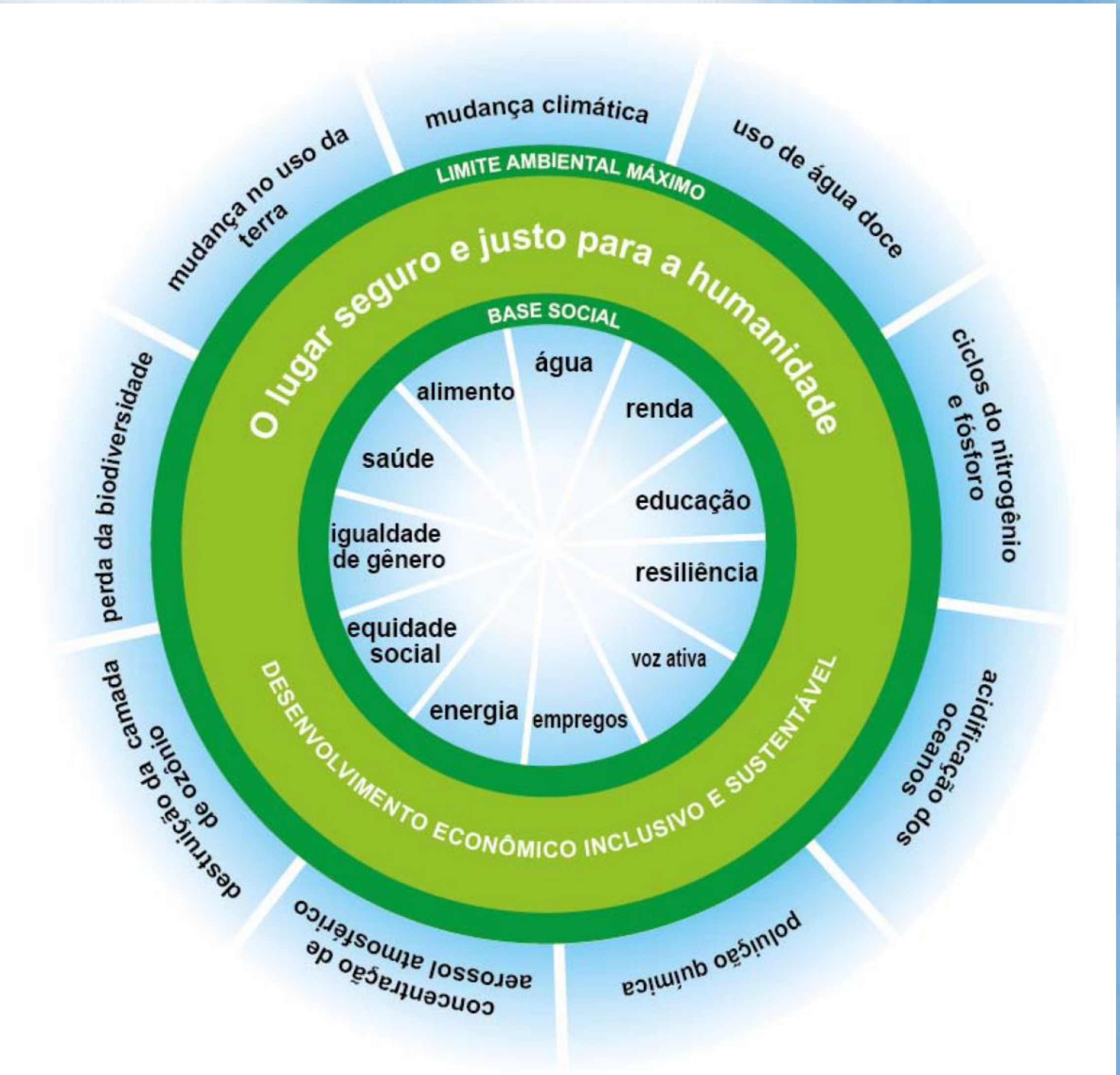
Os 17 objetivos do desenvolvimento sustentável adotados pela ONU

O desenvolvimento sustentável é definido como o desenvolvimento que procura satisfazer as necessidades da geração atual, sem comprometer a capacidade das futuras gerações de satisfazerem as suas próprias necessidades.

OBJETIVOS DE DESENVOLVIMENTO SUSTENTÁVEL
17 OBJETIVOS PARA TRANSFORMAR NOSSO MUNDO

Como construir um espaço seguro e justo para nossa humanidade?

Combinando o Sistema Terrestre com aspectos sociais

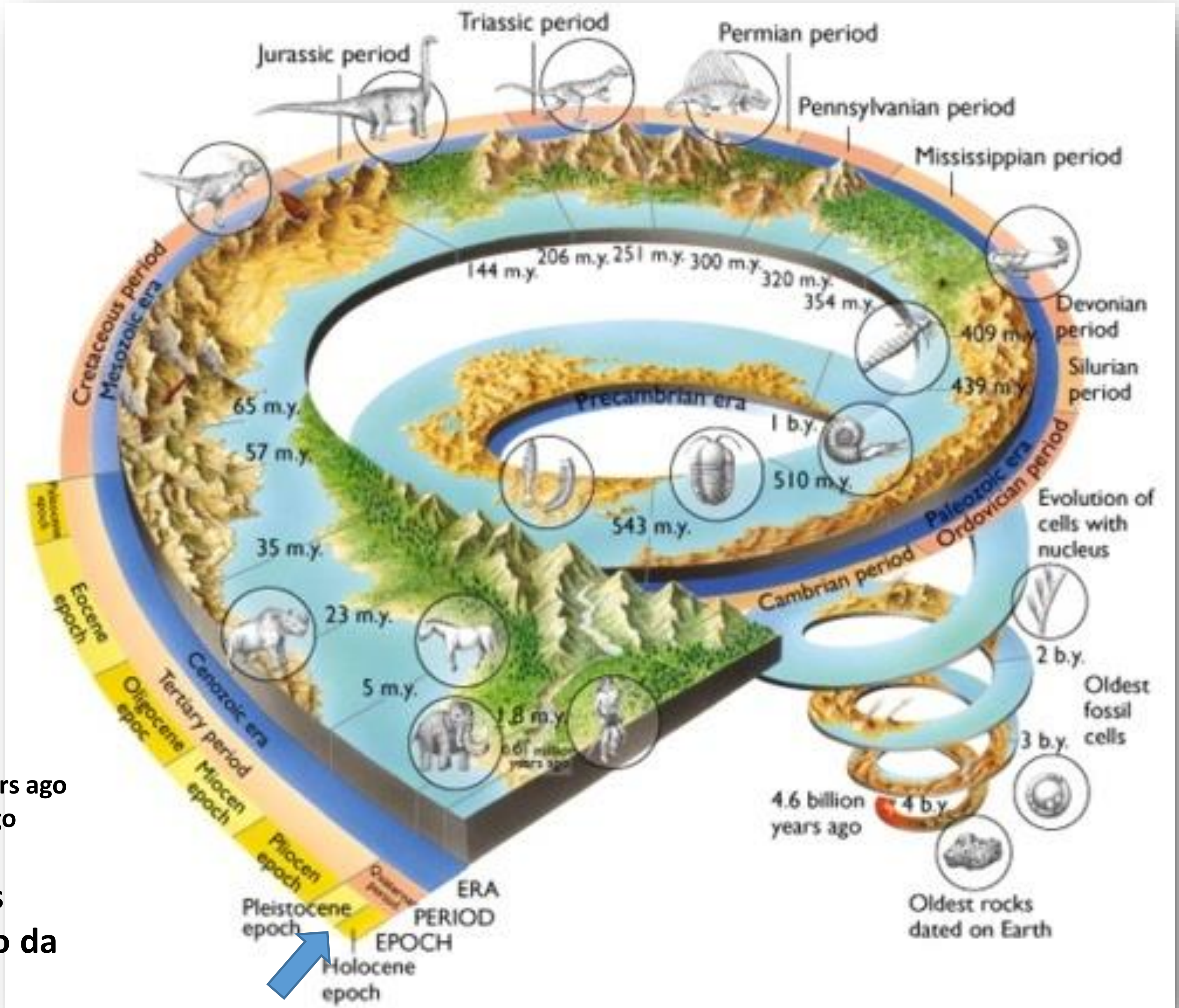


Steffen et al. 2015, Science

Precisamos de sólida ciência interdisciplinar para construir este espaço

Solid science on climate change and impacts

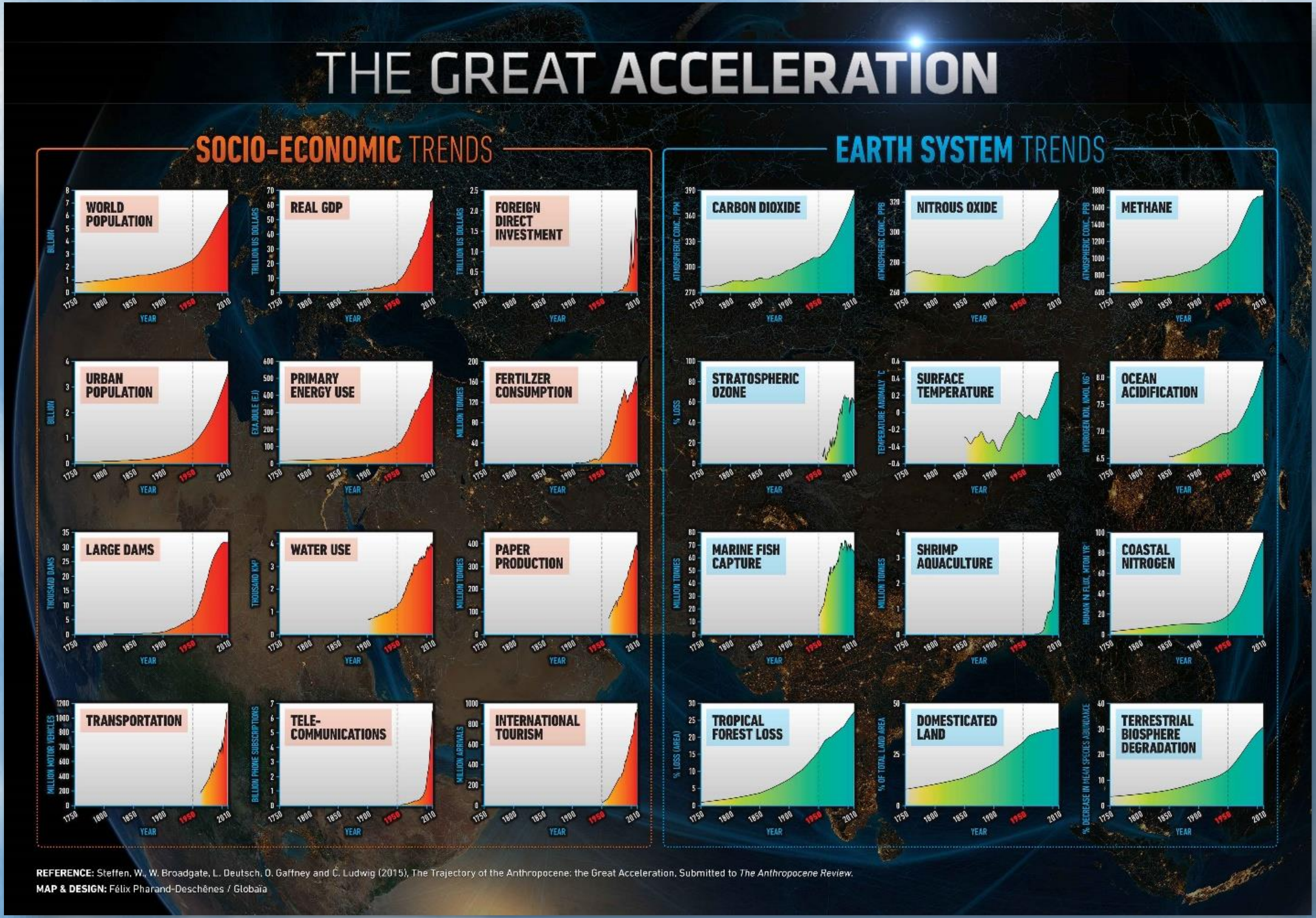
A evolução conjunta da Vida e da Geologia em nosso planeta



Homo sapiens in Africa: 200.000 years ago
Holocene: Started at 11.700 years ago

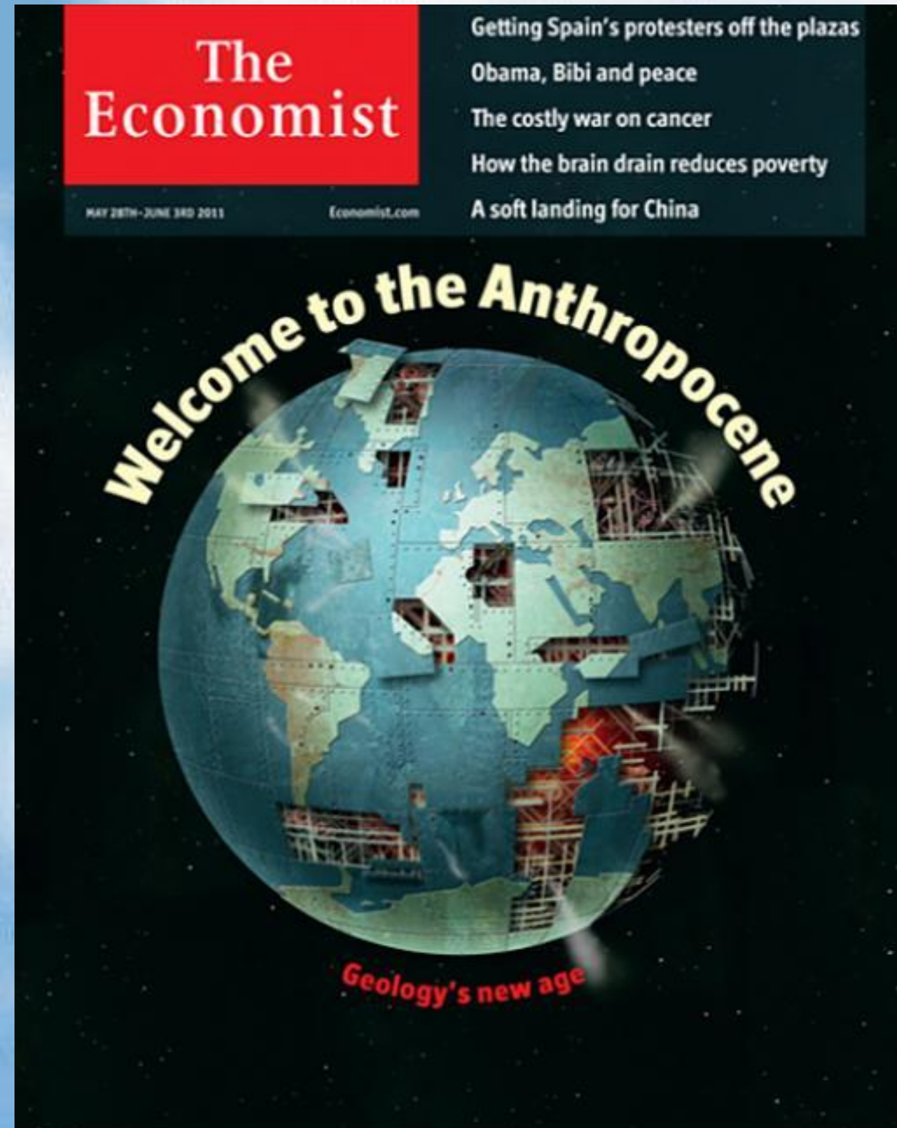
Os humanos estão presents somente no ultimo segundo da história de nosso planeta

Estamos mudando nosso planeta rapidamente e de muitas formas



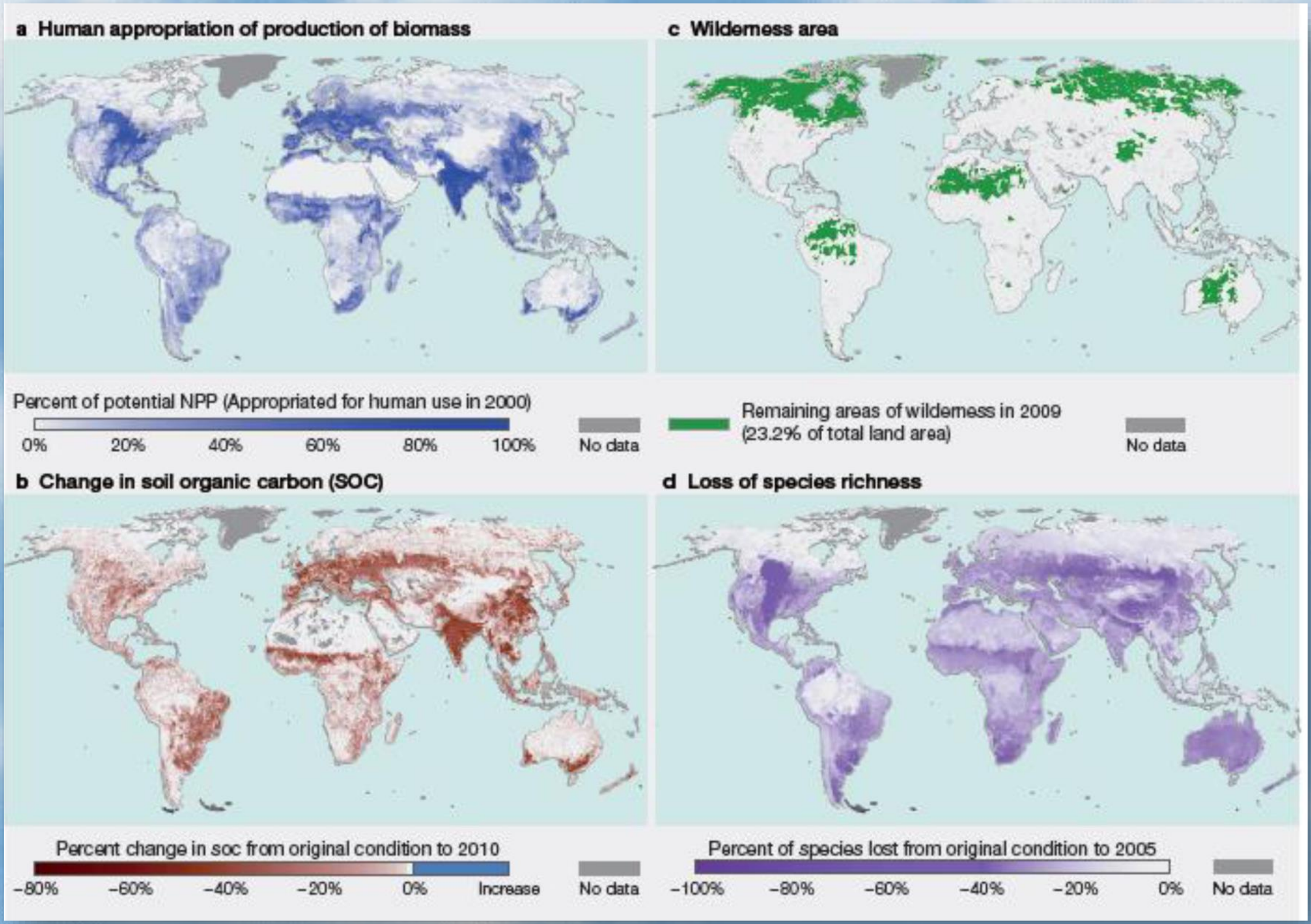
Quais são os impactos destas mudanças?

O Antropoceno se refere à época recente em que os humanos e nossas sociedades se tornaram uma força geofísica planetária



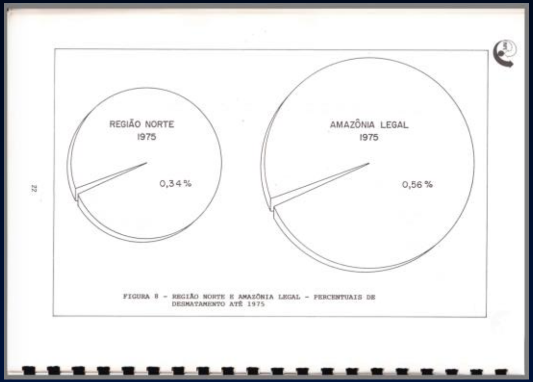
The Economist, 2011

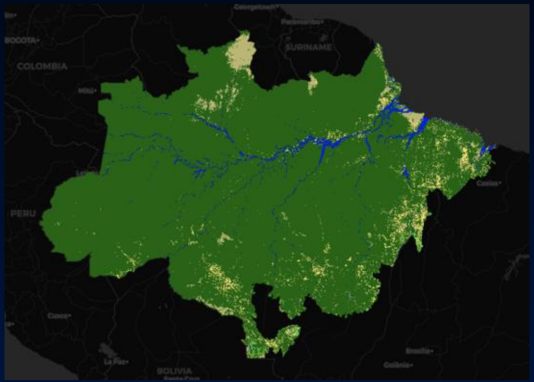
Impacto da atividade humana no planeta



IPBES, 2018

Evolution of deforestation in Amazonia 1975-2018





1975

0,5 %

1988

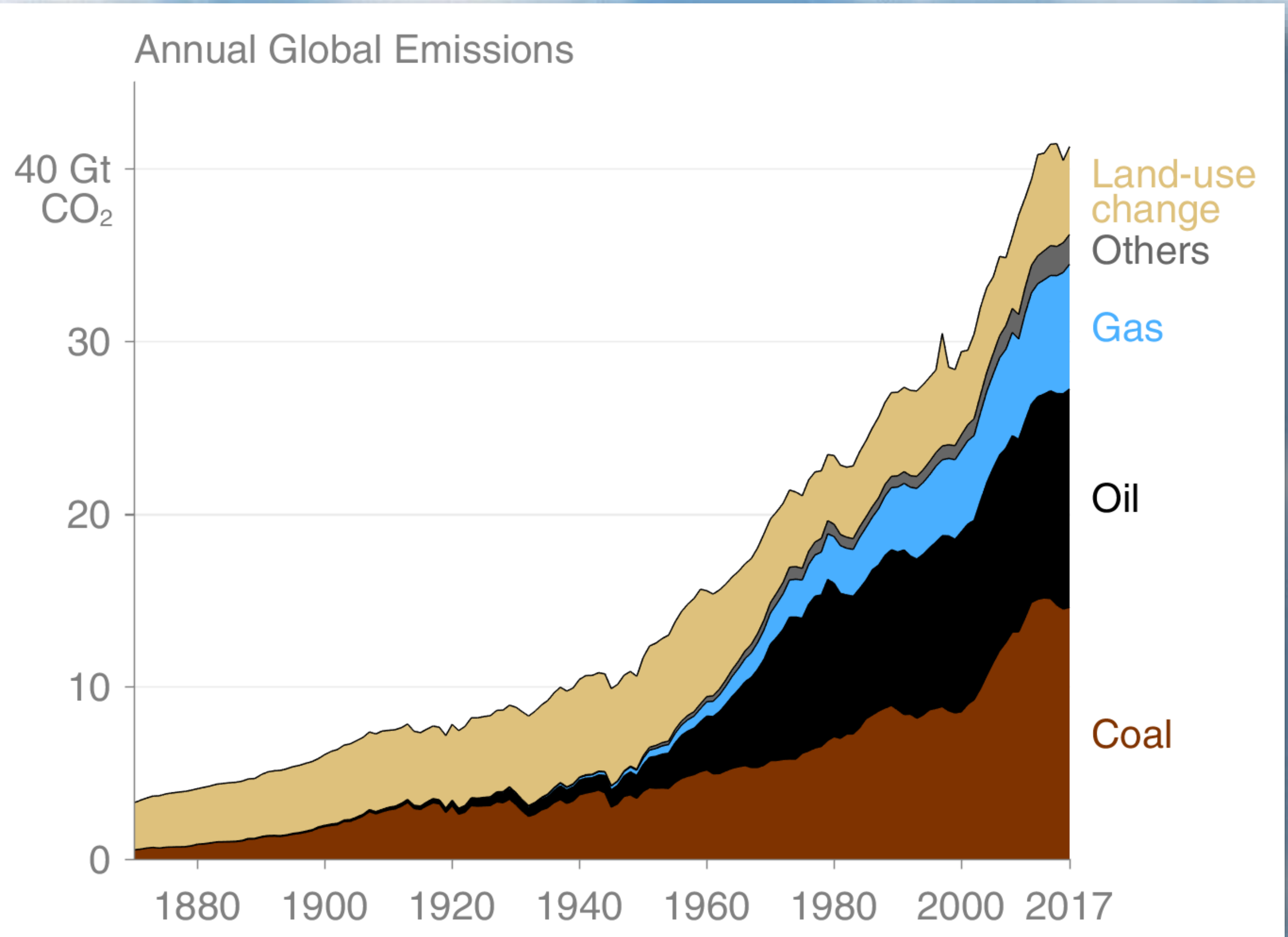
5,0 %

2018

19 %

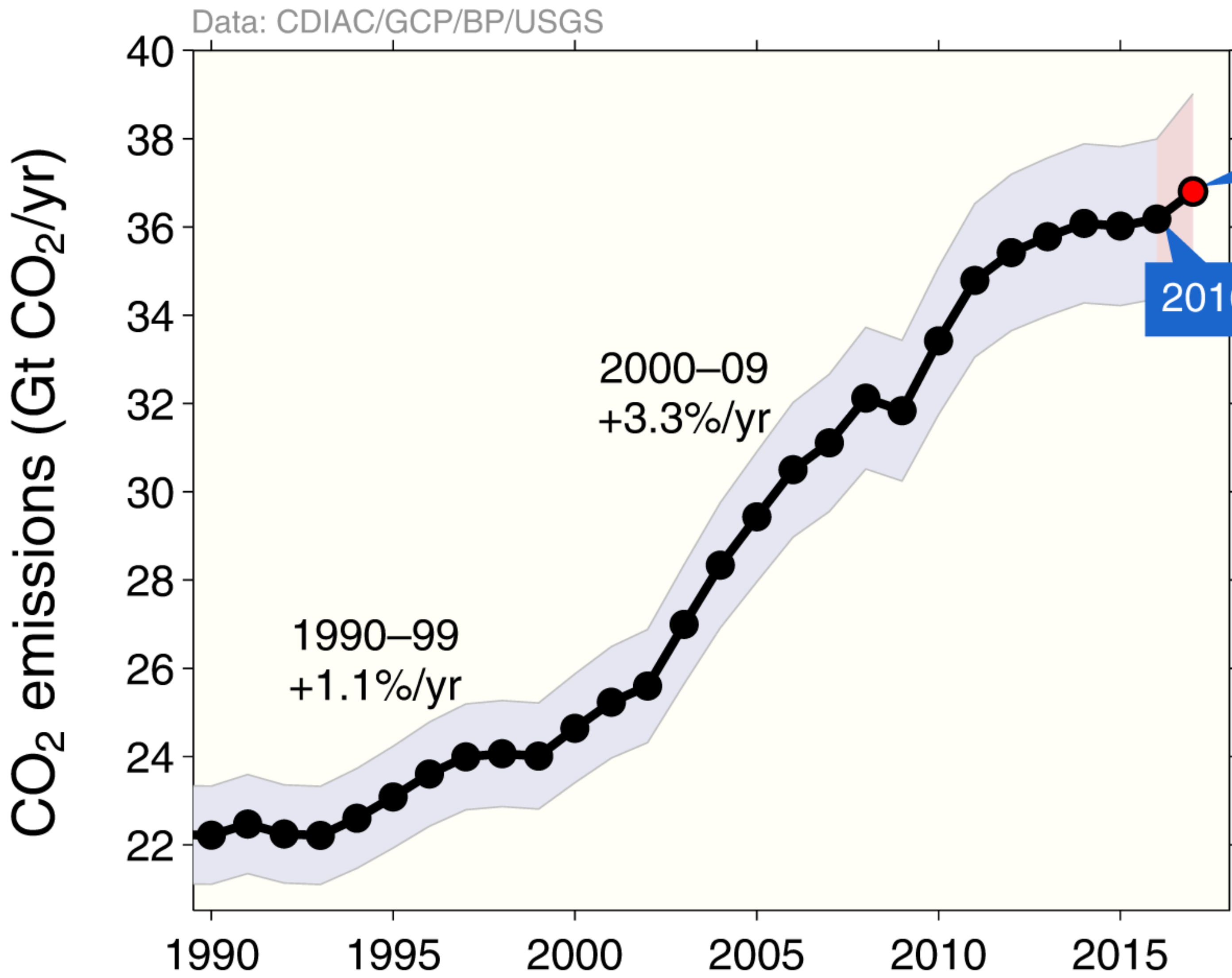
Souce: Prodes/INPE, MapBiomas

Emissões globais de carbono: Mudanças de uso do solo dominaram as emissões até 1940. Combustíveis fósseis dominam hoje (90%)



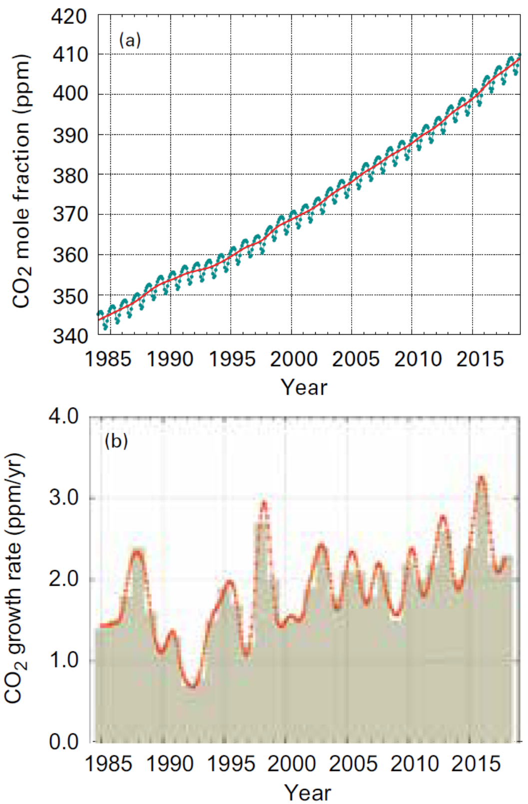
Source: Le Quéré et al 2018; Global Carbon Budget 2018

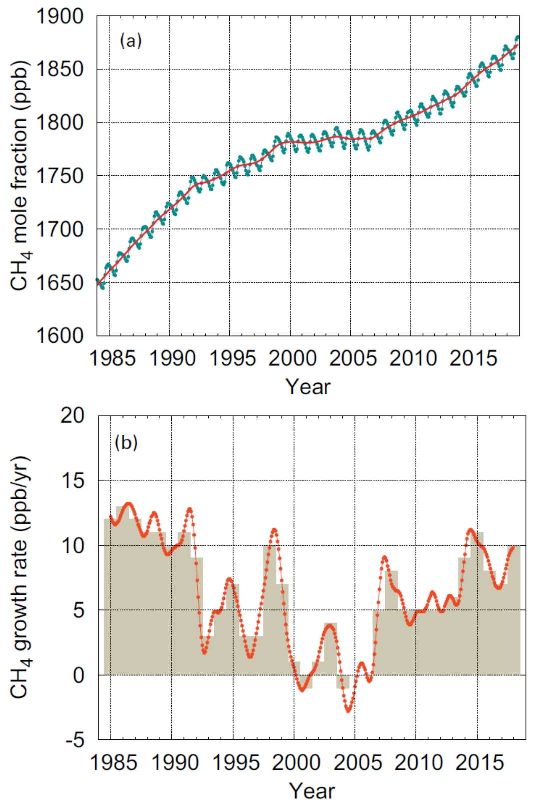
Emissões globais de CO2:
36.8 $GtCO_2$ em 2017, 62% acima de 1990

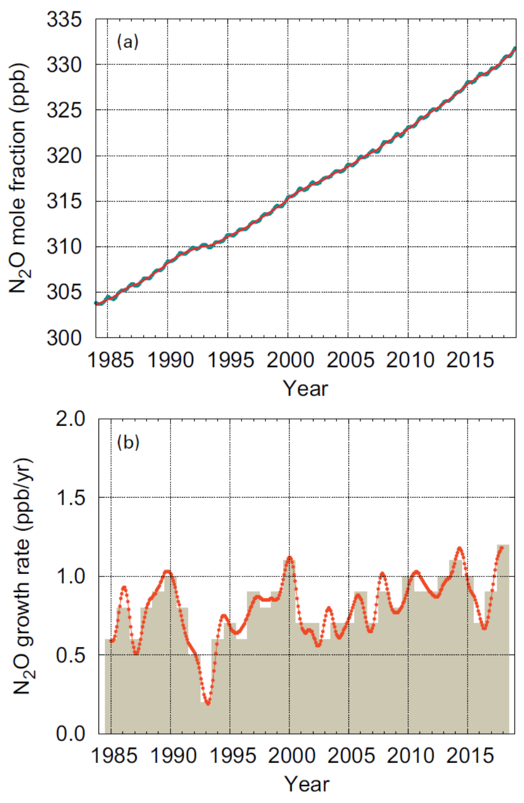


Global Carbon Budget 2017

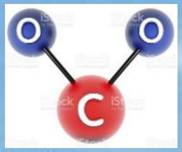
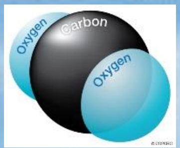
Concentrações de CO_2, CH_4 e N_2O

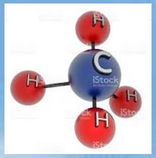
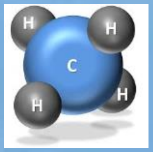
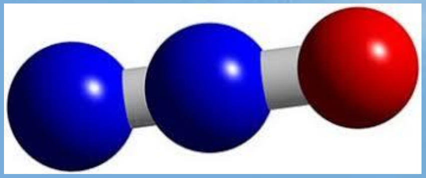




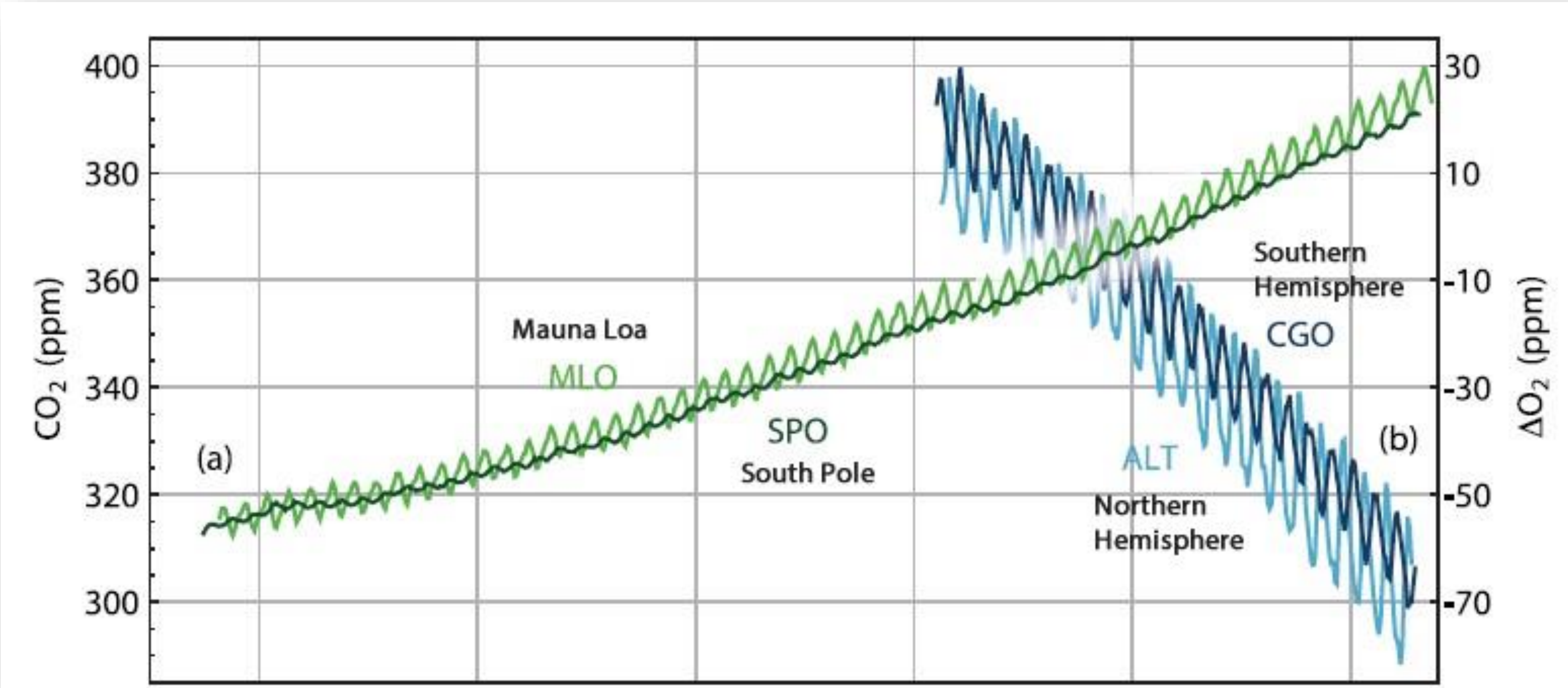


Aumentos desde 1750: CO_2: 147%, CH_4: 259%, N_2O: 123%

Aumento de CO_2 e diminuição de O_2



1950

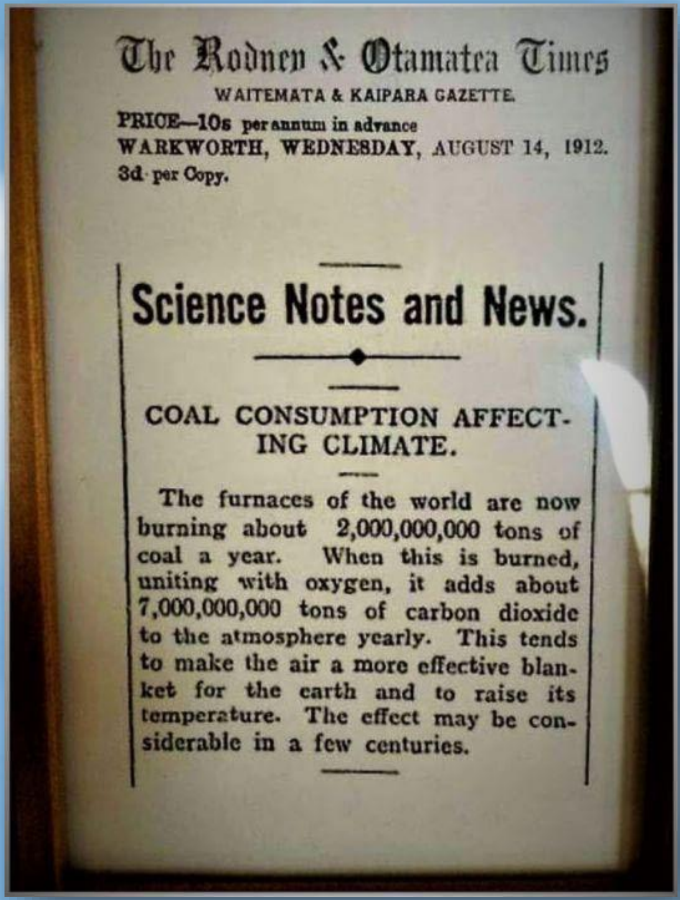
2015

Em 1896, a primeira previsão climática: Svante Arrhenius

Arrhenius

Arrhenius quantificou em 1896 as mudanças na temperatura da superfície (aprox. 5 C) que deveriam ocorrer se dobrássemos a concentração de CO_2, baseado nos conceito do efeito ”glass bowl” introduzido em 1824 por Joseph Fourier.

Matéria de jornal de 1912!!!



The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE.

PRICE—10s per annum in advance

WARKWORTH, WEDNESDAY, AUGUST 14, 1912.

3d per Copy.

Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

Global sources and sinks of CO_2 in 2019

Global fossil CO_2 emissions: 36.8 ± 2 $GtCO_2$ in 2019, 61% over 1990

32.4 $GtCO_2$/yr

87%

Sources

13%

4.4 $GtCO_2$/yr

17.3 $GtCO_2$/yr

44%

Sinks

29%

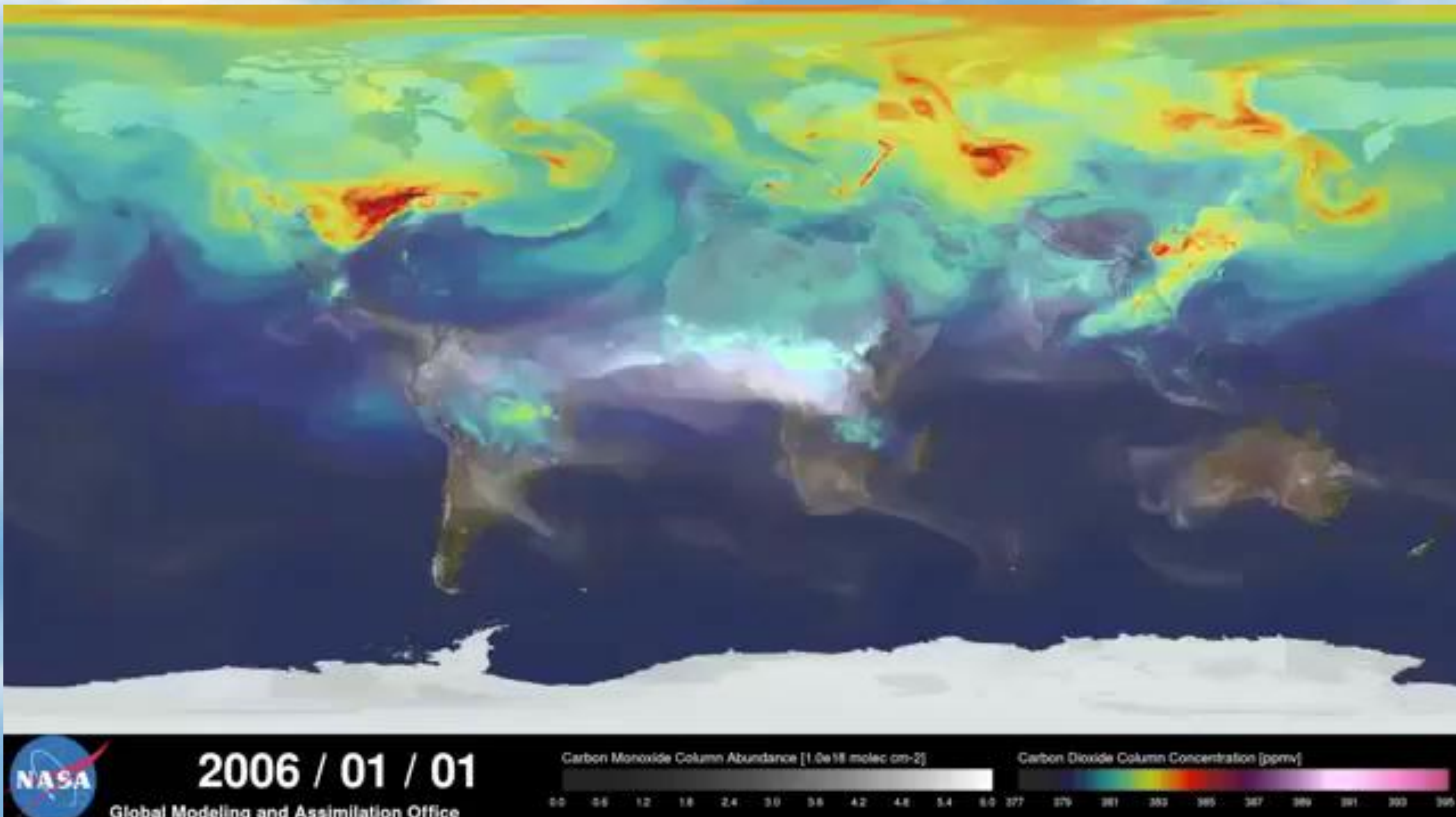
11.6 $GtCO_2$/yr

22%

8.9 $GtCO_2$/yr

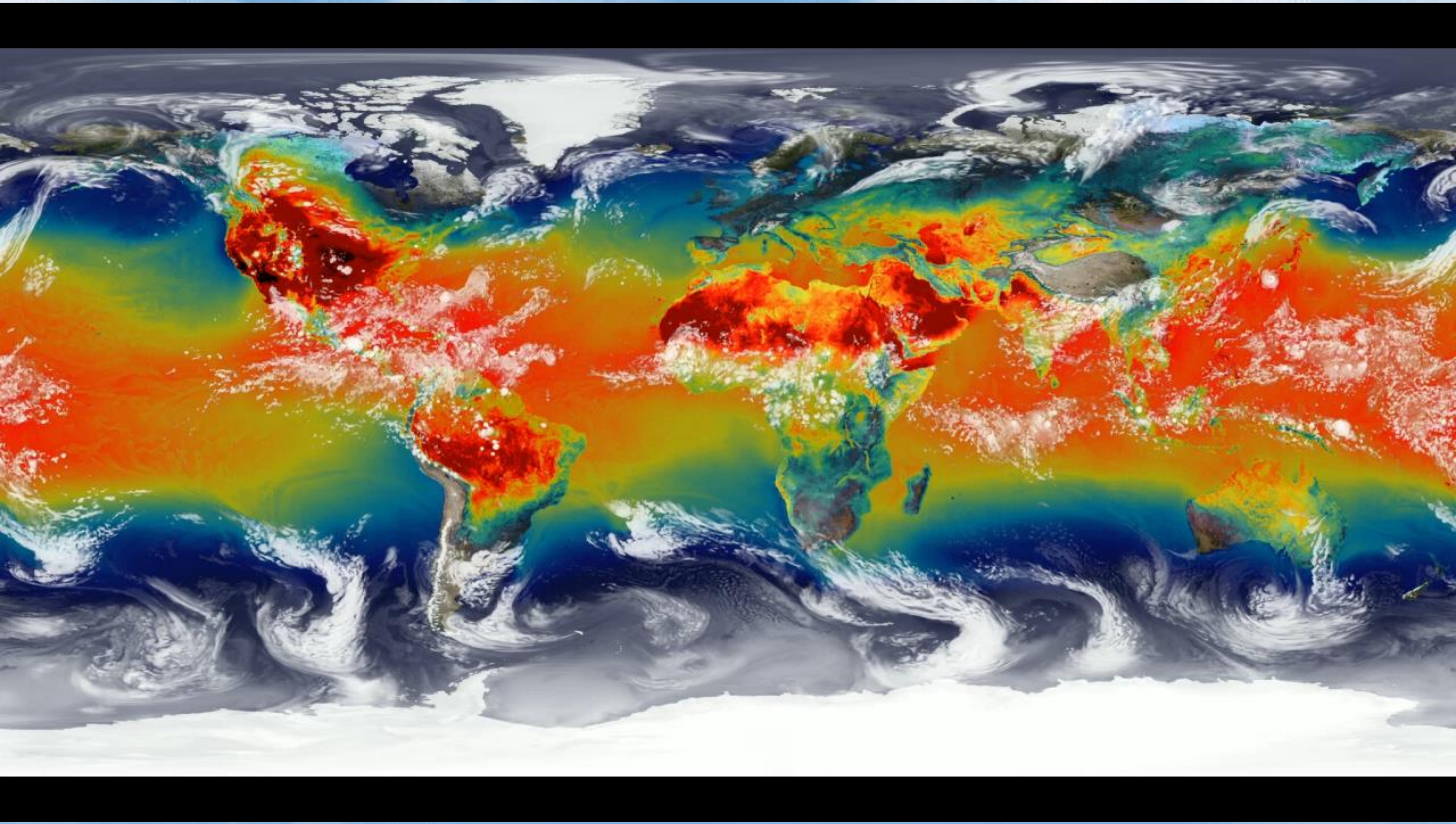
Source: Le Quéré et al 2016; Global Carbon Budget 2019

Distribuição global de CO_2



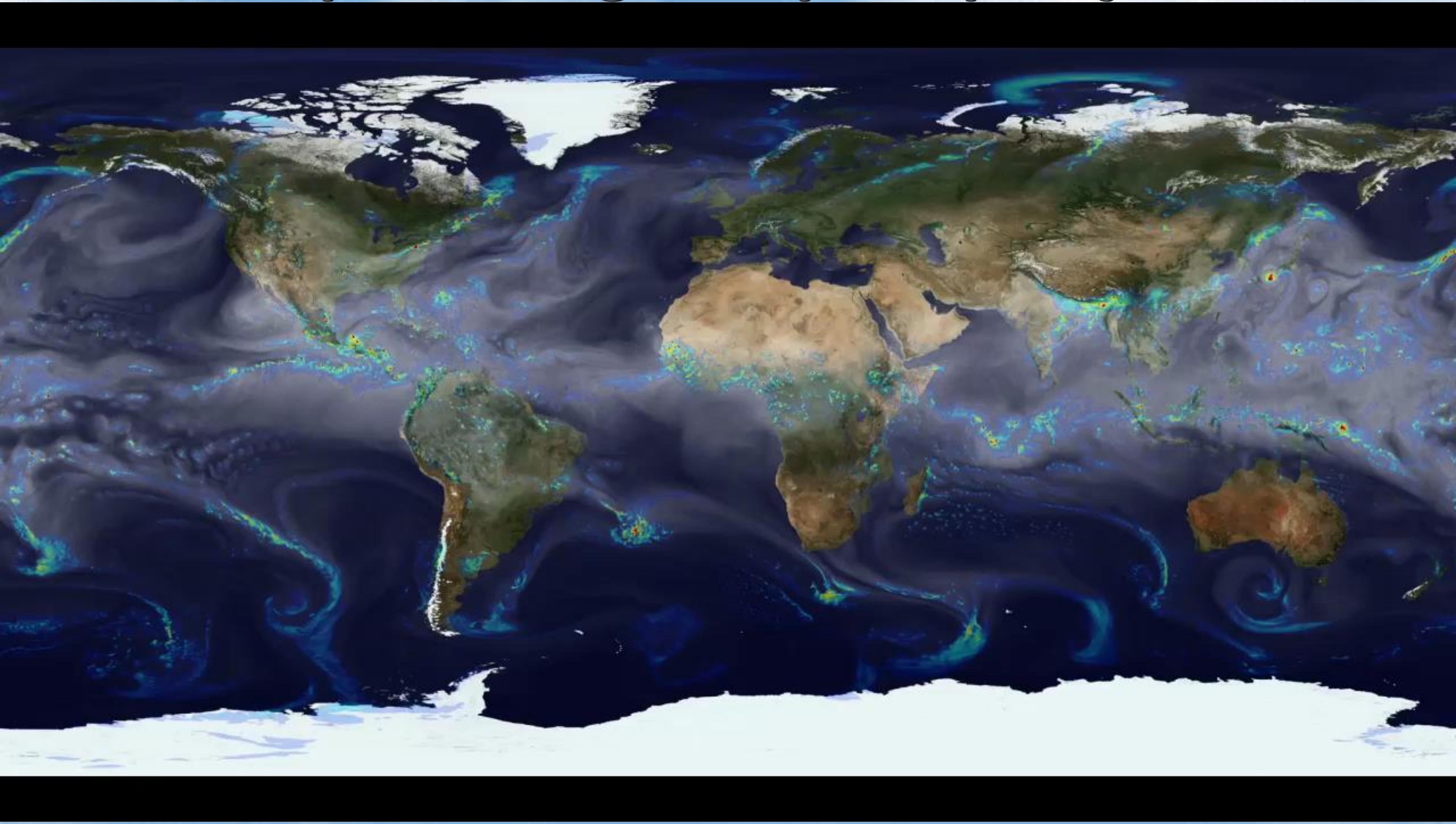
http://svs.gsfc.nasa.gov/goto?11719

Fluxos de energia em nosso planeta



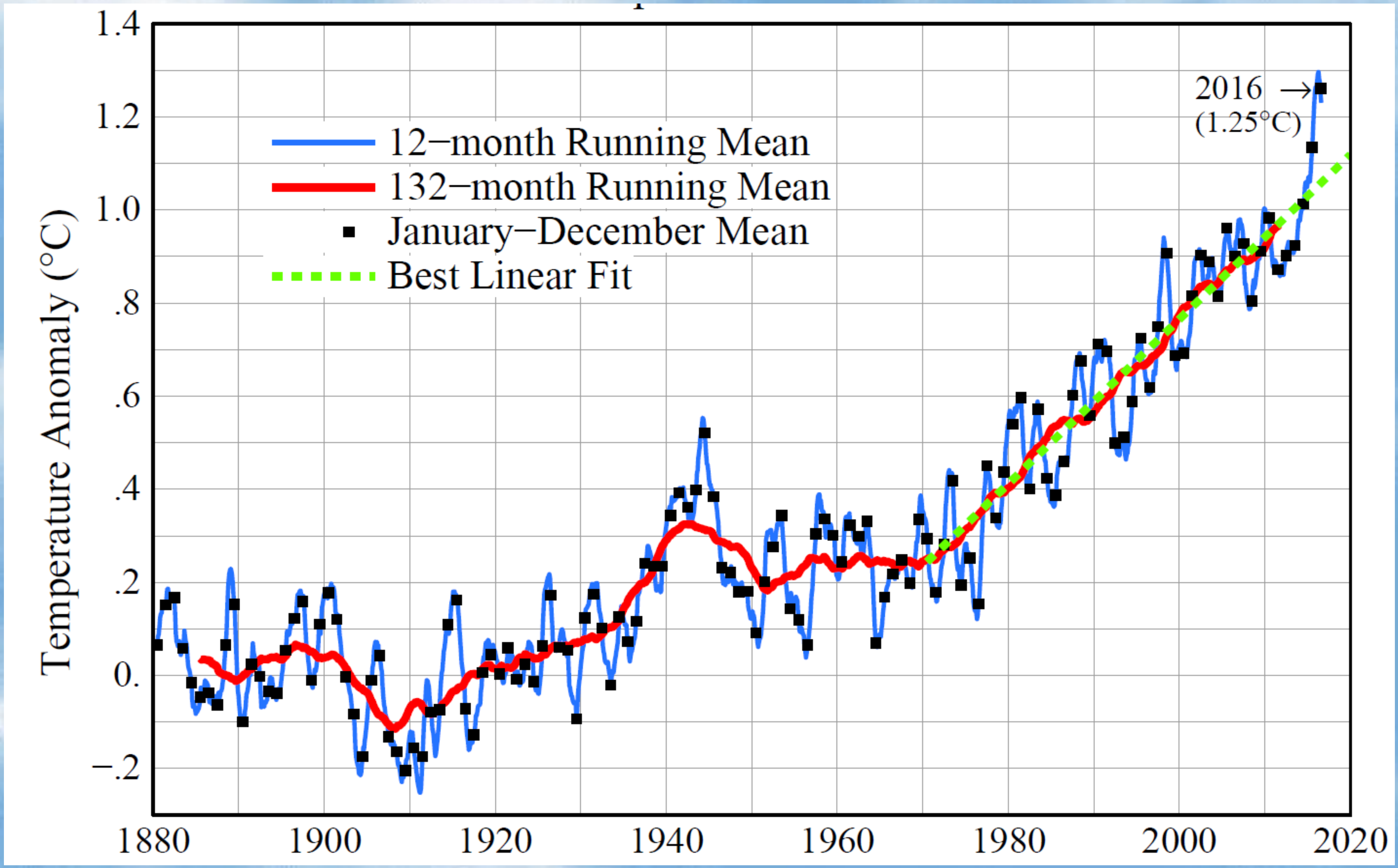
Around the World with Energy
Surface temperature (colors 270-310 Kelvin) and outgoing longwave radiation at the top of the atmosphere (white) representative of clouds in the model.
GEOS-5 simulation of surface temperatures between May 2005 and May 2007. Colors show surface temperatures ranging from 270 to 310 Kelvin. Outgoing longwave radiation at the top of the atmosphere represents clouds (white) in the model. Model: GEOS-5

Vapor de água e precipitação

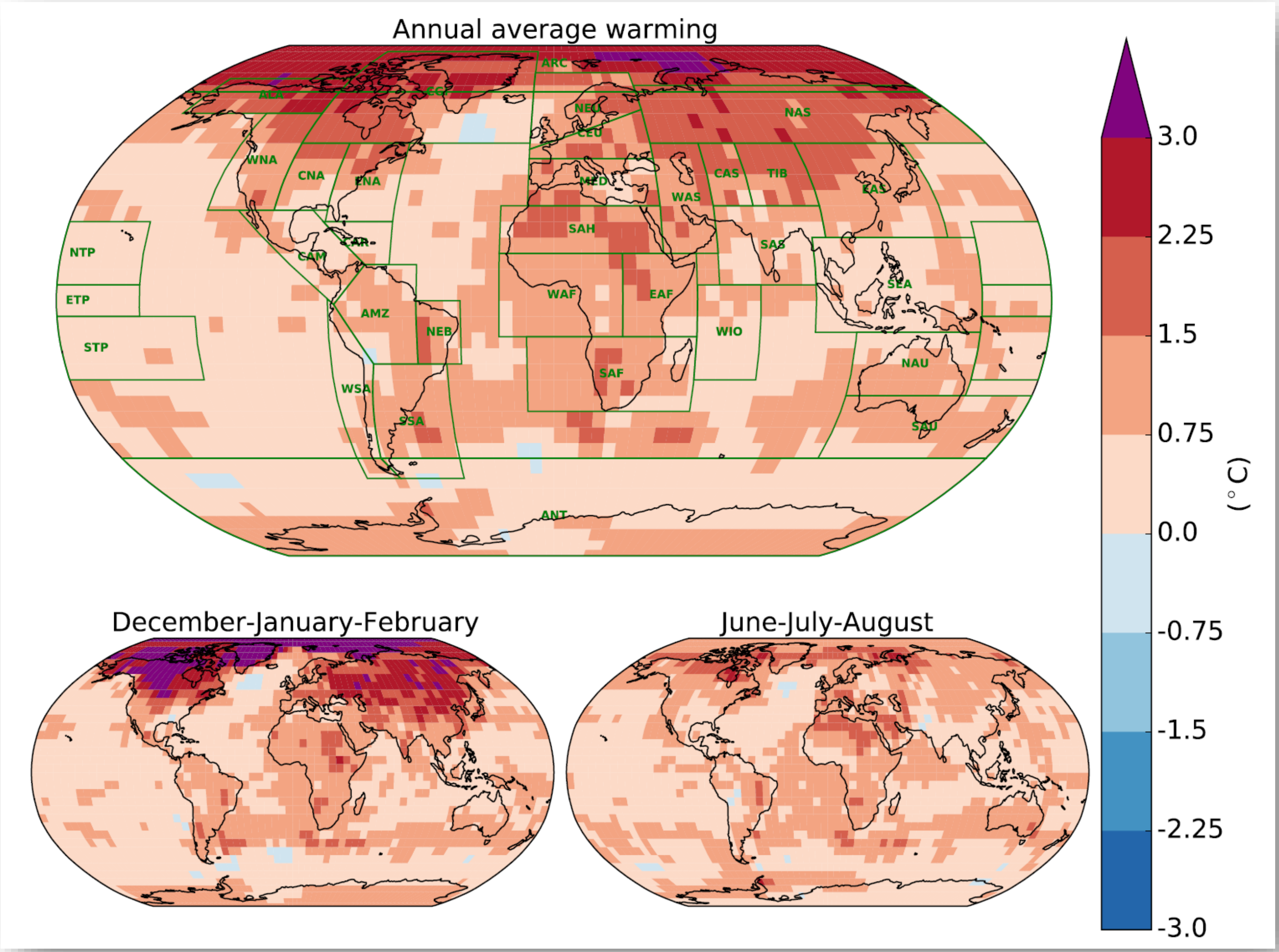


To study the effects of precipitation and how it influences other phenomena, scientists study moisture and precipitation in the atmosphere. Satellite observations cover broad areas and provide more frequent measurements that offer insights into when, where, and how much it rains or snows worldwide. Researchers from NASA's Global Modeling and Assimilation Office ran a 10-kilometer global mesoscale simulation to study the presence of water vapor and precipitation within global weather patterns. In this simulation, from May 2005 to May 2007, colors represent rainfall rates ranging from 0 to 15 millimeters per hour. Total precipitable water, or precipitable water vapor, is depicted in white shades. Such simulations allow scientists to better understand global moisture and precipitation patterns.

Temperatura média global 1880-2017

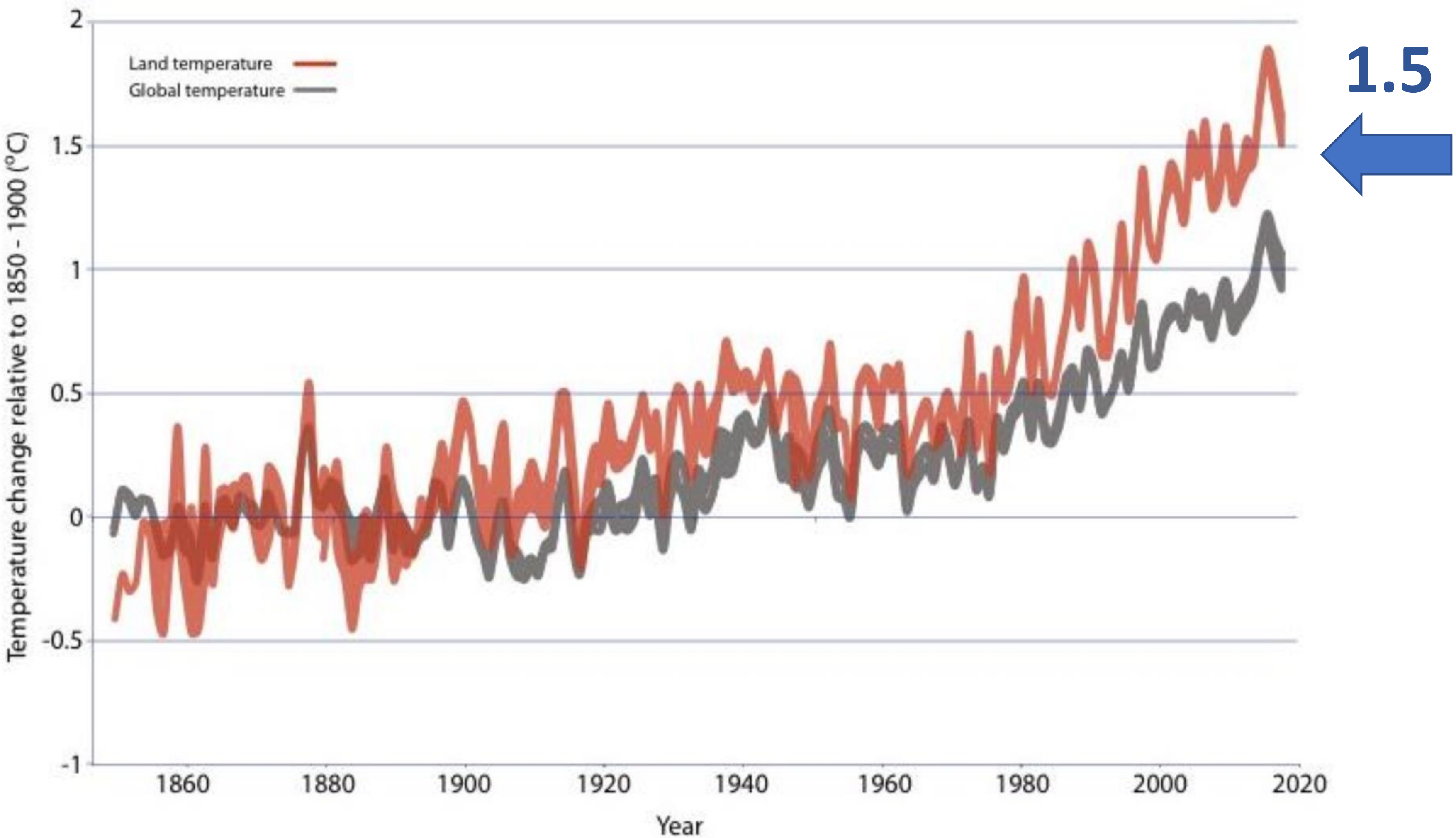


Aumento observado de temperatura de 1901 a 2012
Distribuição espacial não é homogenea



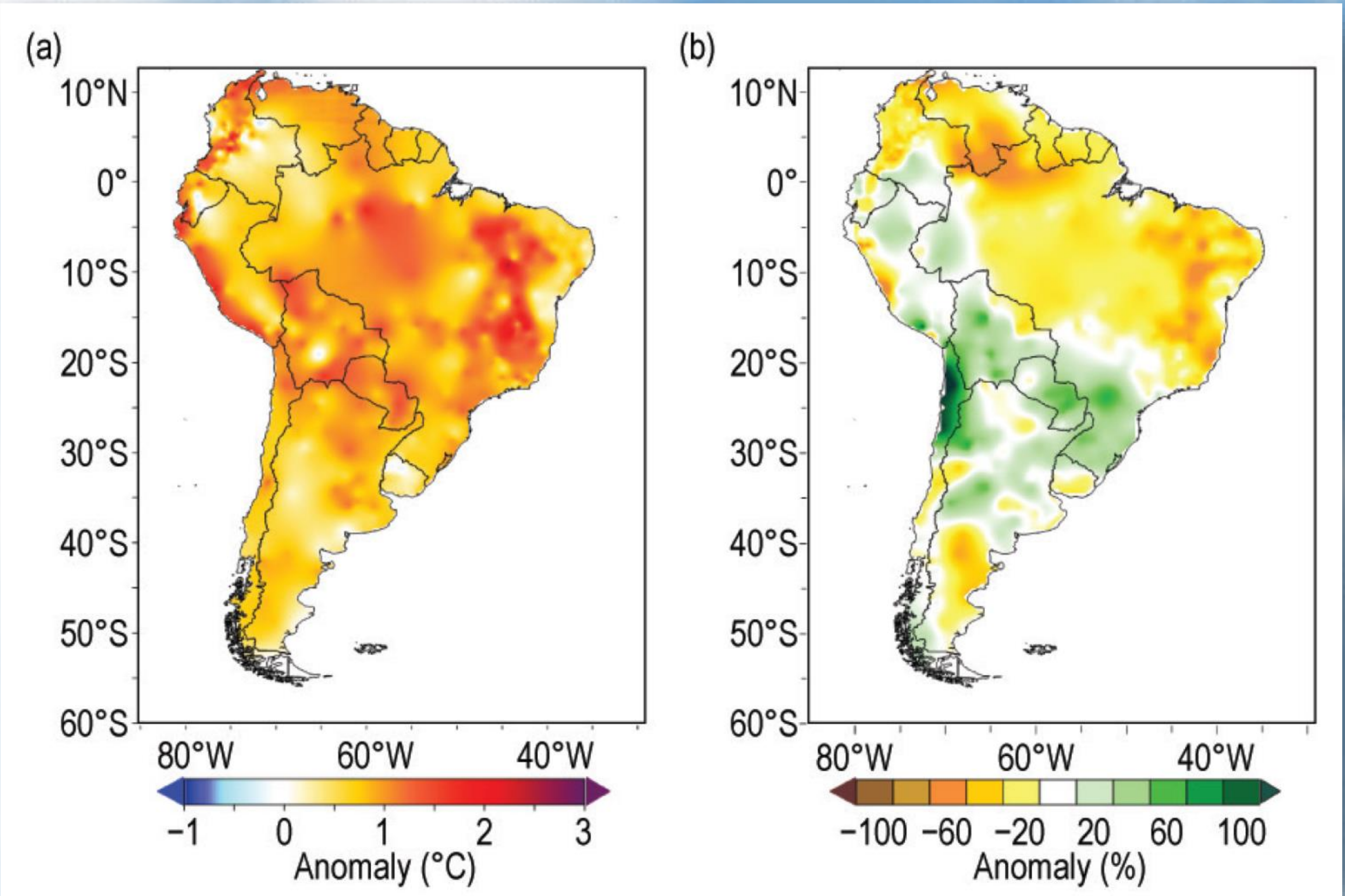
Source: IPCC 2018 Special Report on Global Warming of 1.5°C

Aumento da temperatura nos continentes e aumento global



IPCC SRCCL 2019

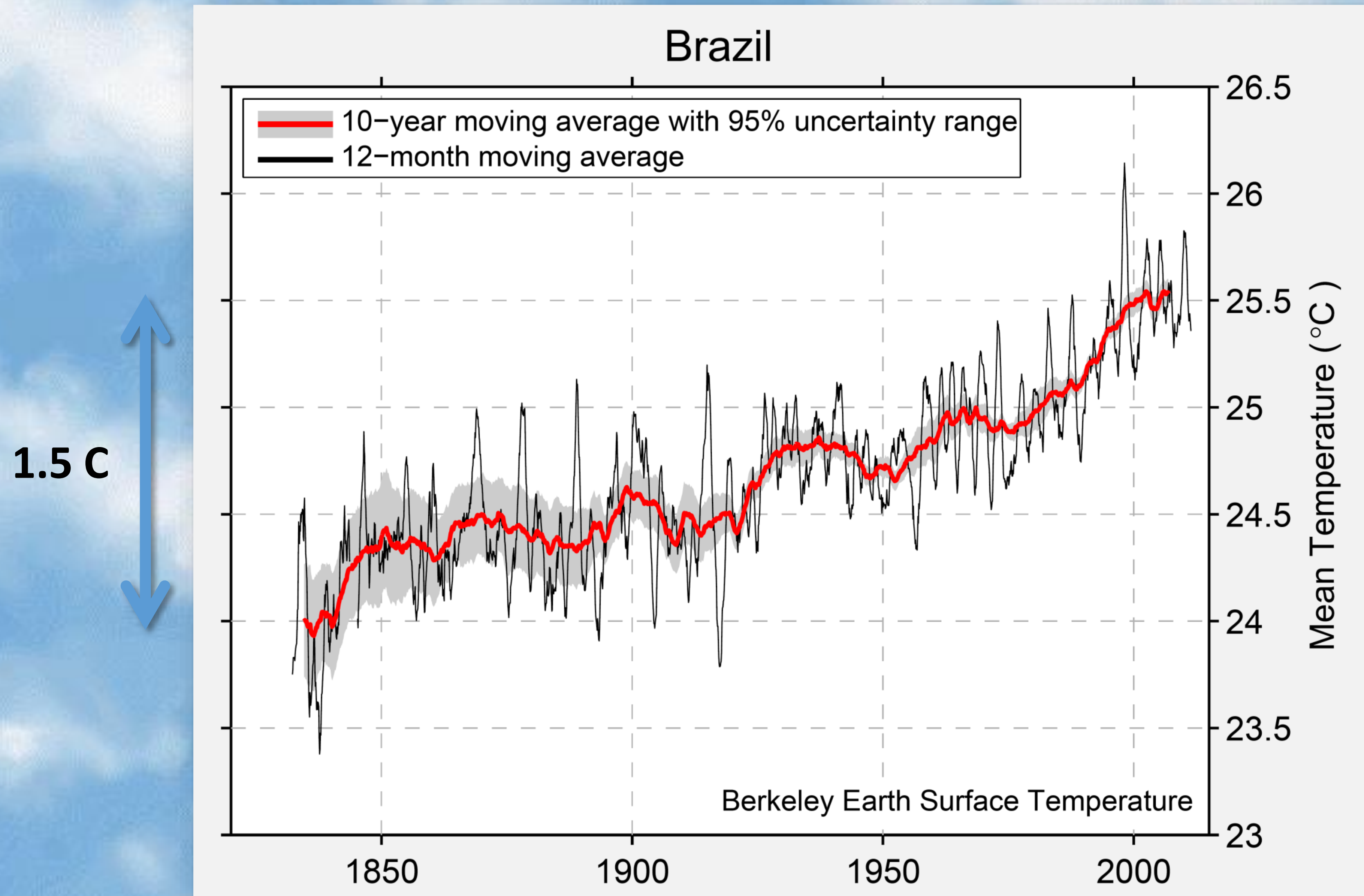
América do Sul: (a) anomalias de temperaturas (°C) e (b) anomalias de chuva (%)



Período de base: 1981–2010.

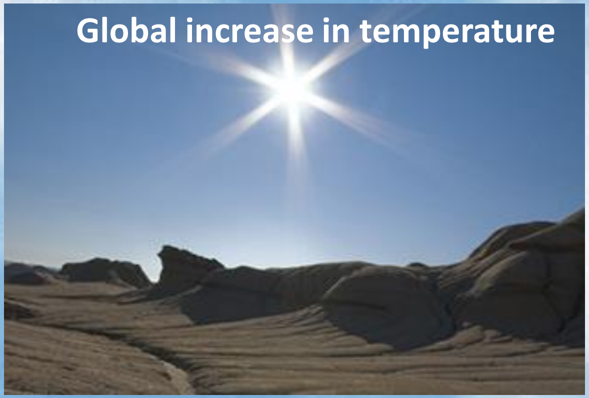
Fonte: State of the Climate in 2015, Bull. Amer. Meteor. Soc., 97 (8), 2016.

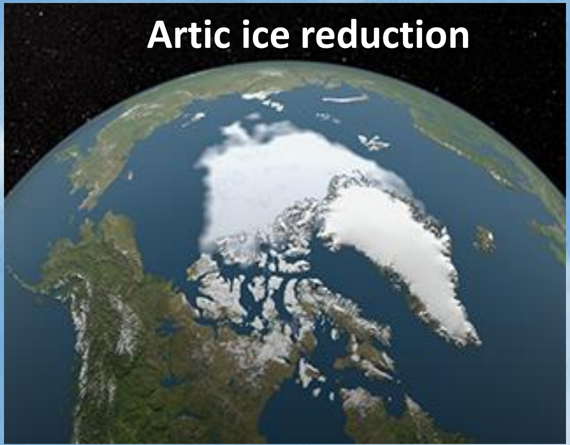
Aumento da temperatura média no Brasil



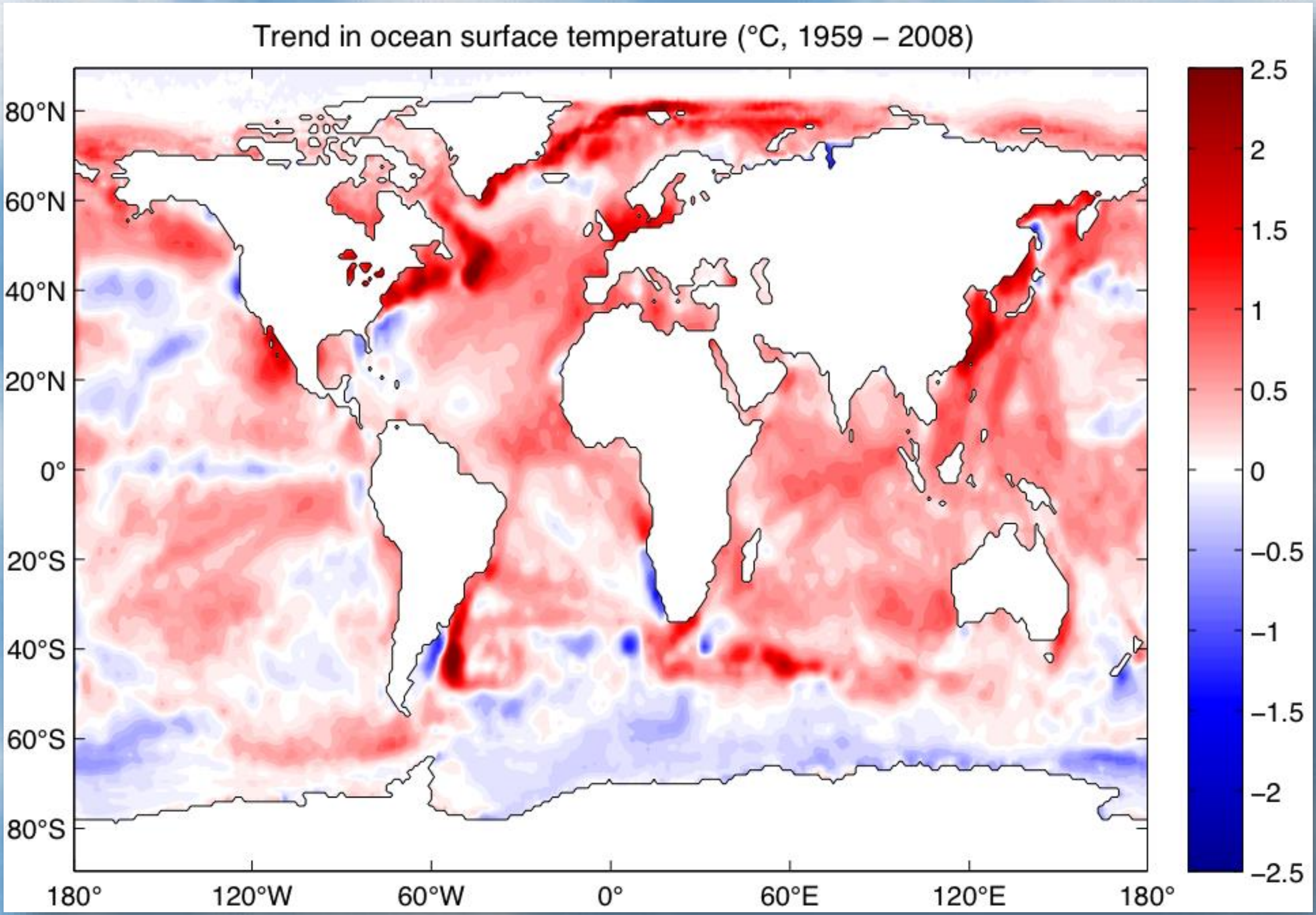
http://berkeleyearth.org/

Evidencias de rápidas mudanças climáticas

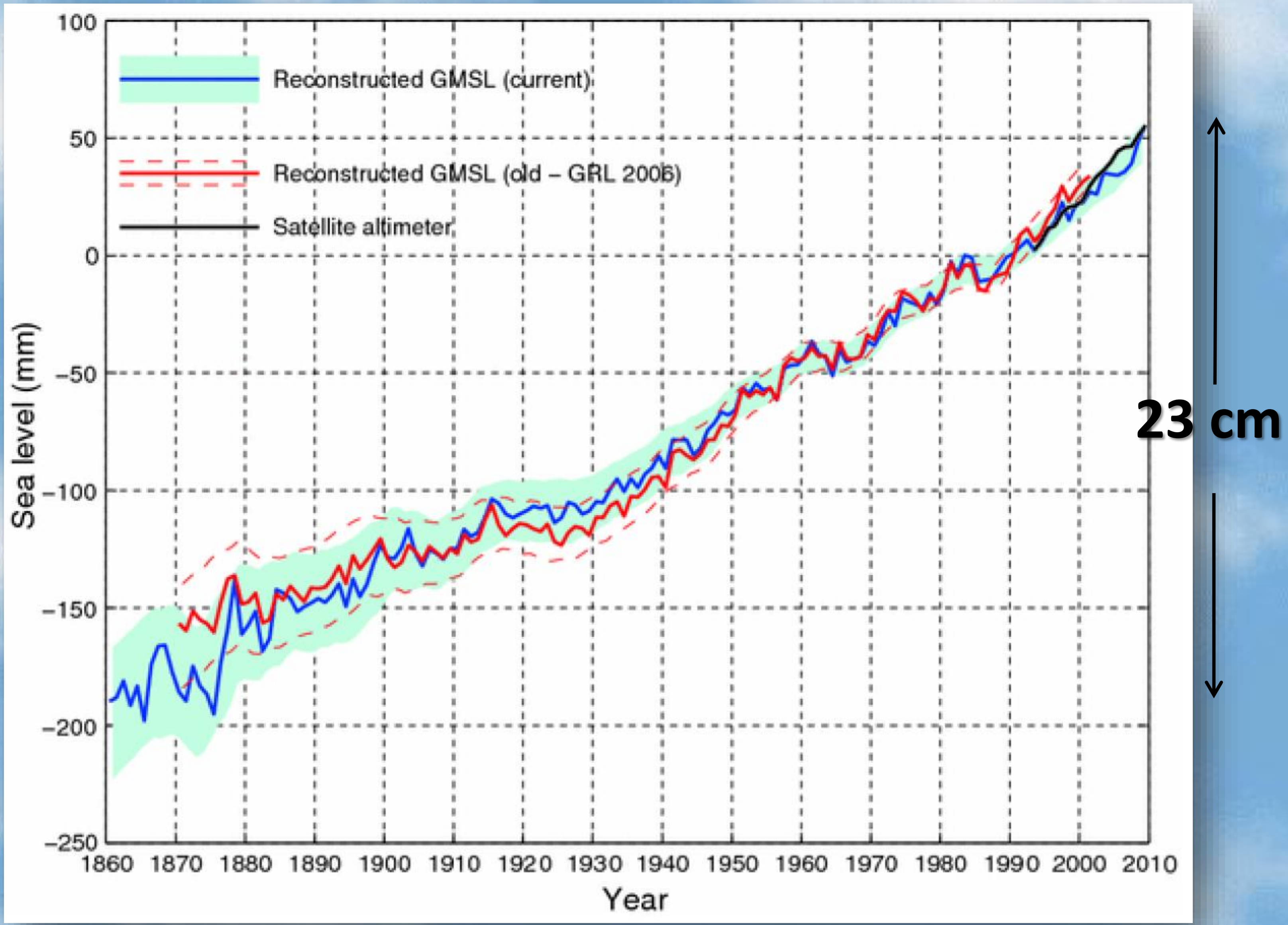




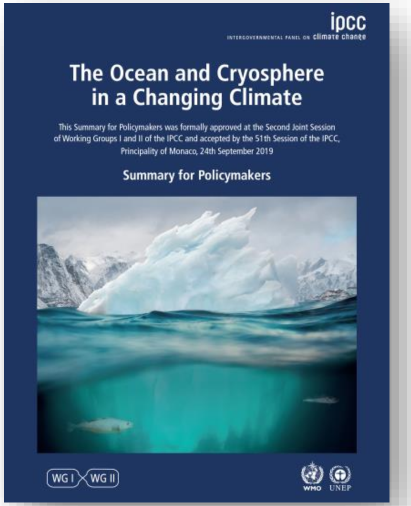
Temperatura do oceano, também aumentando - 1959 - 2008



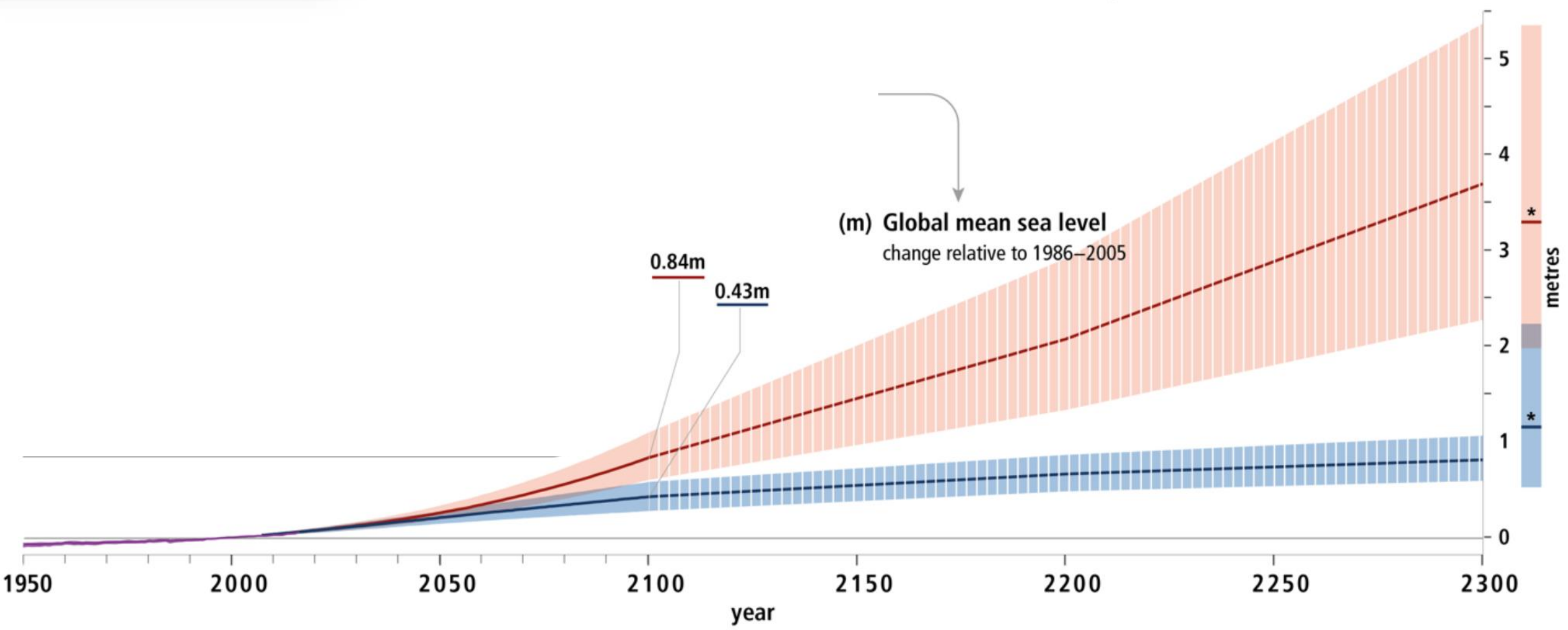
Nível médio dos oceanos subindo - 1860 a 2010



Global mean sea level (GMSL) reconstructed from tide gauge data (blue, red) and measured from satellite altimetry (black). *Source:* Church and White (2011).



Aumento do nível do mar em 1950 – 2100 - 2300

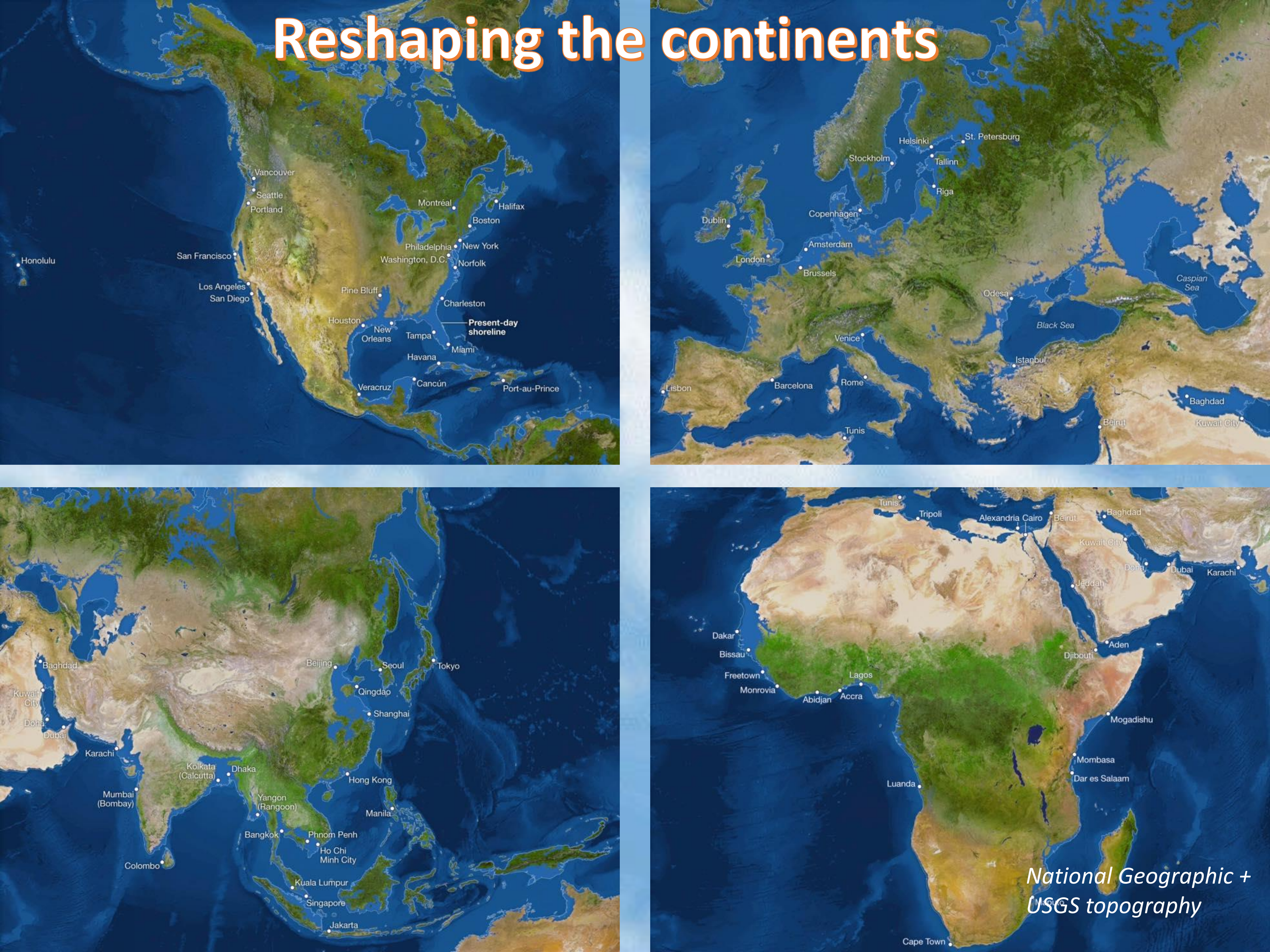


IPCC SRCC 2019

O futuro da América do Sul?

National Geographic + USGS topography

Reshaping the continents



National Geographic + USGS topography

NO ANTROPOCENO

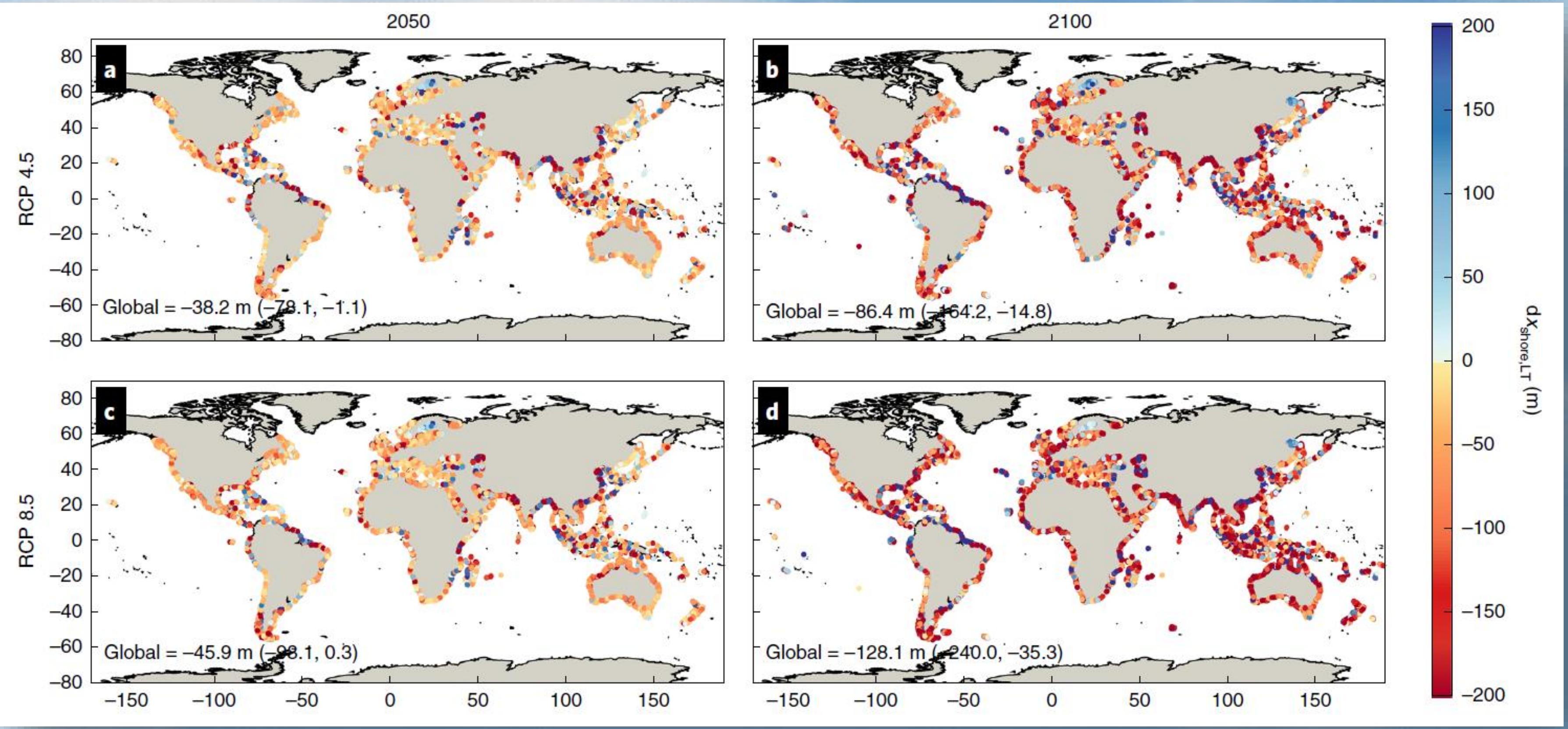
OS OCEANOS ESTÃO SOFRENDO TRANSFORMAÇÕES INÉDITAS EM ATÉ 300 MILHÕES DE ANOS

1°C
MAIS
QUENTES

26%
MAIS
ÁCIDOS

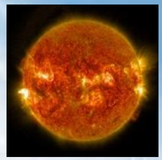
2%
A MENOS DE
OXIGÊNIO
DISSOLVIDO

Mudanças na extensão das praias em 2050 e 2100

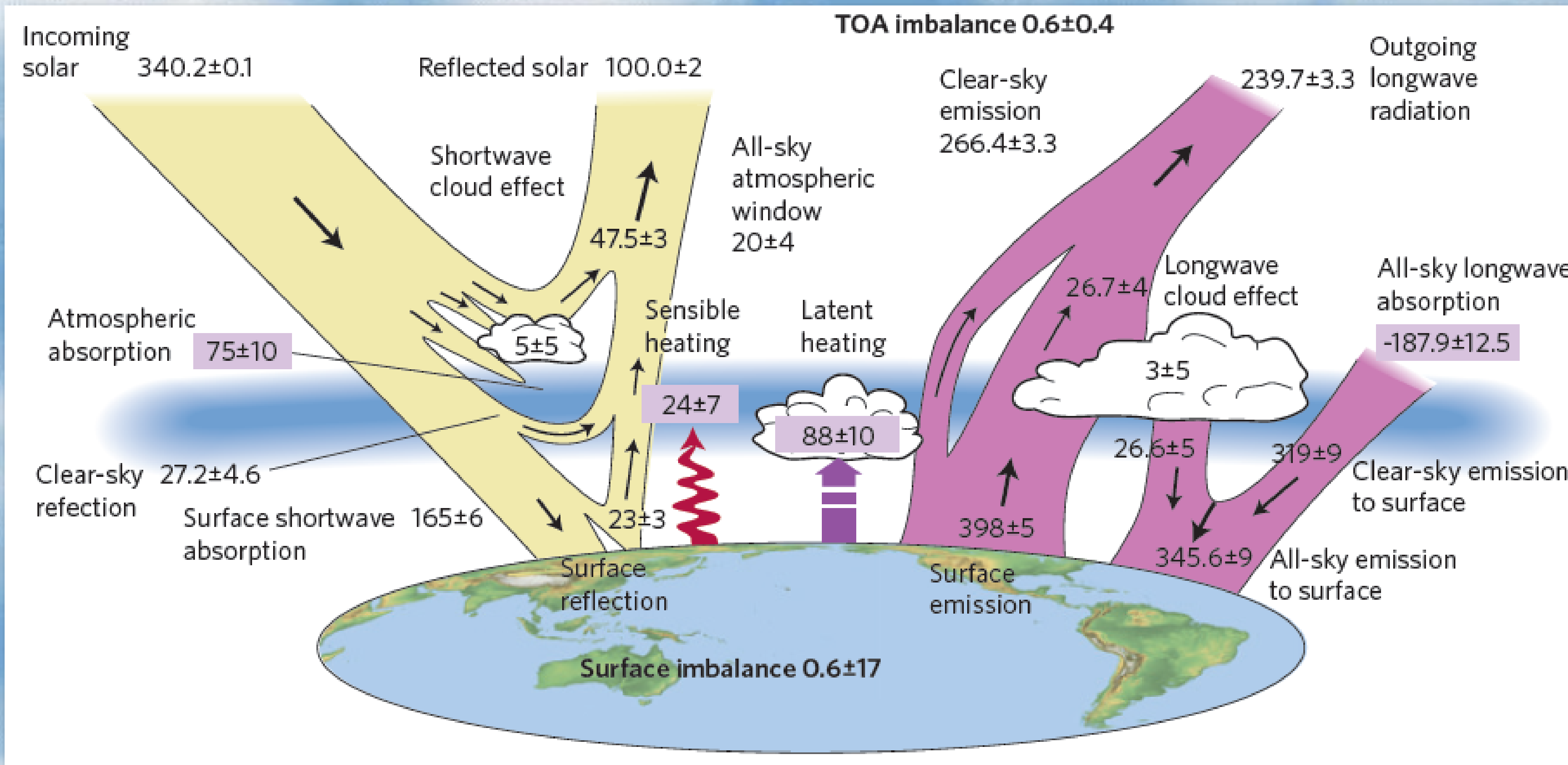


Redução nas praias de 100 m em 2050 no cenário RCP2.5 e de 240 metros no cenário RCP8.5

Nature Climate Change Março 2020, https://doi.org/10.1038/s41558-020-0697-0

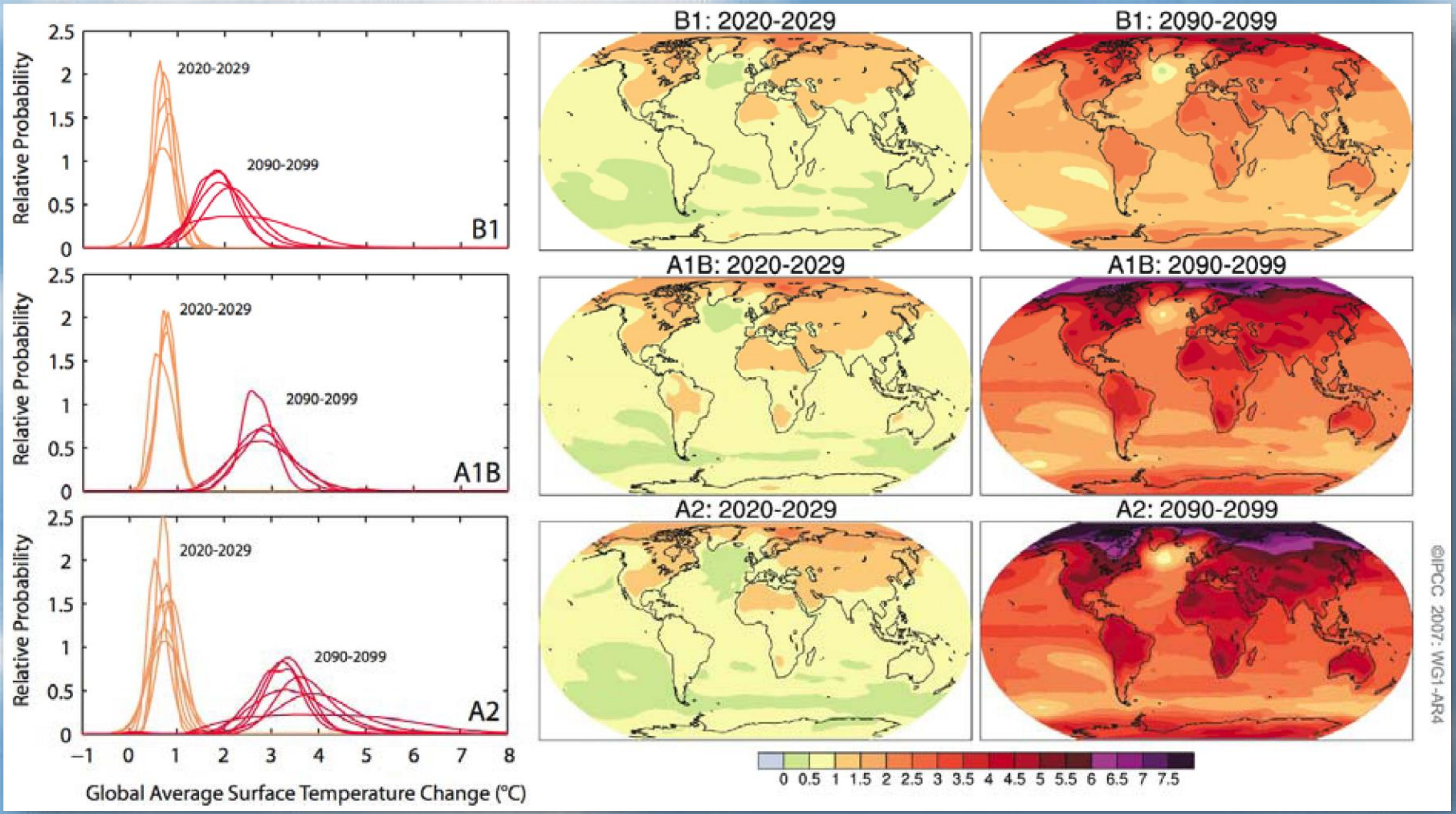


Balanço de energia do nosso planeta (W/m²)

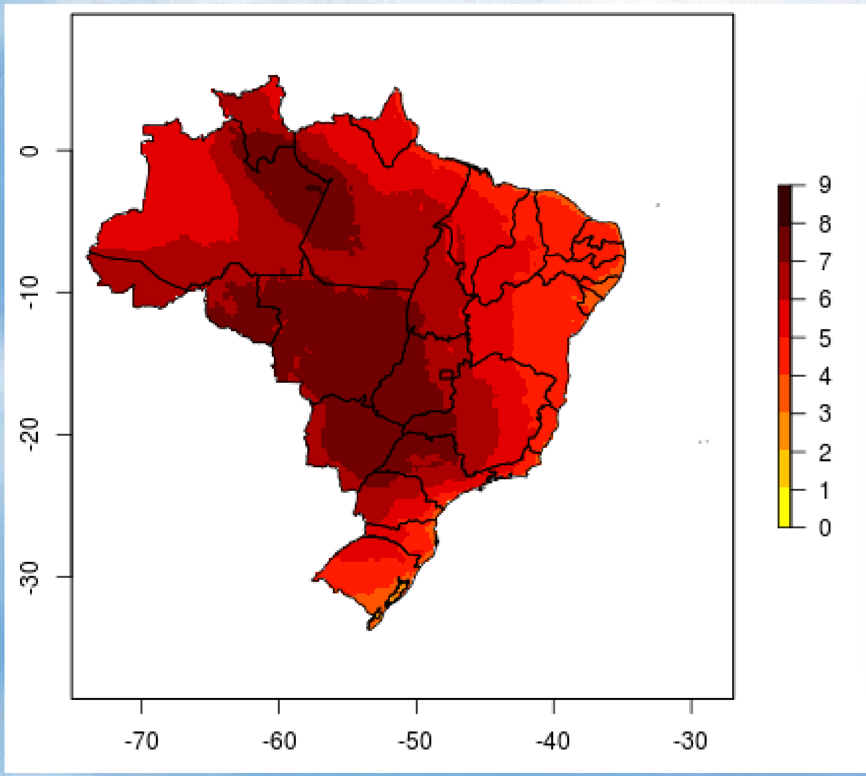


The global annual mean energy budget of Earth for the approximate period 2000–2010. All fluxes are in Wm^{-2}. (Stephens, Nature 2012)

Estimates of temperature increase for 2029 and 2099 following 3 emissions scenarios

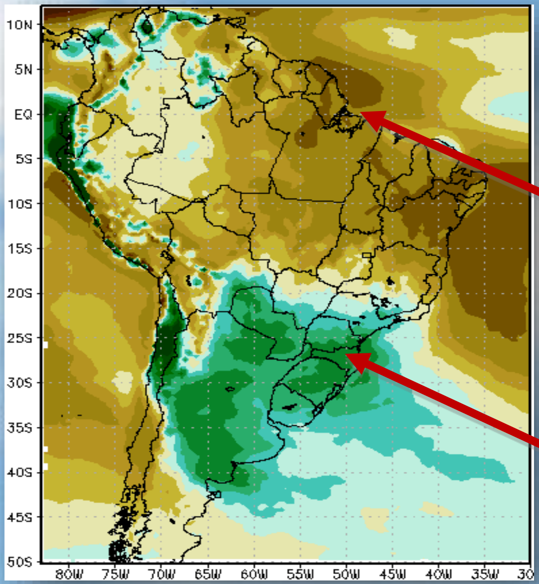


Aumento médio de temperatura esperado para o Brasil 2071-2099



Áreas continentais se aquecem mais que áreas oceânicas

Mudança na precipitação esperada para o Brasil 2071-2100



Mudanças na chuva (%) em 2071-2100 relativo a 1961-90.

Amazonia e Nordeste do Brasil → deficiência de chuvas

Sudeste da America do Sul → aumento nas chuvas

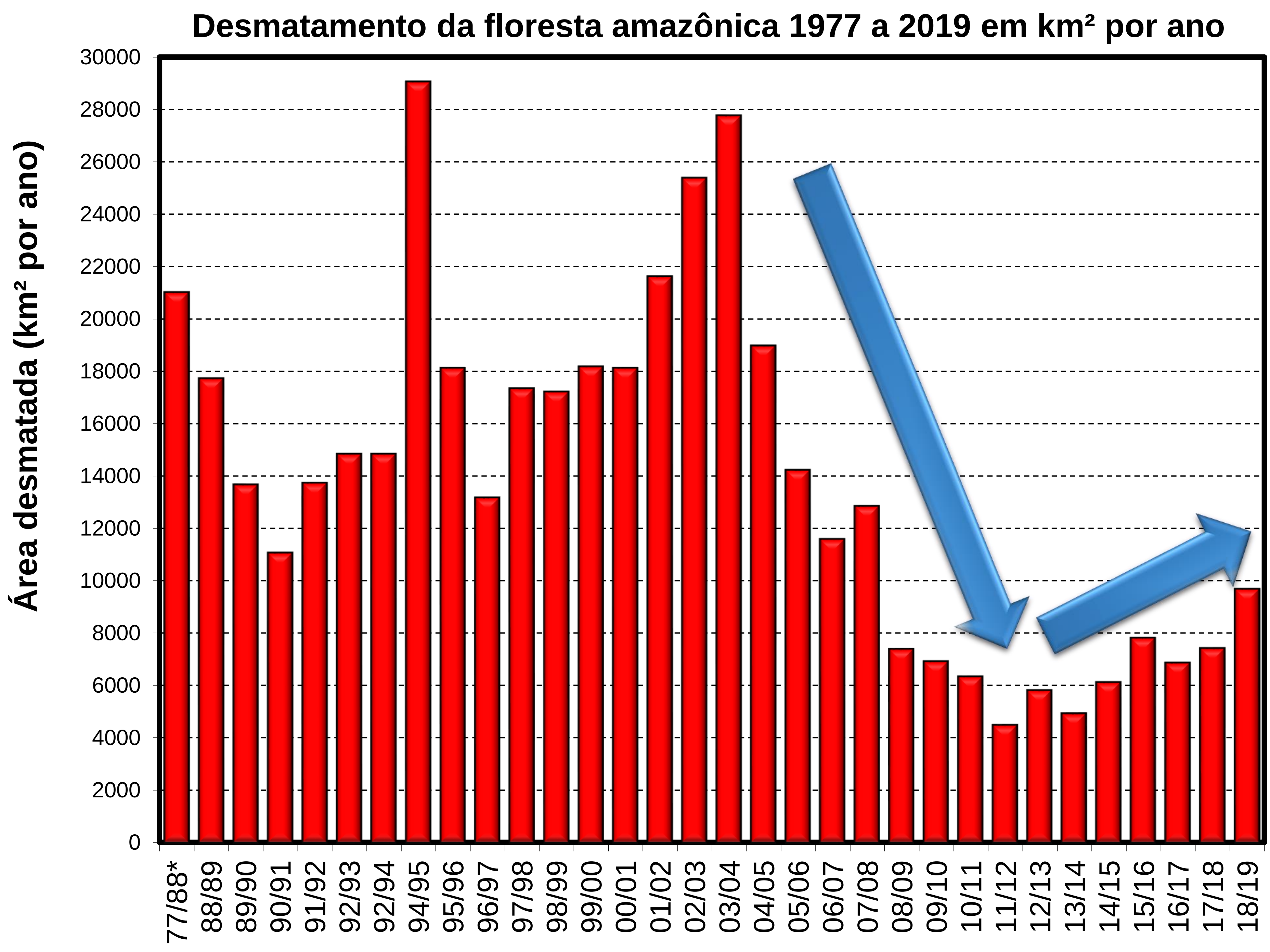
INPE, (RCP 8.5)

Amazonia can be part of the solution: a unique region, with global impacts on the carbon balance and hydrological cycle

Amazonia is a key component of the Earth System

Amazon tipping point: 40% deforestation and 30% less precipitation

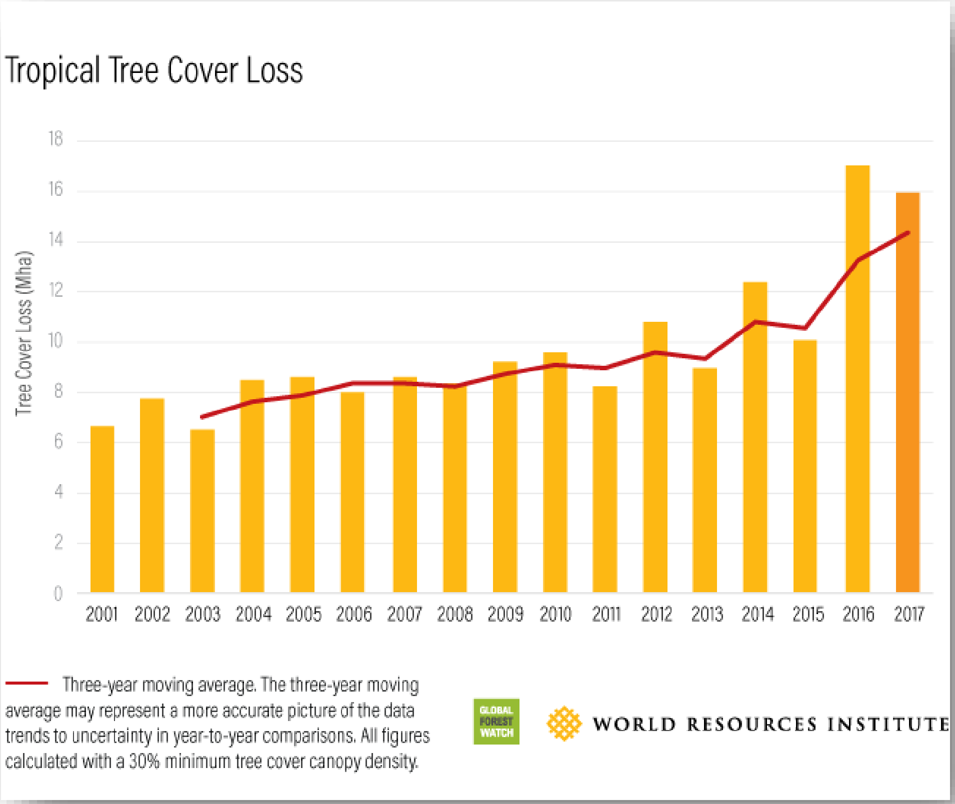
Lovejoy and Nobre, 2018

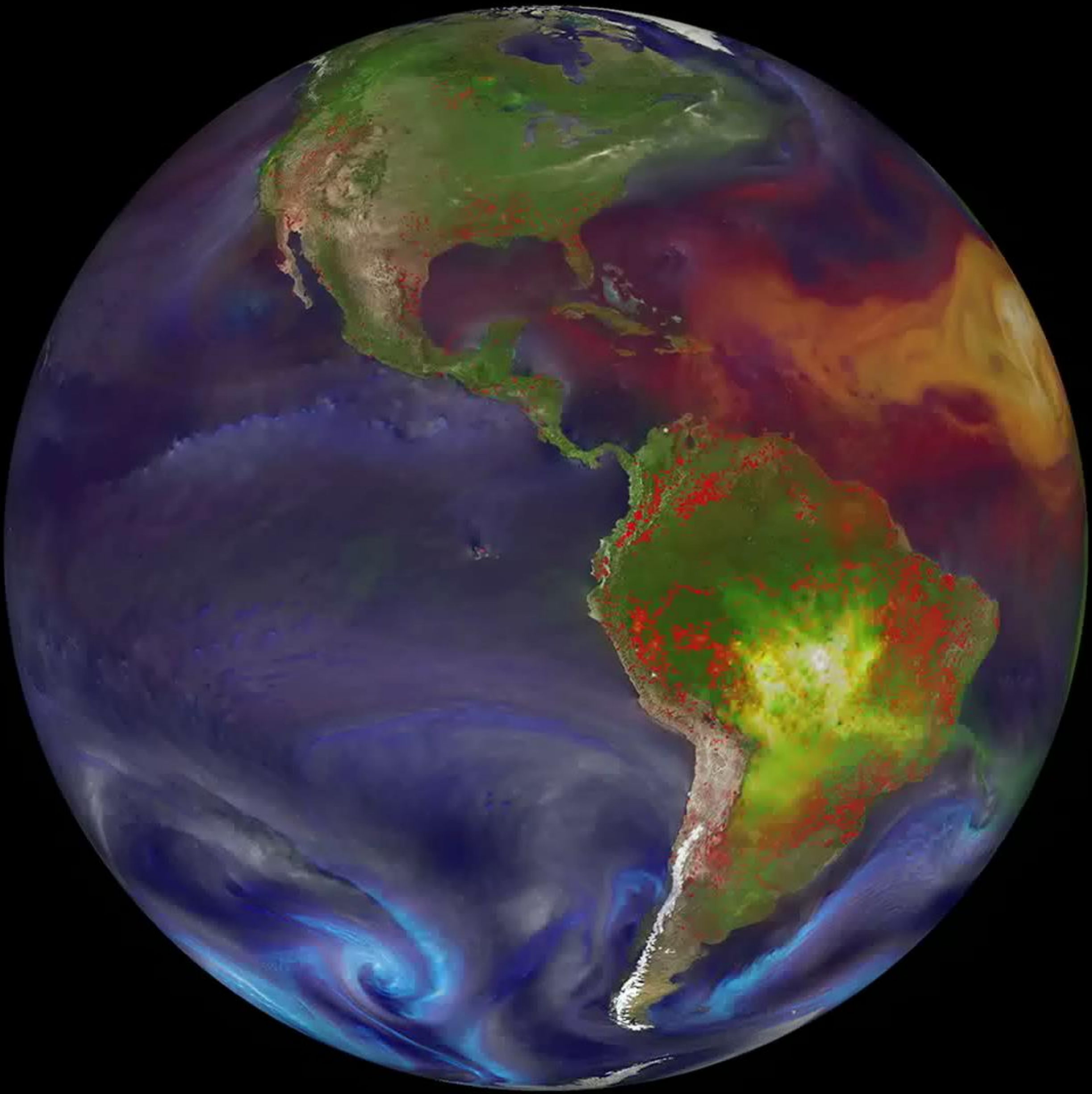


Desmatamento da floresta amazônica 1977 a 2019 em km² por ano
Área desmatada (km² por ano)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
77/88*
88/89
89/90
90/91
91/92
92/93
92/94
94/95
95/96
96/97
97/98
98/99
99/00
00/01
01/02
02/03
03/04
04/05
05/06
06/07
07/08
08/09
09/10
10/11
11/12
12/13
13/14
14/15
15/16
16/17
17/18
18/19

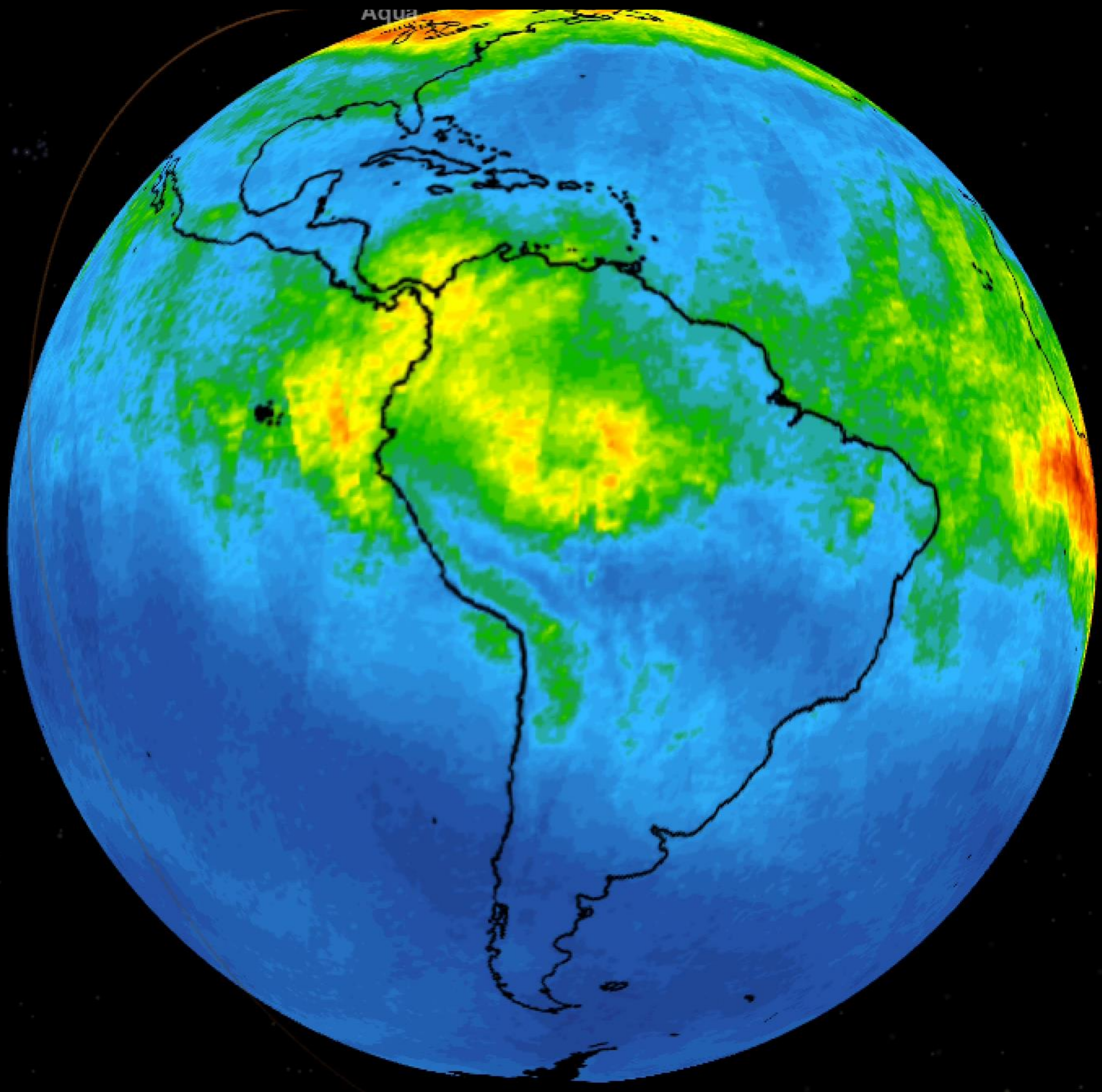
Os 10 países que mais desmataram em 2017

Desflorestamento tropical no planeta





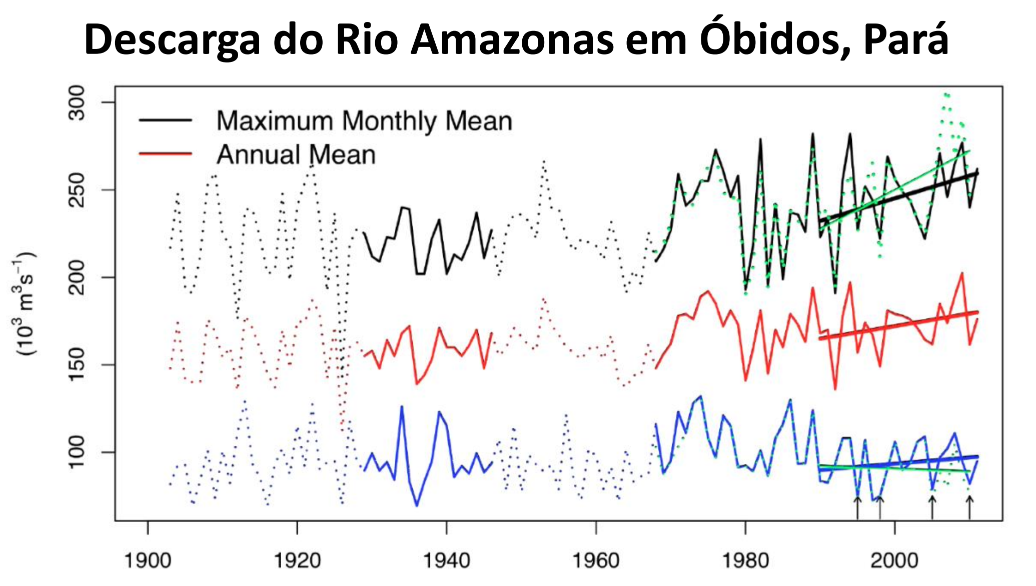
AIRS Carbon monoxide at 18000 ft



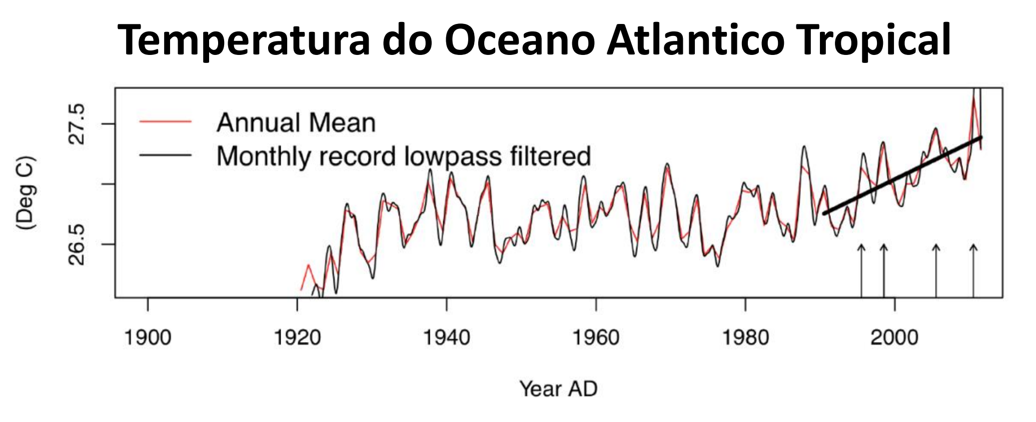

Amazon is critical for water vapor transport over South America
What processes controls these fluxes?
1610 km
Image NASA
Google

O ciclo hidrológico da Amazônia está se intensificando?

Descarga do Rio Amazonas em Óbidos, no Pará, mostrando o fluxos máximos, mínimos e médios.

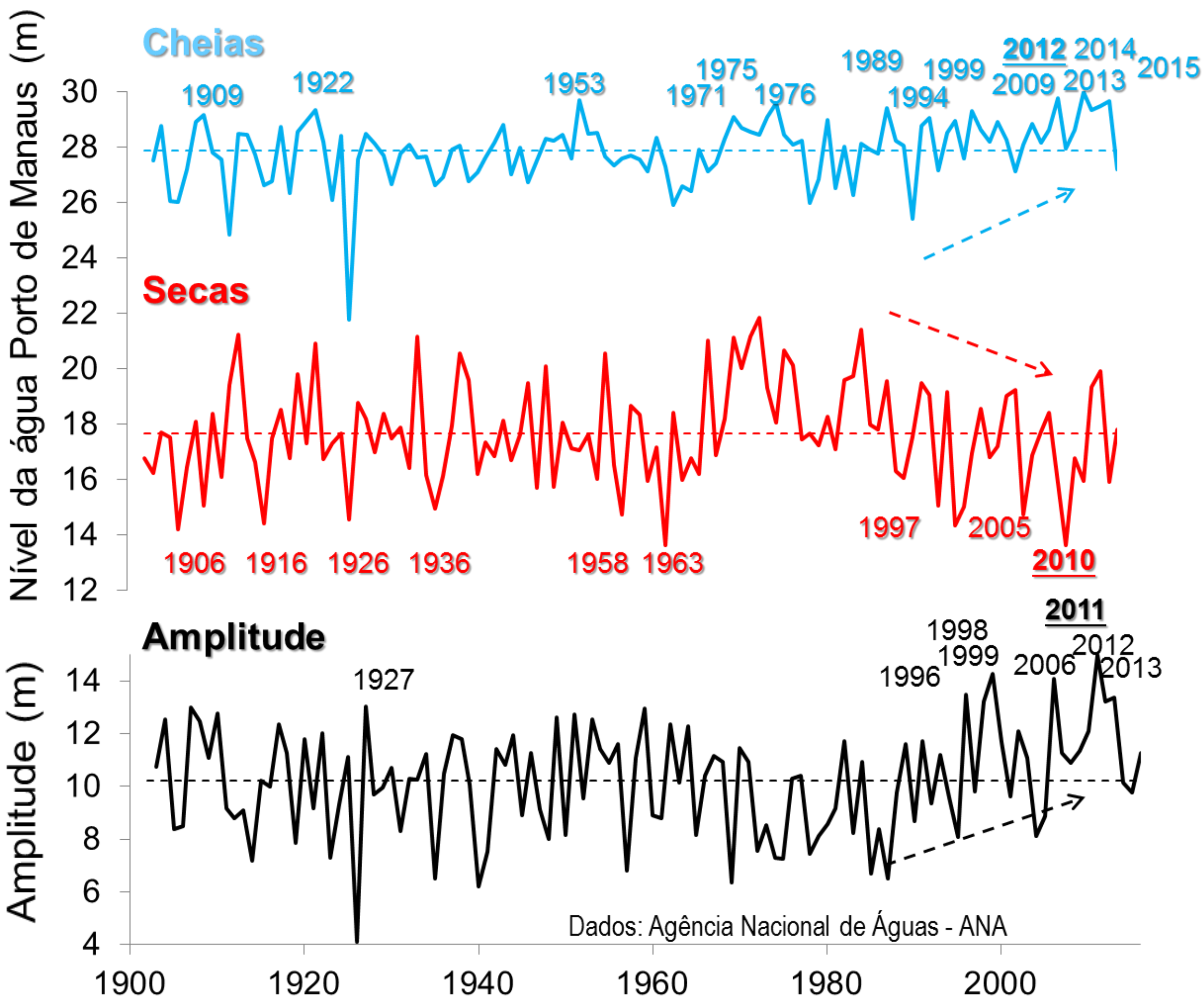


Temperatura superficial no Oceano Atlântico Tropical



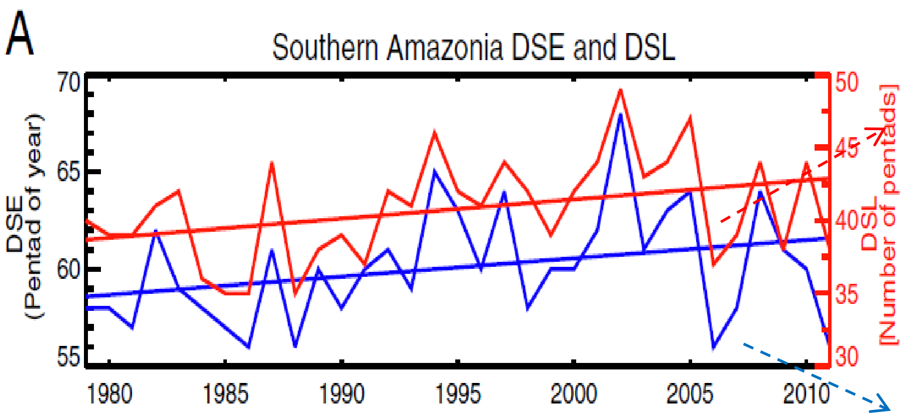
Gloor et al. 2013

Níveis do Rio Amazonas no porto de Manaus 1900-2015



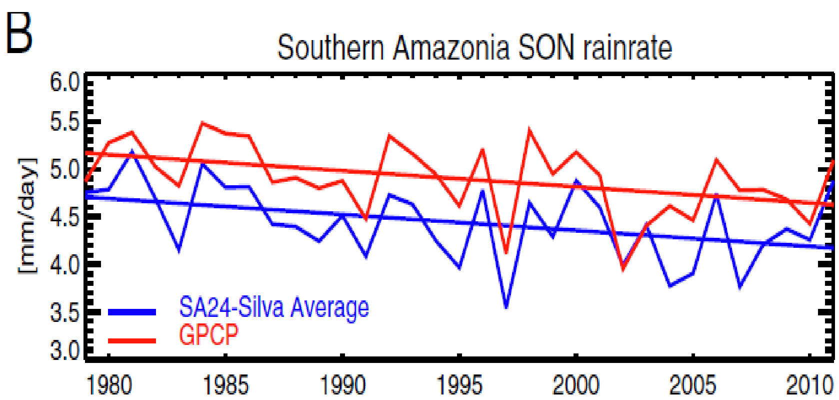
Jochen Schöngart, 2017

Dry season length is increasing in Amazonia



Annual time series of **dry season length (DSL)**

Annual time series of **dry season END (DSE)**

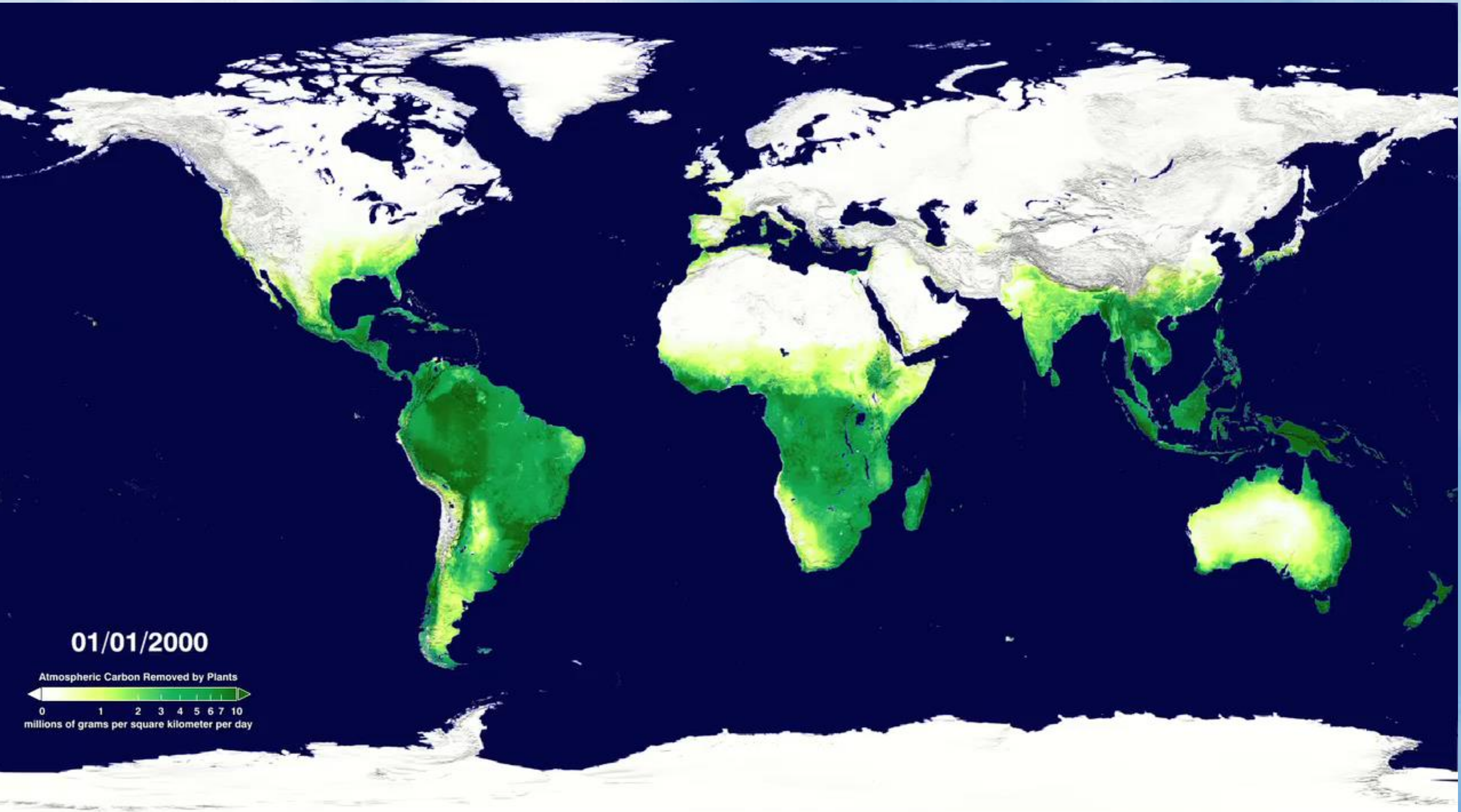


Dry season length has increased by **6.5±2.5** days/decade;

Fu et al. 2013 (PNAS)

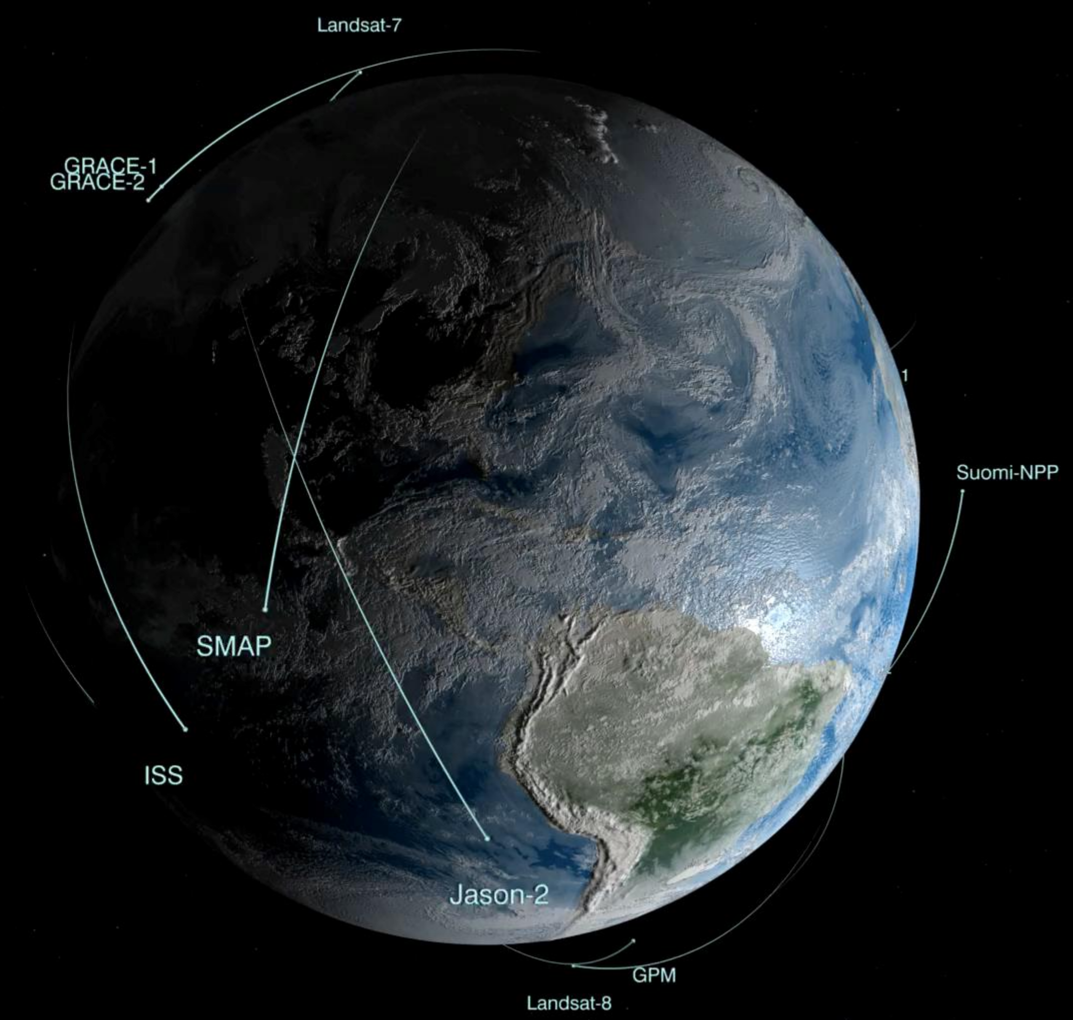
Quanto de carbono as plantas retiram da atmosfera?

NDVI do MODIS (GPP): estimativas de 2000 a 2010

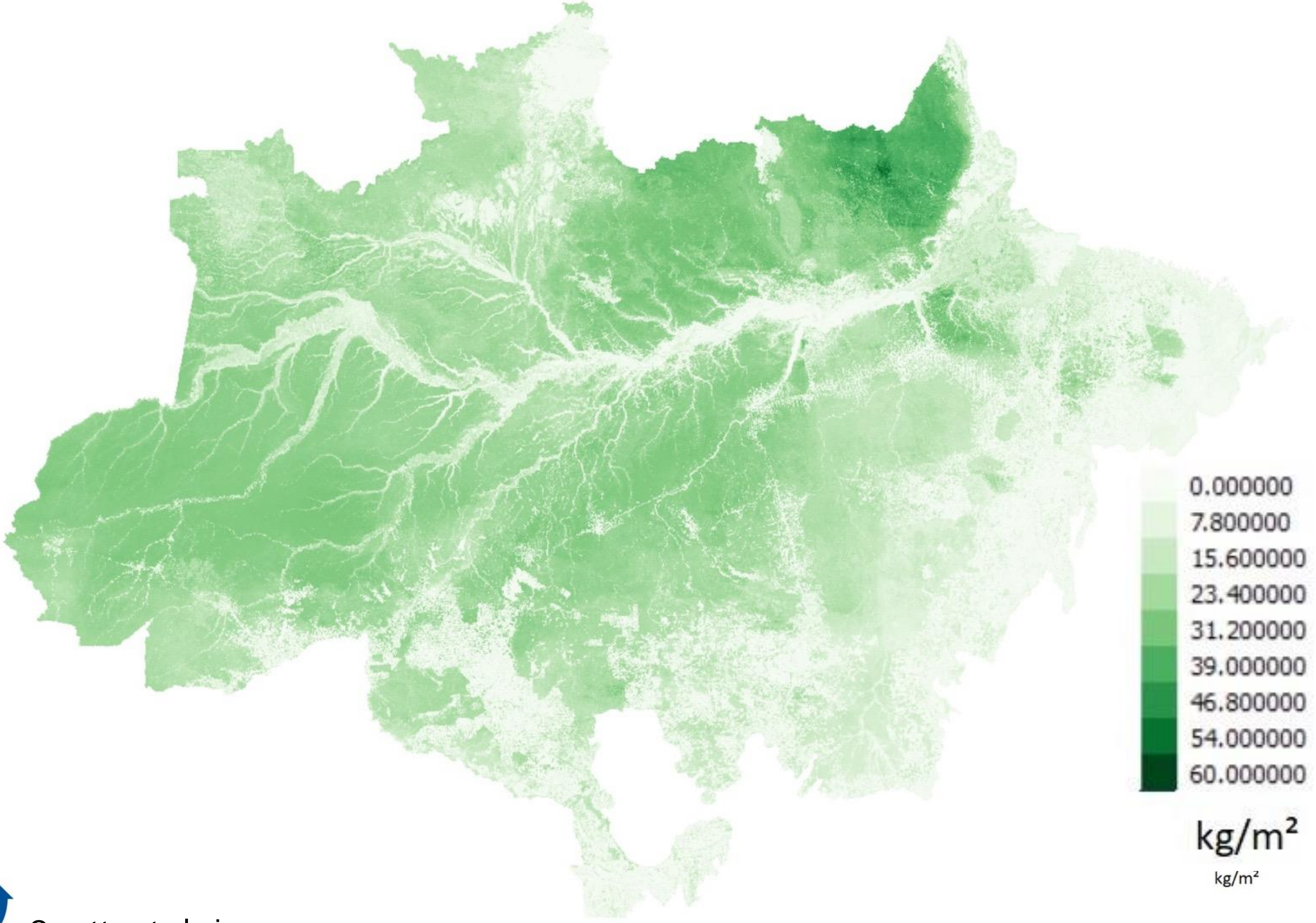


Amazônia: contem de 100 a 150 bilhões de toneladas de carbono

Satélites monitorando ciclo do carbono e variáveis acessórias

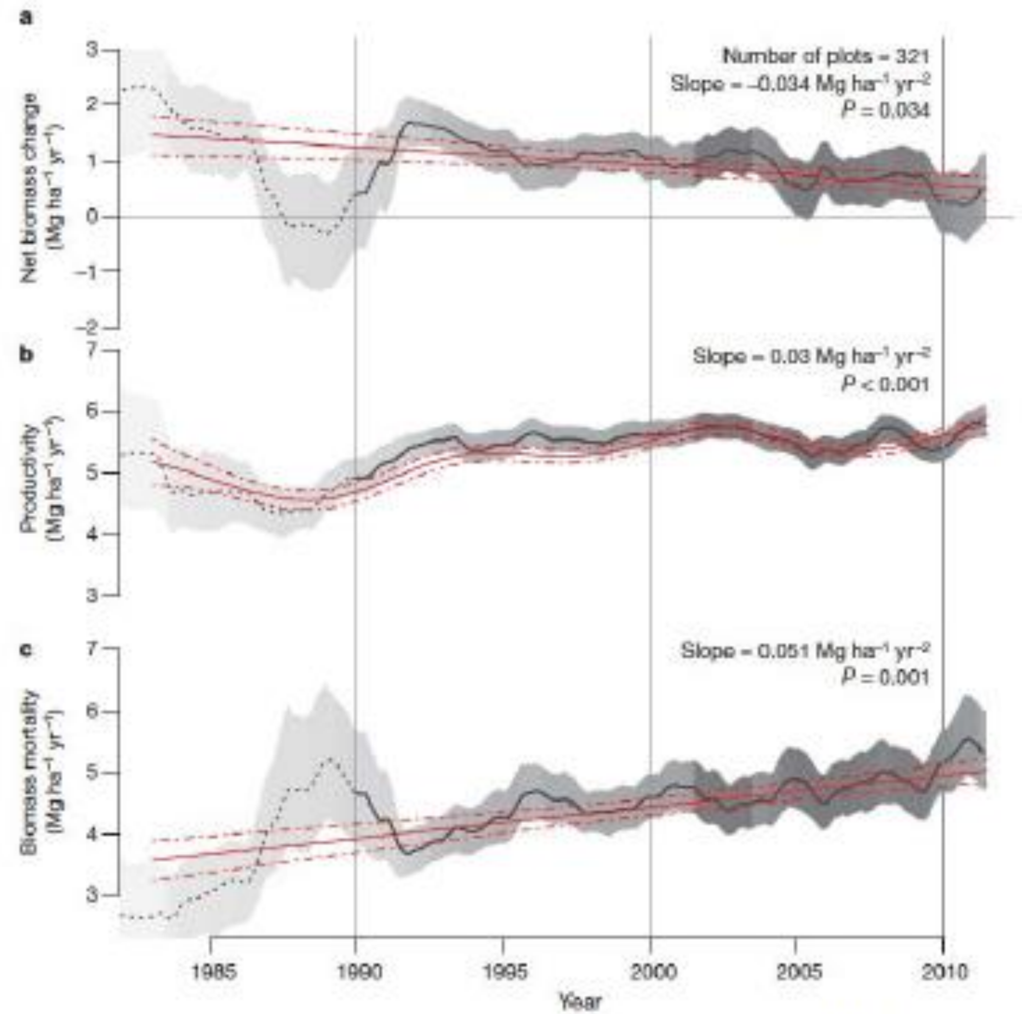


Amazon forest biomass distribution map in Kg/m²



Ometto et al., in press

Ciclo do Carbono: A Amazônia armazena 100-150 Tg C (10 anos de queima de combustíveis fósseis)



(Brienen et al., 2015)

Fluxo líquido de carbono hoje: ZERO

Mortalidade das árvores: aumento significativo

nature

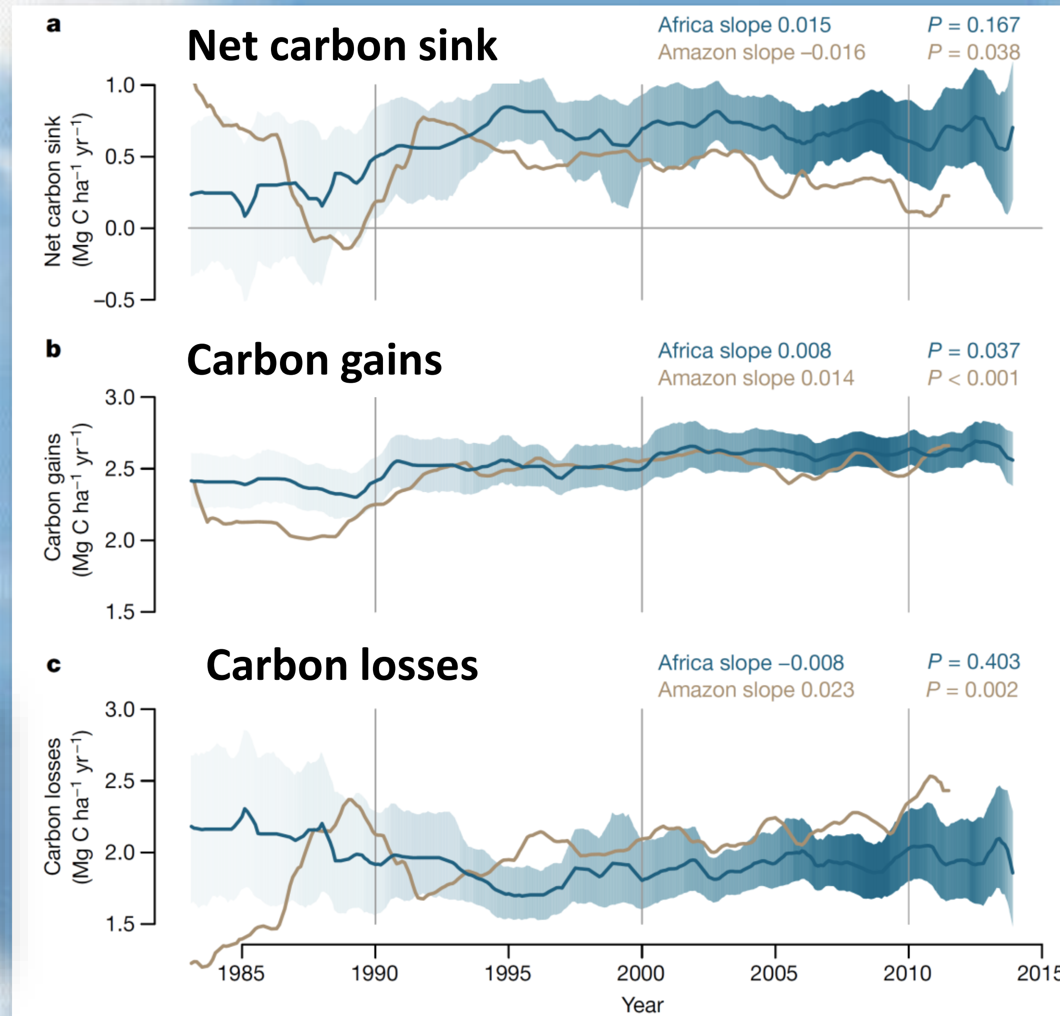
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

March 5, 2020

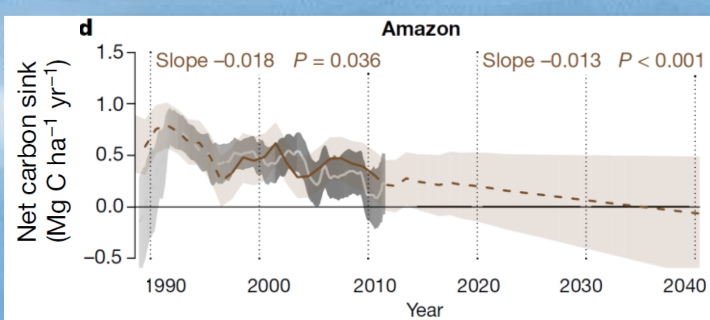
Article

Asynchronous carbon sink saturation in African and Amazonian tropical forests

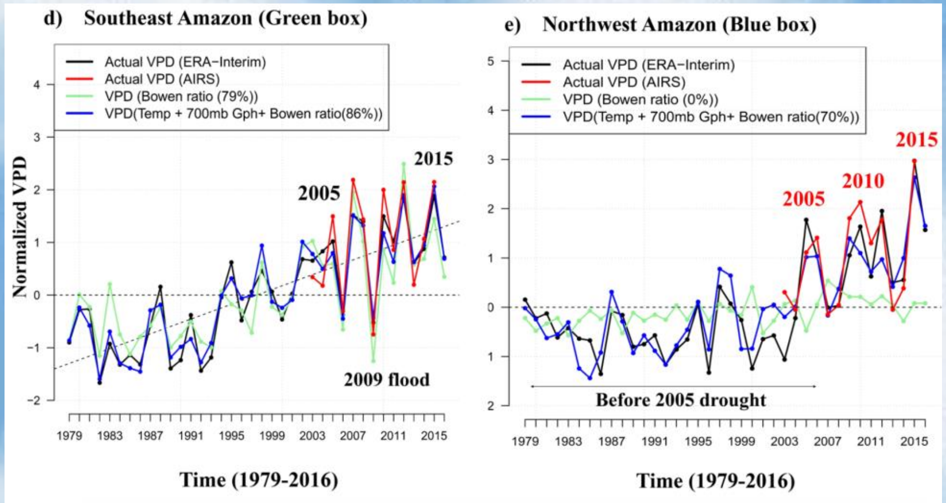
Long-term carbon dynamics of structurally intact oldgrowth tropical forests in Africa and Amazonia.

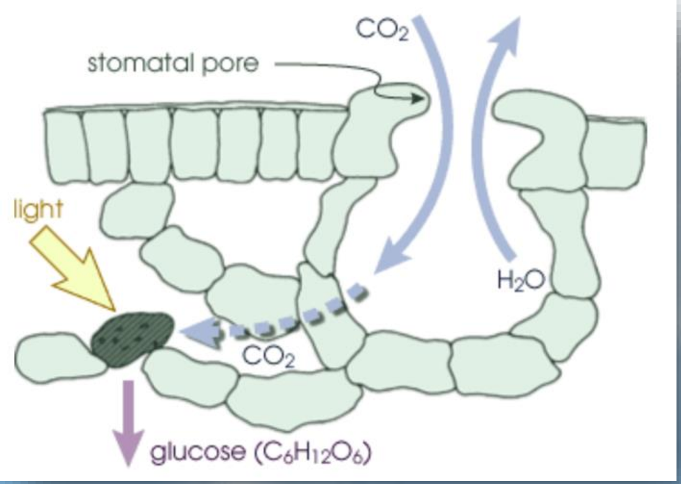


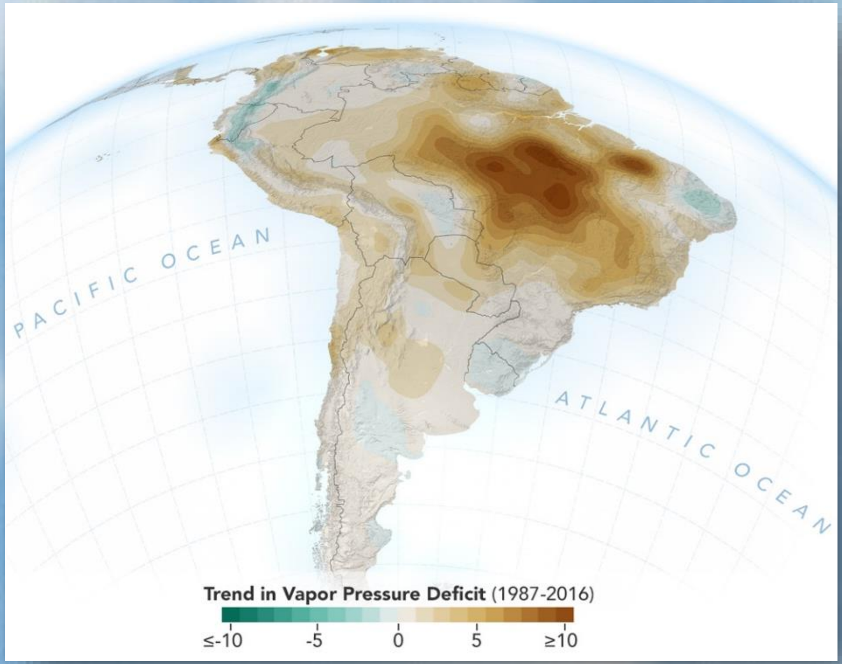
Net Carbon sink 1990-2040



Increase in the Vapor Pressure Deficit: Decrease in evapotranspiration in Amazonia





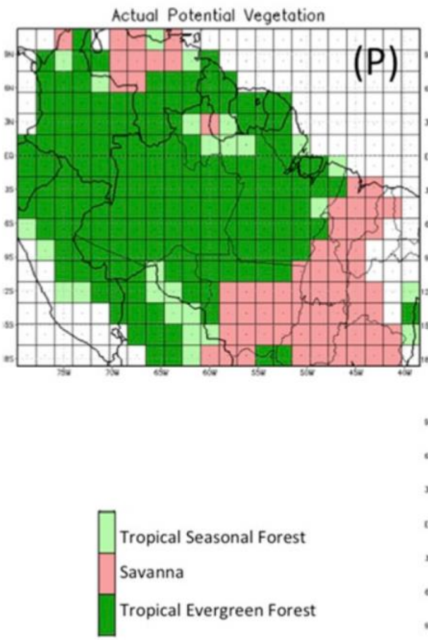


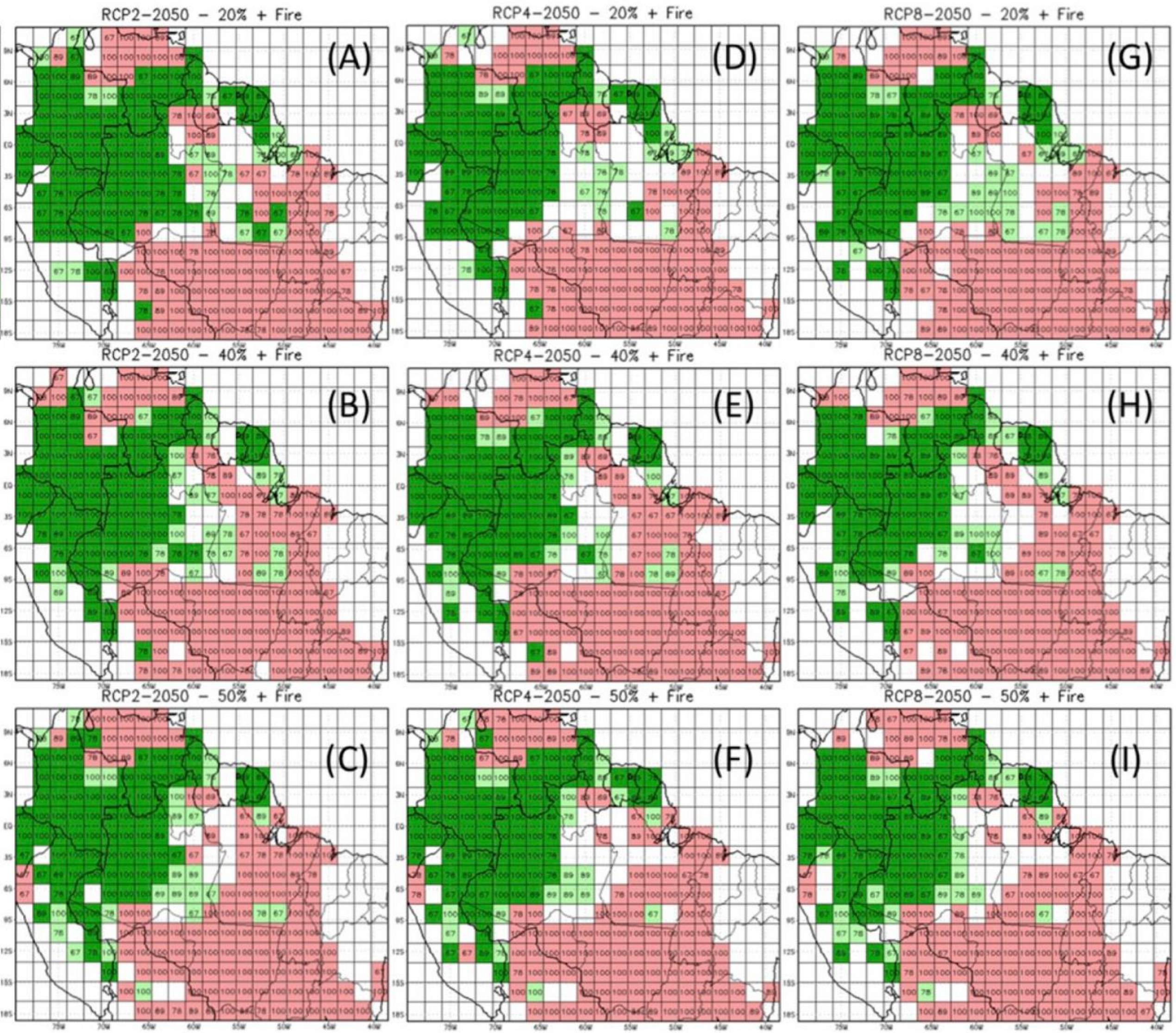
O déficit da pressão de vapor ou VPD é a diferença entre a quantidade de umidade no ar e quanta umidade o ar pode conter quando está saturado

O aumento da VPD combinado com o decréscimo da fração evaporativa são as primeiras indicações de mecanismos de feedback positivos na Amazônia.

Barkhordarian et al., Nature Scientific Reports, doi : 10.1038/s41598-019-51857-8, 2019

Projected distribution of natural biomes for RCP 2.4, 4.5 and 8.5. Deforestation scenarios for 20%, 40% and 50% + Fire effect

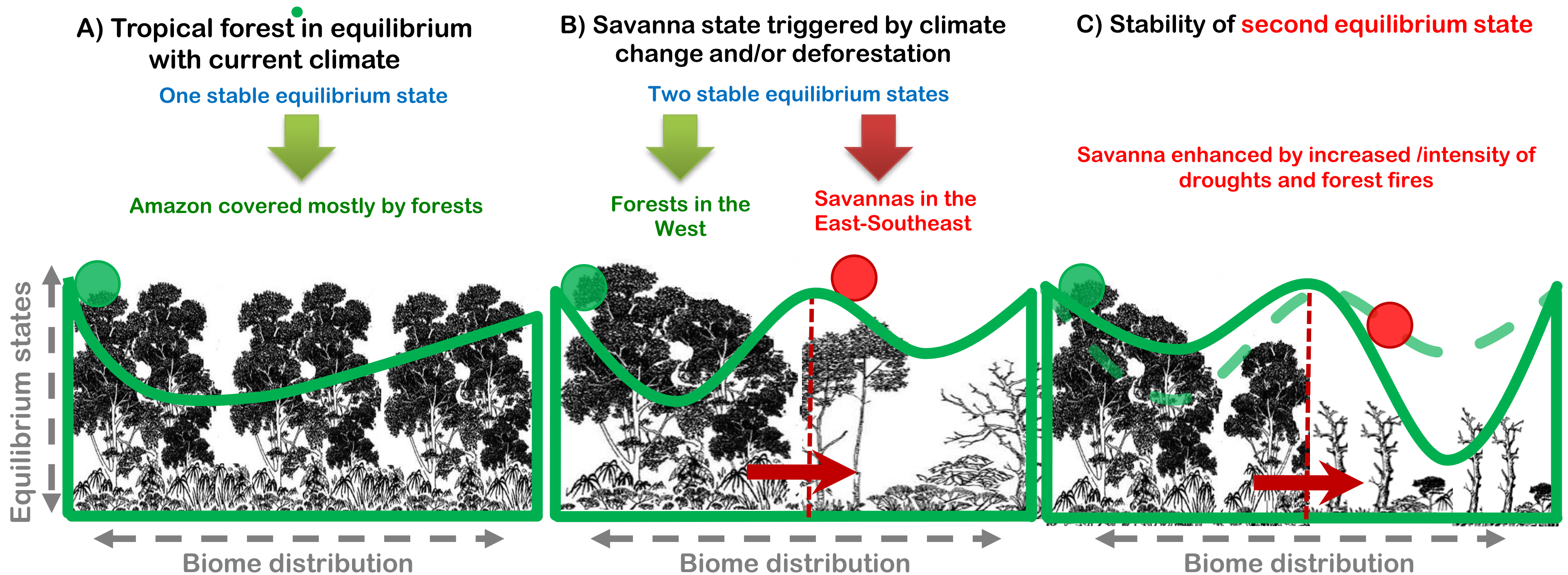




We believe that the sensible course is not only to strictly curb further deforestation, but also to build back a margin of safety against the Amazon tipping point, by reducing the deforested area to less than 20%, for the commonsense reason that there is no point in discovering the precise tipping point by tipping it.

Nobre et al., PNAS, 2016

'TIPPING POINTS' OF FOREST-CLIMATE EQUILIBRIUM IN THE AMAZON



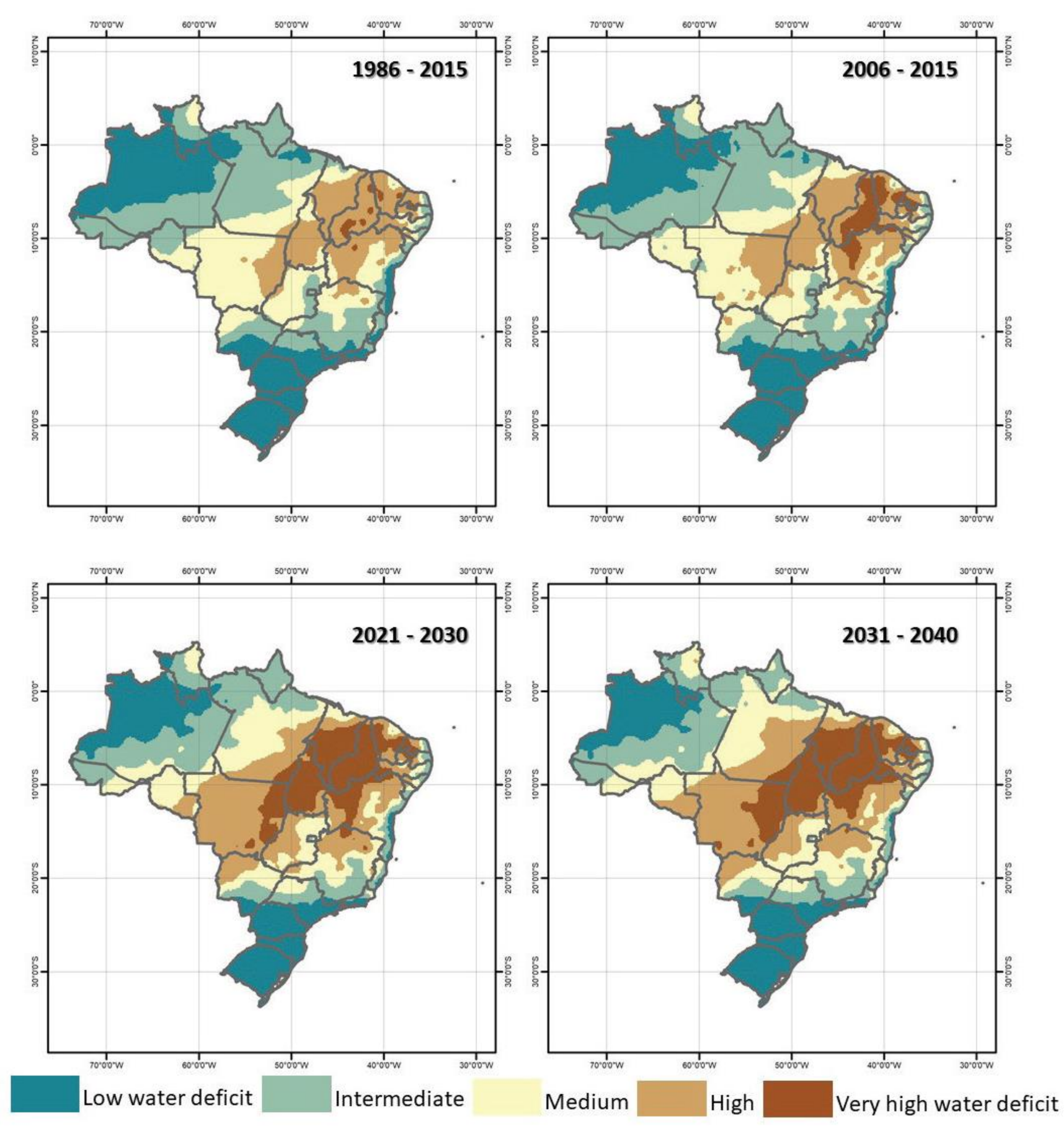
Thresholds for tipping
from state A to state B ≈ 4°C Amazon warming or
≈ 40% of total deforested area

- Observations: ΔT ≈ 1.1 to 1.5°C
- Deforestation: ≈ 18%
- Forest fire frequency (increasing)
- Lengthening of dry season (increasing)
- Increasing climate extremes

Adapted from Nobre et al., 2015, 2016

Water deficit in Brazil 1986-2040

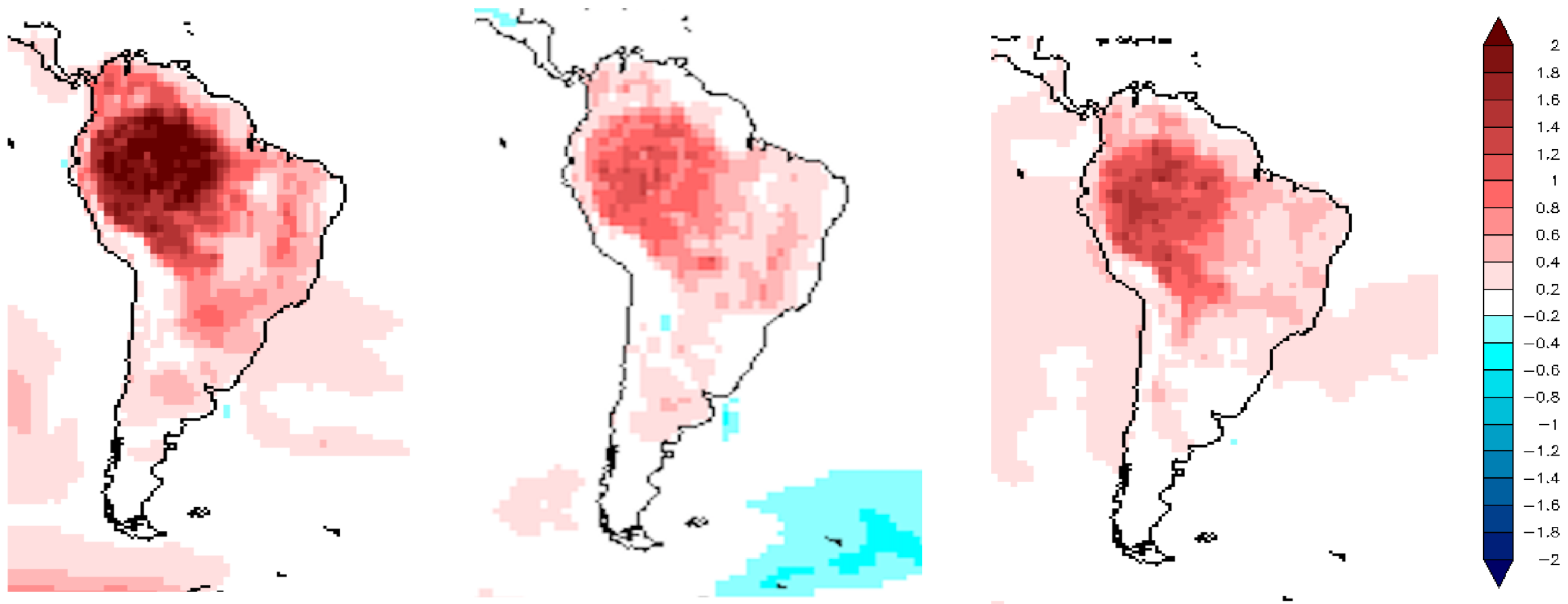
Brazil is already becoming a dryer area



Embrapa Informática Agropecuária, 2019

The world without Amazonia in 2050…

Changes in surface temperature, °C



SSP1, 100%   SSP1, 50%   SSP5, 50%

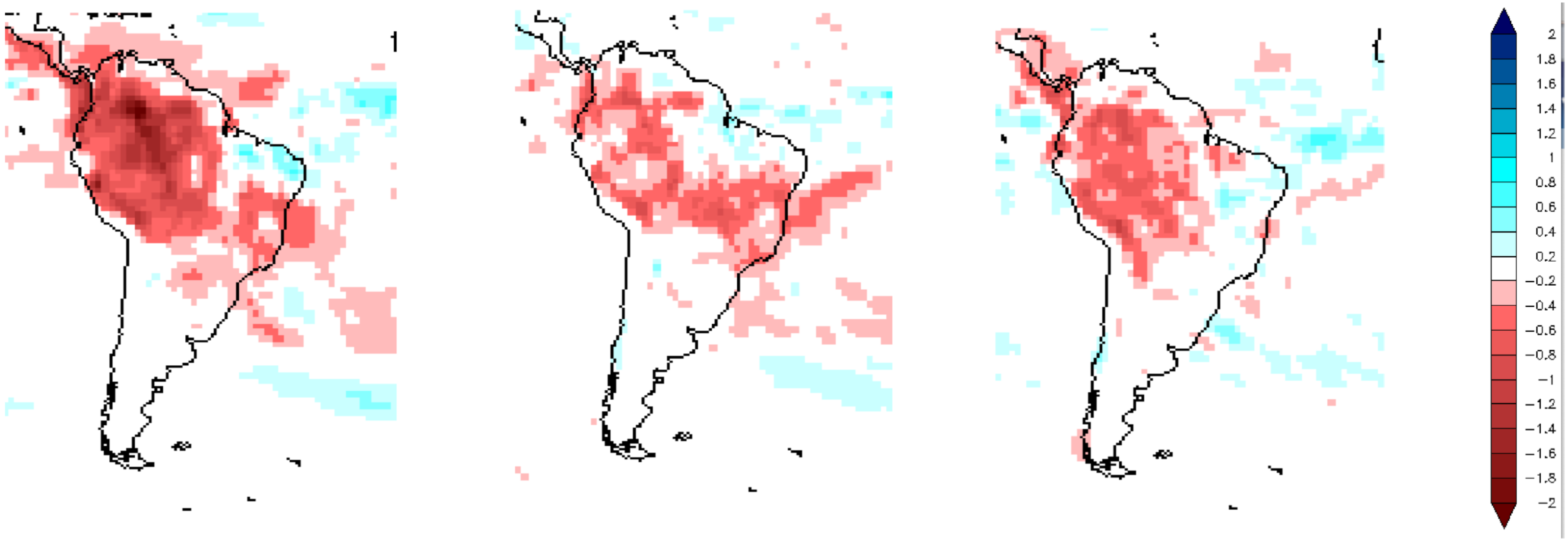
Geophysical Fluid Dynamics Laboratory 8

Simulations GFDL – 50% and 100% deforestation and SSP1 SSP5

Shevliakova and Pacala - Exploring a World Without the Amazon 2019

The world without Amazonia in 2050…

Changes in precipitation, mm/day



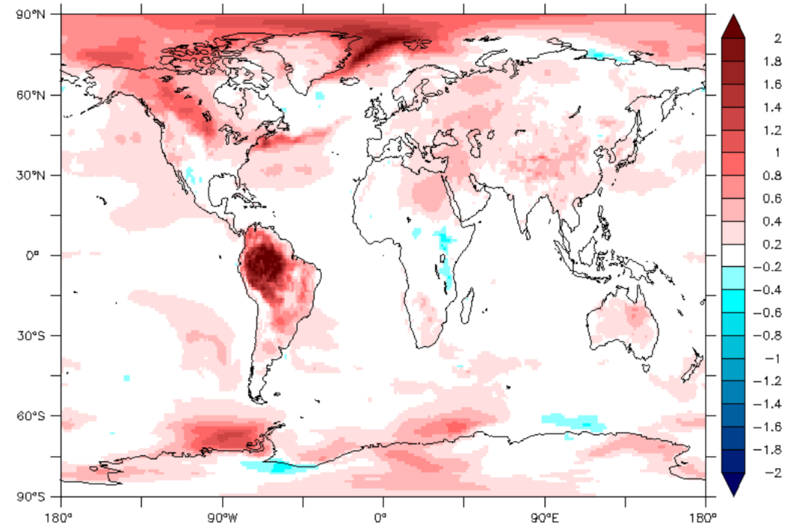
SSP1, 100%   SSP1, 50%   SSP5, 50%

Shevliakova and Pacala - Exploring a World Without the Amazon 2019

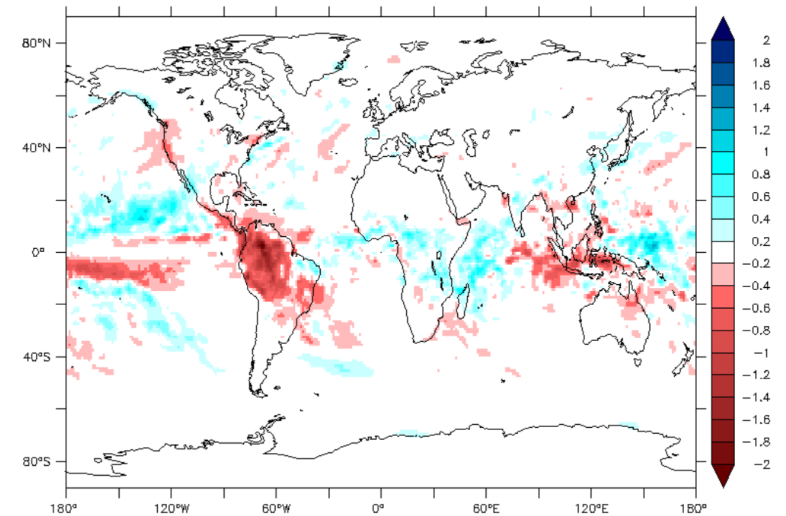
The world without Amazonia in 2050…

Global effect under the ambitious pathway (100%)

Temperature change



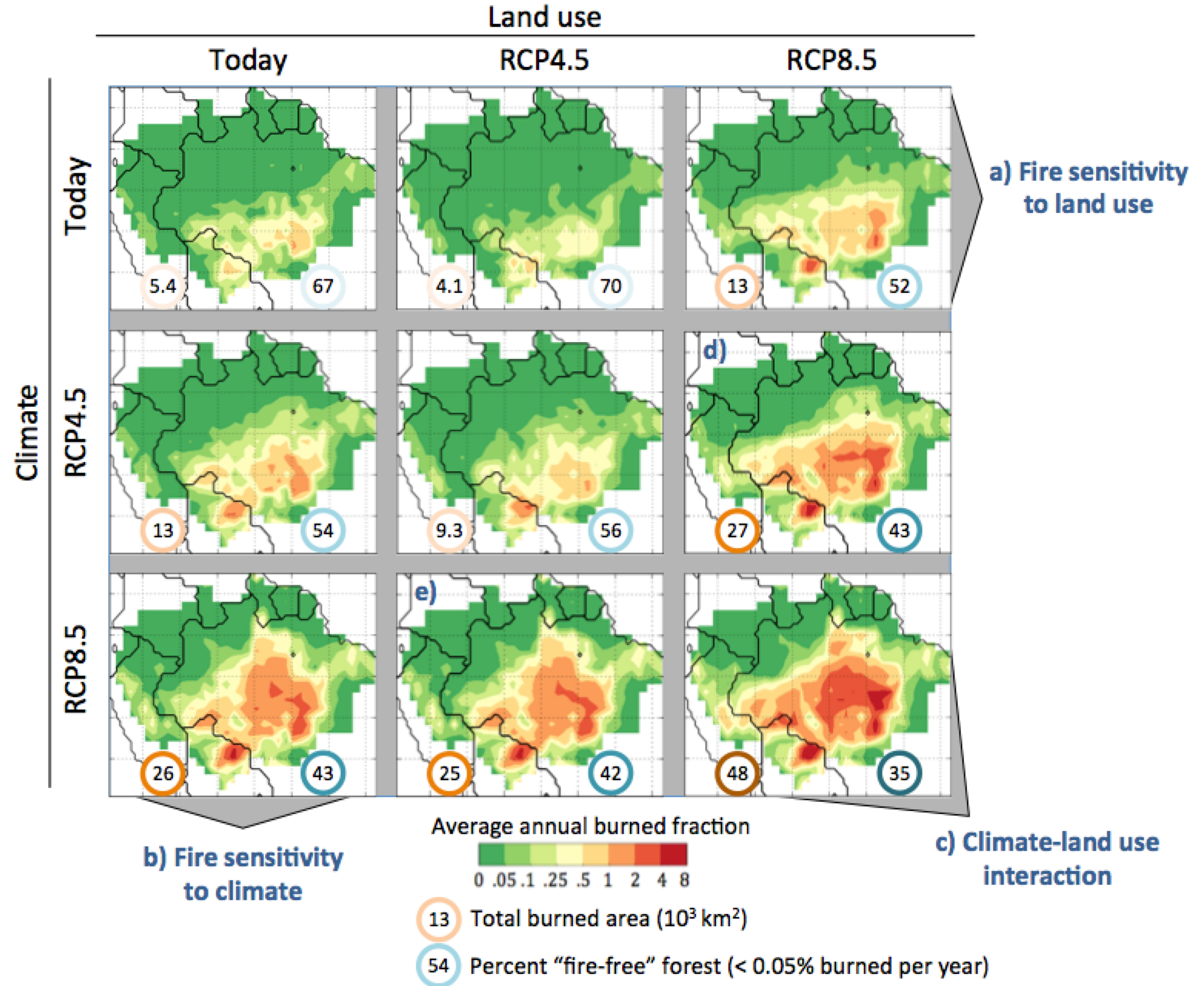
Precipitation change



ΔT increase: 0.25 C, Δ CO_2: 30 ppm

Shevliakova and Pacala - Exploring a World Without the Amazon 2019

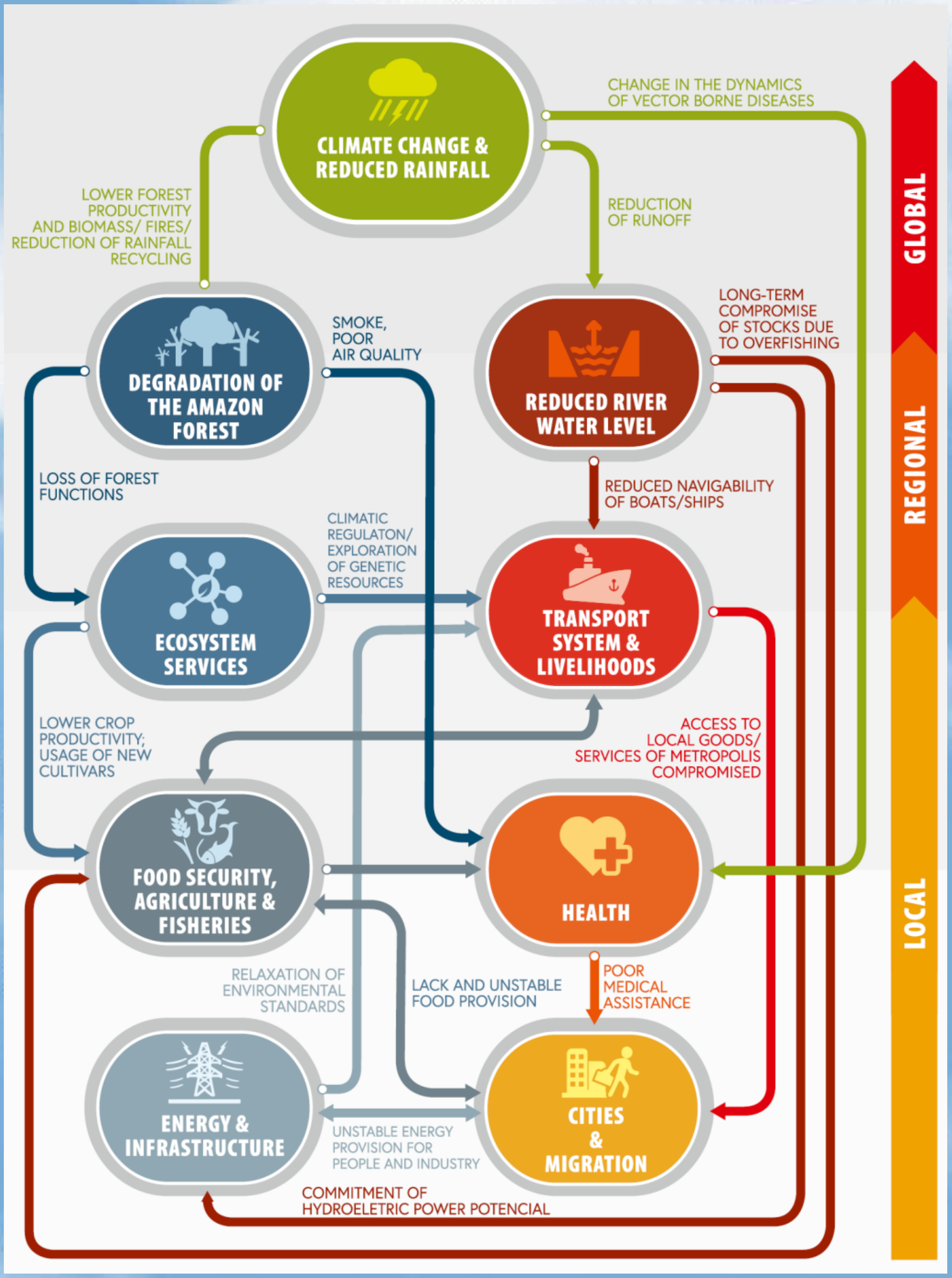
Fire sensitivity to Climate and Land Use



Alone, restricting further deforestation will not protect Amazon forests from greater fire risk in coming decades.

Le Page et al., 2017

Causal chain of climate change, ecological degradation of the Amazon Forest, and their impacts on different sectors of the regions socioeconomy

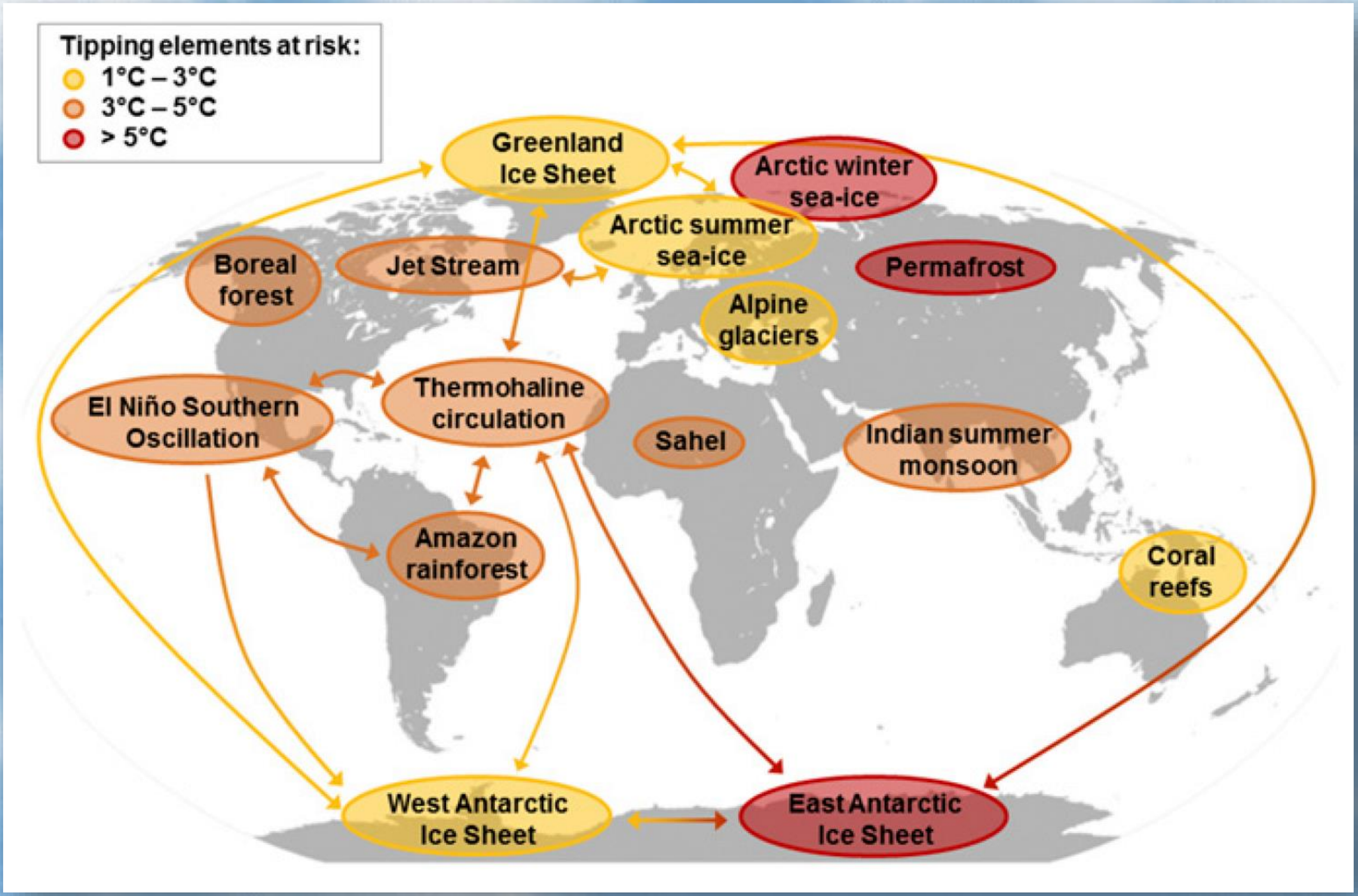


Lapola et al., PNAS Vol,. 115, no. 46-11671-11679
doi: 10.1073/pnas.1721770115

How close to the edge do we dare to get?

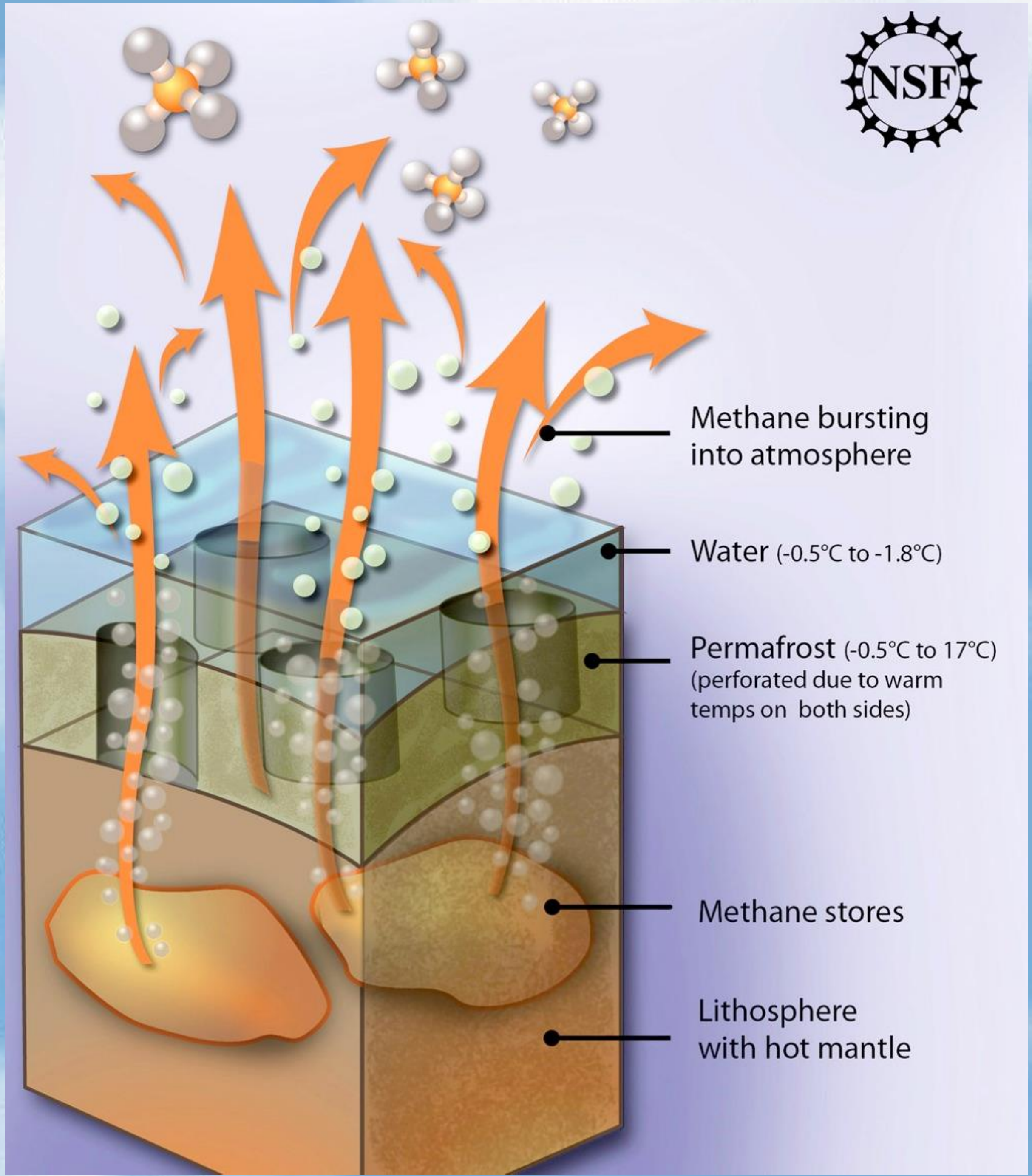
The tipping point issue…

Tipping points of the Earth climate system

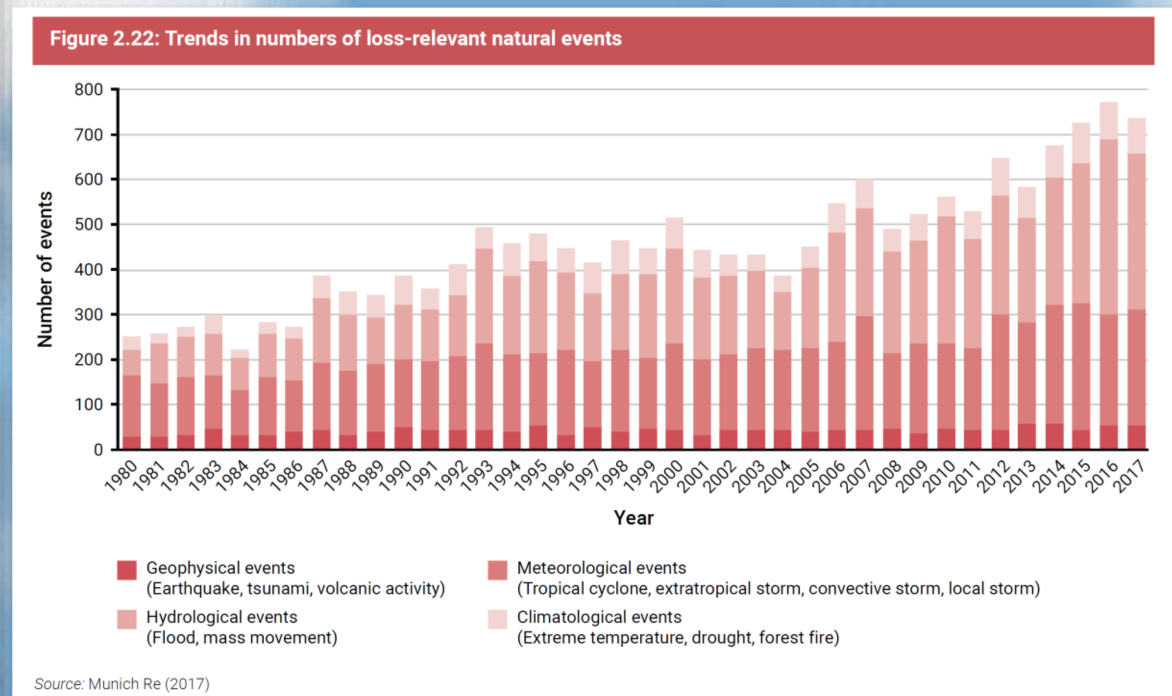


UNEP GEO-6 2019

Feedbacks: Arctic permafrost methane leakage to the atmosphere



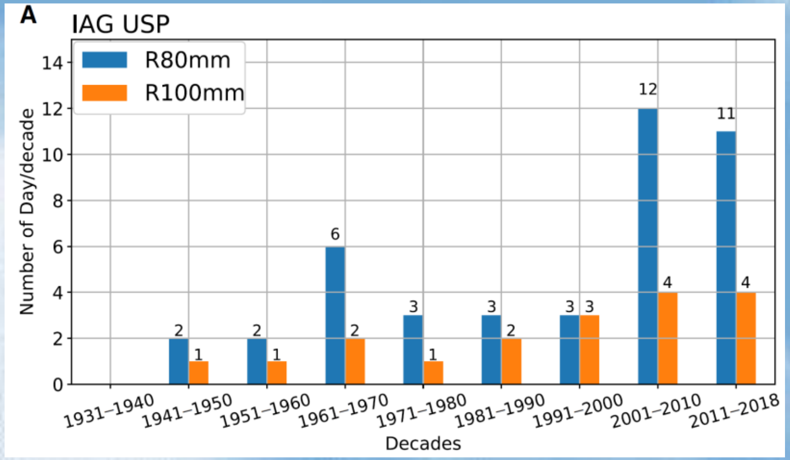
Riscos: Aumento na intensidade e frequencia de eventos climáticos extremos



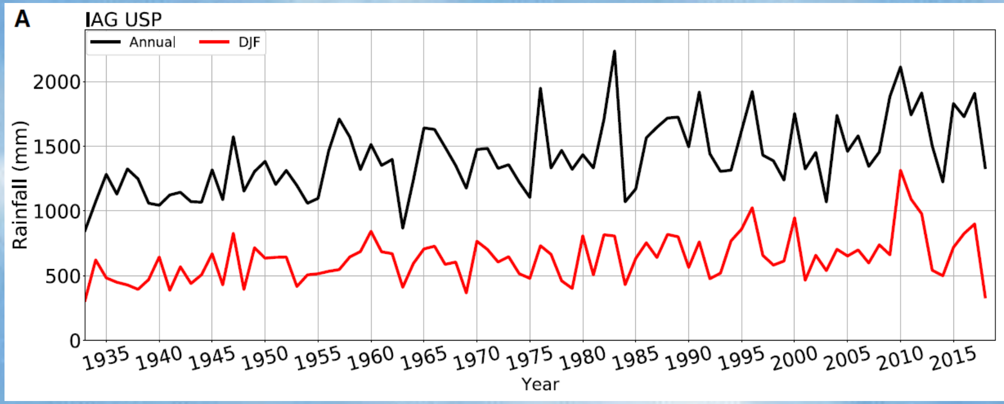
Já está ocorrendo desde a década de 80

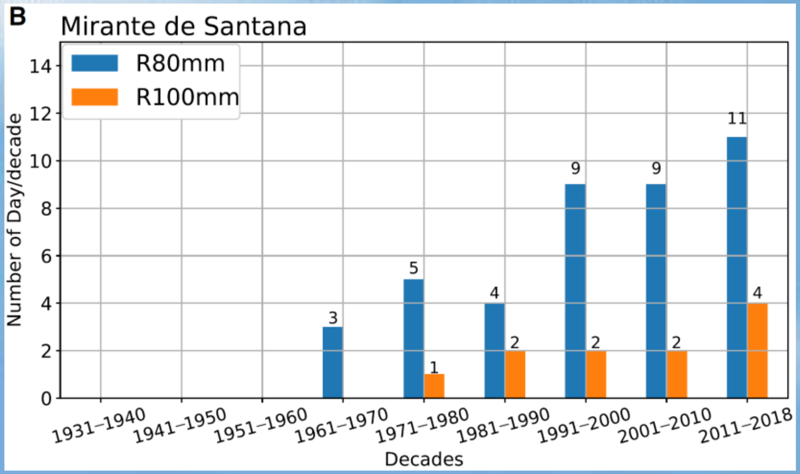
Enchentes em São Paulo e outros centros urbanos no Brasil

Numero de dias com chuva acima de 80 mm e 100 mm em 1 dia



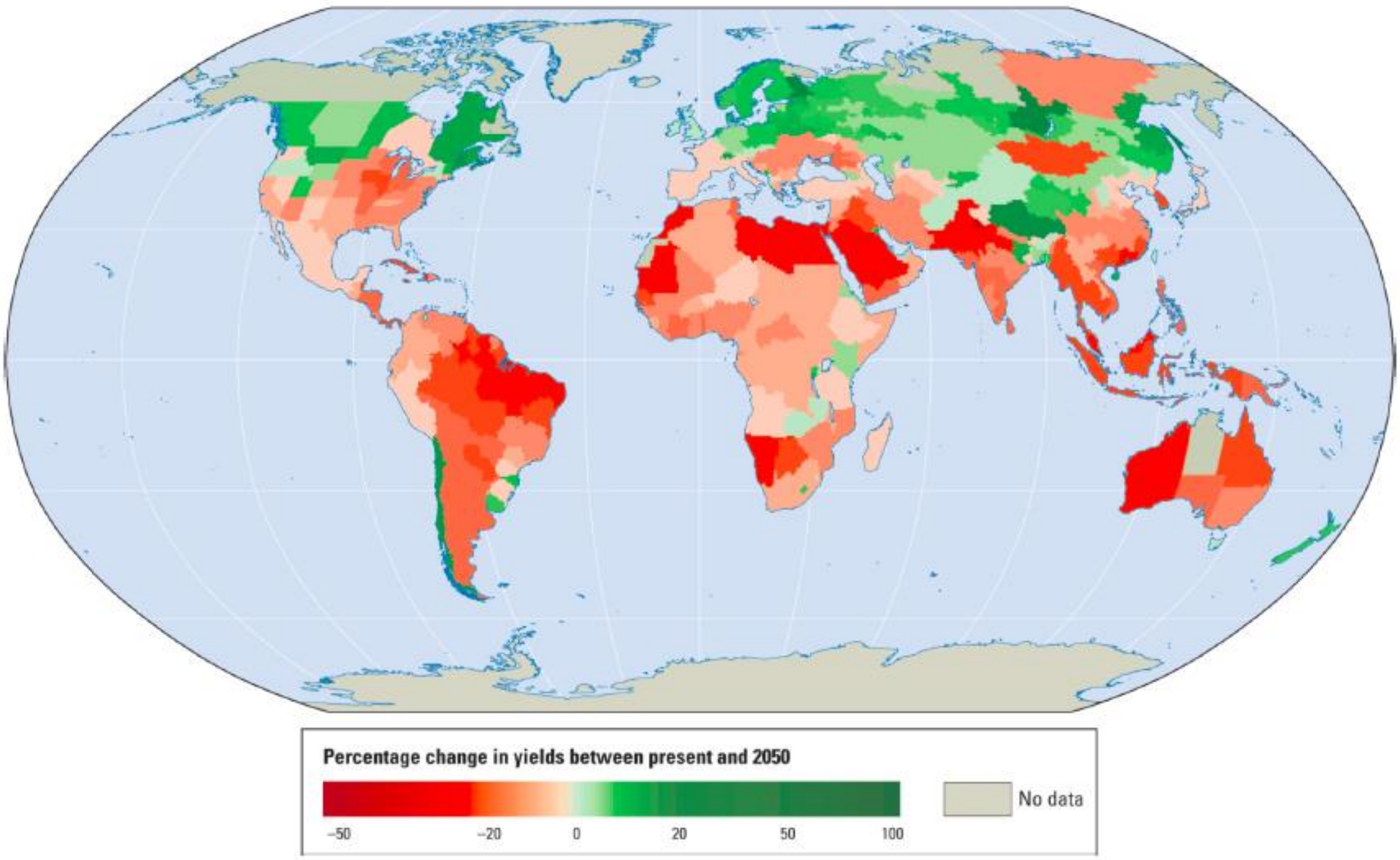
Chuva mensal em São Paulo de 1935 a 2018





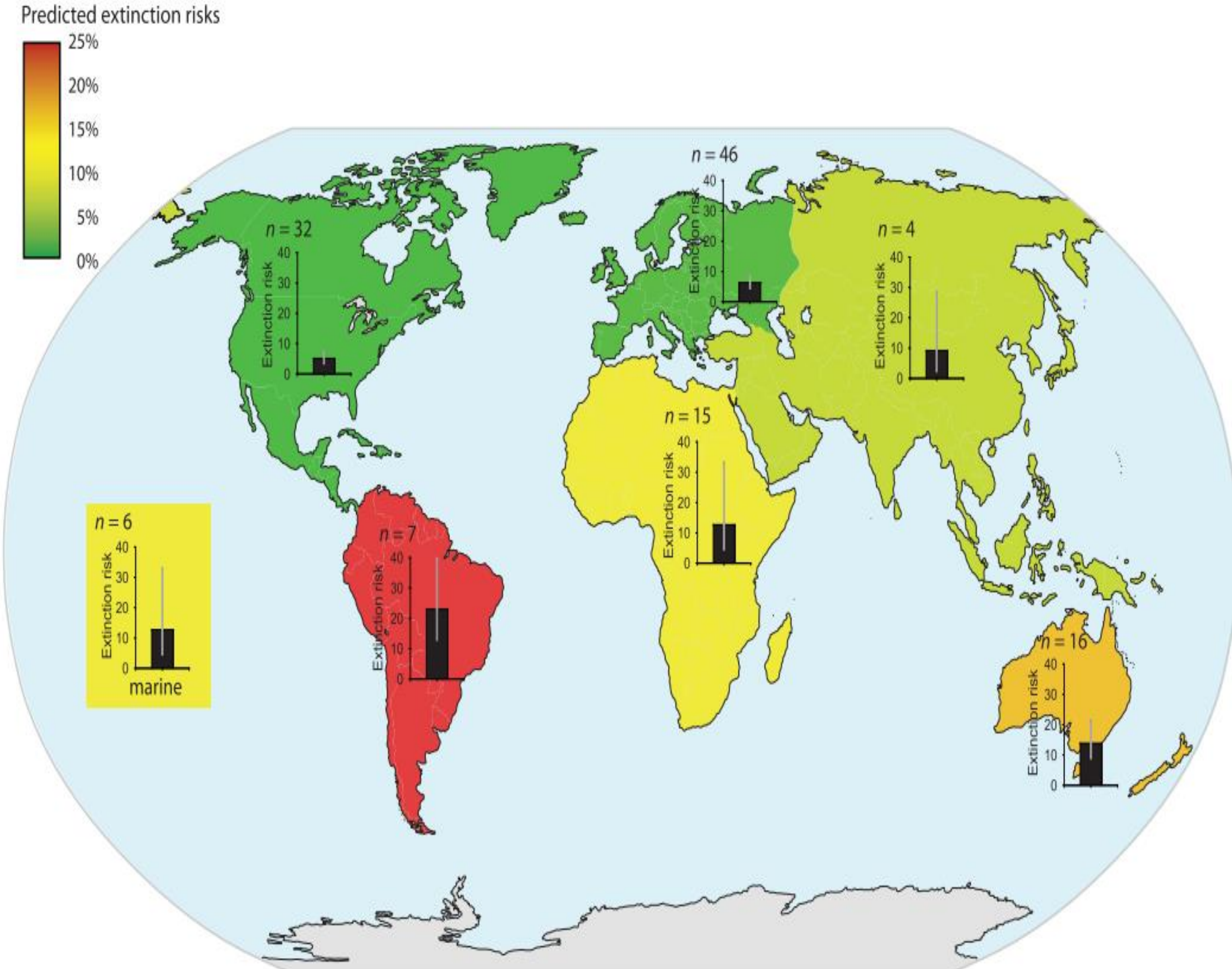
Marengo et al., doi: 10.1111/nyas.14307, Ann N.Y. Acad. Sci. 2020

Impactos na produção de alimentos em um planeta 3°C mais quente



World Economic Forum: Global Risks 2016

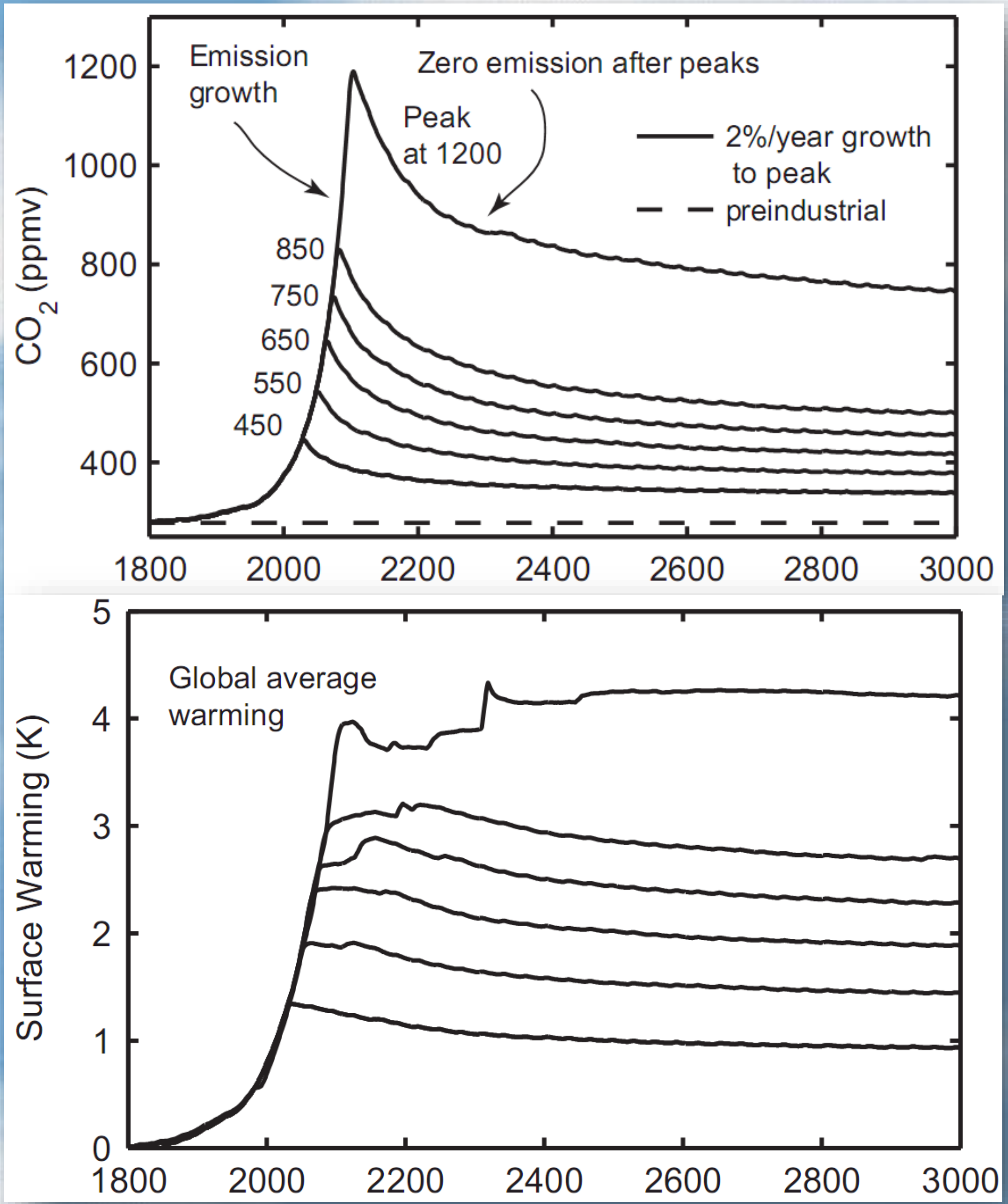
Predicted Extinction Risks of Biological Species



The highest risks: South America, Australia, and New Zealand (14 to 23%)

Source: Urban M.C-Nature, 2015

How much time the CO_2 will affect the climate?



Susan Salomon PNAS Fev 2009

Note the scale: Till year 3000 ⟶

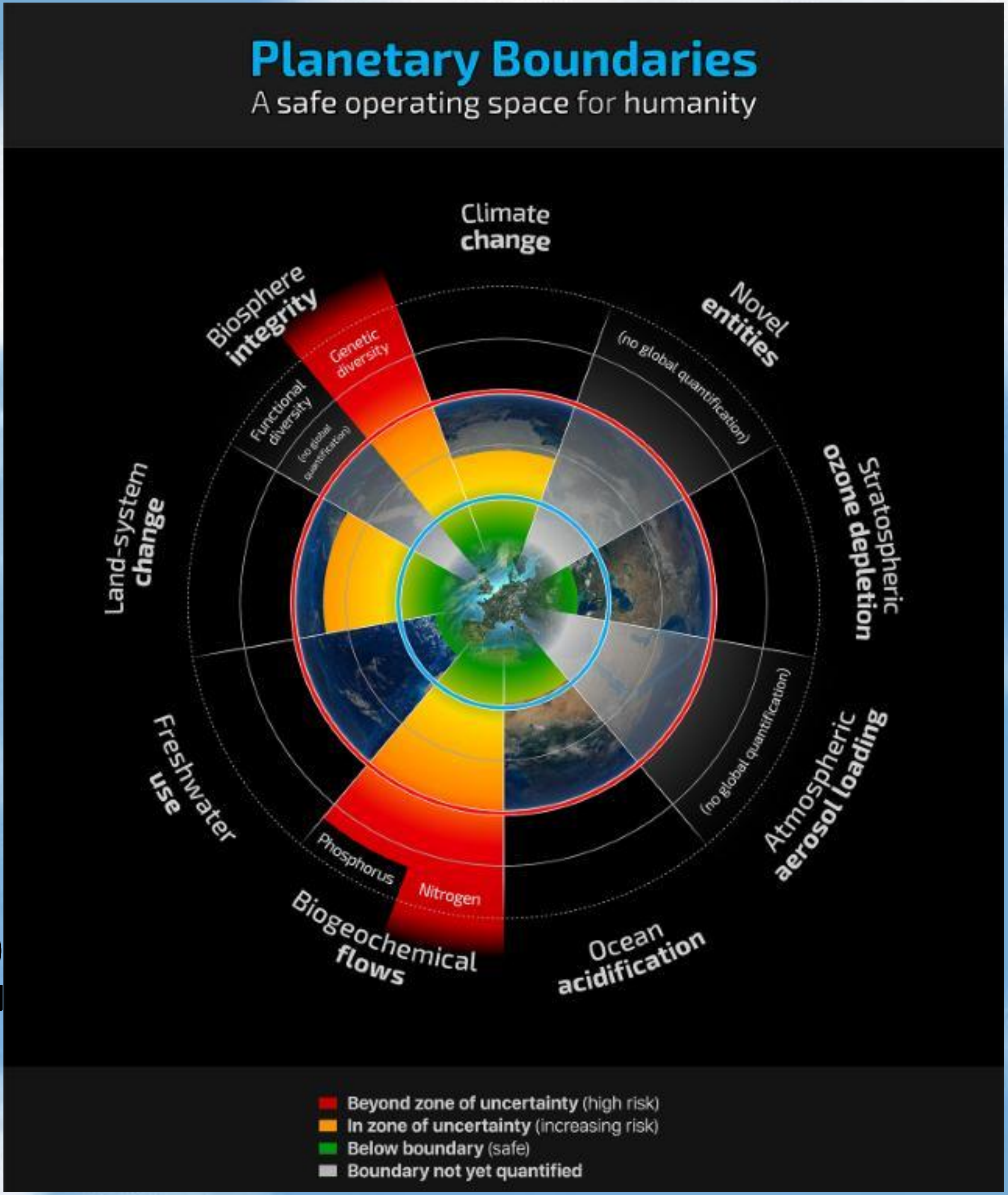
Limites planetários: Aonde estão os limites seguros para a humanidade?

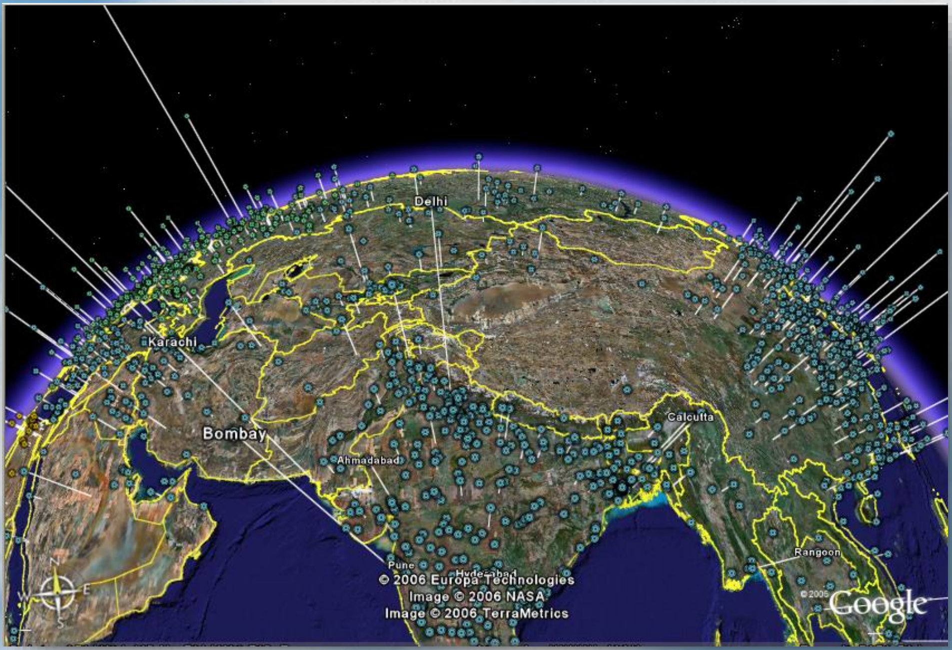
9 **Boundaries identified**

4 **transgressed:**

- **Climate**
- **Biosphere integrity**
- **Land use (deforestation)**
- **Biogeochemical flows (N and P fertilizer use)**

Science Feb 2015





Em 2100 80% da população mundial estará vivendo em cidades...

Soluções

More efficient use of energy

Greater use of low-carbon and no-carbon energy
- Many of these technologies exist today
- Nearly a quadrupling of zero- and low-carbon energy supply from renewable energy by 2050

Improved carbon sinks
- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage

Lifestyle and behavioural changes

AR5

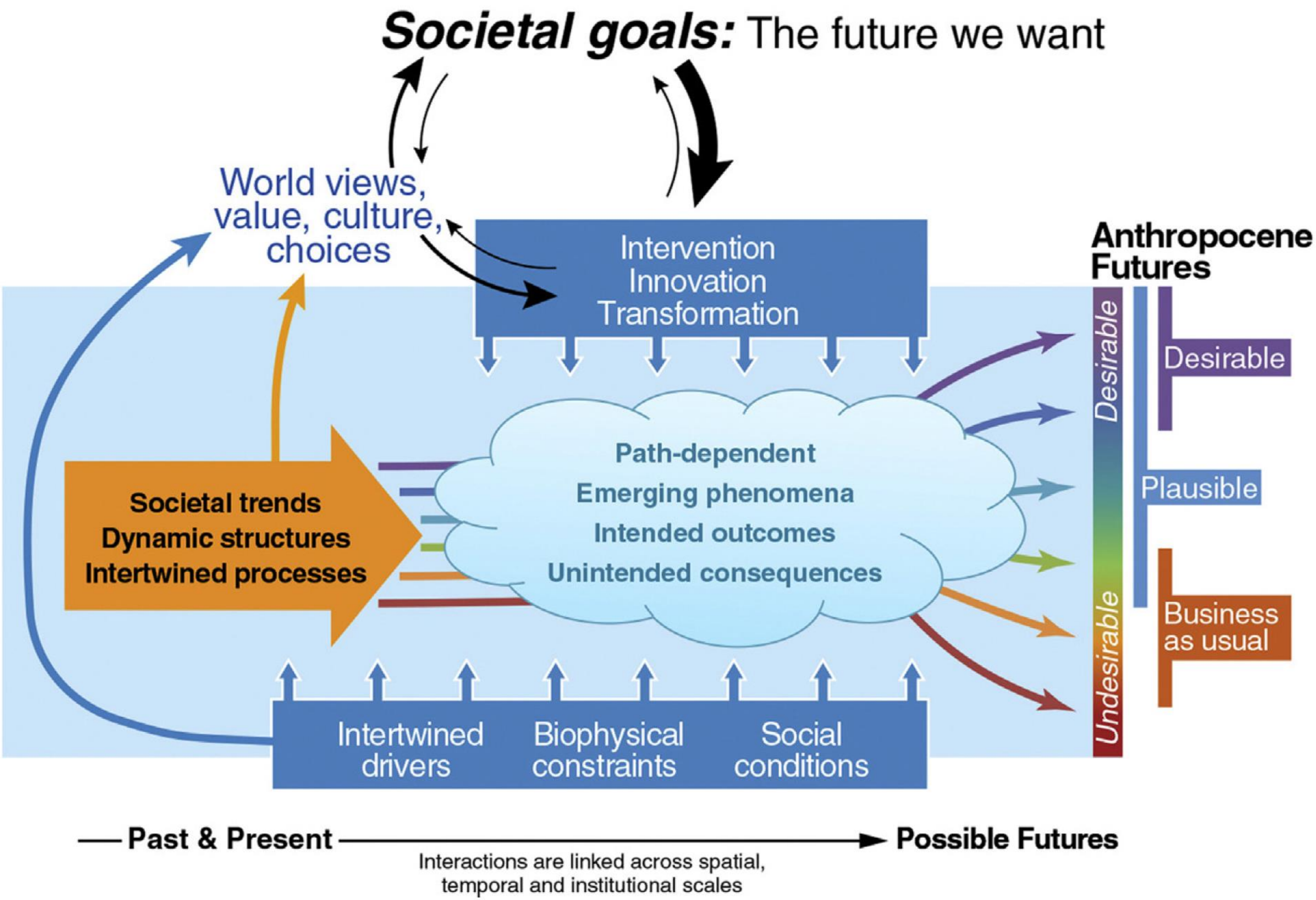
Produção de energia

Transporte

Agricultura

Biocombustíveis

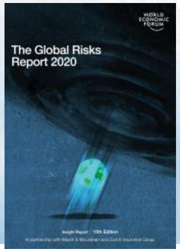
Qual o futuro que queremos? O futuro do Antropoceno



Global Environmental Change 39 (2016) 351–362

WORLD ECONOMIC FORUM

Fórum Econômico Mundial: O relatório dos Riscos Globais em 2020



Os 5 maiores riscos globais em termos de probabilidades 2007-2020

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1st	Infrastructure breakdown	Blow up in asset prices	Asset price collapse	Asset price collapse	Storms and cyclones	Income disparity	Income disparity	Income disparity	Interstate conflict	Involuntary migration	Extreme weather	Extreme weather	Extreme weather	Extreme weather
2nd	Chronic diseases	Middle East instability	China economic slowdown	China economic slowdown	Flooding	Fiscal imbalances	Fiscal imbalances	Extreme weather	Extreme weather	Extreme weather	Involuntary migration	Natural disasters	Climate action failure	Climate action failure
3rd	Oil price shock	Failed and failing states	Chronic diseases	Chronic disease	Corruption	Greenhouse gas emissions	Greenhouse gas emissions	Unemployment	Failure of national governance	Climate action failure	Natural disasters	Cyberattacks	Natural disasters	Natural disasters
4th	China hard landing	Oil price shock	Global governance gaps	Fiscal crises	Biodiversity loss	Cyberattacks	Water crises	Climate action failure	State collapse or crisis	Interstate conflict	Terrorist attacks	Data fraud or theft	Data fraud or theft	Biodiversity loss
5th	Blow up in asset prices	Chronic diseases	Deglobalization (emerging)	Global governance gaps	Climate change	Water crises	Population ageing	Cyberattacks	Unemployment	Natural catastrophes	Data fraud or theft	Climate action failure	Cyberattacks	Human-made environmental disasters

Economic | Environmental | Geopolitical | Societal | Technological

Os 5 maiores riscos globais em termos de impactos 2007-2020

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1st	Blow up in asset prices	Blow up in asset prices	Asset price collapse	Asset price collapse	Fiscal crises	Financial failure	Financial failure	Fiscal crises	Water crises	Climate action failure	Weapons of mass destruction	Weapons of mass destruction	Weapons of mass destruction	Climate action failure
2nd	Deglobalization	Deglobalization (developed)	Deglobalization (developed)	Deglobalization (developed)	Climate change	Water crises	Water crises	Climate action failure	Infectious diseases	Weapons of mass destruction	Extreme weather	Extreme weather	Climate action failure	Weapons of mass destruction
3rd	Interstate and civil wars	China hard landing	Oil and gas price spike	Oil price spikes	Geopolitical conflict	Food crises	Fiscal imbalances	Water crises	Weapons of mass destruction	Water crises	Water crises	Natural disasters	Extreme weather	Biodiversity loss
4th	Pandemics	Oil price shock	Chronic diseases	Chronic disease	Asset price collapse	Fiscal imbalances	Weapons of mass destruction	Unemployment	Interstate conflict	Involuntary migration	Natural disasters	Climate action failure	Water crises	Extreme weather
5th	Oil price shock	Pandemics	Fiscal crises	Fiscal crises	Energy price volatility	Energy price volatility	Climate action failure	Infrastructure breakdown	Climate action failure	Energy price shock	Climate action failure	Water crises	Natural disasters	Water crises

Economic | Environmental | Geopolitical | Societal | Technological

2020

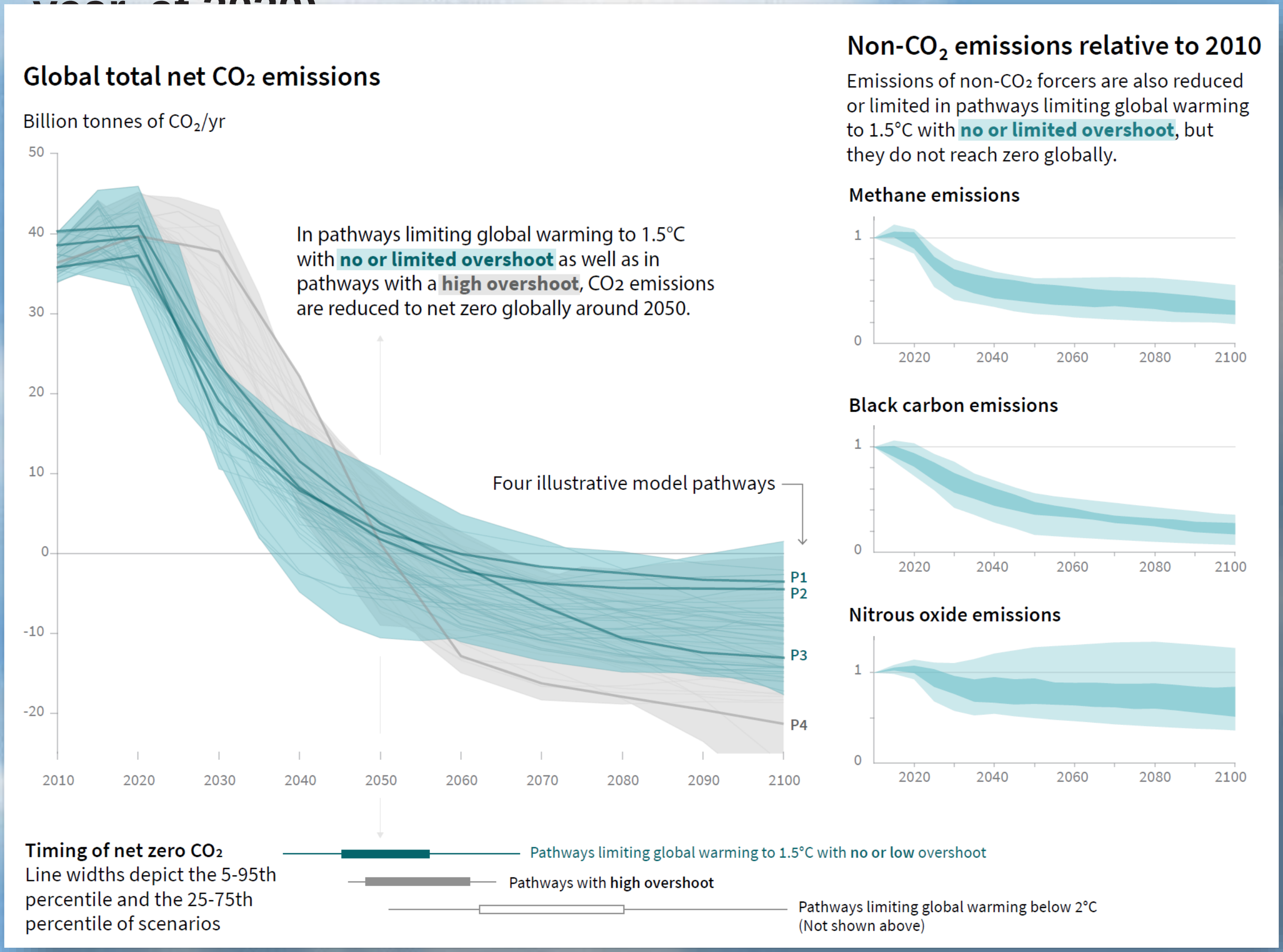
- Extreme weather
- Climate action failure
- Natural disasters
- Biodiversity loss
- Human-made environmental disasters

P.S.: Não são preocupações de cientistas, ONGs ou grupos ambientais, mas do WEF…

Source: World Economic Forum Global Risks Perception Survey 2019-2020.

Emissions pathways to limit temperature increase to 1.5 degrees with Short Lived Climate Forcers

Fast immediate reductions on CO_2 emissions (-3 % per year, at 2020)



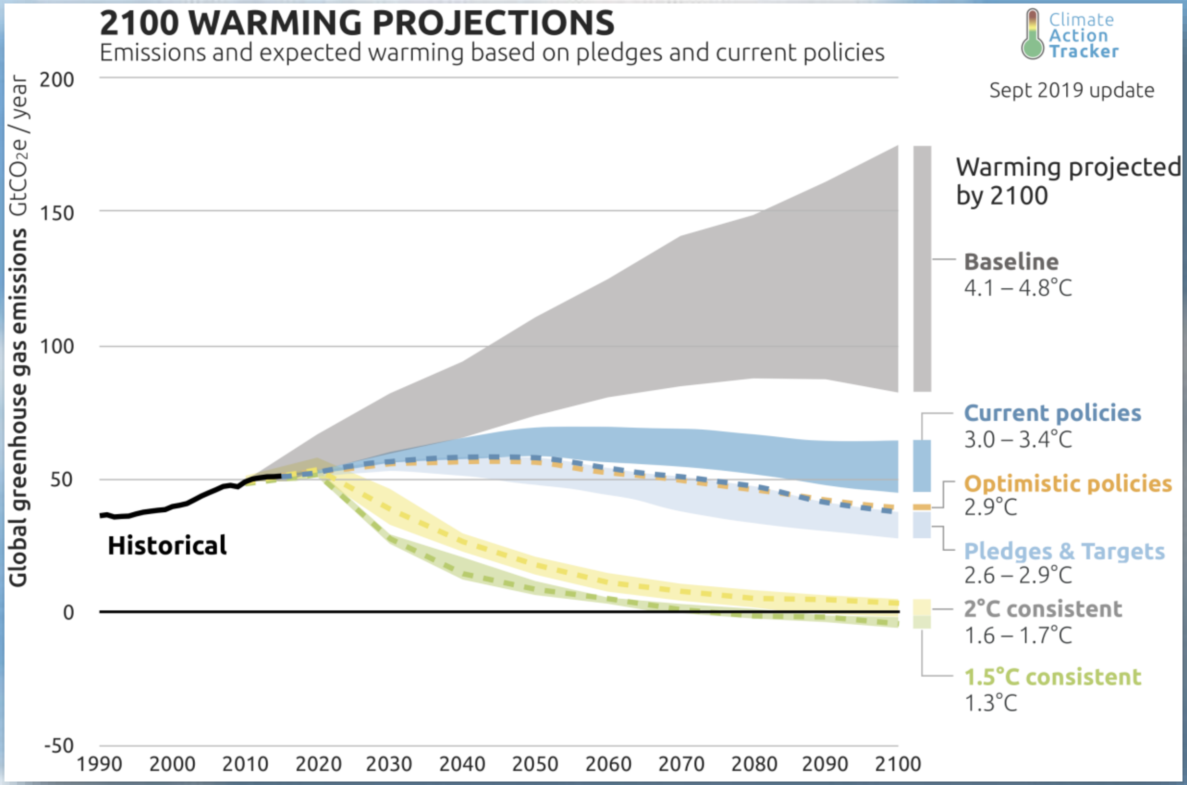
70% Methane reductions

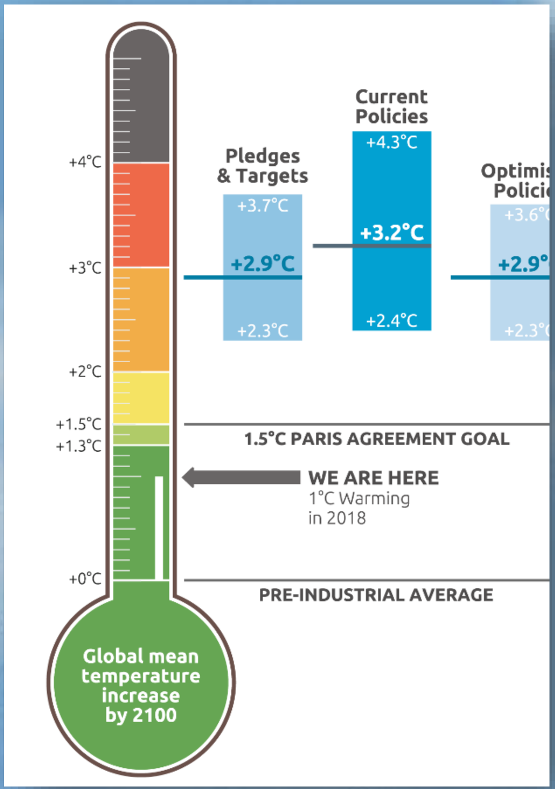
90% Black Carbon reductions

Lifetime of SLCF:
Methane: 11 years
Ozone: 30 days
Black Carbon: a few days

Source: IPCC Special Report on Global Warming of 1.5°C

Acordo de Paris: Se todos os países cumprirem seus compromissos: Aquecimento de 3.2 graus em 2050





http://climateactiontracker.org

- **Simple and realistic accounting with Paris Agreement: 3.2 degrees average heating**

- **In continental areas: 4.2 C**

- **Removal of regional air pollution: + 0.7 C, makes 4.9 C**

- **80% of population will be urban: Urban heat island: additional 1.0 C, makes 5.9 C**

- **We are heading to : 5.9 C where people live (in cities)**

Brazilian iNDC

Emissions reductions in 2025	Reduction in 2030
37%	**43%**

A few of the Brazilian iNDC commitments (*Reference point:* 2005):

- **ZERO illegal deforestation at 2030 and compensation of emissions from legal deforestation at 2030;**
- **Restore and reforest 12 millions hectares of forests till 2030, for multiple uses;**
- **Restoration of 15 millions of hectares in degraded pastures till 2030**
- **Participation of 45% renewable energy in the energy system at 2030**

Papel das empresas e setor privado

Governos respondem muito mais aos interesses empresariais do que interesses públicos. Em geral empresas e governos tem visão limitada a no máximo 4-6 anos. Quem pensa no planeta daqui a 50 ou 100 anos?

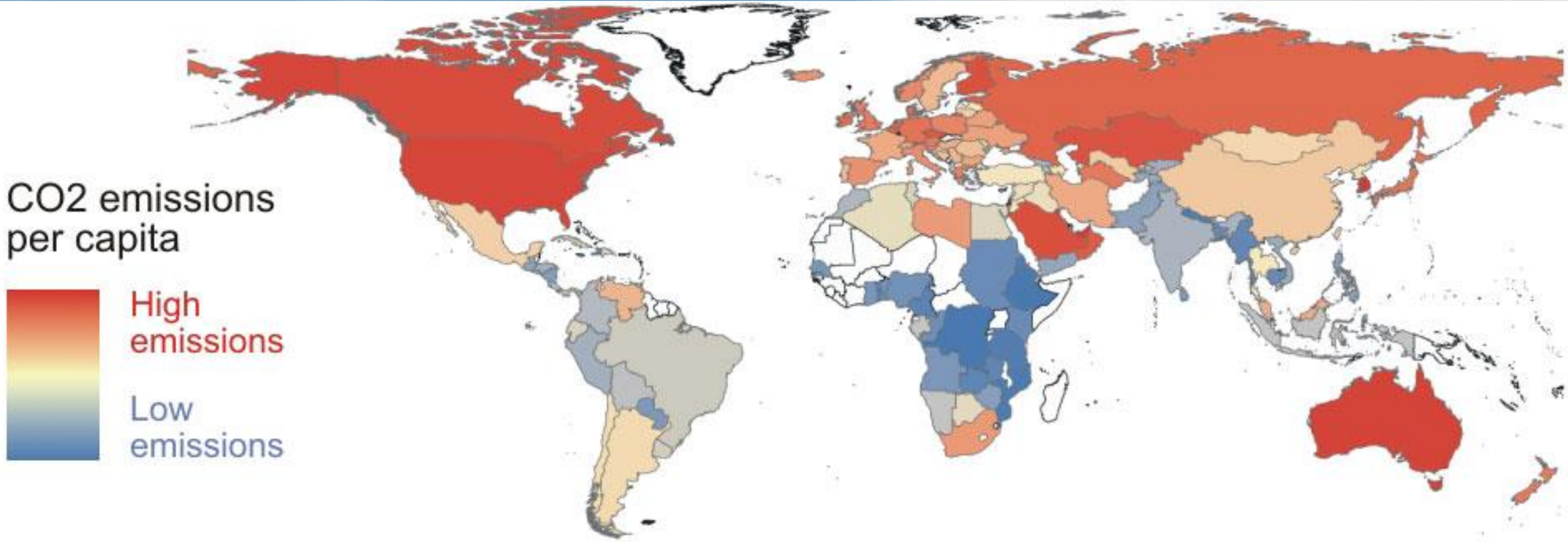
Papel das empresas até o momento:

Setor petrolífero: Shell, BP, Exxon sabiam nos últimos 70 anos dos impactos. Industria teve lucros de mais de centenas de trilhões de dólares. Quem paga a adaptação e os efeitos nos 7 bilhões de habitantes do planeta?

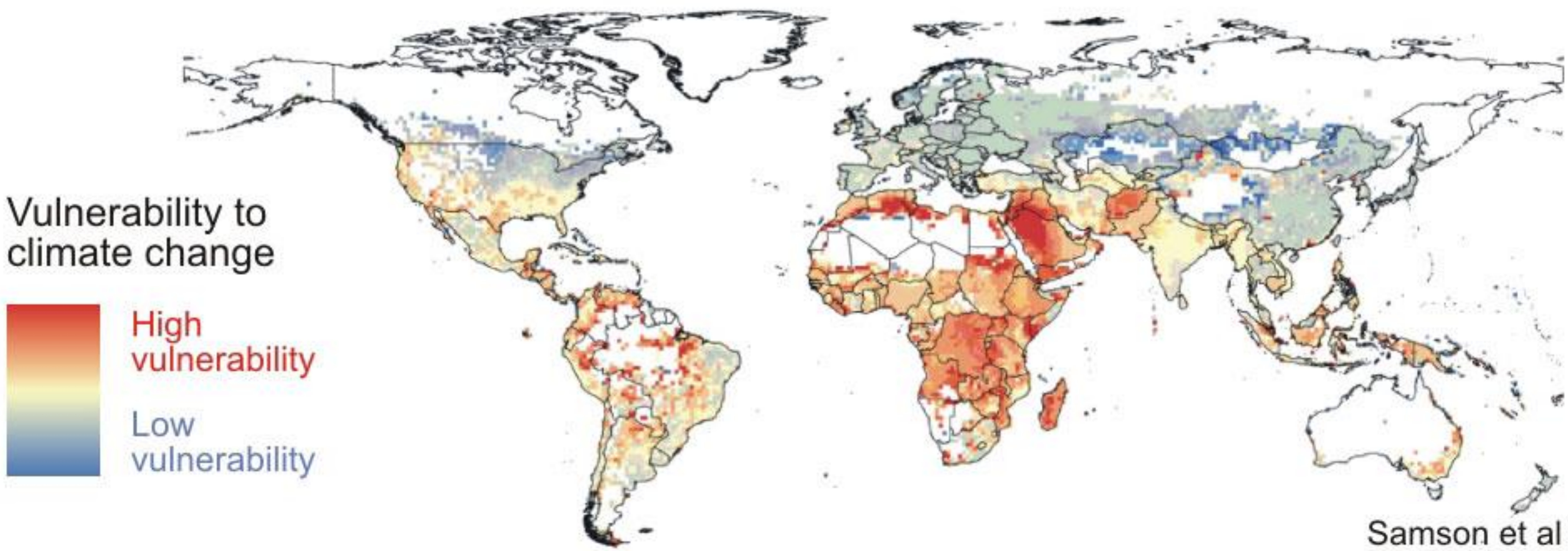
Setor automobilístico: Volks, AUDI, e outros fabricantes na questão das emissões de veículos a diesel: Se pudermos enganar a legislação, o faremos.

Setor agropecuário brasileiro: Pressão para desmatar o mais possível a Amazônia, para plantar soja e criar gado de modo ineficiente, ignorando o potencial futuro.

Setor privado fica com os lucros, setor publico paga os prejuízos. É justo e eticamente correto?



Those who contribute the least greenhouse gases will be most impacted by climate change



Samson et al 2011

Governance is a critical issue

Stephen Hawking "Our planet and the human race face multiple challenges. These challenges are global and serious – climate change, food production, overpopulation, the decimation of other species, epidemic disease, acidification of the oceans. Such pressing issues will require us to collaborate, all of us, with a shared vision and cooperative endeavor to ensure that humanity can survive."

We have not yet managed to adopt a model of production capable of preserving resources for present and future generations, while limiting as much as possible the use of non-renewable resources, moderating their consumption, maximizing their efficient use, reusing and recycling them.

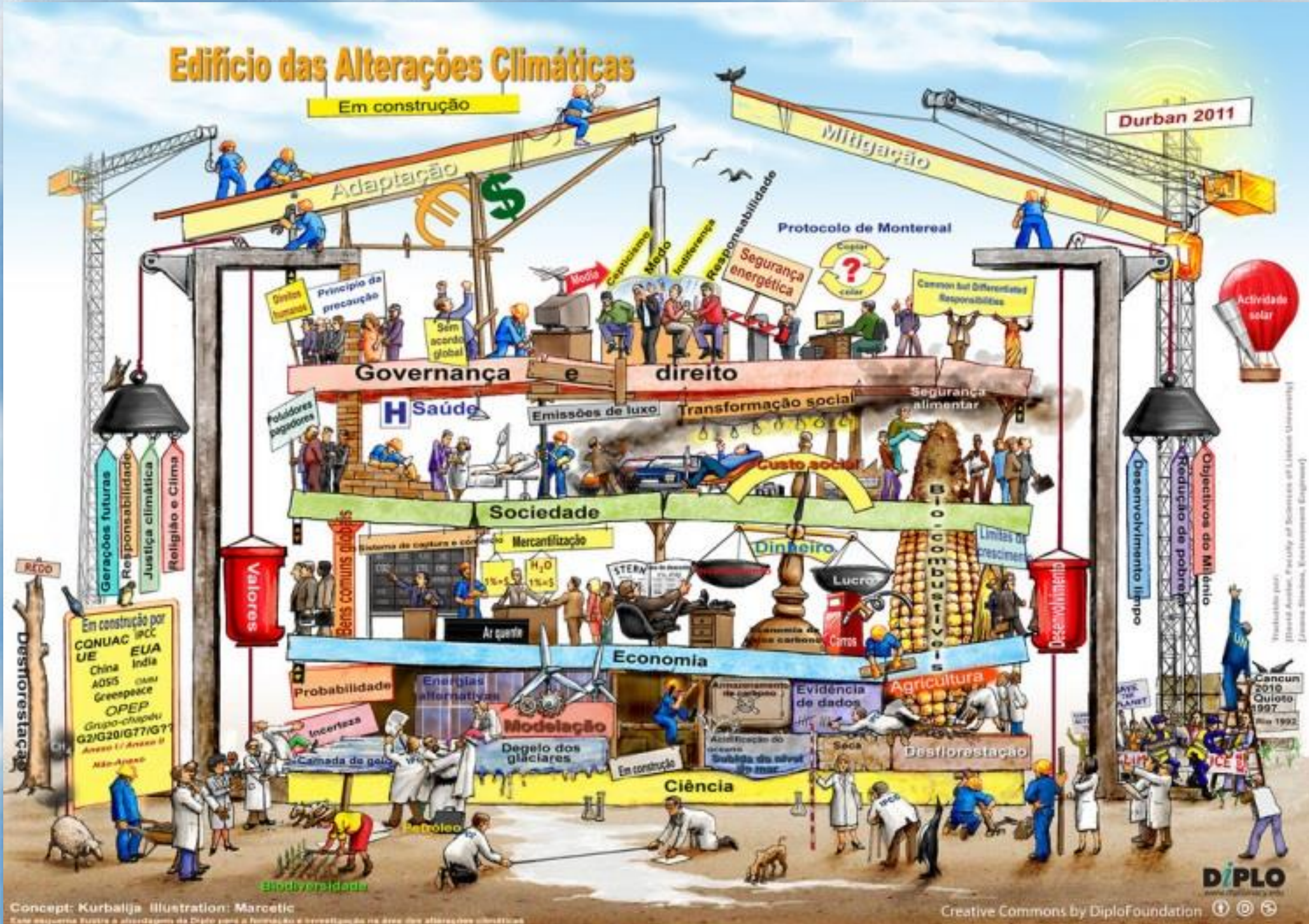
Governance is key:

How the necessary measure will be implemented?

Who drives and controls the implementation?

Consumo em uma semana...

O papel da ciência versus economia, sociedade, governança...



Olhem para o futuro

As seis grandes transformações necessárias para o mundo em 2050

Energia

Decarbonização, eficiência, acesso à energia

Consumo e Produção Sustentáveis

Uso de recursos, economia circular, suficiência, poluição

Alimentos, Usos da Terra & Biosfera

Intensificação sustentável, oceanos, biodiversidade, florestas, água, dietas saudáveis, nutrientes

Objetivos de Desenvolvimento Sustentável:

- Prosperidade
- Inclusão social
- Sustentabilidade
- Paz social

Revolução Digital

Inteligência artificial, big data, biotecnologia, nanotecnologia, sistemas autonômos

Cidades

Moradia, mobilidade, Infraestrutura sustentável, água, poluição

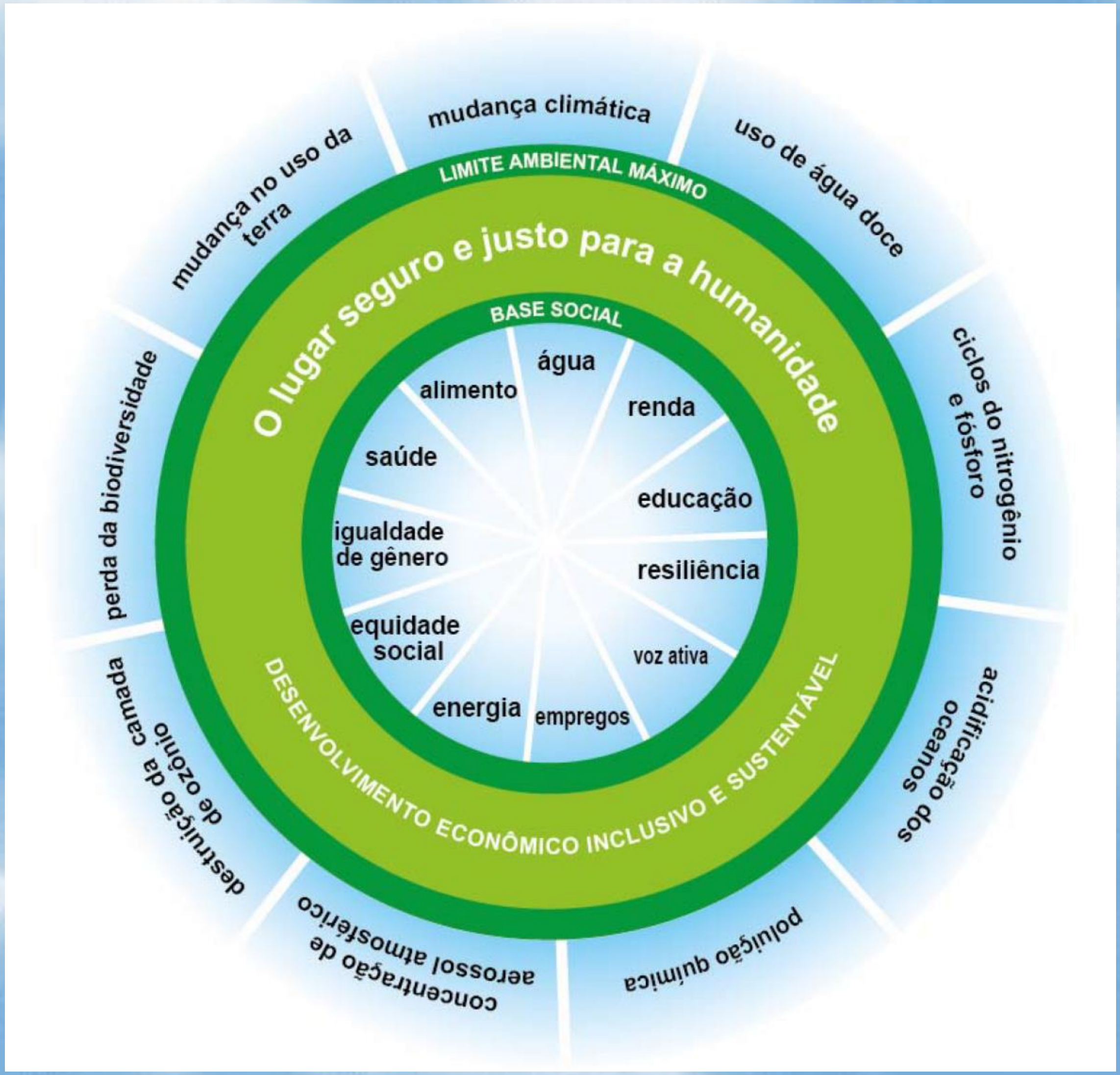
Capacitação Humana & Demografia

Educação, saúde, envelhecimento, mercado de trabalho, gênero, desigualdade

Adaptado de The World in 2050

Como construir um espaço seguro e justo para nossa humanidade?

Combinando o Sistema Terrestre com aspectos sociais



Steffen et al. 2015, Science

Precisamos de sólida ciência interdisciplinar para construir este espaço

Precisamos de ciência sólida em todas as áreas para encontrar meios de usar os recursos naturais de nosso planeta de modo mais eficiente e inteligente.

Obrigado pela atenção!!!